

# Bostwickite, a new calcium manganese silicate hydrate from Franklin, New Jersey

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**ABSTRACT.** Bostwickite,  $\text{CaMn}_6^{3+}\text{Si}_3\text{O}_{16} \cdot 7\text{H}_2\text{O}$ , is a new species from the Franklin Mine, Franklin, New Jersey. Chemical analysis yielded MgO 0.9, CaO 5.1,  $\text{Mn}_2\text{O}_3$  56.3,  $\text{Fe}_2\text{O}_3$  0.5,  $\text{Al}_2\text{O}_3$  1.0,  $\text{As}_2\text{O}_5$  1.0,  $\text{SiO}_2$  20.1,  $\text{H}_2\text{O}$  [15.1], sum = 100.0%. This yields  $(\text{Ca}_{0.76}\text{Mg}_{0.19})_{20.95}(\text{Mn}_{5.97}^{3+}\text{Fe}_{0.05}^{3+})_{26.02}(\text{Si}_{2.80}\text{Al}_{0.16}\text{As}_{0.07}^{5+})_{23.03}\text{O}_{16} \cdot 7.01\text{H}_2\text{O}$ , corresponding to the idealized formula. The strongest lines in the X-ray powder diffraction pattern are (*d*, *I*): 11.3, 100; 3.548, 30; 2.898, 30; 2.567, 40; 2.262, 25; 2.238, 25; 1.470, 25. Bostwickite is dark red in colour; hardness *c.* 1 (Mohs<sup>9</sup>); density (meas.) = 2.93 g/cm<sup>3</sup>. It occurs in radial aggregates of acicular compound crystals. Optically, bostwickite is biaxial negative with  $2V_\alpha = 25^\circ$ ;  $\alpha = 1.775$ ,  $\beta = 1.798$ ,  $\gamma = 1.800$ ; dispersion strong,  $r < v$ ; strongly pleochroic with  $\alpha = \beta = \text{red-brown}$ ,  $\gamma = \text{yellow-brown}$ ; absorption is  $\alpha = \beta > \gamma$ . Bostwickite is named in honour of Richard C. Bostwick, collector and compiler of data on the minerals of Franklin and Sterling Hill.

THE new species described herein has been known to mineralogists for over a century. It was found in the Taylor mine, one of numerous small mines in what later became the Franklin mine, in 1874. The specimens were acquired by Frederick Canfield, a collector of New Jersey minerals, were later studied by E. S. Larsen, *Jr.* and were tentatively considered (Palache, 1935) to be arseniosiderite. This tentative identification was later disproved by subsequent examination by Drs Harry Berman and Clifford Frondel who noted (Frondel, 1972) that it was a calcium manganese silicate. Examination of impure material by Dunn (1979) verified the composition, but did not name the species. Recent examination of pure material has resulted in the characterization of this species and the description is presented herein.

We take pleasure in naming this species *bostwickite* in honour of Richard C. Bostwick, a collector of Franklin minerals, in recognition of his

contributions to the mineralogy of Franklin and Sterling Hill. He has been instrumental in the preservation of many unique assemblages that might have been overlooked by less sophisticated observers and has contributed over a period of 20 years to our knowledge of the fluorescence of minerals from these deposits. The mineral and the name were approved, prior to publication, by the Commission on New Minerals and Mineral Names, IMA. Type material is preserved at Harvard University and the Smithsonian Institution, the latter under catalogue no. C4222.

*Physical and optical properties.* Bostwickite is dark brownish red with a vitreous to submetallic lustre on prism surfaces. It occurs as divergent sprays of bladed crystals. The surface of these sprays, when the crystals are tightly packed, has a dull appearance similar to brown velvet. The streak is brownish red. The hardness is approximately 1 (Mohs<sup>9</sup>). Cleavage could not be observed inasmuch as apparent 'crystals' are actually composites of tiny microcrystals much too small for cleavage observations. The density, determined by heavy liquid techniques on a particularly dense aggregate, is 2.93 g/cm<sup>3</sup> ( $\pm 0.10$ ), but much lower values were obtained from less compact aggregates. Bostwickite is readily soluble in 1:1 HCl, colouring the solution brown. A cluster of radial bostwickite crystals is shown in fig. 1, showing the lath-like habit.

Optically, bostwickite is biaxial negative with  $2V_\alpha = 25^\circ$ . Indices of refraction, measured in sodium light, are  $\alpha = 1.775(5)$ ,  $\beta = 1.798(3)$ , and  $\gamma = 1.800(3)$ . Dispersion is very strong,  $r < v$ . Bostwickite is strongly pleochroic with  $\alpha = \beta = \text{red-brown}$ ,  $\gamma = \text{yellow-brown}$ . Absorption is  $\alpha = \beta > \gamma$ . The optical orientation, relative to the morphology of the lath-like crystals shown in fig. 1, is:  $\gamma$  parallel

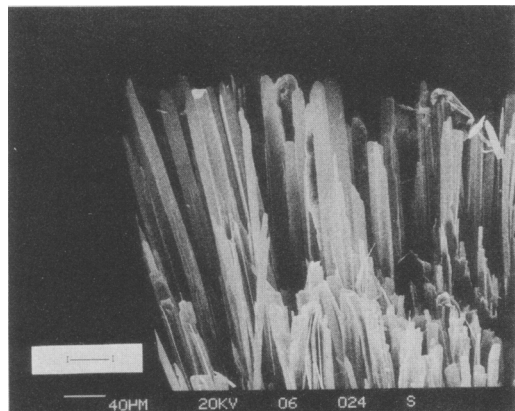


FIG. 1. Radial spray of bostwickite crystals. Scale bar is approximately 40  $\mu\text{m}$ .

to the length of the lath,  $\beta$  parallel to the width of the lath, and  $\alpha$  parallel to the thin dimension of the lath.

