

Sulfide oxidation observed using micro-Raman spectroscopy and micro-X-ray diffraction: The importance of water/rock ratios and pH conditions

**ALEXANDRA COURTIN-NOMADE,^{1,*} HUBERT BRIL,¹ JEAN-MICHEL BÉNY,² MARTIN KUNZ,³
AND NOBUMICHI TAMURA³**

¹Université de Limoges, GRESE, EA 4330, FST, 123, avenue Albert Thomas, 87060 Limoges cedex, France

²Université d'Orléans, CNRS/INSU et Université François Rabelais de Tours, Institut des Sciences de la Terre d'Orléans (ISTO),
UMR 6113, 1A, rue de la Férollerie, 45071 Orléans, cedex 2, France

³Advanced Light Source, Lawrence Berkeley National Lab, 1 Cyclotron Road, Berkeley, California 94720, U.S.A.

ABSTRACT

Oxidative dissolution of arsenopyrite and pyrite from two former mining sites located in the French Massif Central has been studied to determine some of the critical parameters controlling the formation of secondary phases. Micro-Raman spectroscopy (μ RS) and micro-scanning X-ray diffraction (μ SXRD) were used for mineralogical identification and for mapping the distribution of these alteration products. The two mining sites are characterized by different pH conditions and sedimentary environments. Enguailès exhibits acidic conditions (pH \sim 3) and consists of coarse-grained tailings on a steep slope, which have been leached by meteoric waters and represent an oxidizing environment with a high solid/solution ratio. In contrast, the Cheni site shows near neutral conditions (pH \sim 6.3) and consists of muddy tailings deposited in a settling basin, which exemplify an oxidizing environment with a low solid/solution ratio. Amorphous or poorly crystalline iron arsenate (e.g., amorphous scorodite or parasymplectite-like phase) are among the first products precipitated from oxidized arsenopyrites. These iron arsenates are highly mobile and are frequently observed in association with non-arsenian pyrites, where in some instances they have matured into more crystalline forms. Arsenic may also be trapped by amorphous or poorly crystalline iron (oxy)hydroxides, as has been observed for goethite or jarosite in the latter stages of sulfide oxidation. This study also shows that rings of elemental sulfur are formed around altered sulfides, but only when conditions are near neutral.

Keywords: Elemental sulfur, sulfides, iron arsenate, μ SXRD mineral species map