Long-term Sulfide Oxidation, Acid Neutralization and Metal Release Processes in Mine Wastes

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Weathering of mine wastes can lead to the generation of low-quality drainage waters for many centuries after mining has ceased. Integrated studies consisting of geochemical, hydrological and mineralogical analysis of two old mine tailings sites in northern Canada show that rates of sulfide oxidation reactions reached peak values during the first few decades after the tailings were first exposed to atmospheric oxygen. The rates then slowed in an asymtoptic manner over the next several decades. The acid generated through sulfide oxidation reactions has been neutralized at these sites through a series of carbonate, (oxy)hydroxide and aluminosilicate mineral dissolution reactions. At one site that has been weathering for 40 years, acid neutralization reactions have lead to depletion of carbonate minerals to a depth of 2 to 3 m. Anorthite has been altered to amorphous silica, and biotite to hydrobiotite, with decreasing alteration of these phases observed with increasing depth. At a second site that has been weathering for 70 years, the acid released from sulfide oxidation has lead to the complete depletion of carbonate minerals to 6 m depth, and depletion of biotite, chlorite and smectite to a depth of 1 m. At both sites, massive hardpan layers have formed below the active zone of oxidation. Although a portion of metals released from sulfide oxidation reactions has been retained in secondary solids in the unsaturated zone, pore waters containing very high concentrations of dissolved metals are slowly moving downward through the unsaturated zone. Once in the saturated zone, these metals move laterally from the tailings and eventually discharge to surface water bodies. This discharge of low quality water from the tailings area will continue for many more decades or longer. This combination of geochemical, mineralogical and hydrological data, allows predictions of metal loadings to be made over time scales of many decades.