Alpersite (Mg,Cu)SO₄·7H₂O, a new mineral of the melanterite group, and cuprian pentahydrite: Their occurrence within mine waste

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ABSTRACT

Alpersite, (Mg₀.⁵₈Cu₀.₃₇Zn₀.₀₂Mn₀.₀₁Fe₀.₀₁)SO₄·7H₂O, a new mineral species with direct relevance to reactions in mine waste, occurs in a mineralogically zoned assemblage at the abandoned Big Mike mine in central Nevada at a relative humidity of 65% and T = 4 °C. Blue alpersite, which is isostructural with melanterite (FeSO₄·7H₂O), is overlain by a light blue to white layer dominated by pickeringite, alunogen, and epsomite. X-ray diffraction data (MoKα radiation) from a single crystal of alpersite were refined in $P_2_1/c$, resulting in $wR = 0.05$ and cell dimensions $a = 14.166(4)$, $b = 6.534(2)$, $c = 10.838(3)$ Å, $β = 105.922(6)^°$. Site-occupancy refinement, constrained to be consistent with the compositional data, showed Mg to occupy the M₁ site and Cu the M₂ site. The octahedral distortion of M₂ is consistent with 72% Cu occupancy when compared with the site-distortion data of substituted melanterite.

Cuprian pentahydrite, with the formula (Mg₀.₁₈Cu₀.₃₂Zn₀.₀₂Mn₀.₀₁Fe₀.₀₁)SO₄·5H₂O, was collected from an efflorescent rim on a depression that had held water in a large waste-rock area near Miami, Arizona. After dissolution of the efflorescence in de-ionized water, and evaporation of the supernatant liquid, alpersite precipitated and quickly dehydrated to cuprian pentahydrite. These observations are consistent with previous experimental studies of the system MgSO₄-CuSO₄-H₂O. It is suspected that alpersite and cuprian pentahydrite are widespread in mine wastes that contain Cu-bearing sulfo-sulfates. Alpersite has likely been overlooked in the past because of the close similarity of its physical properties to those of melanterite and chalcanthite. Alpersite is named after Charles N. Alpers, geochemist with the United States Geological Survey, who has made significant contributions to our understanding of the mineralogical controls of mine-water geochemistry.

Keywords: Alpersite, pentahydrite, crystal structure, environmental mineralogy, new minerals, XRD data, sulfate mineralogy, chalcanthite, Rietveld refinement, acid mine waste

INTRODUCTION

Secondary sulfate minerals, which occur in sulfide mine waste, play a large role in determining the composition of the effluent that flows from mined areas. Secondary minerals are commonly fine grained and are often mixed with other minerals with which they may, or may not, be in equilibrium. An understanding of the phase relationships and dehydration mechanisms of these sulfate-mineral mixtures is important in determining how the mine waste interacts with the local environment. It is important that we quantify the details of chemical variations, atomic structure, physical properties, and phase relationships of these minerals to understand the processes by which mine waste matures with time and reacts to changes in temperature and (or) humidity. This paper describes the occurrence of alpersite, (Mg₀.₃₈Cu₀.₃₇Zn₀.₀₂Mn₀.₀₁Fe₀.₀₁)SO₄·7H₂O, from central Nevada, and alpersite and cuprian pentahydrite (Mg₀.₁₈Cu₀.₃₂Zn₀.₀₂Mn₀.₀₁Fe₀.₀₁)SO₄·5H₂O from Miami, Arizona. Alpersite is isostructural with melanterite (FeSO₄·7H₂O), and cuprian pentahydrite is isostructural with siderotil (Fe,Cu)SO₄·5H₂O, but both alpersite and pentahydrate have Mg as the dominant cationic species. We suspected that alpersite may have been overlooked because it is similar in color and other physical properties to chalcanthite (CuSO₄·5H₂O) and cuprian melanterite.

OCCURRENCE

The Big Mike mine, located on the south side of Panther Canyon, on the west flank of the north end of the Tobin Range in sec. 23, T. 31 N, R. 39 E in Pershing County, north-central Nevada (latitude 40° 32' 32"N, longitude 117° 33' 25" W), was discovered in the 1930s and production began in 1967. The mine exploited a massive sulfide deposit that occurs in the late Devonian to early Mississippian Havallah sequence (Rye et al. 1984). Ore minerals include chalcocpyrite, bornite, and digenite in the massive sulfide zone, and tenorite and cuprite in the oxide zone. In addition to the high-grade sulfide ore, lower-grade mixed oxide and sulfide ores were mined and stockpiled for hydrometallurgical leaching. By 1970, 2.9 Mt of overburden and 90000 t of ore averaging 10.5% Cu had been mined from an open pit. From 1970 until 1978, a leaching facility treated 270000 t of low-grade ore from the dumps and the periphery of the pit (Rye et al. 1984). The hydrometallurgical process involved addition

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