

Burckhardtite, a new silicate-tellurite from Mexico

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Abstract

Burckhardtite is a new species from the Moctezuma gold mine, Moctezuma, Sonora, Mexico, the type locality for numerous other tellurite species. Burckhardtite occurs as crystalline rosettes less than 0.2mm across, and rarely as single hexagonal or pseudo-hexagonal crystals up to 50 μ with dickite in quartz breccia on the third and second levels of the mine. Minor associated minerals include moctezumite, $\text{Pb}(\text{UO}_2)(\text{TeO}_3)_2$, zemannite, $(\text{Zn,Fe})_2(\text{TeO}_3)_3\text{Na}_x\text{H}_{2-x}\cdot n\text{H}_2\text{O}$, and barite.

Microprobe analysis gave, in weight percent, SiO_2 20.28, TeO_2 17.03, Al_2O_3 5.44, Fe_2O_3 7.25, Mn_2O_3 1.18, PbO 45.23, H_2O (by difference) 3.59, corresponding to $\text{Pb}_2(\text{Fe,Mn})^{3+}\text{AlTeSi}_3\text{O}_{10}(\text{OH})_2\text{O}_2\cdot\text{H}_2\text{O}$.

Most of the crystalline rosettes have centers of dickite, suggesting an oriented overgrowth. Burckhardtite is inferred to have a sheet structure, and is believed to be monoclinic, pseudo-hexagonal. X-ray powder diffraction data can be indexed quite well on a C-centered cell with $a = 5.21$, $b = 9.04$, $c = 12.85\text{\AA}$, $\beta = 90^\circ$, although a number of minor lines fail to index readily. The principal X-ray diffraction lines, with intensities and Miller indices, are 12.8(9)001; 4.51(2)020,110; 4.26(2)111,003,021; 3.70(9)112,022; 3.11(10)113,023; 2.60(7)200,130; 2.26(3b)040,220; 2.24(3b)113,025,115; 2.13(3)222,006,042; 2.00(2)223; 1.840(6)007; 1.590(5)243,153; plus 33 others to 0.793.

Color violet red to pale pink when finely disseminated in clay, streak same but paler. Luster of crystals adamantine to slightly pearly. Cleavage perfect [001]; hardness about 2. Density of crystal rosettes intergrown with clay about 3.2; calculated density, with $Z = 2$, 4.96. Paramagnetic. Insoluble in hot dilute or concentrated HCl. Optically negative, uniaxial or nearly so; $\alpha = 1.82$, $\beta = \gamma = 1.85$; $X = c$. Pleochroism α pale magenta, β and γ carmine red, somewhat variable.

The name is for Carlos Burckhardt (1869-1935), Mexican geologist. Type material is deposited at the Smithsonian Institution (NMNH #144110) and other institutions.

Introduction

The Moctezuma gold mine, Moctezuma, Sonora, Mexico (Gaines, 1970) is the type locality for twelve rare tellurium minerals, including paratellurite, TeO_2 , moctezumite, $\text{Pb}(\text{UO}_2)(\text{TeO}_3)_2$, and zemannite, $(\text{Zn,Fe})_2(\text{TeO}_3)_3\text{Na}_x\text{H}_{2-x}\cdot n\text{H}_2\text{O}$. Another new mineral is relatively common at the mine as dustings of

minute carmine-red crystal rosettes on quartz breccia. Microprobe analysis has shown it to be a unique silicate-tellurite, apparently with a mica-like structure. The mineral is named burckhardtite for Carlos Burckhardt, Mexican geologist, who made important contributions to the knowledge of the Mesozoic in central Mexico. The mineral description

and name have been approved by the New Mineral Names Commission, IMA. Type material is deposited at the Smithsonian Institution, (NMNH #144110), Harvard University, and the University of Delaware.

Occurrence

Burckhardtite is relatively common on the third level of the Moctezuma mine, where it occurs in extremely thin disseminations on angular fragments of light gray cryptocrystalline quartz in a breccia loosely cemented by dickite. Associated minerals are moctezumite and less commonly zemannite and barite. Burckhardtite forms minute rosettes of carmine-red crystals averaging perhaps 0.1mm (Fig. 1); where thickly scattered they impart a faintly pinkish hue to the breccia. The rosettes are tightly attached to the quartz, and can be removed only by scraping, which tends to break up the crystals.

On the second level of the mine, some burckhardtite was found in small open fractures, associated with dickite, zemannite, moctezumite, and tellurite, TeO_2 . Here the burckhardtite formed larger rosettes, up to 0.3mm, with occasional single crystals 50μ across. These rosettes were concentrated along with moctezumite when heavy-liquid separations were being made of the latter for analysis. The best and coarsest fractions of burckhardtite were separated in this manner and were used in establishing its composition and properties.

