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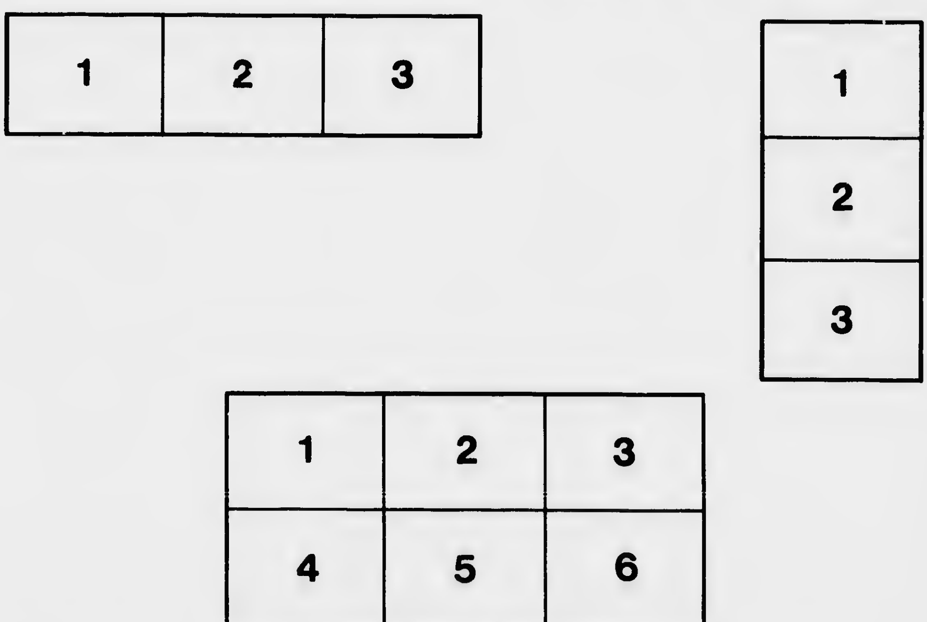
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ON THE ROCKS AND CUPRIFEROUS BEDS OF PORTAGE LAKE, MICHIGAN.

By Thomas Macfarlane.

During the summer of 1865 I was employed on the Geological Survey of Canada in making certain explorations on the north and east shores of Lake Superior. I had instructions to visit also the mines of the south shore, in order to acquire some idea of the experience there gained in mining the deposits of native copper, it being anticipated that such might be advantageously applied in explorations on the Canadian side of the lake. The observations which I made on the south shore, although sufficiently interesting, could not well find a place in a report having reference to Canadian territory, and, Sir William Logan having kindly consented, I have made them the subject of the following paper.

One of the most conspicuous geographical features of the south shore of Lake Superior, is Keweenaw Point. Like the rocks constituting it, it strikes out into the lake in a north-easterly direction for a distance of fifty miles. Portage Lake is situated near its base, and together with Sturgeon River, which flows into Keweenaw Bay, almost severs the point from the main land. The north-western part of Portage Lake intersects the various strata of trap and other rocks which run along the whole length of Keweenaw Point. While to the north-eastward, at Eagle River and elsewhere, the mines of greatest note are generally situated upon veins crossing the strike of the trap, those in the neighbourhood of

Portage Lake are worked almost exclusively upon beds, the strike and dip of which are parallel with that of the enclosing rocks. Such beds are not, however, altogether absent in other districts of the copper region, where they have been called 'ash beds,' but it is in the Portage Lake district that they occur most frequently, and are mined most successfully. The rocks with which they are interstratified are principally what are called traps and greenstones, together with conglomerates and sandstones. They maintain a general strike of N. 20° to N. 40° E., and have a dip of 50° to 60 north-westward.

In attempting to describe these rocks more minutely, I shall begin with those lying immediately west of the great cupriferous bed on which the Quincy, Pewabic and Franklin mines are situated, and proceed then to notice those lying to the eastward, which are, geologically, lower lying rocks.

