PROVINCE OF QUEBEC, CANADA

Department of Mines and Fisheries

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# DEPOSIT
# OF
# TITANIC IRON ORE
# OR
# ILMENITE

by

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CHAPTER IV

## DEPOSIT OF TITANIC IRON ORE OR ILMENITE (1)

St Urbain deposits (near la Baie St-Paul)

Deposits of Morin Anorthosite massif { Ivry / Vicinity of St. Jérôme / Randon township.

All these deposits possess similar characteristics and constitute a much more definite type than the titaniferous magnetite deposits. They occur in the form of irregular bodies with well defined walls, in normal anorthosite bearing no trace of dynamic action or of contact effects. These bodies are of all sizes. At St-Urbain, they are extensive. In other places, in the contrary, the bodies are very small and are reduced, as minimum, to pockets or spots a few inches in diameter. These pockets of ilmenite then appear on eroded surfaces of anorthosite as spots or bleds of pitch.

### ST-URBAIN DEPOSITS (near Baie St-Paul)

The deposits are situated in St-Jérôme and St-Urbain ranges, St-Urbain parish, Charlevoix county. The village of Saint-Urbain is connected by a road with the small harbour of Baie St-Paul on the St-Lawrence river, nine miles distant.

The country is cut by a wide sandy valley in the bottom of which the du Gouffre river flows. Below the village of St-Urbain the sides of the valley which is at least two and a half miles wide, rise in fairly gentle slopes to about midway to the summit where the sands end, and anorthosite appears.

These anorthosites lead, on the right side of the valley, to a wide undulating plateau,, the altitude of which above the sea varies between 1100 and 1200 feet. On this plateau, or more properly speaking, on its southeast border, lie the great deposits of titanic iron which constitute the subject of this study. The central part of this plateau, and the low parts generally, are cov-

(1) Translated from the French.

ered with clay; in some points borings showed a depth of 12 feet. The clay covering interferes with prospecting and no doubt conceals iron deposits. Nevertheless, the nature of the underlying rocks can be ascertained from various outcroppings.

This plateau rises imperceptibly towards the west and ends at the foot of rather large mountains, the altitude of which seems to exceed 3,000 feet. Thus, by means of the barometer, we found the height of one of these mountains which we ascended, to be 2,300 feet above Baie St. Paul, and, in front of us, the mountain known in this part of the country as the Lac de l'Islet mountain, rose more than 1,000 feet higher.

## GEOLOGY.

The geology of the region under consideration may be divided into three parts:

The anorthosites and their granular and gneissic varieties;

The Ordovician sediments (Trenton limestone);

The glacial and post-glacial deposits.

To explain the nature of these deposits, it will be sufficient to briefly describe the anorthosites and to say a few words about the glacial and post-glacial deposits.

In fact, the Trenton limestones are of but secondary interest to us; they are found in outcrops in the shape of isolated outliers in various places along the valley of the Rivière du Gouffre from its mouth to St. Urbain village.

The anorthosites in the St. Urbain plateau may be classified into two chief varieties:

The compact anorthosites;

The granular and gneissic anorthosites.

## COMPACT ANORTHOSITES.

These are rocks generally of a light color, with medium grain and of fairly high crushing strength. In hand specimen they seem to consist almost entirely of feldspar, sometimes light grey, sometimes white, at times pinkish and at others red or blue. Dark coloured constituents are rare; some specimens contain none. Thus, behind the boiler-house of the former Canadian

Titanic Iron Company, is a grey, almost white, anorthosite, which might very easily be taken for marble by a casual observer.

Most of these light-coloured anorthosites change to white on the surface. Some or them would supply very fine material for building or decorative purposes. I would especially mention the anorthosite on the east side of the St. Urbain plateau, on lot 482 of St. Lazare range, of the parish of Baie St. Paul. There is at that place a high, perpendicular rocky cliff, and the pieces that have fallen from it form a talus at the base. The colours of the anorthosite are very pretty; sometimes pink feldspar predominates in a light yellow ground; sometimes the same feldspars are mixed with blueish grey ones. It would certainly take a very fine polish and its working would be facilitated by the precipitous side of the mountain. An aerial tramway three-quarters of a mile long could take the material down to the level of the Rivière du Gouffre, where a branch railway of about 6 miles would convey it to Baie St. Paul. The most frequent among the rare dark constituents visible to the naked eye are ilmenite and black mica.

As a rule the grains of feldspar are of fairly even size, but large individual grains of grey feldspar are rather frequently met with amidst grains of yellow or reddish feldspars. Such is the case especially as regards the anorthosites north of the mill of the Discharge, on the road leading to the Seminary mine.

The feldspars are not generally oriented in any special direction; nevertheless, on lot 485 and lot 480 of St. Lazare, a general elongation of individuals is very clearly seen. This direction is emphasized by some threads of black constituents, titanic iron or black mica. These anorthosites are but a short distance from the gneissic anorthosite we speak of further on; probably the strain which gave rise to the formation of the gneissic structure in the neighboring rocks made itself felt also, but to a lesser degree, in these compact anorthosites.

As seen through the microscope, these true anorthosites consist of lime-soda feldspars, sometimes perfectly sound, but frequently cracked. The fissures are then filled with greenish or yellowish elements of alteration in the nature of bastite.

Near certain deposits of titanic iron the cracks in the feldspars

are filled with a mosaic of very small fragments of broken feldspar indicating a beginning of granulation of the constituents.

