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Lead-tellurium oxysalts from Otto Mountain near Baker, California: IV. Markcooperite, $Pb(UO_2)Te^{6+}O_6$, the first natural uranyl tellurate

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Abstract

Markcooperite, $Pb_2(UO_2)Te^{6+}O_6$, is a new tellurate from Otto Mountain near Baker, California, named in honor of Mark A. Cooper of the University of Manitoba for his contributions to mineralogy. The new mineral occurs on fracture surfaces and in small vugs in brecciated quartz veins. Markcooperite is directly associated with bromian chlorargyrite, iodargyrite, khinite-4*O*, wulfenite, and four other new tellurates: housleyite, thorneite, ottoite, and timroseite. Various other secondary minerals occur in the veins, including two other new secondary tellurium minerals: paratimroseite and telluroperite. Markcooperite is monoclinic, space group $P2_1/c$, a = 5.722(2), b = 7.7478(2), c = 7.889(2) Å, β = 90.833(5)°, V = 349.7(2) Å^3, and Z = 2. It occurs as pseudotetragonal prisms to 0.2 mm with the forms {100} and {011} and as botryoidal intergrowths to 0.3 mm in diameter; no twinning was observed. Markcooperite is orange and transparent, with a light orange streak and adamantine luster, and is non-fluorescent. Mohs hardness is estimated at 3. The mineral is brittle, with an irregular fracture and perfect {100} cleavage. The calculated density is 8.496 g/cm^3 based on the empirical formula. Markcooperite is biaxial (+), with indices of refraction α = 2.11, β = 2.12, γ = 2.29 calculated using the Gladstone-Dale relationship, measured α-β birefringence of 0.01 and measured 2V of 30(5)°. The optical orientation is X = **c**, Y = **b**, Z = **a**. The mineral is slightly pleochroic in shades of orange, with absorption: $X > Y = Z$. No dispersion was observed. Electron microprobe analysis provided PbO 50.07, TeO_3 22.64, UO_3 25.01, Cl 0.03, O≡Cl –0.01, total 97.74 wt%; the empirical formula (based on O+Cl = 8) is $Pb_{2.05}U_{0.80}Te^{6+}_{1.18}O_{7.99}Cl_{0.01}$. The strongest powder X-ray diffraction lines are [d_{obs} in Å (*hkl*) *I*]: 3.235 (120, 102, $\bar{1}$02) 100, 2.873 (200) 40, 2.985 ($\bar{1}$21, 112, 121) 37, 2.774 (022) 30, 3.501 (021, 012) 29, 2.220 (221, $\bar{2}$21, 212) 23, 1.990 (222, $\bar{2}$22) 21, and 1.715 (320) 22. The crystal structure (R_1 = 0.052) is based on sheets of corner-sharing uranyl square bipyramids and tellurate octahedra, with Pb atoms between the sheets. Markcooperite is the first compound to show Te^{6+} substitution for U^{6+} within the same crystallographic site. Markcooperite is structurally related to synthetic $Pb(UO_2)O_2$.

Keywords: Markcooperite, new mineral, tellurate, uranyl, crystal structure, Otto Mountain, California