Assessment of groundwater contamination in abandoned mine areas, South Korea, using hydrochemical and sulfur isotope data

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Hydrochemical and sulfur isotopic investigation was conducted to assess groundwater contamination in three abandoned metallic mine areas of South Korea. The mines in this study are Budden Au-Ag (BD), Sambo Pb-Zn-barite (SB), and Samkwang Au-Ag (SK). Multi-level samplers with the maximum depth of 30 m were installed in the vicinity (< 300 m away) of mine tailings to monitor the migration and behaviors of solutes including heavy metals. Very high TDS values of shallow groundwater were observed: 540–9050 mg/L (BD), 540–1080 mg/L (SB), and 130–1240 mg/L (SK). Most of the water samples characteristically showed the chemistry of Ca-SO_4 type with substantial contamination by heavy metals (As, Cd, Ni, Al, Fe, Mn, and Zn), owing to the oxidation of hydrothermal sulfide minerals. The sulfur isotopic compositions of dissolved sulfate were 2.2 to 6.0‰ (BD), –2.4 to 0.5‰ (SB), and –14.3 to 5.2‰ (SK), which are generally in agreement with the ranges of sulfide minerals in ores. The minimum pH of groundwater was circum-neutral (5.5 to 7.3). The concentrations of sulfate in water correlated well with those of Ca and Mg ($R^2 > 0.95$), suggesting the quick buffering of mine water via dissolution of carbonate and silicate minerals in rocks during groundwater flow. With increasing distances from mine tailings, the concentrations of heavy metals and sulfate decreased in a systematic manner. This attenuation is attributed to the sorption onto and/or coprecipitation with Fe- and Al-oxyhydroxides. This study shows that careful investigation of hydrochemical and sulfur isotope data using multi-level sampling can be very helpful to examine the origin and fates of contaminants in mine areas.