The rock which is observed at the side of the road leading past the Quincy mine to the Pewabic, and which lies several hundred feet west of the cupriferous bed, is distinctly of a compound nature, but all its constituent minerals are not large enough to be accurately determined. Conspicuous among them is a dark green chloritic mineral, the grains of which vary from the smallest size to one fourth of an inch in diameter. In the latter case they are irregularly shaped, with rounded angles, but they are never quite round or amygdaloidal. They frequently consist in the centre of dark green laminæ. The mineral is very soft and has a light greenish-grey streak. It fuses readily before the blow-pipe to a black magnetic glass, and it would seem to be the preponderating mineral in the rock. The other constituents are in very fine grains, and consist of a reddish-grey feldspathic mineral, with distinct cleavage planes, and closely resembling it, light greenish-grey particles but whether of a feldspathic, pyroxenic or hornblendic nature could not be determined. The prevailing colour of the rock is dark greyish-green. Hydrochloric acid produces no effervescense with it, even when in a state of fine powder. Its specific gravity is 2.83, and the magnet attracts a very small quantity of magnetite from its powder. The colour of the powder when very fine is light greenish-grey. When ignited it loses 3.09 per cent. of its weight and changes to a light brown colour. When digested with nitric acid, and then afterwards with a weak solution of caustic potash (to remove free silica) it experiences, including the loss by ignition, a loss of 46.36 per cent. This consists of

Silica	14.73
Alumina	7.17
Peroxide of iron	14.87
Lime	4.47
Magnesia	2.03
Water	3.09
	46.36

In the undecomposed residue light red and dark coloured particles are discernible. On digesting it with hydrochloric acid and subsequently with a weak solution of potash, it sustains a further loss of 10.6 per cent., which consists of

Silica	3.48
Alumina	3.03
Peroxide of iron	1.98
Lime	1.76
Magnesia	.35

The undecomposed residue was still found to consist of a light red and a dark coloured constituent. The latter was the heavier, and an approximate separation was accomplished by washing. The dark coloured particles, which could not however be freed wholly from the light coloured felspathic constituent, fused readily to a dark brown glass. To judge from its gravity and fusibility it would not appear unreasonable to regard it as either pyroxene or hornblende. In quantity, however, it did not exceed one-eighth of the felspar. The latter fused easily before the blow-pipe to a colourless glass, tinging the flame strongly yellow. It would therefore seem to be of the nature of labradorite, although it is only slightly decomposed by hydrochloric acid. Since, according to Girard, neither labradorite, nor pyroxene nor magnetite are decomposable by nitric acid, it may reasonably be concluded that the constituents removed by the nitric acid are those of the chloritic mineral. On treating the rock, previous to ignition, with hydrochloric acid, much of the iron is removed as protoxide. Although some peroxide is also possibly present, I have calculated the whole of the iron as protoxide, and have moreover added the difference of weight between it and the iron as peroxide, to the loss sustained by ignition, and put it down as water. In this way the composition of the chloritic mineral calculated to 100 parts, would be

Silica	31.78
Alumina	15.47
Protoxide of iron	28.87
Lime	9.64
Magnesia	4.37
Water	9.87
	100.00

In these figures the quantity of iron is much greater, and that of magnesia much less than in ordinary chlorite. In its composition, and in being easily decomposed by acids, the mineral most closely resembles the ferruginous chlorite of Delesse,* (the delessite of Naumann), but differs from it in containing a considerable amount of lime, and in being readily fused before the blow-pipe. Assuming, nevertheless, that the chloritic constituent is delessite, and that one half of the iron removed by hydrochloric acid belongs to the magnetite, then the rock would be composed mineralogically of

Delessite	46.36
Labradorite	47.43
Pyroxene or hornblende	5.26
Magnetite	0.95
	100.00

The next rock to the eastward, to which I paid some attention, is that which constitutes the hanging wall of the Quincy Mine. It is a fine-grained mixture of reddish-grey feldspar, and dark green delessite, the former predominating. In this mixture larger crystals of feldspar and larger rounded grains of the ferruginous chlorite are occasionally discernible. Its sp. gr. is 2.83. The powder is of a reddish-grey tint, and the magnet shews the presence in it of a trace of magnetite. On ignition it changes to light brown,

* The following is the composition of ferruginous chlorite according to Delesse's analysis:

Silica	31.07
Alumina	15.47
Peroxide of iron	22.21
Protoxide of manganese	traces
Lime	0.46
Magnesia	19.14
Water	11.55

Bischof: Chemical and Physical Geology, III, 228.

sustaining at the same time a loss of 1.32 p. c. No effervescence is produced by hydrochloric acid, which dissolves out from the rock 32.44 per cent. of bases, consisting of

Alumina	7.52
Peroxide of iron	15.04
Lime	4.34
Magnesia	5.54

which, doubtless, principally belong to the chloritic mineral. The residue contains a very small quantity of the heavier and darker constituent which was found in the rock first described. The residue is not decomposed by concentrated sulphuric acid.

