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A REMARKABLE OCCURRENCE OF THUCHOLITE AND OIL IN A PEGMATITE DYKE, PARRY SOUND DISTRICT, ONTARIO

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INTRODUCTORY

In 1928, H. V. Ellsworth described in this Journal[1] an occurrence of a radioactive carbon mineral in a pegmatite dyke occurring on lots 9 and 10 of concession IX in the township of Conger, Parry Sound district, Ontario. For this mineral, Ellsworth has proposed the name thucholite, in place of the older term anthraxolite, which was originally given to a primary carbon from Lake Superior, and which has since been applied more specifically to the anthracite-like carbon of vein-like deposits in the Sudbury district, Ont. The name anthraxolite has also been used generally for the carbonaceous material found at a number of scattered localities in the Pre-Cambrian crystalline rocks (pegmatites) of Canada.

The writer has recently observed an even more remarkable occurrence of thucholite than that described by Ellsworth, the chief points of interest being (1) that the material occurs, in part, in the form of well-defined, cubic crystals, which are apparently pseudomorphic after uraninite, and (2) that the pegmatite carrying the material also contains hydrocarbons both in the form of a rather thin oil, and also as small blebs or droplets of solid, asphalt-like material, both the latter occurring in cavities and cracks in two distinct cross-fracture zones that cross the dyke. Ellsworth remarks in his paper (p. 434) that thucholite and the tar-like hydrocarbon which he found in some Canadian pegmatites had not thus far been found in one and the same dyke, and the occurrence described below seems therefore of added interest.

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[1] *Amer. Mineralogist*, Vol. **13**, No. 8, August 1928, pp. 419–41.

LOCATION AND DESCRIPTION OF DEPOSIT

The occurrence described here lies some 50 miles northwest of that in Conger township described by Ellsworth, and is situated on lot 5, concession B of the township of Henvey, Parry Sound District. It lies two miles northeast of Britt station, on the Sudbury-Toronto line of the Canadian Pacific railway, which is the shipping point for the feldspar produced The property is known as the Besner mine.

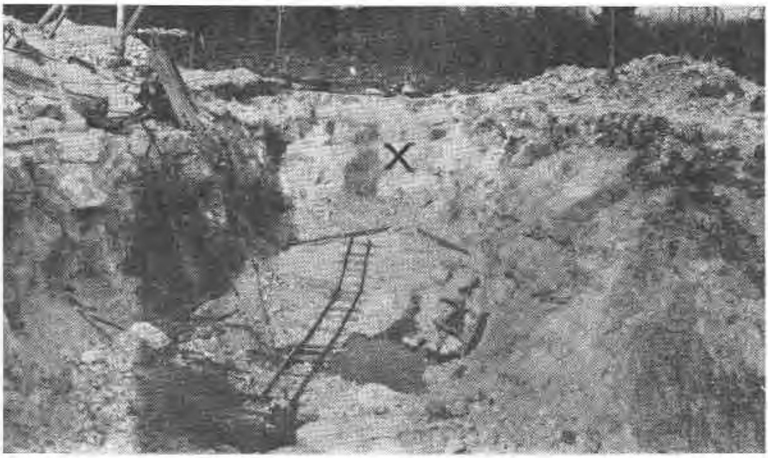

FIG. 1. View of quarry opening at Besner feldspar mine, Henvey township, Ont. Most of the thucholite found in place occurred in pockets along the right (south) wall of the pit (see Fig. 2). One of the oil-bearing zones described in this paper crosses the dyke along the face shown at the far end of the pit (x).

When visited in 1929, the quarry opening consisted of a vertical open pit, 150 feet long by 50 feet wide and 30 feet deep (Fig. 1). The total width of the dyke-mass is about 70 feet: its total length is not known, owing to a heavy drift cover at the east end. The dip is vertical, and the enclosing country rock is biotite gneiss. The gneiss has suffered considerable shattering, being traversed by innumerable cross joints, which have broken it into angular blocks. Thin stringers of pegmatite and white quartz are abundant in the gneiss.

In its general character, the dyke resembles the ordinary run of pegmatites that are found abundantly in the Archean gneisses of eastern Canada. It consists of large crystal masses of light pink, fine- to medium-textured perthite, separated by zones of massive white quartz. Large thin flakes of biotite, altered in great part to chlorite, are scattered in some quantity throughout much of the dyke, but this is the only conspicuous accessory mineral present away from the wall zones. It is in the latter that the minerals described in this paper are chiefly found, although some of them, notably cyrtolite and allanite, occasionally occur in small amount in the feldspar and quartz of the dyke-body proper.

FIG. 2. View of south wall of pit, showing two of the thucholite-bearing pockets.

There is no tourmaline present, and muscovite and garnet, common minerals in the pegmatites of the Sudbury district, further to the north, occur in comparatively small amount.

The following notes on the thucholite and other minerals of the Henvey pegmatite are of a preliminary nature only, since there has not yet been opportunity to have more detailed microscopic and analytical work conducted on the material. The unusual mineral association in this dyke, however, is so interesting that it has been thought worthy of record, pending closer examination and study of the material.

THUCHOLITE

OCCURRENCE

The most remarkable feature of the pegmatite is the presence of a relatively large amount of the carbon mineral, thucholite.

The occurrence of small buttons of coal-like carbon in Canadian pegmatites, on the whole rather rare, is not new. Such material was reported over 30 years ago from pegmatites in the Saguenay district, lower St. Lawrence, in Quebec, where the buttons occur in massive quartz or upon cleavage planes in the feldspar. But at none of the recorded localities is the material present in anything approaching the quantity found in the Henvey dyke.

