ORIENTATION OF BIXBYITE ON TOPAZ

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Through the courtesy of Mr. John Melhase the writer was permitted to examine and measure a fine specimen of topaz and bixbyite from the Thomas Range, Utah. The specimen is of particular interest because it differs from material hitherto described from this locality.[1] As may be seen from the photograph, Fig. 1, many small bixbyite crystals are attached to one topaz crystal in a horizontal girdle. Closer examination reveals that the bixbyite crystals, which have a cubic habit, (100) modified by (211), as described by Montgomery, have a common orientation, or rather, as appeared after measurement, two complementary orientations.

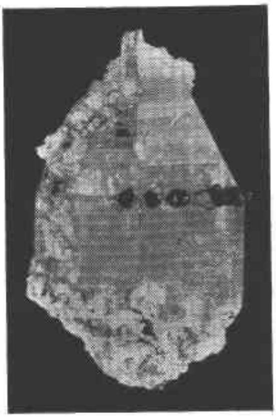

FIG. 1. Crystals of bixbyite oriented on topaz. ×3.

Using a two-circle goniometer, measurements were made on both, topaz and bixbyite at a single setting. The pale amber colored topaz crystal shows only the forms (110), (120), (111) and (021), referred to the axial ratio, 0.5285:1:0.9539, which is in accord with the unit-cell dimensions.

The bixbyite crystals are all attached to the prism faces of topaz, mostly to (110), and reach a maximum dimension of about one millimeter. Since they show mosaic structure and some slight variation of orientation, they could not be measured together. By using an auxiliary magnifying lens attached to the goniometer telescope and a slit dia-

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[1] Montgomery, Arthur, A recent find of bixbyite and associated minerals in the Thomas Range, Utah: *Am. Mineral.*, vol. **19**, pp. 82–87, 1934.

TABLE 1. TWO-CIRCLE GONIOMETER MEASUREMENTS ON BIXBYITE REFERRED TO AXES OF TOPAZ

	Measured		*Calculated*			
			turned 32°50′		turned 33°42′	
Bixbyite no. 1 turned clockwise	ϕ	ρ	ϕ	ρ	ϕ	ρ
100	93° 8	88°36	90°—	90°—	90°—	90°—
001	1 12	31 56	0 —	32 50	0 —	33 42
$1\bar{1}2$	78 16	24 55	76 19	24 51	74 32	25 4
$2\bar{1}1$	99 12	55 50	98 28	55 38	97 54	55 31
$1\bar{2}1$	139 46	38 45	138 42	38 13	137 58	37 34
211	56 56	83 6	55 21	83 1	55 16	83 30
Bixybite no. 2 turned counter-clockwise						
100	89° 7	90° 1	90°—	90°—	90°—	90°—
010	0 41	57 43	0 —	57 10	0 —	56 18
121	40 13	38 42	41 18	38 13	42 2	37 34
211	80 2	56 16	81 32	55 38	82 6	55 31
112	101 6	25 0	103 41	24 51	105 28	25 4
$2\bar{1}1$	124 14	84 26	124 39	83 1	124 44	83 30

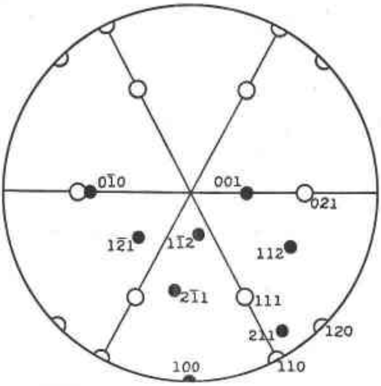

FIG. 2. Stereographic projection of bixbyite crystal oriented on topaz. Black circles indicate poles of bixbyite faces.

phragm to isolate the reflections from a single minute crystal, it was possible to obtain fairly complete sets of observations on six bixbyite crystals, not in contact with each other nor obscured by the adhering matrix of small colorless quartz crystals. All angles for bixbyite were referred to the axial system of topaz. These measurements showed that the [100] axes of the bixbyite crystals nearly coincide with the [100] axis of the topaz crystal and that a cube face of bixbyite, say (001), is inclined about 32°53′ (average of 6 determinations) to the right or the left from the basal face of the topaz.

Figs. 2 and 3 show the relation of the bixbyite to topaz in stereographic projection and in a front elevation.

