Application of Synchrotron-based Micro-analysis to Mine Waste Mineralogy

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Synchrotron-based micro-analysis has proven to be a powerful tool that can be used to identify mineralogical hosts of arsenic in contaminated soils and sediments. This is important for understanding whether arsenic will remain sequestered in association with the solid phase or released as environmental conditions change.

We have conducted grain-by-grain microXRD and As K-edge microXANES in gold mine waste from a large site near Yellowknife in northern Canada. Arsenic is present at two to five orders of magnitude above the Canadian government soil guideline of 12 ppm. The arsenic was originally present in sulfide form (as arsenopyrite (FeAsS) and arsenic-bearing pyrite (FeS_2)) and introduced naturally as part of the ore-forming process.

The ore was roasted in order to liberate gold. This transformed most of the arsenopyrite and much of the pyrite to arsenic-bearing iron oxides. Our synchrotron work has shown that these roaster oxides are nanocrystalline composite grains of maghemite and hematite that contain up to 7 wt% As as a mixture of AsV and AsIII. The trivalent arsenic species persist in the roaster oxides even where they have been exposed to the atmosphere for over sixty years. We have also determined that the solid arsenic-bearing phases are vulnerable to reductive dissolution when buried in the oxygen-poor environment of lake sediments.