

# Contributions to Canadian Mineralogy, 1923

## EXPLANATION OF PLATE IV

- Fig. 1. Tough-Oakes Mine—gray, coloradoite—white, altaite and gold—black, gangue ( $\times 80$ ).
- Fig. 2. Tough-Oakes Mine—gray, coloradoite—white, altaite—black, gangue ( $\times 80$ ).
- Fig. 3. Tough-Oakes Mine—dark gray, petzite—light gray, coloradoite—black, gangue ( $\times 150$ ).
- Fig. 4. Tough-Oakes Mine—gray, coloradoite—white, low relief, altaite—high relief, melonite ( $\times 150$ ).
- Fig. 5. Miller-Independence Mine—white, calaverite—gray, chalcopyrite ( $\times 150$ ).
- Fig. 6. Miller-Independence Mine—white, calaverite—gray, pyrite and chalcopyrite ( $\times 150$ ).

FROM THE

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THE NORTH MOUNTAIN BASALT OF NOVA SCOTIA:  
GLACIATION, TUBULAR AMYGDALOID,  
MORDENITE, AND LOUISITE

By T. L. WALKER and A. L. PARSONS

*Local Glaciation*

Many workers have recorded their observations on the glaciation of Nova Scotia. Some, like Chalmers,<sup>1</sup> have regarded it as entirely local, radiating from the high central part of the province in all directions toward the sea. Chalmers was of the opinion that the peninsula has not been swept by a great glacier of a continental nature. In a map accompanying his report, the directions of the glacial striae are indicated. Goldthwait,<sup>2</sup> however, favoured general continental glaciation, and on his map indicated the directions of the movement as shown by the glacial striations. Others have favoured general continental glaciation, followed by local glaciation from the centre of the province towards the borders.

While the writers were engaged during 1921 and 1922 in the study of the occurrence of the zeolites of Nova Scotia, they observed what appears to be a very clear example of local glaciation from the highlands of the South Mountain in a north-westerly direction across the Annapolis Valley and the North Mountain to the shore of the Bay of Fundy. Their observations are submitted herewith as a contribution to this subject.

Just east of the wharf at Hampton, Annapolis County, there is a very good section consisting of twenty feet of a tough reddish boulder clay overlain by ten feet of well-sorted stratified gravel and sand. The clay shows stratifi-

<sup>1</sup>Chalmers, R., *Geol. Surv. Can.*, 1896, Vol. VII, Part M.

<sup>2</sup>Goldthwait, J. W., *Geol. Surv. Can., Sum. Rep.*, 1913, p. 244, and *Museum Bulletin*, No. 14, 1915.

cation on a small scale suggesting that the boulder clay has been formed by the melting of masses of floating glacial ice in deep quiet water, thus permitting the deposition of the whole burden without any sorting. The boulders are principally metamorphic slates and quartzites, and are well striated, as shown by the accompanying illustration of a boulder from the till (Plate I, Fig. 1). The clay, as already stated, is very tough and of a reddish brown colour. A sample freed from coarser sand grains and pebbles was analysed by E. W. Todd with the following result:

SiO <sub>2</sub> .....	72.16
Al <sub>2</sub> O <sub>3</sub> .....	10.97
Fe <sub>2</sub> O <sub>3</sub> .....	2.86
FeO.....	1.29
CaO.....	2.88
MgO.....	1.54
K <sub>2</sub> O.....	2.14
Na <sub>2</sub> O.....	1.57
MnO.....	.14
TiO <sub>2</sub> .....	.71
P <sub>2</sub> O <sub>5</sub> .....	.11
H <sub>2</sub> O.....	2.76
CO <sub>2</sub> .....	1.33
	<hr/>
	100.46

The high content of K<sub>2</sub>O as compared with Na<sub>2</sub>O, of MgO as compared with CaO after deducting the amount of lime to combine with the carbonic acid (viz., 1.54:1.20), and the high content of TiO<sub>2</sub> all suggest that the clay has been derived from material already well leached and weathered.

In the small cove forming the harbour at Hampton there is a very fine beach consisting of well-rounded pebbles. The pebbles are similar to those found in the boulder clay with only a small representation of trap. The beach fragments along the shore to the north of the North Mountain are usually almost entirely trap, and in this the assemblage of lithological types at Hampton is quite exceptional.

To the south-east of Hampton the land rises in a series of ill-defined terraces to an altitude of about 240 feet. This suggests a considerable elevation of the shore since the glaciation, a condition which would provide for the deposition of the boulder clay in deep, still water.

About three-quarters of a mile to the south-east of Hampton on the north slope of the mountain in pasture fields there was observed, covering an area of about ten acres, a remarkable assemblage of enormous granite erratics. One was found on measurement to be twelve feet long, while another was nearly thirty-three feet in circumference. The rock is a very coarse grey biotite granite with porphyritic crystals often three inches in length (Plate II, Fig. 1). This very characteristic granite does not resemble any New Brunswick granite known to the writers, while it appears to be identical with the typical South Mountain granite which is very constant over wide areas. Just north of Lake Groskil along the road over the mountain toward Bridgetown, a few blocks of the same granite were observed along with metamorphics like those seen in the till. Near the crest of the mountain on the road to Bridgetown the trap was seen to be well striated and grooved, the striae being N. 32° W., while the deeper grooves are N. 50° W. (Plate I, Fig. 2). Similar striations were observed on the trap a few hundred feet east of the wharf at Hampton.

When in the vicinity of Lawrencetown, one observes a distinct valley leading up to a gap in the North Mountain, which probably served as the outlet for the local glacier which carried the peculiar assortment of erratics towards Hampton. In the vicinity of Lawrencetown the small areas of metamorphics bordering the South Mountain batholite appear to provide most of the lithological types observed in the till on the beach at Hampton.

When in the vicinity of New Ross in Lunenburg County, the writers observed that in some places the coarse grey porphyritic biotite granite, almost identical with that seen in the great boulders, was weathered to a considerable depth. A mile or two north of New Ross on the way to Kentville

there is a great pit by the roadside from which at least one hundred cubic yards of decomposed granite had been taken for surfacing in roadmaking. This seems to indicate that in this region there had been little, if any, glacial scouring, and the writers suggest that the glacier which debouched at Hampton moved from the New Ross region as a centre in a north-westerly direction over the Annapolis Valley and the North Mountain to Hampton. The amount of depression cannot be stated with accuracy, as there are few fixed elevations in the region concerned. A depression and subsequent elevation of at least 250 feet, which is indicated by the beaches referred to, would flood the Annapolis Valley and provide for the formation of the very abrupt face of the traps on the south side of the North Mountain.

Many of the data contained in this account are in accord with the previous observations by Chalmers. An attempt has been made to indicate very definitely the observations on which our conclusions are based, so that they may be checked by others interested in this field. In our opinion, the facts assembled prove that, while there may possibly have been a general continental glaciation of Nova Scotia as maintained by Goldthwait, there has certainly, as a last act, been a northward movement from the highlands of north-eastern Lunenburg, which is now over 800 feet above sea level, across the Annapolis Valley and the North Mountain to the Bay of Fundy at Hampton.

*The Distribution of Tubular Amygdaloid in the Traps of Nova Scotia*

In 1922 the writers called attention to the occurrence of a tubular amygdaloid in the traps along the shores of the Bay of Fundy, particularly at Mill Brook, near Morden, Kings County, and at Margaretville, Annapolis County. In the following summer its distribution was noted in a large number of places where the traps are well exposed. So

<sup>1</sup>Walker, T. L., and Parsons, A. L., *Contributions to Canadian Mineralogy*, 1922.

general does it appear to be that it may be recognized on almost every day's tramp in the trap region. On the south-west of Partridge Island the tubes range from one and a half to three inches in diameter and stand normal to the flows which here dip to the north. They have also been observed in loose blocks at Cape Sharp, on the Blomidon shore about one mile west of Captain Kidd's Cove, and in the vicinity of Amethyst Cove. The same structure is apparent in blocks at Wasson's Bluff and on the shore of the larger of the Two Islands. An unusually fine display was observed in the sea-washed floor between low and high tide, both to the east and to the west of Sheffield Vault, in Kings County. In the neighbouring cliffs, tubes are well developed in compact dark trap. The zeolites occur here, either filling the whole tube or more commonly as the filling of the individual cells of the tubular structure. In the base of the amygdaloidal flow, spike amygdules, sometimes nearly a foot long and about a quarter of an inch in diameter, are well developed with a tendency to bend over towards the south-east, thus indicating the direction in which the molten lava flowed at this point.

The most spectacular development of tubular amygdaloid yet observed was found in the central cliff at Ste. Croix Cove, where the amygdaloidal tubes reach a maximum of six inches in diameter. They extend from the amygdaloidal basal portion of the flow, through the more compact central part to the porous upper portion.

The observations of 1922 are in accord with the suggestion in our earlier paper, in which we regarded the tubes as due to the escape of hot water vapours from the moist floor, through cracks in the chilled and solid underpart of the flow, into the still molten central part. It seems probable that much of the cellular structure in the tops of the flows is due to these vapours rather than to gases which were a part of the magma at the time of eruption. For an examination of these structures the writers suggest a visit to Mill Brook, Sheffield Vault, or Ste. Croix Cove.

*Mordenite from New Localities in Nova Scotia*

In June, 1922, the writers spent two days along the shore in the vicinity of Hall Harbour, Kings County, Nova Scotia. Mordenite was found as beach pebbles between White Water and Chipman Brooks, and also for about a quarter of a mile west of Hall Harbour. It was found forming radiating masses in blocks of reddish basalt, sometimes *in situ*, half way between Murray Brook and Black Rock. In the last instance the mordenite is slightly reddish in colour and forms finely radiated fibrous masses up to an inch in diameter. The basalt is seen in thin sections to be unusually fresh and slightly porphyritic in character. A sample from the last-named locality was prepared for analysis by the use of a heavy liquid composed of bromoform and carbon tetrachloride. Analysis by E. W. Todd:

SiO <sub>2</sub> .....	67.18	1.119	÷9=	124
Al <sub>2</sub> O <sub>3</sub> .....	12.36	.122	}	.123
Fe <sub>2</sub> O <sub>3</sub> .....	.24	.001		
CaO.....	3.42	.061	}	.119
Na <sub>2</sub> O.....	3.34	.053		
K <sub>2</sub> O.....	.47	.005		
H <sub>2</sub> O.....	13.23	.734	÷6=	122
	<hr/>			
	100.24			

S.G. 2.125

This analysis corresponds almost exactly to the formula  $RO \cdot Al_2O_3 \cdot 9SiO_2 \cdot 6H_2O$ . It may be noted that since How described mordenite from Morden and Margaretville in 1864 it has not been found in any other point in Nova Scotia till its discovery at the above three new localities.

