Variability in soil geochemistry in the Yellowknife region beyond mine lease boundaries

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Introduction

Legacy mining activities in the Yellowknife region have resulted in significant land and water contamination due to poor or non-existent emission controls during the early years of mine operation. At Giant Mine arsenopyrite-bearing (FeAsS) Au ore was roasted from 1949 until 1999, resulting in the release of an estimated 20,000 tonnes of roaster generated arsenic trioxide (As_2O_3) to the surrounding environment[1]. To assist in characterizing the extent of contamination caused by mining activities, regional scale data representative of un-impacted areas, as well as potentially impacted areas, has been collected in order to compare differences in soil geochemistry at a number of sites. The average background concentration of arsenic in and around the Yellowknife area was determined to be 150 mg/kg by the Government of the NWT[2]. Remediation objectives for arsenic in Yellowknife area soils are 160 and 340 mg/kg for residential and industrial land use areas, respectively[2].

Primary Research Objectives:

1. Characterize the behavior of arsenic within various soil units.

- How much arsenic is present? And in what form (species)?
- Is the arsenic naturally derived from the weathering of arsenic rich bedrock? Or is it present as a result of roaster stack emissions?

2. Determine the extent of arsenic contamination within a 30km radius from the City of Yellowknife.

- What is the spatial extent of roaster stack emissions from Giant Mine?
- Are some areas impacted more heavily than others?

Study Area

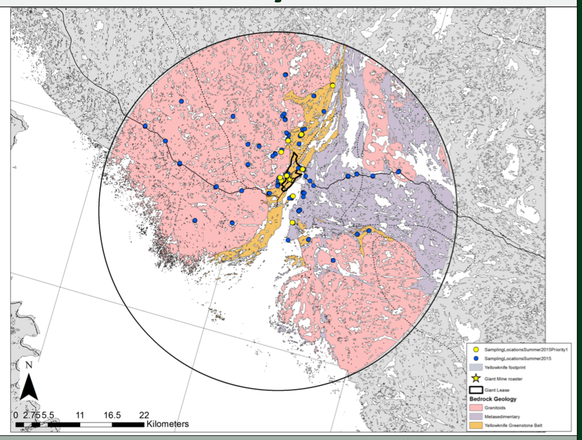

Figure 1. Map of study area around Yellowknife showing sample locations in relation to Giant Mine lease boundary.

Soil samples were collected from approximately 165 sites within a 30km radius of Yellowknife over a 6 week period during the summer of 2015. The goal of the regional soil sampling survey was to achieve a large spatial distribution of sample sites throughout a variety of soil media. Four primary units were sampled within the study region: outcrop soils, forested canopy soils, wetland soils and peat.

Methods

Target areas were selected based on 1) ease of accessibility, 2) distance from the former Giant roaster, 3) direction from the roaster with respect to prevailing wind direction, and 4) location with respect to past or on-going research. Within each target area multiple sample sites were chosen with the primary goal of avoiding disturbed areas.

Sample Collection:

- Soil cores were retrieved with Al tubing that was driven into the soil surface using a drive-head and a sledgehammer, or by cutting into the peat using a saw.
- In areas where core samples were not feasible, grab samples were retrieved.
- Cores and grab samples were frozen for transport back to Queen's University in Kingston, ON.

Figure 2. A) Peat core sample being labeled at a sample site. B) Outcrop soil core sample being measured on a high outcrop out Ingraham Trail.

Sample Sites

Various soil types were investigated to compare the degree and characteristics of contamination between the different units. Sample sites were selected based on the availability of various soil units, as well as the quality and quantity of soil at site. At some locations multiple soil samples of a similar soil unit were collected to test for local site variability.

Figure 3. A) A grab sample taken from an outcrop soil pocket. B) A peat sample retrieved from the peat land off the Bypass Road. C) An outcrop soil pocket sampled during the first day of field work. D) A wetland soil core sample taken within close proximity to lake YK-67. E) A forested canopy area high up on an outcrop. James gets ready to drive in an Al-core using the drive-head and sledgehammer.

Ongoing & Future Work

All soil samples were kept frozen prior to lab preparation. The soil cores will be cut open and sub-sectioned using a variety of methods depending on the type of sample. Priority samples downwind from the roaster are currently being prepared for analyses. ICP-MS and ICP-OES methods will be used to test for total arsenic and metal concentrations. Sub-sectioned material will also be set aside for SEM-MLA analyses, which will be used to identify the species of arsenic persisting within the soils.

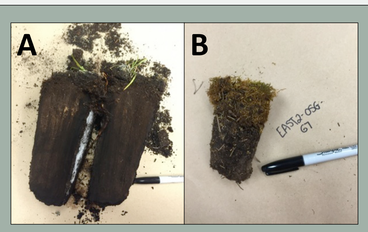

Figure 4. A) Frozen peat sample being sub-sectioned at ASU. B) Frozen outcrop grab sample.

Previous and ongoing research in the area has been focused on the extent and fate of arsenic and other mining-related contaminants in local lake waters and sediments. A regional-scale soil sampling initiative will complement previous geochemical surveys undertaken throughout the study area. This research will work towards understanding the connections between terrestrial and aquatic systems in the region by filling knowledge gaps in soil geochemistry and mineralogy. It is hoped that new tools and methodologies to differentiate between anthropogenic and natural forms of arsenic will also be developed and refined as a result of this work.

Acknowledgments

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