Next, in downward succession, comes the cupriferous bed generally known as the 'Pewabic Lode,' although it possesses none of the characters of a vein. It has a thickness of about 12 feet, and in places resembles the rock which constitutes the foot-wall of the mine, into which it seems to graduate. In its characteristic varieties it differs, however, completely from that rock. It is a reddish-brown or chocolate coloured uncrystalline rock with amygdaloidal structure and uneven, almost earthy fracture. The matrix sometimes contains some small amygdules, which are not always completely filled, and thus render the rock porous. The matrix is fusible to a black, slightly magnetic glass. It is in places impregnated with grains of metallic copper, from the minutest size to those having a diameter of a tenth of an inch. Those of a still larger size very generally project from the matrix into the amygdules, or form rounded particles lying entirely within these cavities, and filling them. The copper is here accompanied by a mineral of a light green colour, very soft, and separable from the rock as a green powder. It fuses before the blowpipe to a black slightly magnetic glass. On ignition it changes to a light yellow colour losing 0.4 p. c. of its weight. It is decomposed by hydrochloric acid and the resulting solution contains protoxide as well as peroxide of iron. On analysis, it gave the following results, in which all the iron is calculated as protoxide, and the difference between it and peroxide put down as water

Silica	46.48
Alumina	17.71
Protoxide of iron	21.17
Lime	9.89
Magnesia	trace

Alkalies	1.97 by difference.
Water	2.78
	100

It is probably a variety of green-earth. Some of the amygdules are altogether filled with it, in which case it frequently contains small isolated grains of metallic copper. Sometimes calcspar is found along with the green-earth, the two minerals generally occupying separate parts of the cavity. Very frequently the green mineral merely lines the cavities, and the rest is filled up with calcspar. The foregoing description is of a specimen of the bed exceedingly rich in copper. At other places the matrix is more compact and darker coloured, and the amygdules are exclusively filled with calcspar, without any enclosing film of green-earth. Sometimes quartz, delessite, laumontite and prehnite occur filling the cavities. In many parts of the bed, large irregular patches and veins of calcspar are seen, through which and through the adjoining rock, run huge irregular masses of copper frequently weighing several tons, with which small quantities of native silver are associated. Epidote is also often met with in the bed, generally unconnected with the amygdules, and forming small irregular masses in the chocolate-coloured rock. The foregoing description applies equally to the cupriferous bed as developed in the Pewabic and Franklin mines. These are situated on the north side of Portage Lake. The continuation of the bed to the south-east was sought for a long time fruitlessly, until at last it was discovered accidentally at a distance of about four miles south-west of Portage Lake. At this point, on the property of the South Pewabic Mining Company, it is being opened and presents the following characters. The rock is of the same colour as on the Quincy Mine, but it is finer grained, and in places a conchoidal fracture is even observable. The amygdules are smaller, and the metallic copper seems altogether confined to them, forming solid rounded pellets. It is accompanied by delessite, calcspar, laumontite and prehnite, which minerals also occur in the cavities alone. The matrix of this bed is also fusible to a black magnetic glass.

The rock which underlies the copper-bearing bed of the Quincy Mine is distinctly amygdaloidal. The matrix is fine grained, but it is crystalline and is seen to consist of different constituents. Its colour is dark reddish-grey, and it is fusible to a black glass. The cavities, which seldom exceed the size of a pea, are filled with what appears to be the same chloritic mineral which occurs as a constituent in the first two rocks above described. It is very soft and may be cut into small, slightly coherent slices. These fuse readily to a black glass, which is slightly magnetic. In fine powder its colour is light greenish grey, and by ignition it turns dark brown, losing 5.85 p. c. of its weight. Hydrochloric acid decomposes it readily. On analysis, and calculation as above described, it gave,

Silica	30.59
Alumina	26.07
Protoxide of iron	22.01
Lime	1.92
Magnesia	12.36
Water	7.23
	100.18

It will be observed that these results correspond much more closely with the composition of delessite than that calculated from the constituents dissolved by nitric acid from the rock first described. The specific gravity of the rock, including the amygdules, is 2.78. The colour of the fine powder is dark reddish-grey. On ignition it turns brown and loses 2.33. Nitric acid dissolves 25.67, and hydrochloric acid 34.12 of its weight. In the residue from treatment with the latter acid, no heavy dark coloured constituent could be detected. From the above particulars the following mineralogical composition is deducible.

