

MINERALOGICAL NOTES

BISMUTHIAN BINDHEIMITE, MAMMOTH MINE, EUREKA, UTAH¹

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ABSTRACT

A variety of bindheimite (hydrous antimonate of lead) containing 6.8 percent Bi₂O₃ and 0.8 percent Ag₂O was identified in an oxide zone of the Mammoth Mine, Eureka, Utah. The chemical analysis of bismuthian bindheimite shows a low antimony content, presumably due to the substitution of bismuth for antimony in the lattice structure. Optically, the mineral grains are heterogeneous, showing a range in index of refraction, color, and clarity. X-ray diffraction shows the presence of a single mineral phase with a pyrochlore-type structure.

INTRODUCTION

A bismuth-bearing variety of bindheimite was identified in a large sample of lead-silver-bearing ore from the Mammoth Mine, in the south end of the Tintic Mining District near Eureka, Utah (Lindgren, 1919). The sample consists mainly of a porous and vuggy quartz rock. Tiny crystals of barite, quartz, calcite, and dolomite occur in the vugs. Limonite, hematite, wad, and small quantities of cerussite, bismuthian bindheimite, plumbo argentojarosite, minium, plumboferrite, and malachite coat the cavities and the rock itself. Minute amounts of the sulfide minerals, sphalerite, pyrite, and chalcopyrite also occur sporadically.

SAMPLE PREPARATION

The material for chemical, optical, and X-ray diffraction analyses was concentrated from a minus 65 plus 325 mesh representative sample of the ore by heavy liquid separation using tetrabromoethane sp. gr. 2.95. The sink fraction was further separated into various mineral components using a Franz Isodynamic Separator. Bismuthian bindheimite concentrated in a product obtained between 1.0 and 1.25 amperes. Admixed limonite was removed prior to analysis by treatment with hydrochloric acid.

CHEMICAL PROPERTIES

The chemical composition of bindheimite is variable. Mason and Vitaliano (1953) suggest that a complete range in composition is possible. Argentinian, cuprian, and calcian varieties exist. The chemical analyses of most bindheimites previously described by Mason and Vitaliano and by Dana (1951) show more antimony pentoxide than that contained in the bismuthian variety. The low antimony content presumably is due to the substitution of bismuth in the positions normally occupied by antimony. The chemical analysis of bismuthian bindheimite is compared in Table 1

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with an analysis of bindheimite, Lovelock, Nevada, taken from Mason and Vitaliano (1953).

OPTICAL PROPERTIES

The optical properties of bismuthian bindheimite were determined using a petrographic microscope and immersion oils. The mineral grains are heterogeneous and vary both in index of refraction and in color. Roughly half of the grains are clear, pale yellow, and range from 1.72 to 1.74 in refractive index. Most of the remaining material is deep yellow in color, earthy, and has a refractive index which varies from 1.74 to 1.79. Occasional deep yellow-brown, cloudy grains with a somewhat higher

TABLE 1. CHEMICAL ANALYSES OF BISMUTHIAN BINDHEIMITE
COMPARED WITH BINDHEIMITE, LOVELOCK, NEVADA

	Bismuthian Bindheimite Eureka, Utah	Bindheimite Lovelock, Nevada
Sb ₂ O ₅	24.5	43.63
PbO	48.3	36.54
Fe ₂ O ₃	6.3	4.30
As ₂ O ₅	1.6	—
Bi ₂ O ₃	6.8	—
Ag ₂ O	.8	—
H ₂ O	7.8	5.78
Insol	4.0 ^a	6.32
	100.1	96.57

^a The insoluble material consists of locked barite and quartz.

refractive index were noted. The variation of the refractive indices, color, and clarity is probably due to the variability of the composition of the various bindheimite grains. All three types contain similar quantities of bismuth and silver. Chemical analysis shows, however, that high index, deep yellow-brown grains contain considerably more iron oxide.

X-RAY DIFFRACTION DATA

Pale yellow, dark yellow, and deep yellow-brown grains of bismuthian bindheimite were isolated and analyzed by X-ray diffraction. All three types gave similar patterns, showing a relatively pure mineral with the typical bindheimite pyrochlore-type structure, and a few weak peaks due to quartz and barite impurities. The pale and deep yellow grains are well-crystallized, whereas the X-ray peaks obtained from the deep yellow-brown grains are weak and diffuse showing a lesser degree of crystallinity. The data obtained from the tracings which were made on a

General Electric XRD-5 are essentially identical with X-ray data for bindheimite compiled by Mason and Vitaliano (1953).

REFERENCES

- PALACHE, CHARLES, HARRY BERMAN, AND CLIFFORD FRONDEL (1951), *The System of Mineralogy . . . of Dana, 7th ed. vol. 2*, 1018-1020.
 LINDGREN, WALDEMAR, AND G. F. LOUGHLIN (1919) Geology and ore deposits of the Tintic Mining District, Utah. *U. S. Geol. Surv. Prof. Pap.* **107**, 282 pp.
 MASON, BRIAN, AND CHARLES J. VITALIANO (1953) The mineralogy of the antimony oxides and antimonates. *Mineral. Mag.*, **30**, 100-110.

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MEASUREMENT OF THE DISTORTION INDEX (DELTA) OF CORDIERITE

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ABSTRACT

Identification and use of K_{α_1} reflections in the X-ray diffraction pattern permit more reliable determination of the distortion.

Miyashiro and his affiliates first discovered that cordierite, $(\text{Mg, Fe, Mn})_2\text{Al}_4\text{Si}_5\text{O}_{18}$, occurs in different structural states (Miyashiro & Iiyama, 1954; Miyashiro, Iiyama, Yamasaki & Miyashiro, 1955; Miyashiro, 1957). This phenomenon probably reflects long-range order-disorder relations of Al-Si and Mg-Al (Miyashiro, 1957, p. 45; Schreyer & Yoder, Yoder, 1964, p. 311; Gibbs, 1966, p. 1072). The disorder arrangement would be realized in hexagonal high cordierite (called indialite by the earlier Japanese authors), whereas an increase in ordering would result in an orthorhombic crystal structure. The ordering is thought to be a continuous process, its degree, and thus the degree of distortion from the hexagonal structure being tied to a certain maximum. The degree of ordering in a certain cordierite would be mainly dependent on P-T conditions during and subsequent to its growth (Schreyer, 1966). The variation in structure can be demonstrated in X-ray diffraction diagrams, preferably between $2\theta = 29^\circ$ and $2\theta = 30^\circ$, Cu K_{α} . The hexagonal high cordierite shows one peak in this region, $12\bar{3}1$ (Iiyama, 1956); whereas in orthorhombic forms it is split up into as many as 3 peaks, 511 (A), 421 (B) and 131 (D) (Iiyama, 1956). Empirically, Miyashiro (1957) found that an appropriate measure for ordering in cordierite is given

by the distortion index: $\Delta = 2\theta_{131} - \frac{2\theta_{511} + 2\theta_{421}}{2}$, Cu K_{α} -radiation.