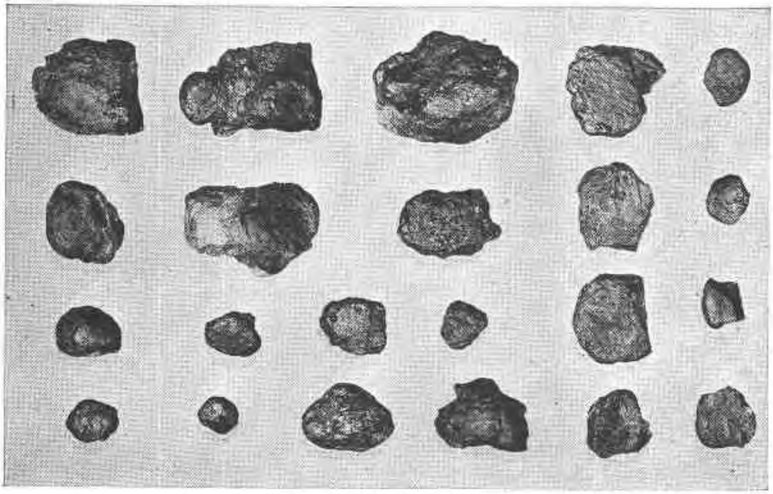

FIG. 3. Specimens of nodular thucholite. Two-thirds natural size. The eight specimens of the two rows on the right have been flattened by pressure, probably while still in a semi-solid state.

Most of the thucholite found occurred near the dyke walls, at or near the surface. Only minor traces of it were noted in the lower part of the pit. It occurs, for the most part, more or less closely associated with radiated groups of a highly-altered, green mineral (Figs. 11, 12) that is now principally chlorite, but which may originally have been a variety of allanite (pyrorthite?). This mineral appears to have been formed between the cleavage planes of shattered oligoclase feldspar, and forms fan-like aggregates. Each group is distinct and has a common radial point which is always uppermost. Several of such groups occur along the south wall of the pit and within ten feet from the surface (Fig. 2). The thucholite is present both in and alongside this chloritized mineral, and also, in greater amount, at the outer (or lower) margin of the groups.

The thucholite occurs in five forms: (1) Irregular massive, filling crevices and cavities. (2) In small, usually rather flattened, bean-like nodules in the chlorite mineral and also as more symmetrical nodules in titanite, biotite and feldspar (Fig. 3). (3) In rough, cubic crystals, often somewhat flattened or distorted,

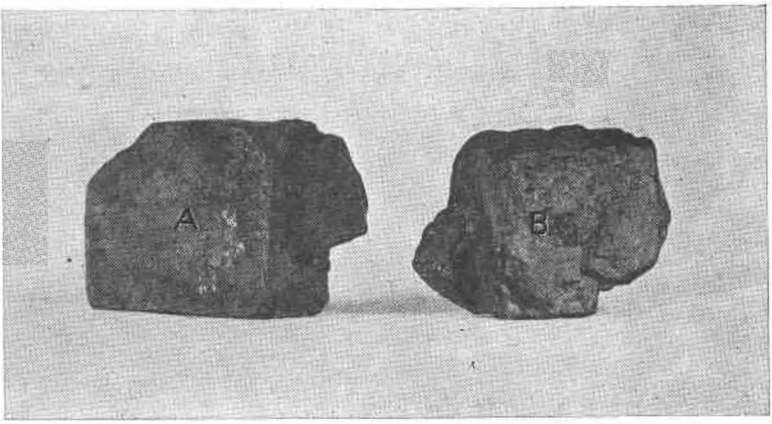

FIG. 4. Uraninite crystal from Wilberforce, Ont. (A), and thucholite crystal from Henvey township (B), showing similarity of form. Both crystals have a smaller penetration twin growing from the side. Seven-eighths natural size.

and sometimes with smaller penetration twins growing from the side. The cubes are found sometimes in the massive thucholite and sometimes also partly embedded in the chlorite or titanite. Their form strongly resembles that of the cleveite variety of uraninite, and suggests that they may be pseudomorphic after that mineral (Figs. 4, 5, 6). (4) As more perfect cubic crystals, with sharper outlines, in the feldspar surrounding the chlorite groups: these crystals often exhibit a slight development of the dodecahedron face (Figs. 5, 6). (5) As thin films and minute veinlets in the feldspar and other minerals closely associated with the chlorite. These minerals have evidently been highly shattered, and the carbon has penetrated along the joints and hair-cracks formed in them. The carbon is thus the latest mineral to have been introduced.

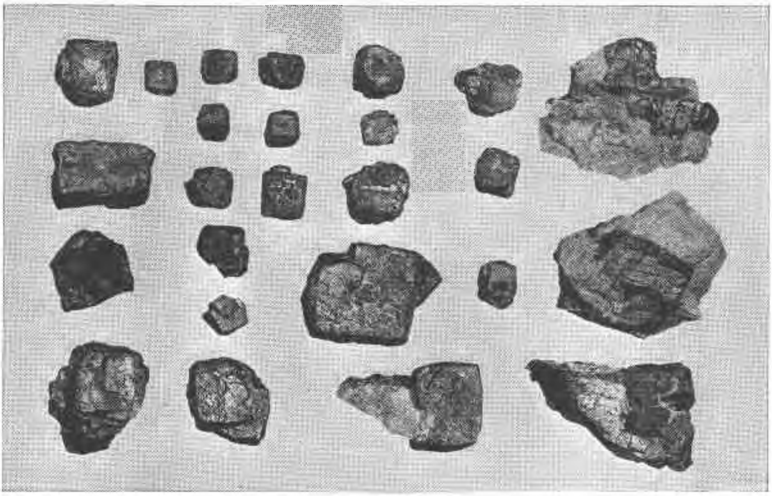

FIG. 5. Specimens of thucholite crystals from Henvey township, Ont. One-half natural size. The three specimens on the right show crystals in a matrix of feldspar and altered titanite.