*On the Nature of Louisite*

In 1878 Honeymann<sup>1</sup> gave this name to a zeolite which formed part of a boulder picked up on the Blomidon shore by Robert Starr, who accompanied Honeymann while he

<sup>1</sup>*Nova Scotian Institute of Natural Science*, Vol. V, p. 15.

was engaged in 1877 in the study of the geology of that region. It was analysed by H. Louis, after whom it was named by Honeymann. The mineral was closely related to apophyllite in composition, except that it was much higher in silica.

The type specimen is the property of the Provincial Museum in Halifax; and when Mr. Harry Piers, curator of that institution, suggested that it should be re-examined, I gladly followed his suggestion in order to find the true place of lousite among the zeolites.

The specimen, which is waterworn, weighs less than one pound. It is white on the outer surface, and when examined by a strong lens is seen to contain innumerable tiny roundish masses somewhat glassy in lustre. The white crust extends to a depth of about an eighth of an inch and surrounds the leek-green glassy mineral which has been known as lousite. Louisite is quite cleavable in one direction, possesses a vitreous lustre, and as it can be readily scratched with a knife, appears to be about 5 in the scale of hardness. Its streak is white, and according to Louis has a density of 2.41.

A thin section prepared for microscopic study showed, when examined between crossed nicols, that lousite is an aggregate of radiating spherules of quartz in cleavable apophyllite (Plate III, Fig. 1). A portion from the centre of the mass was crushed and treated with a heavy liquid consisting of bromoform and carbon tetrachloride of such a density that about half of the powdered mineral floated, while the rest sank to the bottom. When these two portions were examined with the microscope, it was found that the lighter was almost entirely free from quartz spherules, and had a density of 2.369, which agrees with the known values for apophyllite. In the heavier portion nearly all the grains were complex, consisting of radiating masses of quartz usually attached to fragments of apophyllite. The density of the heavier portion was found to be 2.542, which would correspond to a mixture of quartz and apophyllite in the ratio of 2:1.

The apophyllite was analysed by E. W. Todd with the following result:

	%	Molecular Ratio	Apophyllite	Balance
SiO <sub>2</sub>	53.64	.893	.864	.029
Al <sub>2</sub> O <sub>3</sub>	.12	.001	.....	.001
Fe <sub>2</sub> O <sub>3</sub>	.18	.001	.....	.001
CaO	24.19	.432	.432	.....
Na <sub>2</sub> O	.64	.010	.007	.003
K <sub>2</sub> O	4.42	.047	.047	.....
H <sub>2</sub> O	16.61	.923	.905	.018
F	.48	.026	.026	.....
Less Oxygen equivalent	.20			.....
	100.08			

The molecular ratios of the different constituents are indicated in the second column. In the third, the constituents which go to form the apophyllite on the basis of the formula of Rammelsberg,  $4\text{CaO} \cdot 8\text{SiO}_2 \cdot 8\text{H}_2\text{O} \cdot \text{K}(\text{F}, \text{OH})$ , are indicated. In the last column the balance is very small, consisting of 1.74% SiO<sub>2</sub>, .12 Al<sub>2</sub>O<sub>3</sub>, .18 Fe<sub>2</sub>O<sub>3</sub>, .18 Na<sub>2</sub>O, and .32 H<sub>2</sub>O. Chemically considered, the lighter portion is very nearly pure apophyllite with a little quartz and very slight mixture probably of some zeolite.

The optical properties of the two minerals which make up the aggregate known as louisite, were examined by the immersion method and found to possess indices of refraction in accord with the suggestion that the individual minerals are quartz and apophyllite.

We wish to acknowledge the kindness of Mr. Piers in permitting us to examine the only known specimen of louisite.

## ELLSWORTHITE AND ASSOCIATED MINERALS FROM HYBLA, ONTARIO

By T. L. WALKER and A. L. PARSONS

(Presented, Mineralogical Society of America, December, 1922.)

In 1922 the Royal Ontario Museum of Mineralogy obtained some specimens from a pegmatite deposit on Lot 18, Concession VII, Monteagle Township, Hastings County, Ontario. At that time the deposit was being worked as a quarry for feldspar. Some specimens were composed of very coarse salmon-coloured calcite, which was penetrated by much corroded smoky quartz. In these two minerals were included numerous small crystals of zircon, an occasional crystal of titanite, and two unknown minerals, one amber yellow and the other dark chocolate brown. These two as will appear later are closely related chemically and may be considered as varieties of a single species. The yellow type is more common in the calcite, while the darker type is often surrounded by the smoky quartz. Some masses are made up almost entirely of a single variety, while others contain both, the dark type forming the centre, the yellow the border.

Both varieties are massive, devoid of cleavage, and adamantine in lustre. The fracture is small conchoidal. Hardness about 4. Under the microscope they are seen to be isotropic, one pale yellow and transparent, the other brownish and transparent only in thin splinters and small grains. The indices of refraction in both varieties are higher than 1.74. The streak varies from pale brownish yellow to pale chocolate. The yellow type resembles some varieties of sphalerite and garnet, but the lack of cleavage and the low hardness serve as distinctive features. In colour and lustre the darker type bears some resemblance to the chocolate coloured

titanite from Renfrew, Ontario. In density the darker type is somewhat higher.

The analyses by E. W. Todd are as follows, I lighter, II darker:

	I		II		
Nb <sub>2</sub> O <sub>5</sub> .....	34.22	.125	34.27	.125	
Ta <sub>2</sub> O <sub>5</sub> .....	4.32	.009	4.27	.009	
TiO <sub>2</sub> .....	10.47	.131	9.79	.122	
SnO <sub>2</sub> .....	.10	.001	.25	.002	.30
SiO <sub>2</sub> .....	2.54	.042	2.68	.047	
F.....	.22 (x $\frac{1}{2}$ )	.005	.49 (x $\frac{1}{2}$ )	.013	
UO <sub>2</sub> .....			8.42	.031	
UO <sub>3</sub> .....	18.50	.065	10.68	.037	
CaO.....	11.73	.209	13.62	.243	
MnO.....	.43	.003	.22	.003	.321
PbO.....	.24	.001	.41	.002	
Rare Earths.....	.21	.001			
Fe <sub>2</sub> O <sub>3</sub> .....	4.10 (x $\frac{3}{2}$ )	.038	3.80 (x $\frac{3}{2}$ )	.036	
Al <sub>2</sub> O <sub>3</sub> .....	.42 (x $\frac{3}{2}$ )	.006			
H <sub>2</sub> O.....	12.22	.677 ÷ 2 = .338	11.42	.634 ÷ 2 = .317	
	99.72		100.32		
S.G.....	3.608		3.758		

From the above analyses and calculations the formula RO.Nb<sub>2</sub>O<sub>5</sub>.2H<sub>2</sub>O is deduced for both types with RO=UO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, and CaO while TiO<sub>2</sub>, SiO<sub>2</sub>, UO<sub>2</sub>, and Ta<sub>2</sub>O<sub>5</sub> replace Nb<sub>2</sub>O<sub>5</sub>. Both the yellow and the brown minerals are, therefore, metatitanoniobates of uranium, lime and iron with two parts of water and appear to be distinct from all other isotropic minerals containing uranium and niobium. Being intermediate in water content between ampingabéite and hatchettolite, it is remarkable that they are much lower in specific gravity than either of them. Chemically the two varieties differ principally in the state of oxidation of the uranium. In the dark form about half of the uranium is in a lower state of oxidation, is acidic in character, and apparently causes the darker colour.

Both types give up considerable water at 100°. At 176° the dark type has given off 5.92% of water. At 200° it gains

in weight, and changes in colour from black to yellow brown, so as to resemble the powder from the yellow type. At 225° it is still heavier than at 176°. This gain in weight ac-

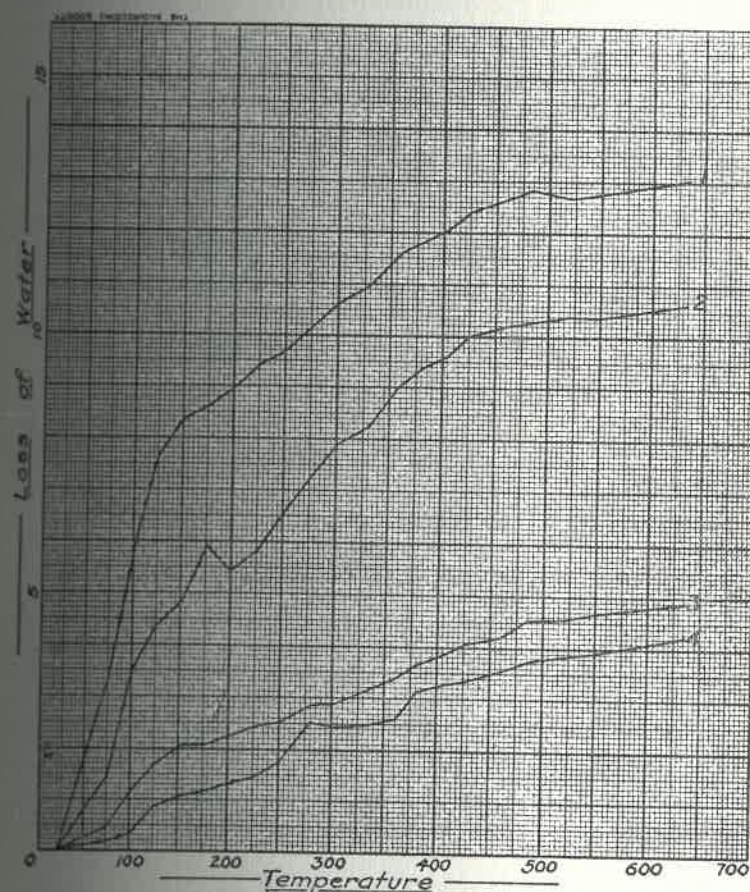


Fig. 1. Dehydration curves. (1) Yellow Ellsworthite, (2) Dark Ellsworthite, (3) Light Hatchettolite, (4) Dark Hatchettolite.

companied by the change in colour probably indicates the oxidation of the uranium from the dioxide to the trioxide. The gain in weight, while not known exactly, owing to the



simultaneous evolution of water and oxidation seems to be about the amount of the oxygen necessary to convert all the uranium to the higher state of oxidation as shown by the titration of the dissolved mineral with permanganate. The question as to whether the uranium or iron is in the lower state of oxidation may be decided in favour of the former since the gain in weight is marked by the mineral becoming lighter in colour rather than the reverse, as is characteristic for iron compounds. The details of the dehydration of both types is shown graphically in Fig. 1.

