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Yedlinite, a New Mineral from the Mammoth Mine, Tiger, Arizona

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Abstract

Yedlinite is a new hydrated oxychloride of lead and chromium found associated with diaboleite, quartz, wulfenite, dioptase, phosgenite, and wherryite on specimens from the Mammoth Mine, Tiger, Arizona. Yedlinite occurs as prismatic crystals up to one millimeter long which are red-violet, transparent to translucent and somewhat sectile, with white streak, Mohs' hardness of about 2 1/2, and observed density of 5.85 g/cc. Crystals show rhombohedral symmetry with forms $\{11\bar{2}0\}$, $\{1\bar{1}01\}$, $\{0001\}$, $\{10\bar{1}0\}$ and $\{20\bar{2}1\}$ in order of decreasing prominence. Crystals are occasionally doubly terminated and exhibit distinct $\{1120\}$ cleavage. The morphological axial ratio is $c/a = 0.763(2)$. Yedlinite is optically uniaxial negative and dichroic with $\omega = 2.125$ (pale cobalt blue) and $\epsilon = 2.059$ (lavender). X-ray diffraction shows space group $R3$ or $R\bar{3}$ ($R\bar{3}$ is indicated by morphology and confirmed by structure determination), $a = 12.868(2)$ Å, $c = 9.821(2)$ (hexagonal axes), $c/a = 0.7632(3)$. The most intense powder diffraction lines in order d (**I**) (hexagonal *hkil*) are: 2.952 **100** *31$\bar{4}$1*, 2.622 **68** *3142* and *13$\bar{4}$2*, 4.506 **65** *01$\bar{1}$2*, 6.44 **32** *11$\bar{2}$0* and 2.473 **27** *32$\bar{5}$1* and *03$\bar{3}$3*. Electron probe analysis combined with structural information yields the chemical formula $Pb_6Cl_6CrX_6Y_2$ with $X = O$ or (OH) and $Y = H_2O$ or (O,OH). The hexagonal unit cell content, $Z = 3$, and the calculated density is 5.80 g/cc. The name honors Mr. Neal Yedlin.

Introduction

The mineral herein described was first noted in 1967 by Mr. Neal Yedlin of New Haven, Connecticut, a well-known amateur mineralogist, collector, lecturer, and writer on micromounting in mineralogy, in whose honor it has been named. Mr. Yedlin first observed the species on material obtained from Schortmann's Minerals, Easthampton, Massachusetts, and deposited several fragments in the National Museum of Natural History. Other specimens were later noted in the NMNH collection and were included in an ongoing study by one of us (RAB) of the Mammoth Mine suite. All specimens seem to date from collections made at the mine in 1940–41 (Palache, 1941). About 150 crystals are presently known. The name and species have been approved by the IMA Commission on New Minerals and Mineral Names.

Occurrence

Yedlinite is known only from the Tiger locality and is found sparingly on a few specimens; perhaps the most notable is NMNH R-8171. It is associated with the most complex paragenesis yet observed in Mammoth Mine material. Minute, doubly-terminated quartz crystals, which replaced primary galena, formed a framework for deposition of diaboleite. This was later relaced by phosgenite and rarely matlockite, and altered to wherryite. Yedlinite crystals are commonly found growing upon and partly surrounded by diaboleite or in intimate contact with phosgenite. Wulfenite, dioptase, cerussite, mimetite, willemite, hemimorphite, fluorite, and quartz were later superimposed. The latter assemblage is usually observed separately on other specimens from the mine. Yedlinite is rarely observed perched on dioptase and among the fluorite and drusy quartz. Crys-

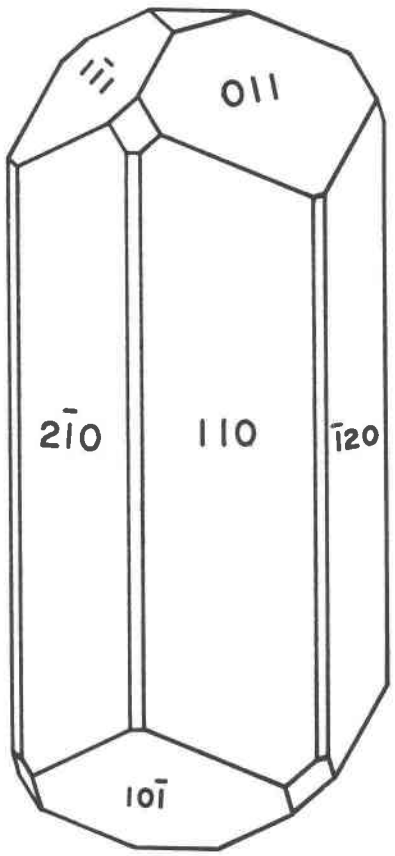

FIG. 1. Axonometric projection of an idealized crystal of yedlinite. The c axis is vertical, and a_2 is to the right. Faces of the two most important forms are indexed with the superfluous i index omitted.

tals of other minerals are never observed to be implanted on yedlinite. A little earthy hematite is occasionally present.

