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Pinalite, a new lead tungsten chloride mineral from the Mammoth mine, Pinal County, Arizona

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Abstract

Pinalite, $Pb_3WO_5Cl_2$, is orthorhombic, *A2aa* or *Amaa,* with $a = 11.073(5)$, $b = 13.086(8)$, $c = 5.624(3)$ Å, and $Z = 4$; the strongest lines in the X-ray powder-diffraction pattern (d_{meas}, I/I_0,*hkl*) are 6.52(3) (020), 3.778(9) (211), 3.284(4) (131), 2.926(10) (231), 2.814(4) (002), 2.770(3) (400), and 1.642(5) (262,233). Pinalite occurs as exceedingly rare, bright yellow, acicular, bladed crystals (0.03 × 0.01 × 0.2 mm in size), associated with leadhillite, cerussite, and other minerals at the Mammoth mine, Pinal County, Arizona. The composition is PbO 70.7, WO_3 23.3, Cl 7.1, less O = Cl 1.6, total = 99.5 wt%. The name is for the county in which the new mineral occurs.

Introduction

The mineral described herein was first reported by Bideaux (1980), who noted it was unique. In the intervening years, it was sought in hopes of finding additional material, but none was found. We have characterized this species, although the quantity of available material is extremely small and some measurements could not be made. This new species is named *pinalite* for the county in which it occurs; the county in turn was named for the Pinal Apache Indians. The species and its name were approved by the IMA commission on New Minerals and Mineral Names. Type material is preserved in the Smithsonian Institution under catalogue no. NMNH 165890 and in the National Museum of Natural Sciences, Ottawa, under catalogue no. NMNS 53775.

Description

Pinalite occurs in acicular, bladed crystals (up to 0.03 × 0.01 × 0.2 mm), which are elongate on [001], flattened on (010), often terminated by an *h0l* form, and twinned by a 90° rotation about [010]. Pinalite forms isolated crystals, but more commonly forms slightly divergent sprays. It is bright yellow in color, varying to light yellow in mats of filamentary crystals. Some crystals have orange overtones, tending toward a golden color. The mineral is transparent with adamantine luster, and there is no discernible fluorescence in ultraviolet radiation. Cleavage and fracture were not observed; the mineral is brittle under compression. The hardness is undetermined. The density is also undetermined, owing to extreme paucity of material, but is greater than 4.2 g/cm³, as determined using heavy-liquid techniques; the calculated value is 7.78 g/cm³.

Optical data were obtained through the courtesy of Dr. Sidney Williams who determined them some years ago. He found pinalite to be biaxial, positive, $2V = 70°$ (meas), 70.5° (calc), with $\alpha = 2.490$, $\beta = 2.495$, and $\gamma = 2.505$. Using his orientation drawing, we have determined the orientation to be $X \parallel \mathbf{b}$, $Y \parallel \mathbf{c}$, and $Z \parallel \mathbf{a}$; pleochroism is indiscernible, and dispersion is $r > v$, moderate.

X-ray crystallography

X-ray precession photographs show pinalite to be orthorhombic with possible space groups *A2aa* and *Amaa.* The crystal used in single-crystal studies measured 0.025 × 0.008 × 0.15 mm ($a \times b \times c$). Film exposures required 2–4 d with Mo$K\alpha$ radiation operating at 1.5 kW. The unit-cell parameters were refined from X-ray powder-diffraction data (Table 1) obtained with a 114.6-mm diameter Gandolfi camera, a polycrystalline sample, and Cu$K\alpha$ (Ni-filtered) radiation. The refined unit-cell parameters and volume are $a = 11.073(5)$, $b = 13.086(8)$, $c = 5.624(3)$ Å, and $V = 814.9(2)$ Å³. The axial ratio $a:b:c$ is 0.8462:1:0.4298, and there are four formula weights per cell.

