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Secondary mineralogy and microtextures of weathered sulfides and manganoan carbonates in mine waste-rock dumps, with implications for heavy-metal fixation

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ABSTRACT

The secondary mineralogy and microtextures of weathered waste-rock dumps derived from the mining of galena-sphalerite ore in quartz veins containing manganoan carbonates were examined using back-scattered electron imaging, X-ray diffraction, and chemical analysis. Sphalerite, pyrrhotite, and arsenopyrite were coated or replaced by iron oxyhydroxides in the earliest stage of the weathering, and were then replaced by sulfur. Galena shows a thin alteration rim of anglesite. Oxidation of pyrite has resulted in porous boxworks of Fe oxyhydroxides. The relative resistance to oxidation, from most resistant to least resistant, was observed to be pyrite ≈ galena > arsenopyrite ≈ sphalerite > pyrrhotite. Rhodochrosite dissolved to form hydrohetaerolite pseudomorphs, and manganoan calcite has an outer alteration rim of hydrohetaerolite and an inner zone of smithsonite. Rock and mineral fragments were cemented by fine aggregates of plumbojarosite, Fe oxyhydroxides/sulfates, and manganates. Microchemical analysis and sequential extractions showed a close association of As with Fe oxyhydroxides/sulfates, of Pb, Cu, Zn, and As with plumbojarosite, and of Pb and Zn with manganates. Despite their lower acid-neutralizing capacity, manganoan carbonates played an important role in the fixation of Pb and Zn by the formation of manganates.