Delessite in amygdules and grains	38.
Labradorite	62.
	100

An occasional crystal of feldspar is met with in the rock, which seems to be identical with that occurring in the matrix, and is only partially decomposed by hydrochloric acid.

The various bands of rock which underlie the Pewabic lode have been intersected by a cross-cut, more than five hundred feet in length, from the seventy fathoms level of the Pewabic mine. This working has passed through the following rocks, the local names and thicknesses (horizontally) of which are as follows:

Trap	137 feet.
Old Pewabic lode	34 "
Trap	85 "

Green amygdaloid vein	19	feet.
Trap	98	"
Albany and Boston vein	7	"
Trap	45	"
Epidote or Mesnard vein	23	"
Trap	20	"
Fluckan	1	"
Conglomerate	31	"
Sandstone	6	"
	506	feet.

The general strike of these strata is N. 38° E. and the dip 55° northwestward. The two beds above denominated as the Green amygdaloid vein and the Mesnard vein are also found on the Quincy property, where the first named bears a general resemblance to the rock of the Pewabic lode. The matrix is perhaps darker coloured, and contains grains and crystals of feldspar as well as amygdules of green-earth and calcspar, the latter containing copper in fine grains. The rock of the Mesnard vein is dark brown, with a bluish tint. The minerals of the amygdules are principally green-earth, quartz and metallic copper. This bed is also called the Epidote vein but the green-earth has probably been mistaken for epidote.

The trap which overlies the conglomerate in the Albany and Boston Mine is a fine grained mixture of dark green delessite, (in grains less distinctly isolated than in the rocks already described) greenish-grey feldspar, and reddish-brown mica, some of the laminæ of the latter shewing ruby-red reflections. Its sp. gr. is 2.81, and the smallest trace only of its powder is attracted by the magnet. The colour of the powder is greenish-grey, which changes on ignition to brown, a loss of 4.19 being sustained. Nitric acid dissolves from it 24.52 p. c., which consist of

Alumina	5.96
Peroxide of iron	14.78
Lime	3.41
Magnesia	0.37

These figures agree pretty closely with the quantities of bases dissolved from the rocks already described, but the quantities of lime and magnesia are a little smaller. The residue consists of a dark coloured, heavier, and a reddish-white coloured lighter part, the latter about twice as large in quantity as the former. The dark coloured portion consisted probably in greater part of mica, and to judge from the comparatively low specific gravity of the rock, little or no pyroxene or hornblende could be present. The mineralogical composition of this trap is therefore probably as follows :

Delessite	40
Mica	20
Labradorite	40
	100

The 'Fluckan' which underlies the trap last described is separated from it by a small seam of clay. The fluckan itself is a fine grained, dark-red shaly rock in which pieces of a greenish blue colour are sometimes seen. Both substances are fusible before the blow-pipe and contain occasionally small grains and flakes of copper. It resembles the old *Thonstein* (claystone) of the Germans, now more properly named Felsite tuff.

The conglomerate upon which the foregoing rock rests, has acquired some celebrity on account of its being mined for copper on the property of the Albany and Boston Mining Company. The boulders and pebbles consist of various species of porphyry. One of them has a dark brown matrix with small white crystals of feldspar; another has a matrix of the same colour but with larger crystals of orthoclase, while a third variety consists principally of a fine grained mass of orthoclase with which a small quantity of a dark coloured mineral occurs in particles too small for determination. The matrix consists of a coarse grained sand of porphyritic material, impregnated with calcareous matter. In many places the interstices are not at all filled up, in others calcspar is the matrix, and very often in the lower part of the bed the matrix is almost pure metallic copper. Sometimes the metal completely fills the whole space between the pebbles, sometimes it is accompanied by calcspar, but much more frequently it is disseminated in fine particles through the coarse grained matrix. Sometimes a pebble is found quite saturated with copper, but it seems to have been of a more porous nature than the others and an amygdaloidal structure may be detected in it.