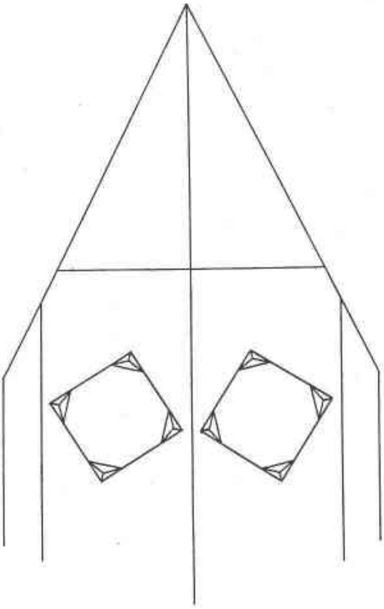

FIG. 3. Front elevation of bixbyite crystals in complementary orientations on topaz.

In Table 1 are given the two-circle measurements on two bixbyite crystals in the positions shown in the front elevation of Fig. 3, together with the angles calculated for bixbyite with [100] coincident with [100]

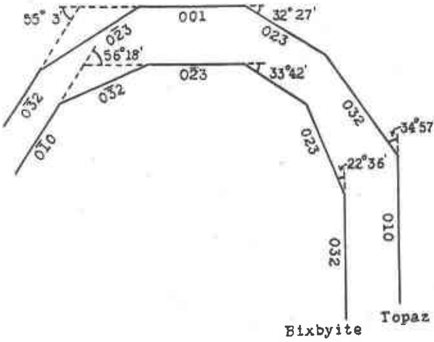

FIG. 4. Correspondence of certain interfacial angles of topaz and bixbyite.

of topaz, and 001 turned clockwise or counterclockwise on the [100] axis either 32°50′ or 33°42′ from the horizontal position. These turning angles were selected from structural considerations explained below.

From Fig. 4 it can be seen that the observed orientation very nearly brings the $0\bar{1}0$, $0\bar{2}3$, 001 and 032 faces of bixbyite into parallelism with the $0\bar{3}2$, 001, 023 and 010 faces of topaz.

Formerly this might have been a satisfying explanation, but Royer[2] and others have shown that regular intergrowths and overgrowths of two minerals are dependent upon the correspondence of spacing and arrangement in certain planes of the structures. Fortunately the structures of bixbyite[3] and of topaz[4] have been fully determined and it is possible to find a structural explanation of this regular overgrowth.

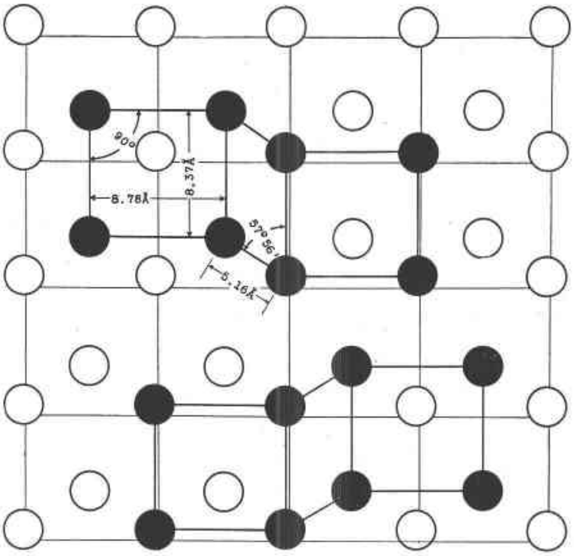

Fig. 5. Arrangement of oxygen atoms in the general position parallel to the 100 face of topaz.

Figure 5 shows the arrangement of oxygen atoms in the general position in a plane parallel to (100) in 16 unit cells of topaz. Figure 6 shows the arrangement of oxygen atoms in a plane parallel to (100) in 16 unit cells of bixbyite. The arrangements of certain groups of eight atoms is

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[2] Royer, M. L., Recherches expérimentales sur l'épitaxie ou orientation mutuelle de cristaux d'espèces différentes: *Bull. Soc. Fran. Min.*, vol. **51**, pp. 7–151, 1928.

[3] Pauling, Linus, and Shappell, M.D., The crystal structure of bixbyite and the *C*-modification of the sesquioxides: *Zeits. Krist.*, vol. **5**, pp. 128–142, 1930.

[4] Alston, N. A., and West, J., The structure of topaz, $[Al(F, OH)]_2SiO_4$: *Zeits. Krist.*, vol. **69**, pp. 149–167, 1928.

emphasized by blacking in the drawings to show the extent of the correspondence between the two structures. Inspection of the drawings will show that all oxygen atoms in these or similar planes belong to similar groups.

A comparison of the dimensions entered on the diagrams will show that turning the bixbyite lattice some 33° or 34°, either clockwise or counterclockwise, will bring one or another of the marked groups into near-coincidence with a similar group in topaz. The discrepancy in the fit is well within the limits of tolerance found by Royer for the effect of orientation.