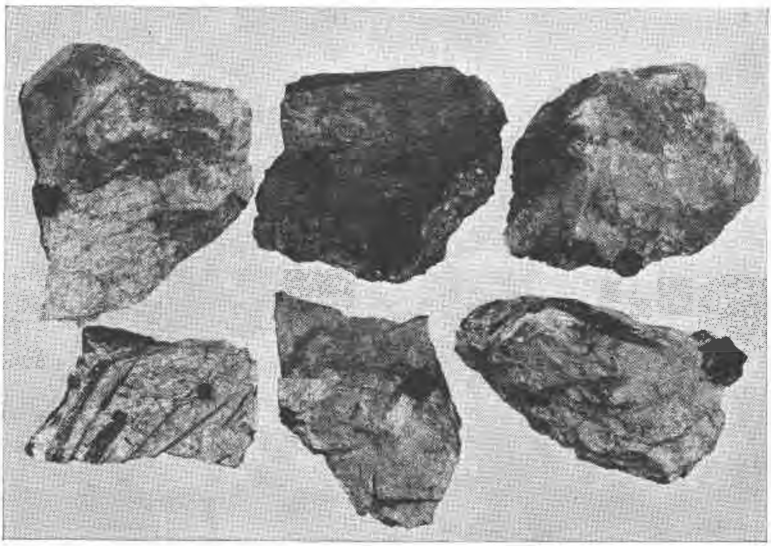

FIG. 6. Crystals of thucholite in feldspar and titanite matrix. One-half natural size. The middle, upper specimen is partly embedded in the altered (chloritized) mineral (pyrorthite?) with which the thucholite is so conspicuously associated, plates of which are also visible in the other specimens.

A peculiar slickensided effect is often noticeable upon the surface of the nodular thucholite, particularly of flattened nodules, the wavy lines characteristic of slickensided surfaces being very pro-

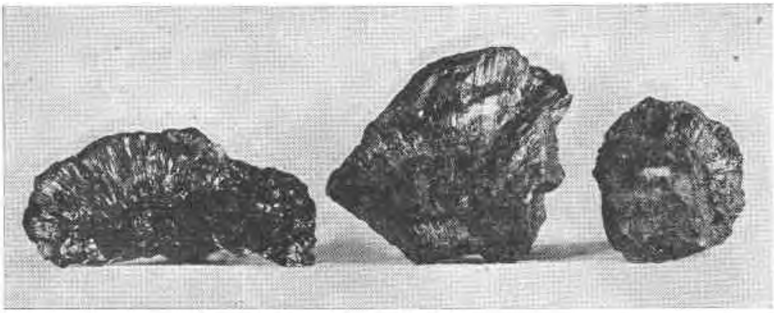

FIG. 7. Specimens of nodular thucholite, showing radial, slickenside striations, due to pressure while the mineral was in a semi-solid state. Three-fifths natural size.

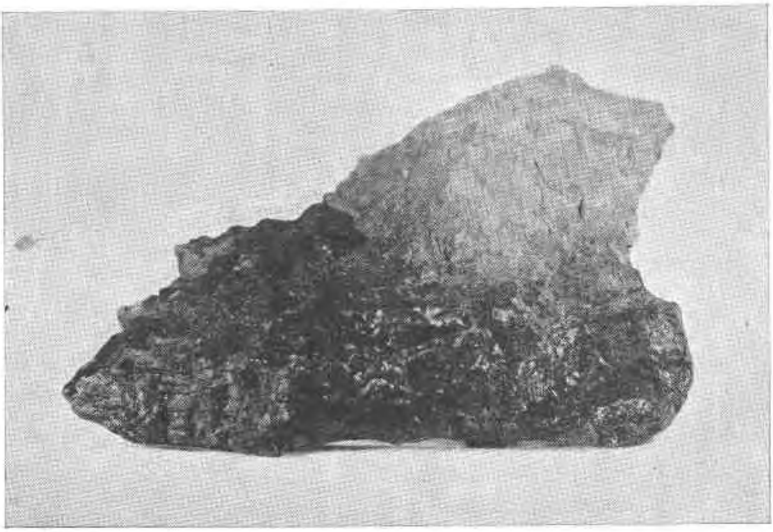

FIG. 8. Mass of thucholite, with adhering feldspar (light). The specimen consists of at least four large, deformed thucholite crystals, embedded in massive thucholite, but this detail is lost in the photograph. Two-thirds natural size.

nounced. The same structure sometimes also is seen in the massive thucholite often found enclosing obscure thucholite crystals, the wavy lines then extending radially from the faces of the crystals

(Fig. 7). The effect would seem to be the result of later squeezing, probably while the mineral was in a semi-solid state.

Most of the thucholite cubes are small, from $\frac{1}{4}''$ to $\frac{1}{2}''$ in diameter; the largest perfect cube found measured 1″ (Fig. 4). The largest single mass of thucholite secured (Fig. 8) measured $4\frac{1}{2}''$ by $2\frac{1}{2}''$ by 1″, although larger masses were found: these, however, broke up badly while being extracted from the rock. The nodules range from $\frac{1}{4}''$ to 1″ in length (Fig. 3).

Character

The massive thucholite possesses the characteristics described by Ellsworth for the Conger material. It is jet black, has a brilliant lustre when fresh, and exhibits a conchoidal fracture. No signs of cleavage were observed. It is extremely brittle, and has a sooty, brownish-black streak. Hardness about 4. It is opaque in the thinnest flakes. Specific gravity = 1.57 at 21°C, which is slightly less than that of the Conger mineral.

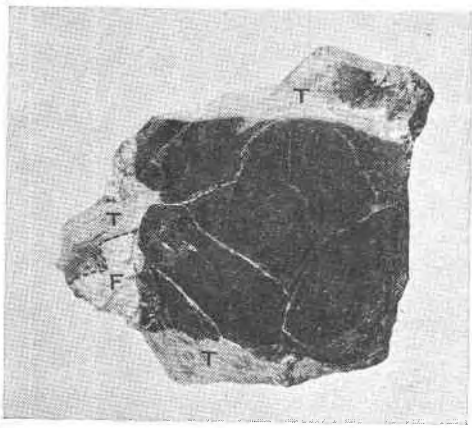

Fig. 9. Polished face of thucholite crystal, with adhering feldspar (F) and titanite (T). The structure figures described in the text and illustrated in Fig. 10, are faintly visible. The strong, irregular white lines are cracks. Magnification $1\frac{1}{3}$ diameter.

