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Long-term Stability of Mixed Oxidation States of Arsenic (III and V) in Gold Mine Tailings

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Beamline(s): X26A

Introduction: Fifty years of gold mining and processing adjacent to a populated area has posed a potential threat to human and ecological health. 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.

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 (eg. calcine), and soils from the Giant Mine Townsite. Typical arsenic concentrations in the tailings are in the order of 1,000 ppm to 6,000 ppm. Samples were mounted as intact polished thin sections (Figure 1). The arsenic-bearing phases were identified petrographically and analysed by electron microprobe (EMPA). Arsenic K-edge micro-XANES spectra have been collected from individual grains of arsenic-bearing particles including, roaster-derived iron oxides and weathered rims of iron oxyhydroxide on iron sulfides. Standards included pure powdered arsenopyrite (FeAsS), arsenic trioxide (As₂O₃) and scorodite (FeAsO₄·2H₂O) in order to cover a wide range in oxidation state (-I, III and V respectively).

Results: The micro-XANES analysis has determined the presence of mixed oxidation states (III and V) within roaster-derived iron oxide grains. The mixed oxidation state is present in all ages of tailings (fresh from the mill to > 50-years old). Based on linear combination least squares fitting of our standards to the 'unknown' spectra (Using WinXas™, Ver. 2.3), the As III content varies, but is typically 20% to 40% with the balance being As V. Total arsenic content in these grains by EMPA are in the range of 3 to 6% (w/w). Weathered iron oxyhydroxide rims on pyrite also contain arsenic at similar concentrations. However, micro-XANES spectra of these phases identified only As -I and As V.

Conclusions: Results of this work indicate the persistence of As III in roaster-derived iron oxide phases in 50-year old, unsaturated and oxidizing tailings. Weathered pyrite grains from the same zone have developed arsenic-bearing iron oxyhydroxide rims that contain only As V. This suggests that arsenic bound to (or within) the roaster-derived iron oxide phases may be more stable than arsenic sorbed to iron oxyhydroxides.

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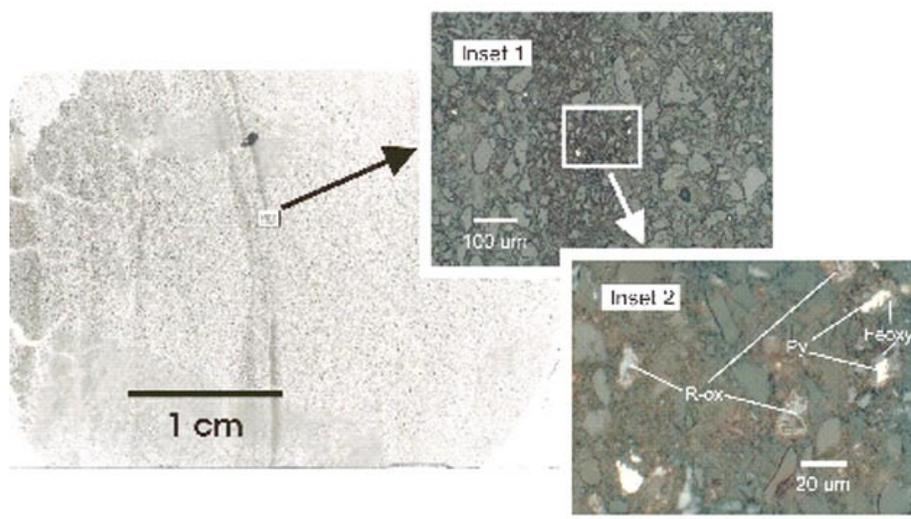


Figure 1. Thin section scan of stratified 50-year old tailings. Insets 1 and 2 are plane polarized reflected light photomicrographs which provide progressive magnification of one of the darker silt layers. Darker layers are calcine-rich and contain arsenic-bearing roaster iron oxides (R-ox, Inset 2). Two weathered pyrite (py) grains with arsenic-bearing iron oxyhydroxide rims (Feoxy) are identified for comparison.