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Using microXANES to Identify and Speciate Arsenic-bearing Particles in Thin Section

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Introduction: The toxicity and mobility of arsenic in solid waste is determined by its mineral form and oxidation state. The objective of our research is to characterize arsenic-bearing solids present in mine waste from the Yellowknife area in northern Canada. The results will be used to determine whether arsenic is attenuated in the solid materials or released to the aquatic environment. Fifty years of gold mining and smelting adjacent to a populated area has posed a potential threat to human and ecological health.

Methods and Materials: Our sample suite includes tailings of various disposal ages and environments from the Giant and Con mines, recent mill and roaster products, and soils from the nearby townsite. All samples were mounted as polished thin sections and the arsenic-bearing phases were identified petrographically and analysed by electron microprobe. Arsenic microXANES spectra have been collected from individual grains of arsenic-bearing particles including sulfide minerals (arsenopyrite, arsenical pyrite), roaster-derived oxides (maghemite, hematite, arsenolite) and weathering products including iron oxyhydroxides. Standards included pure powdered arsenopyrite, arsenolite (As_2O_3) and scorodite (FeAsO_4), as well as mixtures of these standards.

Results: MicroXANES spectra of arsenic-bearing phases including roaster-derived iron oxides (maghemite and hematite) and sulphides (arsenical pyrite and arsenopyrite) from the Giant mine indicate the presence of three oxidation states of arsenic (Figure 1). Deconvolution and comparison with standard mixtures can be used to quantify the amount of each type of arsenic present when mixed oxidation states are identified within individual grains. Samples from the Con mine include As(0) and As(V) only, probably due to a different processing technique. The soil samples from the townsite include waste rock fill that contains sulphides that have weathered to form As(V)-bearing oxyhydroxides rims.

Conclusions: It is necessary to identify the arsenic-bearing particles in mine waste and determine the oxidation state of the arsenic in each phase in order to predict the long-term stability and environmental hazard associated with the contaminated material. MicroXANES analysis of particles in thin section provides one of the only ways to accomplish this. In the case of the Yellowknife area, the presence of As(III), the most toxic and the most rare form of arsenic in mine waste, has been confirmed. Future work will determine how the As(III) is bound to the iron oxide. Yellowknife mine waste also contains As(0) in sulphide minerals, that exhibit partial weathering to iron oxyhydroxide. These, in turn, contain significant amounts of As(V).

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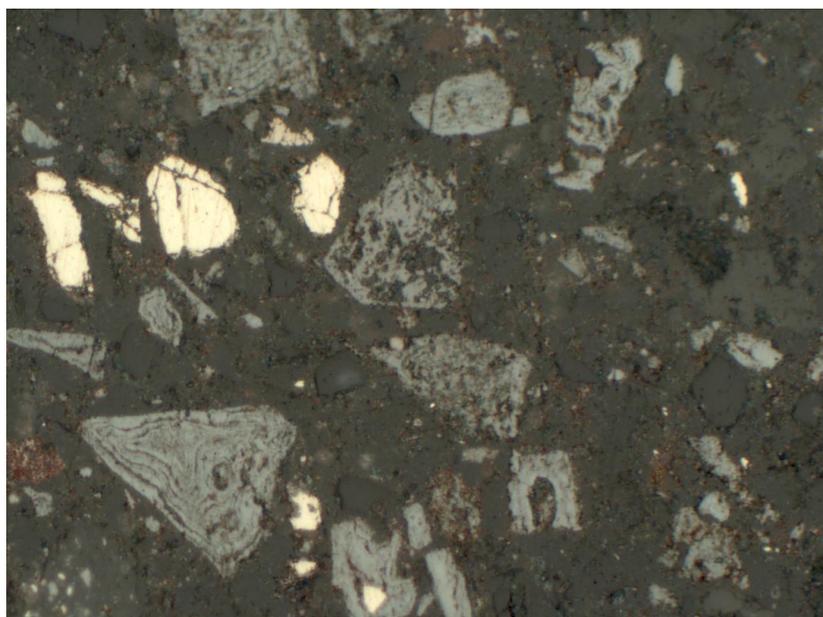


Figure 1 Roaster-derived iron oxides and pyrite.

Blue-grey grains are roaster iron oxides (mostly maghemite) and brighter yellowish grains are pyrite. The roaster oxides are arsenic-bearing and microXANES analysis of individual grains consistently show the presence of both As(III) and As(V). MicroXANES of arsenical pyrite reveals a more reduced oxidation state similar to arsenopyrite (nominally As(0)).

Field of view is 0.16 mm x 0.1 mm.