**Chemistry.** Bostwickite was chemically analysed utilizing an ARL-SEM-Q electron microprobe using an operating voltage of 15 kV and a sample current of 0.025  $\mu\text{A}$ , standardized on brass. The standards used were manganite (Mn), synthetic olivenite (As), and hornblende for all other elements. The data were corrected using a modified version of the MAGIC-4 computer program. A wavelength-dispersive microprobe scan indicated the absence of any elements with atomic number greater than 8, except those reported herein. A spectrographic analysis indicated the absence of any light elements. Water was calculated by difference. The resultant analysis is presented in Table I, together with the theoretical composition. Calcula-

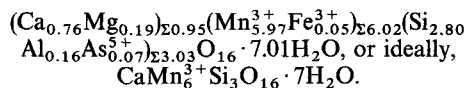
TABLE I. Microprobe analysis of bostwickite

	Bostwickite	$\text{CaMn}_8^{3+}\text{Si}_3\text{O}_{16}\cdot 7\text{H}_2\text{O}$
MgO	0.9	—
CaO	5.1	6.71
$\text{Mn}_2\text{O}_3$	56.3	56.66
$\text{Fe}_2\text{O}_3$	0.5	—
$\text{Al}_2\text{O}_3$	1.0	—
$\text{As}_2\text{O}_5$	1.0	—
$\text{SiO}_2$	20.1	21.58
$\text{H}_2\text{O}$	15.1*	15.05
Total	100.0	100.00

\* Water by difference.

Accuracy of data:  $\pm 4\%$  of the amount present.

tion of a formula based on 16 oxygen atoms in the anhydrous part of the formula yields:



Manganese was assigned to the 3+ oxidation state based in part on the Gladstone-Dale relationship and in part on the intense dark red colour of bostwickite, which is consistent with the absorption of  $\text{Mn}^{3+}$  in the visible range. The given formula is tentative; the final formula will have to be determined by analysis of the crystal structure, when and if material of sufficient quality is found.

**X-ray powder diffraction data.** Detailed examination of a number of bostwickite crystals failed to yield any fragments or crystals suitable for single-crystal study. Those examined were all composed of tiny crystallites or were warped and bent. X-ray powder diffraction data for bostwickite was obtained using a 114.6 mm diameter Gandolfi camera and  $\text{Cu-K}\alpha$ , nickel-filtered, X-radiation. The resultant powder data are presented in Table II. Neither the powder data nor the composition suggest relationships to known species.

TABLE II. X-ray powder diffraction data for bostwickite

$d$ (obs.) (Å)	$I$	$d$ (obs.) (Å)	$I$	$d$ (obs.) (Å)	$I$
11.3	100	3.110	2	2.074	10
8.19	10	2.898	30	1.951	5
6.03	2	2.718	15	1.863	5
5.57	2	2.567	40	1.794	15
4.575	5	2.475	20	1.679	10
3.951	10	2.442	20	1.634	5
3.826	5	2.262	25	1.599	10
3.786	5	2.238	25	1.501	10
3.548	30	2.094	15	1.470	25
3.238	15				

Intensities estimated visually.

**Occurrence.** Little is known of the geologic relations of the *in situ* occurrence of bostwickite. The samples were all obtained from museum collections. Bostwickite was originally found in 1874 in the Taylor mine, one of many mines later consolidated (in 1897) as the Franklin mine. At least six specimens are known to have been preserved and others may repose as unknowns in systematic collections. Bostwickite occurs on a medium-grade ore consisting of franklinite, calcite, and fluorite with minor willemite. The presence of the fluorite in

the ore is uncommon and may suggest very localized and uncommon conditions of occurrence. The matrix is nearly identical on all examined specimens.

Bostwickite occurs as radial aggregates and hemispherules up to 3.0 mm in diameter. Some of these hemispherules are linked to form thin patches and matted aggregates up to 1.0 cm in diameter. Bostwickite occurs directly on the ore surface, as well as on secondary carbonates that coat the ore in places. There are also spherules of an unknown mineral, which are badly altered and have a silvery, fine-grained appearance. Another species, not yet characterized, is present as bright yellow, hexagonal, platy crystals, which, to the casual observer, resemble native gold in hand specimen.

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#### REFERENCES

- Dunn, P. J. (1979) *Mineral. Record*, **10**, 160-5.  
Frondel, C. (1972) *The minerals of Franklin and Sterling Hill; a check list*, p. 43. John Wiley & Sons, New York.  
Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. *U.S. Geol. Surv. Prof. Paper*, **180**, 122.

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