Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36186

Timing secondary mineral formation: A new approach to reconstructing mine waste reactivity

OLIVIA CLAY AND BAS VRIENS

Queen's University

Re-processing and remediating mine wastes requires novel approaches to increase [critical] mineral supply, improve resource circularity, and maintain long-term environmental management. Historic and active mine sites typically host waste rock and tailings that can contain valuable metals not prioritized or fully recovered during initial operations. However, exposure of these granular materials to ambient conditions drives mineral weathering, potentially generating acidity and mobilizing metals to surrounding environments. Effective re-mining and mitigation strategies therefore require a quantitative understanding of mineral reactivity over practice-relevant (decadal) timescales. Unfortunately, limited historical records, particularly at legacy sites, hinder assessments of material exposure and weathering extent.

The composition and structure of weathering products can reflect fluid chemistry, pH, and redox state at the time of formation, and could provide an archive of the geochemical conditions under which primary minerals reacted. If these precipitates could be dated, they would offer a pathway to reconstruct past weathering conditions and/or establish in-situ mineral reactivity rates. We are evaluating the potential of radiogenic isotopes ($^{137}Cs/^{210}Pb$) as short-term geochronometers to date secondary mineral crusts formed on mine waste materials, thereby offering a novel avenue to assess weathering reactivity.

Because predicted ^{137}Cs and ^{210}Pb activities are below detection limits of conventional gamma-ray spectrometry, especially in mine wastes from deposits with low natural background radioactivity, we are developing a pre-concentration approach to isolate and enrich (unsupported) Pb associated with secondary phases. Secondary minerals were selectively separated from primary assemblages using a hydroxylamine hydrochloride leach. Pb was subsequently captured from the leachate using anionic trapping solutions (carbonate/phosphate) to precipitate Pb salts prior to gamma analysis. Ultra-trace level ICP-MS analyses of leach residues and scanning electron microscopy (SEM) and laser-ablation ICP-MS of trapping precipitates was used to assess the efficiency of secondary mineral removal and Pb recovery. We will first present gamma counting data before and after preconcentration.

Our methodological framework helps establish radiogenic isotopes in mine waste materials as decadal-scale geochronometers. Dating secondary precipitates will enable reconstruction of past geochemical conditions and mineral reactivity, ultimately informing improved mine waste management, remediation strategies, and environmentally responsible re-mining practices.