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URANINITE AND THUCHOLITE FROM PIED DES MONTS, CHARLEVOIX COUNTY, QUEBEC

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INTRODUCTORY

The brief notes given below on the character and occurrence of uraninite and thucholite at the Pied des Monts mine are based on a visit paid to the property in October, 1936, and on a rather superficial study of a suite of specimen material secured on that occasion.

Two good specimens of the uraninite and one of the thucholite were sent to Dr. A. C. Lane, in 1937, as a contribution to the work of his Committee on the Measurement of Geologic Time, and one of the uraninite pieces was turned over by him for investigation and analysis to O. B. Muench, whose report has been published (*Jour. Am. Chem. Soc.*, **61**, 2742, 1939).

Muench's results showed a lead-uranium ratio of 6.67/49.25=0.135. There was a rather high ignition loss of 12.07 per cent, due probably to the thucholite content, as indicated by the radiographs accompanying this paper. Noteworthy was the almost complete absence of thorium and rare earths, a feature that makes this uraninite exceptional among those of which analyses have been published. The calculated age is 956 million years.

Muench's analysis gave rather different figures for uranium and lead as compared with those obtained by Ellsworth (see footnote reference 6) on a specimen previously analyzed by him, which yielded a lead-uranium ratio of 10.84/73.08=0.148. Ellsworth notes that his specimen was very fresh, with no evidence of alteration, and presumably it contained far less thucholite.

The lead extracted by Muench was sent to A. O. Nier, at Harvard University, for the isotopic determination, the result of which showed[1]

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[1] Nier, A. O., The isotopic constitution of radiogenic leads and the measurement of geological time: *Physical Review*, **55**, No. 2, 158–159 (1939).

about 4 per cent to be common lead. The age calculated from AcD/RaG was 905 million years, and from RaG/U^{238}, 882 million years.

Description

The two matrix specimens of uraninite, and the single specimen of nodular thucholite associated with it, from the old Pied des Monts mica mine, in Lacoste township, Charlevoix County, Que., which I gave to Dr. Lane early in 1937, formed part of a small mixed lot of these minerals which I obtained in 1936. The pegmatite from which they came is the old, classic locality from which J. Obalski, many years ago, obtained similar material, and which he described briefly in *Mining Operations in the Province of Quebec for the Year 1903*, a publication of the Quebec Department of Lands, Mines and Fisheries, pp. 65–68, as well as in *Journal of the Canadian Mining Institute*, **7**, pp. 245–256 (1904). Obalski's description was based on reports made on the uraninite (cleveite) by Rutherford, then at McGill University, and by the Curies, in Paris.

The location of the deposit, as near as I can state it, is 70° 20′ W. and 47° 45′ N., about 100 miles below Quebec city, on the north shore of the St. Lawrence. It lies 13 miles north of the end of the branch railway leading from Murray Bay to La Chute, on the Murray River, and one can drive by car to within 2½ miles of the mine.

Opened originally for muscovite mica by a French company in the early years of the century, the property subsequently lay idle until 1935, when it was acquired by Quebec interests, the Syndicat Charlevoix Radium Exploration, who have since done intermittent work for both mica and radioactive minerals on the two exposures originally opened up and have taken out a little mica, as well as a small amount of the uraninite and thucholite material.

Most of the work done in the early days was conducted on an exposure of pegmatite on the upper flank of the mountain forming the northeast side of Lac Pied du Monts, about one mile from the lower end of the lake. These workings lie about 600 feet above the lake, and 100 feet below the summit of the ridge. Here, the exposures suggest a rather flat-lying pegmatitic sill, about 12 feet wide, cutting dark gneiss, and with an apparent northeasterly strike. At the east end, the dyke has been surface-blasted to a depth of 12–15 feet for a distance of about 75 feet along the strike, which is diagonally up the mountain side, and at the lower, or west end, two short tunnels have been driven. The lower of these has been carried in a distance of 50 feet along the strike, on a 25° rise; the upper is 25 feet long, heading diagonally towards the lower one, but not connecting with it. In addition, the present operators have done further work on a shallow pit sunk on the left bank of the small creek flowing out of the lake, about 450 yards from the lake. The creek flows through a narrow gorge, and the pit has been sunk at the base of the steep rock-wall forming its northeast side, practically at water level. As a result, this working floods rapidly and has to be continuously pumped out when work is proceeding. The pit has been carried to a depth of 30 ft., and from its bottom a drift has been carried 50 ft. to the southeast. All of this work is in pegmatite, but the exposures are insufficient to indicate clearly either the width of the dyke or the strike and dip. There is, however, an apparent width of at least 15 ft., with no walls showing.