A similar recalculation of the analyses of other isotropic uranium niobates and titanates shows the following formulae:

Pyrochlore. . . . .	RO . Nb <sub>2</sub> O <sub>5</sub>
Hatchettolite. . . . .	RO . Nb <sub>2</sub> O <sub>5</sub> . H <sub>2</sub> O
Ellsworthite. . . . .	RO . Nb <sub>2</sub> O <sub>5</sub> . 2H <sub>2</sub> O
Ampangabéite. . . . .	RO . Nb <sub>2</sub> O <sub>5</sub> . 3H <sub>2</sub> O
Euxenite. . . . .	RO . 2Nb <sub>2</sub> O <sub>5</sub> . H <sub>2</sub> O, Maberley, Ontario
Wiikite. . . . .	RO . 2TiO <sub>2</sub> . H <sub>2</sub> O
Betafite. . . . .	2RO . 3Nb <sub>2</sub> O <sub>5</sub> . 3H <sub>2</sub> O
Samiresite. . . . .	RO . 2Nb <sub>2</sub> O <sub>5</sub> . 5H <sub>2</sub> O
Euxenite <sup>1</sup> . . . . .	RO . 2Nb <sub>2</sub> O <sub>5</sub> . H <sub>2</sub> O
Blomstrandite <sup>1</sup> . . . . .	RO . 2Nb <sub>2</sub> O <sub>5</sub> . 3H <sub>2</sub> O

The mineral is strongly radioactive, as is shown by the following table, giving data on the comparative activity of a number of minerals as determined by the electroscopes:

Mineral	Locality	Uranium	ThO <sub>2</sub>	Activity
Euxenite. . . . .	Maberley, Ont.	8.91 <sup>2</sup>	1.34 <sup>2</sup>	1
Ellsworthite (yellow). . . . .	Hybla, Ont.	15.40		1.023
Ellsworthite (black). . . . .	Hybla, Ont.	16.31		1.114
Pitchblende. . . . .	Unknown			5.000
Columbite. . . . .	Hybla, Ont.		3.34	.110
Hatchettolite. . . . .	Hybla, Ont.	9.27	.42	.803
Hatchettolite. . . . .	Hybla, Ont.	13.58	.52	1.128

<sup>1</sup>Lacroix, *Min. de la France*, V, pp. 27 and 72.

<sup>2</sup>Ont. Bureau of Mines, Vol. XXVI, p. 316.

Some of the associated minerals when in contact with the ellsworthite have undergone interesting colour changes, which at first were supposed to be due to radioactivity. The calcite, which is salmon-coloured at a distance from the mineral (Plate III, Fig. 5), is pale purplish or cream-coloured where it is in contact with the ellsworthite. In contrast to the yellow type, which is usually found in calcite, the dark type occurs surrounded by quartz, which always shows radial shattering (Plate III, Fig. 4). The fracturing may be due to the expansion caused by hydration with loss in density or to the ellsworthite possessing a lower coefficient of expansion, so that in the fall from a higher temperature at which the quartz was probably formed, the quartz was no longer able to contain the included mineral without radial fracturing. The changes in colour are due to oxidation of iron and manganese in the shattered zones.

The uranium-lead ratios for the two types would appear to indicate that the yellow mineral was deposited about 114 million years ago, while the brown type has an age of 197 million years, which is much less than the age usually assigned to the Grenville rocks in which the pegmatite occurs. Most of the material is embedded in calcite which may indicate a much later period of deposition than for the pegmatite as a whole. According to Rutherford,<sup>1</sup> the radium content varies with the uranium content. Since three metric tons of metallic uranium contain one gram of radium, the mineral from Hybla should contain 51 milligrams per ton. The proportion of ellsworthite in our specimens and its richness in radium indicate that we have at Hybla the most interesting known occurrence of radium in Canada.

We propose the name ellsworthite for this mineral, in honour of Dr. H. V. Ellsworth of the Geological Survey of Canada, who for some time past has been engaged in the examination of the deposits of radioactive minerals in Canada.

<sup>1</sup>Rutherford, E., *Radioactive Substances*, p. 462.

The minerals associated with the ellsworthite in certain cases show features of considerable interest, and a brief description follows:

*Zircon.*—Zircon occurs embedded in calcite and to some extent in quartz. The crystals are seldom brilliant enough to give good signals on the goniometer. The following forms are recognized: a(100), m(110), p(111), u(331), v(221), y(141), and as an etch form L(142). Many of the crystals are somewhat constricted at the centre, giving a curvature to the prismatic faces. The contact between the zircon and quartz shows corrosion of the quartz, giving evidence that both were constituents of the original pegmatite.

*Quartz.*—The quartz is somewhat smoky, and marked corrosion characterizes the surface of this mineral, both in the calcite and in crevices and cavities of the pegmatite.

*Microcline.*—The major part of the feldspar is pale flesh pink microcline. One crystal suitable for measurement yielded the forms c(001), b(010), m(110), x( $\bar{1}01$ ), e(111), and the new form ( $\bar{1}02$ ).

*Oligoclase.*—Several crystals were suitable for determining forms. Signals were obtained from c(001), m(110), M( $\bar{1}\bar{1}0$ ), and b(010). The form x( $\bar{1}01$ ) was determined by inspection. In addition e(021), n( $0\bar{2}1$ ), j( $\bar{1}\bar{1}1$ ), and r(120) were observed as striated corrosion forms which yielded approximate measurements with the contact goniometer. A similar face, which was much more deeply corroded, occupied the position between m(110) and c(001), possibly corresponding to (111). The form ( $\bar{1}\bar{1}1$ ) is new for this mineral. The striking feature of these crystals is the presence of the corrosion faces, which usually show corrosion troughs parallel with (010), but in some cases the troughs are nearly at right angles to the usual direction or somewhat curved.

*Calcite.*—The calcite which accompanies ellsworthite is a deep salmon pink in colour and of a coarse crystalline texture, with cleavage parallel to r(01 $\bar{1}1$ ) and sometimes to e(01 $\bar{1}2$ ). An analysis by E. W. Todd follows:

	Percentages	Molecular Parts
CaO.....	55.43	990
CO <sub>2</sub> .....	43.86	995
FeO.....	.28	004
MnO.....	.21	003
SiO <sub>2</sub> .....	.03	001
Moisture.....	.10	005
Total.....	99.91	

No traces of Nb<sub>2</sub>O<sub>5</sub>, Ta<sub>2</sub>O<sub>5</sub>, TiO<sub>2</sub>, ZrO<sub>2</sub>, WO<sub>3</sub>, SnO<sub>2</sub>, rare earths, Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, U<sub>3</sub>O<sub>8</sub>, MgO, ZnO, F, S, SO<sub>3</sub>, or P<sub>2</sub>O<sub>5</sub>, were found. The colour is due to manganese and possibly ferrous iron, as is clearly shown by the decolouration of the calcite near the contact with the ellsworthite, where secondary hematite has been formed in cleavage cracks, together with a black mineral which is possibly pyrolusite, though in too minute a quantity to be identified with satisfaction.

*Titanite.*—Two specimens of dark chocolate-brown titanite were obtained, which with the contact goniometer were found to have the forms Y(101) and o(310).

*Pyrrhotite.*—A single mass of pyrrhotite was collected from the dump. The field relations were not observed. The specimen shows marked polarity.

*Chalcopyrite.*—This mineral was observed as a few scattered particles in pyrrhotite.

At least two distinct periods are shown by the minerals associated with ellsworthite; first the original pegmatite with microcline, oligoclase, quartz, zircon, dark ellsworthite, and titanite; second, calcite and the yellow ellsworthite.

The order of crystallization is somewhat puzzling, as zircon has not been observed with either of the feldspars, but so far as can be judged the order is zircon, titanite, quartz, and the feldspars for the original pegmatite. Portions of the pegmatite show indisputable evidence of corrosion, and the cavities thus produced are largely filled with calcite, which encloses zircon, ellsworthite, and quartz.

A striking feature of the association is the marked radial shattering of quartz, which was first observed where the quartz enclosed zircon and later around the inclusions of ellsworthite. Distinct shattering of other minerals is not pronounced, but the decolouration of the calcite about the ellsworthite with inclusions of hematite in the cleavage cracks is distinct evidence of a shattering of the calcite. The two types of shattering appear to be due to two distinct causes: difference in the coefficient of expansion where zircon and quartz are involved, and an increase in bulk where ellsworthite is present. These phenomena are more fully discussed elsewhere (p. 25).

HATCHETTOLITE AND ASSOCIATED MINERALS FROM HYBLA, ONTARIO

By T. L. WALKER and A. L. PARSONS

At the feldspar quarry of the Pennsylvania Sand and Glass Co. on Lot 17 of the Eighth Concession of Monteagle Township quite a variety of minerals was observed in 1922 when the quarry was in active operation. The pegmatite, where exposed, is seen to strike northeast-southwest with the general strike of the containing granite-gneiss complex. The pit is about 40 feet wide and 200 feet long. The feldspar is mostly pink to grey microcline, with a smaller proportion of beautiful green microcline lined with white glassy plagioclase in a perthitic fashion.

*Hatchettolite*

This mineral appears in two slightly different types, one black, the other somewhat amber-tinted in thin splinters. They are both conchoidal in fracture, and about 4 in hardness. The hatchettolite occurs without crystal form in irregular masses closely associated with reddish feldspar and cyrtolite. Both types are nearly isotropic and possess refractive indices higher than 1.74. The two types were analysed by E. W. Todd with the following result:

	Dark Type			Light Type		
Nb <sub>2</sub> O <sub>5</sub> . . . .	31.33	.117	} .334	31.70	.119	} .281
Ta <sub>2</sub> O <sub>5</sub> . . . .	10.29	.023		15.28	.034	
TiO <sub>2</sub> . . . . .	11.37	.142		8.82	.107	
UO <sub>2</sub> . . . . .	11.40	.042		5.72	.021	
SiO <sub>2</sub> . . . . .	1.57	.026		1.56	.026	
ZrO <sub>2</sub> . . . . .	4.12	.034		5.90	.048	
ThO <sub>2</sub> . . . . .	.52	.002		.42	.002	
SnO <sub>2</sub> . . . . .	1.44	.009		1.46	.010	

	Dark Type			Light Type		
UO <sub>3</sub> .....	4.41	.015	} .307	5.08	.018	} .313
CaO.....	13.25	.236		13.62	.243	
Ce <sub>2</sub> O <sub>3</sub> , etc.	.12			.50	.002	
Y <sub>2</sub> O <sub>3</sub> , etc..	.62	.003		.62	.003	
Fe <sub>2</sub> O <sub>3</sub> .....	3.46	.022		3.63	.022	
MgO.....	.36	.009		.20	.005	
PbO.....	.54	.002		.24	.001	
MnO.....	.51	.007		.43	.006	
H <sub>2</sub> O.....	4.29	.239		5.05	.280	
	99.60			100.23		
S.G.....	4.509		4.417			

From the calculated molecular ratios it will be seen that, with the omission of silica, zirconia, tin, and thoria, both types can be well expressed by the hatchettolite formula RO.Nb<sub>2</sub>O<sub>5</sub>.H<sub>2</sub>O with tantalum and titanium replacing niobium and with lime as the principal base. These two types, light and dark, bear a relationship to one another analogous to that shown by the two types of ellsworthite. In both cases the light variety carries more water, and less lead, contains its uranium in a higher state of oxidation, and is somewhat lower in density. For hatchettolite and ellsworthite the light-coloured types are probably secondary, derived from the dark types by hydration and oxidation. Being younger, the lead content, resulting from the break-up of the uranium, is also lower. The relative radioactivity of these types is given on page 16, while the hydration curves are shown in Fig. 1 (p. 15). The density of mineral is somewhat lower than that of the hatchettolite from the type locality, but this may be readily accounted for by the fact that our mineral contains less tantalum and more titanium than is found in the mineral from the type locality. This is the first reported occurrence of hatchettolite in Canada.

