Windblown Tailings Dust as a Source of Metals to Surface Water

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Background & Objectives

- Uncovered tailings provide a source of dust including fine particles containing metal or metalloids of concern

- Changing climate and intense weather events may increase dust generation

Do tailings minerals dissolve in receiving water?

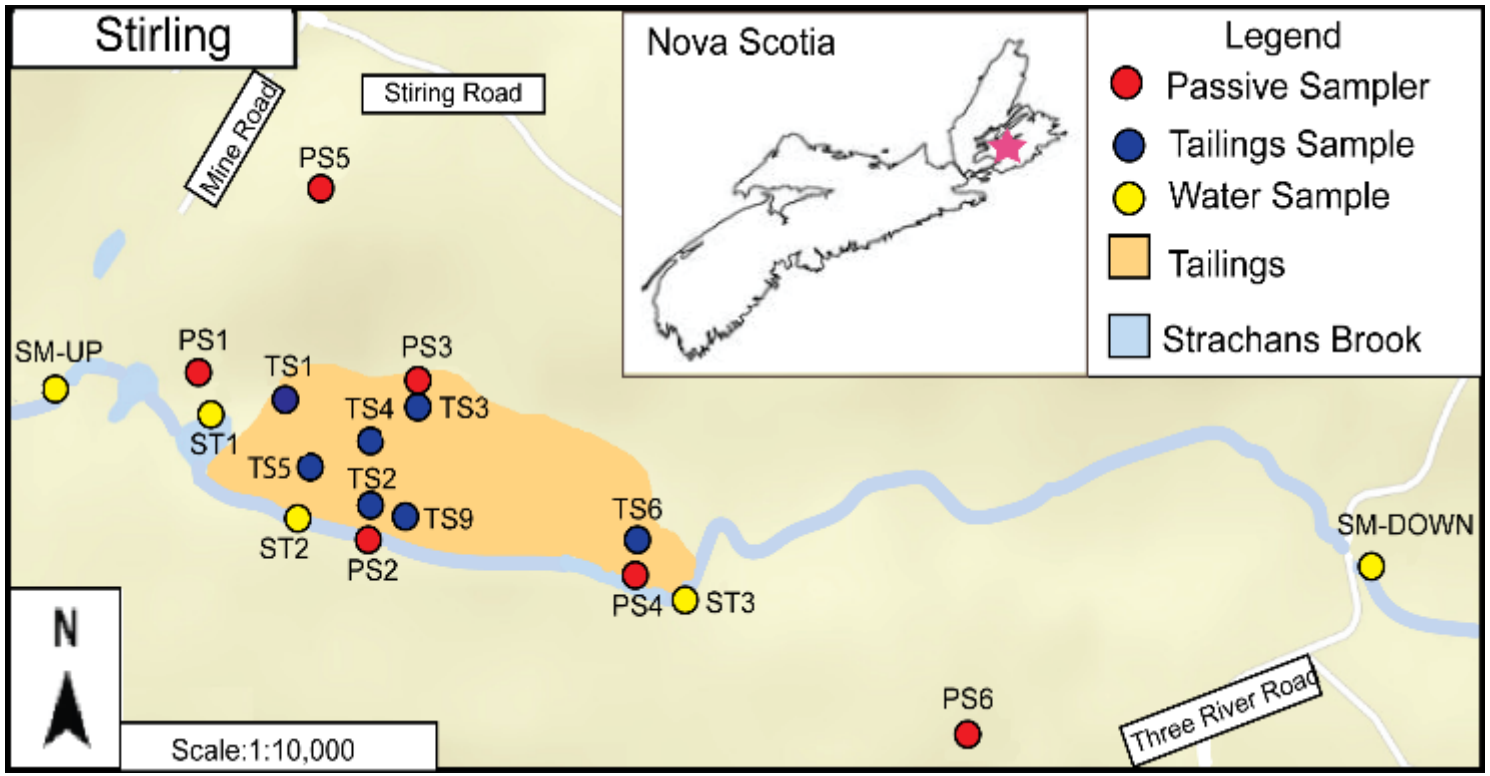
How important is this source of dissolved metal?

