CHALCOMENITE FROM BOLIVIA

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SUMMARY

Good crystals of chalcomenite—$CuSeO_3 \cdot 2H_2O$ from a new locality, Hiaco mine, Pacaake, about 30 km. ENE. of Colquichaca, Bolivia, are orthorhombic, disphenoidal; $a:b:c=0.7325:1:0.8077$, in agreement with the form of the artificial salt. Forms: $*c\{001\}$, $*b\{010\}$, $n\{120\}$, $m\{110\}$, $q\{011\}$, $d\{101\}$, $o\{111\}$, $p\{\bar{1}11\}$, $\delta\{141\}$. Structure cell: simple orthorhombic; class 2 2 2; space group $P\,2_1\,2_1\,2_1$; $a_0=6.65$, $b_0=9.10$, $c_0=7.36$ Å; $a_0:b_0:c_0$ $=0.731:1:0.809$; contains $Cu_4Se_4O_{12} \cdot 8H_2O$. Cleavage none; H slightly over 2; G=3.35. Crystals clear blue, transparent, pleochroic. X (light blue)$=a[100]$, Y (darker blue) $=c[001]$, Z (darker blue)$=b[010]$. Indices (Na): $nX=1.712$, $nY=1.732$, $nZ=1.732$, all ±0.002. Negative; $2V$ nearly zero; $r<v$, strong.

Chalcomenite, a hydrous selenite of copper from Cerro de Cacheuta in the Argentine, was named by Des Cloizeaux and Damour (1881), who described the crystals as monoclinic. In a separate communication Damour (1881) gave an analysis of the new mineral and derived the composition $CuO \cdot SeO_2 \cdot 2H_2O$. Friedel and Sarasin (1881 A) succeeded in preparing large crystals of the same composition; these were found by the same authors (1881 B) to be orthorhombic, and apparently unlike the natural salt in form. These papers remain after more than fifty years the sole source of information concerning this uncommon mineral.

Chalcomenite has now been determined among the oxidation products of the nickel-copper selenide, blockite, recently described by Herzenberg and Ahlfeld (1935)[1]; a study of this new occurrence permits a revision and extension of our knowledge of the older species. The specimens studied were sent to the Harvard Mineralogical Museum by Dr. Ahlfeld; they came from the lead-silver mine, Hiaco, in Pacaake, about 30 kilometers ENE. of Colquichaca, Bolivia. Herzenberg and Ahlfeld mention a number of oxidation products associated with blockite, including white needles of what they took to be selenolite and a red mineral regarded as new and named ahlfeldite, but later recognized as cobaltomenite. It is hoped that better material will come to hand which will enable these little-known minerals to be exactly described.

On the few small specimens available, consisting mostly of blockite, there are various acicular white minerals, one of which could be identified as cerussite; molybdomenite is probably among them and cobaltomenite is also present in several druses. Chalcomenite, with the charac-

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[1] Since this paper went to press blockite has been identified with penroseite by Bannister and Hey (1937).

teristic clear blue color, appears in cavities lined with limonite, together with the minerals already mentioned, or quite alone. The largest crystal seen is not more than 3 mm. in greatest dimension. The common habit is acicular, the needles measuring but a fraction of a millimeter in diameter. Despite their minute size, the crystals gave fairly consistent measurements.

Crystallography. The new crystals of chalcomenite were measured and projected with reference to the axis of acicular development. The resulting projections showed a vertical axis of two-fold symmetry, which was also clearly expressed by the development of the faces, but no vertical plane of symmetry. The crystals thus appeared to be monoclinic, elongated with the symmetry axis; and it was easy to choose elements leading to a notable simplification of the complex indices of Des Cloizeaux and Damour.

Optical study by Dr. Berman showed, however, that the principal optical directions coincide with possible orthorhombic crystal axes; while an x-ray study, also by Dr. Berman, proved the presence of two rectangular axes of two-fold symmetry perpendicular to the needle axis. These observations indicated that the crystals are orthorhombic-disphenoidal rather than monoclinic. Taking the needle axis as the vertical axis, the simplest choice of orthorhombic elements, which were found to agree with the elements of the structural lattice, gave values that correspond closely with those of Friedel and Sarasin when the axes of these authors are suitably interchanged.

One difficulty remained, however. Opposite ends of a disphenoidal crystal present the same aspect while the terminations at opposite ends of the symmetry axis of a monoclinic crystal are in right- and left-hand relation. Doubly terminated crystals were not found; but both right- and left-hand projections were obtained from the singly terminated crystals. This fact may be explained in three ways: (1) the crystals are monoclinic with rectangular axes; (2) they are disphenoidal with hypothetical twinning on (001); (3) they are disphenoidal with the unit disphenoids in right-hand {111} and left-hand {1$\bar{1}$1} positions equally common, never occurring together, and not distinguishable. Of these three possibilities the last appears to be the most probable.

Table 1 gives the forms and measured angles obtained from crystals of chalcomenite. The best measurements lead to the elements: $a:b:c = 0.7325:1:0.8077$ which agree well with the ratio: $a:c:b = 0.7358:1 :0.8111$, computed from Friedel's and Sarasin's measurements on the artificial salt.