*Zircon, variety Cyrtolite*

This mineral occurs along with the hatchettolite, and makes up about half the mass in some of our specimens. It is for the most part quite massive, grey in colour, and fine grained. It has a pitchy lustre and sometimes constitutes irregular stringers half an inch wide and two inches long. On the outer surfaces, where the mineral is in contact with the feldspar, imperfect crystallization may be seen. All the crystal surfaces are much curved as in the type for this variety. The pyramid is the most prominent form. This mineral was analysed by E. W. Todd with the following result:

SiO <sub>2</sub> .....	26.14	.436
Nb <sub>2</sub> O <sub>5</sub> .....	.72	.003
ZrO <sub>2</sub> .....	62.16	.509
CaO.....	1.16	.019
FeO.....	1.72	.023
Fe <sub>2</sub> O <sub>3</sub> .....	2.06	.013
UO <sub>3</sub> .....	1.26	.004
H <sub>2</sub> O.....	4.21	.234
	99.43	
S.G.....	4.102	

The niobium and uranium were probably derived from hatchettolite which could not be completely separated from the cyrtolite. This variety of zircon in general contains considerable water and an excess of zirconia over silica. In the present example the specific gravity is somewhat lower than for zircon. It can hardly be regarded as an alteration from the normal zircon, as its massive form and curved crystal surfaces appear to be primary characteristics.

*Columbite*

One specimen of massive columbite, described on page 35, was obtained from the operators at the quarry, who said that it occurred sparingly with the other rare minerals.

*Garnet*

Garnet is found in intimate association with quartz and feldspar. It is brownish black in colour and occurs as rough crystal aggregates in which the individuals are sometimes nearly an inch in diameter. The rhombic dodecahedron is the only prominent form. Less frequent is the trapezohedron (211). Three hexoctahedra have been observed, the most prominent of which lies in the zone (110) : (211). With the exception of the rhombic dodecahedron all the forms appear to be represented by only a few of the faces which go to make up the whole form. The mineral powder, when examined under the microscope in methylene iodide, is seen to be brown in colour and isotropic with an index of refraction higher than 1.74. Some of the grains are brown in colour, but anisotropic. This material forms aggregates of small grains and fibres probably formed by the alteration of the garnet.

## SHATTERING OF MINERALS AND ROCKS ABOUT INCLUSIONS

By T. L. WALKER and A. L. PARSONS

During the investigation of the new mineral ellsworthite, the writers were much impressed with a marked shattering of some of the associated minerals about inclusions and were led to examine further material which either exhibited shattering of a regular character macroscopically or gave evidence of such shattering because of differences in certain physical properties.

One of the early examples of regular shattering about an inclusion is recorded for muscovite by Holland,<sup>1</sup> who says:

A very interesting occurrence of natural pressure and percussion figures was found by Dr. T. L. Walker at Gudladona in the Nellore district. The rays of both figures appeared to radiate from an inclusion in the mica, apparently an altered allanite: on examination it was found that the rays of the compound figure intersected one another as nearly as possible at angles of 30°, and that one of the rays occupied the correct position of the principal ray of the artificially produced percussion figure.

Through the courtesy of the Director of the Geological Survey of India the writers were furnished with a specimen of this mica for study. The radiating figure is well shown in the accompanying illustration (Plate III, Fig. 2) and is a striking example of shattering in definite crystallographic directions.

Observations on the radial shattering of minerals have also been made by Ellsworth,<sup>2</sup> who says:

Another very characteristic indication is the presence of small cracks or fractures in the rock radiating from the mineral in all directions. These radiating fractures occur in feldspar, quartz, or mica surrounding radioactive minerals and are apparently caused by pressure which the mineral has exerted outwardly, due possibly to increase of volume resulting from internal radioactive changes.

<sup>1</sup>Holland, T. H., *Mem. Geol. Surv. India*, Vol. XXXIV, pt. 2, p. 20.

<sup>2</sup>*Geol. Surv. Can., Sum. Rep.*, 1921, Pt. D, p. 58.

In the material accompanying ellsworthite at Hybla, Ontario, the following cases were observed which have a bearing on the problem.

*Quartz enclosing Zircon.*—Many etched crystals and masses of quartz were found to have a nucleus of zircon and in nearly every case the quartz was shattered radially about the zircon so as to resemble some of the common radiate minerals. This is well shown at the centre of the accompanying illustration (Plate III, Fig. 3).

*Quartz enclosing Ellsworthite.*—The rupturing action of ellsworthite is even more striking than the effect of zircon in shattering quartz, as is evident in the polished specimen which is reproduced in the illustration (Plate III, Fig. 4).

*Calcite enclosing Ellsworthite.*—The calcite at Hybla is characteristically salmon pink in colour due to the presence of manganese and possibly ferrous iron (p. 18). Near the ellsworthite the pink colour has disappeared, and a microscopic examination showed the presence of minute stringers of hematite and a black mineral (probably pyrolusite) in cleavage cracks. The contrast in colour in the calcite is shown in the accompanying illustration (Plate III, Fig. 5).

*Calcite enclosing Zircon.*—In the specimen just mentioned crystals of zircon are also present, but except in the vicinity of ellsworthite there appears to be no marked decolouration.

The following examples from other localities have also been observed.

*Euxenite in Orthoclase.*—A section of potash feldspar enclosing euxenite from Maberley, Ontario, was examined to see whether any trace of shattering could be observed. Although the shattering was not radial the feldspar was markedly ruptured and the cleavages and fractures were filled with hematite, which gives a deep red colour to this feldspar in contrast to the pale colour which characterizes most of the feldspar from this quarry.

*Fluocerite in Quartz.*—A specimen of fluocerite in quartz from Osterby, Sweden, shows the radial shattering very

characteristically (Plate III, Fig. 6). The fluocerite shows a well-marked zone of alteration on the margin.

*Allanite in Granite.*—Radial shattering involving both quartz and feldspar is shown in an allanite granite from Seguin Falls, Ontario. The allanite crystals are brilliant within, but altered near the margin. The feldspar is deeper red at the contact with the allanite. No microscopic examination was made, but the red colour appears to be due to ferric oxide.

In view of the observations on the material at their disposal the writers are of the opinion that the shattering is of two types; one caused by expansion of the inclusion, the second caused by contraction of the host. In the case of minerals that alter by oxidation and hydration there is usually, though not always, an increase in volume. This will account for the outward pressure of euxenite, ellsworthite, allanite, and fluocerite. The polished surface of our zircon shows no evidence of marginal alteration, but appears to be homogeneous throughout. When in quartz it causes radial shattering, but when embedded in calcite it causes no shattering so that in this respect it is distinct in its action from ellsworthite and apparently has exerted no pressure on the calcite as a result of alteration. If it be assumed that the quartz and zircon formed in the pegmatite at a temperature of 575° C., up to which temperature the expansion of quartz is regular, and then cooled to normal crustal temperature, the difference in coefficient of expansion would account for sufficient strain upon the quartz to cause rupture. The figures for the coefficients of expansion of these two minerals as given in Hintze's *Mineralogie* are

Quartz.....	c .00000781	a .00001419
Zircon.....	c .00000443	a .00000233

Shattering due to differences in coefficient of expansion will be directly proportional to the size of the inclusion, so that little shattering is to be expected about microscopic inclusions of zircon, whereas in the case under discussion the crystals sometimes reach half an inch in length and the greater

part of them are between an eighth and a quarter of an inch in length with a lateral measurement about two-thirds as great.

Such shattering furnishes a great number of channels by which solutions and gases may pass through the rock and thereby more rapidly bring about chemical changes. The shattering by expansion of an inclusion due to hydration may be even more severe than that caused by differences in coefficient of expansion, but it offers no explanation of the channels through which the solutions reach the mineral that is to cause the shattering.

The writers are desirous of securing further material illustrating shattering of minerals about included material.

## NOTES ON CANADIAN MINERALS—ALLANITE, AXINITE, COLUMBITE, AND SILLIMANITE

By T. L. WALKER and A. L. PARSONS

### *Canadian Allanite*

This mineral appears to be frequent in pegmatite masses which intersect the gneisses of the Grenville series in Ontario and Quebec. The following description refers to two occurrences, one of which, so far as is known, has not been mentioned in the literature, while the other gives promise as a commercial source of cerium.

*Seguin Falls, Ontario.*—Recently the Royal Ontario Museum of Mineralogy received from Mr. David Hall some specimens of allanite in pegmatite from Lot 20, Concessions A and B of Monteith Township, Parry Sound district. The mineral occurs in a very coarse red biotite granite, in the form of black crystals from a quarter of an inch to half an inch in diameter and up to two inches in length. The crystals are rhomboidal in cross section and show the orthopinacoid (100) as the most prominent form, the basal pinacoid (001) not quite so large, and the positive hemi-orthodome (302), relatively small. There are no distinct terminal faces. The crystals appear to have been the first to form from the magma as they are frequently broken across, and the parts while still in approximate position cemented by quartz and feldspar. The crystals are dull brownish black on the outer surface, while the central core is jet black and of brilliant adamantine lustre. When the powdered mineral is examined with the microscope, it is seen to be doubly refracting, brownish green in colour, and pleochroic in varying tints of olive green to brown green. The general index of refraction is about  $1.735 \pm .003$ . Birefringence, .01. A sample carefully prepared from the central parts of

the crystals was analysed by E. W. Todd with the following result:

SiO <sub>2</sub> .....	31.88	.531	
ThO <sub>2</sub> .....	.44	.002	
CaO.....	12.94	.231	} .400
FeO.....	9.56	.133	
MnO.....	.74	.010	
MgO.....	1.03	.026	
Al <sub>2</sub> O <sub>3</sub> .....	16.66	.164	
Fe <sub>2</sub> O <sub>3</sub> .....	4.91	.030	} .260
Ce <sub>2</sub> O <sub>3</sub> , etc.....	19.58	.059	
Y <sub>2</sub> O <sub>3</sub> , etc.....	1.64	.007	
H <sub>2</sub> O.....	1.33	.074	
	<hr/>		
	100.71		
	<hr/>		
S.G. ....	3.658		

The chemical composition of this mineral appears to be in accord with the formula 3RO.2R<sub>2</sub>O<sub>3</sub>.4SiO<sub>2</sub>.H<sub>2</sub>O.

