THE OCCURRENCE, CRYSTAL HABIT AND COMPOSITION OF THE URANINITE FROM THE RUGGLES MINE, NEAR GRAFTON CENTER, NEW HAMPSHIRE

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During 1935 the Whitehall Company of New York opened a new pit in the old Ruggles pegmatite, at the top of the mountain where the pegmatite is 300 feet wide. Formerly this mineral deposit had been opened at lower elevations by a series of pits, open cuts, shafts and drifts, in search for mica. The location is 1½ miles N. 40° W. from Grafton Center (71°59′33.6″ W. Long., 43°35′22.3″ N. Lat., Cardigan quadrangle, New Hampshire). The locality is easily reached by a road; the distance from the village is three miles.

During the operations for feldspar, which occurs as an extensive and unusually pure deposit of this material, the operators occasionally en-

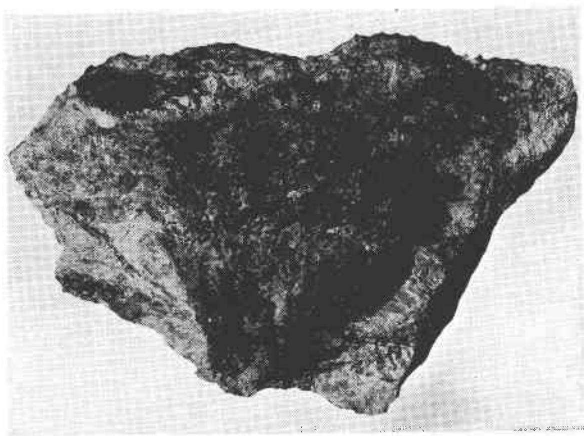

FIG. 1. Uraninite occurring as a three-dimensional dendritic intergrowth in albite-rich perthite. The intergrowth has a fan-shaped directional development. X=0.25.

countered remarkable segregations of uraninite and other minerals. The uraninite occurs in all stages of alteration from pitchy black crystals to an impalpable yellowish-white powder, together with an intermediate suite of uranium-bearing minerals which are distinct alteration products. An appreciable quantity of this material was rescued from the dumps and it is hoped that eventually a sufficient amount of the several uranium-bearing minerals may be recovered pure enough to make a detailed study of their physical and chemical properties.

In an occasional specimen of the segregated material the uraninite occurs in small well developed crystals, except for the points where they were originally attached. The faces on a few of these were lustrous enough to give reflections on the two-circle goniometer. It is the purpose of this paper to describe at this time the occurrence, crystallography and chemical constitution of the uraninite.

Modes of Occurrence of the Uraninite

The usual and most common occurrence of the uraninite consists of a three-dimensional dendritic intergrowth in an albite-rich perthite, and also in massive albite into which the perthite grades. The cleavelandite variety of albite is absent in the part of the pegmatite where the uraninite is found. The intergrowths are often distinctly directional in character, developing at times into a somewhat fan-shaped structure, Fig. 1. In these directional intergrowths the uraninite crystals are usually joined as is shown by the radiogram, Fig. 2. The crystals occasionally appear to occur as individuals in some cross-sections, in other parallel sections, however, they are probably very often connected. Another frequent occurrence of the uraninite in the perthite consists of spheroidal or ellipsoidal knots consisting of a three-dimensional intergrowth with the feldspar. Both of these occurrences are usually completely surrounded by solid perthite in all directions. The perthite rarely contains individual crystals. One of these, the largest crystal found, consists of a very rough and distorted rhombic dodecahedron modified by a trapezohedron, Fig. 3A.

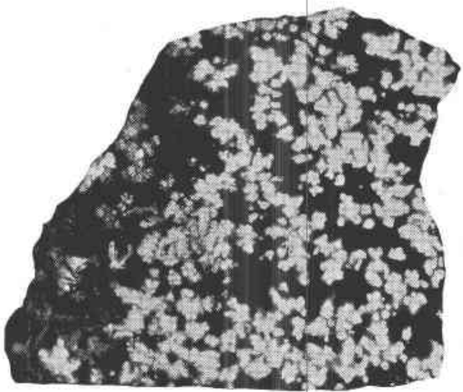

FIG. 2. Radiogram of dendritic uraninite in feldspar.

