

# Curetonite

## a new phosphate from Nevada

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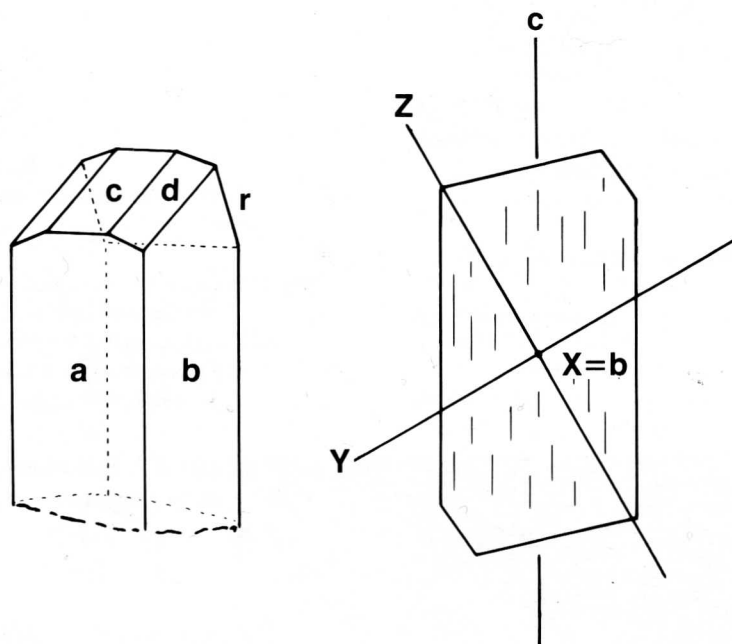


Figure 1. Crystal forms and optic orientation of curetonite;  $a\{100\}$ ,  $b\{010\}$ ,  $c\{001\}$ ,  $d\{011\}$ ,  $r\{201\}$ .

### ABSTRACT

Curetonite was found by Forrest and Michael Cureton at a barite prospect near Golconda, Nevada. It occurs in veins in cherts and shales that have been replaced by barite; associated species include adularia, barite, and variscite. Color yellow-green, Mohs hardness = 3.5, specific gravity = 4.42 (4.31 calc).

Crystals are monoclinic  $P2_1/m$ ,  $a=6.957$ ,  $b=12.55$ ,  $c=5.22$ ,  $\beta=102^\circ$ ;  $Z=1$ . Strongest lines are 4.290(5), 3.286(8), 3.230(10), 2.991(6), 2.816(6), 2.251(6), 2.199(6), 1.686(7). Biaxial +,  $2V=60^\circ$ ;  $\alpha=1.676$ ,  $\beta=1.680$ ,  $\gamma=1.693$ . Chemical analysis indicates  $Ba_4Al_3Ti(PO_4)_4(O,OH)_6$  for the ideal formula.

### INTRODUCTION

The new mineral curetonite described herein was found by Forrest Cureton II and Michael Cureton, and is named for both. The type locality is a barite mine in Sec. 12 (T37N, R41E) near Golconda, Nevada.

The rocks at the locality are cherts and shales of the Comus formation (Hotz and Willden, 1964) that have been extensively replaced by barite. Deposits of this nature are common in Nevada and more detailed studies of them elsewhere in the state have been reported by Ketner (1975) and by Shawe *et al.* (1969).

At the type occurrence barite replaces sericitic, phosphatic, and black organic cherts and shales that locally carry fossil trash. The replacement begins along thin veinlets cutting the cherts. These veins have a central barite core and walls of chalcedonic quartz. Stippling of the chert with lacy barite crystalloblasts appears to be the next step in a process leading eventually to massive barite rock.

The massive barite is then sometimes cut by veins of coarse-grained barite and perfectly euhedral adularia crystals. It is these veins that carry curetonite. Crystals up to 3 mm in maximum size may be found attached to the vein walls or floating as inclusions in larger adularia crystals. When occurring in adularia the curetonite crystals may actually be an

aggregate of optically aligned islands whose distribution outlines one large euhedron. Crystals lining veins are frequently corroded and coated by a mantle of finely fibrous barite.