Chromium, essential to yedlinite, is apparently an extremely minor element in the Mammoth Mine ores. Exceptional fornacite crystals are rarely locally abundant. Crocoite has been reported, but cannot be confirmed by our observations. Sparsely occurring yellow-green cerussite and wherryite, yellow leadhillite, and brilliant red wulfenite may owe their color to this element.

Physical, Crystal and Optical Properties

Crystals of yedlinite are transparent to translucent hexagonal prisms up to about one millimeter in length and are generally about 0.4 as thick as they are long. The color is red-violet, and may vary both in hue and intensity within a single crystal. The streak is white. The Mohs' scale hardness is about two and one half, and the mineral is generally not brittle and somewhat sectile. The densities, determined by weighing two single crystals and calculating their volumes from microscopic measurements, were 5.88 g/cc for a 21 μg crystal and 5.81 for a 45 μg crystal; the observed density is thus about 5.85 g/cc.

Crystal morphology suggests point group $\bar{3}\,2/m$ and is dominated by the second order hexagonal prism $\{11\bar{2}0\}$ and the relatively flat rhombohedron $\{1101\}$. Usually also present are the basal pinacoid $\{0001\}$, the first order prism $\{10\bar{1}0\}$, and sometimes the rhombohedron $\{20\bar{2}1\}$. The crystals are occasionally doubly terminated. The goniometric axial ratio using hexagonal axes is $c/a = 0.763 \pm 0.002$ based on measurement of 17 faces of the $\{1\bar{1}01\}$ form ($\rho = 41.4°$) and seven faces of the $\{20\bar{2}1\}$ form ($\rho = 60.6°$) on four crystals. An idealized crystal drawing is shown in Figure 1. Distinct prismatic cleavage, $\{11\bar{2}0\}$, is detectable.

Optically, yedlinite is uniaxial negative with $\omega = 2.125$ and $\epsilon = 2.059$ ($\lambda = 570$ nm). Crystals are

TABLE 1. Indexed Powder Pattern for Yedlinite*

$I_{rel.}$	$d_{obs.}$	$d_{calc.}$	hkl	$I_{rel.}$	$d_{obs.}$	$d_{calc.}$	hkl
9	7.375	7.368	101	4	1.530	1.527	621
32	6.440	6.434	110	2	1.502	1.498	306, 036
11	4.861	4.846	021	5	1.475	1.474	$62\bar{2}$, 262
65	4.506	4.494	012	2	1.461	1.459	226, $22\bar{6}$
23	3.879	3.871	211, 121	1	1.439	1.436	$24\bar{5}$
11	3.719	3.715	300			1.402	155
11	3.287	3.274	003	6	1.399	1.397	164, $61\bar{4}$
12	3.206	3.217	220			1.392	
		3.197	122			1.340	802
100	2.952	2.948	$31\bar{1}$	5	1.341	1.340	345
6	2.683	2.680	401			1.336	$53\bar{4}$
68	2.622	2.616	312, $13\bar{2}$	4	1.289	1.290	633
27	2.473	2.474	321			1.285	$16\bar{5}$, 615
		2.456	033	2	1.238	1.237	535
11	2.436	2.432	140, 410	1	1.215	1.215	372
15	2.297	2.295	$22\bar{3}$, 223			1.215	265
11	2.126	2.121	214	1	1.207	1.206	$52\bar{6}$, 526
5	1.953	1.952	$41\bar{3}$, $14\bar{3}$			1.160	191, $56\bar{1}$
		1.936	$24\bar{2}$, 422	5	1.159	1.158	093
15	1.935	1.934	$01\bar{5}$			1.156	740
		1.922	$31\bar{4}$	3	1.137	1.136	562, $19\bar{2}$
		1.857	600			1.134	464
8	1.855	1.853	152	2	1.104	1.107	$32\bar{8}$
		1.842	404			1.103	832
4	1.804	1.804	431	1	1.091	1.090	$47\bar{3}$
		1.784	250			1.082	167
19	1.787	1.780	$21\bar{5}$	2	1.031	1.030	930
4	1.719	1.716	$34\bar{2}$, 432			1.030	$84\bar{2}$
2	1.679	1.675	$61\bar{1}$, 161			.988	906
6	1.609	1.606	$16\bar{2}$	1	.981	.983	$93\bar{3}$
		1.605	$04\bar{5}$			.980	835
		1.571	$53\bar{1}$			.978	1.0.10
14	1.570	1.567	523, 253, $25\bar{3}$	1	.894	.894	188
		1.557	325			.892	4.10.0

