ART. VIII.—THE TRAP MINERALS OF NOVA SCOTIA.

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WE cannot now say positively who first sailed the Bay of Fundy, but as soon as the attention of the early European adventurers was directed to America we find numerous references to its tides and treasures.

We know, however, that for nearly one hundred years before the early part of the seventeenth century, its shores were visited by numerous daring sailors lured by the charm of the unknown, and the hope that they might acquire fortunes by a lucky discovery of mines of gold and silver.

In the patent granted by King Henry of France in 1603 to DeMonts, he is directed to carefully seek and mark all sorts of mines of gold, silver and copper, the tenth part of which was to be paid in royalty to the King. In 1604, DeMonts, Pontrincourt and Champdor visited Minas, and among other treasures deemed of value, they found at Blomidon great store of jasper, agate and amethyst. A number of these amethysts were carried to France and presented to the King, who ordered the choicest to be cut and set in some of the state crowns and swords. I believe that some of these jewels are still to be seen in the Paris museums, and they form an interesting memorial of those bold spirits who fondly dreamed that they were destined to found a second France on the American continent.

During the same day Champdor visited St. Mary's Bay with a mineralogist, and it is related that they found "pure copper," probably at Cape D'or.

Lescharbot found in 1606 "steel" in the rocks near St. John, which was smelted and made into knives. He also found "marcasite of copper" at LaHave. Writing in 1609, he speaks of the native copper of the Bay of Fundy as being "very pure in the stone," and adds, "many goldsmiths have seen it in France, which do say that under the copper mine there might be a gold mine, which is very probable."

Sir Humphrey Gilbert and others among the more celebrated

of the early sailors, commonly carried in their ships a few "rare refiners of mines."

Passing from these romantic explorers, whose dreams were of empires and gold mines, forts and Governorships, we come down to those who have studied the trap minerals in our own days. Among those may be mentioned Titus Smith, whose views on geological subjects were, for his day, sound and well sustained, although the modern geologist congratulates himself that his beloved study has passed such a rudimentary stage. In 1833, Messrs. Jackson and Alger visited the Bay of Fundy, and collected immense quantities of the trap minerals.

The late Dr. How and Dr. Webster also devoted much attention to this subject, and we are indebted to the former gentleman for many valuable analyses of these minerals and for the discovery of several new species. The labours of the latter are best known to you by the beautiful Webster collection now in the Provincial Museum, and by many specimens presented by him to the Museum of King's College. The study of these minerals also claims its list of martyrs, for a Professor of Acadia, with several students, was drowned in exploring the cliffs of Blomidon.

Their description of the Bay of Fundy minerals has directed the attention of mineralogists to the rich harvests its shore presents, and now there are few cabinets in America or Europe which do not contain specimens from its basaltic cliffs.

I purpose this evening to lay before you a brief outline of the process of formation of the measures related to these minerals, and to give the various analyses, etc., that I have been able to collect from the writings of Dawson, Dana, How and others. I am aware that my list cannot be considered complete, but will feel that the work has not been thrown away if others who have been enabled to devote more time to the study of these interesting minerals will kindly supply the deficiencies of my paper.

I may say to you that a visit to the trap districts of the Bay of Fundy will amply repay the lover of picturesque scenery. From Economy to Five Islands, Parrsboro and Cape D'or, there are presented continuous variations of fertile valleys and rugged cliffs. The shore, composed of strata varying from the almost incoherent triassic sandstones to the granite-like columnar

basalt, has been worn by the fierce tides into every curve and bold outline which can charm the artist's eye.

Those who have wandered under the beetling, forest-crowned cliffs of Blomidon, and watched the tides foaming in the ledges of Cape Split, and bearing in endless circles the luckless coaster who attempts the passage without favoring winds, have enjoyed one of the boldest and most picturesque views on the Atlantic coast, from Florida to the Labradors.

The narrow entrance to Annapolis Basin, the passage of the Islands, and the beautiful little cove that should have been named by a fairy, the site of an ancient crater, adorned by a lake and embowered in mingling verdure of field and forest, luxuriating in its shelter from every rude blast under the protection of encircling hills, all form landscapes which would amply repay the painter's art.

