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Lead-tellurium oxysalts from Otto Mountain near Baker, California: VIII. Fuettererite, $Pb_3Cu_6^{2+}Te^{6+}O_6(OH)_7Cl_5$, a new mineral with double spangolite-type sheets

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Abstract

Fuettererite, $Pb_3Cu_6^{2+}Te^{6+}O_6(OH)_7Cl_5$, is a new tellurate from Otto Mountain near Baker, California, named for Otto Fuetterer who is largely responsible for the development of the mining claims on Otto Mountain. The new mineral is known from only two specimens, one from the NE2 vein and the other from the Bird Nest drift. Fuettererite occurs in vugs in quartz, on the first specimen associated with Br-rich chlorargyrite, iodargyrite, and telluroperite and on the second specimen associated with anglesite, anatacamite, atacamite, chalcopyrite, galena, goethite, hematite, muscovite, phosphohedyphane, timroseite, and wulfenite. It is interpreted as having formed from the partial oxidation of primary sulfides and tellurides during or following brecciation of quartz veins. Fuettererite is hexagonal, with space group $R\bar{3}$, a = 8.4035(12), c = 44.681(4) Å, V = 2732.6(6) Å^3, and Z = 6. Crystals are tabular to short prismatic, exhibit the forms {100}, {101}, and {001} and reach a maximum dimension of 50 μm. The color is bluish green, the streak is pale bluish-green, and the luster is adamantine. The Mohs hardness is estimated at between 2 and 3. The new mineral is brittle with irregular fracture and one perfect cleavage on {001}. The calculated density based on the empirical formula is 5.528 g/cm^3. Fuettererite is uniaxial (–), with calculated indices of refraction of ω = 2.04 and ε = 1.97, and is dichroic bluish-green, $E < O$. Electron microprobe analysis provided: PbO 41.45, CuO 30.35, Al_2O_3 0.23, TeO_3 12.80, Cl 12.08, H_2O 3.55 (structure), O=Cl –2.73, total 97.73 wt%. The empirical formula (based on 18 O + Cl apfu) is: $Pb_{2.88}Cu_{5.92}^{2+}Al_{0.07}Te_{1.13}^{6+}O_{6.59}(OH)_{6.12}Cl_{5.29}$. The ten strongest powder X-ray diffraction lines are [d_{obs} in Å (*hkl*) *I*]: 6.106 (104) 44, 3.733 (0.0.12) 100, 2.749 (12$\bar{1}$) 53, 2.6686 (12$\bar{4}$) 49, 2.5289 (12$\bar{7}$) 41, 2.2772 (1.2.11) 38, 1.9637 (315, 1.2.$\bar{1}$6) 87, 1.8999 (multiple) 48, 1.5976 (multiple) 40, and 1.5843 (410, 1.2.23, 143) 44. The crystal structure of fuettererite (R_1 = 0.031 for 971 reflections with $F_o > 4\sigma F$) contains edge-sharing sheets of CuO_5Cl and TeO_6 octahedra. These sheets are virtually identical to that in the structure of spangolite, but in fuettererite they are linked together to form a double sheet. The double octahedral sheets alternate with thick double layers of PbO_2Cl_6 polyhedra. The CuO_5Cl octahedra exhibit pronounced Jahn-Teller distortions and the PbO_2Cl_6 polyhedron has a lopsided distribution of bond lengths attributable to the localization of the Pb^{2+} $6s^2$ lone-pair electrons.

Keywords: Fuettererite, new mineral, tellurate, crystal structure, spangolite, Pb^{2+} $6s^2$ lone-pair, Otto Mountain, California