American Mineralogist, Volume 96, pages 1–13, 2011

A mineralogical, geochemical, and microbiological assessment of the antimony- and arsenic-rich neutral mine drainage tailings near Pezinok, Slovakia

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Abstract

The mineralogical composition of mining wastes deposited in voluminous tailing impoundments around the world is the key factor that controls retention and release of pollutants. Here we report a detailed mineralogical, geochemical, and microbiological investigation of two tailing impoundments near the town of Pezinok, Slovakia. The primary objective of this study was the mineralogy that formed in the impoundment after the deposition of the tailings (so-called tertiary minerals). Tertiary minerals include oxyhydroxides of Fe, Sb, As, Ca and are present as grains and as rims on primary ore minerals. X-ray microdiffraction data show that the iron oxyhydroxides with abundant As are X-ray amorphous. The limiting (lowest) Fe/As (wt/wt%) ratio in this material is 1.5; beyond this ratio, the hydrous ferric oxide does not retain arsenic. The grains with less As and little to moderate amounts of Sb are goethite; the grains where Sb dominates over Fe are poorly crystalline tripuhyite ($FeSbO_4$). Even the most heavily contaminated samples (up to 29 wt% As_2O_5) are populated with diverse communities of microorganisms including typical arsenic-resistant heterotrophic species as well as iron reducers and sulfur oxidizers. Several recovered clones cluster within phylogenetic groups that are solely based on environmental sequences and do not contain a single cultivated species, thus calling for more work on such extreme environments.

Keywords: Antimony, iron oxides, weathering products, electron microprobe, X-ray microdiffraction, microbial diversity