As above mentioned, a bed of sandstone underlies the conglomerate. It shews traces of stratification, is of a dark-red colour, and evidently consists of the same material as the conglomerate pebbles but in finer particles.

The trap which underlies this sandstone is amygdaloidal, but becomes more compact at a distance from the sandstone. In the adit which is being driven across the strata on the Quincy property, and which, so far as it has yet gone, is in the trap underlying the conglomerate, the rock much resembles the one first described as occurring on the road passing the Quincy mine. The grains of delessite are however smaller, seldom exceeding one tenth of an inch in diameter. An occasional crystal of feldspar is also observable in the fine grained mass of the rock. This mineral is in places reddish-grey, and in others greenish-grey, fuses readily to a colourless blebby glass and colours the blow-pipe flame strongly yellow. The sp. gr. of the rock is 2.89, and the colour of the powder light greenish-grey, but somewhat darker than that of the rock first described. It changes like that to a light brown on ignition, losing at the same time 2.77 p. c. On being treated with nitric acid and caustic potash the following substances are removed from it :

Silica	12.41	per cent.
Alumina	5.96	"
Peroxide of iron	15.85	"
Lime	3.77	"
Magnesia	1.84	"
	39.83	per cent.

These substances, together with the water lost on ignition, calculated in the same manner as in the case of the rock first described, for 100 parts give

Silica	29.52
Alumina	14.00
Protoxide of iron	33.47
Lime	8.80
Magnesia	4.29
Water	9.92
	100.00

The residue from this treatment, which amounts to 57.17 per cent. of the original rock, on being digested in hydrochloric acid lost 6.7 p. c. additional, consisting of

Alumina	2.38
Peroxide of iron	2.45

Lime	1.57
Magnesia	.30

The residue consisted of the same dark and light coloured parts as in the case of the rock first described. Calculated in the same manner as it, the mineralogical composition of this rock from the Quincy adit would be

Delessite	42.60
Labradorite	50.69
Pyroxene or hornblende	5.62
Magnetite	1.09
	100.00

From the particulars above given, it would seem that the constituents of the traps of the Portage Lake district are principally feldspar of the labradorite species, and chlorite of a species allied to delessite, with which are found occasionally mica, small quantities of magnetite and perhaps of augite or hornblende. Similar results are given in Foster and Whitney's Lake Superior Report II, 87; but the relative proportions of the constituents are not given, nor is the peculiar nature of the chlorite referred to. The name of greenstone would seem altogether inapplicable to these rocks, because augite or hornblende only occurs in them occasionally if at all, and then in comparatively small quantity. As to the name of trap, the rocks previously so called have been by the best lithological authorities subdivided into two families, Melaphyre and Basalt.* The latter family which includes dolerite, anamesite and common basalt is distinguished by the dark, mostly black or greyish-black colour, the high specific gravity, and the richness in augite and magnetite of its rocks, and by the frequent occurrence in them of olivine and zeolites. The melaphyres on the other hand are characterised by their apparent want of augite, by their comparatively low specific gravity, by their colour of reddish-grey mixed with green and black, and their frequent development as amygdaloidal varieties; in which case quartz, calcspar and delessite fill the cavities more frequently than zeolites. The traps above described would seem to belong to the class of melaphyres, and to resemble especially those of Mansfeld described by Freiesleben, of Saxony,† and that of Faucogney described by Delesse.

* Naumann; Lehrbuchder Geognosie i, 599; Senft. Classification und Beschreibung der Felsarten, pp. 262 & 272.

† Geognostische Beschreibung des Konigreiches Sachsen ii, 447.