As accessory constituents one finds titanic iron, white mica, black mica (especially in the vicinity of deposits of titanic iron), but all in very small quantities.

The feldspars very seldom show the small black thread-like inclusions so frequent in the anorthosites.

### GRANULAR OR GNEISSIC ANORTHOSITES.

I have included under this head a series of rocks with rather variable characteristics, but the mass whereof is made up mostly of lime-soda feldspars. They seem to be derived from the true anorthosites by dynamic metamorphism. These rocks are generally yellowish, sometimes grey in colour; they are friable and break along irregular and granulous surfaces. To the naked eye and even to the magnifying glass, the feldspars show but imperfect cleavages; the surfaces of the breaks are often curved.

Some varieties contain dark elements which are most frequently in line. The rock then assumes a gneissic aspect, which is especially apparent on the large bare outcrops which have been weathered.

The most abundant black constituent seems to be a titaniferous magnetite. To the presence of this magnetite must be attributed, beyond a doubt, the local variations shown by the dip needle. It rather frequently happens in fact that the needle dips to fairly wide angles, attaining as much as 25 or 30 degrees without any ore outcrop being visible.

If we take into account the fact that the masses of titaniferous iron now known, exert but a comparatively weak influence on the needle in proportion to their dimensions, it would be unreasonable to conclude that the magnetic variations in the neighbourhood of the gneissic anorthosites are due to the existence of deep masses of slightly magnetic titanic iron, rather than to the direct influence of the small quantities of magnetite disseminated through the rock.

In fact such grains of titaniferous magnetite disseminated through the gneissic anorthosites exercise an influence on the

compass wholly comparable to that of masses of titanic iron. Each of these grains is in effect much more magnetic than a grain of titanic iron. This can easily be ascertained in the field. By crushing a gneissic anorthosite, the dark constitutents are attracted in abundance by the magnet. On the contrary, by crushing a compact anorthosite adjoining a mass of titanic iron, which itself contains small grains of iron ore, only a very slight portion of the ferruginous elements are picked up by the magnet. These results are confirmed by chemical analysis. After crushing three samples: one from the solid mass of the Lac des Islets mountain, another from the mountain dominating the Renny river in the direction of the Bouchard mill (gneissic anorthosite), and the third from lot 621 of the St. Jérôme range (anorthosite in contact with a mass of titanic iron), I had an analysis made of the iron grains contained in the rock and hand-picked. I obtained the following results:

| | Iron | Titanium | Prop. Fe Ti |
|---|---|---|---|
| Iron ore from the gneissic anorthosite of Lac des Islets mountain..... | 64.06% | 4.61% | 13.93 |
| Iron ore from the gneissic anorthosite at Bouchard's mill | 57.16% | 4.03% | 14.27 |
| Iron ore from the anorthosite on lot 622..... | 32.71% | 20.74% | 1.05 |

It would seem, therefore, that the iron ore accompanying the granular and gneissic anorthosites is titaniferous magnetite, while the compact anorthosites contain practically ilmenite only.

It should be further observed that hitherto all the deposits of titanic iron of any importance are in compact anorthosite. In the immediate vicinity of the mass, the anorthosite often contains grains of titanic iron, but, a few feet from the contact, the grains of titanic iron visible to the naked eye disappear almost completely and ilmenite is only an accessory element in the rock.

On the contrary, the granular and gneissic anorthosites which are rather uniformly charged with ferruginous elements, over a small area, contain no mass of ore of any importance in the region under consideration.

A particularly interesting region, as regards the study of gneissic anorthosites with ferruginous elements, is that of the Lac à l'Islet mountain, about two miles to the northwest of the

PLATE XI.

FERRUGINOUS GNEISSIC ANORTHOSITE.

St. Thomas range of St. Urbain parish in the unsurveyed lands of the seigniory of Beaupré. There the ferruginous elements show very clearly on the altered surfaces and form a more or less continuous network of black threads surrounding the grains of feldspar (See photograph No. XI). Throughout the whole,

these threads extend in a direction from north to south, which is remarkably constant over the whole length (about 1½ mile), where I was able to observe it.

Without doubt it is to the disaggregation of these gneissic anorthosites that the iron sands are due, which are met with on the eastern slope of the St. Urbain plateau. The process of the mechanical concentration of these sands into magnetite can, moreover, be actually observed. In all the ruts in the roads of the St. Urbain plateau, especially after heavy rains, black streaks of fine magnetic sand may be seen. The same occurs in the hollows and furrows of the rocks of the intrusion at Lac de l'Islet. And even when no black train is seen, the mere running of the magnet through the sands filling the cavities, suffices to bring out magnetite.

The accessory constituents visible to the naked eye in these granular and gneissic anorthosites are hornblende, hypersthene and mica.

Under the microscope all these rocks reveal a common character, showing the effects of the pressure to which they have been subjected. The feldspars as a rule have no crystallographic outline; individuals penetrate one another by curved and irregular lines. Frequently the polysynthetic twinning is effaced as it were; at other times the bands are curved parallelly. The feldspar individuals are fissured and the cracks are filled with a green or yellow substance of the nature of serpentine (bastite).

Some of these rocks are particularly friable; they are those of the most pronounced yellow colour. This friability, and the colour also, are due to a more or less continuous pellicular network of bastite surrounding each grain of feldspar.