Nowhere on the Atlantic coast do the waves, accumulating before the southerly gales on their unimpeded march across the ocean, burst with more fury and afford a nobler sight than when they encounter the precipitous cliffs of Briar Island. Not unfrequently they maintain so steadily their furious attacks that for several days the unfortunate traveller can solace the tedium of his enforced detention only by watching their masses scattering in clouds of driving spray.

The geology of Nova Scotia presents a great void between the triassic and the boulder clays, so that here we look upon the former as quite a youthful representative of the long geological sequence. We learn that at the time when the deposition of the triassic strata commenced the Bay of Fundy presented an outline closely resembling that of the historical era.

The detrition of the carboniferous rocks surrounding it was effected by tides of great force, not, however, so powerful as those that now excite our curiosity. The fine sand and mud worn away by these tides was deposited in beds which we now see in the valleys of the Annapolis, Cornwallis, Avon and Salmon rivers, and at numerous other points along both sides of the Bay. The manner of their deposition was closely analogous to that now going on outside our dyked lands. These measures, as now exposed, are almost entirely composed of reddish sandstones,

with layers having greenish and purple tints, and have in the lower part beds of conglomerate. The sandstones are soft and not well adapted for the builder's art, although they are sometimes quarried for hearth and chimney stones.

They are frequently traversed by fissures filled with fibrous and translucent gypsum and calcspar, and have, as a rule, a calcareous cement. The presence of these salts of lime is readily accounted for when their abundance in the Lower Carboniferous measures is remembered; their particles carried into the newly formed beds have been dissolved by water and concentrated as veins and masses in the fissures and open spaces.

The soil of these sandstones, enriched by these two fertilisers, and the decomposed ingredients of the volcanic material about to be described, is of an excellent farming quality, so that Cornwallis and the valley of the Annapolis river are justly called the "Garden of Nova Scotia."

While these beds were forming, or shortly after their deposition, great subaqueous outbursts of volcanoes occurred. Enormous masses of scoriæ and dust were poured out and settled in extensive beds; these were succeeded by, or accompanied rivers of lava which rapidly consolidated into the basaltic masses now presented to our view. The history of the succeeding oscillations of level of the trias and its associated trap is not yet ascertained. The denudation has doubtless been very great, and both sandstone and trap have apparently once extended a long distance south of their present boundaries. The foci of these outbursts are still unknown, no systematic examination having yet been made of the courses of the trap, or of the effect of the tides on the submarine beds of scoriæ, etc., while they remained unconsolidated.

The most striking section of these measures can be seen at Blomidon. Here the sandstones dip at an easy angle to the north-west, and are succeeded by an immense bed of amygdaloidal trap, generally of a greyish color, but with tints of red. This bed is full of cavities and fissures holding the minerals to be noticed further on. In places the lower part of the amygdaloid appears to be very intimately mixed with sand, as if it had settled in the unconsolidated strata forming at the moment of

the volcanic outbursts. Above this comes a mass of compact dark, roughly columnar trap.

On the north shore of the Cape of Blomidon the sandstones appear on the beach; as they gradually rise to the south they finally attain a height equal to that of the trap, which by its hardness has preserved them from being washed away. Similar indications of the conformability of the trap, amygdaloid and sandstone are presented at other points, although, as might be expected, the former frequently alternate.

As the tides wear away the sandstones immense masses of the amygdaloid and trap, loosened by the rain and frost, are spread along the shore, and open a rich field to the mineralogist. This noble cliff, 400 feet in height, torn by the storms and frosts of winter, and mantled by trees and shrubs which vainly try to hide its losses, presents, with its dark walls and waving woods, a scene hardly to be expected in our usually tame landscapes.

There is a strong resemblance between the Nova Scotia trap and that which occurs along the Atlantic coast, in strata considered to be of Triassic age, as far as South Carolina. All being of one species and forming varieties of dolerite made up essentially of Labradorite and Pyroxene, with more or less disseminated magnetic oxide of iron, etc. No single analysis or set of analyses could exactly represent the composition of this great mass of rock.

We may first notice the economic minerals found in the rock under consideration:—

IRON ORES.