* *Taken in a 114.6 mm Debye-Scherrer camera with CuKα radiation. A pseudo-powder pattern taken with a Gandolfi-type device contained an additional 33 lines, indicating extensive structure damage in producing a powder.*
The superfluous i *index is omitted from all* hkil *reflection indices.*

moderately dichroic with ω pale cobalt blue and ϵ lavender and more strongly colored.[1]

X-Ray Diffraction Study

Yedlinite single crystals were examined by the oscillation and Weissenberg techniques using Cu$K\alpha$ ($\lambda = 1.5418$ Å) radiation. Systematic absences on Weissenberg films coupled with diffraction symmetry 3 showed the space group to be either $R3$ or $R\bar{3}$. The morphological $\bar{3}$ axis indicated the space group to be $R\bar{3}$ and this was verified by the crystal structure determination (Wood, McLean, and Laughon, 1974). Measurements of 2θ for 29 Weissenberg reflections were used to refine the unit cell dimensions by the least squares method yielding $a = 12.868(2)$ Å and $c = 9.821(2)$ for the hexagonal cell ($a = 8.119$ Å and $\alpha = 104.84°$ for the rhombohedral cell). The X-ray axial ratio is $c/a = 0.7632(3)$.

A powder diffraction pattern was prepared using Cu$K\alpha$ radiation and a 114.6 mm Debye-Scherrer camera. Relative intensities were visually estimated, and the lines were indexed (Table 1) using the hexagonal unit cell parameters and intensities calculated from the crystal structure.

Chemical Composition

Crystals of yedlinite were analyzed using an ARL electron microprobe. Wavelength scans disclosed only Pb, Cr, Mn, and Cl in major amounts and trace amounts of Cu and Fe. Quantitative data were collected using a one micron diameter beam at 15 kV, 0.15 μA and ten second counting periods. Ten peak readings were obtained for each of the four major elements, and averaged. Comparison with standards prepared from matlockite, hemihedrite, diaboleite, and manganese metal was used to arrive at values for Pb, Cr, Cl, and Mn, respectively. Stoichiometry was assumed for these mineral species.

It was recognized from bubbling on the surface of yedlinite when exposed to the electron beam that an unknown quantity of volatiles was escaping and, consequently, that the counts obtained for non-volatile elements would be erroneously high. The chemical formula derived from the microprobe analysis was therefore treated only as an approximation. As there is insufficient material to use other common analytical methods, it was necessary to determine the details of the composition by determining the crystal structure. The crystal structure analysis (Wood *et al,* 1974) shows the hexagonal unit cell to contain $3[Pb_6Cl_6CrO_6O_2]$ with hydrogen undetermined. Depending on the valence of Cr, 4 or 7 hydrogens are required for neutrality. Many compositions are possible, but the most likely are $Pb_6Cl_6CrO_6 \cdot 2H_2O$, $Pb_6Cl_6Cr(O,OH)_6(O,OH)_2$, and $Pb_6Cl_6Cr(OH)_6(O,OH)_2$. These compositions result in a calculated density of 5.80 which compares well with the measured density of 5.85 g/cc. Application of the rule of Gladstone and Dale with the measured optical data and the composition $3(PbO) + 3(PbCl_2) + CrO_3 + 2(H_2O)$ indicates a density of 5.74. Analytical results are shown in Table 2.

TABLE 2. Chemical Analysis of Yedlinite

Element	Probe	$Pb_6Cl_6CrO_6 \cdot 2H_2O$	$Pb_6Cl_6Cr(OH)_6(O,OH)_2$
Mn	.7 wt. %	- -	- -
Pb	79.4	75.8 wt. %	75.7 wt. %
Cr	3.8	3.2	3.2
Cl	7.5	13.0	13.0
O	8.6*	7.8	7.8
H	- -	.2	.3
	100.0	100.0	100.0

* By difference.

Acknowledgments

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References

PALACHE, C. (1941) Diaboleite from Mammoth Mine, Tiger, Arizona. *Am. Mineral.* **26,** 605–612.

WOOD, MICHAEL M., W. JOHN MCLEAN, AND ROBERT B. LAUGHON (1974) The crystal structure and composition of yedlinite. *Am. Mineral.* **59,** 1160–1165.

[1] Optical data were determined by Dr. Sidney A. Williams of Phelps Dodge Corporation.

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