Case study #1. Stirling mine, Nova Scotia

- Abandoned Zn-Pb-Cu-Au-Ag deposit
- Operated 1935-1938 and 1952-1956
- Hosted in siltstone-chert-dolomite

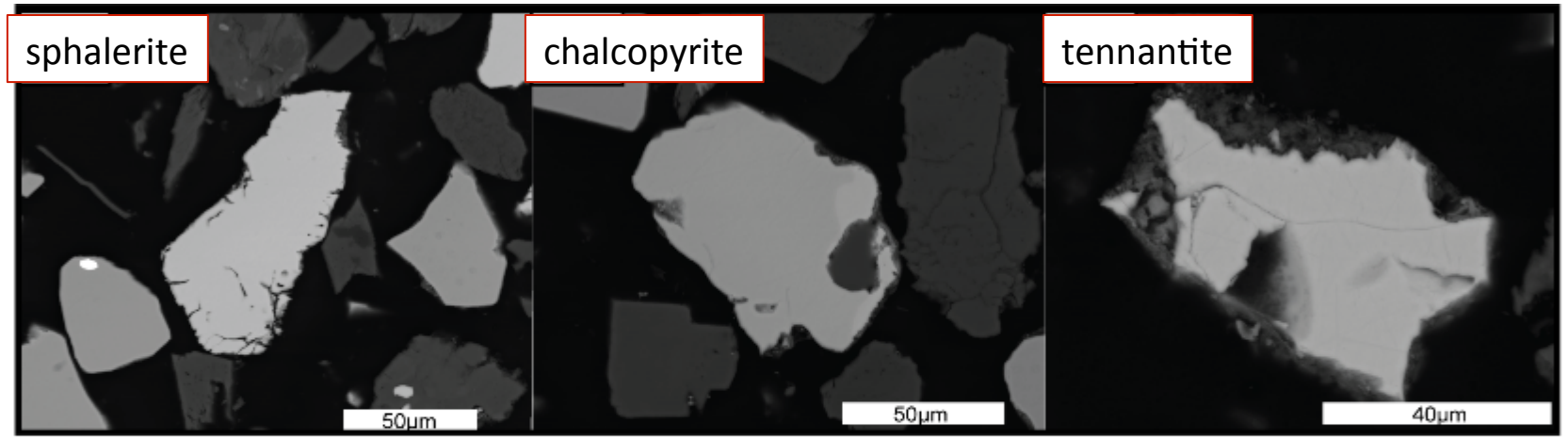
Tailings were sieved to <63µm as proxy for dust

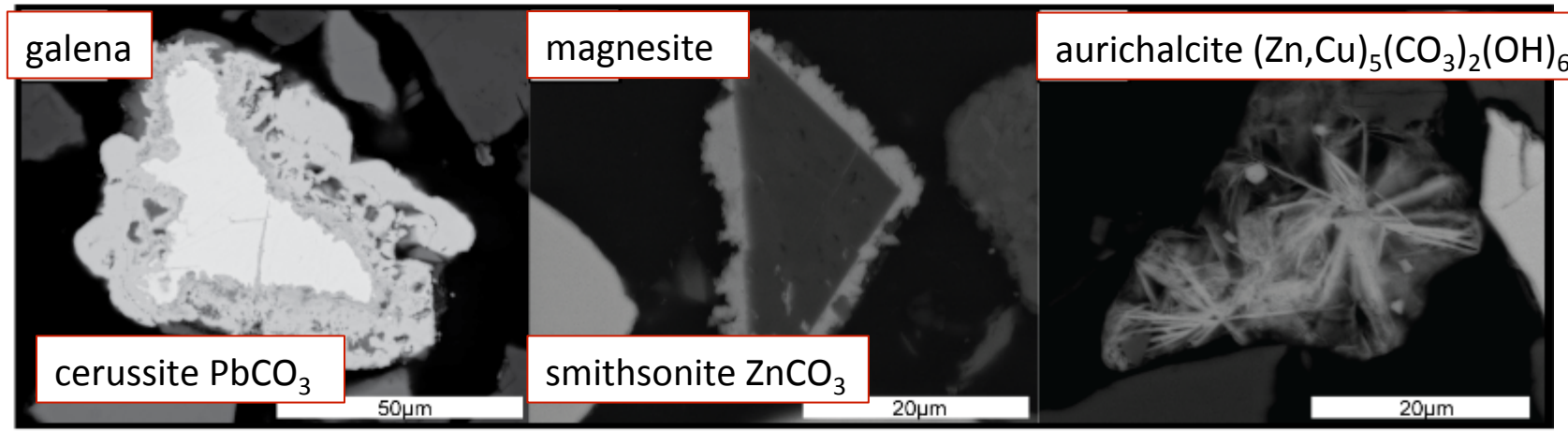
Passive dust samplers provided information on metal content and deposition rates, but insufficient sample for detailed mineralogy