The pronounced directional uraninite-feldspar intergrowth frequently occurs as a part of a directional asymmetric banding, starting from the normal perthite through an albite-rich perthite with intergrown uraninite, to an apatite-albite intergrowth which meets the normal perthite again at the opposite side of the banding. The apatite-albite intergrowth is likewise a directional development and often contains uraninite crystals within the albite.

Occasionally the dendritic uraninite in the perthite becomes dense enough to have the appearance of being massive.

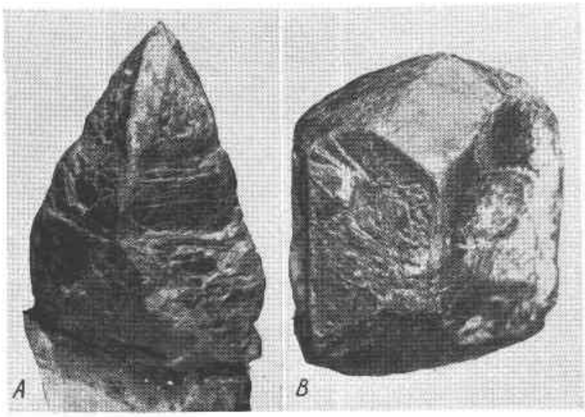

FIG. 3 (A) A distorted rhombic dodecahedron of uraninite with a trapezohedron. The crystal was completely surrounded by perthite. X=2.55. (B) Rhombic Dodecahedron of altered uraninite from an apatite-albite intergrowth. X=4.5.

Another three-dimensional uraninite-feldspar intergrowth occurs in which there is no apparent directional development of the uraninite, which, in this instance, appears as distinct and sharply outlined skeleton crystals intimately intergrown with massive to medium or fine-grained albite. Some parts of the skeleton crystals are very long in comparison to their thickness, as is shown by the radiogram, Fig. 4.

Two other relationships of the uraninite are noteworthy. One is that of an intricate intergrowth with muscovite in which the uraninite may occur as irregularly developed crystals which sometimes have skeletonized structures. A minor amount of feldspar and quartz may be associated with the muscovite and uraninite. The muscovite in these occurrences is decidedly darkened. The other occurrence of the uraninite is with the quartz of the massive smoky quartz dikes which cut the feldspar, or with the large blebs of smoky quartz in the massive perthite. In these instances the quartz is decidedly darker than elsewhere. The smoky color is undoubtedly due to the effect of being irradiated[1] through

[1] Holden, E. F., The cause of color in smoky quartz and amethyst: *Am. Mineral.*, vol. **10**, pp. 221–222, 1925.

the radioactive properties of uranium and its alteration products.

The occurrence of uraninite within the apatite is not common and in such instances the apatite usually shows a radial fracturing around the uraninite.

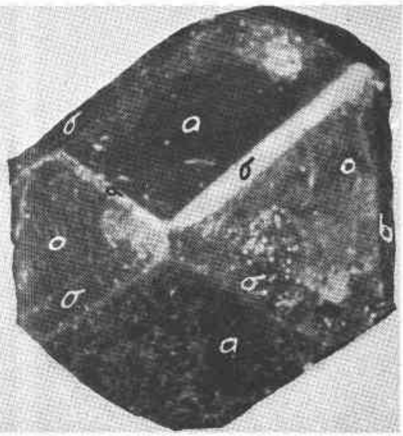

FIG. 4. Radiogram of skeleton uraninite crystals in massive to medium-grained albite.

FIG. 5. A typical crystal of uraninite from the medium to fine-grained albite in the apatite-albite intergrowth. a = cube, o = octahedron, σ = trapezohedron (533). X = 16.