*Labelle County, P.Q.*—Allanite occurs on Lot 13, Range III in the Township of Portland East, in Labelle County in the Province of Quebec. It is found in a dyke of coarse grey pegmatite in the form of large ill-defined crystals sometimes several inches in diameter. In colour the mineral is jet black with a pitchy lustre. The powdered mineral when examined under the microscope, is seen to be olive-green in colour, isotropic with  $n = 1.650$ . It is unusually free from foreign grains. It shows no brownish alteration on the surface and is apparently unusually fresh. The analysis by E. W. Todd is as follows:

SiO <sub>2</sub> .....	31.94	.532	
ThO <sub>2</sub> .....	.52	.002	
CaO.....	14.76	.263	} .455
FeO.....	12.13	.169	
MnO.....	1.10	.015	
MgO.....	.32	.008	

Al <sub>2</sub> O <sub>3</sub> .....	18.18	.178	} .246
Fe <sub>2</sub> O <sub>3</sub> .....	3.80	.024	
Ce <sub>2</sub> O <sub>3</sub> , etc.....	13.44	.041	
Y <sub>2</sub> O <sub>3</sub> , etc.....	.76	.003	
H <sub>2</sub> O.....	2.99	.165	
	<hr/>		
	99.94		
	<hr/>		
S.G. ....	3.279		

In chemical composition, optical properties, and specific gravity these two types of allanite vary considerably. They both appear to be perfectly fresh. If one of them represents an original type and the other an alteration product, the process would appear to have been a very thorough one, as in neither sample does one observe grains of the other type. This puzzle as to the alteration of allanite has recently been carefully studied by Watson,<sup>1</sup> Larsen,<sup>2</sup> and others. No attempt was made to separate the rare earths except as indicated in the analyses. The spectroscope showed that in both samples the cerium group contains considerable didymium.

*Axinite from Marmora Township, Hastings County, Ontario*

The Royal Ontario Museum, a short time ago, received from Dr. W. L. Goodwin for identification a specimen of axinite from the extreme southeastern lot in the Township of Marmora, Hastings County. More recently one of the writers visited the locality and found that the mineral occurs in joints and thin seams in a dark metamorphic hornblende schist not far from the contact with granite-gneiss. Some years previously a pit had been sunk on a prospect which gave some promise for zinc blende. It was from the small dump at this pit that the best material was obtained. The only previous record of axinite in Ontario is by Dr. Bigsby, who found it in cavities in a boulder near Hawksbury.

<sup>1</sup>Watson, T. L., *Bull. Geol. Soc. America*, Vol. 28, p. 463.

<sup>2</sup>Larsen, E. S., *Bull. U.S. Geol. Surv.*, 679, p. 36.



The mineral is said to have been very brilliant when first removed from the pit, but owing to exposure to the weather it had become dull and purplish-grey in colour. The crystals are sometimes an inch and a half in diameter, but appear to be poor in crystal forms and not suited for crystallographic study.

An analysis by E. W. Todd gave the following results:

	I		II	
SiO <sub>2</sub>	41.46	.691		.694
B <sub>2</sub> O <sub>3</sub>	4.88	.070		.071
Al <sub>2</sub> O <sub>3</sub>	19.94	.195	} x <sub>2</sub> <sup>3</sup>	.164
Fe <sub>2</sub> O <sub>3</sub>	.96	.006		.016
FeO	4.56	.063	} .930	.074
MnO	5.44	.076		.057
CaO	19.57	.349	} .916	.393
MgO	1.99	.050		.027
H <sub>2</sub> O	1.61	.090		.095
	<hr/>			
	100.41			
	<hr/>			
S.G.	3.221			

There has always been considerable doubt as to the formula to be assigned to this mineral. The above analysis does not agree with H<sub>2</sub>O.6RO.B<sub>2</sub>O<sub>3</sub>.2R<sub>2</sub>O<sub>3</sub>.8SiO<sub>2</sub>, the formula of Rammelsberg, or with 2H<sub>2</sub>O.8RO.B<sub>2</sub>O<sub>3</sub>.3R<sub>2</sub>O<sub>3</sub>.10SiO<sub>2</sub>, the formula of Whitfield. Ford and Schaller<sup>1</sup> have proposed formulae similar to that of Rammelsberg. There is always a shortage of the sesquioxide. The molecular ratios based on our analysis are given in I, while in II are shown the ratios for the average of all the complete analyses of axinite given by Hintze.<sup>2</sup> If the molecular ratios for all the bases, including hydrogen, be grouped as is shown above for I and II, one obtains the formula 13RO.B<sub>2</sub>O<sub>3</sub>.10SiO<sub>2</sub>, which while simpler has a great advantage in that it agrees well with most of the

<sup>1</sup>Dana, *Syst. of Min.*, Ap. II, p. 11.

<sup>2</sup>Hintze, *Handbuch der Mineralogie*, II, p. 509.

available analyses. In the above calculation the molecular ratios for the sesquioxides, having a higher valency, are multiplied before adding them to those for the regular monoxides and water.

*Columbite*

Columbite is most frequently found in pegmatite veins where it is often accompanied by a great variety of minerals, such as zircon, quartz, orthoclase, muscovite and beryl. So far as is known, it has not yet been recognized in Canada in quantities which are of commercial importance. In presenting the following chemical analyses of columbite accompanied by notes as to localities and mode of occurrence, the writers feel that attention will be drawn to this mineral which may in the past have been overlooked in many places.

The analyses were made by E. W. Todd, research assistant in the Department of Mineralogy of the University of Toronto. An account of his chemical methods will be found on page 40. He has employed for the final determination of niobic and tantallic acids the method of Metzger and Taylor,<sup>1</sup> which is based on the titration of the reduced acids in solution by potassic permanganate. The method is very delicate and gives satisfactory results except for the difficulty of settling the factor to be employed for the permanganate. Mr. Todd has employed throughout the factor obtained by Metzger and Taylor, 1 c.c. of decinormal permanganate equal to .007052 grams Nb<sub>2</sub>O<sub>5</sub>. The difficulty of determining this value is shown by the following statement of Wells<sup>2</sup>:

Metzger and Taylor found that on an average 1 gm. KMnO<sub>4</sub> was equivalent to 2.232 gm. Cb<sub>2</sub>O<sub>6</sub>. As in a blank experiment 1 gm. KMnO<sub>4</sub> was found equivalent to 2.458 gm. Cb<sub>2</sub>O<sub>6</sub>, the average 2.34 was used in computing the Cb.

The comparative values involved are therefore as follows:

Metzger and Taylor.....	-1 c.c. = .007053 gm.
Wells (found).....	-1 c.c. = .007767 "
Wells (factor used).....	-1 c.c. = .007410 "

<sup>1</sup>Metzger and Taylor, *Columbia Sch. Min. Quart.*, XXX, p. 323, 1909.

<sup>2</sup>Wells, R. C., *Am. Jour. Sc.*, Vol. 30, Ser. IV, p. 439.

Such wide differences are doubtless due to the varying impurity of the standard employed for the titration, rather than to the method, which is capable of giving very accurate results. As many columbites contain nearly 70% Nb<sub>2</sub>O<sub>5</sub>, such discrepancies in the factor may give an error of nearly four per cent.

We are indebted to Professor W. P. Headden for kindly supplying for comparison a sample of pure niobic acid.

ANALYSES OF COLUMBITE

	I	II	III	IV
Nb <sub>2</sub> O <sub>5</sub>	63.08 .237	65.49 .246	55.79 .209	66.60 .249
Ta <sub>2</sub> O <sub>5</sub>	14.48 .033	13.89 .031	15.21 .034	1.74 .004
TiO <sub>2</sub>	1.47 .018	.66 .008	5.19 .063	5.22
ZrO <sub>2</sub>				1.25
ThO <sub>2</sub>				3.44
SiO <sub>2</sub>	.34	.10	1.28	.64
SnO <sub>2</sub>	.22	.22	.56	.36
MnO	10.44 .147	14.12 .199	10.24 .144	9.06 .127
FeO	10.46 .146	5.59 .078	10.90 .151	8.61 .120
CaO		.15 .003	.15 .003	.303
Rare Earths			.82 .005	1.68 .006
H <sub>2</sub> O				1.41
	100.49	100.22	100.14	100.01
S.G.	5.613	5.563	5.431	5.147

I. Columbite, crystals, Lavers Mine, New Ross, Lunenburg Co., N.S.

II. Columbite, Hazaribagh, Bengal.

III. Columbite, hemispherical radiations, Lot 23, Con. XV, Lyndoch Tp., Renfrew Co., Ontario.

IV. Columbite, massive with visible rutile, Hybla, Ontario.

A study of the molecular ratios derived from the above four analyses shows that the mineral conforms to the columbite formula if we omit the small amounts of the oxides of zirconium, thorium, silicon, and tin. They appear to be quite independent of the columbite and are probably

derived from small amounts of cassiterite, quartz, and minerals containing zirconia and thoria.

I. *New Ross, Nova Scotia.*—The mineral is found in the form of crystals often weighing several grams, in a coarse pegmatite which cuts an even-grained granite. While the crystals are generally well formed, none was found sufficiently bright for crystallographic measurements.

II. *Hazaribagh, Bengal.*—Columbite occurs in the very coarse pegmatite in which the muscovite is found in the Hazaribagh district. The specimen analysed was part of an irregular mass weighing about half a pound, which was presented to the Museum by the Geological Survey of India. The unusually high content of manganese would suggest that the columbite from Hazaribagh might be called manganocolumbite, corresponding to the well-known manganotantalite.

III. *Lyndoch Township, Ontario.*—Columbite from this locality was first described by Miller,<sup>1</sup> who found it in pegmatite along with beryl. It forms hemispherical radiating masses, sometimes one inch in diameter, which project from the wall of the dyke toward the centre. A microscopic slide prepared from part of the mass used for analysis showed that a very small amount of some yellowish mineral was mingled with the columbite. Dr. W. L. Goodwin,<sup>2</sup> late Director of the School of Mines, Kingston, Ontario, made a partial analysis of this material as shown below:

Rare Acids.....	75.75
SnO <sub>2</sub> .....	.92
FeO.....	11.14
MnO.....	10.22
CuO.....	.03
Rare Earths.....	2.00

100.06

IV. *Hybla, Ontario.*—The feldspar quarry on Lot 17, Concession VIII, Monteagle Township, contains a number of

<sup>1</sup>Miller, W. G., *Bureau of Mines of Ontario*, VII, p. 234.

<sup>2</sup>Miller, W. G., *Bureau of Mines of Ontario*, VII, p. 234.

rare minerals such as hatchettolite, cyrtolite, and columbite. The last-named mineral is quite massive and very fine-grained. Examination of a thin section shows the presence of a small amount of rutile, the presence of which is confirmed by the chemical analysis, from which it may be observed that no simple columbite formula can be derived if the  $TiO_2$  be included with the  $Nb_2O_5$  and  $Ta_2O_5$ , as was done in the case of the previous three analyses. The general complexity is indicated by the presence of not inconsiderable amounts of titanic acid, water, zirconia, tin, and rare earths.