It is in the latter locality that the ferruginous chlorite, of which the analysis is quoted above, is found. It not only occurs in the amygdaloidal varieties of other localities, but, according to Naumann, it is also a constituent of many compact melaphyres. The following translation is from Naumann's Lehrbuch (I, 600) and is descriptive of the peculiarities of the melaphyres. It will be seen at once that it in every particular applies to the melaphyres of Portage Lake. "The principal characteristic of these rocks is "founded, on the one hand, on the decided nature of the felspa-"thic constituent, which when distinctly developed, has always "been recognized as labradorite, and on the other hand on the cir-"cumstance that pyroxene is very seldom present in recognizable "crystals, or grains, and usually cannot be determined mineralogi-"cally. The melaphyres generally appear as micro- or crypto-"crystalline rocks and only sometimes have arrived at a distinctly "granular developement. A third peculiarity is recognizable in "the tendency which these rocks have to the formation of air-"cavities and amygdaloidal structure, on which account the mela-"phyres are very frequently developed as amygdaloids or spilites. "In the amygdules, which sometimes reach a considerable size, "and then appear as geodes of varied constitution, the following "minerals are mostly found:—calcspar or brown-spar, and many "varieties of the species quartz (chalcedony, carnelian, jasper, "quartz, amethyst, agate) as also a mineral resembling chlorite or "green-earth which usually forms the periphery of the amygdules "like a shell or rind. *A similar, soft and green-coloured mineral* "is also often disseminated in the rock in grains and indistinct "crystals. The zeolites which are so frequent in the amygdaloidal "basalts, belong to the more rare occurrences in melaphyres pro-"perly so called. If we now add to these characters the com-"plete absence of quartz in the form of a rock constituent, the "predominating reddish-brown to reddish-grey colour of the mass "of the rock, which sometimes runs into greenish-grey, dark-"green and black, and the frequent occurrence of rubellan or "mica, we shall have tolerably exhausted the general petrographical "peculiarities of the melaphyres." Dr. T. Sterry Hunt, in his valuable paper on lithology, refers to this class of rocks as requiring a distinctive name, but he seems unwilling to adopt that of melaphyre. Since, however, Von Buch, Naumann and Senft*

* My objection to retaining the name of melaphyre is based upon the fact that these authors apply the name to different rocks. Brongniart, who invented it,

favor its adoption, and the science of lithology is already well stocked with terms of by no means general adoption, it would seem advisable to retain the word melaphyre to denote such rocks as those above described. With regard to the copper-bearing beds, the fusibility of the rock, and its transition in places into the neighbouring rock connects it distinctly with the melaphyres. This, together with the total absence of crystalline structure, and its apparently detrital character in places, would lead one to suppose that these beds are melaphyre tuffs, bearing the same relation to melaphyre, which volcanic tuffs bear to trachytes and basalts. The trap of the Portage Lake District might therefore be properly termed granular melaphyre when it is small-grained and crystalline; amygdaloidal melaphyre when cavities are present in a crystalline matrix; compact melaphyre when the rock is fine-grained and crystalline; and tufaceous melaphyre when the matrix is destitute of crystalline structure.

The rocks which occur to the eastward of the trap last described, I had no opportunity of examining minutely. They consist probably however of the same rocks as those above mentioned, alternating with each other for about one and a quarter miles, which is the distance across the strata from the conglomerate bed of the Albany and Boston property to the so called vein explored by the Isle Royale, and other mines.

About 260 feet west of the 'Isle Royale Vein,' the bed occurs upon which the Grand Portage mine is situated. The colour of the matrix is light-green, thus differing greatly from the beds hitherto described. It has an uneven earthy fracture, is non-crystalline, with small white spots here and there through it. It is fusible and gives water when heated in a glass tube. The amygdules are all of a dark-green colour, and frequently consists exclusively of delessite. Quite as frequently, however, they consist of that mineral, with a kernel of quartz, or much more seldom of calcspar. The copper is found oftener in the amygdules than in the matrix. As in the other beds larger aggregations of crystal-

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gave it to black porphyries holding hornblende; Von Buch and d'Halloy use the name as synonymous with an augite-porphyry, while finally Naumann and Senft restrict the term to rocks which contain neither hornblende nor augite, and are not black in color, as the name melaphyre would imply. Hence I agree with Bernhard Cotta in rejecting the name, while admitting at the same time that some term is requisite to designate the important class of anothosite rocks in which a hydrous mineral (ferruginous chlorite) takes the place of hornblende or augite.—T. S. H.—(EDITOR'S NOTE.)

line minerals occur, in which quartz generally preponderates, associated with calcspar, prehnite and native copper. Some specks of native silver sometimes occur in this veinstone. The strike of the bed is N. 30° E., and the dip about 52° north-westward.