The ferro-magnesian constituents are particularly more abundant than in the compact anorthosites. The most abundant are hyperthene, frequently interlocked with titano-magnetite; hornblende; a little olivine generally altered to hydrated ferruginous products. Apatite is sometimes very abundant in broad oval grains; generally a little quartz and zircon are present.

Some rocks contain enough hyperstene to allow of their grading into real anorthosite-gabbros.

Gneissic anorthosites containing large feldspar crystals are not

infrequently met with, especially in the mass of Lac de l'Islet mountain. These crystals have resisted compression and flattening, while, on the contrary, the small crystals around them have been crushed. This structure recalls that of ellipsoidal gneisses, the "augen-gneisses" of the German geologists. These two varieties of anorthosite—compact and granular or gneissic—owe their origin beyond a doubt to the consolidation of one and the same magma. They pass imperceptibly from one to another, and the granular and gneissic varieties must be considered as being merely anorthosites which, towards the end of their consolidation, have been flattened and crushed. The gneissic structure, the friability, the granular aspect of these rocks, are but the evidence of dynamo-metamorphic action.

### POST-GLACIAL DEPOSITS.

These appear under various aspects :

1. The silicious sands at the bottom of the valley of the Gouffre ;

2. The feldspathic and ferruginous sands on the sides of the valley ;

3. The clays of the St. Urbain plateau.

The silicious sands covering the bottom of the valley of the Gouffre form a sort of undulating and hummocky mantle of characteristic aspect. The action of the raging waters has ploughed furrows at times very deep, but without any definite trend in these sands. Several furrows, intersecting one another, bound a sort of sandy plateau which, owing to its permeability and lack of consistency, falls away at its corners and gives rise to a kind of dunes.

These fine sands are due to local changes in the estuary deposits of the Champlain epoch.

The sides of the valley, to a height half way between the bottom and the top, are sometimes covered with coarser, yellowish or reddish sands, consisting almost solely of feldspars and sometimes greatly charged with grains of magnetic iron. These deposits are especially important at the foot of the cliffs of granular anorthosite and their origin must be sought for in the erosion of

these friable rocks at a comparatively recent date, perhaps through wave action at a period when the waters of the sea covered the whole valley of the Gouffre.

The St. Urbain plateau is almost entirely covered by a layer of clay, changing in depth into a kind of shale. The thickness varies between a fraction of a foot and twelve feet.

## DEPOSITS OF TITANIC IRON.

The deposits of titanic iron formerly or at present worked, are all on the eastern side of the St. Urbain plateau in the compact anorthosites. As a rule they are in masses of irregular shape and without any definite direction. In some small deposits the titanic iron stretches out in flattened lenses which look like veins for a short distance, but which thin out and disappear. In the large deposits the length and width of the masses are more even.

In the following description, the deposits are given in the order in which they are met with, going from south to north on the road of the St. Jérôme range in the parish of St. Urbain.

*Glen Prospects—*

At the time of my visit, a small party of men were trenching under the direction of Mr. Glen, of Montreal, on lot 31 of the St. Urbain range of St. Urbain parish, about 2,000 feet to the east of the sketch map. The work followed the bed of a stream and consisted chiefly of trenches in the clay. Two trenches intersecting at right angles had uncovered a fine mass of brilliant and compact titanic iron. This mass showed a width of 35 feet from north to south and 30 feet from east to west. In the north and east it abutted on anorthosite; to the south and west it disappeared under sand and clay.

A hole sunk 70 feet to the west of these trenches struck anorthosite. The prospects were abandoned probably on account of the great depth of sand and clay covering the rock and ore. At some points the trenches went down eight feet before reaching the rock. Working an ore which would sell at a rather low price would have been but little remunerative under such conditions, especially if these conditions of the deposit be compared with

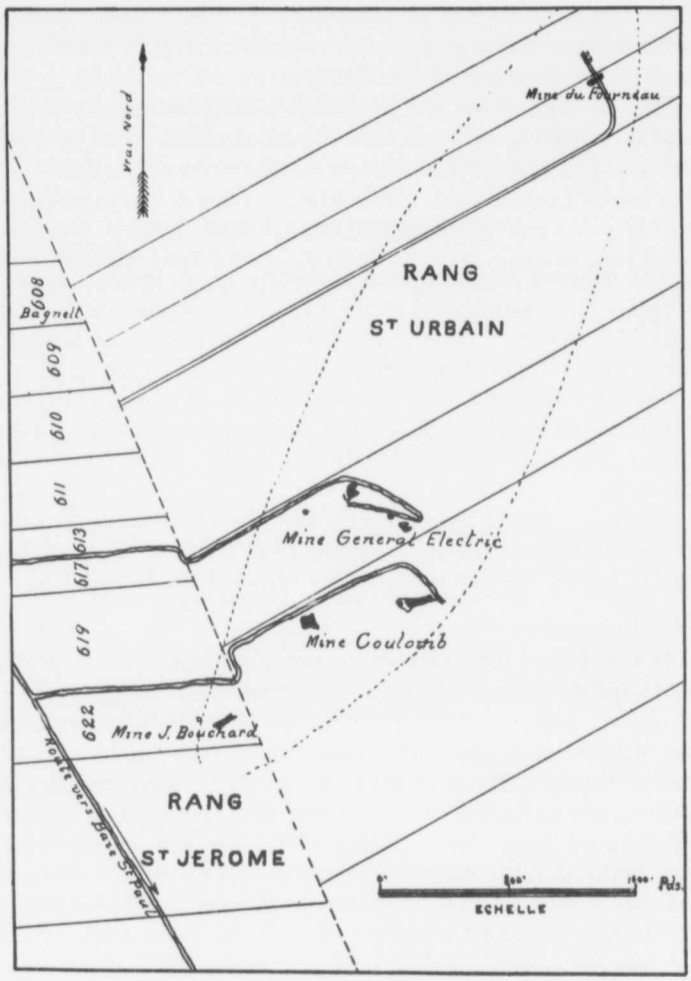


Fig. 1.—Map of St. Urbain deposits, showing their general direction northeast-southwest.

those of the Coulomb or General Electric mines, where the depth of the overlying soil does not exceed four feet and is frequently only half a foot or one foot.