TABLE 1. CHALCOMENITE: TWO-CIRCLE MEASUREMENTS

Form		Mean		Range		No. of faces	Quality
		ϕ	ρ	ϕ	ρ		
*c	001	—	0°00′	—	—	4	good
*b	010	0°00′	90 00	0°02′– 0°10′	—	2	very poor
n	120	35 36	90 00	34 50 –36 22	—	19	very poor
m	110	53 54	90 00	53 31 –54 03	—	9	very good
q	011	0 00	38 51	0 01 – 0 10	38°40′–38°59′	3	very good
d	101	90 00	47 50	89 46 –90 19	47 33 –48 00	10	very good
o	111⎫	±53 47	53 44	±53 05 –54 27	53 32 –54 00	5	poor
p	Ī11⎭						
δ	141	15 50	73 17	14 42 –16 57	72 35 –74 00	2	very poor

* New form.

In the presentation of the crystallography of chalcomenite, Dana (1892) followed Des Cloizeaux and Damour. Goldschmidt (1897; 1912) took the same axial directions but changed the parametral lengths to obtain some simplification of indices. Groth (1908) reproduced the data of Friedel and Sarasin on the artificial compound. In Table 2 the several settings are correlated by the appropriate transformation formulas and by tabulation of the corresponding form letters and symbols.

TABLE 2. CHALCOMENITE: CORRELATION OF FORMS

Des Cloizeaux & Damour (Dana) to Palache: 10$\bar{2}$/$\bar{1}0\bar{4}$/010
Goldschmidt to Palache: 20$\bar{1}$/$\bar{2}0\bar{2}$/020
Friedel & Sarasin (Groth) to Palache: 100/001/010

Des C. & Damour		Dana	Goldschmidt	Friedel & Sarasin		Groth	Palache
—	—	—	—	—		—	c{001}
—	—	—	—	—		—	b{010}
p	{001}	c	a{001}⎫	a^2	{102}	s	n{120}
o$^{\frac{1}{2}}$	{801}	f	f{201}⎭				
h^1	{100}	a	c{100}⎫	a^1	{101}	r	m{110}
a^1	{Ī01}	g	g{Ī04}⎭				
β	{2.12.1}	β	β{162}	—	—	—	β{012}
ε	{261}	ε	ε{132}	e^1	{011}	q	q{011}
—	—	—	—	e^2	{012}	t	t{021}
—	—	—	—	m	{110}	m	d{101}
m	{110}	m	m{110}	$b^{1/2}$	{111}	o	o{111}⎱ p{Ī11}⎰
δ	{421}	δ	δ{212}	—	—	—	δ{141}

Table 3 compares the fundamental angles of the earlier authors with the new values. The agreement with the values for the artificial salt (Friedel & Sarasin) is very good; the previous measurements on the natural mineral, obtained from poorly developed crystals, accord less well with the new angles.

TABLE 3. CHALCOMENITE: INTERFACIAL ANGLES

Des Cloizeaux & Damour	Friedel & Sarasin	Palache
$m\,h^1 = 35°50'$	—	$om = 36°11\frac{1}{2}'$
$p\,a^1 = 18\ 54$	$a^2a^1 = 19°27\frac{1}{2}'$	$nm = 19\ 27\frac{1}{2}$
$a^1h^1 = 71\ 57$	$a^1a^1 = 72\ 41\frac{1}{2}$	$mm = 72\ 27$
—	$m\,m = 84\ 25\frac{1}{2}$	$dd = 84\ 25$

Table 4 is an angle-table for chalcomenite in the adopted setting.

TABLE 4. CHALCOMENITE—$CuSeO_3 \cdot 2H_2O$

Orthorhombic; disphenoidal—2 2 2

$a:b:c = 0.7325:1:0.8077$ $p_0:q_0:r_0 = 1.1026:0.8077:1$
$q_1:r_1:p_1 = 0.7325:0.9070:1$ $r_2:p_2:q_2 = 1.2381:1.3651:1$

Forms		ϕ	$\rho = C$	ϕ_1	$\rho_1 = A$	ϕ_2	$\rho_2 = B$
c	001	—	$0°00'$	$0°00'$	$90°00'$	$90°00'$	$90°00'$
b	010	$0°00'$	90 00	90 00	90 00	—	0 00
n	120	34 19	90 00	90 00	55 41	0 00	34 19
m	110	$53\ 46\frac{1}{2}$	90 00	90 00	$36\ 13\frac{1}{2}$	0 00	$53\ 46\frac{1}{2}$
β	012	0 00	$21\ 59\frac{1}{2}$	$21\ 59\frac{1}{2}$	90 00	90 00	$68\ 00\frac{1}{2}$
q	011	0 00	$38\ 55\frac{1}{2}$	$38\ 55\frac{1}{2}$	90 00	90 00	$51\ 04\frac{1}{2}$
t	021	0 00	$58\ 14\frac{1}{2}$	$58\ 14\frac{1}{2}$	90 00	90 00	$31\ 45\frac{1}{2}$
d	101	90 00	$47\ 47\frac{1}{2}$	0 00	$42\ 12\frac{1}{2}$	$42\ 12\frac{1}{2}$	90 00
o	111	$53\ 46\frac{1}{2}$	$53\ 48\frac{1}{2}$	38 55	$49\ 22\frac{1}{2}$	$42\ 12\frac{1}{2}$	61 31
p	$\bar{1}11$	$-53\ 46\frac{1}{2}$	$53\ 48\frac{1}{2}$	$-126\ 13\frac{1}{2}$	$49\ 22\frac{1}{2}$	$137\ 47\frac{1}{2}$	61 31
δ	141	$18\ 50\frac{1}{2}$	$73\ 40\frac{1}{2}$	72 48	$71\ 56\frac{1}{2}$	$42\ 12\frac{1}{2}$	24 44

