American Mineralogist, Volume 97, pages 197–202, 2012

Markascherite, $Cu_3(MoO_4)(OH)_4$, a new mineral species polymorphic with szenicsite, from Copper Creek, Pinal County, Arizona, U.S.A.

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ABSTRACT

A new mineral species, markascherite (IMA2010-051), ideally $Cu_3(MoO_4)(OH)_4$, has been found at Copper Creek, Pinal County, Arizona, U.S.A. The mineral is of secondary origin and is associated with brochantite, antlerite, lindgrenite, wulfenite, natrojarosite, and chalcanthite. Markascherite crystals are bladed (elongated along the **b** axis), up to 0.50 × 0.10 × 0.05 mm. The dominant forms are {001}, {100}, and {010}. Twinning is found with the twofold twin axis along [10$\bar{1}$]. The mineral is green, transparent with green streak and vitreous luster. It is brittle and has a Mohs hardness of 3.5~4; cleavage is perfect on {100} and no parting was observed. The calculated density is 4.216 g/cm^3. Optically, markascherite is biaxial (–), with n_α >1.8, n_β > 1.8, and n_γ >1.8. The dispersion is strong ($r > v$). It is insoluble in water, acetone, or hydrochloric acid. An electron microprobe analysis yielded an empirical formula $Cu_{2.89}(Mo_{1.04}O_4)(OH)_4$.

Markascherite, polymorphic with szenicsite, is monoclinic, with space group $P2_1/m$ and unit-cell parameters a = 9.9904(6), b = 5.9934(4), c = 5.5255(4) Å, β = 97.428(4)°, and V = 328.04(4) Å^3. Its structure is composed of three nonequivalent, markedly distorted $Cu^{2+}(O,OH)_6$ octahedra and one MoO_4 tetrahedron. The Cu1 and Cu2 octahedra share edges to form brucite-type layers parallel to (100), whereas the Cu3 octahedra share edges with one another to form rutile-type chains parallel to the b axis. These layers and chains alternate along [100] and are interlinked together by both MoO_4 tetrahedra and hydrogen bonds. Topologically, the structure of markascherite exhibits a remarkable resemblance to that of deloryite, $Cu_4(UO_2)(MoO_4)_2(OH)_6$, given the coupled substitution of $[2Cu^{2+} + 2(OH^-)]^{2+}$ for $[(U^{6+} + \square) + 2O^{2-}]^{2+}$. The Raman spectra of markascherite are compared with those of two other copper molybdate minerals szenicsite and lindgrenite.

Keywords: Markascherite, szenicsite, molybdate, copper oxysalt, crystal structure, X-ray diffraction, Raman spectra