Between the Grand Portage and Isle Royale Veins the trap is of the usual character, reddish-grey coloured, with dark-green grains and spots of delessite impregnating it.

The cupriferous bed of the Isle Royale mine is often of a dark-chocolate colour similar to that of the Pewabic lode. In other places it has the character of the Portage lode, being light-green coloured, non-crystalline and with an uneven fracture, but it is comparatively free from amygdules.

Trap, as usual, underlies the Isle Royale Vein, and, with other rocks, fills up the space between it and Mabb's vein which lies about a mile to the south-eastward. One of these is a conglomerate resembling that of the Albany and Boston mine, so far as the nature of the pebbles is concerned. The matrix is very porous, and in coarse grains, which are in places cemented together by quartz as well as calcspar.

Mabb's Vein, upon which mining has also been commenced by the Isle Royale Co., has a matrix of a much more crystalline character than any of the cupriferous beds already described. It is of a dark-green colour, and is impregnated with grains and irregular spots (but not amygdules) of quartz, which is accompanied by epidote and metallic copper. Sometimes, however, an approach to the light-green earthy rock of the Isle Royale vein is noticeable.

A short distance to the east of Mabb's vein another conglomerate bed is found. The pebbles are porphyritic here also, but contain crystals of quartz as well as of felspar, and the paste is difficultly fusible before the blow-pipe, fine splinters of it only becoming glazed. The pebbles do not seem to be so well rounded as in the other beds.

I had no opportunity of examining any of the rocks further eastward, which form the base of the trap formation, but since those already described form part of a series of strata having a vertical thickness of about 10,000 feet, it may be supposed that they afford good average specimens of the whole.

There is probably no one point, even in Europe, where within a limited area, there are to be found such a number of mines, many of them rich, well appointed and well managed; such a display of beautiful mining machinery; or such magnificent stamp-works as are to be found within say five miles of the towns of Hancock and Houghton on Portage Lake. Even the professional visitor, who has given previous attention to the subject, cannot but be astonished as he rounds the point beneath these towns, and sails up to them, at the scene of life and activity which suddenly opens up before him. Having only spent ten days in the district, it would be impossible for me to attempt to describe with a moderate degree of minuteness even its principal mines. There are at least twelve mines in operation within a short distance of the lake, and of these the majority are producing copper in quantity varying from 20 to 120 tons of the pure metal monthly. The mines which have the largest production are those of the Pewabic lode, and it will be sufficient to refer briefly to their mining and dressing operations.