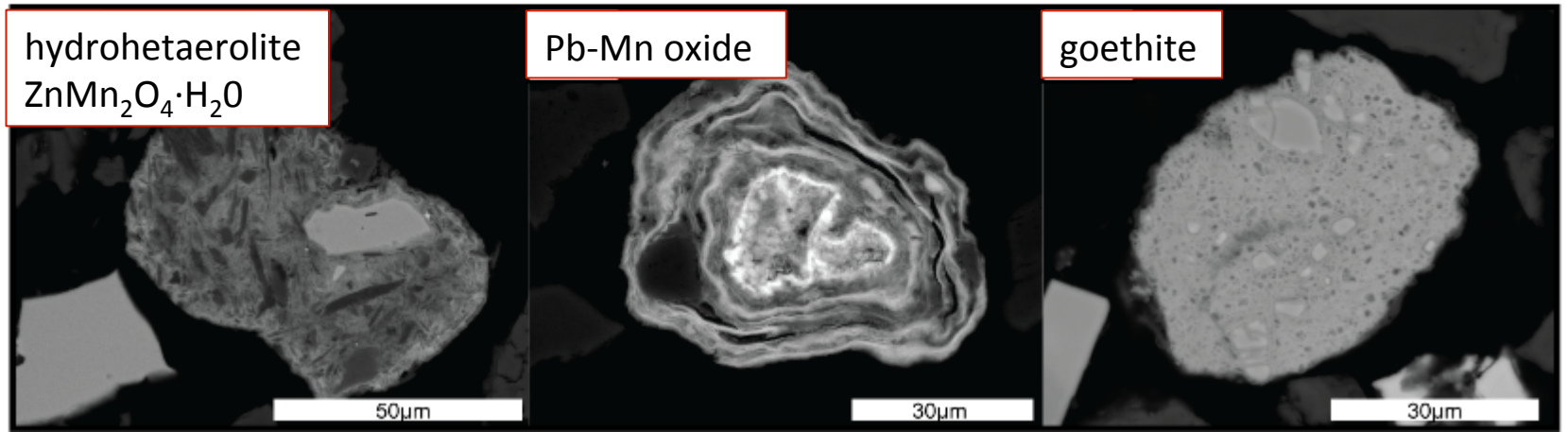


0.12 km^2 of tailings adjacent to small, shallow brook

Tailings are sulfide-rich (20 to 40% pyrite)
Surface water is near neutral (pH = 6 to 7)