X-ray measurements. The following photographs were made on a small crystal of chalcomenite, using copper radiation: rotation, equator Weissenberg and first layer Weissenberg about $c[001]$; and an equator Weissenberg about $b[010]$. These photographs confirm the orthorhombic symmetry and show that the mineral has a simple lattice with the cell dimensions:

$$a_0 = 6.56, \; b_0 = 9.10, \; c_0 = 7.36 \text{ Å}$$
$$a_0 : b_0 : c_0 = 0.731 : 1 : 0.809$$

in good agreement with the morphological ratio.

The systematically missing spectra are: $(h00)$ for h odd, $(0k0)$ for k odd, $(00l)$ for l odd. In the disphenoidal class—2 2 2, these omissions define the space group $P\,2_1\,2_1\,2_1$. From the cell volume and the measured density 3.35 the unit cell contains: $Cu_4Se_4O_{12}\cdot 8H_2O$ or $4(CuSeO_3\cdot 2H_2O)$.

Physical and Optical Properties. Chalcomenite has no cleavage. The hardness is slightly over 2. The specific gravity was determined by Damour as 3.76 but was considered by him to be too high due to adhering impurities. By suspension in Clerici solution Dr. Berman obtained the value 3.35, which is in good accord with the cell volume and molecular weight.

On terminated crystals of chalcomenite from the new locality Dr. Berman obtained:

	n(Na)		
X (light blue) $= a[100]$	1.712		Negative
Y (darker blue) $= c[001]$	1.732	± 0.002	$2V$ nearly zero
Z (darker blue) $= b[010]$	1.732		$r < v$ strong

Composition. A small quantity (21 mg.) of the clean crystalline material was picked out with difficulty under the microscope. On this sample Mr. Gonyer obtained 0.0088 gm. SeO_2, 0.0063 gm. CuO, giving equal molecular proportions of the oxides, as required by the established formula.
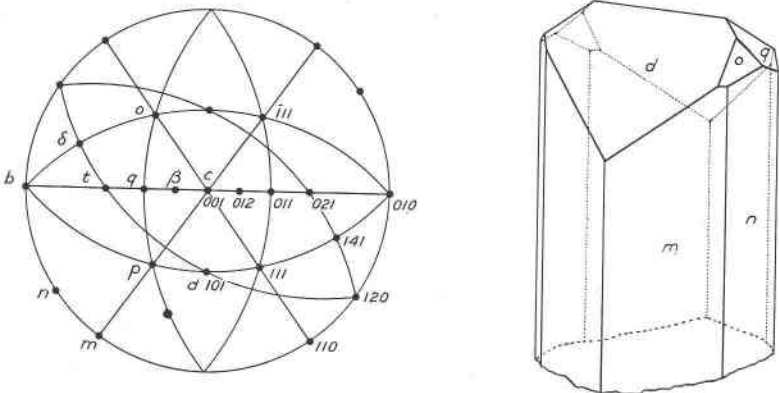

FIG. 1 (left)—Chalcomenite: stereographic projection of the known forms.
FIG. 2 (right)—Chalcomenite: typical crystal from Bolivia, showing the right sphenoid $o\{111\}$.

References

BANNISTER, F. A., and HEY, M. H. (1937): *Amer. Min.*, **22,** 319–324.

DAMOUR, A. (1881): *Bull. Soc. Min. France*, **4,** 164–167.

DANA, E. S. (1892): *System of Mineralogy*—New York.

DES CLOIZEAUX, A. and DAMOUR, A. (1881): *Bull. Soc. Min. France*, **4,** 51–55.

FRIEDEL, C., and SARASIN, E. (1881 A): *Bull. Soc. Min. France*, **4,** 176–178.

———— (1881 B): *Bull. Soc. Min. France*, **4,** 225–228.

GOLDSCHMIDT, V. (1897): *Krystallographische Winkeltabellen*—Berlin.

———— (1913): *Atlas der Krystallformen*, **2**—Heidelberg.

GROTH, P. (1908): *Chemische Krystalographie*, **2**—Leipzig.

HERZENBERG, R., and AHLFELD, F. (1935): *Cbl. Min.*, A, 277–279.