

The attenuation of Ni, Zn, Cu, by secondary Fe phases from surface and ground water of two sulfide mine tailings deposits

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Secondary Fe phases, which could attenuate Cu, Zn, and Ni, formed in samples of unacidified filtered surface and ground water from two deposits of sulfide mine tailings at Thompson and Leaf Rapids, Manitoba. The precipitates were separated from the solutions by filtration, and analyzed by XRD, SEM and EMPA. Phases of different crystallinity were separated by selective dissolution with 0.2 M ammonium oxalate solution at pH 3.

An assemblage of goethite and schwertmannite precipitated from initially anoxic ground water with a pH of 5.7-6.2, whereas jarosite and/or schwertmannite were identified in acidic oxygenated (pH = 2.7-3.2) surface water. This difference in mineralogy is attributed to the redox and acidity conditions. In the surface water, activities of SO_4^{2-} and H^+ control the proportions of minerals in the assemblage and the composition of schwertmannite.

More Cu, Zn, and Ni were precipitated from the ground water than from surface waters due to the higher initial content of Fe and higher pH of ground water. The concentrations of the metals were not significantly changed in the surface water because of limited sorption of cations at low pH.

The affinity of the metals to the precipitate rather than the solution is in the order $\text{Cu} > \text{Zn} > \text{Ni}$. Sequential extraction indicated that Ni and Zn accumulate in poorly crystalline schwertmannite, while Cu concentrates in crystalline phases (goethite and jarosite). However, schwertmannite, as the principal phase in most of the precipitates, contains a significant proportion of Cu. During the recrystallization of metastable schwertmannite to goethite, the metals could be redistributed and released back into the mine water.

Mineralogical controls on acid-mine drainage from waste piles in the Vermont copper belt

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Secondary minerals sequester metals, sulfate, and acidity and complicate interpretations of static tests used to predict acid-mine drainage (AMD). The role of these minerals is evaluated in historic mine waste piles from pre-1958 copper mining of pyrrhotite-rich, Besshi-type massive sulfide deposits in Orange Co., VT, where waste piles in headwaters areas contaminate streams. Composites of <2 mm material from mine-waste pile surfaces were analyzed for mineralogy (semi-quantitative phase analysis using Rietveld refinement on a full XRD profile), acid-base accounting (ABA), chemistry, and leach studies. Waste piles are strongly acid-generating with paste- and leachate pH <3 and net neutralization potentials (NNP) of -14 kg CaCO_3/t or less. The inherent acidity of the deeply weathered mine waste is due to jarosite (4 to 40 wt.%), salts (tr to 2 wt.%, including melanterite, rozenite, copiapite, and halotrichite), and sulfides (<1 to 6 wt.%, mainly pyrrhotite, with minor pyrite, chalcopyrite, and sphalerite). Efflorescent sulfate salts that form locally and intermittently on wastes incorporate Cu and Co. Total S concentrations in wastes range from 1 to 5 wt. %. Sulfate S, and consequently NNP values, vary with HCl concentration and boiling time used for sulfate S determination because of the refractory nature of the jarosite (Vos and O'Hearn, 2001). Any calcite present in the waste was consumed to form gypsum (<0.1 to 1 wt.%). Goethite (10 to 17 wt.%) and silicates (quartz, micas, chlorite, feldspars) provide little neutralization, although biotite reacts to provide K for jarosite. Washing the waste with deionized water (20:1 water:rock) dissolved salts immediately and lowered solution pH to <3.5. After repeated washes, pH stabilized at or above 3.8. Evaporated wash solutions precipitated Fe sulfate salts. Surface runoff composition, simulated by leaching wastes with synthetic rain, approximates measured surface-water chemistry for Cu, Zn, and Cd, which commonly exceeds EPA acute aquatic toxicity standards. Salts, though volumetrically minor, contribute to AMD even after 50+ years of wet/dry cycling of waste piles.

Reference

Vos, R.J. and O'Hearn, T.A. (2001) 8th Ann. B.C. Metal Leaching and ARD Workshop. 1-13.