The nodular thucholite resembles the massive material, but often has a duller appearance, due to a light film of foreign matter on the fractured surfaces. Large nodules often show a core of rather granular thucholite.

The cubes nearly always have a dull, earthy appearance, even on fractured surfaces, and are evidently composed of non-homogeneous material; this strengthens the theory that they are pseudomorphs. Many of them have a distinct core, which may make up half or more of their mass, of a heavy, black mineral which is probably uraninite. Crystals of uraninite of similar form sometimes occur with all types of the thucholite. Rarely, thin films or crusts of green vanadium salts and of yellow uranium

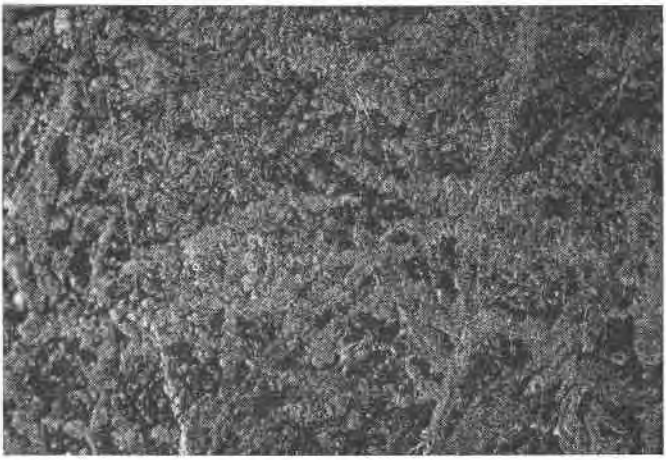

Fig. 10. Portion of polished face of thucholite crystal illustrated in Fig. 9, showing dendrite-like, structure figures of thucholite (light) in process of replacing uraninite (dark). The strong white lines are cracks. Magnification 10 diameter.

salts occur on fractured surfaces in the massive thucholite surrounding thucholite crystals. The specific gravity of three selected crystals was found to be 1.61, 1.92 and 2.00, at 21°C. In contrast to the nodular and massive thucholite, which becomes friable and breaks up rather readily on weathering, the crystal thucholite is fairly compact and resistant to the weather. The crystals sometimes exhibit traces of obscure octahedral parting.

A few crystals were found which exhibit a peculiar pressure effect, the upper cube face having been pressed down while the material was soft, so that a portion of the crystal is flattened out and in part depressed, mushroom-wise, down and around the remainder.

In order to determine whether the thucholite possessed any conspicuous structure, a fairly well-formed crystal measuring one inch in diameter, was ground down and polished on one face (Fig. 9). Even to the unaided eye, the polished surface revealed an interesting structure, and this showed up very plainly under a low magnification as a network of interlacing, dendrite-like figures (Fig. 10). These figures evidently represent secondary mineral matter (carbon) penetrating and replacing an original mineral which is presumed to have been uraninite. The massive and nodular thucholite, when ground down and polished as above, showed no trace of structure, being dense and apparently homogeneous throughout.

All types of the thucholite, when polished, exhibit irregular contraction cracks, which lack any definite orientation and which appear to have developed within the material subsequent to deposition. Such cracks are in part open and in part filled by altered titanite or other mineral matter.

The thin films and veinlets of thucholite penetrating feldspar are composed of rather dull, granular, coal-like material. This is porous, as if it had suffered considerable shrinkage in place, the texture being what might be expected if films of oil had penetrated along cracks and been later carbonized.

Composition

Analyses were made both of the crystal and massive thucholite, and, as expected, the results differed rather widely, owing to the fact that clean and apparently homogeneous material could readily be selected in the second case, whereas the crystals proved difficult to free completely of adhering mineral. The crystals, being presumably pseudomorphs, were also expected to contain more ash in the form of residual matter from the original uraninite.

The sample of crystal thucholite comprised portions of fifteen individuals, eight of which averaged $\frac{1}{2}''$ in diameter and seven $\frac{1}{4}''$. The massive thucholite represented a composite sample of material taken from various places in the pit; only fresh, lustrous mineral was included.

The analyses were conducted by R. A. Rogers, of the Ore Dressing Division of the Mines Branch. Mr. Rogers' report is as follows:

SAMPLE NO. 1: THUCHOLITE CRYSTALS

Weight of sample: 23.512 grams.

Material consisted of roughly cubic crystals, or broken pieces of crystals, ½″ size and smaller.

Specific gravity, determined on total material of sample, at 72° F.,=1.82.

Moisture at 110° C	2.00
Volatile hydrocarbon[2]	20.19
Fixed carbon	50.82
Ash	26.86
	99.87

SAMPLE NO. 2: MASSIVE THUCHOLITE

Weight of sample: 36.791 grams.

Material consisted of irregular, rather flattened fragments, ½″ size and smaller.

Specific gravity, determined on total material of sample, at 72°F., =1.67.

Moisture at 110° C	1.60
Volatile hydrocarbon[2]	19.96
Fixed carbon	61.56
Ash	16.63
	99.75

Moisture was determined by heating a one-gram portion in a platinum crucible in a constant-temperature oven for one hour at 110°C. The sample was cooled over sulphuric acid in a dessicator and weighed. On heating to 230°C, no further loss in weight took place.

Volatile matter was determined on a one-gram sample, powdered to pass 65 mesh. The sample was heated in a platinum crucible, provided with a close-fitting cover, for seven minutes over a Meker burner, cooled and weighed. The total loss in weight, minus the moisture weight determined at 110°C, gave the figure for volatile.

Fixed carbon was determined on the residue from the sample tested for volatile. This residue was placed in an alundum boat and burned in a current of oxygen in a combustion furnace, the CO_2 being absorbed and weighed.

Ash was determined by weighing a one-gram sample of material, crushed to pass 65 mesh, in a silica crucible and burning in a small muffle furnace to constant weight.

Ignition tests on the samples were made with the following results. Fragments of both samples, placed in a muffle at a red heat, ignited easily and burned at first with a yellow flame 1½″ to 2½″ high, indicating the presence of volatile hydrocarbons. Duration of this flame was about 20 seconds. The fragments then burned with a very short blue flame. No decrepitation took place, and the fragments retained their form after cooling.

