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OPTICAL CRYSTALLOGRAPHY OF ORIENTITE FROM ORIENTE PROVINCE, CUBA

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ABSTRACT

The optic orientation, optic angle, optic sign, and pleochroic formula of orientite [$Ca_4Mn_4^{+3}(SiO_4)_5{:}4H_2O$] recorded in the literature are incorrect, and a revision of the optical crystallography of orientite is presented.

Orientite is orthorhombic,

$$\frac{2}{m}\frac{2}{m}\frac{2}{m},$$

dominant forms {110}, {001}, and {010}, prismatic to tabular parallel to {010}, $(110)\wedge(1\bar{1}0)=67°\ 48'$, $a{:}b{:}c=0.6720{:}1{:}0.3958$, imperfect basal {001} and brachyprismatic {120} cleavage, sp. gr. = 3.05. The Barker classification angles are $cr=30°\ 30'$, $am=33°\ 54'$, and $bq=68°\ 24'$.

The optic orientation of orientite is $X=b$, $Y=c$, $Z=a$ with $\alpha=1.756$, $\beta=1.777$, $\gamma=1.794$ (all ±0.002). The optic plane is transverse to the elongation, and the optic angle is large, negative, and variable ($2V_X=68$–$83°$). It has very strong dispersion ($r<v$) of the optic axes which are essentially normal to the brachyprismatic {120} cleavage. Orientite is deep red brown in color and strongly pleochroic in section with X = yellow, Y = yellow-brown, Z = red-brown, and $Z>Y>X$.

X-ray powder diffraction data for orientite are given for reference.

INTRODUCTION

During a mineralogical study of several manganese ores from Oriente Province, Cuba, the writer obtained for comparative purposes a specimen of the type orientite from Oriente, Cuba, originally described by Hewett and Shannon (1)*. It was found that several of the optical properties of this sample of orientite were not in agreement with those recorded for orientite in the standard reference works by Larsen and Berman (2) and Winchell and Winchell (3). A check of the paper by Hewett and Shannon (1) revealed that a typographical error in their reported optical orientation of orientite has been propagated in the subsequent literature. Other optical properties of orientite, such as the optic sign and the optic angle, are in error in the original description. A revision of the optical crystallography or orientite is presented in this paper, and *x*-ray powder diffraction data for the type orientite are included for reference.

OCCURRENCE

Orientite [$Ca_4Mn_4^{+3}(SiO_4)_5\cdot4H_2O$ or $4CaO\cdot2Mn_2O_3\cdot5SiO_2\cdot4H_2O$] is known only from Oriente Province, Cuba, where it occurs as a minor

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* References at end of text.

constituent of oxide manganese ores. The mineral was discovered by Hewett (1) in ores of the Costa, Manuel, and Vicente denouncements, 6 miles south of Bueycito, southwestern Oriente. He later found orientite in ore from the Santa Rosa prospect near Banes, north of Antilla, north central Oriente. The largest known crystals of orientite do not exceed 1 mm. in length.

The regional geology of Oriente Province is discussed by Park (4), Woodring and Daviess (5), and Lewis and Straczek (6), and detailed descriptions of the geology of the manganese deposits in the Bueycito district are given by Burchard (7), Park and Cox (8), and Simons and Straczek (9). In brief, the manganese ores of this district consist of those parts of beds of volcanic tuff which contain a sufficiently high proportion of grains, nodules, pods, and veinlets of manganese-oxide minerals to constitute ore. These bedded tuff ores are intercalated with water-laid basaltic, andesitic, and latitic agglomerates and tuffs and limestone beds which constitute the upper part of the Cobre formation of upper Eocene age. The Bueycito bedded tuff ores are considered to be hypogene and syngenetic, and the manganese oxide minerals are believed to have been deposited by penecontemporaneous replacement of the altered tuff matrix (9). The source of the mineralizing solutions is thought to have been submarine hot springs (4, 9).

According to Hewett and Shannon (1), orientite from the Bueycito district occurs as (1) high-purity drusy aggregates which contain variable amounts of finely disseminated inclusions of a psilomelane-type oxide, (2) drusy cavity linings in psilomelane-type oxide, (3) finely disseminated grains in altered tuff, (4) granular aggregates which selectively replace the glassy portion of rock fragments embedded in the altered tuff, and (4) pseudomorphs after foraminifera (calcite) embedded in psilomelane-type oxide. The principal associated minerals are a psilomelane-type oxide, manganite, pyrolusite, neotocite, ferruginous chalcedony ("bayate"), barite, low quartz, calcite, and zeolites (analcite, stilbite, chabazite, and laumontite). Based on cross-cutting relationships of veinlets and successive cavity fillings, Hewett and Shannon tentatively concluded that the sequence of mineral deposition was (1) ferruginous chalcedony, (2) psilomelane-type manganese oxide and plumose manganite, (3) orientite and barite, (4) prismatic manganite, (5) quartz, (6) zeolites, (7) calcite. The pyrolusite was probably formed by surficial supergene oxidation of the psilomelane-type oxide.