We have found no closely related minerals, but the overall configuration of the X-ray powder-diffraction pattern, i.e., the *d* values and line intensities, suggest that pinalite may be related to natural and synthetic "bismuth oxyhalides" or "Sillén phases" (Sillén, 1942; Dunn and Rouse, 1985). These phases have a tetragonal or pseudotetragonal unit cell with $a \simeq b \simeq 3.9$–4.0 and $c \simeq 12$–

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TABLE 1. X-ray powder-diffraction data for pinalite

hkl	d_{calc}	d_{meas}	*I*	d_{meas}	*I*
020	6.54	6.52	3	1.598	<1
120	5.63	5.63	1	1.561	1
011	5.17	5.19	<1	1.538	2
220	4.23	4.26	1	1.511	<1
211	3.783	3.778	9	1.494	1
031	3.447	3.447	2	1.459	<1
131	3.291	3.284	4	1.439	<1
320	3.215	3.217	2	1.408	2
140	3.137	3.141	1	1.384	<1
311	3.003	3.005	2	1.375	<1
231	2.926	2.926	10	1.360	1
002	2.812	2.814	4	1.349	<1
400	2.768	2.770	3	1.317	1
331	2.519	2.519	2	1.288	<1
122	2.516			1.275	<1
340	2.448	2.458	<1	1.256	2
051	2.373	2.372	<1	1.203	<1
151	2.320	2.321	1	1.193	<1
302	2.237	2.243	<1	1.166	<1
251	2.181	2.180	<1	1.157	<1
431	2.158	2.162	<1		
322	2.117	2.117	3		
440	2.113				
142	2.094	2.092	<1		
260	2.029	2.027	3		
242	1.990	1.989	<1		
402	1.973	1.972	3		
531	1.863	1.864	1		
540	1.834	1.835	<1		
113	1.830	1.822	<1		
213	1.760	1.760	1		
502	1.740	1.740	<1		
611	1.738				
162	1.703	1.700	1		
133	1.702				
262	1.645	1.642	5		
233	1.645				
551	1.619	1.620	2		
180	1.618				

13 Å. Pinalite in a comparative setting has $a/2\sqrt{2} = 3.91$, $c/\sqrt{2} = 3.98$, and $b = 13.09$ Å.

Chemical composition

Pinalite was chemically analyzed utilizing an ARL-SEMQ electron microprobe, a 15-kV operating voltage, a 0.025-μA sample current, a 10-s counting time, and a 5-μm beam spot. A wavelength-dispersive microprobe scan indicated the absence of elements with atomic number greater than 9 except those reported here. The standards used for the final analysis were PbO (Pb), NaCl (Cl), and synthetic $CaWO_4$ (W). The resultant analysis yielded PbO 70.7, WO_3 23.3, Cl 7.1, less O ≡ Cl 1.6, total 99.5 wt%. Full cell contents, calculated on the basis of 28 (O + Cl), are $Pb_{12.35}W_{3.91}Cl_{7.81}O_{20.17}$, which may be simplified to $Pb_3WO_5Cl_2$, with $Z = 4$.

Occurrence

Pinalite is found in the Mammoth mine, Pinal County, Arizona. An overview of the geology, mineralogy, and mining operations was given by Bideaux (1980).

Pinalite is found in small cavities in a fine-grained crystalline quartz matrix. These irregular cavities are pseudomorphic casts after an uncertain precursor mineral, perhaps calcite. Pinalite is usually isolated within a cavity or is associated with and sometimes enclosed by a pale yellow chromian leadhillite. Other secondary minerals occurring in these cavities include cerussite, matlockite, diaboleite, caledonite, connellite, and very rare iranite, murdochite, and fluorite. The composition of pinalite and these associations place it with the anomalous oxidized sequence of minerals (Bideaux, 1980) characterized by Pb, Cu, SO_4, CO_3, and especially Cl. Pinalite is the only W-bearing mineral so far recognized in the Mammoth mine suite.

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