*Sillimanite from Romaine, Quebec*

In 1910, while engaged by the Mines Branch, Ottawa, in the preparation of a report on the occurrence of molybdenite in Canada one of the writers examined a prospect for this mineral on an island opposite Romaine, near the confluence of the Olomanoshibo and the St. Lawrence. The molybdenite occurred on the borders of pegmatite masses which in turn conform to the parallelism of the gneissoid rocks of the region. The country rock is a sillimanite biotite gneiss, in which the sillimanite occurs as long slender glassy colourless crystals up to half an inch in length and one and a half millimeters in diameter.

The crystals do not show terminal faces, though they are well developed in the prismatic zone. An examination on the two-circle goniometer indicates the presence of the prisms (110), (120), and (230). The unit prism is the most prominent and gives the crystals their characteristic prismatic habit with a nearly square cross-section. The macropinacoid is often well developed, though it is difficult to decide whether it is natural or due to cleavage.

The following analysis by E. W. Todd indicates that the mineral agrees well with the formula  $Al_2SiO_5$ :

SiO <sub>2</sub> .....	36.70
Al <sub>2</sub> O <sub>3</sub> .....	62.73
Fe <sub>2</sub> O <sub>3</sub> .....	.63
	<hr/>
	100.06
S.G.....	3.209

The mineral is colourless, transparent, and quite vitreous in lustre. Basal sections under the microscope in convergent light indicate that the optic angle is quite small. The long slender crystals are much jointed by a series of more or less parallel planes, which are always somewhat inclined to the basal pinacoid. If these joints indicate a cleavage, this mineral which is generally regarded as rhombic, should be assigned to the monoclinic or triclinic system.

SOME NEW OCCURRENCES OF TELLURIDES IN  
ONTARIO

By E. THOMSON

Since the writing of the short article by the author on *The Occurrence of Tellurides in Ontario*,<sup>1</sup> tellurides have been discovered in Ontario at the Wright-Hargreaves Mine in the Kirkland Lake district, the Dome Mine in the Porcupine district, and the Chambers-Ferland property in the neighbourhood of Schreiber. These new localities will be taken up very briefly in the order named.

*Wright-Hargreaves Mine*

When the previous paper on tellurides was prepared by the writer no ores of this description had been reported at this mine, although the camp generally was the most prolific in tellurides in the province. Since that time altaite, which is so prevalent in this camp, has been encountered here at a lower level. Its genetic relationships seem to be the same as at the other mines in the Kirkland Lake camp, where the tellurides and the native gold are almost, if not quite, contemporaneous. The common quartz gangue is cut by later stringers of carbonate as at the other mines in the district. In the specimen examined a small amount of chalcopyrite is associated with the other two metallics.

*Dome Mine*

The occurrence of telluride ores adds to the fairly long list of metallic minerals from this mine. The tellurides reported from the Dome are altaite, calaverite, and sylvanite. In the specimens examined by the writer only altaite was observed. It occurs commonly in close association with pyrrhotite, rarely with pyrite. It appears to have been

<sup>1</sup>Thomson, E., *Univ. of Toronto Studies*, Geol. Ser. 14, pp. 91-98, 1922.

deposited later than either of the associated sulphides, as it occupies cracks and cavities at the margins of the sulphide crystals. In places the altaite has replaced the pyrrhotite. Native gold and chalcopyrite were also found in the two sections examined from the mine. The gangue material is chiefly quartz with small secondary carbonate stringers cutting across the main gangue. The order of deposition appears to be as follows: (1) quartz gangue and pyrite; (2) pyrrhotite, chalcopyrite, and carbonate; (3) native gold and tellurides. It seems very probable that further investigations with a larger number of specimens will reveal the presence of additional tellurides.

*Schreiber*

On the Chambers-Ferland group of claims in the vicinity of Schreiber, tellurides were reported by P. E. Hopkins, of the Ontario Department of Mines, through whose kindness the writer was able to secure a specimen for microscopic investigation. As indicated by Mr. Hopkins, the tellurides proved to be chiefly tetradymite associated with small amounts of altaite, native gold, and chalcopyrite. The gangue material is chiefly quartz with little, if any, secondary carbonate. The order of deposition appears to be: (1) quartz gangue; (2) chalcopyrite; (3) native gold and tellurides. As in the Kirkland Lake field the native gold and the tellurides have been deposited at about the same time. The tellurides are not so prevalent in this part of the province, but, as new gold camps are developed, no doubt this section will add to the list of these interesting ores.

In conclusion, the writer wishes to acknowledge the kind assistance rendered by D. G. H. Wright, geologist at the Dome Mine; P. E. Hopkins, of the Ontario Department of Mines; and A. L. Wende, manager of the Wright-Hargreaves Mine at Kirkland Lake. It was through material supplied by these gentlemen that the writer was able to make this addition to the known telluride localities in this province.

## THE ESTIMATION OF NIOBIUM, TANTALUM, AND TITANIUM IN MINERALS

By E. W. TODD

### *Occurrence in Minerals*

An examination of published analyses of minerals containing niobium and tantalum indicates that these elements occur always associated with one another. When one or the other is not reported, it is generally taken for granted that the separation was not made. The experience of the writer would indicate, also, that titanium is commonly present in minerals containing niobium and tantalum. Two samples of columbite from Canadian localities and one from India<sup>1</sup> were found to contain appreciable amounts of titanium. In addition, a number of samples of *pure* niobic and tantalic oxides obtained from different sources for experimental purposes were found to contain titanium. W. P. Headden<sup>2</sup> found titanitic acid in columbite from Black Hills, South Dakota, and from Cañon City, Colorado. Analyses of tantalite and columbite from these and other localities, as given in Dana's *System of Mineralogy*, show no titanium.

### *Department with Reagents*

Under this heading are discussed some reactions, a knowledge of which is of value in choosing methods for the estimation of these elements:

1. Fusion of niobates and tantalates with potassium or sodium bisulphate, and subsequent leaching with water, leaves niobic and tantalic acids as an insoluble residue. A pure titanate treated in the same way goes completely into solution. When the three compounds together are treated

<sup>1</sup>See p. 34.

<sup>2</sup>Headden, W. P., *Proceedings of the Colorado Scientific Society*, Vol. XI, p. 188.

in this manner no good separation takes place. Niobic and tantalic acids go partially into solution and some titanitic acid remains undissolved. Boiling precipitates all three acids while the presence of sulphuric acid tends to increase their solubility. This latter fact is especially true of titanitic acid but applies also to niobium and tantalum. Repeating the fusion does not give a complete separation.

2. Sulphurous acid promotes the precipitation of niobic and tantalic acids.

3. Fusion of titanitic acid with sodium or potassium carbonate forms titanates which are insoluble in water. In the presence of niobium and tantalum some titanium goes into solution, and it is therefore impossible to make a complete separation of titanitic acid by fusion with alkalis.

4. Potassium niobate and tantalate are more soluble than the corresponding sodium salts, hence potassium carbonate or hydroxide should be used when making an alkali fusion for the purpose of separating these elements from other constituents of the mineral.

5. The fluorides of niobium and tantalum, like titanium fluoride, are partially volatilized on ignition. It is necessary to have present a large excess of sulphuric acid when treating the ignited oxides with hydrogen fluoride to remove silica.

6. Niobic, tantalic, and titanitic acids are soluble in hydrogen peroxide and sulphuric acid. This forms the basis of methods for determining the titanium colorimetrically in the presence of niobium and tantalum.<sup>1</sup>

7. Niobic acid is reduced by zinc or tin to a lower oxide, which is indicated by the development of a characteristic blue colour. Tantalum does not react in this way. This fact forms the basis of a method, developed by D. F. Metzger and C. E. Taylor,<sup>2</sup> in which the reduced niobic acid is titrated against standard potassium permanganate. It must be remembered, however, that titanitic acid, which is generally present, is also reduced by zinc.

<sup>1</sup>G. Chesneau, *C.R.*, Vol. 149, p. 1132, 1909.

<sup>2</sup>Metzger, D. F., and Taylor, C. E., *Columbia School of Mines Quart.*, Vol. 30, p. 323, 1909.

*Difficulties of Making Separations*

Most of the methods for separating niobic and tantalic acids are based on the difference in solubility of their compounds. As a general rule salts of tantalum are less soluble than those of niobium. The method of Marignac, based on this fact, gives useful results, provided a large sample is available, and a great amount of patience and care is exercised. Complete separations, however, are not claimed for this method even under the best conditions. Several other methods using the difference in solubility of sodium and potassium niobates and tantalates, have been proposed. None of them give quantitative separations. Further complication results from the presence of titanium, which owing to the effect of association on the deportment of its compounds can only be eliminated quantitatively with great difficulty. Since the actual quantitative separation of the three acids presents such difficulty, it appears that the volumetric method of Metzger and Taylor is the most reliable and easiest to manipulate. Provisions must be made, however, to correct for the error caused by the presence of titanium.

*Methods of Analysis*

In the following paragraphs a description is given of the procedure followed in analysing the niobates and tantalates referred to on pages 14, 21-22, and 34.

*Decomposition.*—One-half gram of the mineral was decomposed with potassium bisulphate which had been previously fused to a dull red heat and cooled. The cooled platinum crucible, containing the melt, along with the lid, was placed in a beaker with 300 cc. of water to which had been added 5 cc. of sulphuric acid. The mixture was boiled until the melt became thoroughly disintegrated, when the crucible and lid were removed and carefully washed. Sulphurous acid was added until the odour was plainly perceptible. The mixture was allowed to stand at a temperature just below

<sup>1</sup>Doelter, *Handb. d. Mineralchemie*, Bd. III, Hfte I, pp. 81-82.

boiling until the precipitate had settled somewhat. After filtering and washing free from acid with hot water, the precipitate contained niobium, tantalum, and silica along with a considerable percentage of titanium. It was also contaminated with compounds of tin, zirconium, iron, and when present in quantity with aluminium, calcium, uranium, and rare earths.

*Removal of Silica.*—The paper was burned off in a platinum crucible and the precipitate strongly ignited in an atmosphere of ammonium carbonate. After cooling and weighing, the precipitate was treated with 2 cc. of sulphuric acid and 3 cc. of hydrofluoric acid. The residue was evaporated to dryness, ignited in an atmosphere of ammonium carbonate, cooled and weighed again. The loss represented silica. Care was taken to avoid loss in driving off the sulphuric acid, as near the end of the operation there is left a pasty mass which is prone to spatter.

*Purification of Niobic and Tantalic Oxides.*—The residue freed from silica was fused with dry potassium carbonate, longer fusion than necessary to dissolve the oxides being avoided. After leaching with 100 cc. of hot water, the precipitate was filtered and washed. The fusing, leaching and filtering were repeated, a smaller amount of potassium carbonate being used. Close filters were used to prevent potassium titanate from passing through. By this procedure the niobium and tantalum were obtained in solution along with some titanium and tin. Much of the titanium and the other impurities remained in the insoluble residue. The filtrate was acidified with sulphuric acid, boiled for 10 minutes, and treated with sulphurous acid. After settling and filtering the washed precipitate was treated on the paper with warm ammonium sulphide solution, and finally washed again with water. This served to remove small amounts of tin present. The precipitate, ignited in ammonium carbonate, then contained the niobic and tantalic oxides with a small fraction of the titanium.