OPTICAL CRYSTALLOGRAPHY

Hewett and Shannon (1, p. 501) state that orientite is biaxial positive with the optic plane parallel to (001) and, in outline form, give the optic orientation as X = *a*, Y = *c*, and Z = *b*. The succeeding text of their paper, however, states that the obtuse bisectrix is normal to (010) which indicates that the correct optic orientation of orientite is X = *b*, Y = *c*, and Z = *a*, provided the optic sign of the mineral was correctly determined. The orientation given in outline form is probably a typographical error which, with one exception, has been repeated in the subsequent literature (2, 3, 10, 11, 12). The exception is an abstract of the original paper by Spencer (13) who correctly recorded the optical orientation of orientite as optic plane parallel to (001) and acute bisectrix (Z) normal to (100). Strangely, Larsen (14) gave the optic orientation as X = *a*, Z = *c*. The present study showed that the optic orientation of orientite is X = *b*, Y = *c*, and Z = *a*, as determined on well-formed crystals.

According to Hewett and Shannon (1) the optic angle of orientite is 67°. This conclusion was based on (1) their observation that crystals that lie on (110) yield a perfectly centered optic axis figure and (2) goniometric measurements that gave $\phi = 56° 06'$ as the angle for the prism or $(110) \wedge (1\bar{1}0) = 67° 48'$. The optic angle as calculated from the indices of refraction reported by Hewett and Shannon ($\alpha = 1.758$, $\beta = 1.776$, $\gamma = 1.795$; all ± 0.005), is, however, (+) $2V = 89° 22'$, although within the stated limits of precision for these indices a calculated $2V_Z$ of 67° is possible.

Both Hewett and Shannon and the writer noted that the axial bars of centered optic axis figures are practically straight. Hewett and Shannon attributed the lack of curvature of the optic axial bars to the high value of β and a resultant 2E of 156° for a 2V of 67°. The writer, however, questioned whether, for the optical system used in this study, the axial bar of a centered optic axis figure of a substance with $2V = 67°$ and $\beta = 1.776$ would be straight. In addition, it was observed that (1) a greater rotation of the microscope state was required to make the isogyres leave the field for a Bx_X figure as compared with a Bx_Z figure, and that (2) the apparent dispersion of the optic axes was $r < v$ for centered Bx_X figures and $r > v$ for centered Bx_Z figures, whereas the true dispersion determined on slightly off-center optic axis figures in which the curvature of the axial bar was recognizable was $r < v$ which is in accord with the dispersion formula given by Hewett and Shannon. Consequently, the indices of refraction were redetermined with results as follows: $\alpha = 1.756$, $\beta = 1.777$, $\gamma = 1.794$ (all ± 0.002). The calculated optic angle is (−) $2V = 83° 02'$, which is in accord with the indications of the qualitative optical tests, but within the stated accuracy limits for these indices of refraction, the calculated optic angle could range from (−) $2V = 70° 44'$ to (+) $2V = 85° 10'$. A subsequent independent determination of the optic angle and sign of orientite with the universal stage showed that the optic angle is negative and variable with 2V=68°–83°. Grains with the larger optic angles (77°–83°) appear to be more common.

Hewett and Shannon reported that orientite has a poor prismatic {110} cleavage which is normal to the optic axes. The present writer also observed the traces of cleavage planes in the prism [001] zone and noted the frequent occurrence of centered optic axis figures on crushed fragments. If the optic axes of orientite are normal to an imperfect prismatic {hk0} cleavage and the optic angle ranges from 68° to 83°, however, this cleavage cannot be parallel to {110} inasmuch as $(110)\wedge(1\bar{1}0)$ was determined by goniometric measurement of crystal faces to be 67° 48′. For an optic angle which ranges from 68° to 83°, the angle between an optic axis and the pole of (110) would range from about 22° to 14°, respectively, and, as a result, (110) cleavage fragments would not yield a centered optic axis figure. The Mallard formula (16, p. 48) shows that for (110) cleavage fragments, the point of emergence of the optic axis in the conoscopic figure would be displaced from the center of the field a distance of two-fifths to four-fifths the radius of the conoscopic field depending on the optic angle and on the Mallard constant of the optical system employed. Alternatively, if the {hk0} cleavage is {120}, the angle between an optic axis and the pole of (120) would range from 4° 51′ in the direction of the *a* axis to 2° 39′ in the direction of the b axis for a corresponding range in the optic angle from 83° to 68°. Cleavage fragments parallel to {120} would always yield a centered optic axis figure regardless of the magnitude of the optic angle within the stated limits. Coincidence of the optic axes with the poles of {120} would occur for a 2V of 73° 18′. It is concluded that the imperfect prismatic cleavage of orientite is probably {120}.

Orientite is strongly pleochroic. In the original paper (1) and all the subsequent literature (2, 3, 10, 11, 12, 13, 14), the pleochroism and absorption is given incorrectly as X=red-brown, Y=yellow, Z=brownish-yellow with $X>Z>Y$. This study shows that X=yellow, Y=yellow-brown, and Z=red-brown with $Z>Y>X$.

