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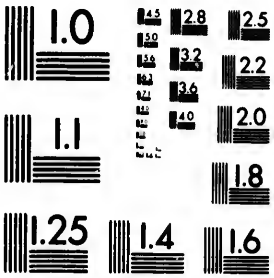

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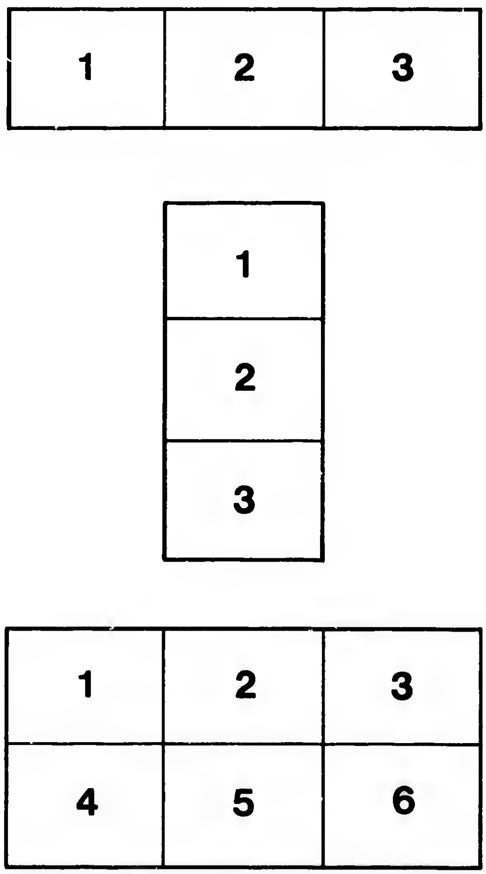

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GEOLOGICAL SURVEY OF CANADA.
ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

NOTES

ON THE

IRON ORES OF CANADA

AND

THEIR DEVELOPMENT,

BY

B. J. HARRINGTON, B.A., PH.D.,
CHEMIST AND MINERALOGIST TO THE SURVEY,

ADDRESSED TO

ALFRED R. C. SELWYN, F.R.S., F.G.S.,
DIRECTOR OF THE SURVEY.

From the Reports of the Geological Survey of the Dominion of Canada for 1873-74.

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ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, May, 1874.

SIR,—Much has been written about the iron ores of Canada, not only by officers of the Geological Survey, but by others interested in the development of the country's resources. The information, however, is to be found mainly in scattered reports and papers, many of which are not readily accessible to the general public. In the accompanying report I have endeavoured to bring together concisely some of the more important facts which they contain, at the same time supplementing them, when possible, with the results of my own more recent observations. Sources of information.

During the past summer a large number of iron localities were visited, and valuable collections of the ores made, which are now available for the Museum. The information contained in the last part of the report, under the head of "Economic Considerations," was partly obtained during this tour among the mines, and partly through the medium of correspondence subsequently carried on. If it is incomplete, the difficulty of obtaining it must be borne in mind.

To Principal Dawson, as well as to many other gentlemen whose names are given in the report, my thanks are due for much valuable assistance and information. Acknowledgment of assistance.

I have the honour to be,

Sir,

Your most obedient servant,

B. J. HARRINGTON.

REPORT.

Distribution of iron ores.

The iron ores of the Dominion have a wide range, both geographical and geological. From Vancouver Island on the west to Cape Breton on the east they occur at varied intervals; little, however, being known of their extent or importance, except in the provinces on the eastern side of the continent.

Concentrating processes.

From the Laurentian days down to the present moment, processes of concentration, both chemical and mechanical, have been in operation, often resulting in the formation of beds and veins of ore. The processes have doubtless, to a certain extent, differed in kind, and have operated under more or less favourable conditions, and the ores, subsequently to their deposition, have frequently been subjected to agencies depriving them of their original characters, so that it is not surprising to find them differing widely in chemical composition and physical characters. They may, however, be classified as follows:—

Classification of ores.

I.—ANHYDROUS OXIDES.

1. Magnetic Iron Ore or Magnetite.
2. Hematite, including crystalline and earthy varieties.
3. Titanic Iron Ore.

II.—HYDROUS OXIDES.

1. Limonite or Brown Hematite.
2. Bog Ore.

III.—CARBONATES.

1. Spathic Ore.
2. Clay Iron-stone.

MAGNETIC IRON ORE.

Age of magnetites.

The most important deposits of this ore occur in rocks of Laurentian and Huronian age, but it is also found in rocks which have been referred to the Lower and Upper Silurian, as well as in the Devonian and the Trias. The iron sands of the Gulf of St. Lawrence, moreover, give us examples of deposits of more recent date, and form one of the best possible illustrations of the great concentrating processes carried on by Nature.

Laurentian and Huronian magnetites classed together.

The mode of occurrence, mineral associations, and chemical composition of some of these ores will now be considered; and since a dividing line cannot, in our present state of knowledge, be in all cases drawn between the Laurentian and Huronian, the magnetites which probably belong to both these great divisions will be classed together.

MODE OF OCCURRENCE AND MINERAL ASSOCIATIONS OF LAURENTIAN AND HURONIAN MAGNETITES.

So few of our mines have been extensively worked that opportunities for studying the character of the deposits are exceedingly limited as compared with those afforded in Norway and Sweden, and also in New York and New Jersey. There seems, however, little doubt, that while the larger and more important deposits, such as the "big ore-bed" in Belmont, are interstratified beds, true veins of magnetic iron ore also occur. Beds and veins.

At the Foley mine in the township of Bedford, the country rock, which is a diorite shewing little or no indication of bedding, is cut not only by the deposits of magnetite, but also by veins of coarsely crystalline calcite, the two minerals being in some cases associated. No one would hesitate in calling the deposits of calcite veins, and the magnetite, so far as could be observed, occurred in quite an analogous manner. The magnetite, moreover, was found here in large octahedral crystals, the axes of which are often more than an inch in length; these crystals are somewhat rude, but their surfaces are covered with smaller ones which though minute are well formed. In the undoubted beds, the magnetite, so far as I have observed, is generally granular or in cleavable masses, but does not occur in large crystals of definite form. The mere occurrence of crystals, however, would in itself be no proof of the deposit being a vein. Foley mine. Octahedral crystals of magnetite.

Again, on lot 6, range 8, of Marmora, near the "marsh ore-bed," an opening has been made in a deposit of magnetite; the opening is too small to give any idea of the true nature of the deposit, but the association of minerals is such as is usually found in veins rather than in beds. The minerals are calc-spar, fluor-spar, feldspar, hornblende, spathic iron, cubic pyrites, magnetic pyrites, copper pyrites. Supposed vein.

Sir William Logan mentions the occurrence of veins of magnetite in the crystalline limestone of Ross, opposite Portage du Fort, (Geol. of Can., 1863, p. 37), and also a vein in Buckingham composed of large cleavable masses of feldspar and magnetite (Ibid. p. 20.). Veins in Ross and Buckingham.

In the Report of the Geological Survey of New Jersey for 1873, p. 27, "a coarse crystalline granitic dyke" is mentioned, and stated to be composed of feldspar, quartz and magnetite. It may be, however, that this is in reality a segregated vein and not a dyke. "Granitic dyke" in New Jersey.

The magnetic ores of New Jersey in many respects resemble our own. The workable deposits are now regarded as of sedimentary origin, though formerly believed to be eruptive.* The latter view was also taken by Sir Roderick Murchison as to the origin of some of the rich deposits of magnetite in the Urals †; and many of the deposits of magnetite in Norway and Eruptive orig of deposits.

* Geology of New Jersey, 1868, p. 533, and also Report for 1873, p. 18.

† Geology of Russia, pp. 372 and 380.

Sweden have been considered as eruptive by Durocher and others. None of the Canadian magnetites, so far as I am aware, have ever been regarded as eruptive, at least by the officers of the Geological Survey.

Origin of sedimentary magnetites.

Concerning the origin of our sedimentary magnetites, the question arises as to whether they were originally deposited as such, or in some other form, and afterwards altered to magnetite. It seems possible that, in some cases, beds may have been formed by the accumulation of iron sands, just as they are forming in the Gulf of St. Lawrence to-day, the material being derived from the disintegration of pre-existing crystalline rocks. Such beds we should expect to contain not only magnetite, but ilmenite, and it is well known that in many cases ores on being pulverised may be more or less completely separated into a magnetic portion containing little or no titanic acid, and a non-magnetic portion consisting essentially of ilmenite. It seems, however, probable that in general their origin has been similar to that of the modern bog and lake ores. Deposits of magnetite, as a rule, do not continue of uniform thickness for any great distance like the enclosing rocks, and this is just what might be expected if we suppose them to have originally occurred as bog or lake ores which accumulated in local hollows or depressions. No ore, moreover, would be more readily converted into magnetite than bog ore, on account of the considerable proportion of organic matter which the latter contains.

Curious deportment of bog ore.

In this connection may be described a very simple but interesting experiment tried with a specimen of bog ore from L'Islet, containing about 22 per cent. of water and organic matter. The pulverized ore was placed in a platinum crucible, and heated for an hour at a temperature of 190° F. At the end of that time it had parted with its combined water, or at any rate with sufficient to cause the colour to change from brown to bright red. It still, however, retained organic matter, and on heating for a few minutes in a tightly closed crucible, and at a temperature considerably below redness, a reduction of the peroxide ensued, and a black strongly magnetic powder was obtained, apparently consisting of magnetic oxide, and not of metallic iron, as it occasioned no precipitation of metallic copper in a solution of the sulphate. The cover was now removed from the crucible and a red heat given, when in a short time the powder again became red, or rather purplish-red, and non-magnetic. Finally, the heat was raised a little higher (to bright redness), and soon the powder became black and strongly magnetic, having apparently parted with a portion of its oxygen. These changes are instructive, for while brought about in the laboratory they might take place in nature. They shew, too, that in some cases magnetites may have been formed from such ores as bog ore at comparatively low temperatures, the reduction being due to the organic matter of the ore.

That a magnetic oxide should be converted into a non-magnetic oxide, as described above, is a curious fact. It is generally stated also that peroxide of iron requires a white heat to convert it into magnetic oxide, but the heat of an ordinary Bunsen burner has been found, to readily convert limonites, even when free from organic matter, into magnetic oxide.

Remarks by Durocher on the rocks of Scandinavia containing magnetic iron ore.

Durocher, speaking of the Scandinavian ores, says: "The deposits of magnetic iron ore occur in rocks of very varied character, and it does not appear that their richness is influenced by the nature of these rocks; some are enclosed in ordinary gneiss, others in quartzose, micaceous or hornblendic schists, or else in calcareous beds; others are found at the line of contact of granite and gneiss, rarely in the granite itself; there are some which form part of dioritic or hornblendic masses enclosed in the gneiss." Most of what Durocher states here might be said with equal truth of our deposits, as will be seen from the examples which follow:

Rocks containing magnetite in Canada.

Hull.

At the well known Hull mines the magnetite occurs in crystalline limestone containing graphite, mica, and, more rarely, pyroxene.

Big ore-bed.

At Blairton in Belmont (the big ore-bed) the ore is interstratified with diabase, greenish epidotic and chloritic rocks, and crystalline limestone.

Seymour ore-bed.

At the Seymour ore-bed in Madoc the ore is underlaid by a thin band of soft mica-schist, and overlaid by reddish-grey, highly feldspathic rocks, in places porphyritic, and occasionally passing into syenite or syenitic gneiss. On the run of the bed to the eastward also, dark grey hornblendic rocks occupy the surface at times, as well as the feldspathic rocks just alluded to. Daubrée mentions the occurrence of a petro-siliceous rock at Dannemora which would appear to resemble somewhat the feldspathic rock near the Seymour ore-bed. It is known to the miners as *hälleflinta*, and is here and there porphyritic. (Ann. des Mines [4], iv. p. 223.)

Chaffey mine.

At the Chaffey mine, in South Crosby, the ore occurs in coarsely crystalline gneiss, containing both mica and hornblende. The gneiss adjoins a band of crystalline limestone.

Bedford.

On the west half of lot six, in the third concession of Bedford, the country rock is of exceedingly varied character. Among my specimens there is one consisting of an aggregate of black hornblende and greenish white feldspar; another consisting almost entirely of green translucent crystalline pyroxene; others are made up of similar green pyroxene, together with a little black hornblende, grains of magnetite, and in some instances a considerable proportion of calcite. Though the ore is more directly associated with these hornblendic and pyroxenic rocks, it is removed but a very short distance from a band of white crystalline limestone.

Bristol.

During the winter of 1872-73 several openings were made in deposits of magnetic ore on lots twenty-one and twenty-two of the second range of Bristol, Pontiac county, Quebec. The ore here forms a series of beds, interstratified with reddish syenitic gneiss and glistening micaceous and hornblendic schists. The thickness of what appeared to be the most important and the uppermost bed could not be ascertained at the time of my visit in July last, as the opening upon it was nearly full of water; judging, however, from the quantity of ore taken out, the thickness must be considerable. Besides this bed, three others had been exposed by stripping; one of them was two feet thick, another only a few inches, but underlaid by occasional small lenticular patches of ore, while the fourth appeared to be about nine or ten feet thick, so far as the small amount of work done enabled one to judge. The micaceous and hornblendic schists in which the last mentioned bed occurs strike approximately east and west, dipping northward at an angle of only 35°. The general strike of the rocks as observed in the country for several miles east of the mines varies between E. and W. and E. 30° N., the angle of dip being usually high.

In the Report of Progress for 1872-73, p. 131, Mr. McOuat mentions the occurrence of magnetite interstratified with quartzite on the eighth portage of the Quinze. The ore forms "layers from the thickness of paper to about an inch, and is interlaminated with similar layers of whitish-grey and dull red, fine-grained quartzite. The iron ore constitutes probably from a fourth to a third of the whole, and, as the thickness of the whole band is about thirty feet, the total thicknes of the layers of iron would probably not be less than eight feet." Some of the Michigan ores occur in an analogous manner, and are, I believe, considered to be of Huronian age. Examples of a similar mode of occurrence are also to be found in Scandinavia. On the third lot of the fifth range of Elzevir magnetic ore is said by Mr. Macfarlane to occur in a talcose or steatitic rock.

The "Quinze."

Elzevir.

In speaking of the Foley mine, on page 5, I have incidentally referred to the ore occurring in diorite. This rock forms extensive beds in the Laurentian as well as in the Huronian series. I say beds, although in many places it is quite impossible to distinguish the rock from diorites of igneous origin. It, however, appears in general to follow the sinuosities of the beds on either side of it, and is sometimes seen to graduate into hornblendic and micaceous schists. Many of the so-called Laurentian granites though locally shewing no parallelism in the arrangement of the constituent minerals, in like manner pass gradually into unmistakable gneisses.

Diorite

The term diorite strictly speaking belongs to an igneous rock, and there seems to be no good name for a similar aggregate of sedimentary origin. Such an aggregate is sometimes called "hornblende-rock;" but this is certainly an erroneous name for a rock which is at times half made up of feldspar. Hornblende rock, strictly speaking, consists mainly of hornblende; but according to Zirkel, by the addition of oligoclase, it passes now and then into diorite.* Cotta also says that the addition of feldspar to hornblende rock causes a transition into diorite. In using the term diorite in this way we make the name depend upon the mineral constituents of the rock, ignoring altogether the origin. What is needed is a term bearing the same relation to diorite that gneiss bears to granite.

Distinctive name needed for diorites of sedimentary origin.

At many places in Hastings and Addington counties, and elsewhere in Ontario, fine-grained diorites occur; those, however, which are associated with magnetic iron ore in the townships of Bathurst and South Sherbrooke are generally coarse-grained. The latter, in addition to black or dark green hornblende, and white, greyish or greenish feldspar, often contain scales of dark brown mica, grains of magnetic iron ore, and small quantities of quartz.†

Analysis of feldspar.

The feldspar was as carefully separated as possible from a specimen of the coarsely crystalline variety occurring at the Fournier mine. It was white to pale grey in colour, and in places shewed the striations characteristic of triclinic feldspars. The specific gravity was 2.63–2.64 and hardness about 6. Before the blowpipe it fused at about 4 to a white enamel. An analysis gave the following results:

Silica	58.58
Alumina	24.78
Peroxide of iron	traces
Lime	4.84
Magnesia	0.20
Soda	6.63
Potash	2.15
Water	1.85
	99.03

It may accordingly be referred to the species oligoclase, although in some respects resembling andesite. The latter species, however, so far as I am aware, has not been noticed as a constituent of diorite. Besides the dark green hornblende associated with it, there were tolerably abundant scales of dark brown mica, and more rarely grains of quartz.

The examples given suffice to illustrate the variable character of the rocks containing deposits of magnetite in our old crystalline series. It should be remarked here that, while it is exceptional to find such deposits

* Lehrbuch der Petrographie, Band I. S. 304

† Gesner in his "Third Report on the Geological Survey of New Brunswick" mentions the occurrence of magnetic ore near Pull Moose Hill in the Parish of Springfield, in rocks which, judging from his description, appear to be somewhat similar to the coarse dioritic rocks of Bathurst and South Sherbooke, although he speaks of them as syenite.

Proximity of magnetites to limestone.

in limestone, they very frequently occur near the junction of other rocks with the limestone. This fact should always be kept in mind in tracing or searching for magnetites, as the limestone bands are continuous and constant in character for long distances.

Mineral associations of magnetite.

The minerals associated with our magnetic ores form a subject of study not only of scientific interest but also of economic importance, inasmuch as the quality of the iron produced often depends largely upon their presence with or absence from the ores, as the case may be. In Norway and Sweden a great many minerals have been detected, associated with the magnetites, which have not been observed with ours; they may, however, be found when the mines have been more fully developed.

The following is a list of the minerals collected last July and associated with the magnetites of this division (Laurentian and Huronian):

Apatite.	Limonite.
Calcite.	Malachite.
Chalcopyrite.	Mica, (probably Muscovite and Phlogopite).
Chlorite.	Pyrite.
Epidote.	Pyroxene.
Feldspar.—Orthoclase and Oligoclase. (see p. 198)	Pyrrhotite.
Fluor-spar	Quartz.
Garnet.	Serpentine.
Graphite.	Siderite.
Hematite.	Talc.
Hornblende (several varieties.)	Uran-ochre.
Ilmenite.	

Apatite.—This mineral occurs in a granular condition, as well as crystallized, associated with the magnetite, at the Foley mine, and also on the adjoining property (Bathurst, lot eight, range nine). At the Foley mine well formed crystals of apatite are sometimes found scattered here and there among the large octahedral crystals of magnetite. Apatite is of course an unwelcome associate, for when the ores are smelted the phosphorus passes into the iron, rendering it *cold-short.* Fortunately the magnetites of this group are in general very free from phosphates.

General freedom from phosphates.

Calcite.—This is a very frequent associate of magnetite. Sometimes it is well crystallized, at others it occurs in large cleavable masses, while in some cases it is granular At the Forsyth mine (Hull) crevices in the ore often contain small but perfect crystals, both in the form of hexagonal prisms and in scalenohedra. Small rhombohedral crystals were also observed associated with the titaniferous magnetite at the Yankee or Mathew's mine in South Crosby. Large cleavable masses of white and pink calcite are associated with the magnetite at several localities in Bathurst, and granular calcite at some of the openings in Marmora. Limestones, we have already seen, are sometimes the country rock and sometimes interstratified with beds of magnetite. Calcite in limited quantity cannot be regarded as an injurious accompaniment of iron ores, as, if not present, it has to be added, in the form of limestone, to form a slag in the smelting process.

Chalcopyrite.—Ores of copper seem to be rarely associated with our magnetites. Copper pyrites, however, is said to accompany the ore at the marsh ore-bed. It also occurs at the opening on the same lot referred to on page 5, and on the seventh lot of the second range of Escott. Small quantities of copper pyrites, partially converted into malachite, were observed in a vein cutting the magnetite of the Seymour ore-bed. The vein was composed mainly of quartz, actinolite, and calcite. The general absence of copper ores from our deposits of magnetite is a point in their favour, as it is well known that copper produces *red-shortness* in iron.