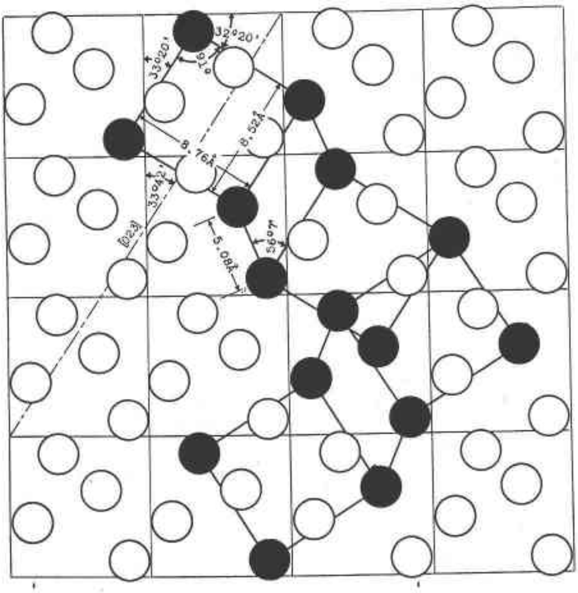

Fig. 6. Arrangement of oxygen atoms in the 100 plane of bixbyite.

If the bixbyite is turned just 33°42′ its [023] axis will coincide with the c axis of topaz. The identity distance along the [023] or [03$\bar{2}$] axis of bixbyite is 33.77Å, at which distance the configuration of atoms in question is repeated. This matches closely 4c, 33.51Å, and 4b, 35.13Å, of topaz.

This is equivalent to matching the area of the 100 plane across 13 cells ($3^2+2^2=13$) of bixbyite, 1140Å^2, over the area of the 100 plane across 16 cells of topaz, 1179Å^2. The discrepancy is only 3.3%. In these areas 8 out of 52 atoms of oxygen in a 100 plane of bixbyite would coincide with 8 out of 32 oxygen atoms in a 100 plane of topaz.

If, on the other hand, the bixbyite is turned just 32°50′, the nearest approach to coincidence of a single group of 8 atoms with a similar group in topaz is obtained. Inspection of Table 1 and consideration of the average angle of turning observed suggest that this is the governing factor in the orientation.

NOTES AND NEWS

ON THE IDENTITY OF AUSTINITE AND BRICKERITE

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In 1932 (*N. Jahrb. Mineral.*, Abt. A, Beil.-Band **66,** p. 44, 1932) Friedrich Ahlfeld called attention to an arsenate of zinc and calcium from Lomitos, Bolivia. A complete description was to be given later by its discoverer, Dr. J. Barrande-Hesse of La Paz, Bolivia, who named it "brickerite."

At the fifteenth meeting of The Mineralogical Society of America at Rochester, N. Y., December 27, 1934, Lloyd W. Staples of Stanford University, presented a paper on a new arsenate mineral from Gold Hill, Utah, and gave a complete description of this new mineral, named by him "austinite" in honor of Professor Austin F. Rogers (*Am. Mineral.*, vol. **20,** pp. 112–119, 1935).

The chemical analysis (by R. B. Ellestad) of the new mineral that occurs with adamite in minute but distinct, well developed, colorless crystals of bladed or acicular habit, found in the oxidized zone of the Western Utah Copper Company's ore body, lead to the chemical composition $CaZn(OH)AsO_4$.

In 1936 (*Zentralbl. Min.*, Abt. A, No. **8,** pp. 226–231, 1936) Friedrich Ahlfeld and R. Mosebach described the above mentioned "brickerite" from the Lilli mine near Lomitos, Bolivia. A chemical analysis of the mineral was made by its discoverer, J. Barrande-Hesse. The analyzed material was not pure, but contained 10.46% $CaCO_3$, 1.65% SiO_2 and 0.66% Fe_2O_3. Unfortunately the analyst neglected to determine the water content and therefore arrived at the erroneous chemical formula: $Zn_4Ca_3As_4O_{17} = 4ZnO \cdot 3CaO \cdot 2As_2O_5$ Specimens of "brickerite," which I have received from Friedrich Ahlfeld, yield an appreciable amount of water when the powdered mineral is heated in a closed tube, and make it probable, that "austinite" and "brickerite" are identical.

At Lomitos the mineral occurs in banded veins with fibrous structure, resembling fibrous gypsum or aragonite. It is found filling small dikes in a greenish dacite. The fibrous layers alternate with crusts of quartz, chalcedony and limonite. Adamite was not observed on the specimens from Lomitos.