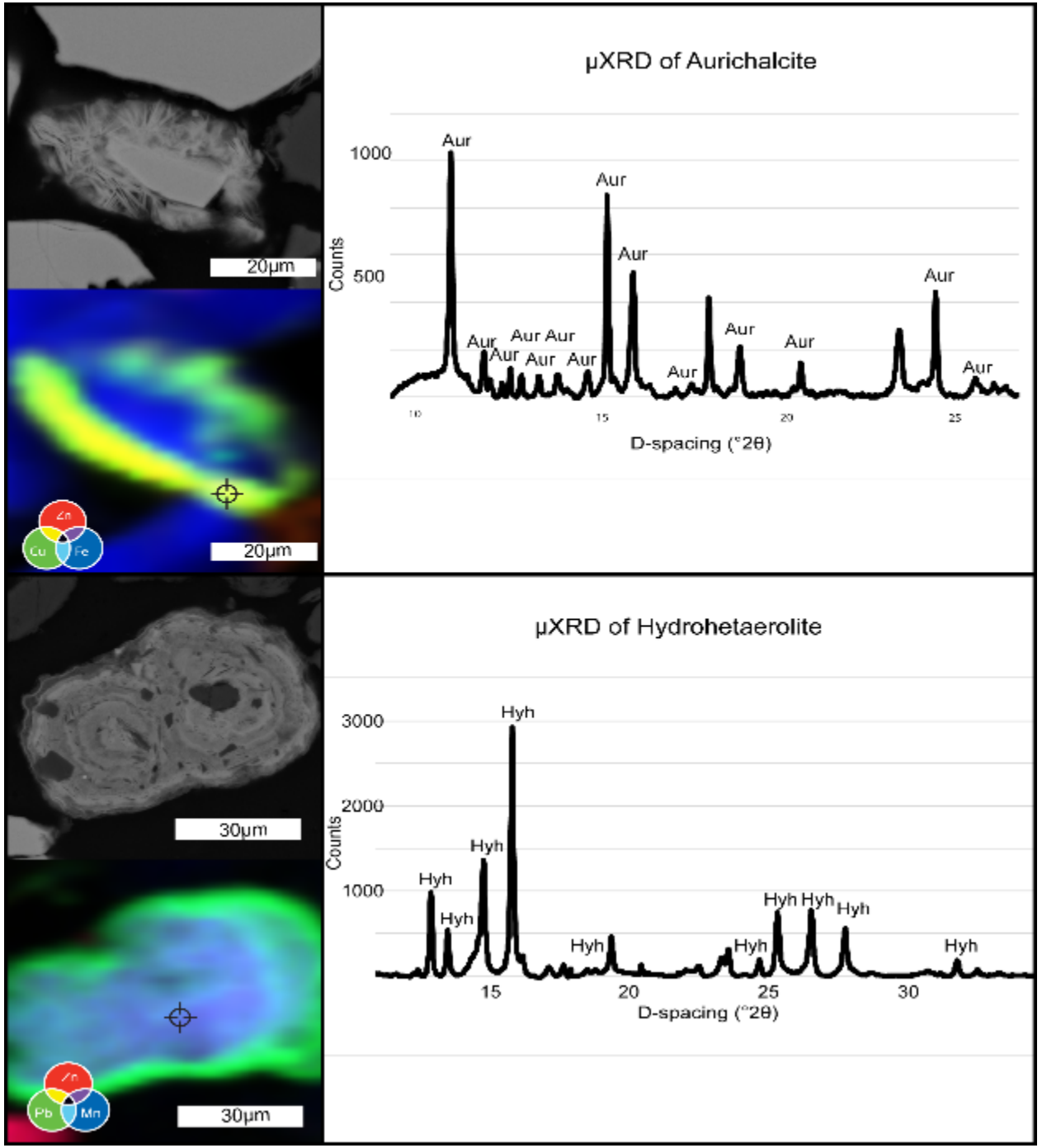




Primary sulfides

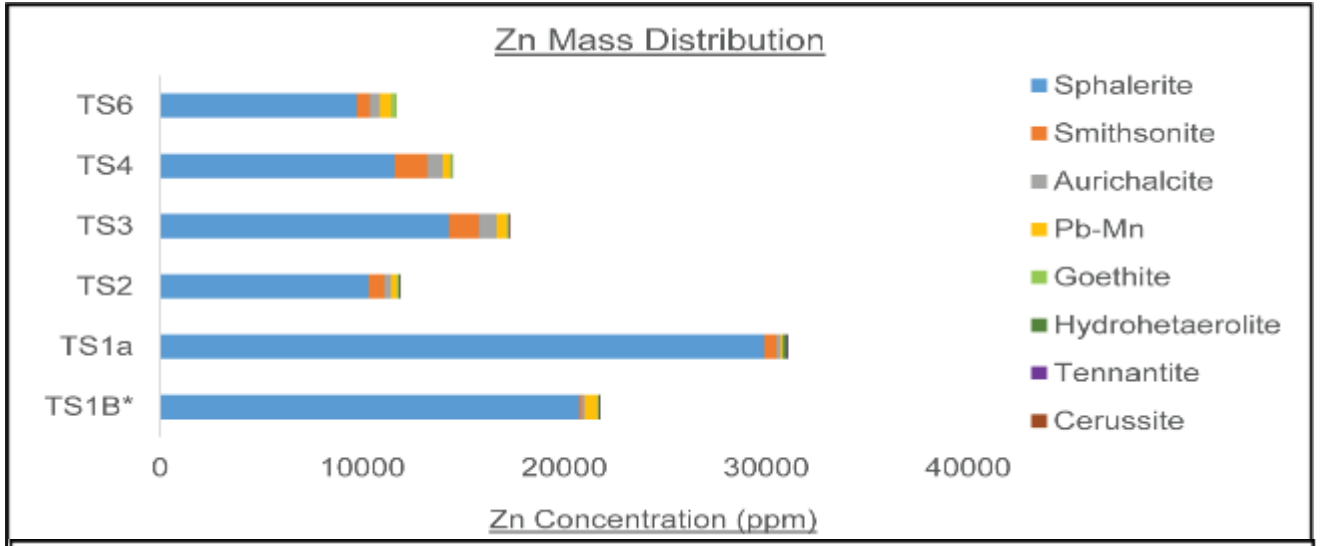
Secondary carbonates

Other secondary minerals

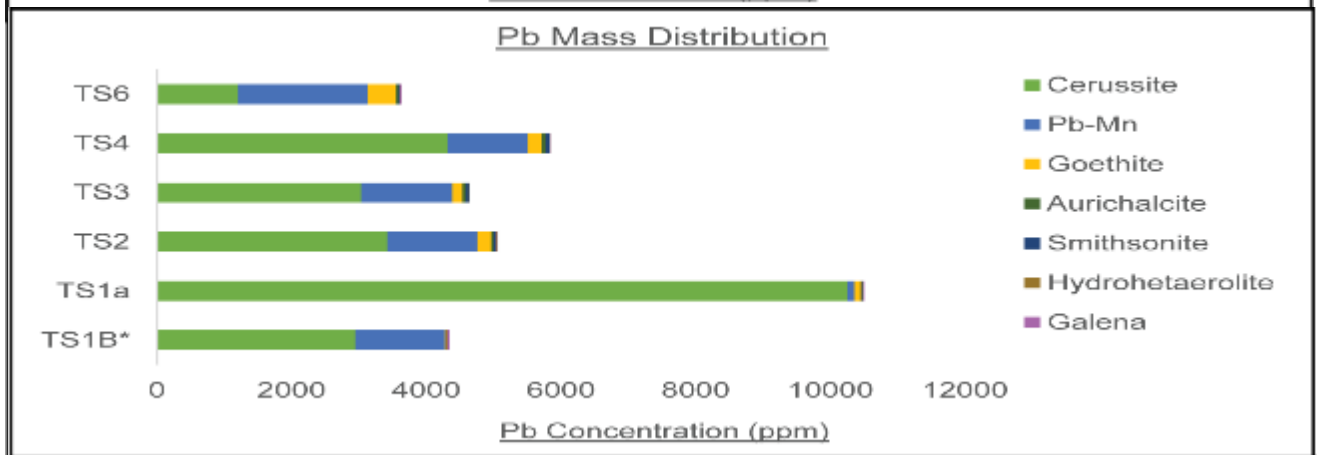


Synchrotron-based element mapping and micro X-ray diffraction

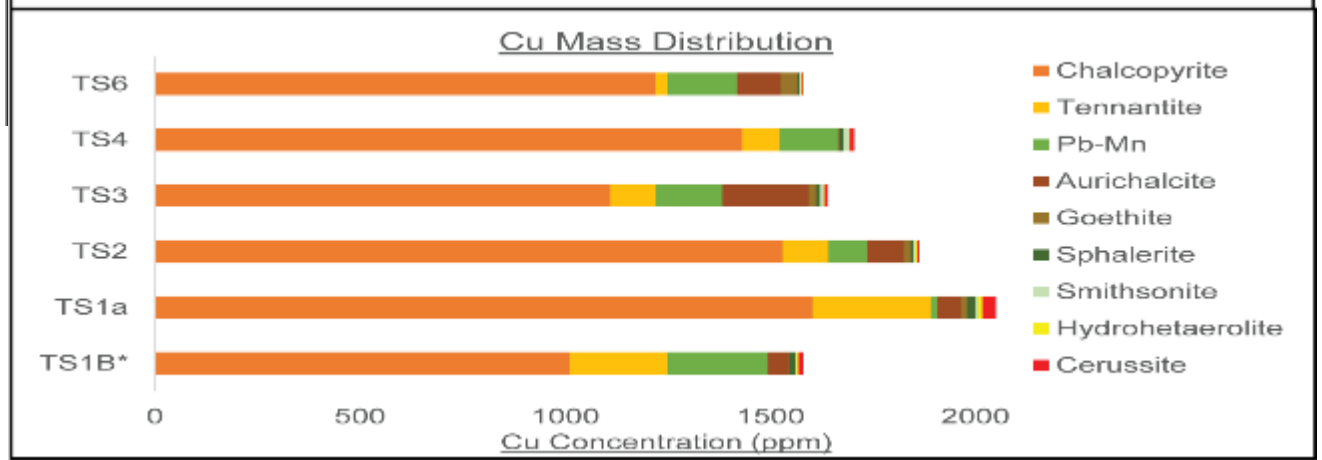
Metal concentrations & Mass Distribution in Tailings



Zn mainly hosted in sphalerite



Pb mainly hosted in cerussite (Pb carbonate)
Pb-Mn important oxides in some samples



Cu mainly hosted in chalcopyrite

Simulated stream
water pH= 7
No Zn, Pb or Cu

After 24 hours,
pH= 6.6 to 6.8
Zn 2700 ppb
Pb 80 ppb
Cu 5 ppb

- Shake flask tests indicate Zn, Pb, Cu are leached at neutral pH
- PHREEQC indicates all primary and secondary metal hosts are undersaturated except goethite
- Inverse modeling and mineralogical observations suggest sphalerite, cerussite and chalcopyrite are sources

Case study #2. Giant mine, Yellowknife, NT

- Former Au mine 1949-1999
- Ore roasted to release gold from arsenopyrite
  - Roaster waste includes As-bearing iron oxides and arsenic trioxide
  - Iron oxides were co-deposited with tailings
  - Arsenic trioxide released through stack emissions, then stored underground