In exploring the cupriferous bed in the Quincy mine, as in following the other beds in the district, the miner has only its lithological character to guide him, there being no distinct joints or walls on either side. The shafts, levels and winzes of the mine are all opened within the bed so that the amount of *dead work* done is the very least possible. At the 100-fathom level the strike is N. 30° E., and the dip 70° north-westward. The shafts on the Quincy mine are from 200 to 300 feet apart, and the levels from 72 to 75 feet beneath each other on the incline of the bed, and 60 feet perpendicularly. The width of the bed is from 6 to 30 feet and the average thickness ten feet. According to the general experience at the mine, the thicker the bed the richer is the rock in copper. About two-thirds of the area of the bed is removed as remunerative; the other third, although it may contain some copper, is left standing, as unworthy of excavation. The amount of ingot copper yielded by the ground actually removed in 1864 was 562 lbs. per cubic fathom. Assuming the sp. gr. of the rock of the lode to be 2.7, it thus yielded 1.4 per cent. Of course the copper was unequally distributed through the bed rock, and the true per centage would be at many places above, and at others below that just mentioned. The bed is excavated by a very judicious combination of over-hand and under-hand stopping. The rock is removed to the shafts in waggons containing about one ton each, and hoisted in *skips* or waggons of a peculiar shape, running on tracks in the inclined shafts. The contrivance whereby these skips are emptied on their reaching the surface is without doubt the simplest and most beautiful anywhere in use. There are six shafts; the deepest, No. 4, is 660 feet vertically, and about 800 feet on the incline of the bed, below the surface. The pumps have a six-inch bore with a seven-inch column, but they only work three hours in twenty-four, so little is the mine troubled with water. On reaching the surface the bed-rock undergoes a sorting and about one-third is set aside as worthless. The other two-thirds are roasted in huge heaps much in the same manner as iron-stone. The object of this operation is to render the rock more easily pulverized. After roasting, the larger masses of copper are sorted out and sent directly to the furnace, where they yield about 60 per cent. The remainder is forwarded in waggons, on an inclined tram-way (where the full waggons in descending pull up the empty ones) to the stamp-work situated close to the lake, below the village of Hancock. Here Wayne's stamps, Shiermann's jiggers and ordinary Cornish buddles are employed in concentrating the ore. Each stamp weighs 900 lbs., and has 16 inches lift. The stamped rock passes through a sieve made of boiler plate, $\frac{1}{4}$ inch thick. The holes are $\frac{1}{4}$ inch in diameter, and have a slight diminishing taper towards the stamps. The latter are stopped every eleven hours in order that the larger pieces of copper may be removed from the stamp-box. The stamped ore is discharged into a shallow run which has an inclination of a half inch in a foot. From this it comes on to a sieve which is constantly in motion, has $\frac{1}{8}$ inch holes, and separates it into coarse and fine work for the jigger. The fine work in passing down into the jigging sieve meets an upward current of water which carries away the slimes from it. The jigging machine, in which the sieve is stationary, apparently cleans the ore very effectually. A sample of the coarse ragging from it was given me which assayed 98.6 per cent., while the *skimpings* or refuse contained only 0.6 per cent. The fine *ragging* from the same machine assayed 89.3 per cent. and the refuse 0.73 p. c. The product from washing the finer stuff on the buddles assayed 78.6 per cent. while the *tailings* from the same operation gave 0.46 per cent. The whole of the refuse products of the stamp-work are, however, passed through an adjoining building, and some part of them worked over. The yield of the rock treated in the stamp-work was, during 1864, 2.96 per cent. I make no attempt to describe the magnificent machinery of the Pewabic and Franklin stamp-works where Ball's patent stamps and washers are employed. To judge, however, from the percentage of copper in the refuse products, the work is not so well done here as in the Quincy stamp-works. With the permission of the superintendent of the Franklin stamp-work, I took several samples from various parts of the run-house, and from the waste heap outside, which assayed as follows:

From head of run	4.93 per cent.
" middle of do	3. "
" end of do	3.13 "
" a heap immediately outside of run house	0.66 "
" sand bank	1.00 "

When it is recollected that the yield of the rock treated in the Franklin stamp-work is only 1.69 per cent. the loss in the refuse products would appear to be very large. At the stamp-works of the Albany and Boston Mining Co., Gates's revolving stamps and Collom's jiggers are employed. This is also the case at the Huron stamp-work. (The Huron mine is on the Isle Royale bed.) It appears to be as yet uncertain as to which system of dressing is the most advantageous, but in view of the experience which is being acquired in the district almost daily, this cannot long remain a matter of doubt. It is, however, singular that in a district where such an enormous amount of capital is invested in mines and stamp-works, there should be no provision made for testing accurately, by the wet process, the various refuse and other products of the ore-dressing operations. It would seem difficult, without such means, to come to a reliable result as to which method of concentration is the best.

The system of dividing the lands into small sections seems to have contributed not a little to the rapid developement of the mines of the Portage Lake district. The sections contain one square mile of 640 acres, and each of these is subdivided into four quarters. Some of the best of the mines have no more length of lode to work upon than may be contained in a quarter section. As a consequence, the attention and energies of the mining companies, and their managers, are, on the discovery of a cupriferous bed, at once turned to exploring and mining in depth. The opposite system, which prevails on the north shore of the lake, of having very large mining locations is as detrimental to the progress of the country as it is to the interests of the owners. The explorations are carried on over too great an area, they are desultory, are not easily superintended, and seldom yield any definite result.

In concluding this paper, I venture to hope that some of the facts which it relates concerning the mines of Portage Lake will be found useful in detecting the presence of remunerative cupriferous beds on the Canadian shore of the lake. The existence of such there can scarcely be doubted, and it is equally certain that if the same energy, intelligence and capital were employed in their developement as on those of Portage Lake, the north shore, now a wilderness, would soon become studded with towns as flourishing and populous as those which now ornament the south shore.

Acton Vale, C. E., January 3, 1866.

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