

# Chalcoalumite from Bisbee, Arizona

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In February of 1971 a local mineral collector, Terry D. Mayberry, brought in a blue crystalline mineral found in the Sacramento pit at Bisbee which we identified as chalcoalumite,  $\text{CuAl}_4(\text{SO}_4)(\text{OH})_{12} \cdot 3\text{H}_2\text{O}$ . We have subsequently found more material in the company's storage bins at Bisbee, but nothing as striking as the first sample.

In all of these samples the chalcoalumite occurs in vugs in a dense quartz-goethite gossan. Cuprite and malachite are also common. The chalcoalumite is beautifully crystallized either directly upon the matrix or perched on corroded cuprite crystals. Some also occurs in pockets of coarse fibrous malachite which grades into pale green malachite needles towards the center of the pocket. These needles may impale tiny but highly perfect chalcoalumite crystals. In much of this material the chalcoalumite is completely altered to massive, botryoidal gibbsite of pale blue color. The material with crystalline chalcoalumite also differs from the specimens found during the past year in the Sacramento pit. These older specimens consist of massive microcrystalline to fibrous chalcoalumite thickly encrusting azurite or malachite.

Commonly the chalcoalumite occurs in small spherules of pale blue color. These spherules are comprised of small, highly perfect crystals (0.5 mm in diameter) which project outward in all directions and, individually, are perfectly transparent and nearly colorless. The crystals are sectile and show a perfect cleavage on {100}.

The original description by Larsen and Vassar<sup>1</sup> (1925) was based on microcrystalline material decidedly inferior to the newly discovered crystals. They considered chalcoalumite to be triclinic. We have studied the crystals goniometrically and by various X-ray techniques and find that they are monoclinic sphenoidal.

Single crystals of both hands appear to be equally abundant. In habit these are triangles, almost perfectly equilateral, with the flat side bounded by {100}, one edge by {010} and the other two edges by {012} and {112}. Such a crystal (right handed) is shown in Figure 1. An angle table is given in Table 1.

Twinning is common and three laws are found. Most common are twins in {100} and in {010}. Twins in {100} closely resemble untwinned crystals but are

Table 1  
Morphological Data for Right-Handed Chalcoalumite

$$a:b:c = 1.917:1:1.1464 \quad \beta = 95^\circ 53'$$

$$P'o = .601 \quad q'o = 1.146 \quad X'o = .103$$

hkl	$\phi$	$\rho$	$\phi_2$	$\rho_2$	C	A
100	90°00'	90°00'	0°00'	90°00'	84°07'	0°00'
010	0°00'	90°00'	...	0°00'	90°00'	90°00'
012	10°12'	30°13'	84°07'	60°19'	29°42'	84°54'
112	-19°01'	31°14'	101°10'	60°39'	33°34'	89°43'
136*	0°17'	29°50'	89°50'	60°11'	30°19'	89°52'

\*not a morphological form

easily detected in polarized light when viewed normal to {100} for they have no extinction position—a feature

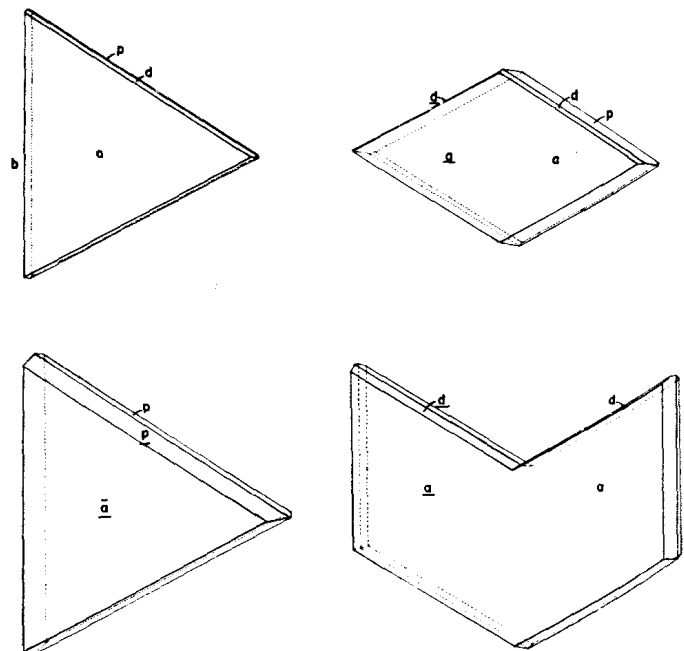


Fig. 1. Upper left, single right-handed crystal; upper right, twin in {010}; lower left, twin in {100}; lower right, twin in {136} and {010}. Forms are a {100}, b {010}, d {012} and p {112}.

previously noted by Larsen and Vassar but ascribed only to strong dispersion. Twins in {010} form diamond-shaped tablets but commonly the composition plane is sutured and may even show internal reflections. Both of these twin laws are also shown in Figure 1.

Less common is twinning in {136} which is a pseudoorthorhombic third order prism. Such twins may have a deep reentrant as shown in Figure 1; the composition plane may be {100} or {136}. All or some of these laws may occur together. Eightlings and fourlings based on the {136} and {100} laws are

<sup>1</sup>Larsen, E. S., and H. E. Vassar (1925) Chalcoalumite, a new mineral from Bisbee, Arizona. *Amer. Mineral.* 10, 79-83.

common. Equally common are diamond-shaped eightlings based on all three laws.

The morphological evidence for sphenoidal symmetry is strong. This symmetry was confirmed by etching of untwinned crystals in concentrated cold  $\text{NH}_4\text{OH}$  and 20%  $\text{HgCl}_2$ .