Magnetite.—This ore is frequently present in the trap, the amount varying in different localities, and may be detected by passing a magnet through the powdered rock. At certain points, among which may be mentioned Digby Neck, St. Mary's Bay and Blomidon, it is concentrated in veins up to a few inches in thickness, frequently associated with amethystine quartz and other forms of silica. The composition of this ore, which is frequently of a very high grade, will appear from the following analysis of a sample from the North Mountain:

Quartz	4.94
Magnesia	4.84
Oxygen	25.19
Metallic iron	65.03
	100.00

Red Hematite.—This occurs in a similar manner as a micaceous ore at many points on Digby Neck and at Cape D'Or, frequently as brilliant crystalline plates in a quartzose matrix. At some points in Hants County it is found in crystals, apparently showing its derivation from Magnetite.

Titaniferous Iron Ore.—This occurs as a sand on the north shore of St. Mary's Bay, apparently concentrated from the trap hills.

The above ores of iron, although of excellent quality, have nowhere been found to exist in quantities which will permit of systematic mining.

Copper.—As already mentioned, this metal is found native at Cape D'Or, Parrsboro', Five Islands and Margaretville, in irregular masses up to 50 lbs. in weight. It presents itself imbedded in the trap, or associated with jasper, zeolites, red copper oxide and carbonate. Operations have been frequently undertaken in the hope of finding deposits suitable for working, but hitherto without success. The occurrence of large and valuable deposits of copper in the Lake Superior trap has naturally raised expectations of similar treasures in this Province. The copper which appears to be derived from the strata with which the trap is associated is not so abundant in the containing measures here as on Lake Superior, and both trap and associated strata are of different age.

So long, however, as the copper continues to be found in plates, masses, etc., attempts will be renewed to prove their value, and it is quite within the possibilities that valuable amounts may be found. Any development in this district will probably be based on a discovery of large masses or layers of the rock containing the copper disseminated in minute grains. At

some localities on Lake Superior, I believe that rock holding one-half of one per cent. of copper is successfully treated by stamping and washing. I am not aware that attention has been directed to our trap with a view of determining if the metal be present under these conditions.

Dr. Dawson mentions the gray sulphuer of copper as occurring at Indian Point.

Antimony. The sulphide of this metal occurs at Margaretville in small quantities in trap.

Our attention is now more partcularly directed to those minerals whose presence in great numbers and beautiful forms has made our trap celebrated among mineralogists. It is stated that Mysore in India alone rivals it in the variety and abundance of its minerals.

These belong to the Fifth division of Dana's mineralogy—oxygen compounds—and may be subdivided into Binary oxygen compounds of the carbon-silicon group—and various subdivisions of the silicate section of the Ternary oxygen compounds.

Oxides of the Carbon Silicon group—series 2.

Quartz. The varieties of this mineral may be divided into two groups. The first comprising all ordinary vitreous quartz, the second the massive flint-like varieties.

First group. *Rock crystal.* This form frequently occurs in trap lining cavities, by itself, or forming a basis for other minerals.

Amethyst. This is found at many places both in the massive state, and in the characteristic crystals. It is frequently found with magnetite, in some cases penetrating it. Its colour varies from a faint violet to deep purple, and is generally considered due to the presence of manganese. But analyses have shown the absence of this element, and the colour has been considered to arise from minute qualities of compounds of iron and soda.

Smoky quartz or *Cairngorm* stone. This occurs with amethyst in the trap, but the largest and best known specimens are from the granite of Paradise, Annapolis County.

Some of the quartz crystals of Nova Scotia are said to show

cavities holding liquids, probably water holding some mineral in solution, or some hydrocarbon compound.

Among the second group may be mentioned—*Chalcedony.* This is a wax-like translucent variety of quartz, frequently found filling fissures in the trap and in botryoidal forms, and containing minute cavities lined by pellucid quartz crystals of almost microscopic size. When of a clear red colour it is called Carnelian. It is also found gray, brown and faint shades of blue and green, and is presented under various names, such as Plasma, Prase, Heliotrope, etc.

In Pliny's time, the Jasper included all these varieties excepting Carnelian.

