

We find also, principally from the Fishery Reports, the following facts:—That Salmon are more vigorous, and their ova equally fertile, that have never been in fresh water, but have been kept in tide-way reserve ponds. (Reports of Tadousac Breeding Establishment). That the Ontario Salmon on the contrary never go to salt water, but are equally vigorous, (see Mr. R. Wilmot's reports,) and that a few in Nova Scotia resist the fresh water changes. These facts are all comparatively new, and bearing as they do, so strongly upon the question of what are called land-locked Salmon, by many scientific men, still in the United States Fishery Commission, they are well worthy of a most minute, exact and scientific series of new observations, which might be made with little expense, if connected with the various fish breeding establishments of the Dominion. The growth of scale, the discolouration of flesh and of body, the changes of teeth and jaws in the male, and the peculiar changes in the pyloric cœca in fresh water and ocean fish (lately pointed out by R. Morrow, a member of our Institute) as taking place in the three forms of all fresh water, all salt water, and partly fresh and salt water, with exact dates and minute comparisons, would well reward the attempt, and be a small boon from the Government to her men of science.

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ART. VIII.—ON THE ANKERITE VEINS OF LONDONDERRY, NOVA SCOTIA.—BY HENRY LOUIS, *Assoc. R. Society, Mines, London.*

(*Read March 10th, 1879.*)

EXTENDING along the base of the southern slope of the Cobequid mountains, and parallel, roughly speaking, to the mountain axis, is a remarkable series of fissure veins, filled with a number of interesting minerals, of which, as at present known, the most plentiful and the most characteristic is the Ankerite. These veins, which I shall in this paper designate the Ankerite veins, although Ankerite is not by any means their sole constituent, occur in a band of slate and shale, varying in colour from a dark blue to a pale olive green, and forming apparently the topmost

beds of the Silurian formation. They are found of all thicknesses from about the tenth of an inch up to fifty feet; the larger deposits are very variable in thickness, much faulted, and approximately parallel to each other and to the general strike of the strata, whilst the rocks between them are frequently traversed in every direction by a network of the smaller veins. These veinlets appear to occur for the most part in the blue slates, but the walls of the larger deposits most frequently consist of greenish-grey shale. I have not been able to make out any definite relations between the modes of occurrence of these two classes of Ankerite veins.

Wherever I have been able to examine these deposits, I have found them to present very similar characters. Most of my observations have been made on the large deposits of Ankerite in the right bank of the west branch of Great Village river, which has been very extensively quarried: I have, however, no doubt but that they will apply equally well to any portion of the series of Ankerite veins.

The following descriptive list includes all the minerals that I have up to the present met with in these veins:—

1st.—Ankerite. This mineral occurs most frequently in the massive crystalline state, readily cleavable into rhombohedra, the cleavage planes being often very large; sometimes, but more rarely, it is cryptocrystalline and granular. I have, however, also found it in true crystals, lining the walls of a small fissure in the vein. The crystalline form is the simple primary rhombohedron, very minute, the largest crystal not being over  $\frac{1}{8}$  inch in length, and the faces too dull for measurement. The colour of Ankerite before it has been exposed to the atmosphere is pure white, but, owing to the rapidity with which its protoxide of iron is per-oxidized, it is usually found of a yellow or brownish colour.

Its specific gravity is 2.998.

The following are analyses of three specimens of the pure mineral; Nos. I and II were white, and No. III of a brownish tinge:—

	I.	II.	III.
Insoluble Siliceous Matter . . . . .	0.57	0.12	0.19
Calcic Carbonate . . . . .	53.64	49.32	54.96
Ferrous " . . . . .	23.29	23.11	21.92
Manganous " . . . . .	0.77	0.68	1.29
Magnesian " . . . . .	21.48	26.29	21.42
Ferric Oxide . . . . .	trace.		1.05
	99.75	99.52	100.83

By taking the mean of these and numerous other analyses, I deduce the following for the average composition of Ankerite, disregarding the insoluble matter:—

Calcic Carbonate . . . . .	53.75	
Ferrous " . . . . .	22.70	} 23.50
Manganous " . . . . .	0.80	
Magnesian " . . . . .	22.75	
	100.00	

This would demand for Ankerite the formula  $8 \text{ Ca Co}_3 + 3 \text{ Fe Co}_3 + 4 \text{ Mg Co}_3$ ; a small proportion of the Iron being replaced by Manganese. The composition corresponding to this formula is:—

Calcic Carbonate . . . . .	53.90
Ferrous " . . . . .	23.45
Magnesian " . . . . .	22.65
	100.00