Copper ores not common with magnetite.

Chlorite.—A green mineral occurring among other places at the Hull Chaffey, and Yankee mines, probably belongs to this species. It is sometimes disseminated through the ore, and sometimes, together with calcite, forms thin veins, or covers the walls of joints. Chlorite occurs in an analogous manner at the celebrated Dannemora mines in Sweden, and Daubrée referring to this fact, says :* "The magnetite is there intimately mingled with chlorite, more rarely with calcite ; the ore, of a dull colour and fine grain, is traversed in every direction by fissures which divide it into little polyhedra. The walls of separation of these polyhedra are planes, and usually clothed with a brilliant coating of chlorite which sometimes also forms little veins."

Chlorite at Dannemora mines.

Epidote.—A green mineral associated with the magnetite of the big ore-bed at Blairton has been referred by Dr. Hunt to this species. It is frequently accompanied by small brilliant crystals of pyrites.

Feldspar.—Examples have already been given of the occurrence of magnetite in gneiss. In such cases the magnetite is often more or less mingled with the orthoclase and other constituents of the gneiss, and places may be observed where there is a gradation of the gneiss into a bed of magnetite by the addition and gradual increase in quantity of the latter mineral. A feldspar from the Fournier mine having the characters of oligoclase has been described on page 9. Oligoclase would form a better gangue-stone for an iron ore than orthoclase, for, being more basic, it would require the addition of smaller quantities of lime in order to form a slag.

Oligoclase as a gangue-stone.

Fluor-spar.—This species was observed as an associate of magnetite in one locality only—on lot six, range eight, of Marmora. A specimen before me is of a pale sea-green colour, but somewhat stained with peroxide of iron. It forms a mass of several cubic inches, embedded in magnetite, pyrites, and calcite. The presence of fluor-spar with iron ores would in many cases be advantageous

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*Ann. des Mines, [4] iv., p. 222.

Garnet.—A reddish-brown variety of this mineral, approaching cinnamon-stone in colour, and associated with several other minerals in smaller quantity, forms the gangue-stone of what is perhaps a *vein* of magnetite on lot three, range five of Grenville. In places the gangue-stone is compact, but more frequently cavernous, the cavities being lined with beautiful dodecahedral crystals of garnet. Occasionally also, delicate rhombic prisms, apparently of hornblende, shoot out from the sides of these cavities.

Beautiful crystals of garnet.

Garnet is frequently associated with magnetic iron ore in other parts of the world, as for example at Schmiedeberg, where, according to Cotta, it occurs in brownish-red or red trapezohedral crystals with striated planes.

Graphite.—This species, as repeatedly noticed in the Reports of the Geological Survey, occurs in the form of scales disseminated through much of the magnetite at the Hull mines. According to Daubrée it is also associated with some of the Swedish magnetites.

Hematite.—At some of the mines, more especially at Hull, Blairton, and Bristol, hematite occurs associated with the magnetite. Sometimes its presence is manifested by the red or reddish colour of the ore, as in the case of the so-called "red-ore" at Hull; at other times, however, the ore is black or greyish-black, but is shown to consist in part of hematite by yielding a decidely red powder to the drill. In the latter case the hematite is probably present in the crystalline condition, while in the former it is earthy. A specimen of the Hull magnetite collected last summer contains little veins of red hematite crossing it in different directions, and others of calcite, of quartz and of pyrites; graphite and brilliant black hornblende are also disseminated through the magnetite, and a mass of steatite forms one wall of a little quartz vein.

"Red ore."

Hornblende a frequent associate of magnetite.

Hornblende.—This is one of the most frequent of all the mineral associates of magnetite, and occurs in several varieties. In Bathurst and South Sherbrooke, where the iron ores occur in the coarsely crystalline diorites already described, they are often associated with cleavable masses of beautiful black or dark green hornblende. Good examples of this variety are to be found on the McVeigh lot (Bathurst lot 11, range 8), also at the Foley and Fournier mines. At the Hull mines black hornblende is often present with the magnetite, but not in large cleavable masses like those just referred to; and at the Bygrove mine in South Sherbrooke well-formed crystals are found.

Analysis of hornblende.

The following is an analysis of a specimen from the McVeigh lot in Bathurst:

Silica	40.02	
Alumina	15.55	
Peroxide of iron	3.44	Metallic iron 8.69
Protoxide of iron	8.60	
Lime	12.21	
Magnesia	14.37	
Potash	2.13	

Soda	2.40
Loss on ignition*	1.81
	100.53

In composition this comes very near the so-called Pargasite from Pargas, in Finland, an analysis of which gave Rammelsberg the following results (Pogg. CIII, 444): **Pargasite of Finland.**

Silica	41.26	
Alumina	11.92	
Peroxide of iron	4.83	Metallic iron, 11.10.
Protoxide of iron	9.92	
Protoxide of manganese	trace.	
Lime	11.95	
Magnesia	13.49	
Potash	2.70	
Soda	1.44	
Water	0.52	
Fluorine	1.70	
	99.73	

The presence of these ferruginous hornblendes with magnetite, in limited quantity, is rather an advantage than otherwise, unless the ores have to be transported for long distances; for, besides a certain proportion of iron, they contain essential constituents for the formation of slags. **The presence of ferruginous hornblendes advantageous.**

The variety of hornblende known as actinolite forms the chief mineral associate of the finely granular magnetite of the Seymour ore-bed. It occurs in scattered radiating bunches and also uniformly disseminated through the ore. A little vein cutting the magnetite at this locality, and already spoken of as containing a small quantity of copper pyrites, was found to be mainly made up of quartz, calcite and actinolite, besides small grains of magnetite. The insoluble residue of a sample of ore from the Seymour bed was found by Dr. Hunt † to consist of magnesia 17.15, lime 11.01, protoxide of iron 11.95, silica, by difference, 59.89—this being the composition of actinolite. According to Professor Chapman actinolite is also an associate of the magnetite on lot twenty, range one, of Snowdon, Peterboro county. Occasional radiating masses of a bright green mineral at the Fournier mine, also, probably belong to this variety of hornblende. **Actinolite.**

According to Bauerman, ores accompanied by such minerals as pyroxene, hornblende, garnet, idocrase and chlorite are called in Sweden "*self-gaejende, i.e.*, self-going or self-fluxing." **Self-fluxing ores.**

Ilmenite.—Many of the magnetic ores of this group are known to be titaniferous, and it is probable that in some cases at least, the titanium is present in ilmenite which is mixed with the magnetite, and is not really a **Titanium.**

* Probably fluorine in part.

† Report of Progress 1866-69, p 259.

constituent of the latter. This was found by Dr. Hunt to be the case with certain ores from the Quebec group in the Eastern Townships; and in some of the Laurentian ores from the Adirondacks the two minerals are said to be distinguishable by the eye, owing to a slight difference in colour and lustre.

Limonite.—Near the surface of deposits of magnetite, a partial alteration to hydrated peroxide of iron may often be observed. This appears to be more frequently the case when the deposits occur in schistose strata like the mica schist at the Bristol mine. The enclosing rocks, also, frequently present a rusty appearance. In some cases the origin of the limonite is probably the decomposition of pyrites associated with the magnetite rather than an alteration of the magnetite itself.

Magnetite more liable to alteration when in schistose strata.

Malachite.—This was observed in only one instance, at the Seymour ore-bed, and then only in sufficient quantity to say that it did exist.

Mica.—The mica found associated with the magnetites of this group probably belongs to several species, which, however, have not been determined. In general it is dark brown or brownish-black in colour; but occasionally of lighter colours. At the Bristol mine much of the mica is of a pale silvery-grey colour. There is no more frequent associate of magnetite.

Occurrence of pyrites.

Pyrite or Pyrites.—The occurrence of this mineral is more frequent than desirable. Occasionally it is well crystallized; sometimes masses of considerable size are found here and there embedded in the magnetite; but more frequently it occurs in minute grains scattered through the ore, or in little strings or veins. At the Bristol mine it occurs in such quantity as to greatly lessen the value of the ore; at Hull, the ore from the Baldwin mine seems to be pretty free from it, but it may be noticed in much of the ore at the Forsyth mine, both in disseminated grains and little veins; at the Foley mine, as well as at the openings on the adjoining properties, the ore seen was very free from it; at the Fournier mine it occurs in small quantity, but generally associated with the hornblende rather than with the magnetite; at the Yankee or Mathews' mine it is almost impossible to find a specimen of the ore not shewing pyrites either in thin strings or disseminated grains. It also is common in the ore at the Chaffey mine. In what was supposed to be an average sample of the ore from the latter locality Dr. Hunt found 1.52 per cent. of sulphur, which, calculated as pyrites, gives 2.85 per cent.

At the Christie's Lake mine a good deal was observed, not, however, generally disseminated through the ore, but in veins which would be readily separable. It sometimes occurs at this locality in well-defined cubes.

Fine magnetite.

The magnetite of the Seymour ore-bed is unusually free from pyrites, and is undoubtedly one of the finest ores in the country. The ore of the marsh ore-bed, and other openings near it, contains large quantities of pyrites. The big ore-bed in Belmont in portions of its thickness contains a good deal, while other portions contain but little; curious concretions occur at this mine, consisting of alternate layers of pyrites and hematite. Ores containing much pyrites should always be roasted before smelting, by which means much of the sulphur is got rid of. The effect of sulphur upon iron, as is well known, is to make it *red-short*, or brittle when hot.

Advantage of roasting.

Pyroxene.—This is a frequent associate of the magnetites of this group, though by no means so common as hornblende. At the Hull mines the limestone adjoining the magnetite contains crytals of pyroxene some of which are green, and others greenish-yellow and transparent; these, like the crystals of apatite in many Laurentian limestones, are often curiously rounded. One of the rocks associated with the magnetite of the big ore-bed is described in the Geology of Canada as a diabase, and, therefore, contains pyroxene as one of its constituents. At this locality, also, a pale green coccolite is occasionally mixed with the magnetite. On lot six, concession three, of Bedford, there occurs with the magnetite a rock which in some places is almost entirely made up of a green, crystalline, translucent pyroxene with a specific gravity of 3.30, and in others contains, in addition to the pyroxene, grains of magnetite, as well as brilliant black hornblende and white calcite.

Rounded crystals of pyroxene.

Pyrrhotine.—This mineral occurs associated with the magnetite of the marsh ore-bed, and its presence is, of course, objectionable. It was not observed in other localities.

Quartz.—Of this species little need be said. It frequently accompanies magnetite in the form of disseminated grains, or in little veins. In some localities, as already mentioned, it constitutes the rock with which the magnetite is interstratified. When present it requires in smelting the addition of lime or other basic substances in larger quantities than would otherwise be necessary.

Serpentine.—The best examples of the occurrence of this mineral are to be found at the big ore-bed, Belmont, where it is found massive, foliated and fibrous. Some of the massive variety is of a dark green colour and some yellowish-green and translucent. The latter passes into foliated and fibrous varieties, marmolite and chrysotile, which are pale green or greenish white. The fibrous serpentine is sometimes mistaken for asbestus, a variety of hornblende.

Good examples of the occurrence of serpentine.

Siderite or Spathic Iron. This mineral was observed associated with magnetite in only one instance; namely, on lot six range eight of Marmora. It was well crystallized, but in small quantity, and accompanied by a number of other minerals enumerated on page 5. The siderite is probably of more recent age than the magnetite, and formed from the alteration of the latter.

Siderite from alteration of magnetite.

Talc.—Among the specimens collected at Hull and also at the Seymour ore-bed, are several shewing small quantities apparently of steatite, the earthy variety of talc, associated with magnetite. In the latter case it appears to be the result of the alteration of actinolite. The occurrence of magnetic iron ore in a "talcose or steatitic substance" on the third lot of the fifth range of Elzevir has already been referred to.

Actinolite altered to steatite.

Uran-ochre.—The occurrence of this mineral at the Seymour ore-bed is mentioned by Dr. Hunt in the Geology of Canada (1863). It forms a lemon-yellow coating or crust upon the walls of fissures in the magnetite. Quite recently Professor Chapman has noticed its occurrence with magnetite on lot twenty, range one, of Snowdon township, Peterboro' county.

Uran-ochre recently observed by Professor Chapman.

MODE OF OCCURRENCE AND MINERAL ASSOCIATIONS OF MAGNETITES MORE RECENT THAN THE HURONIAN.

The metamorphic rocks of the Eastern Townships, which are regarded by Sir W. E. Logan as of Lower Silurian age, occasionally contain deposits of magnetic iron ore. Few of them, however, appear to be of much economic importance, and none, so far as I can learn, are being worked at present. As yet I have had no opportunity of visiting them.

No deposits being worked in the Eastern Townships.

Some of the dolomitic and chloritic schists of this region contain considerable quantities of magnetite in disseminated octahedral crystals. In a specimen from the ninth lot of the ninth range of Sutton, consisting of dolomite and magnetite, Dr. Hunt found the latter mineral to equal fifty-six per cent. of the mass. Minute crystals of magnetite were also found to constitute more than half the weight of a chloritic rock from the second lot of the fourteenth range of Bolton (Geol. of Can., 1863, p. 677).

Magnetite in dolomitic, chloritic and talcose rocks.

In 1872, also, specimens of chloritic and talcose schists, containing disseminated octahedral crystals of magnetite, were brought by Mr. W. McOuat, of the Geological Survey, from Lake Opasatika, which closely resemble some of those from the Eastern Townships, and are possibly of the same age.

According to Dana chloritic slates with octahedral crystals of magnetite occur in Corsica, and also at Fahlun in Sweden.

In the Geology of Canada, 1863, page 677, large loose fragments of magnetic iron ore are spoken of as occurring near a band of serpentine on the second lot of the tenth range of Leeds (Megantic). Since then the ore has been discovered *in situ* on the seventh lot of the fifth range. Mr. Charles Robb, who visited the locality last spring, tells me that the strata had been exposed by stripping for a distance of forty yards in the direction of the strike, and sixteen yards across it. In the latter distance three tolerably regular beds of ore were seen, respectively six, four, and three feet thick, and all dipping to the north-west at an angle of 50°. The beds are separated by bands of chloritic slate containing quartz and calc-spar.

Magnetite of Leeds, Megantic.

The ore is a fine-grained magnetite, more or less mixed with micaceous iron ore, and some specimens exhibiting polarity in a marked manner. A specimen of magnetite from the adjoining township of Inverness, strongly resembling that from Leeds, was sent a short time ago to the Geological Survey office for examination, and its analysis will be given further on. Possibly it is from a continuation of the deposit occurring in Leeds.

Inverness.

In the Seigniory of St. Francis, Beauce, a bed of granular iron ore, forty-five feet wide, occurs in serpentine. It was found by Dr. Hunt to consist of a mixture of about two-thirds magnetite and one-third ilmenite. (Geology of Canada, 1863, p.501.)

Mixture of magnetite and ilmenite.

In the Upper Silurian slates and quartzites of Nova Scotia, magnetite occurs in veins associated with specular or micaceous ores at Londonderry, and also near the East River, Picton county. The proportion of magnetite, however, is usually small. A mixture of this kind from the East River is locally known as "specular magnetic."

"Specular magnetic."

While in Truro, in September last, specimens of magnetite were given me which were said to be from a bed six feet thick and about twelve miles west of Truro, but whether the deposit is really one of importance I cannot say.

Deposit near Truro, N. S.

The fossiliferous hematites of the Devonian slates on the south side of Annapolis Valley have in many cases been more or less completely altered to magnetite, which still, however, holds numerous fossils of Lower Devonian age. This metamorphism, according to Dr. Dawson,* has taken place chiefly at Moose River, to the south of the great mass of granite in Annapolis county. A short time since, however, a massive, fine-grained magnetite, resembling some of the Laurentian ores, was sent to the laboratory of the Geological Survey for examination, and said to be from Nictaux River. It held no fossils whatever, but, like the fossiliferous ores of the district contained a large quantity of phosphorus. Probably it was taken from near the granite, which would account for its highly metamorphosed condition. Magnetic iron ore of Devonian age also occurs on Deer Island in Passamaquoddy Bay, New Brunswick.

Magnetite of Devonian age.

According to Mr. Richardson, deposits of magnetite occur on Texada Island, British Columbia, associated with dioritic rocks and limestones holding Devonian fossils; but little is as yet known of their extent.†

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* See Acadian Geology, pp. 498-501.

† Mr. Richardson has placed in my hands several specimens of magnetite (age unknown) given to him by gentlemen in British Columbia. The specimens are accompanied by the following memorandum:—

No. 1.—From 50 yards back from the Cariboo and Yale waggon road, up a ravine half a mile below Nicomeen, Lytton District. Bed 8 feet thick. Specimen given by Joseph William McKay, Esq., Factor H. B. Co. Service, Victoria.

No. 2.—Ore from one mile up the river at the head of Knight's Inlet. Given by Alexander Donaldson, Esq., of Victoria.

No. 3.—From Mountain, south side of Lake Howse, about 10 miles from Hope, Hope and Similkameen trail. Given by J. W. McKay, Esq.

Absence of magnetite from Carboniferous rocks.

Veins in Triassic trap.

Magnetite is wanting in rocks of Carboniferous age; but passing on to the Trias we find that it occurs in veins in the great ridge of trap bordering the south-eastern side of the Bay of Fundy. These veins can scarcely be regarded as of economic importance, although a few attempts to work them have been made. Thus at North Mountain, in Annapolis county, two miles from Middletown Station, on a farm owned by Mr. John Dodge, there is a vein in the trap, said to be from six to nine inches thick, from which about one hundred and fifty tons of ore were taken in 1871 and carried to the furnace at Londonderry. Much of it is well crystallised in dodecahedra and combinations of the octahedron and dodecahedron. Some of the specimens lying near the furnace at Londonderry were associated with calcite, and others with colourless and amethystine quartz.

Iron sand.

Many of our old crystalline rocks contain disseminated grains and crystals of magnetite and ilmenite, which, on the disintegration of the rocks, are gathered together and form deposits of what is known as "iron sand." This iron sand is always more or less mixed with siliceous sand, so that artificial processes of concentration have generally to be employed before it can be utilized for the manufacture of iron. Grains of garnet are also frequently present, but generally in small quantity.

The most important deposits of iron sand in Canada are those along the north coast of the Gulf of St. Lawrence, at Moisie, Bersimis, Mingan, &c., &c.; but they are also found in places along the shores of the great lakes of the interior. As regards the age of the gulf deposits, some are modern, indeed are being formed at the present moment, but others belong to the Post-pliocene age, when the elevation of the land was much less than it is at present. In some places they are found as high as 100 and even 200 feet above tide-level.*

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* Full information concerning the iron sands of the Gulf may be found in Dr. Hunt's Report in the volume published by the Geological Survey for 1866-69.

COMPOSITION OF MAGNETIC ORES.

Analyses of samples of the magnetic ores from a number of the more important deposits in the country have already been published in the Reports of the Geological Survey, and some of them will be repeated here for the sake of comparison. A few, however, which have been recently made will be given first.

Bristol.—The deposits occurring on the twenty-first and twenty-second lots of the second range of Bristol have been described on pages 7 and 8. The ore, though generally called magnetic iron ore, is really a mixture of crystalline magnetite and hematite, with a streak ranging in colour from reddish to black. The specimen selected for analysis, and regarded as representing the average of what had been taken from the largest excavation up to July last, was rather finely granular, of a dark steel-grey colour, and readily attracted by the magnet. The streak varied from reddish-brown to black in places. Scattered here and there through the mass were nests of pyrites, some of them nearly a quarter of an inch in diameter, and with the glass disseminated grains of quartz and calcite could be seen. The specific gravity was 4.32, and the results of an analysis as follows:

Bristol ore, a mixture of magnetite and hematite.

Analysis of Bristol ore.