An analysis of this ore was made at the Provincial Laboratory (Polytechnic School) Montreal, with the following results:

| | |
|---|---|
| Si $O_2$ | 1.68 |
| Fe O | 55.36 |
| Ti $O_2$ | 38.29 |
| S. | 0.041 |
| Ph. | traces |
| Corresponding to metallic iron | 43.06 |
| " titanium | 23.00 |

*Joseph Bouchard's Mine—*

This mine is on lot 622 of the St. Jérôme range of St. Urbain parish, east of the road of the St. Jérôme range. The first work was done in the spring of 1910 and was begun on a small vein a few inches thick. The vein widened in depth and during the year about 800 long tons of ore were shipped to the Titanium Alloy Co. of Niagara Falls.

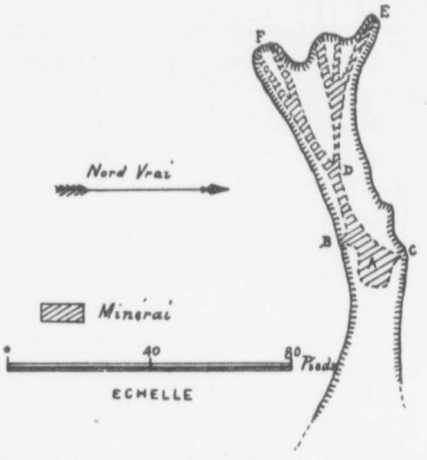


Fig. 2.—Joseph Bouchard's workings, St. Urbain.

The work was abandoned at the time of my visit; the mineralized veins had become very irregular; they dipped in depth and could no longer be conveniently worked open cast; it would

have been necessary to install a hoisting plant. The opening of other mines in the vicinity which were more extensive and more easily worked caused the abandonment of this work. It consisted in a cut 15 feet wide on an average and 100 feet long, excavated to a depth of 15 feet in its deepest part.

The annexed sketch clearly shows the mode of formation of the deposit of titanic iron. There are neither veins nor layers, but segregations essentially irregular, in the midst of compact and sound rock. A central core A. of titanic iron about 8 feet in diameter shoots out tongues in two directions: one in B. and C., the other in D. At this point the deposit forks: one branch towards E. and the other towards F. Thus the ore appears in the bottom of the open workings in a series of radiating veins, but in reality very irregular in occurrence.

The rock is an anorthosite of medium grain, generally light gray in color, containing comparatively little titanic iron in isolated grains. At some points on the weathered surface these grains seem to extend in the same direction and to form a sort of broad stippling in parallel lines.

Near the core A. of the ore, the anorthosite is charged with black mica and assumes a slightly gneissic structure. A similar micaceous anorthosite rock is found in abundance in the Coulomb mine.

The ore is compact and very sound. An analysis with a view to the sale of this ore for titanium, gave 36.64% of titanic acid, or 20% of metallic titanium.

The quantity of ore in sight is not considerable and the dip-needle is but slightly affected in its vicinity.

*Coulomb Mine—*

This mine is at the eastern extremity of the lot marked 319 on the cadastral plan of the St. Urbain range of St. Urbain parish. As a matter of fact, lots 315, 318, 319 and 320 are now in the hands of the same owner, and these lots together constitute what is known as the "Coulomb property". At the time of my visit, it was leased from the Duval estate, which holds the mining rights on a large number of lots in the seigniory, by a local contractor, Mr. Coulomb, who began work in August, 1910.

The work consisted in two open cuts distant about 500 feet from one another and which we will designate as "the western workings" and "eastern workings".

*Western Workings—*

These are situated about 500 feet to the east of the line between the St. Urbain and St. Jérôme ranges of St. Urbain parish. The clay, which covers the lot uniformly to a depth

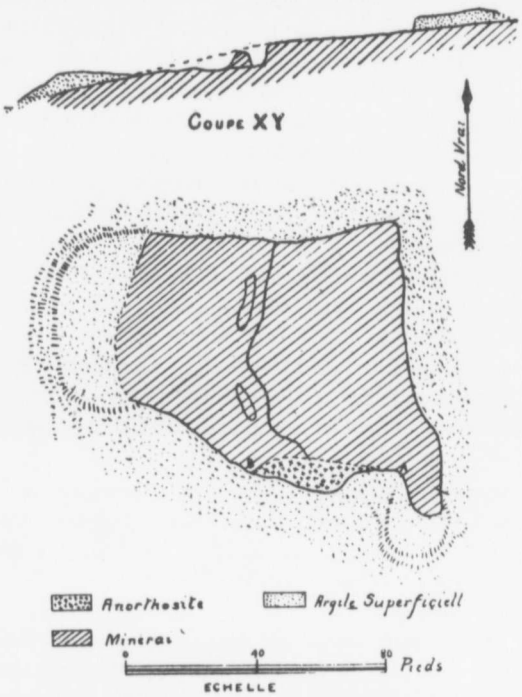


Fig. 3.—Coulomb's workings.—Western open cut

varying between one foot and five feet on an average, has been removed over an area of about 90 by 75 feet. By this means an enormous mass of compact titanic iron has been uncovered, the surface of which shows no barren rock. Towards the south, at A. B., this mineralized mass abuts against an anorthosite, in

every respect similar to the anorthosite in the open cut workings of Joseph Bouchard. The rock is compact and sound without any traces of dislocation or enrichment of dark constituents.