The correspondence of this composition with that actually found is sufficiently close to warrant the above formula for Ankerite. It must, however, be borne in mind that all the Carbonates composing Ankerite are isomorphous, and therefore capable of replacing each other in any proportions; this circumstance of course precludes the possibility of obtaining any universally applicable formula for Ankerite. As an example of the irregularities produced by isomorphism, I may instance the following

analysis of a specimen of white cryptocrystalline Ankerite, which contains much more Lime, and also less Magnesia in proportion to the Iron than the normal mineral:—

Insoluble Matter .....	0.53
Calcic Carbonate .....	71.23
Ferrous " .....	16.41
Manganous " .....	2.65
Magnesian " .....	9.34
	100.16

The formula for this structure is  $13 \text{ Ca Co}_3 + 3 \text{ Fe Co}_3 + 2 \text{ Mg Co}_3$ . It appeared to be perfectly homogeneous in structure, and may possibly be Ankerite altered by the action of water carrying Calcic Carbonate in solution.

2nd.—Sideroplesite.—(Classed by Dana as a variety of Siderite)—This mineral occurs in the Ankerite quarry in small veinlets penetrating the mass of the Ankerite, but appears to become more abundant in the deeper lying parts of the deposits; thus, in the upper levels of the West Mines, Sideroplesite and Ankerite are found in irregularly interlacing veins and masses, in about equal proportions, as will be shown by an analysis to be given below, while in the lower levels of the same mine very large deposits occur, containing only here and there small veinlets and patches of Ankerite; so extensive indeed are these deposits, that if they hold in depth, as they now promise to, they will become of high economic importance. I have never seen any crystals of Sideroplesite, but it is always highly crystalline, although the cleavage planes are smaller than in Ankerite, and, instead of being continuous through large masses, are inclined in all directions, so that a fractured surface shows a number of small and irregularly divergent cleavages. Its colour is pearl grey, but on exposure to the air it oxidises with great rapidity, assuming a brownish tinge.

Its specific gravity is 3.523.

The following are analyses of some characteristic specimens:—

	I.	II.	III.
Insoluble Siliceous Matter . . . . .	0.43	0.47	0.25
Calcic Carbonate . . . . .	1.03	0.59	3.14
Ferrous " . . . . .	67.96	69.20	68.47
Manganous " . . . . .	2.19	1.37	2.08
Magnesian " . . . . .	27.87	28.73	26.02
Ferric Oxide . . . . .		0.08	
	99.48	100.44	99.96

The average composition, exclusive of insoluble matter, as derived from several analyses, is:—

Calcic Carbonate . . . . .	1.92
Ferrous " . . . . .	68.15
Manganous " . . . . .	1.87
Magnesian " . . . . .	28.06
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	100.00

Evidently, the Manganous and Calcic Carbonates are only accidentally present, the main constituents being:—

Ferrous Carbonate . . . . .	70.02
Magnesian " . . . . .	29.98
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	100.00

The formula that most nearly corresponds to this composition is  $5 \text{ Fe Co}_3 + 3 \text{ Mg Co}_2$ . The per centage composition required by this formula is:—

Ferrous Carbonate . . . . .	69.72
Magnesian " . . . . .	30.28
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	100.00

This may also be written for the sake of comparison:—

Carbonic Anhydride . . . . .	42.30
Ferrous Oxide . . . . .	43.28
Magnesia . . . . .	14.42
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	100.00

Breithaupt gives  $2 \text{Fe Co}_3 + \text{Mg Co}_3$  as the formula for his Sideroplesite, and the following as its composition:—

Carbonic Anhydride.....	41.93
Ferrous Oxide .....	45.06
Magnesia .....	12.16
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	99.15

Thus, the composition as well as the physical characters of our Nova Scotian minerals approach very nearly to those of Breithaupt's Sideroplesite, more nearly in fact than to those of any other mineral that I know of, and I think that there can be little doubt but that it should be referred to this variety. Having regard, however, to the very large quantities of this mineral lately discovered at Londonderry, to its well defined chemical composition and physical characters, I would venture to suggest that Sideroplesite is fully entitled to be classed as a well defined mineral species, rather than as a mere variety of Siderite.

The following is an analysis of a sample of mixed Ankerite and Sideroplesite, taken from a large deposit of mineral, in which both species were present, in one of the upper levels of the West Mines:—

Insoluble Matter .....	0.31
Calcic Carbonate .....	27.52
Ferrous " .....	46.09
Manganous " .....	2.28
Magnesian " .....	23.80
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	100.00

This composition corresponds to the formula  $2 \text{Ca Co}_3 + 3 \text{Fe Co}_3 + \text{Mg Co}_3$ ; equal to a mixture of about five parts of Ankerite and six of Sideroplesite.

