Precipitation of Fe-sulfate and Fe-hydroxide intergrowths in laboratory simulations of acid mine drainage: How does co-precipitation affect microtextures?

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In acid mine drainage systems, dissolved iron and sulfate groups in circumneutral to low-pH fluids can precipitate a variety of mineral phases, including ferrihydrite, schwertmanite, goethite, and – in lower pH systems - jarosite, copiapite, melanterite, coquimbite, halotrichite, and rhomboclase. Under specific fluid conditions, these phases can co-precipitate, forming complex intergrowths. Understanding the mechanisms by which these precipitates form is an important step in efforts to prevent and remediate such deposits in acid mine drainage-affected streams. Additionally, efforts to recover and reuse iron from acid mine drainage deposits benefit from an understanding of the microscale structures of these iron-bearing minerals.

Here, we report controlled co-precipitation of Fe-sulfate intergrowths in laboratory-simulated acid mine drainage conditions. Mixtures of 2- and 6-line ferrihydrite [$(Fe^{3+})_2O_3$•$0.5H_2O$], goethite [α-FeO(OH)], schwertmannite [$Fe^{3+}_{16}O_{16}(OH,SO_4)_{12-13}$·$10\text{-}12H_2O$], szomolnokite [$Fe^{2+}SO_4$·$(H_2O)$], potassium jarosite [$KFe^{3+}_3(SO_4)_2(OH)_6$], melanterite [$FeSO_4$·$7H_2O$], copiapite [$Fe^{2+}Fe^{3+}_4(SO_4)_6(OH)_2$·$20(H_2O)$], ferricopiapite [$Fe^{3+}_{0.67}Fe^{3+}_4(SO_4)_6(OH)_2$·$20H_2O$], rhomboclase [$H_5Fe^{3+}O_2(SO_4)_2$·$2(H_2O)$], coquimbite [$Fe^{3+}_2(SO_4)_3$·$9H_2O$], and halotrichite [$FeAl_2(SO_4)_4$·$22H_2O$] are synthesized, extracted, and subsequently analyzed with X-ray diffractometry and visible- to near-infrared spectroscopy.

Laboratory intergrowths are then compared to naturally-precipitated samples from two regions: 1) circum-neutral acid mine drainage systems issuing from abandoned coal mines in the southern anthracite fields of southeastern Pennsvylania; and 2) low-pH acid mine drainage systems in the Rio Tinto / Rio Odiel drainage basin of the Iberian Pyrite Belt of southern Spain, a site of more than 5000 years of mining-induced acid mine drainage and its related precipitates. Significant intergrowth behavior is reported for both circumneutral and low-pH environments.