Chemistry

Table 1 gives the results of microprobe analysis made on homogeneous, dark-colored, single crystals

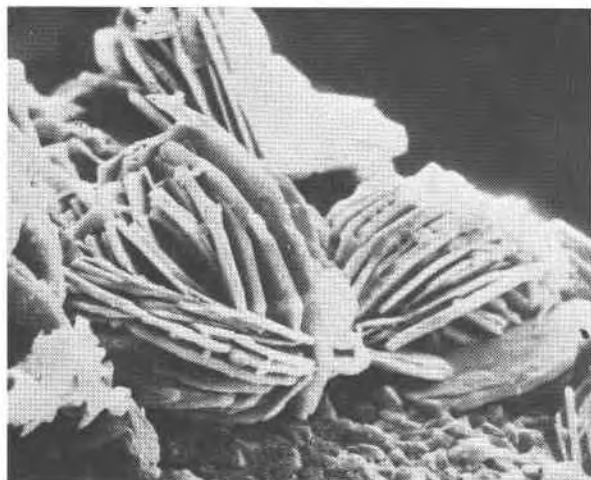


Fig. 1. SEM photograph of burckhardtite rosettes. The rosettes are about 0.1mm in diameter.

Table 1. Analysis and formula of burckhardtite

	Chemical analysis	Atomic proportions	Atoms for Si+Al=4	Theoretical [#] composition
SiO_2	20.28	0.337	3.04	18.91
TeO_2	17.03	0.107	0.97	16.75
Al_2O_3	5.44	0.106	0.96	5.35
Fe_2O_3	7.25	0.091	0.82	8.38
Mn_2O_3	1.18	0.015	0.14	- -
PbO	45.23	0.203	1.83	46.83
H_2O^*	3.59	0.199	1.80	3.78
Total	100.00			100.00

* by difference
[#] $\text{Pb}_2\text{FeTeAlSi}_3\text{O}_{13} \cdot 2\text{H}_2\text{O}$

of burckhardtite of 20μ maximum dimension. Standards were, for Si and Pb, a Corning lead glass containing 34.87 percent SiO_2 and 36.91 percent Pb; for Te, synthetic Bi_2Te_3 (NMNH synthetic 756); for Al, synthetic corundum; for Fe, olivine from Springwater meteorite containing 17.06 percent FeO; and for Mn, manganite (NMNH 80387). The MAGIC correction program gives somewhat more satisfactory ratios than the Bence-Albee correction factors and is used for Table 1. The valences assigned to Te, Fe, and Mn are inferred from the oxidized character of the deposit. Associated minerals contain only quadrivalent Te. The red color of the mineral also suggests trivalent Fe and Mn. A general probe scan failed to reveal significant amounts of any elements other than those in Table 1. Li, Be, and B, not detectable by the probe, are not found in any other species in the deposit and are believed absent from burckhardtite.

If $\text{Al} + \text{Si} = 4$, the formula for burckhardtite is $\text{Pb}_{1.83}(\text{Fe}_{0.82}\text{Mn}_{0.14})^{3+}_{0.96}\text{Te}_{0.97}\text{Al}_{0.96}\text{Si}_{3.04}\text{O}_{12.7} \cdot 1.8\text{H}_2\text{O}$. If the structure is based on a double silicate sheet of composition $\text{AlSi}_3\text{O}_{10}(\text{OH})_2$, the ideal formula would be $\text{Pb}_2(\text{Fe}, \text{Mn})^{3+}\text{TeAlSi}_3\text{O}_{10}(\text{OH})_2 \cdot \text{H}_2\text{O}$.

Crystallography

Single-crystal study could not be made of burckhardtite because of the minute size of even the largest crystals. However, microscopic inspection and SEM photographs show them to be hexagonal or pseudo-hexagonal (Fig. 2). Powder diffraction data are presented in Table 2. Burckhardtite is a strong diffractor and gives a clear, complex pattern. By analogy with the micas, burckhardtite is inferred to be monoclinic, pseudohexagonal, with a C-centered cell. The X-ray diffraction lines can be indexed fairly well on a cell

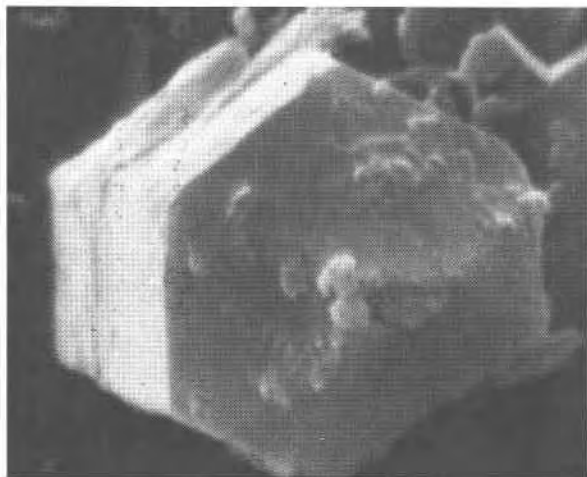


Fig. 2. SEM photograph of a burckhardtite crystal about 10μ in diameter. The pseudo-hexagonal symmetry is evident.

with $a = 5.21$, $b = 9.04$, $c = 12.85\text{\AA}$, $\beta = 90^\circ$. However, not all lines could be indexed, and the cell parameters must be considered approximate. Assigned indices conform to a C-centered cell ($h + k$ even). Attempts to refine cell parameters and assign indices by computerized least-squares fit of the powder diffraction data proved unsuccessful because of ambiguous multiple indexing of many of the lines. Faint lines which calculate to 4.11\AA and 3.46\AA are believed to be K_β reflections and are not included in Table 2. Dickite lines were not seen.