The above two sets of workings are at least one mile apart, and, as far as could be learned, no pegmatite outcrops have been located in the intervening section. However, the character of the rock and associated minerals at both sites is so essentially similar that it seems highly probable that we have to do with two outcrops of one and the same dyke.

The pegmatite consists predominantly of pale pink microcline, with lesser amounts of white albite and quartz. The quartz is mostly in modified graphic intergrowth with the feldspar with very little in free, massive form. Biotite is abundant, often in large, thin plates up to 18 inches across. The dyke also carries muscovite, usually of a smoky, brownish colour, in plates up to 6–8 inches in diameter, and the operators reported 1,500 pounds of cut, merchantable muscovite, in various trade sizes, recovered from their mining in 1936. Occasionally, muscovite and biotite occur intimately associated and even intergrown; fine examples of plates of both micas in parallel growth, or showing a crystal of biotite enclosed within one of muscovite, have been found. The biotite is remarkably rich in pleochroic haloes, as recorded by D. E. Kerr-Lawson.[2] These haloes have been further studied by G. H. Henderson and S. Bateson[3] who deduced from them an age of 750 million years. This compares with an age of 1,070 million years calculated by H. V. Ellsworth from an analysis of the uraninite.[4]

Minor accessory minerals of the pegmatite include the following:

Pink garnet, of hessonite colour, occurs in small crystals, usually in localized aggregates associated with small biotite flakes, and enclosed in intergrown white albite and quartz. The garnets are mostly anhedral, shattered, and penetrated by quartz and biotite along the fractures. Associated with them were noted occasional small grains of an undetermined yellowish mineral, having a resinous lustre, and outwardly resembling microlite.

Beryl, of a pale greenish-white colour, occurs in stout prisms up to 2 in. across, and up to 12 in. in length. The crystals usually have a characteris-

[2] *University of Toronto Studies*, No. **24,** 54–70 (1927), and No. **27,** 15–27 (1928).

[3] *Proc. Roy. Soc.*, A, **145,** 563–581 (1934).

[4] See reference 6.

tically rounded, rod-like section, due to the development of a large number of prism faces. Nearly always some of these are obscured by surface alteration, but on some individuals up to 16 faces can be determined. In only a few instances were crystals noted having the typical six-sided outline of beryl, and these individuals were all small—less than $\frac{1}{2}$ in. across. Externally, the crystals are usually coated with a thin film of a dark-green, chlorite-like substance, and not infrequently prismatic striations are filled with small needles of black tourmaline.

Apatite, of olive-green to blue-green shade, occurs in small amount, usually in small, anhedral grains in feldspar.

Zircon is present in fair abundance, in small, lustrous, clove-brown to greenish-black individuals, usually embedded in feldspar or quartz. The crystals are of typical zircon habit, and measure up to $\frac{1}{2}$ in. in length by $\frac{1}{4}$ in. across. No zircon of the cyrtolite variety, so typical of eastern Canadian pegmatites, was observed.

Several small irregular pieces of monazite, the largest measuring $1\frac{1}{2}$ in. by 1 in. by 1 in., were found on washing the specimens selected for weight from a mixed assortment of uraninite, etc., placed at my disposal by the mine management. As several of the uraninite specimens also were found to carry attached broken fragments of monazite, it is probable that all of the pieces of this mineral originally belonged to a single individual that occurred in intimate association with a pockety aggregate of uraninite (see below). The mineral is dark reddish-brown in colour, and contains numerous minute blebs of thucholite and specks of pyrite. The pieces were rough and irregular in form, and showed no crystal faces.

Pyrite and chalcopyrite were observed as small brecciated fragments, and also filling minute veinlets, within a few of the uraninite specimens.

Uraninite

Unfortunately, no details can be given here regarding the manner of occurrence, association, etc., of the uraninite, since only minor traces of the mineral were seen in place. The whole of the material obtained, amounting to some 10 pounds in all, consisted of about 30 individual specimens, picked more or less at random from a box containing a mixed assortment of uraninite and thucholite put at my disposal by the management, and from which the larger and heavier pieces were rather hurriedly selected, with only specific gravity to guide the choice.

