



GIAM-4: Valorización y estabilización de relaves

Evaporative concentration of toxic elements in tailings of polymetallic deposits

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Most of Chilean tailings impoundments associated with polymetallic mining are located in the arid climate zone. The extreme evaporation on their surfaces provides the forming of efflorescence salts with increased content of toxic metals and metalloids (As, Cu, Mo, and Pb). The grains of those secondary minerals (i.e. formed after deposition of the tailings dump) characterizing by low density and increased surface area can be transported by wind for great distances poisoning the surrounding territories. To reveal the features of evaporative concentration, we studied the secondary mineralization formed on the surface of a tailings dump constructed in central Chile and, then, simulated this process by means of reactive transport modeling. We found that chalcantite, epsomite, gypsum, and mirabilite are the typical minerals precipitating due to evaporation. Those efflorescence salts are characterized by elevated saturation levels and indicate the intensive concentration of tailing fluids. The implemented simulations on the base of PHREEQC and SUTRA codes show that secondary mineralogy and fluid composition depends on (i) the in situ temperature range, (ii) the rainfall rates, and (iii) the mineral composition of tailings. In contrast to deeper levels, the near-surface horizon of ~1 m reveals the maximum extent of mineral dissolution reactions due to the highest variability in temperatures, the aeration by atmospheric oxygen, the periodical evaporation and dilution cycles. However, because of the high porosity of tailings (50-60%) and low residence time of rainwater, the material for secondary mineralization of this type can be mobilized from very limited rock volume. In fact, the exchange between horizons is possible at a scale of centimeters. Using the SEM elemental mapping, we found that in the studied tailings dump arsenic is mainly contained in biotite and chlorite, and the potentially toxic metals, like Cu, Pb and Mo, in chalcopyrite, pyrite and molybdenite. Whereas fluids formed due to evaporation may be highly mineralized, at the presence of atmospheric oxygen they never reach the saturation levels for sulfides. Our simulations predict that the accumulation of toxic alteration products is mostly controlled by dissolution of primary sulfide minerals. This causes the extreme enrichment of evaporative fluids and precipitating efflorescence salts by metals, especially Mo, although the accumulation of As is less intensive.