These two are by far the most abundant of the minerals occurring in these veins, the rest being present only in small quantities, and usually near the walls.

3rd.—Barytes.—This mineral occurs in fissures in the Ankerite veins, occasionally in small tabular crystals, but more often in

highly cleavable masses, sometimes white, usually pink or flesh-coloured.

4th.—Calcite.—This mineral is found lining fissures in the well known form of Dogtooth Spar, and in large, often drusy, scalenohedra. It is not, however, a pure Calcite, as is shown by the following analyses, the first being that of a specimen of Dogtooth Spar, and the second of a large scalenohedron:—

	I.	II.
Insoluble Matter .....	trace.	
Calcic Carbonate .....	95.93	90.69
Ferrous “ .....	1.45	3.25
Manganous “ .....	2.77	1.49
Magnesian “ .....	0.57	4.06
	100.72	99.49

5th.—Aragonite.—It occurs in acicular crystals, lining fissures or cavities in the Ankerite, or implanted upon Barytes or Calcite. The crystals vary in size from an inch or more in length down to microscopic minuteness. Aragonite appears to have been one of the last minerals introduced into the vein, as it is invariably found investing the others.

6th.—Iron pyrites occur sparingly in very minute disseminated crystals, near the south or hanging wall.

7th.—Specular ore occurs in thin veins ramifying through the Ankerite, and in some places forms a layer about one inch in thickness between the Ankerite itself and the hanging wall. Veinlets of Specular Ore are also found penetrating into the shales on the same side.

This list comprises all the original mineral constituents, as at present known, but in addition to these we have in small quantities in the upper parts of the veins the decomposition products of Ankerite and Sideroplesite, which, from their intimate connection with the origin of the Londonderry Iron ores, acquire a high degree of interest. Whilst all these ores are probably derived from the decompositions of the Carbonates, the only one that shows in its actual structure any proof of such origin is that known as “Red ore.”

This ore occurs in deposits having the same average direction as the Ankerite veins, (namely, from  $5^{\circ}$  to  $10^{\circ}$  N. of W.,) and it mostly runs out in descending into Ankerite or, more frequently, Sideroplesite. Rounded boulders of both of these minerals are not uncommon in the "Red ore."

Red ore is amorphous and earthy in fracture. It is often very distinctly pseudomorphous, after Ankerite or Sideroplesite, when the cleavage planes of the original mineral are very evident in the Red ore and are indicated by a strong satiny lustre. The hardness of the ore is between 2 and 3: its colour varies from deep red through all the shades of reddish-brown to pale brown, the red colour being by far the most common, and the clear brown comparatively rare. The following analyses will serve to indicate its general character. Analysis No. I was made on a deep red specimen, and No. II on a brown specimen of the ore, both showing distinctly the cleavage planes of the original mineral:—

	I.	II.
Insoluble Matter .....	2.71	3.73
Alumina .....	trace.	trace.
Ferric Oxide .....	87.21	83.21
Trimanganic Tetroxide.....	1.67	1.83
Lime .....	trace.	trace.
Magnesia .....	0.45	0.65
Combined Water .....	8.01	10.18
Phosphoric Acid .....	trace.	trace.
	100.05	99.60

It will be seen that the composition of these, like all the Londonderry ores, is approximately that of Goethite, namely,  $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; they are, however, not only very different from the ordinary brown Hæmatites of this locality in appearance, but differ also in containing less siliceous matter and phosphoric acid. It is very difficult to assign these Red ores to any definite mineral species, the characteristics of the bright red variety being especially puzzling. While it differs from Turgite, in containing nearly twice as much water of hydration, and in not decrepitat-



ing when heated, its distinct red colour and streak separate it from all the other hydrates of Iron; and numerous and indefinite though they are, there is no species with which it can fairly be classed.