Crystal Habit of the Uraninite

In the apatite-albite intergrowth the uraninite occasionally occurs as well developed euhedral crystals except for the points of attachment before they were completely surrounded by the albite. The crystals range in size from 1 to 10 millimeters and are often fresh with bright, smooth faces. They are bounded by the cube and octahedron, both about equally developed; in addition a third form, a trapezohedron is common. A typical crystal is shown in Fig. 5. The measured angles between the cube and the trapezohedron is 40°13′, an average of 19 measurements, while the angle between the octahedron and the trapezohedron is 14°28′, an average of 22 measurements. The computed angles between the cube and trapezohedron, (533) is 40°19′, and between the octahedron and trapezohedron (533) is 14°25′. The good agreement between the measured and computed angles establishes a new form, trapezohedron (533), for uraninite.

In another apatite-albite intergrowth a distorted rhombic dodecahedron was found; it is shown in Fig. 3B. This form (110) is extremely rare.

Parsons[2] has described a trapezohedron on the uraninite from Cardiff Township, Haliburton County, Ontario. His best average determinations on rough crystals with a contact goniometer were 21° between the cube and trapezohedron, and 35°16′ between the octahedron and the trapezohedron. The same angles for the form (411) are 19°28′ and 35°16′, respectively.

The Grafton Center uraninite adds a new form to those already known. This makes a total of five forms which are the cube, octahedron, rhombic dodecahedron and trapezohedrons (411) and (533).

Chemical Composition of the Uraninite

The freshest crystals obtained from the albite of the apatite-albite intergrowth were broken down in stages and the small amount of intergrown impurities, together with pieces which appeared to be altered in any way, were removed under the binocular microscope. From this material 82 milligrams were sent to Friedrich Hecht in Vienna for a microchemical analysis His determinations are as follows:

Insoluble residue	0.54%
SiO_2	0.80
PbO	3.63
(Pb)	(3.37)
Fe_2O_3	0.66
Al_2O_3	0.44
MnO	0.09
Rare earths	0.21
ThO_2	0.43
(Th)	(0.38)
U_3O_8	90.06
(U)	(76.38)
CaO	0.81
MgO	0.17
P_2O_5	0.16
S	0.04
H_2O (−100)	0.73
Loss on ignition (100°–1000°C.)	1.74
Total	100.51

The analysis shows the mineral to be a very pure uraninite having an unusually low amount of thorium and rare earths. In this respect it is more like pitchblende which occurs in the metalliferous veins than like uraninite occurring in pegmatites. In the latter occurrences the thorium and rare earths frequently range from 5 to 10 per cent.

[2] Parsons, A. L., Crystal habit of uraninite from Cardiff Township, Ontario: *Univ. Toronto Studies, Geological Series*, no. **32**, pp. 17–18, 1932.

Age of the Uraninite

If we assume that the 0 04 per cent of sulphur present is combined with ordinary lead, the lead-uranium ratio becomes 0.041. By using the simplified logarithmic formula[3] one obtains an age of 304 millions of years for the uraninite. According to Holmes[4] this is late Devonian unless a substantial part of the lead is ordinary lead. As the Ruggles pegmatite is located in an area of highly metamorphosed rocks, any data regarding the age of the intrusives is of interest especially to those working with the stratigraphy of the region. A tabulation of the previously reported lead-uranium and lead-thorium ratios for New England together with the ages determined from these by using the logarithmic formula, is given below:

Age Determinations for Some New England Localities by Means of Lead-Uranium and Lead-Thorium Ratios

Locality	Minerals Analyzed	No. of Ratios Avg'd	Avg. of Ratios	Age in Millions of years	
				Logarithmic formula	Corrected for Ac-U*
Bedford, N. Y.	Cyrtolite (*Munech*)[a]	7 for Pb 9 for U	0.051	376	361
Branchville, Conn. (Fillow Quarry) Do Do	Uraninite (*Hillebrand* 3 Anal.)[b] (*Comstock*, 1 Anal.)[c] (*Boltwood*, 1 Anal.)[d]	5	0.052	383	368
Rock Landing, East Haddam, Conn.	Uraninite (*Hecht*)[e]	1	0.040	297	269
Glastonbury, Conn. (Spinelli Quarry)	Samarskite (*Wells*)[f]	1	0.039	291	280
Portland, Conn. (Hale Quarry)	Monazite (*Fenner*)[g]	1	0.037	276	266
Do	Uraninite (*Hillebrand*)[h]	5	0.039	291	280
Strickland Quarry	Uraninite (*Hecht*)[i]	7	0.041	304	293
Fitchburg, Mass.	Uraninite (*Hecht*)[j]	1	0.050	370	356

(*Table concluded on next page*)

[3] Lane, A. C., *Report of the committee on the measurement of geological time, National Research Council, Washington, D.C.*, April 27th, 1935, p. 2.