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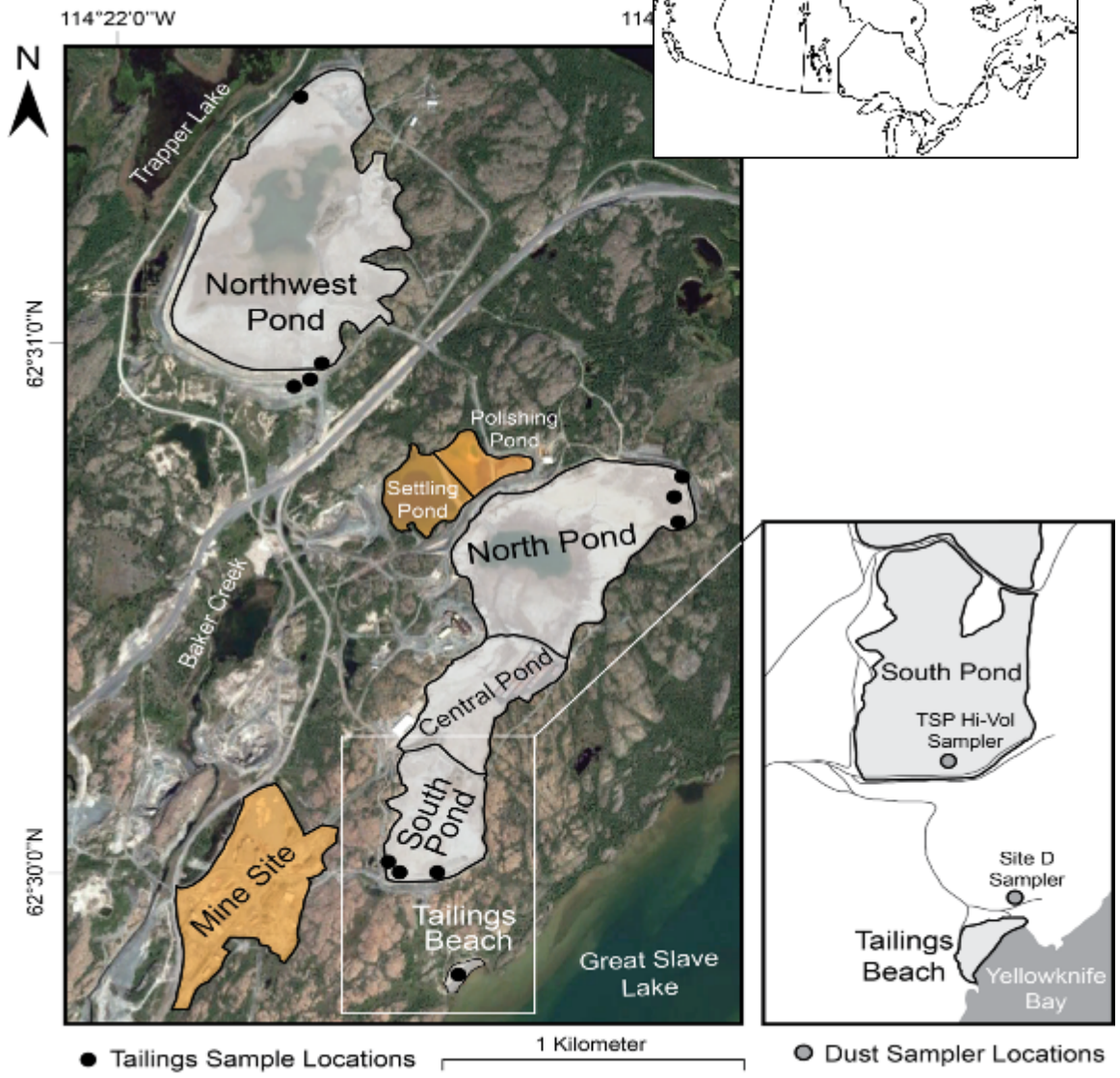
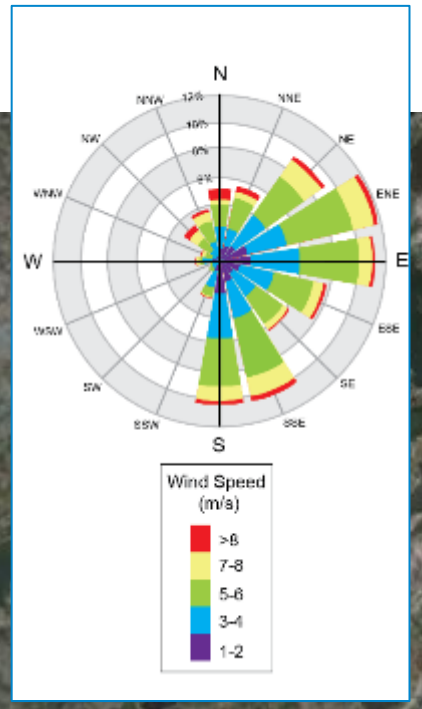
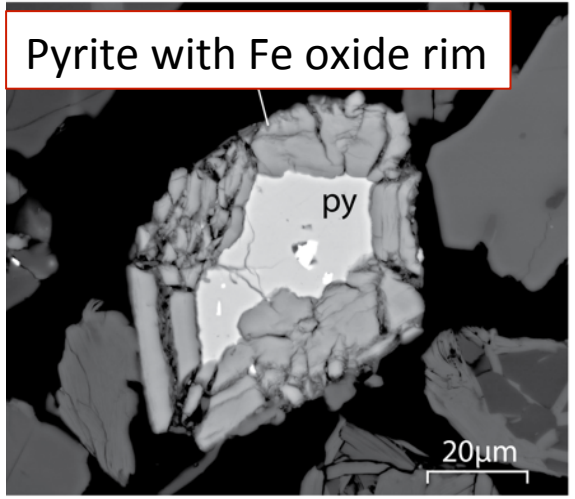