A unit cell was chosen on the basis of single crystal X-ray patterns. The cell has the following parameters:  $a = 17.090\text{\AA}$   $b = 8.915$   $c = 10.221$   $\beta = 95^\circ 53'$  which were obtained by refining powder data. Systematic extinctions in the Weissenberg photographs indicate the space group  $P2_1$ . This cell gives a calculated density of 2.25 (with  $Z = 4$ ) as compared with Larsen and Vassar's measured value of 2.29. The indexed powder pattern is given in Table 2.

The optic orientation is  $Y = b, Z \wedge c = +22^\circ$  and  $2V(+)$  is  $61^\circ$  at  $430\text{ m}\mu$  and decreases to  $46^\circ$  at  $620\text{ m}\mu$ . Just the opposite dispersion is reported by Larsen and Vassar, perhaps arising from observations on twinned crystals. Pleochroism is feeble (even in larger crystals) with  $X =$  pale green,  $Z =$  robins egg blue, and  $Y$  colorless. Optical activity was sought but not found.

**Table 2**  
Indexed Powder Data for Chalcoalumite  
Cr/V Radiation, 114 mm Wilson Camera

$l/l_0^\circ$	d obs. $\text{\AA}$	d calc. $\text{\AA}$	hkl
100	8.502	8.500	200
22	7.898	7.895	110
9	6.705	6.703	011
6	6.393	6.385	111
8	6.103	6.097	111
8	5.445	5.446	211
13	5.100	5.098	211
22	4.786	4.782	310
9	4.573	4.574	202
6	4.314	4.312	120
91	4.250	4.250	400
23	4.178	4.178	202
3	3.849	3.836	410
5	3.705	3.704	411
6	3.501	3.504	320
5	3.335	3.331	112
9	3.177	3.177	510
9	3.059	3.062	213
		3.066	113
		3.050	303
5	2.822	2.818	312
		2.826	131
8	2.726	2.723	422
		2.728	231
8	2.633	2.632	123
		2.632	330
		2.634	223
7	2.585	2.585	512
11	2.520	2.518	132
		2.519	331

plus 14 additional lines to 1.191A

\*measured photometrically

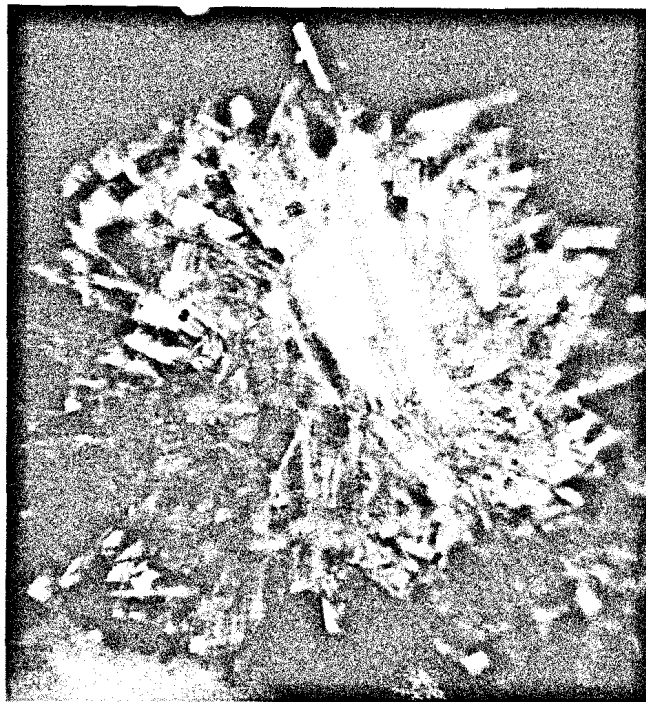


Fig. 2. Cluster of chalcoalumite crystals. Some twinning in  $\{100\}$  may be detected. Crystals about 0.4 mm on an edge.

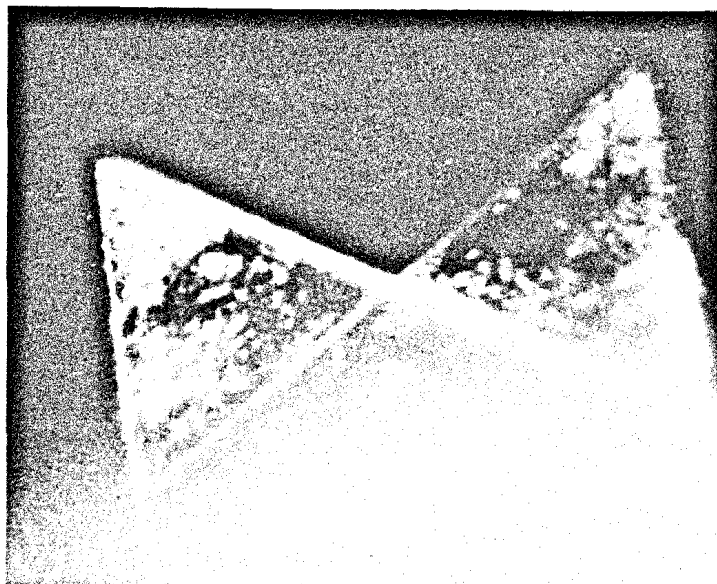


Fig. 3. Chalcoalumite fourling twinned in  $\{136\}$  with composition plane  $\{100\}$  and twinning in  $\{010\}$ . Edges of crystals about 0.4 mm long.

We are grateful to Terry D. Mayberry for bringing the sample to our attention. F. B. Millett provided assistance in the computations involved in indexing and refining the cell.