

Characterization of ferric arsenate-sulfate compounds: Implications for arsenic control in refractory gold processing residues

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ABSTRACT

A combination of techniques, including powder X-ray diffraction (XRD), electron microprobe analysis (EPMA), transmission electron microscopy (TEM), and X-ray absorption spectroscopy (XAFS), is used to characterize the common ferric-arsenate-sulfate compounds, which could result from the pressure oxidation of refractory gold ores at elevated temperatures. Three general types of precipitate are identified; namely, arsenate-bearing basic ferric sulfate [FeSO₄(OH) and designated as BFS], ferric arsenate-sulfate [an extensive solid solution Fe(AsO₄)_{0.2–0.7}(SO₄)_{0.7–0.2}(OH)_{0.7–0.2} and designated as FAS], and hydrated ferric orthoarsenate (FeAsO₄·0.75H₂O). The crystal structure of FAS is solved by precession electron-diffraction experiments. The structures of BFS and FAS are constructed from octahedral Fe³⁺ chains, which are cross-linked by sulfate and arsenate tetrahedra. Extensive substitution of arsenate for sulfate occurs in both types of compounds with charge neutrality being maintained by variations in the (OH) content. The XAFS spectra indicate that the local structures of both BFS and FAS are made of corner-linked single chains of FeO₆ octahedra where the chains are linked by AsO₄ or SO₄ tetrahedra forming alternating layers of FeO₆ octahedra and AsO₄ or SO₄ tetrahedra. Preliminary toxicity characteristics leaching procedure (TCLP) testing of the precipitates indicates that FAS with a molar ratio As/(As+S) ratio of ≤0.5 could be an acceptable material for disposal in a tailings impoundment, whereas more As-rich FAS and BFS may require further treatment. The results for the laboratory-prepared precipitates are compared with those obtained on three residues from the processing of refractory gold ores. The major As-carrier in one of the residues is FAS, whereas As-bearing goethite and hematite are the dominant As-carriers in the other two residues. Thus, the mineralogical characteristics of the residues dictate the appropriate arsenic management and disposal options in the processing of refractory gold ores.

Keywords: Arsenic, arsenate, sulfate, ferric arsenate sulfate, refractory gold, arsenic control, hydrometallurgy, autoclave residue