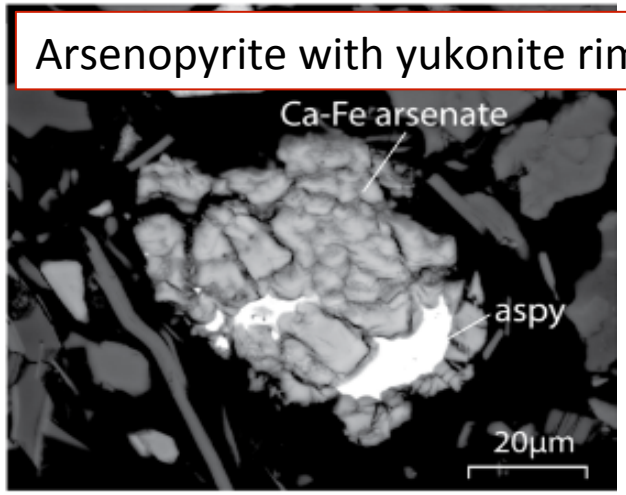


May 22, 2015: Photo of dust, taken from Ndilo (CBC 2015)

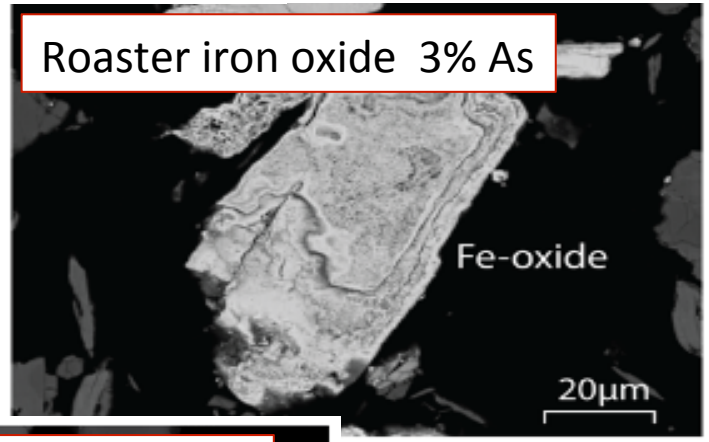
Motivation for the study :
Determine if there is arsenic trioxide in windblown tailings dust

