

Use of a mine-tailing line as a geochemical reactor for treating acid-rock drainage: Bingham Canyon (USA)

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Kennecott Utah Copper Corporation (KUCC) manages $6.8\text{E}+07\text{ m}^3$ of low-pH, high-sulfate, high-metal groundwater in the Jordan Valley (Utah, USA), using the active tailing disposal system as a "geochemical reactor". KUCC evaluated the chemistry and mineralogy of tailing and pipeline scales, conducted laboratory-scale water-rock experiments, monitored the aqueous chemistry of source waters and the chemistry of both solutions and solids throughout the tailing system, and used thermodynamic calculations to shed light on specific mechanisms of reactions observed during experiments and monitoring.

At acidic flows of up to $22\text{ m}^3\cdot\text{s}^{-1}$, the tailing system acts as a nearly ideal plug reactor, with no measurable dispersion in parameters over a 25 km reach and maintains the discharge pH at a value ≥ 6.7 . Reaction of low-pH waters with the acid-neutralization capacity (ANC) of the tailing precipitates Fe- and Al- hydroxides and gypsum and removes trace metals by sorption at rates ranging from 60% for Mn to $> 99\%$ for Al, Cu, Fe and Zn. Because of the very high flux of alkaline tailing, the design-basis flows of acidic water do not deplete the ANC of tailing within the analytical precision of the measurements. By maintaining pH above 6.6, KUCC can meet all regulatory discharge limits.

Thermodynamic data for hydrated ferric sulfates and application to secondary minerals at Iron Mountain, California

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Acid mine drainage (AMD) is a serious environmental problem at many sites. AMD is produced by weathering of pyrite and other sulfides and is rich in Fe^{2+} , Fe^{3+} , Al^{3+} , SO_4^{2-} , and other constituents. Precipitation of secondary minerals from AMD can be caused by several processes including evaporation, oxidation of Fe^{2+} , mixing, neutralization, and change in temperature. Common secondary minerals include hydrated metal oxides and sulfates. The objective of the present study is to determine the thermodynamic properties and stability ranges of selected ferric sulfates by calorimetric experiments. Synthetic ferricopiapite, rhomboclase, and $\text{Fe}_2(\text{SO}_4)_3(\text{H}_2\text{O})_5$ were prepared and used for the experiments along with a natural, Al-bearing coquimbite specimen from Iron Mountain, Calif.

The enthalpy of formation (ΔH°_f) of ferricopiapite, coquimbite, rhomboclase, and $\text{Fe}_2(\text{SO}_4)_3(\text{H}_2\text{O})_5$ was determined by acid-solution calorimetry in 5 N HCl. An appropriate thermochemical cycle was employed for each studied phase. The reference phases were MgO, α -MgSO₄, γ -FeOOH, and H₂O. The ΔH°_f values are (kJ/mol) are -4115.8 ± 4.1 [$\text{Fe}_2(\text{SO}_4)_3(\text{H}_2\text{O})_5$], -12045.1 ± 9.2 (ferricopiapite), -5698.7 ± 3.4 (coquimbite), and -3201.1 ± 2.6 (rhomboclase). Standard entropy of these phases was estimated by considering solid-state reactions among the studied ferric sulfates and phases whose entropy has been measured. The estimated values are 488.2 ± 1.3 [$\text{Fe}_2(\text{SO}_4)_3(\text{H}_2\text{O})_5$], 1449.2 ± 5.0 (ferricopiapite), 641.0 ± 2.2 (coquimbite), and 380.1 ± 1.4 (rhomboclase).

Field relations among copiapite-group minerals, coquimbite, rhomboclase, and other secondary Fe-sulfate minerals at Iron Mountain will be discussed in light of available thermodynamic data.