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Johnbaumite, a new member of the apatite group from Franklin, New Jersey

PETE J. DUNN

Department of Mineral Sciences, Smithsonian Institution
Washington, D. C. 20560

DONALD R. PEACOR AND NANCY NEWBERRY

Department of Geology and Mineralogy, University of Michigan
Ann Arbor, Michigan 48109

Abstract

Johnbaumite, ideally $Ca_5(AsO_4)_3(OH)$, is a new mineral from the Franklin mine in Franklin, Sussex County, New Jersey. It is hexagonal, space group $P6_3/m$ or $P6_3$ with $a = 9.70$ and $c = 6.93$Å. The strongest lines in the X-ray powder diffraction pattern are: (*d, I, hkl*) 2.895 *100* 211; 2.798 *70* 300; 2.820 *70* 112; 3.47 *50* 002; 3.98 *50* 111; 2.683 *45* 202. Chemical analysis by microprobe and DTA–TGA yielded CaO 43.5, FeO 0.2, MgO 0.1, P_2O_5 1.7, As_2O_5 52.2, F 0.2, Cl 0.1, H_2O 1.3, less O = Cl 0.1, sum = 99.2 percent.

Johnbaumite is white to colorless with a vitreous luster. Cleavage is distinct on {100}. The density is 3.68 g/cm^3 (meas.), 3.73 g/cm^3 (calc.). Johnbaumite is uniaxial (−) with refractive indices $\omega = 1.687$, $\epsilon = 1.684$. It is found associated with yeatmanite, romeite, andradite, diopside, franklinite, and copper. Johnbaumite is the arsenate analogue of hydroxylapatite and the hydroxyl analog of svabite.

Introduction

The type specimen was found in the Franklin mine in Franklin, New Jersey in 1944, and was retained because of its unusual mineralogy and the occurrence of specks of native copper within it. Subsequent study of this specimen in 1978 resulted in the description of a second paragenesis for yeatmanite (Dunn and Leavens, 1980). The yeatmanite is enclosed in a massive grayish-white mineral which is the new mineral, $Ca_5(AsO_4)_3(OH)$, the arsenate analog of hydroxylapatite and the hydroxyl analog of svabite. We take great pleasure in naming it johnbaumite in honor of John L. Baum of Hamburg, New Jersey. Mr. Baum is the retired resident geologist for the New Jersey Zinc Company and is presently the curator of the Franklin Mineral Museum in Franklin, New Jersey. He is the geologist who found the specimen, preserved it, and called it to our attention. Its discovery is due entirely to his efforts. Mr. Baum has played an important role in the development of our knowledge of the mineralogy of Franklin and Sterling Hill and continues to be a strong contributor in his role as curator.

Holotype material for johnbaumite is preserved in the Smithsonian Institution as NMNH #144444; in the Harvard University collection under catalog #116461; and in the mineral collection of Mr. Baum. The mineral and the name have been approved by the IMA Commission on New Minerals and Mineral Names.

Physical and optical properties

Johnbaumite occurs as massive anhedral grayish-white granular material with individual grains approximately 8mm or less in diameter. It is colorless in thin section and has a white streak. The Mohs hardness is approximately 4½. The luster is vitreous on cleavage surfaces and slightly adamantine to greasy on fracture surfaces. Cleavage is distinct, parallel to {100}. The density, determined using heavy-liquid techniques, is 3.68(3) g/cm^3, which compares favorably with the calculated value of 3.73 g/cm^3.

Johnbaumite is uniaxial (−) with refractive indices $\omega = 1.687$, $\epsilon = 1.684$, both ±0.003. The Gladstone–Dale relationship, calculated using the constants of Mandarino (1976), yields $K_C = 0\ 184$ for the chem-

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ical composition and $K_P = 0.187$ for physical properties, indicating superior agreement between the analytical and physical data (Mandarino, 1979). Johnbaumite is fluorescent in short-wave UV radiation with a medium pinkish orange response color. There is no response to long-wave UV radiation, and no phosphorescence in either range of wavelengths. Since many calcian mimetites from Franklin and Sterling Hill fluoresce in a similar manner, this property should not be considered diagnostic.

Chemistry

Johnbaumite was chemically analyzed with an ARL-SEMQ electron microprobe using an operating voltage of 15 kV and a beam current of 0.15 μA. The standards used were fluorapatite for Ca, P, and F; hornblende for Mg and Fe; manganite for Mn; synthetic olivenite for As; and chlorapatite for Cl. The data were corrected using a modified version of the *MAGIC-4* computer program of the Geophysical Laboratory, Carnegie Institution of Washington. Water was determined by DTA–TGA. A microprobe scan indicated the absence of elements with atomic number greater than 8 except those reported herein. Johnbaumite is chemically homogeneous over 10μ intervals. The resultant analysis is presented in Table 1, and yields the empirical formula $(Ca_{9.71}Fe_{0.03}Mg_{0.03})$ $(As_{5.68}P_{0.30})O_{23.92}(OH_{1.80}F_{0.13}Cl_{0.04})$ calculated on the basis of the unit-cell parameters and the observed density. This formula is in excellent agreement with the ideal end-member formula $Ca_5(AsO_4)_3(OH)$ with Z = 2.