Peroxide of iron	65.44
Protoxide of iron	14.50
Bisulphide of iron	2.74
Protoxide of Manganese	0.11
Alumina	0.60
Lime	3.90
Magnesia	0.45
Silica	11.45
Carbonic acid	1.64
Phosphoric acid	traces
Titanic acid	none
Water	0.14
	100.97

Iron as peroxide	45.81
Iron as protoxide	11.28
Iron as bisulphide	1.28
Total metallic iron	58.37
Sulphur	1.46

Combining a sufficient quantity of the peroxide of iron with the protoxide to form magnetic oxide, we find the ore to be a mixture of magnetite and hematite, in the proportion of 46.72 of the former to 33.22 of the latter (1.40 : 1).

Leeds.—On page 16 a short description has been given of the deposit of ore occurring on lot seven, range five of the township of Leeds (Megantic). The schistose variety consists of a mixture of micaceous iron ore and magnetite, the latter often in minute octahedral crystals. Mr. Hoffmann has analysed a specimen of this kind, containing a large proportion of the micaceous ore, but still strongly magnetic. The colour was iron-black or in places reddish, and the streak black with a reddish tinge. Through the ore were disseminated small nodules of a mineral with a glassy lustre, apparently orthoclase, with which mineral they were found to agree in hardness and fusibility. The specific gravity was 5.041, and an analysis gave:

Analysis of Leeds ore.

Peroxide of iron	80.758
Protoxide of iron	13 588
Protoxide of Manganese	0.056
Silica (in solution)	0.012
Alumina	0.713
Lime	1.298
Magnesia	0.454
Phosphoric acid	0.471
Sulphuric acid	0.095
Titanic acid	none
Hygroscopic water	0.049
Combined water	0.167
Organic matter	0.041
Insoluble matter	2.748
	100.450
Iron as peroxide	56.531
Iron as protoxide	10.568
Total metallic iron	67.099
Phosphorus	0.206
Sulphur	0.038

The insoluble residue was also analysed and found to contain:

Silica	2.420
Alumina	0.270
Lime	0.014
Magnesia	0.012
Potash	0.076
	2.792

Variable proportions of phosphorus.

The ore appears to vary considerably in the quantity of phosphorus which it contains. Thus, a specimen of the massive magnetite containing 66.33 per cent. of iron gave me 0.335 per cent. of phosphorus. Equal quantities of seven specimens also, broken from loose masses on the surface at intervals along a line of three-quarters of a mile, were mixed together, and the mixture found to contain only 0.025 per cent. The average quantity of phosphorus deduced from the three determinations just given is 0·188 per cent. Another specimen of the massive variety, examined only for iron, gave 64.78 per cent.

Inverness.—A specimen of ore from this township was sent a short time ago to the museum of the Geological Survey by Mr. Edward Major of Montreal. It was a finely-granular magnetite of an iron-black colour and with a specific gravity of 4.77. An analysis gave :

Analysis of Inverness ore.

Magnetic oxide of iron	90.360
Protoxide of manganese	0.175
Lime	3.040
Magnesia	traces
Phosphoric acid	0.443
Sulphur	0.005
Insoluble residue	6.500
	100.523
Metallic iron	65.433
Phosphorus	0.193

It contained no titanic acid whatever. Whether the specimen is from a deposit of importance is not yet known.

Nictaux.—A partial analysis has been made of the specimen of Devonian magnetite mentioned on page 17. It was very fine-grained and tough, breaking with a sub-conchoidal fracture. Calculating the iron as magnetic oxide it contained :

Analysis of Nictaux ore.

Magnetic oxide of iron	69.17
Phosphoric acid	1.82
Sulphur	0.05
Insoluble matter	18.94
Metallic iron	50.09
Phosphorus	0.79

Christie's Lake Mine.—A specimen of compact magnetite from this mine (lot 18, range 3, South Sherbrooke) of an iron-black colour and metallic lustre was found to contain :

Analysis of ore from Christie's Lake mine.

Magnetic oxide of iron	90.61
Titanic acid	2.83
Phosphoric acid	0.05
Metallic iron	65.62

Other constituents were not determined, the ore having been examined more especially with the view of ascertaining whether it contained phosphoric or titanic acids.

TABLE OF ANALYSES OF MAGNETITES.

Constituents.	I.	II.	III.	IV.	V.	VI.
Peroxide of iron...... } Protoxide of iron..... }	73.90	93.82	66.20 17.78	69.77	90.14	72.80
Oxide of manganese...	none.	0.12	traces.	....	traces.	....
Alumina	0.61	0.79	....	5.65	1.33	....
Lime	none.	0.45	1·85	....	0.82	1.69
Magnesia	1.88	0.94	0.18	4.50	0.84	6.86
Phosphorus.	0.027	0.08	0.015	0.085	0.007	0.035
Sulphur	0.085	0.11	0.28	1.52	0.12	0.027
Carbonic acid............	....	....	1.17	....	....	1.50
Silica	20.27	3.75	11.11	7.10	....	....
Titanic acid...............	none.	....	none.	9.80	1.03	....
Graphite	....	....	0.71	....	....	....
Water.....	3.27	....	....	2.45	....	3.50
Insoluble matter	....	....	....	....	5.25	14.73
	100.042	100.06	99.295	100.875	99.537	101.142
Metallic iron.............	53.51	67.94	60.17	50.52	65.27	52.72

Constituents.	VII.	VIII.	IX.	X.	XI.	XII.
Peroxide of iron...... } Protoxide of iron..... }	89.22	58.35 24.87	59.39 26.93	80.76 13.59	65.44 } 14.50 }	90.36
Oxide of manganese...	none.	0.13	traces.	0.06	0.11	0.17
Alumina	....	0.42	0.67	0.71	0.60	....
Lime	none.	1.43	0.33	1.30	3.90	3.04
Magnesia	....	2.56	0.82	0.45	0.45	traces.
Phosphorus...............	0.012	0.07	traces.	0.21	traces.	0.19
Sulphur.....................	0.073	0.04	0.07	0.04	2.74†	0.005
Carbonic acid............	....	....	....	....	1.64	....
Silica	....	11.17	....	0.01	11.45	....
Titanic acid...............	....	0.73	3.23	none.	none.	none.
Water	....	....	....	0.22	0.14	....
Organic matter...........		....	....	0.04	....	....
Insoluble matter.........	10.42	....	8.38*	2.75	....	6.50
	99.725	99.77	99.82	100.14	100.97	100.265
Metallic iron.............	64.61	60.19	62.52	67.10	58.37	65.43

Analysts.

The above table is compiled from different sources. With the exception of number II, the first seven analyses are from the Report of Progress for 1866–69, and are by Dr. T. Sterry Hunt. II is by Professor Chandler, of the Columbia School of Mines, New York, and VIII and IX by Professor Chapman, of Toronto. The three last are from the preceding pages, but are repeated to facilitate comparison. The localities from which the specimens were taken are as follows:

I.—Hull. "Black ore."
II.— " " " A picked specimen.
III.— " The so-called red ore, a mixture of magnetite and hematite.
IV.—Chaffey mine, South Crosby.
V.—North Crosby; from a deposit on land belonging to Hon. George W. Allan, of Toronto.

* Silica and insoluble rock matter.
† Bisulphide of iron.

VI.—Blairton mines, sand-pit bed, Belmont.
VII.—Seymour ore-bed, Madoc.
VIII.—Lot twenty, concession one, of Snowdon, Peterboro' county. (Sp. gr. 4.22.)
IX.—Lot twenty-nine or thirty of the first concession of Bedford, Ont. (near Eagle Lake).
X.—Leeds, P.Q. See pp. 16 and 20.
XI.—Bristol, P.Q " 7 and 19.
XII.—Inverness, P.Q. " 17 and 21.

HEMATITE.

Varieties of hematite.

Under this name are included several varieties of iron ore consisting mainly of anhydrous peroxide of iron, the varieties depending upon texture rather than chemical composition. Specular and micaceous iron ore are terms applied to crystalline varieties with metallic lustre, the latter also having a foliated or micaceous structure. Earthy varieties, often containing clay, are known as red ochre, while intermediate between the highly crystalline and the ochreous ores comes red hematite. The latter term is sometimes used by iron smelters in the same general sense that hematite alone is, to indicate any ore consisting essentially of anhydrous peroxide of iron. As a rule, hematite is freer from impurities than magnetite; it is not so easily reduced as hydrated oxides or carbonates, and is liable to produce grey rather than white iron, a fact of importance in connection with the manufacture of Bessemer pig.

Geological range of hematites.

Geologically our hematites have a wide range in time. They are found in the Laurentian, Huronian, Lower Silurian, Upper Silurian, Devonian, Carboniferous, and Trias. Red ochres of modern age are also occasionally met with. In the Laurentian, hematite is by no means as common as magnetite, and more frequently occurs in the form of red hematite than in the more highly crystalline varieties. The Canadian hematites of Laurentian and Huronian age cannot be regarded as forming a specially important group apart from those more recent, and accordingly the division given under magnetite will not be adopted here.

MODE OF OCCURRENCE AND MINERAL ASSOCIATIONS OF HEMATITE.

Beds and veins.

Hematite occurs in both beds and veins, the beds generally, though not always, being the more important deposits. Like magnetite it is not found solely in any one kind of rock, but often in rocks of most diverse characters. A few examples illustrative of this fact may be of interest. Beginning with the Laurentian, we find at the McNab mine near Arnprior a compact red hematite occuring in crystalline limestone. The bed is inclined at a high angle and has been worked to a depth of about eighty feet when it is said to have thinned out. At the Dalhousie mine, twelve miles from Perth, a compact red hematite, somewhat similar to the McNab ore, also occurs in limestone, although at one point in the workings a soft chloritic-looking slate, with numerous

Hematite in limestone.

crystals of pyrites, seems to intervene between the ore and the underlying limestone. The limestone is highly crystalline; that underlying the main deposit being white and containing large quantities of tremolite, while that which overlies it is stained red with peroxide of iron. When the mine was opened up there appeared to be two beds cropping out in places at the surface with four or five feet of limestone between them. The uppermost and smaller of these was found to run out at few feet in depth, and to extend but a short distance in the direction of the strike. The larger deposit was in places as much as nine feet thick at the surface, and at a depth of eighty feet had an average thickness of four or five feet.

Among other examples of the occurrence of hematite in Laurentian limestone may be mentioned the thin vein of specular ore on lot two range four of Elzevir (Geol. of Can. 1866, p 101), and the finely-granular hematite of Iron Island, Lake Nipissing.

Hematite in gneiss.

The specular ore of the Haycock location, in Templeton and Hull, occurs in highly feldspathic gneiss, mostly of a reddish colour, though interstratified with occasional grey bands. The ore forms a series of apparently parallel beds, striking north-east and south-west and dipping to the north-west at an angle of about 50°. Some of what appeared at the time of my visit to be distinct beds may prove to be merely repetitions of the same one, but sufficient work had not been done to determine this. The thickness of those exposed varied from a few inches up to several feet.* Besides the beds occasional little veins of hematite were observed cutting the gneiss. So far as I am aware this is the only workable deposit of specular ore known in the Laurentian rocks of Canada.

Diorite.

According to Mr. Macfarlane a vein of earthy hematite associated with chlorite occurs in a fine-grained diorite near the iron furnaces at Marmora, and was worked many years ago (Geol. of Can., 1866, p. 102).

Huronian ores in dioritic and diabasic rocks.

No such important deposits as those of Michigan have yet been discovered in our so-called Huronian rocks. Some of those known, however, are very similar in their mode of occurrence, consisting for the most part of alternate layers of compact hematite or specular ore and quartzite or jasper, in dioritic and diabasic rocks. The deposits of Bachewahnung Bay and Gros Cap, Michipicoten, are well known examples. (See Geol. of Can., 1866, p. 130.)

According to Professor Bailey and Mr. Matthew, the Huronian strata of the eastern part of St. John county, New Brunswick, contain red hematite and specular iron ore. At West Beach, twelve miles east of the city

* In a recent letter Mr. R. H. Haycock states that one bed having a thickness of only two feet at the surface has, at a depth of fourteen feet, widened to fifteen feet.

of St. John, a bed of reddish-brown hematite occurs in the upper part of a mass of reddish-grey conglomerate; and two or three miles east of West Beach, near Black River, several beds of specular ore occur, associated with dioritic rocks and micaceous schists. One of these beds is said to have a thickness of twenty feet. The rocks at West Beach and Black River were, until a few years ago, considered to be of Devonian age. (Report, 1870–71, pp. 98 and 223).

Conglomerate.

Potsdam sandstones.

The Potsdam sandstones are sometimes impregnated with considerable quantities of peroxide of iron, and occasionally contain micaceous and specular ores. The quantity of these, however, has never been found sufficient for profitable working. In the metamorphic rocks of the Quebec group, on the other hand, workable deposits of hematite occasionally occur. Some of them have been described in the Geology of Canada under the name of specular schist or itabirite, and are there stated to consist of scales of micaceous iron ore, grains of quartz, and frequently also chlorite. They generally occur interstratified with chloritic slates or chloritic slates, argillites and dolomites. Besides these beds, veins of foliated specular ore with quartz are sometimes met with, but are not of economic importance. (See Geol. of Can., 1863, p. 678 et seq.)

Quebec group.

Specular schists in chloritic slates, argillites and dolomites.

Lower Silurian.

In the Lower Silurian rocks of New Brunswick, also, extensive deposits of hematite occur at Woodstock. They have been described by different writers, and among them by Professor Hind who says of them: * "These ores are vast sedimentary deposits many feet in thickness, interstratified with red and green argillites, or with calcareo-magnesian slates, of a red or green, or mottled red and green color. The ores vary in composition, being both red and black, the black is sometimes feebly magnetic, but it derives its color more from the presence of manganese than from the black magnetic oxide. The red ore is an impure hematite, containing, besides the peroxide of iron, some carbonate of the protoxide, and from one to six per cent. of manganese; it is often seamed with thin layers of graphite." The Woodstock ore, though generally described as hematite, may be a mixture of hematite and limonite, as all the published analyses indicate a considerable proportion of water.

Remarks by Professor Hind on the Woodstock ores.

Upper Silurian.

Rising in the geological scale to the Upper Silurian we find some exceedingly important deposits of hematite; but this, so far as known, only in the Province of Nova Scotia. As specular or rather micaceous iron ore, it is found in veins in the Cobequid Hills of Londonderry, and near the East River of Pictou County, that of the latter region being regarded by Dr. Dawson as the equivalent of the Londonderry ore. Earthy red ore in veins also occurs in large quantity near Londonderry, while beds of siliceous red hematite of enormous extent occur in Pictou County.

* Preliminary Report on the Geology of New Brunswick, together with a special Report on the Distribution of the "Quebec Group" in the Province. Fredricton, 1865.

Country rock at Londonderry.

At Londonderry the country rock consists of grey, blackish and olive slates, alternating with bands of grey quartzite, and overlaid by grey and brown sandstones and shales of Carboniferous age. The former are cut by irregular veins, which sometimes attain a thickness of many feet, and at others disappear altogether, or are represented by a network of small reticulating veins. These reticulating veins appear to be more common in the quartzite than in the slates.

Materials constituting veins.

The materials constituting the veins consist of ankerite, spathic iron, earthy red ore, micaceous and specular iron ore, limonite and small quantities of several other minerals which will be noticed further on. The ankerite seems to have formed the largest part of the original material of the veins, and is the gangue-stone of the specular ore. By its decomposition, as well as that of the spathic ore, large quantities of limonite and earthy red ore have been produced.

Specular ore of Londonderry.

Though specular ore is rarely absent from the Londonderry veins, being scattered through the ankerite, and sometimes also through the limonite and red ore, in little bunches and strings, the proportion is generally small. Near the west bank of Cook's Brook, however, a level was many years ago driven on the course of the main vein for a distance of one hundred and fifty yar .s. The vein is said to have been struck at about fifty yards from the mouth of the level, and to have had an average thickness of three or four feet, consisting of specular or micaceous ore with small quantities of red ore and ankerite. Much of the ore is readily attracted by the magnet, so that there must be also magnetic oxide present. At the time of my visit in September last the level was closed up, and all that could be seen was the ore which had been taken from it, and was piled at its mouth. The reason assigned for its not having been employed at the furnace was that it was too difficult to reduce, and it is easy to understand how persons accustomed to smelting limonite might at first experience difficulty in the treatment of specular ore.

Specular ore of Pictou County.

In Pictou County specular ore has been discovered in a number of localities, but the only one which has been shown to be of much economic importance is that a short distance west of the east branch of the East River, on area 100 of the government plan. Though I visited it last September, I can say little of it from personal observation, as the openings were at that time full of water. It was first described by the late Mr. Edward Hartley in the Report of the Geological Survey for 1866–69, and was subsequently reported upon, in 1872, by Mr. G. M. Dawson, Associate of the Royal School of Mines, London. From the report of the latter gentleman, kindly placed in my hands by Principal Dawson, I extract the following, as being the fullest and most recent information on the subject:

Extract from Mr. G. M. Dawson's report.

"This ore (specular iron ore) occurs on the square mile marked 100 on the government plan. The country rock is a blackish slate with occasional beds of quartzite, and it is with one of the latter beds that the ore is most closely associated. The strata are in general undulating, and in places somewhat contorted, but preserve a pretty uniform southerly dip at an angle of from 60° to 70°.

"The ore deposit occurs as a true lode following very nearly the strike of the containing rocks, and, so far as our explorations have gone, appearing to be as nearly as possible vertical. It has been exposed by trenching and proved by small shafts from the eastern boundary of the area westward for a considerable distance, though as yet not quite across to the western line. Of its extension across the entire area, however, there can be no doubt from the indications, and the ore is known to occur on some of the other areas both east and west of this, though its value has not yet been proven by actual exposure of its thickness and quality.

"At the eastern boundary of area 100 the outcrop of the lode is exhibited in a trench and shows a thickness of twelve feet of ore, though with some thin leaves of intercalated slate. A short distance west of this is another costeaning trench in which the lode is shown to have a thickness of 5 feet 6 inches, of good and pure ore.

"About 900 feet westward from this, a shaft 18 feet deep has been sunk on the crop of the lode. At a short distance from the surface a horse of hard quartzite rock, more or less impregnated with ore, encroached on the southern side, but at the bottom this was passed through, and the ore found passing under and cutting it out.

"The lode was cross-cut at a depth of 13 ft., and the thickness found to be 10 ft., including, however, about a foot of slate. At the bottom of the shaft the lode was widening. From this shaft alone about 40 tons of good ore were extracted. In connection with the quartzite horse and wall a small quantity of iron pyrites was found in association with the ore.

"From this shaft westward 1,086 ft. on the course of the lode a second opening was made and carried down to a depth of about 13 ft. At this place the true lode was missed, and quartzite and hard slate impregnated with ore continued to the bottom. By subsequent trenching the lode was discovered to lie about 30 ft. south of the shaft, and it there exhibited a a very favorable appearance, and showed 20 ft. of good and very pure ore. The southern wall was not found, as the rock dipped away fast, and the water was troublesome.

"This deposit of micaceous and specular iron ore is situated on high ground, and the course of the lode is cut across in several places by deep brook vallies, which, though encumbered by drift, and presenting no good exposures of the deposit at present, will offer great advantages by allowing free drainage to a very considerable depth."

The ore of this locality, judging from what I saw upon the surface, resembles closely the micaceous ore of Londonderry.

The so-called "red ores" of Londonderry, mentioned on page 25 have **"Red ores" of Londonderry.**

evidently been produced from the decomposition of spathic iron and ankerite, as they frequently exhibit the rhombohedral forms characteristic of these minerals, and this even when the iron is entirely converted into peroxide. They differ much in colour, and probably consist of varying mixtures of anhydrous and hydrous peroxide of iron. A specimen of a reddish-brown colour from the Peter Totten lot, apparently produced by the alteration of spathic ore holding little veins of calcite, was found to contain 69.86 per cent. of peroxide of iron and 5.74 of combined water.