The ore is black with a rather greasy lustre. It is rather friable and breaks into a multitude of fragments with small facets pointing in every direction. This friability is chiefly noticeable in the surface samples. It does not seem to be due to the existence of cleavage planes in the ilmenite, but rather to that of surfaces of easy fracture which show themselves especially when the ore has been subjected to the action of secondary alteration. It would seem that the same thing happens in the case of these compact masses of titanic iron as happens for instance in the case of basalts, in which the jointage planes are developed subsequently to cooling. It would then seem that there are in such titanic iron, internal tensions, due either to phenomena of cooling or to phenomena of secondary alterations, which manifested themselves by abrupt and irregular fractures. These phenomena are chiefly apparent in the ore of the mine called the "Seminary Mine," which we will deal with later on. The ore is sometimes very pure, containing but a few yellow grains of sulphides; at other times the pyrite is fairly abundant and shows in thin sheets parallel to one another. Other samples show white and friable spots; these are imbedded feldspars which weathering has altered.

The portion which has not been determined by analysis, comprises magnesia, lime and alkalis derived from feldspars and ferro-magnesian elements imbedded in the mass of titanic iron.

*Eastern Workings—*

These are situated about 500 feet to the east of the foregoing and consist in an open cut about 160 feet long and averaging 30 feet wide at the bottom. The face of the working widens and attains a breadth of 50 feet with a height of 20 feet. As the ground slopes and the bottom of the trench is level, the height of the working face increases as the work proceeds. Around this open cut, especially to the west, the clay has been removed and the rock uncovered. The annexed sketch shows how the ore and the anorthosite outcropped at the time of my visit. The

sections XX, YY, ZZ, convey an idea of the shape of the mineralized mass.

The entrance of the cut probably corresponds to the edge of a mass which widens as it proceeds towards the west. The northern wall or side of this mass is fairly easy to follow; it dips about 80 degrees to the south and its strike is perceptibly to the west.

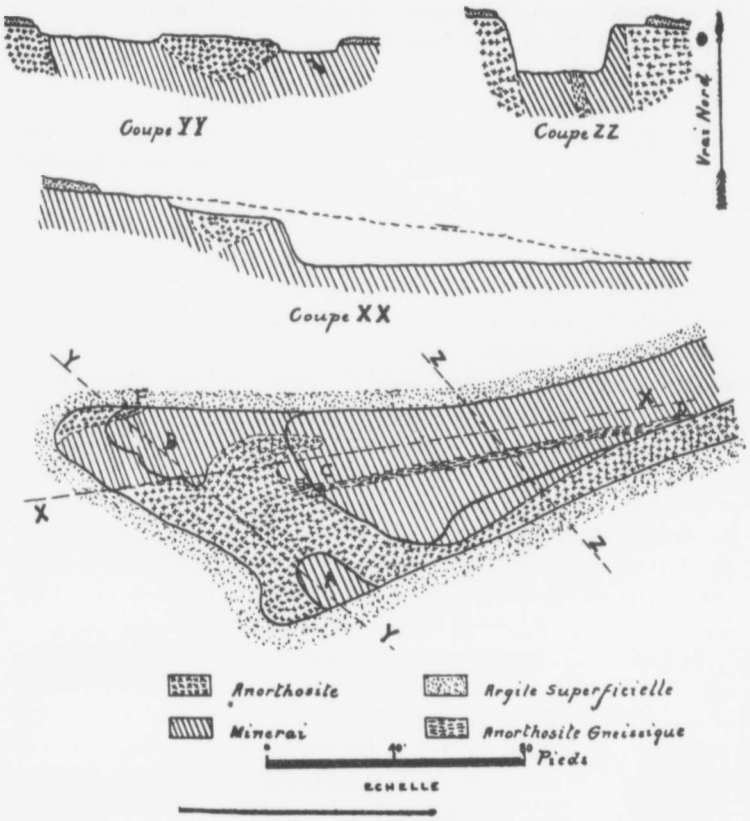


Fig. 4.—Coulomb Mine.—Eastern workings.

The southern wall is more uncertain; it shows at the entrance of the open working, but disappears under the clay towards the west.

Two cuts some 20 feet wide have been made at A. and B., whence fine ore has been extracted. The section YY shows how this ore is covered by a layer of anorthosite.

The anorthosite appears in the shape of a medium-grained rock, grey or whitish grey in color. Under the microscope it seems to be entirely composed of plagioclase feldspars in which bastite crystals or filaments have developed. These crystals are often accompanied by patches of hematite. Grains of titanic iron are very rare. The feldspars are split and contain the usual inclusions.

In the very mass of titanic iron, lenses or veins of a rock appear which has black and white grains, is of gneissic structure and is generally very friable. The white grains are a feldspar with an appearance of porcelain; the black grains are titanic iron or black mica. A vein about two feet wide is visible in the trench and runs throughout its length. (Vein C. D.)