[2] Author's note. While most of this figure probably represents hydrocarbon, a proportion of it possibly is to be assigned to water of composition of the ash residue.

When the samples were powdered and ignited as above, No. 1 burned to a reddish-brown ash, and No. 2 to a greenish-black ash. Under the microscope, both powders are seen to contain a proportion of lighter-coloured particles. When No. 1 powder was burned in a current of oxygen, it had a tendency to fuse into globules.

Under the microscope, the fragments from the ignition test are seen to have a pale, olive-green colour internally, while a mottled brownish-red was noted on the outside. The red colouration was much more pronounced in the No. 1, or crystal sample. The larger pieces still preserve traces of the conchoidal fracture of the fresh thucholite; they are traversed by numerous fine hair cracks. The material is clearly not homogeneous, small flakes of calcined mica or chlorite being visible in No. 1 sample, while No. 2 contained a proportion of almost black mineral.

When tested in the electroscope, the ash from both No. 1 and No. 2 samples was found to be strongly radioactive. Equal weight and surface areas of each sample and of a carnotite standard containing 0.87 per cent U_3O_8 were compared[3] with the following results:

No. 1 was 10.4 times as active as the standard.
No. 2 was 62.5 times as active as the standard.

These results proved rather contrary to what had been expected, as it was thought the crystal material would be more active than the massive. Ellsworth found the ash of the Conger thucholite to have an activity 13.6 times as great as a carnotite standard of 1.55 per cent U_3O_8 content, from which he deduced a U_3O_8 content of 21.08 per cent. By the same method of calculation, the ash of No. 1 sample would contain 9.05 per cent U_3O_8, and that of No. 2 sample, 54.37 per cent. Such calculations for U_3O_8 content, however, do not give dependable results when the uranium content of the sample is much greater than that of the standard.

COMPARISON OF THE HENVEY AND CONGER THUCHOLITE

Ellsworth found for the Conger thucholite described by him, carbon contents of 42.24, 45.18 and 50.48 per cent, respectively. On three different samples, he obtained the following moisture and ash values:

Moisture at 110°C	7.64	8.63	8.40
Ash	24.48	24.20	28.06

[3] Determinations by A. Sadler, Chemical Division, Mines Branch.

Comparing these figures with those obtained for the Henvey thucholite, the widest discrepancy is shown by the moisture content, the Henvey mineral being very much lower in water than the original.

The Conger thucholite, which is described as occurring in close association with uraninite, might be expected to correspond more closely with the crystal than with the massive type from Henvey, which, in fact, it does.

An important difference between the thucholite from the two localities is that Ellsworth found the Conger material to contain

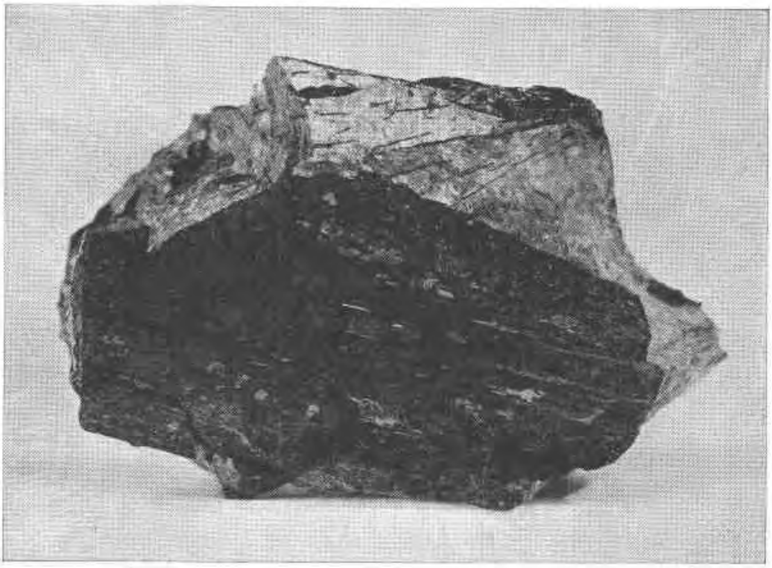

FIG. 11. Platy crystal of the altered, dark-green mineral (pyrorthite?) with which the thucholite is prominently associated, penetrating feldspar (light). The wedge form of the mineral is shown, andal so the longitudinal striations. Two-thirds natural size. (Reverse of Fig. 12.)

no volatile hydrocarbons, whereas th e Henvey thucholite contains in the neighbourhood of 20 per cen t. This figure, however, was obtained by difference and not by a direct method, and thus may be too high.

The specific gravity (1.57 to 1.67) of the massive thucholite from Henvey, as determined on several samples, is 0.20 to 0.10 lower than that of the Conger mat erial (1.77), while that of the crystal thucholite (1.61 to 2.00) varied from 0.16 lower to 0.23 higher.

The comparative radioactivity of the ash yielded by the mineral from the two localities has already been noted in the preceding section.

MINERALS ASSOCIATED WITH THE THUCHOLITE

As already noted, the thucholite is usually found enclosed in oligoclase feldspar and associated with radiated groups of thin, wedge-shaped plates of a dark green, altered, and often highly-carbonaceous mineral (Figs. 11 and 12) that is now principally chlorite and whose original identity is doubtful. Pending further study, this mineral is provisionally classed as pyrorthite. Other interesting minerals that are closely associated with the thucholite are the following.