Physical properties

Most of the burckhardtite rosettes have centers of dickite, and some of the burckhardtite crystals appear to be overgrowths on plates of dickite, suggesting a close structural relationship. The intimacy of this intergrowth has made it difficult to determine some of the physical properties of burckhardtite, notably density and optical constants, although chemistry was established with confidence on strongly colored, homogeneous single crystals.

The color of burckhardtite is carmine- to violet-red; where finely disseminated it may impart a pale pink color to clay on quartz fracture surfaces. The streak is pale red, the luster adamantine to slightly pearly. Burckhardtite has perfect basal cleavage, like the micas. Hardness is about 2, for crystals can be broken up easily with a steel needle. Because most grains are minute and intergrown with clay, the correct density cannot be determined. The density of clusters intergrown with clay is about 3.2, by heavy liquids; the calculated density for the formula and

cell, with $Z = 2$, is 4.96. Burckhardtite is paramagnetic, nonfluorescent in long- or short-wave ultraviolet radiation, and insoluble in hot dilute or concentrated HCl. Most tellurites are soluble, and this last property helps to confirm the essential character of silica in burckhardtite.

The minute size of burckhardtite crystals and their common intergrowth with clay prevented precise determination of the optical constants. In addition, there seems to be a range in the refractive indices of the mineral. Burckhardtite is optically negative, essentially uniaxial, with the fast direction parallel to c . The maximum values of the indices of refraction are $\alpha = 1.82$, $\beta \cong \gamma = 1.85$. The color and pleochroism are somewhat variable, with α pale magenta and $\beta = \gamma$ carmine-red. The red colors of burckhardtite are reminiscent of the colors in such manganese minerals as rhodonite and bermanite, which contains both divalent and trivalent manganese, and the color variation of burckhardtite may be due to variation in the amount and valence of the contained manganese.

Speculations on atomic structure

The morphology and association with dickite suggests that burckhardtite contains silicate sheets, and the formula readily conforms to a double sheet of composition $\text{AlSi}_9\text{O}_{10}(\text{OH})_2^-$. If such double sheets are in fact principal units of the structure, the Pb, Te,

Table 2. X-ray diffraction data of burckhardtite

d	I	hkl	d	I	hkl
12.8	9	001	1.236	1b	
4.51	2	020,110	1.205	2	423,353
4.26	2	111,021,003	1.180	2	424
3.70	9	112,022	1.169	1	
3.11	10	113,023	1.121	1b	
2.60	7	200,130	1.104	1-	
2.56	1	131	1.095	1-	
2.42	1	132	1.076	1-	
2.26	3b	040,220	1.013	1-	
2.24	3b	025,115,133	0.996	1-	
2.16	1	213	0.931	1b	
2.13	3	222,042,006	0.926	1b	
2.04	1-	134	0.901	1-	
2.00	2	223	0.878	1b	
1.952	1-	231	0.866	1-	
1.840	6	007	0.845	1-	
1.590	5	243,153	0.829	1-	
1.563	1-	235	0.818	1-	
1.526	2		0.803	1-	
1.508	2	060,314,154	0.793	1-	
1.426	1-	009,155			
1.371	1-	340,334			
1.340	1-				
1.318	1				
1.306	2	400			

Gandolfi camera, 114.59 mm diameter
Cu/Ni radiation.

and Fe, along with excess O, OH, and H₂O, must lie between the sheets or between their bases.

Fe³⁺ commonly has octahedral coordination, but neither Pb nor Te could fit into the octahedral sites of a conventional mica structure. Pb normally shows 8- to 12-fold coordination. In most Te oxysalts, Te is quadrivalent and has either 3-fold coordination with Te at the apex and O at the base of a trigonal pyramid, or 4-fold coordination in the shape of a trigonal dipyramid with one of the corners of the equatorial triangle unoccupied (Zemann, 1968).

A plausible structure for burckhardtite is one in which a complex sheet of composition Pb₂FeTeO₂·H₂O⁷⁺ or Pb₂FeTeO(OH)₂⁷⁺ occupies the normal octahedral sheet position between the tetrahedral silicate sheets. Such a structure is compatible with the low hardness of burckhardtite, since

successive silicate-tellurite-silicate layers would be bound only by van der Waals forces. It is compatible also with the *c*-axis length of burckhardtite, 12.85Å, longer than the micas but shorter than the chlorites.

Acknowledgments

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