Tables 1 and 2 are a summary of the revised optical and crystallographic data for orientite. Shannon's original orientation of the crystallographic axes has been retained for simplicity and because it seems pointless to introduce another arbitrary setting of the orthorhombic axes in the absence of *x*-ray structural data. For determinative purposes, however, it may be useful to transform the crystallographic data for orientite in terms of the Barker (15) classification angles for the orthorhombic system.

With rare exception, all the known crystals of orientite have only one prism zone and two pinacoids. In the absence of well-developed pyra-

TABLE 1. MORPHOLOGICAL CRYSTALLOGRAPHY AND PHYSICAL PROPERTIES OF ORIENTITE, ORIENTE PROVINCE, CUBA

Symmetry: orthorhombic system; rhombic-dipyramidal (barite) class,

$$\frac{2}{m}\ \frac{2}{m}\ \frac{2}{m}$$

Forms:

common	rare
basal pinacoid {001}	brachydome {021}
brachypinacoid {010}	macrodome {101}
unit prism {110}	unit pyramid {111}
$(110)\wedge(1\bar{1}0)=67°48.$*	

Barker classification angles†: $cr=30°30'$, $am=33°54'$, $bq=68°24'$

Axial ratio: (0.6720:1:0.3958)‡

Habit: dominantly prismatic and pseudohexagonal; subordinately tabular parallel to {010}

Cleavage: imperfect parallel to the basal pinacoid {001} and the brachyprism {120}; $(110)\wedge(120)=19°27'$§

Color: deep red-brown to almost black; brown when powdered

Luster: resinous to sub-vitreous

Specific gravity: 3.05

Hardness: $4\frac{1}{2}$–5

Note: soluble in hot HCl with evolution of chlorine, and separation of residual insoluble silica; insoluble in HNO_3.

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* Measured goniometrically by Shannon (1); checked with microscope on basal sections in present study.

† For crystals with complete development of forms.

‡ c/b is an approximation based on measurement with the microscope by Shannon of $(101)\wedge(\bar{1}01)=61°00'$ on one crystal (1).

§ Calculated angle.

midal faces and the occurrence of only one prism zone, Barker auxiliary setting rule (v) is applicable. The forms {110}, {010}, and {001} become {101}, {100}, and {010}, respectively, and cr $(001\wedge101)=33°\ 54'$.

For the orientite crystal with additional forms described by Shannon, the Barker setting of the parametral plane differs from that given by Shannon, but the orientation of the crystallographic axes remains the same. The preferred setting based on the Barker rules is the one which gives the maximum number of simple planes (indices with no numbers except 0, 1, and $\bar{1}$). As a result, {011}, {102}, and {112} of Shannon become {021}, {101}, and {111}, respectively, and $c:b$ of Shannon (0.7916) becomes $c:b/2$ (0.3958). The Barker classification angles are cr $(001\wedge101)=30°\ 30'$, am $(100\wedge110)=33°\ 54'$, and bq $(010\wedge011)=68°\ 24'$.

TABLE 2. OPTICAL PROPERTIES OF ORIENTITE, ORIENTE PROVINCE, CUBA

Indices of Refraction	Optic Angle and Sign
$\alpha=1.756\pm0.002$	(−) $2V=83°02'$ (calculated from indices of refraction)
$\beta=1.777\pm0.002$	
$\gamma=1.794\pm0.002$	(−) $2V=68°$–$83°$ (measured with universal stage)
γ-$\alpha=0.038$	

Orientation	Pleochroism and Absorption
$X=b$	X=yellow
$Y=c$	Y=yellow-brown; $Z>Y>X$
$Z=a$	Z=red-brown

Dispersion of optic axes

$r<v$ very strong

Remarks

Optic plane parallel to {001} and transverse to elongation of prismatic crystals

Optic axes essentially normal to the brachyprismatic {120} cleavage

TABLE 3. X-RAY POWDER DIFFRACTION DATA FOR ORIENTITE, ORIENTE PROVINCE, CUBA

(Fe radiation, MnO filter)

d, Å	I	*d*, Å	I	*d*, Å	I
9.42	50	2.10	25	1.29	5
5.89	25	2.05	20	1.26	5
5.05	50	1.96	10	1.24	15
4.77	10	1.94	5	1.20	10
4.40	60	1.87	10	1.17	15
4.07	30	1.84	15	1.15	5
3.93	10	1.81	5	1.13	15
3.69	10	1.77	10	1.12	5
3.42	10	1.73	5	1.11	5
3.26	50	1.69	50	1.10	20
3.05	75	1.64	35	1.09	5
2.90	40	1.61	10	1.05	5
2.78	10	1.59	15	1.04	5
2.68	100	1.52	50	1.03	5
2.58	50	1.51	10	1.02	5
2.51		1.44	10	1.01	5
2.44	20	1.38	5	1.00	5
2.34	50	1.34	5	0.996	10
2.23	30	1.32	35	0.978	5
2.19	10	1.30	10	0.974	5

X-RAY POWDER DATA

X-ray powder diffraction data for orientite are given in Table 3.

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