

TABLE 3. OPTICAL PROPERTIES OF URANOSPHERITE

	Orientation	New data	Larsen (1921)
X	<i>a</i>	1.959	1.955
Y	<i>b</i>	1.981	1.985
Z	<i>c</i>	2.060	2.05

optics were measured, using phosphorus and Larsen-Meyrowitz index liquids, and the results are in agreement with those reported by Larsen (1921) on a specimen from the Roebbling collection. The values obtained are given in Table 3.

Z is parallel to the elongation of the laths and X is normal to the cleavage. The optic sign is positive, and  $2V$  is calculated as  $56^\circ$ . Larsen observed strong dispersion,  $r < v$ . There is no marked absorption or pleochroism. The mineral is probably orthorhombic. A U. S. National Museum specimen, no. R-5892, labelled uranospherite, was examined optically and its identity was verified. The x-ray diffraction pattern of the Vienna specimen is given in Table 1.

Fletcher (1913) attempted to measure the melting point of supposed uranospherite from Sabugal, Portugal. He states that small particles "lose body" at  $1170^\circ\text{C}$ ., and that larger particles melt with iridescence at  $1320^\circ\text{C}$ . His material is from an undescribed locality for this mineral, and its authenticity is very doubtful.

This study is part of a program conducted by the U.S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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## IDENTITY OF PILBARITE WITH THOROGUMMITE AND KASOLITE

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Pilbarite was described by Simpson (1910) from the Wodgina area of the Pilbara goldfields, Western Australia. The mineral occurs as small nodules enclosed in albite in weathered outcrops of tantalite-rich pegmatites. Occasional residual cores of thorogummite indicate that the

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pilbarite is pseudomorphous after a primary thorium mineral, probably uranoan thorite. Weathering or hydrothermal alteration of the original thorium mineral yielded what Simpson (1930) considered a chemically related series of distinct species—maitlandite, nicolayite, pilbarite, and hydrothorite. Frondel (1953) has shown that maitlandite, nicolayite, and hydrothorite are minor chemical variants of the phase thorogummite. In a later paper Frondel (1956) mentions pilbarite as an ill-defined substance which needs further study.

The present study was undertaken as part of a broad research into the mineralogy of the uranium and thorium silicates. Two specimens of pilbarite were available for study: a U. S. National Museum specimen originally from Simpson, and a specimen from the O. I. Lee collection originally from the Government Museum, Western Australia. Both specimens match the description of Simpson in all respects. The mineral is bright yellow with the rims of nodules bleached somewhat lighter, and their surfaces coated by iron oxide. Luster earthy. Hardness  $2\frac{1}{2}$  to 3. Specific gravity 4.15 to 4.95, with most fragments giving a value near 4.68. The wide range is due to variable porosity of the earthy aggregates, and to varying proportions of the component minerals.

X-ray powder patterns of both specimens prove the pilbarite to be a mixture of thorogummite and kasolite. All lines of standard patterns of both minerals are present. Optical examination under high magnification shows the material to be a microcrystalline aggregate of apparently isotropic grains with an average index of refraction of 1.74, and minute anisotropic grains with a mean index of 1.9. This latter value is near that to be expected from kasolite with  $n_X = 1.877$ ,  $n_Y = 1.880$ ,  $n_Z = 1.935$ . The apparent isotropism of the thorogummite results from the submicroscopic size of the component crystallites.

Simpson described pilbarite as a hydrated silicate of lead, uranium, and thorium with the composition shown in Table 1. From this Simpson derived the empirical formula  $\text{ThO}_2 \cdot \text{UO}_3 \cdot \text{PbO} \cdot 2\text{SiO}_2 \cdot 4\text{H}_2\text{O}$ . It is

TABLE 1. COMPOSITION OF PILBARITE

SiO <sub>2</sub>	12.72	MnO	nil	ThO <sub>2</sub>	31.34
P <sub>2</sub> O <sub>5</sub>	1.08	FeO	nil	Ce <sub>2</sub> O <sub>3</sub>	0.19
K <sub>2</sub> O	0.09	Fe <sub>2</sub> O <sub>3</sub>	0.20	Y <sub>2</sub> O <sub>3</sub>	0.49
Na <sub>2</sub> O	0.04	Al <sub>2</sub> O <sub>3</sub>	0.15	H <sub>2</sub> O (-)	3.50
CaO	0.57	Ta <sub>2</sub> O <sub>5</sub>	0.47	H <sub>2</sub> O (-)	4.16
PbO	17.26	UO <sub>3</sub>	27.09	CO <sub>2</sub>	nil
MgO	0.21	UO <sub>2</sub>	nil		99.56

Simpson, E. S. (p. 465, 1928).

readily seen that thorogummite,  $\text{Th}(\text{SiO}_4)_{1-x}(\text{OH})_{4x}$ , and kasolite,  $\text{Pb}(\text{UO}_2)(\text{SiO}_3)(\text{OH})_2$ , can account for the stated composition. The proportions of the two minerals in the mixture cannot be ascertained from the analysis because it is not known how much of the  $\text{PbO}$  is present in kasolite and how much is present in the thorogummite from radioactive disintegration of uranium and thorium. The optical and  $x$ -ray study suggests that the two minerals are present in approximately equal amounts.

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UNIT CELL AND SPACE GROUP OF LARSENITE,  $\text{PbZnSiO}_4$ 

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Larsenite from Franklin, New Jersey was described in 1928 by Palache, Bauer, and Berman, and a summary description was given by Palache in 1935. On morphological and chemical data, the mineral was placed in the Olivine Group and has been so accepted by later writers. No single-crystal or powder  $x$ -ray diffraction work has been reported thus far. Recently, samples of larsenite were supplied by the Harvard Mineralogical Museum to Dr. Heinrich Neumann of the University of Oslo, who drew our attention to the fact that powder photographs of the mineral are not of the general olivine type.

An  $x$ -ray single-crystal study of type larsenite from Franklin has been made by the rotation, Weissenberg, and precession methods using Cu and Mo radiation. This work has shown that larsenite is not isostructural with the Olivine Group, but is related dimensionally thereto. The  $a$  and  $b$  axes of larsenite are approximately double those of olivine and the  $c$