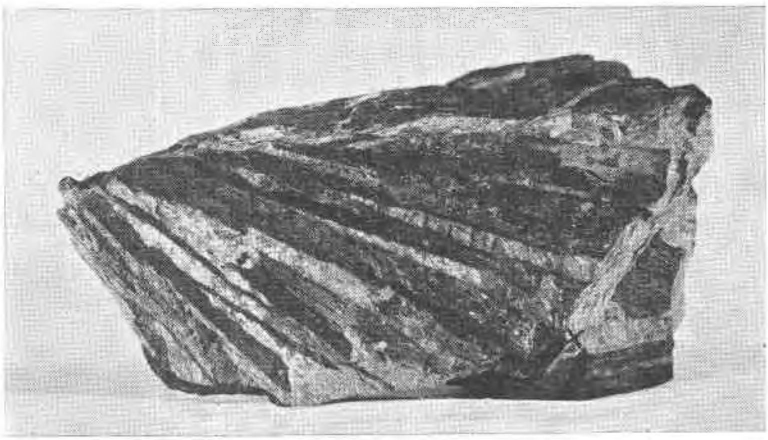

Fig. 12. Specimen showing typical radiating habit of the altered, green mineral (pyrorthite?) with which the thucholite is associated. The plates, which attain a length of 30 inches and radiate fan-wise from a common nucleus, are frequently impregnated with carbon. Thucholite nodules and crystals occur along their margins and sometimes embedded in them. Such an embedded thucholite crystal is visible (x) in the lower, right corner. Two-thirds natural size. (Reverse of Fig. 11.)

Allanite

A dark-coloured, brown to black mineral, that is probably allanite, is fairly common in more or less close proximity to the thucholite. It has a vitreous to resinous lustre and a sub-conchoidal fracture, when fresh. Most of this mineral found was massive, with no traces of crystal outline.

Well-formed crystals, up to 3″ long, of a black mineral, that may be highly-altered allanite, also occur with the thucholite and the same mineral also occurs in small, formless masses in feldspar at various places throughout the dyke. The material of these small masses, while also considerably altered, is fresher than that of the crystals, has a dull, resinous lustre and often so closely resembles dull thucholite as to make it difficult to tell the two substances apart in the rock. The crystals, on the other hand, are matt and earthy on broken surfaces, and the mineral is often so highly altered as to readily slake in water to an earthy powder.

Beryl

A few specimens of massive greenish-blue, glassy beryl were found associated with allanite, titanite and thucholite, and also several small beryl crystals up to 1½″ in length, embedded in feldspar. The mineral is rare.

Biotite

Large plates of biotite occur in some abundance, distributed irregularly through the dyke-mass, and more particularly in its western portion. The plates attain a diameter of 30″, but are seldom over 6″ thick and are usually much thinner. They often contain layers of garnet and martite, that penetrate between the sheets, and also sometimes enclose small nodular masses of martite. More rarely, round nodules of thucholite, up to 1″ in diameter, are found enclosed in the biotite.

Cyrtolite

An almost invariable associate of the massive and nodular thucholite is cyrtolite, which occurs in small masses up to a pound or more in weight. The surface of the masses exhibits well-formed crystals of square prismatic habit, with curved faces. The colour of the mineral is brownish-grey to reddish-brown. It sometimes contains small inclusions of lustrous thucholite.

Occasional small masses of cyrtolite are also common in the body of the dyke, enclosed in feldspar, and unaccompanied by thucholite.

The association of cyrtolite with the thucholite is of interest since Ellsworth records the same association in the dyke in Conger township.

Garnet

Small amounts of granular, reddish-brown garnet, that is probably almandite, occur with the thucholite, usually closely intergrown with the chlorite. Individual crystals are rare, but a few small, deformed ones were observed.

Massive garnet often occurs in wedge-shaped layers, up to 1″ in thickness, between the plates of large biotite crystals, and these layers also include well-formed garnet crystals, some of them $\frac{1}{2}$″ in diameter.

Martite

Considerable martite occurs in the dyke, usually in the form of small, nodular masses, up to 1″ in diameter, enclosed in feldspar. Similar nodules, as well as wedge-shaped layers up to $\frac{1}{8}$″ thick, also sometimes occur enclosed in large biotite individuals.

Pyrorthite (?)

The altered mineral, now principally chlorite, that is such a conspicuous associate of the thucholite, has a dark greenish-colour and a greenish streak: with increasing carbon content the latter becomes brown-green. It occurs in broad, flat, platy crystals that attain a length of 30″ and are often 2″ to 4″ wide. The individuals are seldom over $\frac{1}{2}$″ thick and are usually much less (Fig. 11). They occur in radiated groups in feldspar, but without parallel axial arrangement. They have a tapered form, both widening and thickening with increasing distance from the common nucleus from which groups of crystals start (Fig. 12). They also taper laterally to a wedge-like edge. The broad faces are uneven and carry strong longitudinal striations (Fig. 11). Traces of obscure, scaly cleavage parallel to the tabular faces are sometimes evident, but in the main the mineral exhibits uneven fracture. The lustre is dull to earthy. Hardness $= 2\frac{1}{2} - 3$. The crystals are distinctly non-homogeneous and contain considerable pyrite. They often also contain appreciable amounts of thucholite in thin seams between the platy layers. The texture is rather loose.

Dana (6th Ed., p. 523) lists a variety of allanite, high in carbon, —pyrorthite—described by Berzelius from Sweden, with which the Henvey mineral seems to have broad similarity and with which it may possibly be identical.[4]

[4] Note.—Since the above was written, the writer, through the courtesy of

Titanite

Another invariable associate of the massive and nodular thucholite is titanite, which occurs in considerably greater amount than cyrtolite. It is rather highly altered and of a light greenish-grey colour. In some cases, the alteration has been so pronounced as to have converted the original mineral into a grey clay, resembling impure kaolin.

The titanite occurs in large irregular masses, which, on breaking, are seen to be made up of an aggregate of broad, platy, wedge-shaped crystals. These exhibit the typical twinning of titanite. The individuals measure up to 2″ across the faces.

Under the microscope, the titanite is seen to often contain small seams and cavities, which are lined with minute crystals, possibly also titanite. It is also full of very small specks of a brown, lustrous mineral, that are probably remnants of fresh, unaltered titanite, and it is frequently traversed by fine, hair-like veinlets of thucholite. Minute black specks of an included black, brilliant substance may also be thucholite.