On the west side of Cumberland Brook, a little over two and a half miles in a straight line west of the Londonderry furnace, an earthy red ore is being mined at present, and apparently exists in large quantity.

Siliceous hematite of Pictou County, N.S.

The siliceous bedded hematite, mentioned on page 25, occurs in rocks which are referred by Dr. Dawson to the Lower Helderberg (Ludlow of Great Britain) and regarded by him as more recent than those containing the specular ore of the region. They are coarser-grained and much more contorted and faulted, but, like them, consist of slates and quartzites, the former being of different shades of grey, greenish-grey and black, and the latter grey, brownish-grey, and red or reddish where ferruginous. Occasional calcareous bands holding fossils also occur. The ore consists of little siliceous grains enveloped with peroxide of iron. It is sometimes earthy but more frequently hard and compact, the latter kind often having a somewhat schistose or slaty structure. In portions of its course the bed holds fossils, while in others none can be detected.

Character of country rock.

Fossils.

Distribution of hematite in Pictou County.

The principal developments of this ore, so far as known, are near the east branch of the East River of Pictou County, and on the upper part of Sutherland's River, and apparently belong to two lines of outcrop of the same bed on opposite sides of an anticlinal. On the northern side of the anticlinal it has, according to Dr. Dawson, been traced completely across area 101 of the government plan, and it is thought that it will be found to continue across area 49 and to connect with exposures known on 48. Exploratory work undertaken under the direction of Mr. G. M. Dawson, in 1872, shewed the thickness of workable ore to range from 10 to over 20 feet. The surface thickness of the bed in several places where I measured it was from 27 to 30 feet, and this with a high angle of dip. All the ore observed on this side of the anticlinal was free from fossils.

On the south side of the anticlinal traces of the ore are found across the northern corner of area 102, and in the southern corner of 45 extensive exposures occur; the band then curves round, and passing through the eastern corner of area 46 enters 108, which it partly crosses, with a course a little east of south, or nearly at right angles to its course on 102. The only exposure on this side of the anticlinal which I visited was on area 45 (Blanchard's). Here the bed forms a ridge projecting several feet above the general surface of the ground, and large quantities of ore could easily be obtained from it; but unfortunately much of it is very fossiliferous.

Going northward again we find the ore bed repeated on Sutherland's River, at a distance of between two and three miles from where it is exposed on area 101. It has here a southerly dip, and appears to occur at the northern side of a synclinal corresponding to the anticlinal referred to above. Of the extent or importance of this portion of the deposit little is as yet known.

Hematite of Upper Silurian age in Ontario.

In the Geology of Canada, p. 682, the occurrence of red hematite in Ontario, in rocks belonging to the Clinton formation, is mentioned. The deposits, however, are not known to be of any economic importance.

Devonian hematite.

According to Dr. Dawson, * the Devonian slates of Nictaux River, Nova Scotia, contain a bed of highly fossiliferous red hematite, having a thickness of from 3½ to 4 feet. The fossils—the most abundant of which is a *Spirifer* (*S. Nictavensis*)—"seem to give indubitable evidence that the Nictaux iron ore is of Lower Devonian age." At Moose River, as already noticed, the ore of similar age exists largely in the condition of magnetite.

Hematite of Carboniferous age.

Passing now to the Carboniferous we find in Nova Scotia, near Clifton, (formerly Old Barns) and the mouth of the Shubenacadie, ores which are mixtures of red hematite, red ochre, limonite, göthite, and considerable quantities of earthy impurities. The deposits visited, however, did not appear to be of much economic importance. They occur in the form of veins in the sandstones and laminated limestones of Lower Carboniferous age. Near "Black Rock," on the Shubenacadie, openings have been made on several of these veins, but the material extracted so far is of very poor quality. Near Clifton, also, a shaft has been sunk to a depth of 35 feet on a vein in coarse red sandstone holding concretions of clay. The vein is said to be about 6 feet thick, but could not be seen at the time of my visit as the shaft was nearly full of water. In sinking, a considerable quantity of ore had been taken out, but was of inferior quality, being largely mixed with sandstone, sulphate of baryta, &c.

At Gallas or Gallows Point, on the eastern side of Hillsborough Bay, Prince Edward Island, a series of rocks occurs, consisting of red and brown sandstones, red and mottled red and grey clays, and occasional thin bands of impure concretionary limestone. These beds have been regarded by Dr. Dawson as Upper Carboniferous, although it is admitted at the same time that they have a somewhat Permian aspect. Some of

* Acadian Geology, 2nd Ed., p. 498.

them contain nodules or concretions of red hematite, many of which, as the rocks are disintegrated by the waves, are left strewn upon the beach. Trunks of fossil coniferous trees also are abundant in places, and some of them have been infiltrated with hematite. The quantity of ore, however, which could be obtained from these sources is too small to be regarded as of any economic importance.

In Cape Breton deposits of hematite are said to occur in rocks of Carboniferous age, but I have been unable to obtain any reliable details concerning them.

Triassic hematite.

In the great ridge of Triassic trap bordering the eastern side of the Bay of Fundy, veins of specular iron ore occur, but are nowhere known to be of sufficient dimensions to be considered workable.

Modern red ochres.

The modern red ochres referred to on page 23 are unimportant. They have probably been produced in many instances from the ordinary bog ores by the action of bush fires.

Mineral associations of hematite.

Most of the minerals associated with the different varieties of hematite have already been noticed incidentally, but a few additional facts concerning them may not be out of place here. The following list probably includes most of those which have been observed:

Ankerite.	Graphite.
Barytes.	Hornblende.
Calcite.	Limonite.
Chalcocite.	Magnetite.
Chalcopyrite.	Malachite.
Chlorite.	Mica.
Dolomite.	Pyrites.
Epidote.	Pyroxene.
Feldspar.	Quartz.
Fluor-spar.	Siderite.
Gœthite.	Talc.

Most of these, it will be noticed, are the same as those occurring with magnetite, and several are rather constituents of the rocks in which the hematite occurs than mineral associates, strictly speaking, of the latter.

Ankerite.—This mineral may be regarded as dolomite in which part of the magnesia is replaced by protoxide of iron, and generally also by protoxide of manganese. As already stated, it is found at the Acadia mines,

Ankerite used as a flux.

Londonderry, and also in Pictou County. At the former locality it has long been mined as a flux for the blast furnace. Before exposure to the weather it is white or greyish-white in colour, but the protoxide of iron readily becomes converted into hydrous and anhydrous peroxide, causing it to assume yellowish, reddish and brownish colours. This change in the condition of oxidation of the iron, together with the loss of carbonates of lime and magnesia and the taking up of water, has resulted in the pro-

Analyses of ankerite.

duction of large quantities of limonite. The following are analyses of ankerite from Londonderry:

	I.	II.	III.	IV.
Carbonate of lime.........	54.00	43.80	49.20	51.61
Carbonate of magnesia...	22.00	30.80	30.20	28.60
Carbonate of iron	23.20	23.45 }	20.30	19.59
Carbonate of manganese	....	0.80 }		....
Silliceous sand.............	0.50	0.10	....	0.13
	99.70	98.95	99.70	99.93

I.—White variety, by Dawson. III.—Brown variety, by C. J. Jackson.
II.—Yellow " " C. J. Jackson. IV.— " " " H. How.

Barytes with specular iron, calcite, fluor-spar and feldspar.

Barytes or Heavy-spar.—This species occurs at the Haycock mine in Templeton, but was observed in one spot only. Specimens were obtained in which crystals of barytes were associated with specular iron, calcite, beautiful green fluor-spar, and reddish feldspar. Possibly these were from a vein.

Crystals of barytes coated with oxide of iron.

In Nova Scotia barytes is sometimes associated in small quantity with specular ore and ankerite at the Acadia iron mines, and is very common with the ores of Clifton and the mouth of the Shubenacadie. At the latter place it often occurs in white and reddish crystals, about a quarter of an inch long, lining the walls of cavities in the ore or the containing limestone. In some cases these crystals have been curiously coated over with velvety oxide of iron, giving them a rounded outline.

Fossil trees containing barytes.

The fossil coniferous trees of Gallas Point, Prince Edward Island, stated on page 30 to have been infiltrated with peroxide of iron, often contain large quantities of barytes.

Calcite.—The occurrence of hematite in beds of limestone has already been referred to. At the Dalhousie mine cavities in the limestone near the hematite sometimes contain good crystals of dog-tooth spar. At the Haycock mine calcite occurs containing masses of specular ore, and penetrated in all directions by crystals of beautiful, glassy, green pyroxene, from a sixteenth of an inch or less up to a quarter of an inch thick; rhombic crystals of mica occur in an analagous manner, though more sparingly than the pyroxene. Calcite sometimes forms veins in ankerite at Londonderry, or in crystals lines the walls of little cavities. In the form of dog-tooth spar also, as well as in veins, it is found in the red ore of the Peter Totten lot, Londonderry. Near the mouth of the Shubenacadie, at the locality referred to under barytes, calcite is very common, and occurs crystallized in several forms. The crystals are often stained red with peroxide of iron, and some of them have their faces much curved. Curious aggregations of rhombohedral crystals piled one upon another are also found here.

Crystals of calcite with rounded faces.

Chalcocite or Copper-Glance.—See under Dolomite and Feldspar.

Chalcopyrite.—Small quantities of chalcopyrite or copper pyrites are occasionally met with in the specular ore of Londonderry, and sometimes also in the red ore.

Chlorite.—The specular schists of the Eastern Townships are said to frequently contain disseminated scales of chlorite. The only chloritic ores from this region which I have seen are titanic iron ores. According to Mr. Macfarlane chlorite occurs in a vein of earthy hematite at Marmora.

Dolomite.—Specular schists are stated in the Geology of Canada to be interstratified with dolomite in the Eastern Townships, and specular ore, copper-glance, feldspar and dolomite to occur together in the township of Leeds.

Epidote.—This mineral is said to be associated with specular ore in the Eastern Townships. In New Brunswick also, small veins of specular ore are found in epidotic rocks supposed to be of Huronian age.

Orthoclase at the Haycock mine.

Feldspar.—Under this general term 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 the principal constituent of the enclosing rock, but masses of it being embedded in the ore. In Leeds (Megantic) tabular plates of hematite are associated with feldspar, copper-glance and dolomite (Geol. of Can., p. 510.)

Fluor-spar.—As already mentioned, beautiful green fluor-spar occurs at the Haycock mine associated with specular ore, heavy-spar, calcite and feldspar. This is the only locality in which it was observed.

Needle iron ore.

Göthite.—This hydrated oxide of iron occurs associated with the hematite and limonite of Clifton and the mouth of the Shubenacadie, Nova Scotia, often being found in the form known as *nadeleisenstein* or needle iron ore. Veins of it associated with black oxide of manganese and calcite also cut the lamellar Lower Carboniferous limestones at Black Rock near the mouth of the Shubenacadie. A specimen before me from this locality consists of beautiful radiating needles with adamantine lustre, the ends of which are capped with rhombohedral crystals of calcite.

Graphite.—The hematite of the Woodstock mines, New Brunswick, is stated by Professor Hind to be often seamed with thin layers of graphite; and the mixture of magnetite and hematite at the Hull mines known as red ore frequently contains scales of graphite. According to Professor Chapman it is also present in the specular ore of the Haycock mine, Templeton.

Hornblende.—This mineral, which is so frequently associated with magnetite, I have nowhere noticed in deposits of hematite, although it sometimes forms an important constituent of the containing rock.

Mixtures of anhydrous and hydrous oxides of iron.

Limonite.—The red ores of Londonderry are frequently associated with limonite; they often contain a considerable proportion of water themselves, and may then be regarded as mixtures of hematite and limonite. The same is probably true of the red ores in many other localities. The specular ore of Londonderry is also frequently accompanied by limonite. The ores of Clifton and the mouth of the Shubenacadie have already been described as mixtures of red hematite, red ochre, limonite, &c. Sometimes radiating masses may be obtained shewing alternate layers of red hematite and limonite.

Malachite.—In places the veins at Londonderry containing specular ore also hold very minute quantities of copper pyrites which is generally coated with malachite. In the red ore of the Peter Totten lot also, copper pyrites and malachite may occasionally be noticed.

Magnetite.—The occurrence of magnetite and hematite together is very frequent, and has been noticed several times in the preceding pages. At Londonderry and on the East River of Pictou County the specular ores often contain a considerable proportion of magnetic oxide. The same is the case with specimens of ore brought by Mr. Charles Robb last autumn from the Whykokogomagh mines, Cape Breton. The fossiliferous Devonian hematites of the Annapolis Valley, Nova Scotia, have also in many cases been altered to magnetite, and every gradation may be observed from normal non-magnetic hematite with a red streak, to strongly magnetic ores with dark brown or black streak. The alteration is probably due to the neighboring igneous rocks, and the presence of organic matter. Mixtures of hematite and magnetite.

Mica.—Under this term may be comprised several species, which, however, are not easily distinguished without analysis. Muscovite and phlogopite probably both occur, and hydrous micas of somewhat variable composition are frequently found associated with specular and micaceous iron ores in the Eastern Townships.

Pyrites.—The Laurentian and Huronian hematites appear in general to be much freer from pyrites than the magnetites of corresponding age. At the Dalhousie mine there is none visible in the ore, but on sinking a trial hole a short distance south-west of the present workings, instead, as was expected, of coming upon the hematite, a bed of pyrites four feet thick is said to have been struck—a fact suggesting that the hematite may be the result of the decomposition of pyrites. The specular ore of the Haycock mine is exceedingly free from this as well as from other impurities, and it is difficult to find specimens in which pyrites can be detected by the eye. The only specimens which I have seen of the jaspery hematite of Bachewahnung contained a good deal, but specimens from Gros Cap in the museum of the Geological Survey shew none whatever. The specular ore of Londonderry, so far as may be judged from what has been mined, is very pure; but a good deal of pyrites was observed in that which has been mined near the East River of Pictou. Hematites freer from pyrites than magnetites.

Pyroxene.—This mineral is occasionally found associated with hematite. At the Haycock mine the ore is sometimes penetrated by long crystals of green pyroxene about a sixteenth of an inch in diameter. Similar crystals, though often much larger, occur in calcite at the same locality (see p. 31.)

Quartz.—The occurrence of hematite, interstratified with jasper and quartzite has already been mentioned (p. 24). The metamorphic rocks of the Eastern Townships, and also of New Brunswick, are often cut by veins composed of quartz and specular ore, and beds of hematite of different ages frequently contain little veins of quartz. The great hematite beds of Lower Helderberg age in Nova Scotia are generally made up of grains of sand enveloped with red oxide of iron. The proportion of these siliceous grains at times becomes so great that the ore passes into a ferruginous sandstone.

Siderite or Spathic Iron.—This mineral occurs in the Londonderry veins, sometimes with specular ore, and Dr. Dawson informs me that large quantities of it were mined many years ago near Great Village River, and smelted in the blast furnace. From its decomposition limonite and earthy red ore have often been produced, and at the Peter Totten lot, Londonderry, specimens may be obtained shewing every gradation from spathic ore to red ore containing no trace of the carbonate, though still displaying its cleavage planes.

Limonite and earthy red ore formed from spathic ore.

Talc.—Some of the hematites of the Eastern Townships are said to contain flakes of talc; but I have seen no specimens shewing it.

RECENT ANALYSES AND ASSAYS OF HEMATITES.

Several analyses and assays of hematites from different parts of the country have recently been made in the laboratory of the Survey. Among the ores examined is a slaty hematite from the great Lower Helderberg bed of Pictou County, Nova Scotia. It was from a locality known as "Webster's" on area No. 101 of the Government plan, and was made up largely of grains of sand enveloped with peroxide of iron. A partial analysis gave as follows:

Analysis of hematite from area 101, Pictou county, N.S.

Peroxide of iron	52.300
Protoxide of iron	traces.
Protoxide of manganese	0.148
Phosphoric acid	0.198
Sulphur	0.338
Water	1.980
Metallic iron	36.610

Another specimen from "Blanchard's" on what was formerly known as the Hudson area (now area 45 of the Government plan) was examined by Mr. Hoffmann. It was more earthy than the preceding and contained a few fossil shells.

Analysis of ore from the Hudson area.

A partial analysis gave,

Peroxide of iron	60.710
Protoxide of manganese	0.183
Phosphoric acid	0.633
Sulphur	0.085
Insoluble residue	29.976
Metallic iron	42.497

An assay of another specimen of earthy red hematite from a deposit on area 108, supposed to be a continuation of the bed exposed at Blanchard's, gave 42.77 per cent. of iron. The proportion of phosphorus in this Lower Helderberg hematite is very variable, according as it is fossiliferous or not, a fact which should be borne in mind in working it. In many parts of its course the bed shews no fossils whatever, while in other parts it holds them in great abundance. A highly fossiliferous sample examined some time ago gave me no less than 3.25 per cent. of phosphorus. **Phosphorus**

An analysis of the ore from the Peter Totten lot at the Acadia mines, Londonderry, may be given here, since it is generally known as a "red ore," although containing a considerable proportion of water. The specimen was of a dark brownish-red colour, and had a specific gravity of 3.29. **Analysis of ore from the Peter Totten lot, Londonderry.**

Its analysis gave,

Peroxide of iron		69.86
Protoxide of manganese		2.25
Alumina		traces.
Lime		11.70
Magnesia		0.42
Silica		0.07
Carbonic acid		9.20
Phosphoric acid		none.
Sulphuric acid		0.04
Water	hygroscopic	1.33
	combined	5.74
		100.61
Metallic iron		48.90
Sulphur		0.015

This ore would probably be easy to smelt, and, on account of its purity and the considerable proportion of manganese which it contains, would produce the best of pig iron for conversion into steel. As yet only a small quantity has been mined, and little is known of the extent of the deposit, although it is well worthy of being thoroughly examined.

The specular ore of Cook's Brook (p. 26) has been analysed by Mr. Hoffmann and found to be exceedingly pure. The specimen examined had a specific gravity of 4.93, and contained, **Specular ore from Cook's Brook, Londonderry.**

Peroxide of iron		96.93
Protoxide of manganese		traces.
Alumina		0.33
Lime		0.04
Magnesia		0.11
Phosphoric acid		0.007
Sulphuric acid		none.
Water	hygroscopic	0.03
	combined	0.79
Insoluble residue		1.26
		99.497
Metallic iron		67.85

The insoluble residue consisted of,

Silica	1.20
Alumina with traces of peroxide of iron	0.07
	1.27

No doubt this is richer than the average of the ore which could be obtained on a large scale.

Assay of specular ore from East River, N.S.

An assay of the specular ore from area 47, East River, Pictou County, gave 66.74 per cent. of iron.

On the thirtieth lot of the sixth range of Elmsley, Ontario, a fine red hematite occurs, but Mr. Vennor tells me that the deposit is too small to be considered workable. A specimen of the ore was sent to the office of the Geological Survey by Mr. A. B. Savage, of Montreal, and a partial analysis gave,

Analysis of ore from Elmsley, Ontario.

Peroxide of iron	89.10
Phosphoric acid	0.02
Sulphur	0.07
Titanic acid	none.
Metallic iron	62.37

The hematite was mixed with white talcose matter and a little mica.

Slaty hematite from Lake Nipigon.

In the Report of Progress for 1871-72, p. 104, Professor Bell mentions the occurrence of a slaty iron ore on the east side of Lake Nipigon. A specimen of this ore has been examined and found to contain 51.51 per cent. of peroxide of iron (metallic iron 36.06), traces of manganese, 0.076 per cent. of phosphoric acid, and 8.00 of alumina, the remainder being chiefly silica.*

Ore from Dalhousie mine.

When at the Dalhousie mine in July last, a specimen of the ore was selected by the manager (Mr. Gerald C. Brown,) and myself, which appeared to represent fairly the average of that then being mined. It contained 86.20 p.c. of peroxide, equal to 60.34 of metallic iron, and 10.30 of insoluble matter.