*Determination of Niobic and Tantalic Oxides.*—A small proportion of the mixed oxides was weighed out, fused with

potassium bisulphate, dissolved in sulphuric acid and hydrogen peroxide. The titanous acid was then determined colorimetrically by comparison with a standard titanium solution. In the remainder of the precipitate the reduced niobic and titanous acids were titrated against decinormal potassium permanganate solution, according to the method of Metzger and Taylor. The permanganate value of the standard titanium solution used in the determination of titanous acid was checked, under identical conditions, by a blank experiment. The amount of the permanganate, used in oxidizing the reduced titanous acid contaminating the niobic acid, was then calculated and deducted. The remainder represents the niobic oxide in the mineral. Tantalic oxide was obtained by difference after deducting the values for titanium and niobium as determined above. Metzger and Taylor give  $Nb_2O_3$ , as the oxide to which the  $Nb_2O_5$  is reduced. This requires that 1 cc. decinormal  $KMnO_4 = .00705$  grams  $Nb_2O_5$ . Experiments by the writer would seem to confirm this, as the following values were obtained on a nearly pure niobium salt prepared by Marignac's method from a mineral low in titanium and tantalum: .00709, .00708, .00711. The method gives concordant results. The following amounts of permanganate were required on five .2 gram samples of a mixture of niobic and tantalic oxides containing some titanium: 23.4 cc., 23.6 cc., 23.4 cc., 23.5 cc., 23.2 cc.

*Determination of Titanium.*—The titanium dioxide was determined colorimetrically on a different sample of the mineral. On account of the large dilution necessary to obtain comparable colours, the accuracy of the method decreases with the rising titanium content. For a mineral containing 10% of titanium dioxide the error may amount to one-half of one per cent. The gravimetric determination of titanium is very difficult on account of the trouble encountered in separating it from niobium and tantalum. However, in the procedure outlined above, the greater part is freed from these elements and can be determined gravimetrically. To the amount found in this way is added the part determined in obtaining the results for niobium and

tantalum. This serves as a useful check on the colorimetric determination.

*Other Constituents.*—The residue from the potassium carbonate fusions was ignited, fused with potassium bisulphate, and combined with the filtrates obtained in the purification of the niobium and tantalum. The other constituents were then determined according to the standard methods.

## THE MINERAL ASSOCIATION OF THE SALT DEPOSITS AT MALAGASH, N.S.

By H. C. RICKABY

The discovery of salt at Malagash dates back to 1912 when a farmer in that district, while boring a well, obtained a flow of salt water at a depth of 80 feet. Reference to the existence of salt springs at this locality and the probable presence of salt had been made much earlier. In 1917 drilling operations proved the presence of considerable bodies of salt at convenient depth and mining operations commenced very soon afterward. Reports by L. H. Cole,<sup>1</sup> and A. O. Hayes,<sup>2</sup> give accounts of the history, development, and geology of the Malagash deposit. Cole also discusses the importance of the discovery to Canada and particularly to the Maritime Provinces. Previous to the development of this mine southwestern Ontario had been the only region in Canada where salt was produced on any considerable scale. The demand for salt for domestic purposes, and especially in that region for use in the fishing industry, created a ready market for a large output.

According to Hayes the Malagash salt deposit was formed by the evaporation of sea water during the recession of the Mississippian sea in Windsor time. Although up to the present only a small proportion of the ground underlain by deposits from which brine has been obtained, has been examined, yet one shaft cuts through a salt stratum sixty feet thick measured at right angles to the dip. In November, 1922, a six-foot seam of pure white salt containing 99.1% of NaCl was discovered.<sup>3</sup> This discovery enabled the proprietors to enter the market with a pure domestic salt, whereas formerly they could not do so owing to the presence of a small percentage of calcium sulphate. Potassium chloride also

<sup>1</sup>Cole, L. H., *Dept. of Mines, Mines Branch, Sum. Rep.*, 1918.

<sup>2</sup>Hayes, A. O., *Geol. Surv. Can., Mem.* 121, 1920.

<sup>3</sup>*Can. Chem. and Metallurgy*, March, 1923, p. 77.

occurs as sylvite along with the halite in lenticular deposits of varying thickness. Two zones at a depth of about 100 feet have been encountered, and further investigations are being carried on with a view to the possibility of larger deposits at greater depth.

In the following pages an account is given of an examination of material collected in 1922. The minerals present are halite, sylvite, anhydrite, and magnesite.

### *Halite and Sylvite*

Six samples of the salt were analysed for potassium chloride. They vary in colour from pure white to grey, pink, or pale greenish-yellow. The material was ground, dried at room temperature, and analysed. The results were as follows:

Sample No.	Colour	KCl
1	pure white	2.25%
2	grey to pale yellowish-green	42.50
3	grey to pink	14.05
4	" " "	8.80
5	" " "	6.50
6	" " pale yellowish-green	47.50

An analysis of a portion of a crystal of the pale green material with good cubic cleavage from No. 6 showed it to contain 92 per cent. KCl.

A more complete analysis of material from No. 4 resulted as follows:

	Per- centages	Molec. Proportion	NaCl	KCl	CaSO <sub>4</sub>	MgCl <sub>2</sub>
Na.....	35.55	1.545	1.545			
K.....	4.58	.118		.118		
Cl.....	59.20	1.668	1.545	.118		.005
CaO.....	.21	.004			.004	
SO <sub>4</sub> .....	.30	.004			.004	
Mg.....	.08	.002				.002
Insoluble..	.35					
Water....	.13					
	100.40					



Hypothetical composition	Percentages
NaCl	90.38
KCl	8.80
MgCl <sub>2</sub>	.19
CaSO <sub>4</sub>	.49

The material insoluble in water was made up chiefly of silica and anhydrite. In the above analysis of No. 4 it is seen that the combined halite and sylvite make up 99% of the salt and in none of the six samples was this proportion less than 98%.

The relation of the halite and sylvite is brought out by the accompanying photograph (Plate II, Fig. 2), which was obtained by the following method. A polished surface made on a fragment from sample No. 6 was immersed for a few minutes in a saturated solution of sodium chloride which dissolved out some of the sylvite. After drying it was treated with india ink and polished slightly to remove the ink from the smooth surface of the halite. A photograph was then taken by reflected light. The greyish material represents halite, while the dark represents the areas formerly occupied by sylvite. The granular appearance of the latter is due to the ink and is not to be taken to represent a granular texture of the potassium salt, some of which showed quite large crystals with good cubic cleavage. In all of the samples, however, halite forms the main mass, while the sylvite is more or less interstitial.

According to van't Hoff,<sup>1</sup> saturated solutions of the two salts contain per 100 grams of water, NaCl 36.1 grams, KCl 36.5 grams, while a solution saturated in both salts containing per 100 grams of water 28.9 grams NaCl, and 16.1 grams KCl. The analyses of samples 2 and 6 show a higher percentage of potassium chloride than would correspond to a mother liquor saturated in both salts.

According to the same author, the occurrence of pure sylvite as a primary mineral crystallizing from sea water is impossible in nature. It always occurs as a secondary

<sup>1</sup>Zur Bildung der Ozeanischen Salzablagerungen.

mineral after carnallite, which would imply re-solution of the latter salt with removal of the magnesium chloride and redeposition of the potassium chloride. The association of halite and sylvite in the samples analysed would appear to be very similar to sylvinites, which is a mixture of the two salts described by Riemann<sup>1</sup> as occurring in the Stassfurt deposits. There he ascribes the deposition of pure sylvite along with pure halite to the agency of circulating waters. The absence at Malagash of other salts, such as kieserite and kainite, which commonly occur in such deposits, and the interstitial appearance of the sylvite would seem to support this theory.

In addition to the six samples selected at the mine, specimens of the salt as sacked and shipped from the mine were obtained. The salt is graded into three sizes according to the use for which it is intended. Determinations of potassium chloride were made on a sample of each of these with the following results:

Coarse, 2.40%; Medium, 0.76%; Fine, 2.10%.

### *Bromine*

Qualitative tests for bromine were made on several of the samples, and these showed varying proportions from traces up to one-tenth of one per cent. The higher concentration of the bromine was connected with the material containing considerable potash, the highest result being obtained by using a twenty gram sample from No. 6.

The two chief sources of bromine at present are the salt deposits at Stassfurt in Germany, and Michigan and Pennsylvania in the United States. A comparison with these is difficult, since the percentages given are calculated on the mother liquor after removal of the commercial potassium and sodium salts. At Stassfurt the percentage of bromine in the liquor from which it is extracted is given as three-tenths

<sup>1</sup>Die Geologie der Deutschen Salzlagertstätten, p. 27.

of one per cent., while in the American deposits the percentage is higher.

### *Anhydrite and Magnesite*

Anhydrite, which was identified by optical methods, occurs along with the halite in thin layers or beds as small rectangular crystals and fragments with a maximum length of about 1 millimetre. Masses containing anhydrite carried little potassium chloride, as the  $\text{CaSO}_4$ , being the least soluble, was one of the minerals which were the first to crystallize out. Associated with the anhydrite were small hexagonal rhombohedral crystals of what proved on analysis to be magnesite. The crystals are mostly prismatic, sometimes thick tabular, with a maximum length of five millimetres and a diagonal width of three millimetres. Magnesite crystals of similar habit are mentioned by Dana<sup>1</sup> as occurring at Gross-Reifling in the Ennsthal, Germany, along with gypsum. In colour they are grey to brownish, sometimes almost colourless, transparent to translucent, with a vitreous lustre. They have perfect cleavage parallel to the rhombohedral face *r*.

Two-thirds of the faces give good reflections, while the remainder are not so good, owing to inclusions of anhydrite which project from the crystal. Measurements were made on six crystals, the following forms being present: the base  $c(0001)$ ; the unit prism  $m(10\bar{1}0)$ ; the rhombohedron  $r(10\bar{1}1)$ ; and the prism of the second order  $a(11\bar{2}0)$ . The forms *c*, *m*, and *a*, were present on all of the crystals while *r* was present on four of them. The average value of the angle  $c:r$  was  $43^\circ 3'$  and for  $p_0$  was .5394. The corresponding values, according to Goldschmidt's Winkel-Tabellen, are  $c:r = 43^\circ 4'$ ,  $p_0 = .5397$ . The habit of the crystals is shown in the accompanying clinographic drawing (Fig. 2), in which the prominence of the forms is approximately proportional to the size of the faces.

<sup>1</sup>Dana, E. S., *System* (6th ed.), p. 275.