As regards the origin and formation of the Londonderry deposits, the following appears to be their history, as far as our present limited Geological knowledge of this region allows us to read it. The close of the Silurian epoch was brought about in this region by the elevation of the land now forming the Cobequid Mountains. This elevation was accompanied by extensive dislocation and fracture of the strata, and in this way a long series of clefts was produced in the region extending along the base of the Cobequids, this having evidently been the line of least resistance to fracture. These fissures were then filled with Ankerite and Sideroplesite, introduced, as I believe, in solution in water. It has been supposed by some that these minerals were introduced into the fissures in a state of fusion, or at any rate, under conditions of intense heat. I am not aware that the feasibility of fusing either of these minerals without decomposition has ever yet been demonstrated, but as Calcic Carbonate has been fused under pressure, it is possible that a similar result might be obtained with them. If then the plutonic hypothesis is the correct one, their formation must have been effected at a sufficient depth in the interior of the earth to produce the necessary pressure as well as heat; but it is by no means clear to me how, at so great a depth, where the surrounding strata must at least have been softened, such sharp and extensive fissures could have been produced. Moreover, the effect of this intense heat ought to be traceable in the walls of the veins. Some of the walls of the very narrow veins certainly consist of highly metamorphic slate, but I found that a sample taken from the walls of the large Ankerite vein at Acadia Mines was highly plastic when ground fine and mixed with water, and that it contained as much as 8.15 p.c. of combined water. These walls had surely not been exposed to a temperature above red heat, unless indeed rehydration in such a case were possible. Fragments of the walls with sharp edges, and apparently differing in no respect

from the wall itself, are occasionally found embedded in the Ankerite. The general appearance too of the vein, its wedge-like shape, narrowing downwards, and the mode in which the minerals are arranged in it, all appear to me to suggest its formation by aqueous agency.

As to the other minerals present, they are evidently of far later date than the vein itself, and have been formed by the action of water percolating through the fissures of the Ankerite. I may here mention as an instance of such action, that I have found near the Ankerite quarry conglomerates consisting of pebbles of Ankerite and other rocks united by a calcareous cement. In this connection too, it is interesting to note that whenever Aragonite and Calcite are present in the same fissure, the former invariably invests the latter, but never vice versa. The most generally accepted theory regarding these two minerals is, that Aragonite was deposited from hot water and Calcite from cold; this theory, if true, would lead us to infer that the Ankerite vein was exposed to the action first of cold, and at a later period, of heated waters.

When a mass of Ankerite or Sideroplesite is left exposed to the atmosphere for a number of years, a thin crust of brown or red hydrate of Iron forms upon its surface, the Calcic and Magnesian Carbonates being superficially carried off in solution. Here we have reproduced before our eyes the chemical phenomena to which we owe the Red ore. This ore has been produced by the joint action of air and moisture upon the Carbonates in the Ankerite vein. The air and Carbonic acid, dissolved in common water, would probably suffice for this reaction, which might perhaps be aided by a low degree of heat; but at a red heat, as I have ascertained by experiment, anhydrous Ferric oxide, (and not Ferric hydrate,) is produced, even when steam is passed over the heated mineral. So gradual has the decomposition of the original minerals been, that their shape and cleavage have been perfectly maintained during the course of the metamorphism.

As to the Brown Hæmatites forming the bulk of the Londonderry ores, their mode of formation is somewhat more obscure, but is probably as follows: At a period subsequent to the formation of

the Ankerite veins, perhaps at the close of the Carboniferous epoch, the strata then existing were again much dislocated and fractured in consequence of further upheaval of the land in the Cobequid region, as is shown by the excessive faulting and numerous slickensides in the Ankerite veins. A fresh series of fissures was formed in about the same line of weakness as before, but this time with an average direction of  $10^{\circ}$  S. of W. Carbonated and aerated waters, trickling through the Ankerite veins, dissolved the Carbonates of Iron, Lime and Magnesia, perhaps with the simultaneous production of Red ore in the upper portions of the veins. The dissolved bicarbonate of Iron was then in its turn decomposed, oxidised, and deposited in the form of a bog ore, together with some of the comminuted shales derived from the surrounding rocks, this being the source of the siliceous matter present in the Londonderry Brown Hæmatites. These ores have all the appearance of bog ore, and also resemble it in composition; at times, too, they show small boulders of shale and Ankerite, as would be expected from such a mode of origin. They are thus secondary products of decomposition and solution, while the Red ore is the product of the primary decomposition *in situ* of the original Carbonates.

The mode in which the Brown Hæmatites have been produced may be readily illustrated in the laboratory. In the course of some experiments on this subject, I found that when Ankerite finely ground was suspended in water, and a current of Carbonic anhydride passed through it for about 10 hours, 13.5 p.c. of the Ankerite was dissolved. On blowing air through the clear solution, the Iron present was deposited in the form of a yellowish brown hydrate. On repeating the experiment with Sideroplesite, I obtained similar results, but the current of Carbonic anhydride was only kept up for about six hours, dissolving 8.2 p.c. of the mineral.

In conclusion, I once more wish to remind you that the geological relations of these veins to the surrounding strata are yet very obscure, and that the sketch of their history which I have here attempted to produce, may at any time be liable to correction when an exhaustive geological survey of the district shall have been made.