Following crystallization of curetonite was an episode of deformation. Both curetonite and adularia may be strained and show pronounced curvature. By contrast the barite seems to have relieved itself of strain by recrystallization. Fracturing associated with the deformation is frequently healed by veining. Species such as opal, an amorphous phosphate gel (perhaps evansite), variscite, montgomeryite, and hisingerite occur in these veins. Two unknown phosphates were also noted here; both are replacement products of curetonite.

### PHYSICAL PROPERTIES

Curetonite is readily visible in its gangue because of its green color. Usually it is bright yellow-green (Royal Horticultural Society 138D) but in some samples is nickel green (R.H.S. 130C). The streak is invariably white. The Mohs hardness is 3.5 and crystals are brittle, yielding easily to white powder under pressure. No fluorescence was noted in long or short wavelength ultraviolet light although several of the late fracture vein minerals fluoresce and phosphoresce strongly. There is good cleavage following  $d\{011\}$  and a pronounced parting on  $b\{010\}$ .

The specific gravity was determined as  $4.42 \pm 0.05$  using measured adamite and barite as bracketing standards. This value is about 2.5% high, possibly due to unseen bubbles adhering to standard grains.

### CHEMISTRY

The chemical analysis was a nightmare consuming several months time. A preliminary spectrographic analysis showed P, Mg, V, Ti, Ca, Al, Ba, Sr, and Si. The Mg, Sr, Si, and Ca were subsequently found to be trace constituents.

Water was found by the Penfield method and is readily released before the mineral fuses to a grey, intumescent slag. Microchemical tests showed no halogens, and sulfate was shown to be absent by

Table 1. Chemical Analysis of Curetonite

	Meas.	R	Theory <sup>7</sup>
BaO <sup>1</sup>	53.09%	.346	53.01
Al <sub>2</sub> O <sub>3</sub> <sup>2</sup>	12.81	.126	13.22
TiO <sub>2</sub> <sup>3</sup>	6.84	.085	6.91
P <sub>2</sub> O <sub>5</sub> <sup>4</sup>	23.39	.165	24.53
V <sub>2</sub> O <sub>5</sub> <sup>5</sup>	1.27	.007	
H <sub>2</sub> O <sup>6</sup>	2.46	.137	2.33
	99.86		100.00

- 1.) avg. of 52.53, 52.75, 53.99 by electron probe; benitoite standard
- 2.) avg. of 13.43, 13.43, 14.31 by electron probe (anorthite standard), 11.15 and 11.71 by wet methods
- 3.) by wet methods following NaOH fusion
- 4.) average of 22.70, 23.98, 23.48 by electron probe, apatite standard
- 5.) average of 1.25, 1.29 by wet chemistry and emission spark spectroscopy
- 6.) Penfield method
- 7.) for Ba<sub>4</sub>Al<sub>3</sub>Ti(PO<sub>4</sub>)<sub>4</sub>(O,OH)<sub>6</sub> OH:O = 1:1

electron microprobe. Despite the easy fusibility of curetonite it resists attack by all acids tried and is digested only by fusion methods.

The results of the chemical analysis are summarized in Table 1 with footnotes explaining the method used. A particularly nettlesome problem was presented by titanium. Interference with barium gave high values on the electron microprobe. Early analysis following pyrosulfate fusion gave low values due to precipitation of some TiO<sub>2</sub>; the low values at first seemed especially believable because they were determined both by A.C. spark spectroscopy and by wet methods with excellent agreement. Fusion by NaOH finally provided reliable results.