The ultraviolet fluorescence of johnbaumite is quite similar to that of Franklin mine samples which have been called hedyphane and svabite in the past (Palache, 1935). Analytical examination of those specimens labelled "hedyphane" indicates that with few exceptions, they are all highly calcian mimetites with 56–70 percent PbO. Of twenty-one Franklin samples labelled hedyphane, seventeen were mimetite, containing calcium and strontium in substitution for lead. We were unsuccessful in finding additional samples of johnbaumite. Inasmuch as the mineralogy of Långban, Sweden is similar to that of Franklin in some respects, we also analyzed Långban "hedyphanes" in the search for additional samples of johnbaumite. Of 25 samples, 22 are mimetite containing calcium and barium in substitution for lead. Hence, Långban "hedyphanes" are mostly mimetite. Johnbaumite remains a most rare mineral. The type specimen is the only one known at this time.

Table 1. Chemical data for johnbaumite

	$Ca_5(AsO_4)_3(OH)$	JOHNBAUMITE
CaO	44.21	43.5
FeO		0.2
MgO		0.1
P_2O_5		1.7
As_2O_5	54.37	52.2
F		0.2
Cl		0.1
H_2O	1.42	1.3*
Less O =F,Cl		0.1
Total	100.00	99.2

* Water determined by DTA-TGA

Accuracy of data: ±3% of the amount present.

X-ray crystallography

Cleavage fragments were studied using standard precession and Weissenberg techniques. These results verified that the space group is $P6_3/m$ or $P6_3$. As all data indicate that johnbaumite is a member of the apatite group, we assume that the true space group is $P6_3/m$. Photographs were carefully examined for the occurrence of superstructure reflections or deviations from hexagonal symmetry, as some apatites have been shown to be monoclinic with one *a* translation doubled over that of common apatites. No superstructure reflections were observed.

Powder X-ray diffraction data was obtained using a polycrystalline sample with Si as an internal standard mounted in a 114.59mm-diameter Gandolfi camera. Powder data are presented in Table 2. Lattice parameters ($a = 9.70\pm0.02$ and $c = 6.93\pm0.02$Å) were obtained through least-squares refinement of the powder data. The data were obtained with Cu*Kα* X-radiation.

Occurrence

Johnbaumite is known on only one specimen which was collected by John Baum in the Franklin mine in 1944. The appearance of the hand specimen originally suggested it might be a copper-bearing feldspar and it was recognized as being unique on that basis. The specimen was found in a small lenticular body located at 830 S, 170 E, elevation −760 in the 730 S Palmer shaft pillar, in the third sub-level below 750 level. The lenticular body was surrounded on both sides by calcareous ore bands. The sample

Table 2. X-ray powder diffraction data for johnbaumite

hkl	d (calc)	d (obs)	I/Io
100	8.40	8.43	30
101	5.35	5.35	10
110	4.85	4.86	20
111	3.98	3.98	50
201	3.59	3.58	5
002	3.47	3.47	50
102	3.20	3.22	20
210	3.18	3.14	20
211	2.888	2.895	100
112	2.820	2.820	70
300	2.802	2.798	70
202	2.674	2.683	45
301	2.597	2.593	10
310	2.331	2.330	20
221	2.290	2.287	20
311	2.209	2.212	30
203	2.025	2.034	40
213	1.868	1.879	45
321	1.858	1.858	15
410	1.834	1.835	10
402	1.797	1.798	10
411	1.773	1.773	5
004	1.733	1.739	30
		1.688	35
		1.653	20
		1.590	10
		1.574	5
		1.54	20
		1.515	25
		1.479	30
		1.466	10
		1.385	10
		1.312	15
		1.280	5
		1.267	5
		1.256	10
		1.211	5
		1.199	5
		1.187	10
		1.175	5
		1.165	5
		1.136	2
		1.133	2

Table 3. The apatite group

FLUORAPATITE	$Ca_5(PO_4)_3F$	Hexagonal
HYDROXYLAPATITE	$Ca_5(PO_4)_3(OH)$	Hexagonal
CHLORAPATITE	$Ca_5(PO_4)_3Cl$	Monoclinic
SVABITE	$Ca_5(AsO_4)_3F$	Hexagonal
JOHNBAUMITE	$Ca_5(AsO_4)_3(OH)$	Hexagonal
HEDYPHANE	$(Ca,Pb)_5(AsO_4)_3Cl$	Monoclinic ?

was taken 52 feet from the hanging wall and 54 feet from the footwall contact.

Johnbaumite is the massive matrix host for a number of other species which occur within it in small amounts. The most important of these is yeatmanite (Dunn and Leavens, 1980), which occurs in euhedral lath-like crystals in apparent chemical equilibrium with johnbaumite. In addition to yeatmanite, johnbaumite is host to diopside and andradite (both containing approximately 8 percent MnO), franklinite, copper, and romeite, a species new to the deposit. The texture of the specimen is similar to that of a typical metamorphic skarn assemblage and there is no evidence of replacement. Thin-section examination indicates that diopside was the first phase to form; it is rimmed by andradite with inclusions of romeite in the andradite. Romeite is moderately abundant in the specimen, occurring as formless blebs within andradite, franklinite, yeatmanite, and johnbaumite. The yeatmanite $(Mn_5Sb_2)(Mn_2Zn_8Si_4)O_{29}$, is essentially arsenic-free, and johnbaumite is essentially antimony-free. We observed no epitaxy among any of these species.

Relationship to other species

Johnbaumite, $Ca_5(AsO_4)_3(OH)$, is a member of the apatite group. It is the arsenate analog of hydroxylapatite, $Ca_5(PO_4)_3(OH)$, and the hydroxyl analog of svabite, $Ca_5(AsO_4)_3(F)$. The three arsenate analogs of the common apatites are now known and the group is listed in Table 3.

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