Agate. This may be considered a variegated chalcedony, the colours being banded, clouded, or due to visible impurities, and are caused by traces of organic matter, iron, manganese, etc. Specimens of great beauty are found at nearly all points along the Bay shore, and sometimes weigh as much as 100 lbs. It is frequently noticed in little veins and strings.

Onyx and *Jasper* also occur abundantly, beside many varieties arising from mixtures of these substances.

Opal. This variety of quartz is a form of lower hardness, lesser specific gravity, and not possessed of capability of crystallization. The precious opal has been occasionally found here, but of small size. When of good colour it forms a valuable jem.

Cacholong is a softer variety frequently occurring as a lining of cavities. Semi or common opal is also frequently met. One common form of the opal is that of the accumulation and partial consolidation by resolution of the silicious shells of infusoria, which consist essentially of opal silica.

Among the Hydrous Silicates we may mention first the Pectolite group of the Bisilicates, represented by—

Laumontite. This mineral is generally flesh coloured, sometimes red, and both massive and crystalline. It is met here at Peter's Point, Port George, Long Point, and at Margaretville coloured green by copper.

The following analysis is by Dr. How, of a specimen from Port George :

Si 0.	Al 0.	Ca 0.	H 0.
57·43	21·64	12·07	15·26.

Gyrolite. Found on apophyllite between Margaretville and Port George. The following is an analysis of it :

Si. 0.	Al 0.	Mg. 0.	Ca. 0	K 0	H 0
51·90	1·27	·08	29·95	1·60	15·05

Centrallasite. This mineral, regarded as a variety of Okenite, occurs with Cyanolite and Cerinite in amygdaloid. It is of a radiated and lamellar form and of a whitish colour with pearly lustre.

The following is the composition of a Nova Scotia specimen :

Si. 0.	Al 0	Mg. 0	Ca. 0	K 0	H 0
1·86	1·14	·16	27·92	·59	11·42

Cyanolite. Amorphous of a bluish gray colour, and little lustre —occurs at Black Rock and vicinity. The following analyses are by Dr. How :

Si. 0	Al 0	Ca 0	K 0	H 0
74·15	·84	17·52	·53	7·39
72·52	11·24	18·19	·61	6·91

Dana remarks that it is probably the same as Centrallasite but impure with silica, or it is the same mineral with Chalcedony.

Louisite. This, the latest addition to our list of trap minerals, may be inserted here. Its colour is leek green, translucent with vitreous lustre.

The following analysis is by Mr. H. Louis :

Si 0	Al 0	Fe 0	Ca 0	Mg 0	K 0	Na 0	H 0
63·74	·57	1·25	17·27	·38	3·38	3·38	·08	12·96

It is apparently intermediate between the two last named minerals, and may perhaps be considered a variety of Okenite.

Chrysocolla. A silicate of copper holding water and iron is occasionally found as an incrustation.

The *Unisilicates* are represented by the Calamine and Apophillite groups.

The first group is represented by

Phrenite. A hydrated silicate of alumina and lime holding iron, occurring as firm, hard encrusting masses usually mamillated; among the localities yielding it may be mentioned Black Rock.

The second group is represented by

Apophillite. This mineral has been found at the same localities as Laumontite, and also at Chute's Cove, Swan's Creek, and Blomidon. It is presented both massive and crystalline, with white, red and green colours, and associated with zeolites. It is named from its exfoliation before the blow-pipe flame, and is also called fish eye from its resemblance to the eye of a boiled fish.

The following analysis of a Nova Scotia specimen is by Keakirt:

$$\begin{array}{cccccccc} Si\,O_2 & - & Ca\,O & - & K_2O & - & Fe\,O & - & H_2O \\ 52{\cdot}60 & - & 24{\cdot}88 & - & 5{\cdot}14 & - & 1{\cdot}71 & - & 16{\cdot}67 = 101{\cdot}00 \end{array}$$

The *Zeolite* section of the hydrous silicates however claims most attention. Dana divides them into eight groups, and remarks that the resemblance to the Feldspar group in oxygen ratios seems at first thought to imply resemblance in the scheme of composition at least. But there is wide divergence of crystalline form and physical character, while these points are grounds of unity in the Feldspar group. The water present has produced a wide divergence from the Feldspars, and it is therefore probable that it is in part at least basic.