Whykkoomagh mines.

An ore from the Whykokomagh mines, Cape Breton, collected by Mr. C. Robb, contained 42.64 per cent. of iron and 0.26 p.c. of phosphoric acid. It was slightly attracted by the magnet, gave a dark purplish-grey powder, and apparently consisted of a mixture of micaceous iron ore, magnetite, and a considerable quantity of siliceous matter. A second sample contained 41.28 per cent. of iron.

* In the event of ore ever being smelted on Lake Nipigon, limestone could be obtained in places for a flux. The following is an analysis of a specimen from the south side of an island known as the Inner Barn:

Carbonate of lime	69.69
Carbonate of magnesia	3.32
Soluble alumina and peroxide of iron	0.70
Insoluble residue	26.45
	100.16

The following table is compiled from different sources, and will serve to further illustrate the composition of Canadian hematites:

TABLE OF ANALYSES OF HEMATITES.

Constituents.	I.	II.	III.	IV.	V.
Peroxide of iron	84.42	84.10	88.08	89.80	85.45
Protoxide of iron	....	....	6.86	7.06	5.24
Protoxide of manganese	....	....	0.24	trace.	0.15
Alumina	....	....	....	....	....
Lime	3.02	4.93	0.55	trace.	0.41
Magnesia	0.50	....	0.13	0.22	0.17
Phosphoric acid	0.03*	....	0.16	trace.	0.13
Sulphur	0.065	....	0.03	trace.	0.07
Carbonic acid	2.93	3.87	....	....	....
Silica	....	4.00	....	....	....
Titanic acid	....	....	3.17	2.34	2.12
Graphite	....	....	0.35	0.43	0.28
Water	....	....	....	....	....
Insoluble matter	7.16	....	0.26	0.11	5.77
	98.125	96.90	99.83	99.96	99.79
Metallic iron	59.09	58.87	66.99	68.35	63.89

Constituents.	VI.	VII.	VIII.	IX.	X.
Peroxide of iron	82.25	86.80	} 75.67	92.01	96.63
Protoxide of iron	....	....	}	....	0.89
Oxide of manganese	....	....	0.52	2.16	....
Alumina	....	....	0.45	0.21	....
Lime	trace.	none.	1.37	0.71	....
Magnesia	....	....	0.46	0.20	....
Phosphoric acid	0.026*	trace.	0.22	0.08	none.
Sulphur	....	0.092	0.29	0.16	0.06†
Carbonic acid	....	....	1.59	0.79	....
Silica	....	....	19.43	3.68	3.20‡
Titanic acid	....	....	trace.	trace.	....
Water	0.66	....	....	....	....
Insoluble matter	16.05	12.75	....	....	....
	98.986	99.642	100.00	100.00	100.78
Metallic iron	57.57	60.76	54.36	64.41	68.33

I.—Red hematite from the MacNab mine near Arnprior. By Dr. Hunt. See Report of Progress, 1866–69, p. 260.

II.—Red hematite from the same locality as No. I. By Dr. Hunt. Geol. of Can., 1863 p. 678.

III., IV., and V.—Specular ore from the Haycock mine, Templeton. By Professor Chapman. (Supplementary Report on the Haycock Iron Location. Toronto, 1873.) Nos. III. and IV. are analyses of selected examples—the latter of a fragment of a crystal—and No. V. of a large sample supposed to represent the average of a heap of about 300 tons. Professor Chapman says that, "as a rule, the ore is practically non-magnetic, but in places it exerts a feeble action on a delicately suspended needle, and shews slight polarity. Some of my specimens, however, are pretty strongly magnetic, but are, I believe, from a different bed from those examined by Professor Chapman.

VI.—Red hematite from the Cowan or Dalhousie mine. By Gordon Broome, F.G.S Report of Progress, 1871–72, p. 123.

VII.—Red hematite from Gros Cap, Lake Superior. By Dr. Hunt. Report of Progress, 1866–69, p. 260.

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* Phosphorus. † Pyrites. ‡ Silica and insoluble matter.

VIII.—Red hematite from East River, Pictou County, Nova Scotia. By Stevenson Macadam, F.R.S.

IX.—Specular ore from East River, Pictou County, Nova Scotia. Also by Macadam.

X.—Specular ore from the same locality as No. IX. By Dr. T. E. Thorpe, of the Andersonian University, Glasgow.

TITANIC IRON ORE OR ILMENITE.

Age of titanic iron ore.

This ore is found chiefly in rocks of Laurentian age, more especially in the Upper Laurentian, and often forms deposits of very considerable magnitude. Some of the ores of Brome and Sutton, in rocks of the Quebec group, also belong here, as they have been found to contain from twenty to thirty per cent. of titanic acid. In some instances the titanic acid found in the analysis of magnetic ores appears to be present as one of the constituents of the magnetite, but in other cases it is due to the presence of ilmenite mechanically mingled with the magnetite. An example of a mixture of this kind, noticed by Dr. Hunt, in the rocks of the Eastern Townships has already been cited on page 17. Similar deposits would also be produced by the consolidation of the iron sands of the gulf.

Occurrence of magnetite and ilmenite together.

Ilmenite of Bay St. Paul.

The largest deposit of ilmenite known in Canada is that at Bay St. Paul.* It occurs in a rock mainly made up of triclinic feldspar, and is said to have a thickness of about ninety feet. According to Dr. Hunt the ore is sometimes penetrated by crystals of a greenish triclinic feldspar, and frequently also contains grains of orange-red transparent titanic acid. No. I. is an analysis by Dr. Hunt, and No. II. by the late Dr. Frederick Penny of Glasgow:

Analyses by Dr. Hunt and Dr. Penny.

	I.	II.
Peroxide of iron	10.42	20.35
Protoxide of iron	37.06	29.57
Alumina	......	4.00
Lime	......	1.00
Magnesia	3.60	3.17
Titanic acid	48.60	40.00
Silica	.....	1.91
	99.68	100.00
Metallic iron	36.12	37.24

According to Dr. Penny the ore contains no manganese, phosphorus or sulphur.

St. Jerome.

A specimen of titanic iron ore from St. Jerome, recently examined, was found to contain,

Metallic iron	24.65
Titanic acid	32.36

St. Julien.

Another from St. Julien, six miles from St. Lin, (from a property belonging to Joseph Barsalou, Esq., of Montreal) gave,

Metallic iron	38.27
Titanic acid	33.67

* See Geol. of Can., 1863, pp. 501 and 754; also this Report, p. 60. Large deposits of ilmenite, associated with labradorite rocks, have been observed on the Saguenay River and on the shores of Lake Kenogami.

This specimen was much weathered, but the gangue apparently consisted of a partially decomposed feldspar. In the proportions of iron and titanic acid it comes very close to the titanic ore from the Bay of Seven Islands, which gave Dr. Hunt 38.70 per cent. of metallic iron and 34.30 of titanic acid. (Report of Progress, 1866-69, p. 260). The Bay of Seven Islands ilmenite occurs in labradorite rock, and is said to form a very extensive deposit. Dr. Hunt alludes to its being "pretty strongly magnetic," and this is also the case with the ore from St. Julien.

Bay of Seven Islands.

In the Geology of Canada, page 501, some of the ores in the metamorphic rocks of Brome and Sutton are said to contain one or two hundredths of titanic acid. This amount would of course not detract from their value; but it must be borne in mind that in this same region there are also deposits which on account of their large proportion of titanic acid should be classed as titanic iron ores. Thus a finely granular ore of a dark iron-grey colour from the ninth lot of the eleventh range of Sutton gave,

Titanic iron ores in the Eastern Townships.

Sutton, lot 9, range 11.

Metallic iron	40.87
Titanic acid	27.20

With the glass it shewed numerous grains of silica, and occasional scales of mica or perhaps chlorite. It was but slightly affected by the magnet and gave a brown streak. A similar ore from the eighth lot of the ninth range of Sutton (Lee's lot) gave,

Sutton, lot 8, range 9.

Metallic iron	39.14
Titanic acid	29.86

Another from the first lot of the third range of Brome contained,

Brome, lot 1, range 3.

Metallic iron	41.46
Titanic acid	24.16

Like the others it gave a brown streak, and was but very slightly affected by the magnet. It contained a little vein of quartz holding small quantities of carbonate of copper.

LIMONITE.

This ore, which in some of its forms is often called brown hematite, consists essentially of peroxide of iron combined with water, the theoretical proportions being 85.6 of the former to 14.4 of the latter.

The term limonite is generally made to include bog ores, which, however, will be considered separately here, as a distinction seems necessary, or at least convenient.* The ores to be described as limonite usually occur in veins, being the result of the alteration, generally *in situ*, of other ores of iron or of such minerals as ankerite; if they contain organic matter at all, it is, so far as known, in very small quantity. The bog ores, on the other hand, appear generally to contain a considerable quantity of organic

Bog ores considered separately.

* The name limonite, being from λειμών, a meadow, is, strictly speaking, especially applicable to bog ores, but could not well be restricted to them now.

matter; they occur, moreover, as patches or beds in low grounds, and are not the result of the alteration of pre-existing ores *in situ*.

Age of Canadian limonites.

No important deposits of limonite are known to occur in Canada in rocks older than the Middle or Upper Silurian, or newer than the Lower Carboniferous.* Those occurring in these rocks are chiefly in the Province of Nova Scotia. In the Middle or Upper Silurian of this Province the principal deposits are the result of the alteration of the spathic ore and ankerite of the great Londonderry vein, which, together with its country rock, has already been partly described under hematite, and which, extends for a distance of many miles. The alteration has not been continuous along the entire vein, but only local, and frequently, instead of limonite, earthy red hematite, or mixtures of red and brown hematite occur. The depth to which the alteration has extended is also variable, sometimes reaching only a few feet from the surface, while at the Martin's Brook workings, in September last, it was being mined at a depth of two hundred feet. The limonite of this vein varies much in texture, sometimes occurring in botryoidal and stalactitic masses with lustrous surface, as at Ross' Farm; at others fibrous and with a beautiful silky lustre, as on the hill on the east side of Cumberland Brook; in other cases compact and lustreless, or earthy and porous. At Martin's Brook much of the ore consists of honey-combed masses with reticulating walls of compact limonite and cavities containing earthy or ochreous ore of a brownish-yellow colour: this ore has probably been produced from ankerite, and frequently contains nests and strings of specular ore which originally had the ankerite as a veinstone.

The Londonderry vein.

Pictou County, area 105.

On going eastward we again find limonite, probably of the same age as that at Londonderry, in Pictou County, on area 105 (Cullen's, near the West Branch of the East River). Here, in the banks of a small stream, a band of quartzite is exposed which has been much broken up or shattered, and has the cracks filled with numerous veins of limonite. The largest of these observed was about a foot thick, and it would be difficult to obtain ore in quantity sufficiently free from gangue for smelting. It is, however, possible that on tracing the deposit it will be found that the rocks have in places been less fissured, and that the numerous small reticulating veins are there represented by single veins of greater thickness. At all events masses of ore too large to have come from such veins as those exposed are scattered about on the surface for a considerable distance from the stream. Should large deposits be discovered here they would be especially valuable on account of their proximity to the Provincial Railway.

* Limonite is said to occur at the Jacksontown mines near Woodstock, N.B., in rocks of Lower Silurian age; but the only specimen which I have seen should be classed as hematite. According to Gesner (First Report, p. 72) an important deposit of ore, consisting of the hydrate of iron, argillaceous oxide of iron, and hematite occurs on the Nerepis road, near Coot Hill, N.B., in argillaceous slate which is older than the Carboniferous.

Further to the east, on area 100, according to Dr. Dawson, masses of limonite are found in the vicinity of the vein of specular ore, of which a description has already been given, but the ore has not been discovered in place. On crossing the East Branch of the East River, however, a number of openings have been made on a vein of limonite which, unlike the preceding, occurs at the line of junction of the Silurian and Carboniferous. "The vein follows the sinuosities of the margin of the older rocks, and varies in thickness and quality in different places; being apparently richest opposite the softer slates and where these are in contact with a black manganesian limestone, which here, as in many parts of Nova Scotia, forms one of the lowest members of the Carboniferous series. The ore is sometimes massive, but more frequently in fibrous concretionary balls of large size, associated with quantities of smaller concretionary or 'gravel ore.' In some places the ore of iron is associated with concretions or crystalline masses of Pyrolusite and Manganite." * The right-of-search areas on which the limonite referred to by Dr. Dawson occurs are numbers 46 and 48 of the Government plan. Besides the ore found in place, large quantities of loose masses, sometimes of considerable size, are scattered about on the surface, or buried in the drift. Unfortunately at the time of my visit in September, none of the openings on the vein were accessible, but on what is known as the Fraser Saddler area (a mining area taken out on the right-of-search areas 46 and 48) the ore was exposed close to a small brook, and shewed a thickness of about eight feet of very fine, compact, botryoidal and fibrous limonite, occasionally containing small quantities of sulphate of baryta (see p. 44). This is the portion of the vein discovered by Mr. Hartley in 1868, and described by him in the Report of the Geological Survey for 1866–69, page 440. Close to the spot where the ore was uncovered by this gentleman, Mr. G. M. Dawson has since (in 1872) made an excavation and found the vein to be no less than fifteen feet thick, two feet eight inches consisting of loose concretionary limonite known as "ore gravel," and the remainder of the more solid varieties mentioned above. One wall of the vein was composed of solid slate, and the other of stiff red and white clay.

Pictou County, area 100.

Limonite of the East Branch of the East River.

Fraser Saddler area.

Thickness of the vein.

A short distance further down the river, or nearer to Springville, a shaft has been sunk by Mr. David Fraser to a depth of 42 feet, and on cross-cutting the vein reached and found to be twenty-two feet six inches thick. Silurian slates, Dr. Dawson tells me, occurred on one side of the vein, and on the other Lower Carboniferous limestone; the latter, however, being separated from the ore by a selvage of clay. Still nearer to Springville, in another opening made close to the roadside by Mr. Gilpin, the vein is reported to have a thickness of twenty-three feet.

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* Dr. Dawson.—Can. Nat., new Ser., vol. vii., p. 137.

Brookfield, N.S.

At Brookfield near the line of the railway between Halifax and Truro, large masses of limonite are said to occur scattered over the surface, and, according to Dr. Dawson, probably near the junction of the Lower Carboniferous with older rocks. The occurrence of important veins *in situ* has, however, so far as I can learn, not yet been proved.

Clifton and the mouth of the Shubenacadie.

The ores of Lower Carboniferous age at Clifton and the mouth of the Shubenacadie have been described under hematite (p. 29), though consisting of both hydrous and anhydrous oxides of iron.

Minerals accompanying limonite.

The more important minerals accompanying limonite have already been noticed; they are ankerite, barite, calcite, göthite, hematite, manganite pyrolusite, and siderite.

COMPOSITION OF LIMONITES.

Several analyses of Nova Scotia limonites have been made in the laboratory of the Geological Survey. Four of the specimens examined were from the Acadia mines, Londonderry, one from the West Branch of the East River (Cullen's area), and one from the East Branch of the East River (Fraser Saddler area). The analyses of the Londonderry specimens will be given first and then those of the East River specimens.

Analyses of Londonderry ores.

Ross' Farm, Acadia Mines.

The ore at this locality occurs mostly in the form of lustrous botryoidal or mammillary and stalactitic masses of a dark brown colour and exhibiting a fibrous structure when broken. An analysis of a specimen with a specific gravity of 3.98 gave Mr. Hoffmann as follows:

Peroxide of iron	84.73
Protoxide of iron	traces.
Protoxide of manganese	0.23
Alumina	0.23
Lime	0.14
Magnesia	0.14
Phosphoric acid	0.19
Sulphuric acid	0.01
Water { hygroscopic	0.33
Water { combined	11.07
Insoluble residue	2.67
	99.74
Metallic iron	59.311
Phosphorus	0.083
Sulphur	0.004

The insoluble residue consisted of,

Silica	2.54
Alumina with traces of peroxide of iron	.09
	2.63

Martin's Brook, Acadia Mines.

Much of the ore at this locality is ochreous, but it also occurs in dark brown botryoidal masses with fibrous structure within. A specimen of the latter variety with a specific gravity of 3.91 gave Mr. Hoffmann:

Peroxide of iron	82.65
Protoxide of iron	traces.
Protoxide of manganese	0.25
Alumina	0.56
Lime	0.15
Magnesia	0.10
Phosphoric acid	0.38
Sulphuric acid	0.02
Water { hygroscopic	0.31
Water { combined	10.51
Insoluble residue	4.79
	99.72

Metallic iron	57.855
Phosphorus	0.166
Sulphur	0.008

The insoluble residue was found to consist of,

Silica	4.51
Alumina with traces of peroxide of iron	0.28
	4.79

Large quantities of this ore have been smelted at Londonderry, the average yield in the furnace being nearly 50 per cent. A sample of the bar iron made from it contained only 0.018 per cent. of phosphorus. Phosphorus in bar iron.

Cumberland Brook, North Vein, Acadia Mines.

This specimen was a hard compact limonite of a dark brown colour and without lustre, except on the surfaces of occasional cavities. It had a specific gravity of 3.77, and yielded on analysis:

Peroxide of iron	82.13
Protoxide of iron	1.00
Protoxide of manganese	0.72
Alumina	0.66
Lime	0.88
Magnesia	0.25
Silica	1.93
Phosphoric acid	0.86
Sulphuric acid	0.04
Water { hygroscopic	0.44
Water { combined	11.07
	99.98

Metallic iron	58.27
Phosphorus	0.37
Sulphur	0.016
Insoluble residue	2.05

Cumberland Brook, South Vein, Acadia Mines.

The sample of ore from this place analysed was an ochreous limonite of a yellowish brown colour and having a specific gravity of 3.31. It contained:

Peroxide of iron	79.68
Protoxide of iron	none.
Protoxide of manganese	2.51
Alumina	0.63
Lime	0.57
Magnesia	0.34
Silica	3.05
Phosphoric acid	0.44
Sulphuric acid	0.01
Water { hygroscopic	0.78
Water { combined	11.65
	99.66

Metallic iron	55.776
Phosphorus	0.192
Sulphur	0.004
Insoluble residue	3.040

Fraser Saddler Area, East River, Pictou County.

Analyses of ores from the East River, Pictou County.

The specimen was a beautiful fibrous limonite of a light brown colour, and specific gravity of 3.84. It contained but little sulphur or manganese, although heavy-spar, manganite, and pyrolusite are all found occasionally associated with the ore in parts of the vein. An analysis gave:

Peroxide of iron	85.01
Protoxide of iron	none.
Protoxide of manganese	0.38
Alumina	0.69
Lime	0.49
Magnesia	0.19
Phosphoric acid	traces.
Sulphuric acid	0.055
Water { hygroscopic	0.36
Water { combined	10.77
Insoluble residue	2.14
Organic matter	traces.
	100.085

Metallic iron	59.51
Sulphur	0.022

The insoluble residue was found to consist of,

Silica	1.98
Alumina, with traces of peroxide of iron	.18
Lime	traces.
	2.16

Area 105 (Cullen's), West Branch of the East River, Pictou County.

A specimen (loose) of the ore from this locality with a specific gravity of 3.955 has been examined by Mr. Hoffmann. It was a compact limonite of a dark brown colour and contained:

Peroxide of iron	76.930
Protoxide of iron	4.972
Protoxide of manganese	0.068
Alumina	1.019
Lime	0.313
Magnesia	0.052
Silica	5.836
Phosphoric acid	0.989
Sulphuric acid	0.114
Water { hygroscopic	0.175
Water { combined	9.287
Organic matter	0.180
	99 935
Metallic iron	57.718
Phosphorus	0.431
Sulphur	0.046
Insoluble residue	6.350

The amount of water indicated by all these analyses is less than that required theoretically to form limonite, the average deficiency being about three per cent.; at the same time it is greater than in göthite, so that the ores may be regarded as mixtures of limonite with oxides of lower degrees of hydration, or of limonite with anhydrous peroxide. Water in limonites.

