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The role of the iron oxyhydroxides and efflorescent sulfates in remediation by natural attenuation of mining contaminated systems

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Acid mine drainage (AMD) is a common problem associated with the weathering of metal sulfide wastes in abandoned mining areas, which can be rich in toxic metals and metalloids. The formation of secondary mineral phases such as iron oxyhydroxides, oxyhydroxysulfates, and efflorescent sulfates may be a natural attenuation process in mining soils because these minerals can scavenge potentially toxic elements (PTE). Typically formed by the evaporation (efflorescent salts) or precipitation (ochreous iron-rich oxyhydroxides) these minerals could be highly soluble and reactive. Therefore, their inventory and characterization are particularly important for predicting the cycles of retention or accumulation zones of PTE and acidity in mining systems.

The abandoned mines of Valdarcas (W-mine) and São Domingos (Cu-mine) were selected for the present study due to the AMD signature and occurrence of some of these secondary minerals. The collected samples were analyzed with different techniques: binocular microscopy, SEM-EDS, TEM, DRX, and FTIR.

In Valdarcas mine area, typical ochreous phases such as schwertmannite and goethite were identified as the dominant secondary phases. These brownish-yellow ferric amorphous and poorly crystalline minerals can remove PTE via adsorption processes, contributing to their retention in the mining environment. In contrast, at São Domingos, efflorescent sulfate salts are more abundant. Melanterite and copiapite were the prevailing salts identified. With different morphologies, these minerals are highly soluble and therefore play a relevant key in the retention/mobilization cycles of hazardous contaminants, such as arsenic (As).

This integrative methodologic approach, based on the use of several techniques, allowed a complete characterization of these minerals. Therefore, the study revealed a diversity of behaviors for the identified phases, suggesting various roles in increasing the resilience of the contaminated systems.