Uraninite

Uraninite is present in relatively large amount in the mineral assemblage intimately associated with the thucholite. It was not observed elsewhere in the dyke. It occurs rarely in small cubic crystals enclosed in thucholite, the crystals seldom being over $\frac{1}{4}$″ across. The habit suggests that it is to be referred to the variety cleveite. Cubes of apparent thucholite often indicate by their weight that they contain a core of a very heavy mineral that is probably uraninite; and broken crystals, composed externally of thucholite, frequently are seen to be made up in part of uraninite.

Considerable massive uraninite is also present in the form of small veins, which sometimes attain a width of as much as $\frac{1}{2}$″.

Dr. L. J. Spencer, of the British Museum, has been able to secure two specimens of the type pyrorthite from Kararfvet, near Fahlun, Sweden, and has compared the material with that from Henvey. The Swedish mineral consists of small, thin, bladed crystals, penetrating oligoclase feldspar, and is black, lustrous and quite fresh, in contrast to the green, chloritized Henvey mineral. The amount of thucholite present is very small, only a few minute specks being visible under the microscope: these lie in the feldspar, adjacent to the pyrorthite but not within it. While the Swedish and Henvey minerals differ markedly in appearance, the habit of both is similar, and it seems probable that the Henvey mineral is altered pyrorthite.

Both uraninite crystals and massive uraninite are usually bordered by a shell of thucholite, but there is no sharp line of demarcation between the two substances. In both cases, the uraninite is traversed by minute veinlets of thucholite which is apparently in process of replacing uraninite.

The uraninite is usually composed of an outer zone having grey-black colour, dull lustre and conchoidal fracture, and an inner core of more brilliant, black, granular mineral.

The uraninite crystals are sometimes bordered by a zone of brown, resinous mineral that is evidently an alteration product, but whose identity has not been determined. Earthy incrustations of yellow uranium salts frequently line cracks in the feldspar, thucholite and other minerals surrounding uraninite, and a few specimens of uranophane, in radiated groups of lemon-coloured, fibrous crystals having a waxy lustre, were found in similar association.

NOTE.—The entire assemblage of minerals associated with the thucholite, containing, as it does, much included thucholite in the form of irregular masses, nodules, pellets and minute veinlets, exhibits, in its character, just what might be expected if we suppose the pocketty zones in which such minerals occur to have become saturated with oil which later was carbonized. This hypothesis is supported by the remarkable occurrence of oil in the dyke, as described in the following section.

OIL

The presence of an oily substance in the dyke is of extreme interest, since it suggests at once that both it and the thucholite may have a similar origin.

The oil is present in far smaller amount than the thucholite, and, as far as observed, is confined to two parallel fracture-zones that cross the dyke at right angles. These zones are narrow, only about 12 inches wide, and occur some 40 feet apart. Owing to the pegmatite-gneiss contact being concealed by overburden, it was not possible to determine whether the fractures extend into the gneiss on either side of the dyke, but they do not appear to do so, and there is no evidence of any lateral faulting of the dyke.

The most westerly zone, about midway of the pit, is made up of angular, brecciated fragments of feldspar and quartz, cemented in part by calcite and in part by grey, chalcedonic silica. Numerous angular cavities exist in this breccia, and are lined sometimes with sharp, scalenohedral calcite crystals and sometimes with quartz crystals, upon which were found small crystals of marcasite or pyrite. In the second zone, which crosses the pit near the east face, both quartz and feldspar have been shattered to form thin parallel plates. The crevices between these plates are similarly lined with calcite crystals, upon which sit small crystals of pyrite. Some of the specimens carried, also, among the pyrite crystals, numerous minute, twisted wires or hairs of a bright, greenish-yellow, metallic mineral, that is probably marcasite.

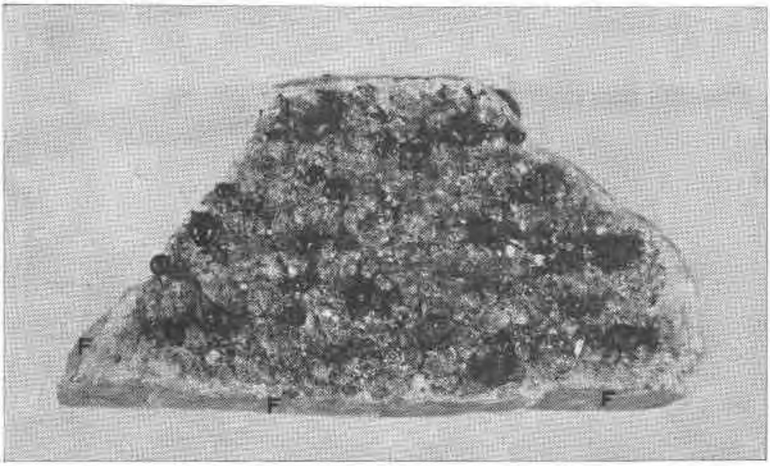

FIG. 13. Small balls of a tar-like mineral (hardened oil) sitting on calcite and pyrite crystals lining a crevice in shattered feldspar (F). The balls range up to ½″ in diameter. Natural size.

Both zones are heavily saturated with a heavy, yellow oil, resembling a thin vaseline. Water, trickling down the face, carries the oil from freshly-broken surfaces to the sump, where it forms a conspicuous film. The oil has the characteristic odour of crude petroleum. On exposure, it soon becomes viscous and extremely sticky.

In addition to the thin oil, there are present in the cavities and crevices of the shattered rock, and sitting upon the calcite or quartz, numerous small, pea-like balls of hardened oil (Fig. 13). In freshly-broken rock, these have a pale, olive-green colour and are soft and tacky, resembling elaterite. On exposure, they gradually harden, first to a rubbery consistency and finally to a hard, pitch-like substance. In the hardening (oxidation) process, they change colour, darkening to brown and finally to black. Films of the oil undergo exactly the same change. The balls range in size from small specks to as much as ½″ in diameter. They are sometimes covered with a coating of pyrite or marcasite crystals.

