

Redox transformations of mine tailings in the environment: minerals, metal(loid) speciation and microbes

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Vast amounts of mine wastes are produced from the extraction and processing of mineral and energy deposits. Tailings, the crushed rock and fluids remaining after processing of the source materials in mills, washeries or concentrators, are one of the most common types of solid mine wastes. Mine tailings are discharged directly to the surface environment, used as backfill underground, and stored in open pits or in tailings impoundments. Once in these environments, tailings can undergo complex biogeochemical redox transformations that impact on their mineralogy and metal(loid) speciation.

Tailings minerals comprise gangue minerals, residual uneconomic sulphides and oxides, and secondary oxides, oxyhydroxides and oxyhydroxysulfates. Many of these minerals contain redox-active metal(loids) and other elements, including As, Cu, Fe, Mn, Sb and S, and they are therefore susceptible to redox transformations. Examples include the oxidation of arsenopyrite to As(V)-bearing Fe oxides and oxyhydroxysulfates in tailings deposited on floodplains following the 1998 Aznalcóllar tailings dam spill [1], the oxidation of stibnite to Sb(V)-bearing Fe oxides in Bolivian mine tailings [2] and the reductive dissolution of goethite-containing mine tailings with concomitant release of As(III) [3]. Many tailings redox transformations are microbially-driven. Bacterium GM1, for example, converts As(III) to As(V) from tailings stored underground in Yellowknife, Canada [4].

Although considerable advances have been made in characterizing and understanding redox transformations in mine tailings, the characters of secondary minerals produced, the kinetics, pathways and magnitudes of metal(loid) speciation changes and in the identities and biochemistries of microbes involved still represent significant knowledge gaps.

[1] Hudson-Edwards *et al.* (2005) *Chem. Geol.* **219**, 175-192.
[2] Kossoff *et al* (2012) *Min. Mag.* **76** 1209-1228. [3] Paktunc (2013) *Appl. Geochem.* **36**, 49-56. [4] Osborne *et al* (2010) *BMC Microbiol.* **10**, 205.