Pseudojohannite from Jáchymov, Musonoï, and La Creusaz: A new member of the zippeite-group

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ABSTRACT

Pseudojohannite is a hydrated copper(II) uranyl sulfate described from Jáchymov, Northern Bohemia, Czech Republic (type locality). Pseudojohannite also occurs at the Musonoï quarry near Kolwezi, Shaba, Congo, and the La Creusaz prospect, Western Swiss Alps. At all three localities, pseudojohannite formed through the interaction of acid sulfate mine drainage waters with uraninite (Jáchymov and La Creusaz) or uranyl silicates (Musonoï). Pseudojohannite forms moss green, non UV-fluorescent aggregates consisting of irregularly shaped crystals measuring up to 25 μm in length and displaying an excellent cleavage parallel to $(\bar{1}01)$. d_{meas} is 4.31 g/cm^3, d_{calc} 4.38 g/cm^3, and the refractive indices are $n_{min} = 1.725$ and $n_{max} = 1.740$.

A high-resolution synchrotron powder diffraction pattern on the material from Musonoï shows that pseudojohannite is triclinic ($P1$ or $P\bar{1}$), with $a = 10.027(1)$ Å, $b = 10.822(1)$ Å, $c = 13.396(1)$ Å, $\alpha = 87.97(1)°$, $\beta = 109.20(1)°$, $\gamma = 90.89(1)°$, $V = 1371.9(5)$ Å^3. The location of the uranium and sulfur atoms in the cell was obtained by direct methods using 1807 reflections extracted from the powder diffractogram. Pseudojohannite contains zippeite-type layers oriented parallel to $(\bar{1}01)$. The empirical chemical formula calculated for a total of 70 O atoms is $Cu_{6.52}U_{7.85}S_{4.02}O_{70}H_{55.74}$, leading to the simplified chemical formula $Cu_{6.5}[(UO_2)_4O_4(SO_4)_2]_2(OH)_5 \cdot 25H_2O$. The distance of 9.16 Å between the uranyl-sulfate sheets in pseudojohannite shows that neighboring layers do not share O atoms with the same $Cu\Phi_6$ [$\Phi = (O,OH)$] distorted octahedrons, such as in magnesium-zippeite. Rather, it is expected that $Cu\Phi_6$ forms a layer bound to the zippeite-type layers by hydrogen bonding, as in marécottite, or one apex of the $Cu\Phi_6$ polyhedron only is shared with a zippeite-type layer, as in synthetic SZIPPMg. The higher number of cations in the interlayer of pseudojohannite (Cu:S = 1.6:1) compared to marécottite (3:4) and SZIPPMg (1:1) indicates that pseudojohannite has a unique interlayer topology.

Ab-initio powder structure solution techniques can be used to obtain important structural information on complex micro-crystalline minerals such as those found in the weathering environment. Pseudojohannite represents a new member of the zippeite group of minerals, and further illustrates the structural complexity of zippeite-group minerals containing divalent cations, which have diverse arrangements in the interlayer. Peudojohannite and other divalent zippeites are common, easily overlooked minerals in acid drainage environments around uranium deposits and wastes.

Keywords: New mineral, pseudojohannite, uranyl sulfate, XRD data, IR spectroscopy, Jáchymov, La Creusaz, Musonoï