They are composed essentially of silica and alumina with some alkali and more or less water, and generally gelatinise in acids.

1. *Mesotype group.*

Thomsonite. This occurs at Peters Point, and North mountain of Kings Co., in long and slender crystallisations of a grayish white colour, and as globular masses of radiated and interwoven crystals.

Mesole. This variety occurs in sperical concretions a few miles west of Blomidon. The following analyses are of Nova Scotia specimens:

Si. O_2	Al. O_3	Ca. O	Na. O_2	H. O_2	K. O_2	
41·26	29·60	11·71	5·29	12·63	——	=100·59 How.
41·64	30·52	9·21	4·95	13·11	·44	= 99·87 Marsh.

Natrolite. This occurs at Gates mountain, Cape d'Or, Two Islands, etc., often in bunches of transparent crystals. The following analyses are by Prof. Marsh :

	Si. O_2	Al. O_3	Ca. O	Na. O_2	K. O_2	H. O.
(1)	46·84	27·19	·24	14·89	1·50	9·79.
(2)	48·43	28·38	— —	14·23	1·16	10·11.

(1) Five Islands. (2) Cape Blomidon.

Scolecite, so called from its curling up like a worm before the blowpipe, also occurs with the above-named minerals.

Mesolite is found in the North mountain of Kings Co., and Gates mountain with Farœlite, in masses up to the size of a man's head, usually having the interior of fine pibrous radiated and somewhat plumose crystals.

	Si. O_2	Al. O_3	Ca. O	Na. O_2	Ka. O_2	H. D.	
(1)	46·66	26·48	9·63	4·83	——		How.
(2)	46·71	26·48	9·55	5·68	——		"
(3)	45·89	27·55	9·13	5·09	·48		Marsh.
(4)	45·39	28·09	7.55	5·28	·49		"

(1) & (2) Gates mountain. (3) Blomidon. (4) Sandy Cove.

1. *Levynite group.*—Not represented here.

3. *Analcite group.*—Represented in Nova Scotia by the mineral of the same name.

Analcite—So called from its weak electric power when heated. It is found at Martial's Cove, Five Islands, Cape D'or, Swan's Creek and McKenzie Head, as trapez ohedrons. It is generally presented in crystals in amygdaloid, sometimes an inch in diameter. A curious variety is described by Dr. Jackson, as occurring on the south shore of the Bay of Fundy. The crystals were verdigris green outside, and paler green within, from holding 2 to 3 per cent. of carbonate of copper. It is sometimes found attached to plain cuts of copper holding it to the rock or suspending it in cavities.

4. *Chabazite Group.*

Chabazite. This is one of the most characteristic of our trap minerals, and occurs usually in rhombohedrons of gray or wine-colour tints, with Heulandite, Analcite, and Calcite at Five Islands, Swan's Creek, Mink Cove, and Williams Brook. This mineral occasionally contains Baryta, and Strontia.

The following are analyses of specimens from Parrsboro':

Si. O_2	Al. O_3	Ca. O	Na. O_2	K. O_2	H. O_2	Fe. O	
51·46	17·65	8·91	1.09	·17	19·66	·85	Hoffman.
52·14	19·14	7·84	·71	·98	19·19	—	Ramelsberg.

Acadialite is a reddish coloured variety, so named from its having been first found in Nova Scotia. In some specimens the colouring matter is arranged in layers and bands in the body of the crystals.

The following analyses are by Hayes :

Si. O_2	Al. O_3	Ca. O	Na. O	K. O	H. O
52·02	17·88	4·24	4·07	3·03	18·30
52·20	18·27	6·58	2·12	—·-	20·52

The difference being chiefly in the greater amounts alkalies and lessened percentage of lime in the latter mineral. Among the localities yielding it most abundantly may be mentioned Two Islands.

Gmelinite. This species is not very common here, it being met principally at Blomidon (as Ledererite) and on the north shore nearly opposite Cape Sharp, in geodes with analcite, and frequently implanted on quartz.