In the anorthosite, black mica is found at some points in contact with the titanic iron. Thus, at E. and F., the anorthosite, otherwise very compact and very hard, shows flakes of black mica, lying parallel to the plane of contact with the titanic iron. This mica disappears very rapidly away from the contact with the titanic iron and, at a distance of a foot, the anorthosite resumes its normal composition.

Borings have been made at various points between the western and eastern workings. Titanic iron has been found under the clay at many spots and it is probable that the two masses of titanic iron of the two workings form part of a single mass which would thus extend over a length of 600 feet.

In both workings the mining is carried on by open cuts. The ore, which is rather friable, is blasted out with small dynamite charges of 40%; it is broken with a sledge and piled behind the working. It is then hauled to the wharf in the village of Baie St. Paul. All the work is done by hand without any hoisting apparatus, so that the cost of mining could be considerably reduced by using derricks, tramways, booms, etc. No sorting is done in the western open workings; in the eastern all that is done is to put to one side the blocks from the feldspathic veins.

The sampling of the ore piled in heaps was done hastily.

From every heap a sample of about 40 pounds was taken for testing; then it was crushed on the spot and reduced by quartering to about two pounds. The analysis made in the Laboratory of the Department (Polytechnic School, Montreal) gave the following results:

| | I. | II. | III. |
|---|---|---|---|
| S. $O_2$ | 2.64 | 3.12 | 2.68 |
| Fe O | 51.54 | 55.14 | 52.98 |
| Ti $O_2$ | 41.00 | 25.46 | 38.40 |
| Ph. | 0.040 | 0.044 | 0.041 |
| S. | 0.041 | 0.040 | 0.040 |
| Not ascertained | 4.729 | 6.196 | 5.859 |
| Total | 100.00 | 100.00 | 100.00 |
| Metallic Iron | 40.09 | 42.89 | 41.21 |
| Titanium | 24.62 | 21.30 | 23.06 |

Column I. represents the ore from the Western workings; Column II. the ore extracted from the small open workings A. and B. (Eastern workings); Column III. the ore taken from the open cut (Eastern workings).

At the time of my visit, 1500 tons had already been taken out and shipped to the Titanium Alloy Co. of Niagara Falls.

*General Electric Company's Mine—*

This mine is at the eastern extremity of the lot, three arpents wide, corresponding to the lots marked 321 and 325 of the St. Urbain range of St. Urbain parish, on the cadastral plan. At the time of my visit, the mining rights had been leased by the owners, the Duval estate, to the General Electric Company of Schenectady, who had begun somewhat active mining oper-

ations in the sumer of 1910. In 1911 these consisted in two open cuts about 150 feet from one another.

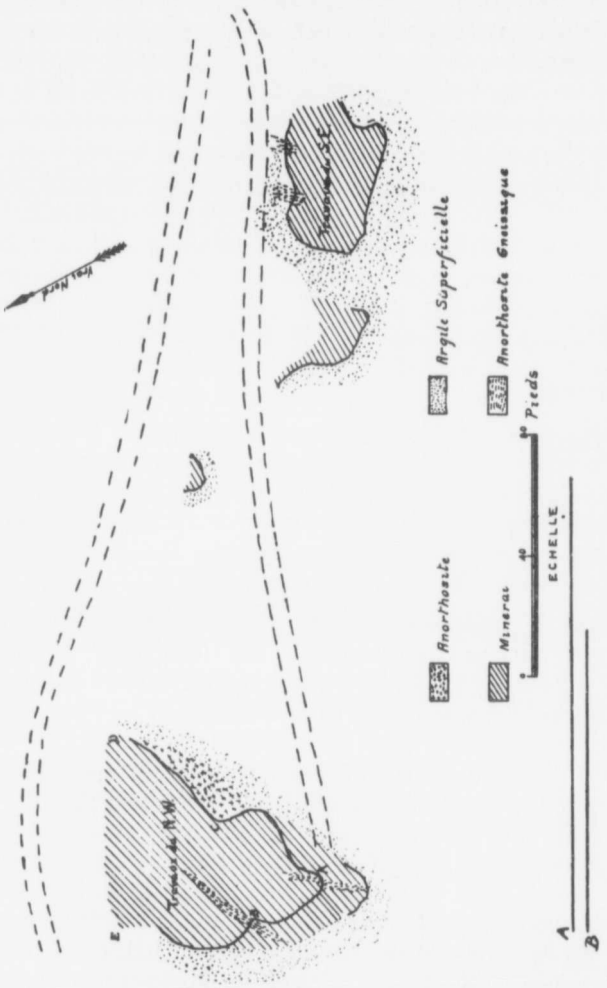


Fig. 5.—General Electric Mine, St. Urbain.

In the northwestern open working the clay had been removed The rock consisted of massive titanic iron, except at the points over a triangular area of three equal sides of about 90 feet each.

A., B. and C. The ore, less friable than that of the Coulomb mine, was also much less charged with sulphides and feldspars. From D. to E., a distance of 85 feet, the titanic iron showed in a single mass without any barren inclusions.

In A. and B. appear two lenses, with a thickness of 1½ and 2½ inches respectively, of a rock of gneissic structure, white and black. The white constituents are a brittle feldspar; the black elements are either titanic iron or black mica.

In C. the mass of titanic iron stops against an anorthosite. In fact, judging from the appearance of the contact surface, it looks as if the mass of titanic iron broadens in depth under the anorthosite. Thus the anorthosite must cover a mass of much greater dimensions than the outcrop indicates.