[4] Holmes, Arthur, *The Age of The Earth*, p. 176, Thomas Nelson and Sons Ltd., London and New York, 1937.

Blueberry Mt., Mass.	Allanite (*Ellsworth*)[k]	1	0.043	310	298
Topsham, Maine Do	Monazite (*Kroupa*)[l] Samarskite (*Gonyer*)[m]	1 1	0.079 0.031	574(?) 232	554(?) 224
Grafton Center, N. H. (Ruggles pegmatite, pit at top of Mt.)	Uraninite (*Hecht*)	1	0.041	304	293

* Holmes, Arthur, *The Age of the Earth,* p. 153, Thomas Nelson & Sons Ltd., London and New York, 1937.

[a] Munech, O. B. The analysis of cyrtolite for lead and uranium: *Am. Jour. Sci.*, vol. **21,** pp. 350–357, 1931.

[b] Hillebrand, W. F., On the occurrence of nitrogen in uraninite and on the composition of uraninite in general: *Am. Jour. Sci.*, (3), vol. **40,** pp. 384–394, 1890; also in *U.S.G.S., Bull.* **78,** p. 64, 1891.

[c] Comstock, W. J., On the chemical composition of the uraninite from Branchville, Conn.: *Am. Jour. Sci.*, (3), vol. **19,** pp. 220–222, 1880.

[d] Boltwood, B. B., On the ultimate disintegration products of the radio-active elements: *Am. Jour. Sci.*, (4), vol. **23,** pp. 78–88, 1907.

[e] Hecht, Friedrich, and Kroupa, E., *Report of the Committee on the Measurement of Geologic Time,* p. 61, May 2, 1936, *National Research Council, Washington, D.C.*

[f] Wells, R. C., *Report of the Committee on the Measurement of Geologic Time,* p. 76, April, 1935, *National Research Council, Washington, D.C.*

[g] Fenner, Clarence N., The age of a monazite crystal from Portland, Conn.: *Am. Jour. Sci.*, vol. **23,** pp. 327–333, 1932.

[h] Hillebrand, W. F., On the occurrence of nitrogen in uraninite and on the composition of uraninite in general: *U.S.G.S., Bull.* **78,** p. 62, 1891.

[i] Foye, W. G., and Lane, A. C., Correlation by radioactive minerals in the metamorphic rocks of southern New England: *Am. Jour. Sci.*, vol. **28,** p. 133, 1934.

[j] Lane, A. C., Age of the Fitchburg granite: *Science,* vol. **78,** p. 435, 1933.

[k] Holmes, Arthur, *Bull.* **80,** p. 343, *National Research Council, Washington, D.C.*, 1931, cites analysis by H. V. Ellsworth in the *Report of the Committee on the Measurement of Geological Time by Atomic Disintegration,* April 28, 1928. Issued privately.

[l] Kroupa, E., *Report of the Committee on the Measurement of Geologic Time,* p. 58, May 1, 1937, *National Research Council, Washington, D.C.*

[m] Gonyer, F. L., *Report of the Committee on the Measurement of Geologic Time,* p. 60, May 1, 1937, *National Research Council, Washington, D.C.*

Summary

The Grafton Center uraninite is unique in occurring chiefly as a three dimensional dendritic intergrowth with perthitic feldspar, and also as skeleton crystals in the same material but more especially in albite intimately associated with the perthite. Individual crystals are associated chiefly with a granular albite intergrown with apatite and also sparingly within the feldspar. A new crystal form, trapezohedron (533) occurs on the uraninite associated with the albite and apatite. The com-

position of the uraninite is chiefly the oxides of uranium, the rare earths and thorium are very low. The lead-uranium ratio is 0.041 which gives it an age of 304 millions of years which is late Devonian.

Acknowledgments

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