Ledererite (mentioned above) is ordinary Gmelinite impure with free silica. Marsh has shown that it does not differ in the percentage of water, and Descloiseaux that its crystalline angles are the same.

The following analyses by Prof. Marsh are of specimens from the vicinity of Cape Blomidon. The two first show an excess of silica due to visible quartz which was separated in the third analysis :

Si. O_2	—	Al. $O_{2\ 3}$	—	Ca. O	—	Na. O	—	K. O	—	H. O_2.
53·71	—	17·63	—	6·52	—	3·10	—	·80	—	17·98
51·32	—	18·45	—	6·41	—	——	—	3·48	—	20·35
47.19	—	20·13	—	7·44	—	3·54	—	·91	—	20·53

5. *Phillipsite Group.*

This group as represented by Phillipsite is reported to have been found in this Province, but I have not seen any specimens myself. It is well known as showing beautiful cruciform crystals, of three twinned prisms crossing each other at right angles.

6th. I am not aware of the occurrence of members of the 6th or Harmotome, or of the 7th, or Stypostilbite, groups among our Nova Scotia varieties.

8th. *Stilbite group.*

Stilbite.—This is the most common of our trap minerals. Its colours usually white and lustrous, whence its name, and it is presented in sheaf-like, lamellar and radiated forms. At Partridge Island it occurs as a perpendicular vein from three to five inches wide and 50 feet long, intersecting amygdaloid. Also found at Isle Haute, Gulliver's Hole, Digby Neck, Black Rock, Hall's Harbor, Blomidon, etc.

Epistilbite. — This variety occurs in small reddish crystals, nearly or quite opaque, at Margaretville, associated with stilbite.

The following analysis are of specimens from this locality:

Si O_2	—	Al $O_{2\ 3}$	—	Ca O	—	Na O	—	K O	—	Fe O	—	H O_2	How
58·57	—	15·34	—	7·00	—	·99	—	·99	—	1·58	—	15·42	"
58·35	—	16·73	—	7·87	—	2·10	—	——	—	——	—	14·98	"

Heulandite.—This mineral occurs at Peter's Point in white and reddish colours, with Laumontite, Apophyllite and Thompsonite, also at Blomidon and Black Rock in crystals, colourless and flesh-coloured, frequently an inch and a half long, and at Two Islands as yellow crystals, and at the localities mentioned under the head of Stilbite.

Cerinite is of a similar composition, but massive with waxy

lustre. It was first described, I believe, by Dr. How, who gave the mean of two analyses :

Si 0	Al 0	H 0	Mglod.	Ca 0	K 0	H 0
57·57	12·60	1·14	1·87	9·82	·37	15·69

It has been noticed forming the thin outer crust of amygdules in trap near Black Rock.

Mordenite.—This mineral, also a discovery of Dr. How, occurs near Morden in trap with Apophyllite, Barite, and a Phrenite like mineral, also with Gyrolite at Peter's Point, eight miles west of the preceding locality.

The following is his analysis :

Silica	Alumina	Lime	Soda	Water.
68·40	12·77	3·46	2·35	13·02

It is presented in small cylindrical and reniform masses, with a whitish yellow and pink colour. It is the most highly silicated of the Aluminous non magnesian hydrous silicates, yet described.

Steelite.—This variety occurs at Cape Split, and is so well defined that it is proposed to give it a place as a variety of Mordenite.

Among the better known minerals, outside the zeolite, may be mentioned :

Chlorophœite, a dark green to brown mineral, found imbedded but generally as a lining in cavities.

Delessite, or Ferruginous Chlorite, has been reported from Partridge Island, where it is said to fill cavities in the amygdaloid.

Glauconite.—This hydrous silicate of iron and potash, belonging to the class found in cavities in eruptive rocks, occurs at several points.

Gypsum.—This mineral occurs fibrous, massive and foliated, at numerous localities.

Calcspar is frequently met with. Fine specimens are met as rhombohedral, white-yellow crystals, and as dog-tooth spar, at Partridge Island, Two Islands and Black Rock.

Barite is also met accompanying many of the above mentioned minerals, in the massive, lamellar and crested forms.