The amount of phosphorus is not high for ores of the class; ranging from mere traces in the ore from the Fraser Saddler area to 0.431 per cent. in that from the Cullen area, or an average of 0.207 per cent. The average percentage of sulphur is very low, being only 0.016. Phosphorus.

BOG IRON ORE.

Descriptions of the principal deposits of this ore known in the country were published in the *Geology of Canada*, in 1863, and since that time but few additional facts have been developed

Bog ores are mainly of recent age, occurring at or near the surface, and generally in sandy regions, ferruginous sands often being the source of the iron. Sometimes they are found in a pulverulent condition, and then known as ochres and better adapted for pigments than for smelting. The colour of these ochres is generally yellowish or reddish-brown, though when freshly exposed they often present other tints owing to portions of the iron having been reduced to the condition of protoxide by organic matter. The variety employed for smelting occurs in concretionary Age and characters of bog ores.

lumps or masses often showing a curious cavernous structure, and either dull and earthy, or at times highly lustrous when fractured. The colour is usually yellowish or reddish-brown, and dark brown or black when much manganese is present. The concretions are either scattered through the soil, or else form continuous layers, generally only a few inches in thickness, though sometimes several feet—in one instance, in Côte St. Charles, Vaudreuil, no less than eight feet! *

Protoxide of iron.

Though the iron in Canadian bog ores occurs chiefly as peroxide, in combination with water, and generally also with organic acids, protoxide of iron is very commonly present, often, apparently, in combination with silica, which separates in a gelatinous condition on treating the ore with hydrochloric acid. Oxides of manganese are frequently present, though in variable quantity, ranging from mere traces up to nearly thirty per cent. The proportion of iron obtained on analysis is likewise variable, averaging about fifty per cent. In the blast furnace, however, the yield has usually been only from 30 to 40 per cent., as the ores often contain a considerable proportion of silica, in the form of sand, which is not easily removed even by washing. When sulphur is present, it is, so far as known, only in very small quantity. The amount of phosphoric acid ranges from mere traces to nearly two per cent. The volatile matter (water and organic matter) averages about twenty per cent. (19.92 as deduced from ten analyses). In an ochre from Ste. Anne, Montmorenci, Dr. Hunt obtained as high as 36.15 per cent. of volatile matter.

Yield of bog ores in the furnace.

Organic matter as a reducing agent.

No ore is more easily reduced than bog ore; for not only is it porous and readily permeable by reducing gases, but the organic matter undoubtedly aids in its reduction. The conversion of bog ore into magnetic oxide by the reducing action of the organic matter has been described on page 6, and Dr. Hunt found that the ochre from Ste. Anne, when heated to redness in a closed vessel, evolved inflammable gases and was converted into a mixture of pyrophoric metallic iron and charcoal.

White and mottled irons.

A large proportion of the pig iron made from bog ores is generally white or mottled, this, no doubt, being due to manganese and phosphorus During the time that the St. Francis furnace was in blast, over fifty per cent. of the iron produced was white and mottled. Though it is generally stated that the wrought-iron made from bog ores is cold-short, such is not always the case, and bar iron produced in an old-fashioned *hearth-finery* was seen at the St. Maurice Forges which was not all cold-short, and which, on analysis, shewed only traces of phosphorus.

Wrought-iron from bog ores not always cold-short.

Localities visited.

The only localities in which I have had an opportunity of seeing deposits of bog ore are in the Seigniory of Vaudreuil and in the vicinity of the St. Maurice Forges. In Vaudreuil the ores are of very variable charac-

* See Geol. of Can., 1863., p. 683.

ter; in Côte St. Charles the ordinary yellowish or reddish-brown concretionary variety is found, and sometimes forms ridges or lenticular patches with intervening hollows. The ridges appear to have been formed by the accumulation of the ore in what were once hollows or basins; the intervening sand was then washed away and a second set of basins formed in which ore has since been accumulating. In Ste. Angelique, on what is known as the McGillis property, and also in Ste. Elizabeth, a black or brownish-black concretionary ore containing a large proportion of oxide of manganese occurs. The concretions average probably not more than three-quarters of an inch in diameter, and are usually free from intermixed sand. A sample from the McGillis property, close to the brook, and a few hundred yards above the site of the old mill, was selected for analysis, and gave the following results: Analysis of ore from Ste. Angelique Vaudreuil.

Peroxide of iron	40.96
Oxide of manganese	26.34
Lime	1.48
Magnesia	traces.
Phosphoric acid	0.60
Sulphuric acid	traces.
Insoluble matter and soluble silica	12.08
Water and organic matter	17.97
	99.43
Metallic iron	28.67

When treated with hydrochloric acid chlorine is evolved and a considerable quantity of silica separates in the gelatinous condition; the latter is probably combined with protoxide of iron, the amount of which could not readily be determined, as the chlorine given off at once converts it into peroxide. The manganese in the above analysis is calculated as protoxide, although a portion of it at least must be present in a higher state of oxidation, judging from the evolution of chlorine. The ore of similar character in Ste. Elizabeth could probably be obtained in considerable quantity, and although not rich in iron would be valuable for mixing with other ores, on account of the large proportion of manganese which it contains. Ste. Elizabeth.

In the vicinity of the St. Maurice Forges several varieties of bog ore also occur, but nothing was observed exactly corresponding to the highly manganesian ore of Vaudreuil. When at the L'Islet Forge a specimen was selected from a pile which had been taken from a bed two feet thick and underlying three feet of peat. The results of an analysis shew it to be an exceedingly pure ore. It contained, Analysis of ore from L'Islet.

Peroxide of iron	69.64
Protoxide of iron	7.25
Protoxide of manganese	0.05

Alumina	0.90
Lime	0.53
Magnesia	traces.
Phosphoric acid	traces.
Sulphuric acid	0.05
Silica	1.93
Water and organic matter	22.04
	102.39
Metallic iron	54.37

The ore was partly compact, partly ochreous, and of a dark brown colour. It was examined for phosphorus by both the molybdate of ammonia and tartaric acid processes, but in neither case could more than traces be detected.

Dr. Hunt's analyses of bog ores.

For the sake of comparison Dr. Hunt's analyses of bog ores, published in the Geology of Canada, page 511, are repeated here in the following table. The iron is given as peroxide, although Dr. Hunt states that in some cases it was present in part as protoxide.

ANALYSES OF BOG ORES.

By Dr. T. Sterry Hunt.

Constituents.	I.	IIa.	IIb.	III.	IV.	V.	VI.	VII.
Peroxyd of iron	74.50	76.95	....	57.15	77.80	77.60	74.30	64.80
Sesquioxyd of manganese	....	....	....	....	....	0.30	traces.	5.50
Alumina	0.30	0.80	....	1.60	....	....	....	....
Silica	7.10	1.50	5.43	21.60	1.76	5.40	3.60	4.80
Phosphoric acid	....	....	1.52	....	0.61	1.81	1.80	undet.
Volatile matters	18.95	19.80	19.70	18.85	16.50	17.25	22.20	23.65
	100.85	99.05	....	99.20	96.67	102.36	101.90	98.75
Metallic iron	52.15	53.86	....	40.00	54.46	54.32	52.01	45.36

I.—From Petite Côte, Vaudreuil.
II. a. and b.—From Côte St. Charles, Vaudreuil.
III.—From Upper Rocky Point, Eardley.
IV.—From Bastard, twentieth lot, second concession.
V., VI. and VII.—St. Maurice Forges.

SPATHIC IRON ORE.

This ore, which is composed of crystalline carbonate of iron, may be regarded as the least important of all the iron ores of the Dominion, only one deposit being known which gives any prospect of being of economic value. In New Brunswick it is found in rocks referred by Professor Bailey and Mr. Matthew to the Huronian, sometimes in the form of veins, the thickest of which, however, are only about four inches. Its occurrence in small quantity in rocks of the St. John group, as well as in slates of Devonian age, is also mentioned by the same writers (Report of Pro-

Age of spathic ores.

gress, 1872–73, p. 227.) The deposit alluded to above as probably of economic importance occurs near Sutherland's River, in Pictou County, Nova Scotia, and was described by Mr. Edward Hartley in the Report of Progress for 1866–69, page 441. It appears to be a bed, the rocks above and below being sandstones of the Millstone-grit formation. Since Mr. Hartley's visit, further explorations have been carried on by Mr. G. M. Dawson, from whose report the following is extracted:

Extract from a report by Mr. G. M. Dawson on the spathic ore of Sutherland's River, N.S.

"The surface of the country is very deeply and uniformly covered by drift-material, and explorations on the area have been attended with considerable difficulty, it having been necessary to sink and cross-cut in the enclosing rocks. The ore is very well exposed in the bank of a brook. At this point, and near the level of the brook, a shaft 14 ft. deep has been made, and the ore proven to that depth, and its general character more clearly defined. It is evidently somewhat nodular in structure, being softer and harder in some places, and its junction with the overlying and underlying rocks having an undulating character. At the brook level the bed has a thickness of 10 ft. 6 in. At the bottom of the shaft this has decreased to 6 ft. 6 in., and it is probable that the ore, as followed, will continue thinning and thickening alternately. The dip of the ore and surrounding rocks is about S. 25° E., at an angle of 60°, and underlying the main bed of ore about 4 ft. was a small ore bed 6 in. in thickness. A shaft was sunk both east and west of the brook exposure, and at distances from it of 941 and 215 ft. respectively. The measures have been cross-cut several feet north and south in each, but as yet without discovering the ore bed. Small strings and layers of carbonate of iron contained in reddish clayey sandstone were passed through in both places, showing that the bed was not far off; and in the north level from the west shaft, when we were obliged to suspend operations, the prospects seemed very good."

Thickness of ore seen at Sutherland's River.

None of the openings were accessible at the time of my visit, so that the only place in which the bed could be seen was in the bank of the brook, where, as stated by Mr. Dawson, it has a thickness of between ten and eleven feet. Before its real extent and value can be determined further explorations will be necessary.

Dr. Dawson has called attention to the fact of its being at no great vertical distance from a bed of gypsum, and to its being somewhat similar in mode of occurrence to the non-fossiliferous sub-crystalline limestones which occur in some parts of the Lower Carboniferous series associated with the gypsum.*

The ore when it has not been weathered is highly crystalline and of a grey or brownish-grey colour. On exposure the protoxides of iron and

* Can. Nat. new ser, VII. 3, p. 132.

manganese pass to a higher state of oxidation and the ore assumes a much darker colour. Some of it is a good deal mixed with limestone, and much of the material which has been extracted from the largest opening east of the brook consists of a porous or cellular grey limestone with scattered crystals of carbonate of iron. This, though probably not rich enough in iron to be smelted as an ore, would make an exceedingly valuable flux.

Limestone containing crystals of spathic iron.

The following analyses shew the ore to be of very fine quality:

ANALYSES OF SPATHIC ORE FROM SUTHERLAND'S RIVER, N.S.

Constituents.	I.	II.	III.	IV.
Sesquioxide of iron	16.98	20.52	....	....
Carbonate of iron	65.61	57.40	88.48	88.59
Carbonate of manganese	7.98	8.29	1.85	2.85
Carbonate of lime	2.67	4.02	2.34	1.53
Carbonate of magnesia	3.23	5.66	5.82	3.48
Silica	3.76	2.38	1.51	2.70
Hygroscopic moisture	.76	1.43	....	....
Sulphur	none.	undet.	....	.55†
Phosphorus	.013	"	. . ....	none.
Organic matter	traces.	none.	.....	....
	101.003	99.70	100.00	99.70
Metallic iron	43.56	42.07	42.71	42.76

I. and II. were made by Mr. Gordon Broome in the laboratory of the Survey; the first specimen was from the outcrop on Sutherland's Brook, the second from a costeaning pit about 75 feet farther westward. (Report of Progress, 1866-69, p. 442.) III. is by Dr. Stevenson Macadam, of Edinburgh, and IV. by Dr. T. E. Thorpe, of the Andersonian University, Glasgow.

CLAY IRON-STONE.

Characters of clay iron-stone.

This is a compact earthy ore varying in colour from light brown or grey to black, the different shades often depending upon the presence of organic or coaly matter, or upon the peroxidation of the iron when the ore has been exposed to atmospheric action. It consists of carbonate of iron mixed with clay and other impurities, and though not rich in iron has been the chief source of that metal in England.

Age of clay iron-stones.

In Canada it is found in rocks of Devonian, Carboniferous, Jurassic, Cretaceous, and Tertiary age. The Devonian iron-stones occur in layers and nodules in the shales which are interstratified with the Gaspé sandstones. They will probably never be of much importance as a source of iron.

Nova Scotia.

In Nova Scotia they occur in the Carboniferous shales of the Cape Breton, Pictou, and Cumberland coal-fields, though very little is really known of the thickness or quality of the deposits. Many years ago

* Insoluble matter. † Sulphate of lime.

attempts were made to smelt the ore from beneath the main seam at the Albion mines, but were not attended with success.

New Brunswick.

Clay iron-stones also occur in the Carboniferous of New Brunswick, but whether they are widely distributed I cannot say. Judging from the return of borings published in Gesner's 3rd Report to the Legislature of New Brunswick in 1840, the quantity at the Salmon River coal-field must be very considerable, as no less than about one-sixth of the 402 feet 9 inches bored through consisted of clay iron-stone. Gesner, however, says nothing as to its quality.

Vancouver Island.

The coal-bearing rocks of Cretaceous age in Vancouver Island often contain iron-stones, though little is yet known as to the quantity. At the Bayne's Sound Mines the nodules are of large size; some of them being flat or lenticular, and others round; the former vary in length from six inches to four or five feet, and in thickness from six to eighteen inches, and the latter are often as much as eighteen inches in diameter. (Report of Progress, 1872–73, p. 43). Mr. Richardson thinks that at this locality sufficient could be obtained for the supply of a blast-furnace. East of the Rocky Mountains Cretaceous iron-stones again occur, but little can be said as to the quantity until further explorations have been made.

Queen Charlotte Islands.

The Jurassic ironstones are found on the Queen Charlotte Islands in the shales associated with the anthracite. They are not known to be of economic importance.

Tertiary iron-stones.

Those of Tertiary age occur in the lignite-bearing strata west of Red River, in the vicinity of the 49th parallel, where they have been observed by Hector, Professor Bell, Mr. G. M. Dawson and others. From the recently published report of the last named gentleman I quote the following: "The ironstones of this formation, though occurring very frequently in the same sections, and in close proximity to the coals, have not been observed in any place to attain a considerable thickness. They generally run in nodular sheets of only a few inches thick, through the clays and argillaceous sands. Externally they weather to various shades of chocolate-brown and reddish-brown, but are hard and compact in structure and within preserve their original bluish or yellowish-grey colour. They ring beneath the hammer, and break off in conchoidal chips. Considerable quantities of this material might be gathered from the surface in some localities, and it is probable that further search might bring to light localities in which so many layers of ironstone occur in the same section as to render it profitable to work over the entire bank. Should these ores ever come to be worked, limestone for use as a flux could be obtained in considerable quantities from the boulders of Silurian age which strew the plains in many places."*

* Report on the Tertiary Lignite Formation in the Vicinity of the Forty-ninth Parallel. By G. M. Dawson, Assoc. R. S. M.

Analyses by Mr G. M. Dawson.

But few of the Canadian iron-stones, so far as I am aware, have yet been analysed. The two following partial analyses of iron-stones of Tertiary age are given by Mr. G. M. Dawson (l. c., p. 30) :—

	I.	II.
Protoxide of iron	49.00	46.72
Water lost at 115° C	1.21	3.57
Carbonic acid lost on ignition	28.57	21.23
Siliceous matter insol. in H Cl	17.04	8.72
Sulphuric acid	0.26	0.30
Phosphorus	trace.	0.03
Metallic iron in raw ore	38.11	36.34
Metallic iron in calcined ore	54.27	49.90

A small quantity of the iron was in the state of peroxide, but was not estimated. No. I. is from Souris Valley and No. II. from 245-mile Valley.

Analysis of ore from the Dirt Hills.

The following is an analysis which I have recently made of a specimen of Tertiary iron-stone brought by Professor Bell from the "Dirt Hills" last summer. The ore is very tough and breaks with a conchoidal fracture, the freshly fractured surfaces being of a brownish-grey colour:—

Protoxide of iron	51.977
Peroxide of iron	1.456
Protoxide of manganese	1.179
Alumina	2.306
Lime	1.140
Magnesia	0.650
Silica	7.026
Carbonic acid	31.850
Phosphoric acid	0.200
Sulphuric acid	0.053
Bisulphide of iron	0.088
Water { hygroscopic	0·846
Water { combined	0.534
Organic matter	0.524
	99.829
Metallic iron	41.486
Phosphorus	0.087
Sulphur	0.068

State of combination of sulphur.

It will be noticed that the largest part of the sulphur is present in combination with iron, which is generally the case in iron-stones. Mr. Dawson, however, states that in the specimens examined by him the sulphur was present "entirely as sulphuric acid and in combination with lime."

In the following table are given the percentages of metallic iron in eight samples of clay iron-stone from different localities:— *Assays of iron-stones.*

Locality.	*P.C. of Iron.*	*Age.*
1.—Pictou County, N.S., north of New Glasgow conglomerate.	30.55	Carboniferous.
2.—Barrasois, Cape Breton..........	27.84	"
3.—Baynes' Sound mines, V.I.......	36.83	Cretaceous.
4.— " " " "	29.78	"
5.—Scissors Creek, about 30 miles west of Fort Ellice................	23.72	Tertiary.
6.—Second Hill, Woody Mountains	39.46	"
7.—First Hill, " "	41.05	"
8.—345-Mile Valley....................	37.95	"

Specimen No. 1 was a nodule collected by Dr. Dawson. On breaking it open it was found to contain zinc blende, a mineral otherwise unknown in the Carboniferous of Nova Scotia.*

No. 2, collected by Mr. Charles Robb.

Nos. 3 and 4, collected by Mr. Richardson and assayed by Mr. Hoffmann.

Nos. 5, 6, and 7, collected by Professor Bell.

No. 8, collected and assayed by Mr. G. M. Dawson.

The average percentage of iron is 33.40.

ECONOMIC CONSIDERATIONS.

Under this head a few notes will now be given on the cost of labour, cost of mining iron ores, cost of shipment, of smelting, and other kindred subjects.

Cost of Labour.—The prices paid for labour in connection with the iron mines vary somewhat in different parts of the country. In general miners get from $1.25 to $1.40 per day, although the price sometimes runs below the former or above the latter figures. This will be best illustrated by a few examples from mines which were being worked in the past summer: At the Haycock location in Templeton and Hull, the average price paid for labour was about $1.30 per day. At the Bristol mine (Bristol, lot twenty-one, range two) the miners received $1.50 per day, this high price possibly being due to the demand for labour in connection with the Arnprior lumber mills. At the Dalhousie mine $1.25 was paid when the men boarded themselves, but only 80 to 90 cents when board was supplied. At the Blairton mines (Belmont) 150 men were being employed, receiving from $1.20 to $1.30 per day, according to the special kind of work in which they were engaged. They were furnished with cottages at the rate of $1.50 per month. At the Chaffey and Yankee *Examples of the cost of labour.*

* Since the above was written Mr. Hoffmann has detected blende in a specimen of coal from Cape Breton.

mines in South Crosby the men were being paid by the month, getting from $20.00 to $26.00 besides their board. This, allowing 26 working days to the month, would be at the rate of from 77 cents to $1.00 per day, besides board. The men employed in connection with the St. Francis (Rivière aux Vaches) furnace and charring ovens, received last year an average of $1.25 per day, without board. About the same price was also paid to the men engaged in collecting ore. At the St. Maurice Forges wages were very low, an ordinary labourer getting in some cases as low as 70 cents a day and boarding himself. The men engaged in collecting bog-ore were being paid 30 cents for every *barrique** of ore taken out. The furnace-keeper and charger received $28.00 per month and the other men employed in connection with the the furnace $22.00.