The transition from the titanic iron to the rock is very abrupt. Museum specimens may be broken off, a portion whereof is massive titanic iron and the other portion is rock without any appreciable quantity of titanic iron. On the other hand, the rock contains many scales of black mica very regularly aligned in planes parallel to the plane of contact. As the distance from the contact increases, the rock, which was rather friable, becomes harder and less charged with mica. Finally, about a dozen inches away, an anorthosite appears with some rare crystals of mica and then the normal anorthosite.

The southern open cut is barely more than 50 feet in its greatest dimension. It is also in a mass of titanic iron with few barren inclusions of a rock composed of feldspar, ilmenite and mica, like that already found in the western open workings.

Between these two open cuts, which are about 160 feet apart, other excavations have been made showing the presence of titanic iron.

Owing to the irregular shape of the masses of titanic iron, it is impossible at present to give the direction in which the mass extends, which has been discovered by the present operators. It is possible that such direction may be southwesterly, if one may judge by that of the lenses of barren rock intercalated in the mass.

A collection of samples similar to those obtained from the Coulomb mine was taken from the ore dump from the northwest-

ern open workings. The analysis of the samples gave the following result:

| | |
|---|---|
| Si O | 1.10 |
| Fe O | 57.24 |
| Ti $O_2$ | 41.61 |
| S | traces |
| Ph | trace |
| Not determined | 0.06 |
| Total | 100.00 |
| Metallic iron | 44.52 |
| Titanium | 24.98 |

Of all the ores collected, this is the richest in iron or titanium and, at the same time, the purest.

Mining is carried on entirely by hand, as at the Coulomb mine, and the hauling is done by horse carts. The General Electric Company has had a rather large wooden shed erected, which is used as a storehouse and as lodgings for some of the men.

The work was stopped at the time of my visit. It is reported that borings made in August, 1911, by the General Electric Company showed titanic iron at a depth of 100 feet.

*Furnace Mine—*

This mine is so called because near it are the ruins of the blast furnaces put up by the Canadian Titanic Iron Co. in 1872. Of the extensive buildings erected by that company in 1871 and 1872, but little now remains: six roasting stalls of 12 x 25 x 9 feet; four walls of fine rubble stone which were a part of the boiler-house and also of that which held the blowing machinery; some heaps of bricks and slag showing where the blast furnaces stood.

When the company failed in 1874, the buildings were sold for the materials and all were torn down to get the stone and brick from them: In fact not a trace can now be seen of the furnaces or machinery.

Of the old workings, about 1500 tons of ore remained on the

dump of the mine and from this the Titanium Alloy Co. made a test of the St. Urbain ore for the first time. A first shipment of 250 tons was made in 1908 and,, in the autumn of 1909, a second shipment of 1,000 tons was effected.

The mine is not worked at present and, in fact, no work has been done since 1873.

All that can be seen of the workings consist of two open cuts on lots 351 and 362 of the St. Urbain range, St. Urbain parish, about 19 arpents west of the road of the St. Jérôme range. The first one, about 75 feet wide, was cut in a mass of titanic iron. Lenses of anorthosite appear in two places, but they seem only an accident in the mineralized mass, the walls of which cannot be ascertained by mere inspection.

The second open cut, about 120 feet southeast of the foregoing, really consists of two holes half filled by slides of surface deposit. Between these two holes an old haulage road runs across the lot westward to join the road of the St. Jérôme range. In one of these holes the face of the cutting, which has an elliptical outline of about 120 feet, is entirely cut in compact titanic iron. The other hole, which is nearly filled up, also shows titanic iron.

About half way between the two workings are two stalls for roasting, in an excellent state of preservation. The ore taken out was apparently piled six feet thick on these gratings; underneath from 2 to 2½ feet thick of cordwood were placed and set fire to. It is odd that the metallurgists of the old company should have thought that such a roasting, at a necessarily low temperature, could have been of any use for the final treatment of the ore.

There are still other roasting stalls further west, descending towards the Gouffre river.

The blast furnaces were erected on lot 364 of the St. Urbain range, ten arpents below the workings whence the ore was obtained. The ore roasted in the stalls was charged in the blast furnaces with charcoal which was made on the left bank of the Gouffre river along the road running through the first "Cran Blanc" range.

The rock of which the slopes of the mountain consist at that place is a fine-grained anorthosite, sometimes slightly reddish; at others grey and occasionally very white and similar to marble.

Various geologists who visited the deposit have had the ore analyzed and I give the result of two of such analyses:

| | Analysis of the Geological Survey of Canada in 1863. | Another analysis of the Geological Survey. |
|---|---|---|
| $SiO_2$ | .... | 1.91 |
| $Fe_2O_3$ | 10.42 | 20.35 |
| Fe O | 37.06 | 29.57 |
| $TiO_2$ | 48.60 | 40.00 |
| $Al_2O_3$ | .... | 4.00 |
| Ca O | .... | 1.00 |
| Mg O | 3.60 | 3.17 |
| Total | 99.68 | 100.00 |
| Iron | 36.25 | 37.21 |
| Titanium | 29.16 | 24.00 |

OTHER OUTCROPS OF TITANIC IRON.

*Bagnell Electric Company's Workings—*

On lot 608 of the St. Jérôme range of the parish of St. Urbain, between the road and the line between the St. Jérôme and St. Urbain ranges, are a dozen small prospecting pits 3 x 3 feet. These holes, which are now covered with branches and half filled by the caving in of the sides, were dug in the clay. Some reached titanic iron and near these holes are some blocks of fine ore which were taken out of them.

