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

W. JOHN MCLEAN,
Department of Geosciences, University of Arizona,
Tucson, Arizona 85721

RICHARD A. BIDEAUX,
1242 West Pelaar, Tucson, Arizona 85705

AND RICHARD W. THOMSEN
2138 Camino El Ganado, Tucson, Arizona 85718

Abstract

Yedlinite is a new hydrated oxychloride of lead and chromium found associated with diaboleite, quartz, wulfenite, diopside, 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 {1120}, {1101}, {0001}, {1010} and {2021} 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 $R3\bar{2}$ ($R3$ 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: 2.952 401 03141, 2.622 608 3142 and 1342, 4.506 006 50112, 6.44 321 1120 and 2.473 273 3231 and 0333. Electron probe analysis combined with structural information yields the chemical formula $\text{Pb}_x\text{Cl}_y\text{Cr}_z\text{O}_w\text{Y}_o$ with $X = \text{O}$ or $(\text{OH})$ and $Y = \text{H}_2\text{O}$ or $(\text{O,OH})$. 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 relaxed 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, diopside, 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 diopside and among the fluorite and drusy quartz. Cryst-
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 3 2/m and is dominated by the second order hexagonal prism {1120} and the relatively flat rhombohedron {1101}. Usually also present are the basal pinacoid {0001}, the first order prism {1010}, and sometimes the rhombohedron {2021}. The crystals are occasionally doubly terminated. The goniometric axial ratio using hexagonal axes is c/a = 0.763 ± 0.002 based on measurement of 17 faces of the {1101} form (ρ = 41.4°) and seven faces of the {2021} form (ρ = 60.6°) on four crystals. An idealized crystal drawing is shown in Figure 1. Distinct prismatic cleavage, {1120}, is detectable.

Optically, yedlinite is uniaxial negative with ω = 2.125 and ε = 2.059 (λ = 570 nm). Crystals are

![Table 1. Indexed Powder Pattern for Yedlinite*](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAgAAAAcCAYAAABAgDIfWAAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQBGRYAAAAWdSegAAAgAAAAAB7AAAAAARDwAAACxjw8AAAAfJREFUeNrsu7+cAAAQgJh8E08...

* Taken in a 714.6 mm Debye-Scherrer camera with CuKα radiation. A pseudo-power 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 hkl reflection indices.
moderately dichroic with \( \alpha \) pale cobalt blue and \( \epsilon \) lavender and more strongly colored.\(^1\)

**X-Ray Diffraction Study**

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

A powder diffraction pattern was prepared using CuK\(\alpha\) 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 \(\mu\)A 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 \(3[\text{Pb}_2\text{Cl}_6\text{Cr}_6\text{O}_2\text{O}_2]\) 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 \(\text{Pb}_6\text{Cl}_6\text{Cr}_6(\text{O},\text{OH})_6(\text{OH},\text{OH})_2\), and \(\text{Pb}_6\text{Cl}_6\text{Cr}(\text{OH})_6(\text{OH},\text{OH})_2\). 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 \(3(\text{PbO}) + 3(\text{PbCl}_2) + \text{Cr}_2\text{O}_3 + 2(\text{H}_2\text{O})\) indicates a density of 5.74. Analytical results are shown in Table 2.

**Acknowledgments**

We are grateful to the U. S. National Museum and to Mr. Neal Yedlin for the loan of specimen material. We are also indebted to Dr. Sidney A. Williams of Phelps Dodge Corporation for the nonroutine determination of the optical properties.

**References**


Manuscript received, December 13, 1973; accepted for publication, June 25, 1974.

\(^1\)Optical data were determined by Dr. Sidney A. Williams of Phelps Dodge Corporation.

---

**Table 2. Chemical Analysis of Yedlinite**

<table>
<thead>
<tr>
<th>Element</th>
<th>Probe</th>
<th>Pb Cl</th>
<th>Cr O</th>
<th>H2 O</th>
<th>Pb Cl</th>
<th>Cr (OH)</th>
<th>(OH) 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>7 wt. %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pb</td>
<td>79.4</td>
<td>75.8 wt. %</td>
<td>-</td>
<td>-</td>
<td>75.7 wt. %</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cu</td>
<td>3.8</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Cl</td>
<td>7.5</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>O</td>
<td>8.6*</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
</tr>
<tr>
<td>H</td>
<td>-</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* By difference.