At the Acadia mines, Londonderry, ordinary labourers received from $1.00 to $1.30, and miners $1.50 per day. The latter, however, were generally paid by the ton of ore extracted, and were making from $40.00 to $45.00 a month. The men employed in connection with the furnace were paid by the ton of pig iron produced, the keeper getting 25 cents and the others 20 cents per ton. This allowing the furnace to produce about 7⅓ tons per day would be $1.83 per day for the keeper and $1.47 for those under him.

In British Columbia no iron mines are, I believe, being worked ; the prices paid coal miners at the mines on Vancouver Island, however, ranged in 1872 from $3.00 to $4.00 per day. Ordinary labourers received from $1.75 to $2.00.†

Cost of labour in Sweden.

In the Swedish iron mines the miners get about 80 cents a day, or about half a dollar less than our iron miners on the Atlantic side of the continent.

Cost of Mining.—The cost of mining (getting and bringing to bank) a ton of ore of course depends upon the character of the ore and the enclosing rock, the position of the mine, depth of the workings, necessity of pumping or otherwise, cost of labour, and numerous other contingencies. In prospectuses it is often put down at 75 cents, but it would be difficult, if not impossible, to find a single instance in the whole country where ore requiring blasting is being mined for less than $1.00 per ton, even under the most favourable circumstances. There is, however, no doubt that in many cases the cost might be materially reduced by careful management and the use of steam drills and (with proper precautions) of such explosives as dynamite and dualin. At present many of the miners are inexperienced, and in drilling holes for blasting seem to be quite

Reduction in the cost of mining.

* 6 bushels, French measure. The *barrique* of ore weighs from 600-800 lbs., according to the quality of the ore.

† Report of the Hon. H. L. Langevin, C.B., Minister of Public Works, (Ottawa, 1872) p. 13.

unconscious of such a thing as *a line of least resistance.* By placing the hole in a wrong position a large proportion of the useful effect of the shot is lost and unnecessary expense involved. In nearly all cases the ore is obtained from open cuttings, there being only two or three iron mines in the whole country where underground mining is or has been carried on. Underground workings would, however, in many cases be advantageous, **Underground workings.** especially where operations are carried on during the winter, in which season, owing to the cold, snow, and ice, the cost of mining has in some instances been nearly double the cost in summer. A few examples of the **Examples of the cost of mining.** cost of mining in different localities may be of interest. At the Haycock location the ore, delivered at the end of the tramway on the bank of the Gatineau River, costs $1.76 per ton. The length of the tramway is 6¼ miles. At the Dalhousie mine the cost of mining for the year ending February, 1871, was $1.25 per ton, not including outlay for plant, and including outlay for plant $1.46. From that date up to February, 1873, the cost was but slightly increased. A portion of the workings are underground. Quite recently operations at this mine have been suspended At the Yankee and Chaffey mines in South Crosby the cost is only $1.00 per ton, but the conditions for mining are very favourable. The Chaffey mine, which is situated on an island in Mud Lake, on the Rideau Canal, is so close to the water's edge that the ore is raised by means of a crane and *dumped* directly into the barges. At the Blairton mine (Belmont) the ore costs $1.25 loaded on the cars which take it to Rice Lake. Much of it is raised from a depth of about 120 feet by an engine of 20 horse-power. Percussion steam drills are employed, the holes drilled being from two to three inches in diameter. A twelve horse-power engine is used for pumping the water which accumulates in the main opening. At the Acadia iron mines, most of the ore (limonite) which has been smelted for some years has been obtained from the Martin's Brook workings about 2½ miles from the furnace. The vein is here of somewhat irregular character, thickening and thinning alternately and often containing "horses." A good deal of "dead work" has accordingly to be done, increasing the cost of winning the ore. Exclusive of dead work the ores cost about $1.00 per ton at the mouth of the level, while if the dead work is included it increases the cost to from $1.90 to $2.00 per ton, Delivered at the furnace the ore costs $2.50 per ton. In the vicinity of the St. Maurice Forges the bog ore costs 30 cents a *barrique*, or from 84 cents to $1.12 per ton. It has, however, to be drawn from 4 to 9 miles, so that the cost at the furnace is more than double the latter figure.

In Sweden the mining of the magnetic ores costs from 55 cents up to **Cost of mining in Sweden.** $3.00, but the ore has often to be raised from depths of several hundred yards.

COST OF TRANSPORTATION.—Most of the ores which are mined in Canada are shipped to the United States to be smelted there. The mines, however, are often situated at considerable distances from railway or water communication, to which the ores have to be drawn by horses. The drawing is generally done in winter, since at that season the farmers are much of the time unoccupied and glad to obtain employment, and because much larger loads can be taken on sleds than on waggons. The prices paid for hauling ore of course vary much in different regions. Probably the smallest remuneration given anywhere has been at the Dalhousie mine, from which to Perth, a distance of 12 miles, the ore was drawn, by contract, during the winter of 1872–73 at the rate of $1.00 per ton. From Perth to the point of shipment on the Rideau Canal, 7 miles, the price paid was 60 cents. For the whole distance of 19 miles, then, the cost for carriage was only $1.60 per ton, or a little less than 8½ cents per mile. "The average weight of loads of ore hauled from the Dalhousie mine, by contract, to Perth in 1870–71 was 4 tons—3.99; in 1871–72 it was 4¼ tons—4.248; in 1872–73 it was 3¾ tons—3.74. The ton of 2240 lbs. is always used. The loads vary from 6,000 to 12,000 lbs., and sometimes run up to 14,000 lbs."* It must be borne in mind that most of the road is horizontal or in places down-hill. Were it up-hill, such large loads could not be carried. During the winter of 1872–73 ore was hauled from the Howse and Chaffey mines in Bedford to Westport on the Rideau Canal, a distance of 17 miles, for $2.40 per ton, or at the rate of 14 cents a mile. The road here is more hilly than that from the Dalhousie mine. At the same time ore was drawn from the Hull mines to the River Gatineau, a distance of about 2 miles, for 30 cents per ton, or 15 cents per mile. The road is horizontal or down-hill all the way, and as much as 5 or 6 tons were sometimes taken in a single load. At the Acadia iron mines, where most of the ore is drawn about 2 miles, the price per ton is from 50 to 60 cents, or 25 to 30 cents per mile; from the Cumberland Brook workings, a distance of about three miles, it is 85 cents. The amount hauled from the Martin's Brook workings to the furnace in a day by a pair of horses is only about 5½ tons.

Examples of the cost of transportation.

The ore of the Hull mines is chiefly shipped to Cleveland and by way of the Rideau Canal. The cost of shipment is said to have been only $2.50 per ton in 1872, but must be much higher now—probably $3.00–$3.50. From the Chaffey and Yankee mines, the ore is carried in barges to Kingston, a distance of 44 miles, for $1.00. From Kingston to Cleveland the cost for these as well as for other ores is $1.25 to $1.50. The Dalhousie ore is carried from the point of shipment on the Rideau to Kingston, about 60 miles, for from $1.25 to $1.50 (including loading).

* Information kindly sent me by Mr. Gerald C. Brown, Manager of the Dalhousie mine.

From the Blairton mine to Pittsburg the cost of transportation is said to be about $4.00.

Besides the ores which are carried to Cleveland, small quantities are sometimes shipped to Charlotte in New York state.

SMELTING OF IRON ORES.—The history of iron smelting in this country is neither a long one nor a brilliant one. The list of failures is greater than the list of successes; but such is always likely to be the case, for a time at least, in countries like our own, where enterprises are too often undertaken by persons of little or no experience.

No less than seventeen blast furnaces have been erected at different times in four provinces of what is now the Dominion, and in the following localities: Number of blast furnaces erected.

ONTARIO.	QUEBEC.	NEW BRUNSWICK.	NOVA SCOTIA.
Madoc.	St. Maurice Forges.	Woodstock.	Albion Mines.
Marmora.	L'Islet.	....	Londonderry.
Furnace Falls or Lyndhurst.	Batiscan.	....	Clementsport.
Normandale.	Rivière aux Vaches.	....	Nictaux (2)
....	Bay St. Paul (2).	....	....
	Hull.	....	....

PROVINCE OF ONTARIO.

Madoc.—The Madoc furnace was built in 1837, but was in blast only a short time when it was abandoned, one of the proprietors having been killed in the mine, and the other not having sufficient means to carry on the operations. The ore smelted was from the Seymour ore-bed in the eleventh lot of the fifth range of Madoc, and is said to have produced iron of very superior quality. For a short time wood was employed as fuel. Wood as fuel.

Marmora.—The Marmora furnace is still standing, though in a dilapidated condition. It was erected before the one at Madoc. Several attempts have been made by different companies to smelt the ore of the big ore bed in it, but have been failures, owing, apparently, to distance from a port of shipment, inattention to the proper sorting of the ore and the nature of the required flux, and also to want of capital.* Causes of failure.

Furnace Falls or Lyndhurst.—A blast furnace was erected here many years ago to smelt the red hematite occurring in the Potsdam rocks of the Township of Bastard, but the supply of ore was found to be inadequate, and the furnace was soon abandoned. Its ruins are still visible.

Normandale.—Many years ago a blast furnace was built here (near Lake Erie, 11 miles from Simcoe) to smelt the bog-ore of the township

* For fuller information concerning the Marmora and Madoc furnaces see "Report on Hastings" by Mr. Macfarlane, in Geol. of Can., 1866.

of Charlotteville. No information has been obtained concerning it beyond what is stated in the Geology of Canada, 1863, page 686; but it has probably been abandoned.

PROVINCE OF QUEBEC.

St. Maurice Forges.—The St. Maurice furnace is situated near the River St. Maurice, eight miles distant from Three Rivers. It was built as early as Early enterprise. 1737, and is interesting as a monument to the enterprise of the early settlers of the region, and from the fact that it is still in blast. The present proprietors are the Messrs. MacDougall of Three Rivers.

The internal dimensions of this furnace are,

Height	30 feet.
Diameter at hearth	2½ "
" " boshes	7 "
" " throat	3½ "

There are two twyers, and the blast which is produced by water power is cold and has a pressure of about a pound to the square inch. At the time of my visit in October last the charge consisted of,

Bog ore	600 lbs.
Limestone	45 "
Charcoal	16 bushels (French).*

About 45 charges were made in the 24 hours, and the furnace tapped at intervals of from 12 to 18 hours. The daily production averaged 4 tons, of which 10 per cent. was white and 10 per cent. mottled iron. The charcoal is made chiefly from soft wood, and is burned both in heaps in the woods, and in charring ovens or kilns near the furnace. When charred in heaps 3½ cords † of wood are required to make 100 bushels of Yield of charcoal. charcoal, but only two cords when the charring is performed in ovens. In the first case the volume of the charcoal would be only 34.32 per cent. of the volume of the wood, an unusually small yield, although the wood employed is of very inferior quality. The yield in the ovens equals 60.1 per cent. of the volume of the wood, an amount only a little below the average obtained in Sweden. The average weight of the charcoal is 11 to 12 lbs. to the bushel, and that prepared in heaps is considered better than that produced in ovens. About 180 bushels are required to make a ton of iron. The average cost is 6 cents per bushel.

Charring ovens. The ovens are built of ordinary red brick, and the dimensions of one of the largest are,

Length	50 feet.
Width	14 "
Height to top of arch	10 "
Thickness of walls	1½ "

* The *minot*=2250 cub. in.

† The cord generally employed in the Province of Quebec contains only 108.375 cub. ft The wood is cut three feet in length, and the piles are 8 ft. long and 4½ ft. high.

The ore smelted is entirely the bog ore of the region, and has now to be drawn for distances of from 4–9 miles, the supply in the immediate vicinity of the furnace having been to a great extent exhausted. In the furnace it yields from 33 to 35 per cent. of iron. The cost of the ore delivered at the furnace is about $2.50 per ton, or sometimes higher. The limestone (Trenton) has also to be carried several miles, and at the furnace costs 25 cents a *barrique* or 93 cents a ton.

Yield of ores.

The furnace is generally in blast for from 10 to 13 months at a time. Nearly all the iron produced is sent to Montreal and there manufactured into car wheels, although formerly it was made into castings on the spot. The pig was worth about $40.00 per ton in Montreal last summer. A small quantity of wrought iron is also made in an old-fashioned *hearth-finery** and used in the manufacture of axes of which 10 dozen are produced daily. These axes are said to have obtained quite a reputation among lumbermen, although it is only a short time since their manufacture was commenced, and orders are received far exceeding the production. The manufacture of cast iron stoves has been discontinued.

Duration of blast.

Manufacture of axes.

An analysis of a specimen of grey pig iron made at St. Maurice, in 1868, gave Dr. Hunt the following results:

Analysis of St. Maurice iron by Dr. Hunt.

Iron	undet.
Graphite	2.820
Carbon, combined	1.100
Sulphur	.025
Phosphorus	.450
Silica	.860
Manganese	1.240

Attempts were made a short time since to smelt the magnetic ore of Leeds (see pp. 16 & 20.) in the St. Maurice furnace, but were unsuccessful. The failure, however, was no doubt due to the want of height and proper lines of the furnace, and perhaps also to the want of experience of the furnace keeper in the treatment of other than bog ores.

Attempt to smelt magnetic

L'Islet.—The Messrs. McDougall are also the proprietors of another furnace at L'Islet, about four miles from the one just described. Details concerning it are unnecessary, as they would differ but slightly from those just given for the St. Maurice furnace.

Batiscan.—Of the Radnor furnace, at Batiscan, I have received no special details. It was in blast during the past summer and iron being shipped to Montreal.

Rivière aux Vaches.—The St. Francis furnace, near the Rivière aux Vaches, in Yamaska county, was completed in April, 1869. Quite recently

* See page 235.

Dimensions of St. Francis furnace.

it has been purchased by the Messrs. McDougall of Three Rivers from the St. Francis River Mining Company. The internal dimensions are,

Height	30 feet.	
Boshes	7 "	2 in.
Hearth	6 "	by 2 feet 2 in.
Depth of hearth	1 "	8 in.

Charge.

There are two twyers placed horizontally, the blast is cold, has a pressure of from one to two inches of mercury and is produced by water power, the wheel having a diameter of 24 feet. The charge which has been found to work best consisted of,

Bog ore	600 lbs.
Limestone	½ bu.
Charcoal	18 "

Yield of ore.

Total production.

The ore has yielded on an average 36 per cent. of iron, of which from 3 tons 4 cwts. to 4 tons 2 cwts. were produced daily, over 50 per cent. consisting of white and mottled iron. The total production from the first blowing in, in April, 1869, up to June, 1873, was 5,520 tons of pig. This was sent to Montreal, the port of shipment being Yamaska on the Yamaska River, 8 miles from the furnace. The cost of hauling to Yamaska was $1.50 per ton of pig. The charcoal was made in ovens 50 feet long, 16 feet wide, and 12 feet high, and intended to hold 75 cords of wood. The wood was both hard and soft (about ⅓ of the former to ⅔ of the latter), consisting of maple, birch, hemlock, spruce, larch, pine, and balsam.

Charcoal.

Number of men and horses employed.

A cord of wood, provided it was dry, gave from 50 to 60 bushels of charcoal weighing from 12 to 13 lbs. to the bushel. This would be equal to from 60.1 to 72.1 per cent. of the volume of the wood employed. According to Mr. Richer, the late manager of the furnace, to whom I am indebted for most of these details, the soft wood looses less in volume by charring than the hard wood. From about the 20th of May till the 1st of December, 25 men were employed in collecting ore; and from December to March, 30 carters with 60 horses in drawing it to the furnace. From the first of December to the first of April, 50 wood-cutters were employed in cutting wood, and 6 carters with 6 horses in drawing it to the charring ovens. Besides the manager, 7 men were employed in connection with the furnace and 7 at the kilns.

Manufacture of iron from titanic iron ore

Bay St. Paul.—Two blast furnaces were completed in November last by the "Canadian Titanic Iron Company" near Bay St. Paul, for the purpose of smelting the titanic iron ore of the region. They have been in blast during the winter, but, although good pig iron has been made, its production, as might have been expected, has not been attended with profit, on account of the large amount of charcoal consumed.

The dimensions of the furnaces are,

Height	40 feet.
Diameter at hearth	4 "
" " boshes	14 "
" " throat	8 "

Each furnace has three twyers and is closed at the throat by the ordinary *cup and cone*, in order to obtain the waste gases for heating the blast. For the production of the latter there are two blowing engines of 30 horse-power each. The fuel has been exclusively charcoal, made partly from white birch (less than half), partly from different kinds of soft wood, and weighing about 16 lbs. to the bushel of 2,675 cubic inches. The wood is charred in kilns, and a cord (128 cub. feet) produces on an average about 50 of the above bushels of charcoal. From 190--237 bushels of charcoal were, under the most favourable circumstances, required to make a ton of pig iron, and towards the spring, when the ore and limestone had become wet or covered with ice, as much as 400 bushels were sometimes necessary. Limestone was employed as a flux, and was obtained in the vicinity. The pig iron produced was entirely white. Generally speaking only from 4 to 5 tons were made in 24 hours by one furnace, but occasionally as much as 6 tons.*

Amount of charcoal consumed.

The following are two analyses of the pig iron by Riley :—

Analyses of pig iron.

	I	II
Carbon	3.966	3.976
Silicium	0.086	0.081
Sulphur	0.030	0.048
Phosphorus	0.253	0.258
Iron	95 245	95.440
Chromium	0·689	0.436
Manganese	minute traces	minute traces
Titanium	?	?
	100.269	100.239

The considerable proportion of chromium is a point of interest.

With regard to the smelting of titanic iron ores, the question is not whether they can be smelted, for of this there is no doubt, but whether, with the large amount of fuel required, they can be smelted profitably. It is said that in Sweden, where titaniferous ores are smelted, as much as 45 cwt. of charcoal are in some cases required to produce a ton of pig iron, this being considerably more than double the amount necessary in smelting the magnetic ores. It is needless to say that with such a consumption of fuel iron could not be profitably made in this country. Though so much has been said by Mushet and others about the beneficial effect of titanium upon iron, the question appears to be one requiring further investigation.

Charcoal required in Sweden.

* For these facts I am indebted to Mr. McColquohar, the manager at Bay St. Paul

As these points are especially important in Canada on account of the numerous and extensive deposits of titanic ore which occur, I take the liberty of quoting from a letter bearing upon them which was kindly sent me, at my request, in February last by Dr. Percy, the highest authority on metallurgical subjects. Dr. Percy says, "Experience here (in England) has shewn that no advantage is derived from the presence of titanium in iron ores. Good iron may be made from such ores, not on account, but in spite, of the presence of titanium. The titanium is worthless stuff and causes increase of fuel, because it must be made to pass into the slag; and *this means loss of heat*."

Remarks by Dr. Percy.

Mixing of titanic with other ores.

If titanic iron ore is to be utilized by the ordinary processes of smelting it must be by mixing it with other ores, so as sufficiently to reduce the proportion of titanic acid and the consumption of fuel. So long, however, as other ores can be obtained in abundance the demand for the highly titaniferous ores cannot be great. In some cases the addition of titaniferous ore to the charge is said to prevent the cutting of the furnace.

Hull.—Details concerning the Hull furnace were given by Dr. Hunt in the Report of Progress for 1866-69, and since 1868 the furnace has not been in blast. Though still standing, it would require a very considerable expenditure to put it into proper condition for smelting, as it was much injured by the forest fires which devastated the surrounding country several years ago. The dimensions as given by Dr. Hunt are, height 38 feet, boshes 10 feet 6 inches, and throat 4 feet 5 inches. At the time of Dr. Hunt's visit in August, 1868, no less than 170 bushels of hard-wood charcoal, weighing from 22 to 23 pounds to the bushel, were being used in making a ton of grey pig iron.