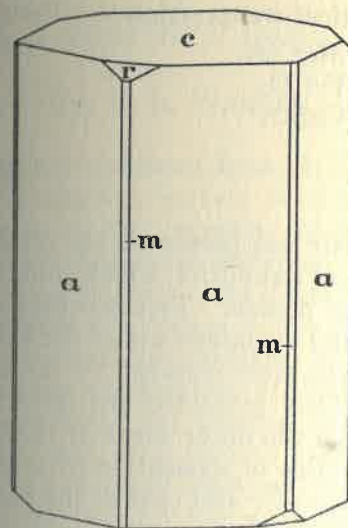


Fig. 2

Some of the crystallized material was ground up, separated as far as possible from impurities and a chemical analysis made with the following result:

	Per- centages	Mol. Ratio	MgCO <sub>3</sub>	FeCO <sub>3</sub>	CaSO <sub>4</sub>	Excess
MgO...	42.52	1.063	1.063			
CaO...	3.84	.068			.068	
FeO...	.75	.010		.005		.005
CO <sub>2</sub> ...	47.02	1.068	1.063	.005		
SO <sub>3</sub> ...	5.60	.070			.068	.002
SiO <sub>2</sub> ...	.22					
H <sub>2</sub> O...	.38					
		100.33				
S.G....	3.02					

Hypothetical composition	Percentages
MgCO <sub>3</sub>	89.29
FeCO <sub>3</sub>	.58
CaSO <sub>4</sub>	9.35
	99.12

The calcium sulphate was present in the crystals of magnesite as small inclusions of anhydrite, which could not be separated by any mechanical means. Thin sections made from some of the magnesite and examined under the microscope showed that these inclusions were confined to the outer part of the prismatic zone. They projected out from all the prismatic faces, but only from the outer edges of the basal or rhombohedral faces. The line of separation between the inner zone of almost pure magnesite and that of the part containing the anhydrite was quite distinct.

From the nature of the occurrence it is evident that the magnesite is a primary mineral crystallizing out with the anhydrite, or in the case of the pure magnesium carbonate, probably slightly preceding it. The line of separation between the pure and impure magnesite would appear to represent a change in the mother liquor, possibly a critical point, or it may represent a change in the rate of diffusion whereby the anhydrite crystals, which were formerly being excluded, now have the magnesium carbonate deposited outside of them, thereby shutting them in. From the fact that the inclusions of anhydrite occur only in the prismatic faces it is highly probable that after this change in the mother liquor had taken place the enlargement of the crystals was wholly diametral; there was no further growth in the longitudinal direction.

## TREVORITE, A DISTINCT MINERAL SPECIES

By T. L. WALKER

In 1922 the writer obtained from A. L. Hall, Assistant Director of the Geological Survey of the Union of South Africa, a specimen of the recently described new nickel mineral trevorite. It had been described by Crosse,<sup>1</sup> whose analysis is given below under I. As it has been placed in the list of doubtful species in a review in the *American Mineralogist*<sup>2</sup> it seems necessary, to vindicate its identity, to give an account of my own examination of this mineral.

In the hand specimen the mineral appears to be black with a greenish hue due, as is seen by examining it with the lens, to the presence of small films and flakes of a greenish nickeliferous mineral, possibly talc or serpentine. Trevorite has the following physical properties: Colour black, opaque, streak black, very strongly magnetic, metallic lustre, hardness about 5, and specific gravity 5.165. It thus closely resembles massive magnetite in its physical properties.

A sample for analysis was prepared by E. W. Todd, using the magnetism and high density of the mineral to eliminate the non-magnetic and less dense minerals (III).

	I	II	III		NiFe <sub>2</sub> O <sub>4</sub>
Fe <sub>2</sub> O <sub>3</sub> .....		54.78	66.24	.415	.415
FeO.....	49.30		1.96	.027	.426
NiO.....	40.30	40.30	29.71	.399	
MgO.....			.24	.006	
SiO <sub>2</sub> .....	6.50	6.50	1.40	.023	
H <sub>2</sub> O.....			.36	.020	
		101.58	99.91		

<sup>1</sup>Crosse, A. F., *Jour. Chem. Met. and Mining Society of S. Africa*, Vol. 21, p. 126, 1921.

<sup>2</sup>Wherry, E. T., *Am. Min.*, Vol. 8, p. 37, 1923.

The state of oxidation was determined by heating the mineral with sulphuric acid in a sealed tube in an atmosphere of carbon dioxide. When the solution was complete the iron was determined by titration with permanganate. The molecular ratios for Analysis III show that the material analysed has the ratio  $RO.R_2O_3$  except for a very small amount of talc.

In II, Crosse's analysis is recalculated so as to show the whole of the iron as ferric instead of ferrous as originally indicated by him. Professor E. Thomson, who kindly polished and examined specimens of trevorite in reflected light, reports that the whole of the black mineral is homogeneous. The above observations seem to indicate clearly that in trevorite we have a new mineral belonging to the magnetite group.

## HURONITE FROM GOWGANDA, ONTARIO

By T. L. WALKER

In 1920 the writer collected some coarsely porphyritic diabase from a dyke by the side of the road from Elk Lake to Gowganda. The exact locality was not noted, though it is probably in the Township of Chown, District of Timiskaming. The diabase is fine-grained and shows a typical ophitic structure. The augite is fairly fresh, though the plagioclase is so strongly altered that only on the outer zone of an occasional crystal can the characteristic twinning be observed.

The porphyritic crystals are somewhat rounded, are pale yellowish-green in colour, and attain at times a diameter of one and a half inches (Plate IV, Fig. 1). In thin sections under the microscope these large crystals betray no sign of lamellar twinning, being composed of an exceedingly fine-grained aggregate, which is somewhat fibrous in structure. This substance seems to be so uniform that it is probably composed of a single mineral. It exhibits bright polarization, so that its birefringence is probably only a little lower than that of augite. Its indices of refraction as determined by the immersion method range from 1.57 to 1.59.

A carefully prepared sample was analysed by E. W. Todd (1).

	I	II	III
SiO <sub>2</sub> .....	46.98	45.80	47.07
Al <sub>2</sub> O <sub>3</sub> .....	30.18	33.92	32.49
Fe <sub>2</sub> O <sub>3</sub> .....	.95	.....	.97
FeO.....	.42	4.32	.....
CaO.....	9.38	8.04	13.30
MgO.....	.39	1.72	.22
MnO.....	.04	.....	.....

	I	II	III
Na <sub>2</sub> O.....	1.36	.....	2.03
K <sub>2</sub> O.....	6.40	.....	2.88
H <sub>2</sub> O.....	4.05	4.16	2.72
CO <sub>2</sub> .....	.27	.....	.....
	<hr/> 100.42	<hr/> 97.96	<hr/> 101.68
S.G.....	2.819	2.862	2.814

For comparison Thomson's<sup>1</sup> original analysis of huronite from a boulder from the shore of Drummond Island, Lake Huron, is given in II, while a later analysis by Evans of similar material from a diabase dyke four miles north-west of Pogamasing station is shown in III.<sup>2</sup> Barlow<sup>3</sup> made a microscopic study of the huronite from the above mentioned localities, and from his description it appears that the original huronite of Thomson is microscopically a very fine-grained aggregate similar to the type from near Elk Lake. With regard to the mineral composition of this aggregate he says: "Under the microscope the phenocrysts of the so-called huronite are seen to be a decomposed aggregate of zoisite, muscovite, epidote, calcite, chlorite, and feldspar." The material from Pogamasing, however, was not so thoroughly altered, as in it there were still considerable areas of well-twinning and little altered plagioclase.

A critical study of Analysis I shows a close resemblance to some types of scapolite, a mineral into which basic plagioclase frequently alters. This is supported by the fact that the mineral contains a small amount of chlorine not shown in this analysis. There has been much speculation as to the place from which the Drummond Island boulders came. Diabase dykes are very common throughout the precambrian area to the north and north-east of Lake Huron, and not

<sup>1</sup>Thomson, T., *Min.*, I, p. 384, 1836.

<sup>2</sup>Harrington, B. J., *Trans. Royal Soc. Canada*, p. 82, 1886.

<sup>3</sup>Barlow, A. E., *Ottawa Naturalist*, Vol. IX, p. 25, 1895.

infrequently the rock is coarsely porphyritic. These may have come from the Elk Lake region, though there is nothing to support this suggestion, except the practical identity of the huronite and diabase in the two cases, and the fact that up to the present no other occurrence has been studied where this marked correspondence has been noted.

## EXPLANATION OF PLATES

### PLATE I

Fig. 1.—Striated boulder, Hampton, N.S. ( $\times\frac{1}{2}$ ).

Fig. 2.—Glacial striae near Lake Groskil, N.S. ( $\times\frac{1}{3}$ ).

### PLATE II

Fig. 1.—Glacial boulders, Hampton, N.S.

Fig. 2.—Halite and sylvite, Malagash, N.S. (microphotograph).

### PLATE III

Fig. 1.—Louisite showing radiating quartz in apophyllite (microphotograph).

Fig. 2.—Muscovite, Gudladona, Nellore District, India, showing natural pressure figures (nat. size).

Fig. 3.—Quartz showing radial shattering enclosing zircon, Hybla, Ontario (nat. size).

Fig. 4.—Quartz showing radial shattering enclosing ellsworthite, Hybla, Ontario (nat. size).

Fig. 5.—Calcite showing decolouration due to shattering enclosing ellsworthite, Hybla, Ontario ( $\times\frac{5}{1\frac{1}{2}}$ ).

Fig. 6.—Quartz showing radial shattering enclosing fluocerite, Osterby, Sweden (nat. size).

### PLATE IV

Fig. 1.—Porphyritic diabase containing huronite, Township of Chown, District of Temiskaming, Ontario (nat. size).



Fig. 1



Fig. 2



Fig. 1



Fig. 2

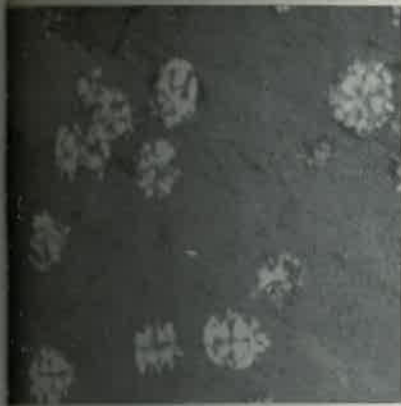


Fig. 1

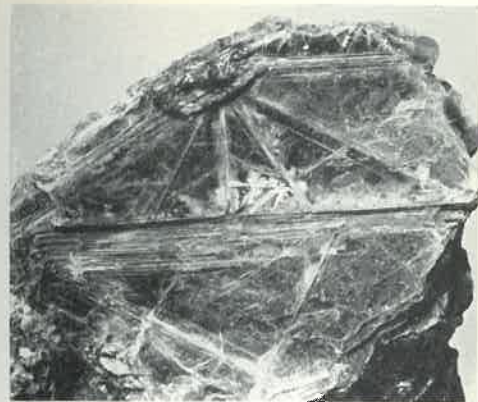


Fig. 2



Fig. 3



Fig. 4



Fig. 5



Fig. 6



PLATE IV



Fig. 1