#### OPTICS AND MORPHOLOGY

In thin section curetonite bears a close resemblance to jagowerite and might also be confused with axinite. Viewed along the *b* axis, crystals are broad and may be crudely composited on {100} and show the following recognizable forms: *b*{010}, *c*{001}, *a*{100}, *d*{011}, and *r*{201}. Viewed along the *a* axis the crystals assume a wedge-shaped habit owing to curved vicinal forms produced by combinations of *d* and *b*.

Polysynthetic twinning is common on *a*{100} resembling that seen in jagowerite. Lamellae are broad and composition planes imperfect.

Although crystals may be colorless in thin section, they may also show splotchy pleochroism in yellow, a color closely resembling that of chondrodite. When pleochroic the formula is X >> Y = Z. The most



Figure 2. Pale nickel-green crystals of curetonite to about 1 mm in size on matrix.



Figure 3. Pale nickel-green crystalline mass of curetonite about 5 mm across showing parting.

**Table 2. X-Ray Powder Data for Curetonite,  
114 mm Camera, CrK $\alpha$**

$1/1_0$ est.	$d$ meas.	$d$ calc.	$hkl$	$1/1_0$ est.	$d$ meas.
1	6.252	6.275	020	2	2.500
1	4.565	4.565	10 $\bar{1}$	1	2.394
5	4.290	4.290	11 $\bar{1}$	2	2.352
1	3.956	3.960	021	6	2.251
2	3.692	3.692	12 $\bar{1}$	3	2.223
4	3.568	3.574	111	6	2.199
		3.564	130	3	2.130
3	3.400	3.402	200	2	2.107
8	3.286	3.284	210	5	1.998
10	3.230	3.236	031	2	1.963
3	3.084	3.084	13 $\bar{1}$	1	1.931
3	3.055	3.055	21 $\bar{1}$	2	1.846
6	2.991	2.991	220	1	1.823
5	2.848	2.849	140	2	1.802
6	2.816	2.815	22 $\bar{1}$	2	1.786
4	2.779	2.783	131	1	1.736
2	2.587	2.586	14 $\bar{1}$	7	1.686
4B	2.544	2.553	002	2	1.668
		2.540	211	4	1.616

deeply colored patches show weak dispersion of the optic axes  $v > \rho$ , and strong inclined dispersion.

Indices determined for NaD are  $\alpha = 1.676$ ,  $\beta = 1.680$ ,  $\gamma = 1.693$ . The  $2V_Z$  was measured as  $60^\circ$  (it is  $58.4$  calculated) for NaD and varies little with  $\lambda$ . The optic orientation is  $X = b$ ,  $Z \wedge c = +30^\circ$  (in  $\beta$ ).

An idealized crystal is shown in Figure 1 alongside an optic orientation diagram. Because of the crystal habit all crystal sections show length slow character whether or not extinction is inclined or parallel.

**X-RAY STUDY**

Curetonite produces a complex X-ray powder pattern with numerous closely spaced lines showing little contrast in intensity. The data provided in Table 2 were used to refine single crystal results to give the following cell:  $a = 6.957\text{\AA}$ ,  $b = 12.55\text{\AA}$ ,  $c = 5.220\text{\AA}$ ,  $\beta = 102^\circ 0.2'$ . The cell volume is thus  $445.8\text{\AA}^3$ , giving a calculated density of  $4.31\text{ g/cm}^3$  for  $Z = 1$ .

Rotation and Weissenberg level photographs taken around [b] and [c] establish the likely space group as  $P2_1/m$ .

**ADDITIONAL COMMENTS**

Curetonite owes its existence to the presence of collophane-bearing laminae in the rocks that have been replaced by barite. It probably formed at mildly elevated temperatures under severely reducing conditions.

A number of specimens comprising several grams of the mineral were found at the type locality. Type material will be provided to the British Museum (Natural History) and the U.S. National Museum.

**ACKNOWLEDGMENTS**

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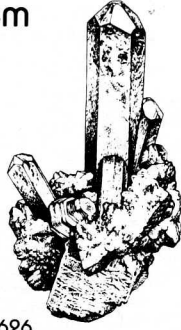
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