Dimensions of Hull furnace.

PROVINCE OF NEW BRUNSWICK.

History of Woodstock furnace.

Woodstock.—As early as 1848 a blast furnace was erected at Woodstock to smelt the hematites of Jacksontown. It was kept in blast, at intervals, until 1862, when it passed into the hands of William E. Smith, Esq., of Sheffield, England. In 1863 it was again blown in and kept in blast, at intervals, for several years. The whole time during which the furnace was actually in blast was only about eight years. Mr. Smith also erected a small cupola furnace in 1866, which, however, was only used for about a year. The blast furnace, which is still standing and said to be in good condition, is (according to measurements published by Professor Bailey in 1864) 39 feet high and 9¾ feet in diameter at the boshes. When it was running a hot blast was most of the time employed, and was produced by steam power, the waste gas from the furnace being utilized for generating the steam as well as for heating the blast. A red sandstone from Gulquac on the Tobique River, Victoria county, is said to have proved an excellent

Dimensions.

material for hearths. Charcoal, made chiefly from maple, birch, and beech woods, was employed altogether as fuel, the charring being performed in brick ovens. Limestone for a flux was obtained from Beccaguimic, seven miles from the furnace. The following are the constituents of the charge, as given by Professor Baily in 1864:

Charge

Ore	1350 lbs.
Limestone	70 "
Charcoal	20 bu.

The burden must subsequently have been reduced, as Professor Hind, writing in 1865, states that the charge then consisted of,

Ore	1180 lbs.
Limestone	59 "
Charcoal	20 bu.

According to the latter authority, 3.33 tons of ore and 126 bushels of charcoal were required to make a ton of pig iron. The charcoal at that time cost seven cents a bushel; allowing that it weighed 20 lbs to the bushel, the quantity by weight required to make a ton of iron was 22½ cwt. The daily production of pig iron from one furnace was about 6¼ tons. Much has been said about its fine quality and its suitability for the manufacture of armour and boiler plate, as well as for steel. The analyses of the ores which have been published, however, indicate such a large proportion of phosphoric acid, that the fine quality of the steel, at least, seems doubtful.

Quality of iron produced.

The above details are mostly from Professor Bailey's *Report on the Mines and Minerals of New Brunswick*, published in 1864, and Professor Hind's *Preliminary Report on the Geology of New Brunswick*, published in 1865

Province of Nova Scotia.

Albion Mines.—A furnace was many years ago built near the Albion mines in Pictou County, but was in blast only a short time when it was abandoned. Some of the ore smelted was from a fossiliferous portion of the great Lower Helderberg bed of hematite described on page 28, and is said to have produced iron which, on account of the phosphorus, no doubt, was "exceedingly hard." Some of this iron has since been manufactured into stamp-heads which were found to wear longer than those made from any other kind of iron.

Iron used for stamp-heads.

Londonderry.—The only blast furnace in Nova Scotia which has produced much iron is the one at Londonderry, which was completed in 1853, and has, at short intervals, been in blast ever since. During the three years previous to 1853 a small quantity of iron had been made in a Catalan forge, which was abandoned on the completion of the blast

Catalan forge at Londonderry

Description of Londonderry furnace.

furnace. The latter is 35 feet high, 9 feet in diameter at the boshes, and 4½ feet at the throat. The stack is built of fire-brick and cased with iron. The hearth is lined with a mixture of fire-clay and pounded quartz (1 part of the former to 2 of the latter), the mixture being pounded in behind an iron cylinder which is afterwards removed. This lining is found to be very durable. The blast is cold and produced by water-power, the wheel, which is an overshot one, being 20 feet in diameter and 5 feet wide. At the time of my visit in September, 1873, the charge consisted of,

Charge.

Ore (Limonite)	550 lbs.
Flux (Ankerite)	90 "
Charcoal	19 bu.

Production of iron.

The number of charges in 24 hours was 59 or 60. For the 9 days previous to the 11th of September the production of pig-iron was 70.75 tons, or 7.86 tons a day, an amount slightly above the average. The following figures were kindly given me by Mr. Romans, manager of the works, and represent the amounts of ore, fuel, and flux employed in the month of August, 1873, and the corresponding production of pig iron:

Returns for August, 1873.

Ore (Limonite)	421 tons 6 cwt. 1 qr. (421.3125 tons).
Flux (Ankerite)	68 " 15 " 2 " 24 lbs. (68.775 tons).
Charcoal	32,471 bushels.
Pig iron produced	221 tons or 7.13 tons per day.

Yield of the ore.

The monthly production is often higher than this, but these figures were chosen as being a fair average. If the ankerite is not taken into consideration, the yield of the ore in the furnace, as calculated from the above figures, is 52.45 per cent. Allowing, however, that the ankerite gives about 10 per cent. of iron, the yield of the ore is reduced to 50.81 per cent., or, in round numbers, 2 tons of ore are required to make a ton of pig iron. The charcoal is made from maple, birch, and beech, and according to Mr. Romans the bushel weighs about 20 lbs. The amount required to make a ton of pig iron in August, 1873, was 146.93 bushels, or about 26¼ cwt. Occasionally, however, it has been as low as 135 bushels, and many years ago as much as 160 bushels are said to have been required. It is burned in heaps by the farmers in the vicinity, and costs, delivered at the furnace, 7½ cents a bushel.*

Charcoal.

On page 58 it was stated that at the St. Maurice iron works as much as 180 bushels of charcoal are required to make a ton of iron from the bog ores; but there the charcoal is of very inferior quality, weighing only 11 or 12 lbs. per bushel of 2,250 cubic inches; and if a comparison by

* The bushel I suppose to be the Imperial bushel of 2218.192 cubic inches, or the same as was in use, according to How, in 1861.

weight be made, it will be found that while over 26 cwt. are required at Londonderry only 18½ are used at St. Maurice.

Duration of blast. The Londonderry furnace is in blast only six or seven months at a time. It is run by night and day shifts, and tapped about once every six hours. *Furnace-men.* During the day six furnace-men are required, besides a blacksmith, during the night only four. They are paid by the ton of iron produced, getting from 20 to 25 cents.

Cost of iron. The cost of production of a ton of pig iron may be estimated as follows:

2 tons of ore @ $2.50	$5.00
⅓ ton of ankerite @ $1.10	.36
147 bushels of charcoal @ 7½ cents	11.02
Labour and manager's salary	2.80
General expenses	1.50
	$20.68

The $1.50 for general expenses is my own estimate, but is probably a fair one.

Forge. Close to the blast furnace there is a forge where a considerable quantity of wrought iron has been produced. The building is 180 feet long and 60 feet in width, and contains five puddling furnaces and one reheating furnace, a 25-cwt. steam hammer, rolls, and other appliances. *Casting-house and steel works.* The casting house and steel works are situated about a quarter of a mile from the furnace, and are large and commodious buildings. The casting house contains two furnaces with the necessary accessories for the manufacture of castings, which have been chiefly car wheels. The building containing the steel works is 250 feet long and 40 wide, and contains a smelting furnace, a converting furnace, three reheating furnaces, two steam hammers and other appliances.

Production of iron since 1853. Since the completion of the blast furnace in 1853 over 30,000 tons of pig iron have been produced, and, according to Professor How, the production of pig iron from 1862 to 1867 was as follows:*

	Pig iron.	Bar iron.
1862	1150 tons	945 tons.
1863	1251 "	911 "
1864	1663 "	1198 "
1865	1784 "	1633 "
1866	2124 "	1093 "
1867	2068 "	421 "

Quality of iron. The quality of the iron is known to be excellent, and Fairbairn says:† "Several specimens of iron from these mines have been submitted t direct experiment, and the results prove its high powers of resistance to

* Mineralogy of Nova Scotia, 1868, p. 89.

† Iron manufacture, 3d. Ed., p. 35.

strain, ductility, and adaptation to all those processes by which the finest descriptions of iron and steel are manufactured."

Analyses by Tookey.

The following analyses of Acadia pig-iron by Tookey were published by Dr. Percy in 1864 : *

Carbon	3.50	3.27
Silicon	0.84	0.67
Sulphur	0.02	0.01
Phosphorus	0.19	0.28
Manganese	0.44	0.37
Iron	94.85	95.70
	99.84	100.30

The manganese contained a sensible amount of cobalt.

Clementsport.—At Clementsport, in Annapolis county, a blast furnace was erected as early as 1831, to smelt the magnetic ores (Devonian) of the vicinity. For the past thirty years, however, it has only now and then been in blast, and but for a few months at a time. Part of the ore smelted recently is from the "Potter mine," about two and a half miles from Clementsport. Both the furnace and the mine are owned by Dr. E. C. Drew and O. Underwood, Esq., of Boston, but were leased to the "Annapolis Iron Company," Clementsport, in August, for $1.50 for every ton of pig iron produced. The furnace was blown in in December last, and kept in blast for two months, during which time about 200 tons of pig iron were made. The mine and furnace are under the management of Col. David Larned, to whom I am indebted for the following details:

Proprietors of mine and furnace.

Description of furnace, &c.

The furnace is built of stone, and is 35 feet high, 4 feet in diameter at the hearth, 9½ feet at the boshes, and 7 feet at the throat. There are three twyers, and the blast, which is hot and has an average pressure of from 1¾ to 2 lbs. to the square inch, is produced by water power, the wheel—a breast-wheel—being 30 feet in diameter. The blowing cylinders, three in number, are of cast iron, 4 feet in diameter and 5 feet stroke of piston. The blast is heated by burning the waste gases from the furnace in a hot blast oven containing 17 siphon pipes through which the air is made to pass. The oven is on a level with the top of the furnace, and is built of brick and bound with iron.

Ore, flux, and fuel.

The ore from the Potter mine is locally known as "grey magnetic." In the furnace it yields as high as 45 per cent. of pig iron. When used alone, it produces white iron of poor quality, but when mixed with an equal weight of Bloomfield bog ore, the quality is improved. The latter ore does not yield over 26 per cent, of metal. The limestone employed as flux is brought from St. John, New Brunswick. The fuel is entirely charcoal, and is made principally from white birch. About 130 bushels

* Percy's Metallurgy, p. 540.

(Winchester) are required to make a ton of grey pig iron from the mixture of equal weights of magnetic and bog ore. The charge consists of from 750 to 800 lbs. of ore, 120 lbs. of limestone, or sometimes less, and 16 bushels of charcoal. The number of charges in 24 hours, when the furnace is working well, varies from 40 to 52.

Charge.

The Potter mine, alluded to above, was first opened as early as 1824. It is simply an open cutting or trench on a bed of ore said to be about 30 inches thick. The trench is about a quarter of a mile long, and 16 feet wide, the greatest depth being 30 feet.

The Potter mine.

Nictaux.—Two furnaces were many years ago (one of them in 1856) built at Nictaux, 37 miles from Clementsport, to smelt the fossiliferous hematite of Nictaux River. They did not, however, remain long in blast, and the iron produced is said to have been of poor quality, no doubt on account of the phosphorus in the ores. According to Mr. Romans, of Londonderry, one of these furnaces was 35 feet high, 9 feet in diameter at the boshes, and $4\frac{1}{2}$ feet at the throat. The other was 38 feet high and 9 feet in diameter at the boshes. They are now in ruins, having been partly torn down by the people in the neighbourhood in order to obtain the bricks.

Dimensions of Nictaux furnaces.

Manufacture of Steel at Quebec.—In the month of June last, I had an opportunity of visiting the steel works erected at Quebec for the purpose of manufacturing steel directly from the purified iron sands of the gulf. Since the death of Mr. Labreche Viger the works have passed into the hands of a new company, the president of which is Mr. Chinic, hardware merchant, of Quebec. The enterprise, so far as I could learn, has not been successful, and at the time of my visit nothing whatever was being done.

The furnace is a well constructed Siemens regenerating furnace, with five gas producers, and except in the construction of the hearth, which is perfectly flat, and in one or two other minor details, resembles the one employed by the Messrs. Cooper & Hewitt at Trenton New Jersey, in the manufacture of steel according to the Siemens-Martin process.

In making steel, the sand, which had been purified by Dr. La Rue's magnetic machine, was mixed with tar and charcoal powder in a box containing revolving knives or beaters, and the mixture then pressed into square blocks by means of a powerful hydraulic press. The blocks were then piled upon the furnace hearth and melted down to steel, which was finally tapped off into ingot moulds containing about 200 lbs.

Process of making steel from iron sands.

The cause of failure I was not told, but difficulty was probably experienced in obtaining a regular and homogeneous product. In the event of

* Since writing the above I have seen Mr. Chinic, who states that further and rather more successful experiments have lately been made with the furnace, and ten or twelve tons of steel produced. A good deal of difficulty was experienced in pouring, and the ingots were frequently *honey-combed*, and after forging were liable to contain flaws. Not more than 500 lbs. of steel were produced at a melting, which required six hours.

this process being abandoned, the furnace could readily be adapted to the manufacture of steel according to the Siemens-Martin process.

Drawbacks.

GENERAL REMARKS.—From what has been said it is evident that exceedingly little has been, or is being, done in the way of iron smelting in Canada; nor is there any prospect of an immediate increase in this important industry, except in the Province of Nova Scotia. This is due to a variety of causes, and among them, in some instances, to scarcity of fuel, in others to difficulty and cost of transportation, or to cost of labour. Notwithstanding such drawbacks, however, there seems little doubt that, with proper management, iron might be profitably made in many localities.*

Shipment of ores.

The owners of iron mines, instead of smelting their ores on the spot, are more and more turning their attention to shipping them to the United States, as this has been found, in most instances, to yield a fair profit. During the past year they were worth from $6.00 to $9.00 a ton in Cleveland.† According to official returns published by the Customs Department at Ottawa, 15,232 tons of iron ore were shipped from the Dominion during the fiscal year ending June 30th, 1870. From that date to June 30th, 1871, the amount was 26,825 tons, or 11,593 tons more than in the preceding year. The next year there was a slight falling off, the amount shipped being 26,175 tons; but in the year ending June 30th, 1873, there was a large increase, no less than 47,200 tons having been shipped. In addition to this exportation of 47,200 tons, an amount which may be estimated at about 12,000 tons was raised, but not shipped, part of it being smelted in the country. The total production of iron ore in the year ending June 30th, 1873, was, therefore, in round numbers, about 60,000 tons,—a quantity exceedingly small, though far ahead of previous years. Nearly the whole of the ore shipped has been from four or five mines.

Blairton mine.

The production of the Blairton mine, Belmont, is now greater than that of any other in the country, and in the last fiscal year is said to have amounted to nearly 30,000 tons. In July last it was being shipped to Pittsburg at the rate of from 300 to 400 tons a day.

Yankee and Chaffey mines.

The annual production of the Yankee and Chaffey mines together, for several years, has been between 7,000 and 8,000 tons. Were the demand

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* It is possible that peat, or the charcoal made from it, might in some cases be advantageously employed in the manufacture of iron in Canada. Peat charcoal is largely employed in some parts of Europe, and, it is said, with satisfactory results. It is, however, generally very friable, and therefore unfit for distant transportation, or to resist the pressure in a blast furnace. It is also liable to contain a very large proportion of ashes, the whole amount in the peat being concentrated in the charcoal. Thus, if we suppose a peat to contain 10 per cent. of ashes and to yield 30 per cent. of charcoal or coke, the latter will contain no less than $33\frac{1}{3}$ per cent of ashes.

† The duty upon iron ores going into the United States is at present 20 per cent. *ad valorem*, and upon pig iron $6.30 (gold) per ton of 2,000 lbs.

for titaniferous ores greater, the production of these two mines could readily be increased.

Dalhousie mine.

From the Cowan, or Dalhousie mine, from 3,000 to 4,000 tons have been annually raised and shipped for several years. Owing, it is said, to the dullness of the market, work has recently been stopped at this mine, although the ore is one of the finest in the country.

Hull mines.

The production of the Hull mines for the year ending June, 1873, was about 15,000 tons, which has since been shipped. No more ore has been mined here since the above date, and it is stated that there is a prospect of the mines passing into the hands of an English company. According to a gentleman in Cleveland who is well acquainted with Canadian ores, that from Hull yields from 60 to 62 p. c. of iron in the furnace, and is valuable for mixing with Lake Superior ores.

Haycock mine.

Since the opening of the Haycock mine in the winter of 1872-73 about 5,000 tons of ore have been raised, but none shipped, the intention being to erect furnaces near the Gatineau River for smelting it. The point chosen for this purpose is 6¼ miles from the mines, with which it is connected by a well built 3-feet-gauge tramway. At the mines there is a 20-horse-power steam sawmill, a boarding house, manager's house, storehouse, and blacksmith's shop.

Bristol mine.

The Bristol mine (see pages 7 and 19) is owned by Messrs. Taylor and Burns of Pittsburg, U.S. It was first opened in January, 1873, and work continued with 8 or 9 men until September. The ore raised during that time amounts to about 4,000 tons, and still lies at the mine awaiting shipment. At the time of my visit in July, the largest opening which had been made was 35 feet long, 24 feet wide, and about 20 feet deep, and from it about 1,500 tons (estimated) of ore had been extracted.

Fournier mine.

At the Fournier mine in South Sherbrooke, several hundred tons of very fine ore were taken out during the winter of 1872-73, and work has since been continued, although the prospects did not appear promising in July last. The ore (magnetite) occurs in thin irregular veins or beds, and is associated chiefly with hornblende and white or green feldspar.

Mines in Bedford township

At the Howse, Chaffey (13 Island Lake), and Christie's Lake mines in Bedford, the Seymour ore bed in Madoc, and a number of other localities in Ontario, a small amount of work has been done during the past year, more especially for the purpose of determining the extent of the deposits of ore; and from lot three, range five, of Grenville, Quebec, several hundred tons of ore are said to have been extracted and shipped to Cleveland, Ohio, for trial.

Grenville.

Acadia mines.

In Nova Scotia, the Acadia mines have since 1839 produced between 60,000 and 70,000 tons of ore, which has been smelted at Londonderry. The mines and works have recently passed into the hands of a new company with a capital of £500,000 sterling, and operations will no doubt be carried on on a larger scale and more systematically than heretofore. The company is entitled the "Steel Company of Canada (Limited)," and the following are the names of the Directors.

C. W. Siemens, Esq., D.C.L., F.R.S., C.E., London *Chairman.* Charles Tennant, Esq., St. Rollox, Glasgow. Archibald S. Schaw, Esq., Glasgow. William Tennant, Esq., 9 Mincing Lane, London. Edward Budd, Esq., Copper Office, Bond Court, London. Graham Menzies, Esq., London. Archibald Orr Ewing, Esq., M.P. Glasgow. George Stephen, Esq., Montreal. Donald McInnes, Esq., Hamilton, Ontario.

According to the prospectus, the Company has acquired no less than "33,000 acres, or 51 square miles of freehold land, together with the mines thereunder, and the work and buildings thereon, and including a pre-emptive right at 40 cents an acre to about 15,000 acres of adjoining land, and a working license at a royalty of 10 cents per ton of coal over one square mile of area No. 42 in the Spring Hill Coal Field." The Company has also "acquired from Dr. Siemens, at a cost of £8,000, the right to use free of royalty, his patent processes for the production of iron and steel and their subsequent working into merchantable form."

Considering the extent of the ore deposits, the facility with which both charcoal and mineral coal may be obtained, the proximity of the Intercolonial Railway, and of a shipping port on the Bay of Fundy, there is every reason to believe that, with proper management, this enterprise will be attended with success.

Pictou County, N.S.

It is to be hoped also that something will soon be done towards developing the valuable deposits of iron ore in Pictou County. Here the ores are abundant and of varied character, they are near to the Pictou coal-field, whence coal suitable for the manufacture of coke could be obtained from a number of mines now in active operation. Limestone suitable for a flux occurs abundantly in the valley of the East River, the Provincial Railway passes through the coal-fields and within a few miles of the ore deposits, and the harbour of Pictou affords an excellent port of shipment during six months of the year.

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