The management stated that about 75 pounds, in all, of uraninite were obtained in the four months, June to September, during which the property was worked in 1936. This was taken from both the upper and lower workings, but apparently most of it came from the main pit on the mountain side, where a single mass, or pocket, was stated to have yielded about 25 pounds. The remainder appears to have been in the form of small, scattered crystals or aggregates disseminated irregularly through the dyke, but probably mainly in a localized zone in the immediate vicinity of the upper tunnel, where the broken rock faces show numerous patches of feldspar of the dark reddish shades typical of colouration by radioactive emanation.

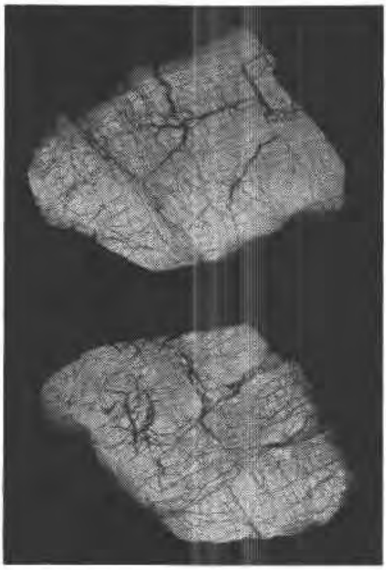

FIG. 1. Radiographs of two halves of a single sliced specimen of uraninite from Lac Pied des Monts, Que. Shows the intensive veining of the material by cracks and minute fissures filled with thucholite. Muench's analysis was made on comparable material. $\frac{2}{3}$ natural size. Exposure 50 hours.

Of the 75 pounds of uraninite reported to have been obtained, however, only about two-thirds, or less, probably would be clean mineral, since the material examined was found to consist largely of masses or cores of uraninite carrying varying amounts of attached pegmatitic material. In nearly all cases, also, the uraninite carries considerable thucholite, in the form both of external crusts and as a network of fine veinlets penetrating right through the cores. In some specimens, small, brecciated nodules and veinlets of pyrite and chalcopyrite occur within the uraninite. Examination of 15 sliced and polished specimens, selected for gravity, showed that very little pure, fresh uraninite could be obtained from them, even the central cores of the largest pieces being extensively seamed by fine veinlets of thucholite.

Owing to the degree of alteration (oxidation) suffered by the uraninite, and to its thucholite content, only the central cores of polished specimen commonly exhibit metallic lustre, this being shown by the small brecciated fragments between the veinlets, and, in general, the mineral has a dull, matt appearance. The colour in the mass is black, but cores less highly veined by thucholite have a steel-blue tone, resembling that of polished Wilberforce uraninite.

Of the specimens obtained, exclusive of those sent to Dr. Lane, of which no record was made, the two largest each measured roughly 3 in. by 2½ in. by 2 in., being practically free of attached gangue. They weighed, respectively, 663 grams and 480 grams. Six pieces were between 2 and

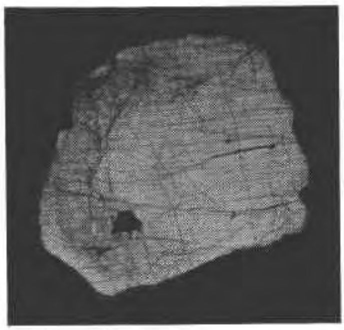

FIG. 2. Radiograph of another specimen of Lac Pied des Monts uraninite, showing rather less intensive veining of core of crystal by thucholite. The small black corroded bleb is biotite. ⅔ natural size. Exposure 50 hours.

3 in. long and 1 to 2 in. in the other dimensions. The remainder were smaller, down to ¾ in. Practically all had suffered some loss by breakage, were of irregular shape, and may be described as roughly nodular, though in a few instances, where the uraninite carried thin plates of biotite on two opposite and approximately parallel, flattened faces, an approach to vein-like form was exhibited. In these latter specimens, also, the thucholite veinlets run predominantly parallel to the long dimension of the specimen, instead of promiscuously, as in the majority of the pieces.[5] Only on one or two of the smallest specimens could any approach to crystal form be noted.[6] Two of these are flattened plates, ¾ in. across and ⅜ in.

[5] Note. The specimens which I gave to Dr. Lane, and which he showed me later, after polishing, also seemed to have vein-like character; in this respect, resembling pitchblende rather than uraninite.