In order to ascertain whether there was any continuity in the mass of titanic iron, I had three excavations made on the adjacent lot No. 609, about a hundred feet to the west of the line, at a point where the variations of the dip-needle were particularly strong. Two of the holes reached the anorthosite at a depth of five and seven feet respectively. The third was abandoned at a depth of eight feet, as nothing was found but sand and clay.

The existence of a thick layer of sand and clay on top of the mineralized mass on the Bagnell lot would make it more expen-

sive to mine than those on the Coulomb and General Electric Company's lots.

*Lot 641, St. Thomas range, parish of St. Urbain—*

About 1,000 feet to the west of the road of the St. Thomas range, on lot 641, quite near lot 640, in a rather friable anorthosite, a small lenticular mass of rather impure titanic iron is found. The mineralized outcrop is about 6 x 4 feet; the iron contains numerous inclusions of feldspar.

The dip-needle is not perceptibly affected in its vicinity; the lens is of small dimensions.

*Gilbert's Workings—*

Slight prospecting work has been done on the left bank of the Gouffre river in the Décharge range, on a lot belonging to Mr. Gilbert, about 3 miles above St. Urbain village. A vein (or rather a lens) of titanic iron ore has been discovered there which is six or seven feet wide and is imbedded in a compact grey anorthosite. The extremities of the lens disappear under the clay.

The ore contains some feldspars and ferro-magnesian elements in its mass.

*Seminary's outcroppings—*

These outcrops are on the land of the seignory of Beaupré, not yet conceded to settlers and still belonging to the Quebec Seminary. They are reached by crossing the Gouffre river over the bridge at Pitre Tremblay's mill, about 14 miles above the parish of St. Urbain; then taking a winding road which intersects the old post-road to Chicoutimi. About 3 miles north northwest of Tremblay's mill, the road, which is swampy or sandy, shows here and there rocky outcrops consisting of very compact anorthosite, sometimes white and like marble, sometimes pink, sometimes grey with coarse elements. Four and a half miles from the mill, on the same road, a lenticular mass of titanic iron appears, which is about five feet long, disappearing on one side beneath a grey anorthosite with large feldspar crystals, and on the other under a thick layer of vegetable soil and moss. No work has been done and it was impossible for us to ascertain the extent of the mass.

A very curious modification appears in the exposed part of the mass: the titanic iron is entirely granulated and one can gather the ore in handfuls by scratching with one's fingers to a depth of three inches. The grains are light yellow ochre in color and about the size of a bean. They are not round, but broken in curved faces with polygonal outline. The shape of some grains approaches that of a pentagonal dodecahedron. These faces do not seem due to crystallisation or cleavage, but appear to be jointage faces due to shrinking, which produced internal strains or to phenomena of secondary alteration.

Two analyses were made of this granulated ore and of the compact ore found six inches below the surface.

| | | |
|---|---|---|
| $Si\ O_2$ | 2.00 | 2.50 |
| Fe O | 63.22 | 65.16 |
| $Ti\ O_2$ | 32.25 | 31.28 |
| S | 0.042 | 0.040 |
| Ph | trace | trace |
| Undetermined | 2.488 | 1.02 |
| Total | 100.00 | 100.00 |
| Iron | 49.17 | 50.68 |
| Titanium | 19.37 | 18.78 |

*Conclusion—*

It may now be considered that, on the St. Urbain plateau and on the slopes overlooking St. Urbain village, there are three well defined deposits of titanic iron from which large quantities of iron ore can be obtained; these are the Coulomb mine, the General Electric mine and the Furnace mine.

At the Coulomb mine the western and eastern open cuts might, in the condition in which I saw them, yield 1100 or 1200 tons each, per foot of depth. Admitting that the two mineralized masses uncovered join one another—which is very probable since intermediate borings have revealed the presence of ore under the clay—we should have a mass 600 feet long and from 40

to 80 feet wide. This would then mean a tonnage of at least 4,000 tons per foot of depth.

A similar calculation for the General Electric mine would give, for the northwestern workings as represented on sketch No. 2, about 600 tons per foot of depth. But, considering that the northwestern and southeastern workings are in a same mass 250 feet long by from 40 to 100 feet wide, we should be able to count upon a minimum tonnage of 1700 tons per foot of depth.

The results of the Furnace mine might compare with these.

These calculations are based on an estimate of 6 cubic feet of ore to the ton.

The other properties outside these three well-known mines can be looked upon merely as prospects. The Glen prospect seems to be the most interesting as regards both the dimensions of the outcrops found under the clay and the quality of the ore. No work has been done on the Bagnell property which would enable an estimate to be made.

Plan Fig. 1, which indicates the location of these various mines, shows that the three large masses of titanic iron lie in the same straight line running slightly to the east of the Bouchard mine. It would seem that all these masses belong to the same mineralized belt, about a mile long and running from north northeast to south southwest. If any searches are to be made in future, it would be advisable that they be directed towards ascertaining the distance covered by that belt.

On the whole, there is a very considerable quantity of titanic iron ore at St. Urbain. A boring made by the General Electric Company found ore at a depth of 120 feet. There is no doubt that, with outcrops such as those already ascertained, the mineralized masses must descend still lower and that the probable quantity of ore should be estimated at more than a million tons.