Mineralogy and chemistry along an arsenic attenuation pathway through an orogenic gold mine, New Zealand

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Arsenic in the processing system

Ore at the world-class Macraes orogenic gold mine typically contains ~1 wt% As as arsenopyrite. A flotation concentrate containing the arsenopyrite and associated pyrite is subjected to pressure oxidation at 225°C before gold extraction by cyanidation. Arsenic-rich tailings are stored in a large impoundment. Dissolved As as high as 10 000 mg/L is inferred from geochemical modelling of mineralogy of the pressure oxidation system. This drops to ~1000 mg/L through the latter part of the processing system. Jarosite is one of the principal oxidation products, along with ferric arsenate and amorphous Fe-As-SO_4 material, in the processing waters.This jarosite contains <0.3 wt% As in solid solution, but has scattered micron scale ferric arsenate inclusions.

Arsenic in mine tailings

Relict Fe^{2+} from incomplete ore oxidation in the tailings waters eventually oxidises and acidifies the tailings to pH 3-6, which hinders dissolution of ferric arsenate. Associated ferric iron oxyhydroxide precipitation facilitates adsorption of dissolved As. Water- rock interactions between the acidified waters and the tailings silicates (muscovite, chlorite, albite) forms clay minerals (kaolinite, illite, smectite) These clay minerals further facilitate attenuation of dissolved As via adsorption. Thus, the tailings waters typically contain <30 mg/L dissolved As.

Percolation of As bearing tailings waters

Acidified waters are progressively neutralised by host rock calcite and silicate reactions in the tailings as the waters percolate through older tailings and the tailings dam structure. Widespread gypsum deposition occurs from the Ca^{2+}-SO_4^{2-} rich waters. Chlorite decomposition to smectite continues along the percolation pathways, releasing more Fe2+ that oxidises to produce more Fe3+ oxyhydroxide and this contributes to further attenuation of dissolved As. Percolating waters emerging from the tailings impoundment have dissolved As is <5 mg/L, and this is further attenuated to <0.1 mg/L in groundwater.