[6] In this connection, see H. V. Ellsworth's paper Uraninite from Lac Pied des Monts, Saguenay District, Quebec: *Am. Mineral.*, **19,** 421–425 (1934). Ellsworth there depicts one of the original uraninite specimens secured by Obalski, and describes it of dodecahedral form, with six developed faces, and weighing 375 grams.

thick, and showing rough hexagonal outline vertical to the dominant upper and lower surfaces. All of the apparent 8 faces of these two specimens are rough and irregular, slightly pitted, and carry small amounts of both muscovite flakes and quartz, which indent the uraninite. In addition, one of them is further roughened by a coating of dull, friable thucholite. From its gravity, this last specimen probably has had its original uraninite replaced in large part by thucholite.

The majority of the specimens carry considerable attached mica, either muscovite or biotite, and in some cases both. This mica is often particularly in evidence on two opposite sides of the specimen, suggesting that the uraninite formed within a "book" of mica, forcing the plates apart in the process. This might account for the dominant platy, or vein-like, form of many of the specimens.

Very little of the uraninite has altered to the orange and yellow secondary products so often formed by surface oxidation of this mineral. Only one of the specimens secured showed a minor trace of a yellowish incrustation. Small amounts of a reddish-orange and yellow powder were, however, observed among the friable, weathered material of a small thucholite pocket, or nodule, in the rock-face near the upper tunnel. This proved to be too indefinite for identification, but probably is gummite, or uranophane.

Thucholite

As noted above, practically all of the uraninite examined proved to carry considerable thucholite, both as external crusts of friable, powdery material, and also filling a network of minute veinlets penetrating the entire mass of the uraninite. Many of the uraninite specimens proved, on polishing, to contain only a residual skeletal core, or in some cases, several isolated cores, of uraninite surrounded by thucholite, while the volume represented by the vein thucholite would average probably about 20 per cent of the whole.

So much for the thucholite associated intimately with the uraninite. Of greater interest is that occurring as discrete, and usually nodular, masses in the pegmatite itself. The largest specimen of such nodular thucholite secured measured 3 in. by 2 in., by $1\frac{1}{2}$ in., was of rather rough, irregular shape, and was partly enclosed by a thin concentric shell of muscovite. As with the uraninite, such a mica envelope is characteristic for the thucholite nodules, and the majority of those obtained have it. From the above size, the nodules range down to small bean-like pellets. A number of those secured were of walnut size. The larger ones commonly are elongated, having the shape of a small potato.

All of the larger specimens have suffered considerably from surface, or near-surface, weathering, and most of them are broken. They consist of very friable material, and break down readily to a granular powder. Curiously, the outer shell seems the most resistant and is usually coherent fresh, and lustrous, while the central core consists of a fine, matt powder. This latter is often grey in colour, and in one specimen is canary-yellow, indicating that the colouration is due to a uranium salt: this yellow powder proved to be feebly fluorescent under the mercury vapour (H-3) lamp.

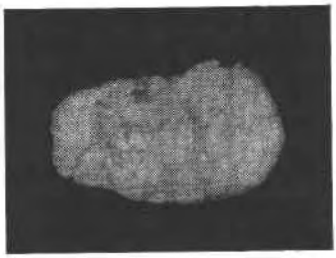

FIG. 3. Radiograph of a small nodule of thucholite from Lac Pied des Monts, Que. The material was very friable and had to be mounted in bakelite for polishing. Natural size. Exposure 96 hours.

The only really fresh thucholite was that of the smallest nodules, of pea to bean size, which were found on the waste dump in fresh, broken masses of pegmatite. In almost every instance, these nodules were enclosed in quartz, only a few being found in a rough, granular aggregate of feldspar and muscovite.

In not a single instance, could any approximation to crystal form be detected on the nodules, such as to suggest that they might be pseudomorphous after uraninite. On the contrary, they all exhibit a concentric, scaly structure, as if the carbonaceous matter had been deposited in a succession of thin layers around a central nucleus. In this respect, the thucholite differs radically from that of the other classic Canadian occurrence of this mineral, the Besner mine, in Henvey township, Parry Sound District, Ontario, where it forms distinct pseudomorphs after uraninite crystals.[7]

Obalski noted the occurrence of thucholite at the Pied des Monts mine, and described it in the report cited above. His analysis gave:

Volatile materials (including combustible gas and water)	40.19%
Fixed carbon	52.59
Ash	7.22
	100.00

The ash was found to contain 35.43 per cent of uranium, and the mineral was determined as radioactive.

[7] Spence, Hugh S., A remarkable occurrence of thucholite and oil in a pegmatite dyke, Parry Sound District, Ontario: *Am. Mineral.*, **15**, 499–520 (1930).