It was not possible to collect a sufficient amount of the thin oil or of the hardened products to provide material for a complete laboratory investigation. A small number of the pea-like balls were, however, secured, and these have been examined in the Fuel Research Laboratories of the Mines Branch. The following report on the material has been furnished by the Superintendent of the Laboratories:

The specimen submitted comprised several pea-like lumps of both hard and soft material. The hard lumps were of a brittle, resin-like nature, while the soft lumps were of a gummy, rubbery consistency.

Specific gravity: 1.000 to 1.086. The higher figure was for the largest hard lump, about the size of a large pea, while the average of nine smaller lumps was 1.021.

Solubility tests were made in several different solvents. Selected lumps were found not soluble in acetone and methyl alcohol and only partially soluble in petroleum ether, carbon bisulphide, benzol, sulphuric ether and chloroform. The proportion of the softer, gummy material soluble in chloroform was approximately half, and the refractive index of the chloroform extract was 1.638 at 36°C. (1.645 at 15.5°C.).

When heated at 107°C. for two hours in a moisture determination oven, the loss in weight was 0.8 per cent and the material did not melt.

The ultimate analysis of the dried gummy material yielded:

	Dry basis	Ash-free basis
Carbon	81.48	86.76
Hydrogen	11.46	12.16
Ash	5.75	—
	98.69	98.92

Ratio of carbon over hydrogen = 7.135.

Remarks: The rubbery nature of the material resembles that of elaterite, the specific gravity of which is listed as ranging from 0.90 to 1.05, but the sample was not sufficient to determine to what extent the physical and chemical properties resemble those of elaterite or other (natural or polymerized) organic substances, or to decide definitely its exact nature.

SOURCE OF THE OIL AND THUCHOLITE CARBON

Two questions of great mineralogic interest are: (1) the source of the oil and thucholitic carbon in the dyke, and (2) whether any relationship exists between the oil and the thucholite.

No trace of oil, or of its solid, asphalt-like derivatives, was noted in place outside of the two oil-saturated, cross fracture zones. No thucholite was observed in these zones. The oil zone midway of the pit can now only be seen in a thin strip of pegmatite remaining on the north wall, at a point opposite the thucholite occurrences in the south wall and in the lower part of the pit. The zone probably extended across the pit, in the same manner as that in the east face, but water and broken rock prevented an examination of the pit floor and the zone is not visible in the south wall. In the case of the second oil zone, that crosses the dyke on the east face, a pocket of thucholite, with some uraninite and titanite, was found almost in the middle of the dyke and close to the oil zone but not visibly connected with it.

No data are available on what may have been the distribution of thucholite in the dyke-mass now worked out. The quarry, when first visited, had reached a depth of 30 feet, the pegmatite having been mined out almost to the gneiss wall on the north side. Along the south wall, however, a strip of pegmatite about 8 feet wide remains in place, and it was in this, at a depth of 6 to 8 feet below the surface, that most of the thucholite found was obtained. No thucholite was noticed in place in the floor of the pit. It therefore seems that the thucholite is not disseminated irregularly throughout the dyke-mass, but that it tends to occur in proximity to the oil zones. This naturally would suggest some relationship between the oil and the thucholite, *i.e.*, that the thucholite has been formed from the oil. The fact that the thucholite is so often found in cubic crystals having the typical form of uraninite, and that the massive thucholite frequently occurs associated with uraninite, prompts the theory that the thucholite owes its formation to radioactive emanations from uraninite acting on oil that has penetrated the dyke-mass adjacent to the oil-saturated fracture zones, with the formation of carbon replacing uranium. That carbon, with an atomic number of 6, should replace uranium, the element with the highest atomic number, seems remarkable. Where uraninite has been incompletely (externally) altered to thucholite, the supply of oil may be regarded as having failed. Where massive thucholite encloses thucholite crystals, an excess of oil was probably present, which, however, radioactivity of the original uraninite nucleus sufficed to alter.

If the above theory be correct, the thucholite cannot be regarded as a primary mineral of the pegmatite, (as concluded by Ellsworth for the Conger mineral), and must, indeed, be one of the last minerals to have formed.

No theory is advanced for the source of the oil hydrocarbon present in the cross fracture zones. No younger (Palæozoic) sediments from which oil seepages might possibly have entered these zones occur in the vicinity of the dyke, nor is the presence of such sediments anywhere in the immediate district indicated on recently-published, geological maps[5] of the region. The entire area covered by these maps is underlain by rocks of Pre-Cambrian age, which, in the immediate vicinity of the deposit, consist of granite, quartz-syenite and gneiss. It is possible, of course, that younger sediments may have existed and have since been removed by erosion.

If the oil be of direct pegmatitic origin, it might be expected to occur irregularly in the dyke-mass proper and not alone in the brecciated zones, as seems to be the case. This, however, does not necessarily preclude an igneous origin, since the mass of the dyke, which is a very tightly frozen rock, may have provided no channels in its upper, already cooled portion for the penetration of the oil. The loose, brecciated ground of the fracture zones would provide such channels, and from these the oil might have traveled into contraction cracks adjacent to the walls—that is, into the zones where most of the thucholite, with its associated uraninite, titanite, cyrtolite, etc., is found.

SUMMARY

The above notes describe what is believed to be the most important occurrence of pegmatitic carbon (thucholite) on record.

In addition to the interest due to the comparatively large amount of thucholite present in the dyke, its occurrence in the form of cubic crystals, which are presumably pseudomorphs after uraninite, is remarkable. The general occurrence of the thucholite indicates that it is not a primary constituent of the pegmatite, but that it has been introduced at a later stage, possibly in the form of oil. It was probably one of the last minerals to form, its deposition coinciding with severe alteration of the titanite, allanite, etc., with which it is often associated. The fact that it contains about 20 per cent of volatile hydrocarbons suggests that the mineral has not reached stable form.

Of added interest is the presence in the dyke of a hydrocarbon in the form of a petroleum-like oil, and of small pea-like bodies of a substance resembling elaterite.

[5] *Geol. Surv. Can.*, Maps Nos. **220A, 221A, 238A, 239A.** These maps embrace an area of over 1,500 square miles, lying to the northwest of the deposit, which is situated near the southeast corner of Map No. **239A** (Key Harbour Sheet).