Arsenic hosts

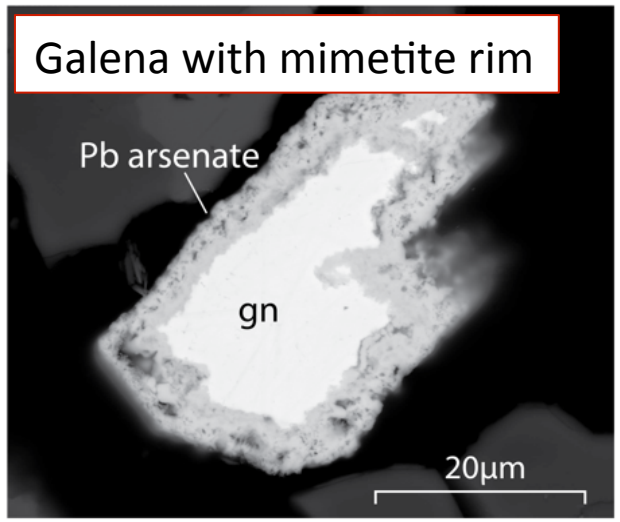


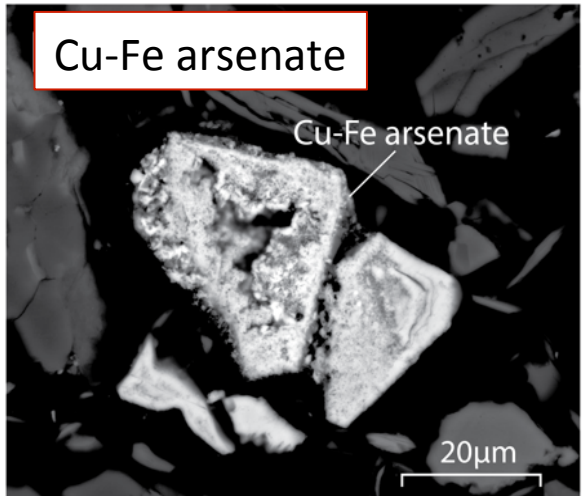


Primary sulfides with secondary rims

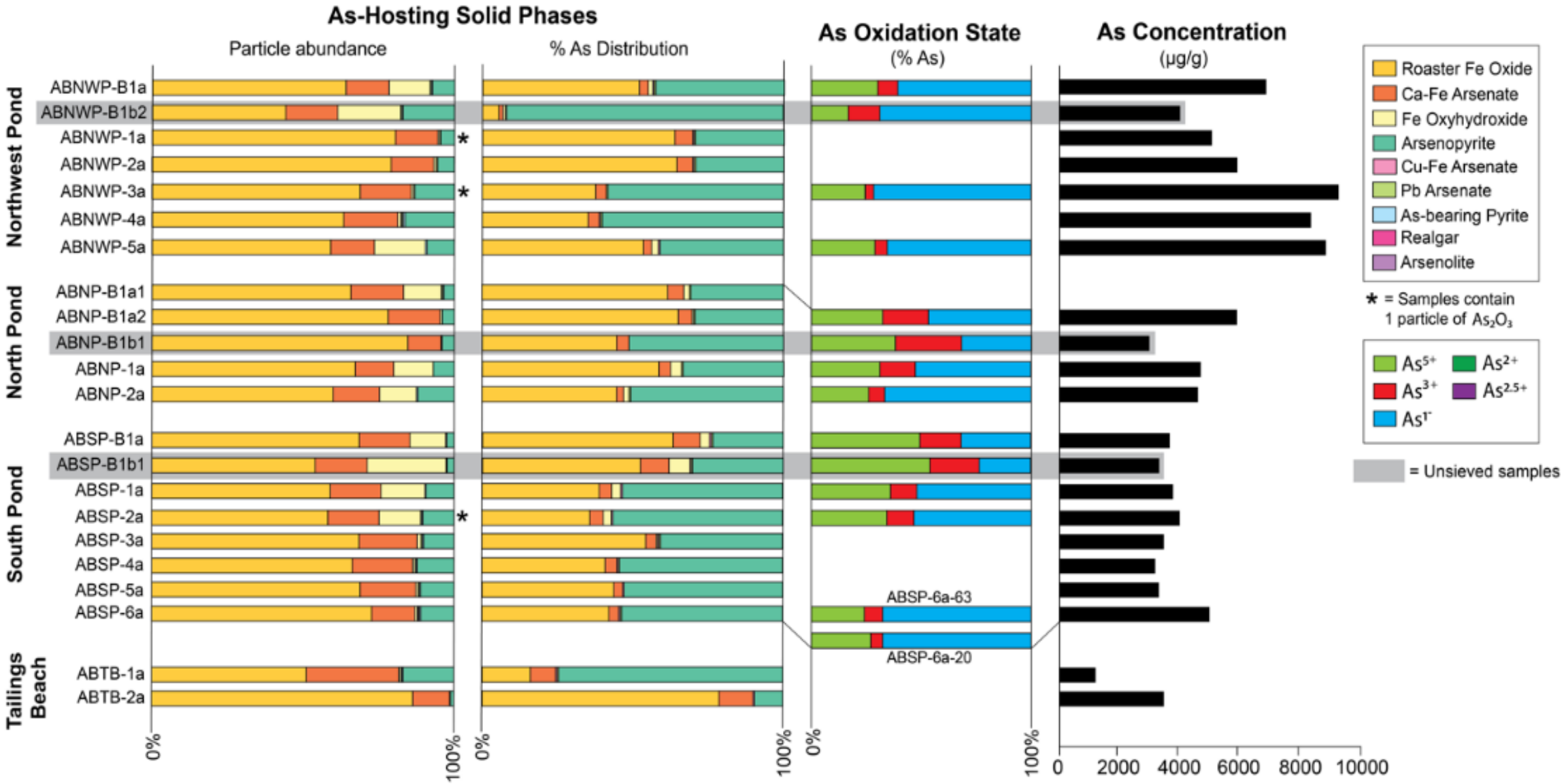


Roaster iron oxide (maghemite) with As





Primary sulfides with secondary rims from roaster or weathering



Only <u>3 particles</u> of As_2O_3 found in surface tailings samples.

Most of As is concentrated in **roaster Fe-oxides** and **arsenopyrite**.

As^{5+} and **As^{1-}** are the dominant oxidation states of As in the surface tailings.

Arsenic appears to be more concentrated in the <63µm fraction of the tailings.

Multiple sources of arsenic to Yellowknife Bay

Includes arsenopyrite, iron oxide with As, arsenic trioxide, etc.

Recent research shows that lake sediments will release arsenic to overlying water under reducing conditions (Chêtelat et al. 2020)

Conclusions and Practical Applications

- Primary minerals, secondary minerals and processing waste can dissolve in pH-neutral surface water
- Impact of windblown dust on water quality depends on
  - Tailings mineralogy
  - Receiving water composition
  - Conditions of sediment-water interface, especially in lakes
- Knowing dust mineralogy provides insight into possible effects on water
- Importance of dust to overall water quality depends on site-specific factors

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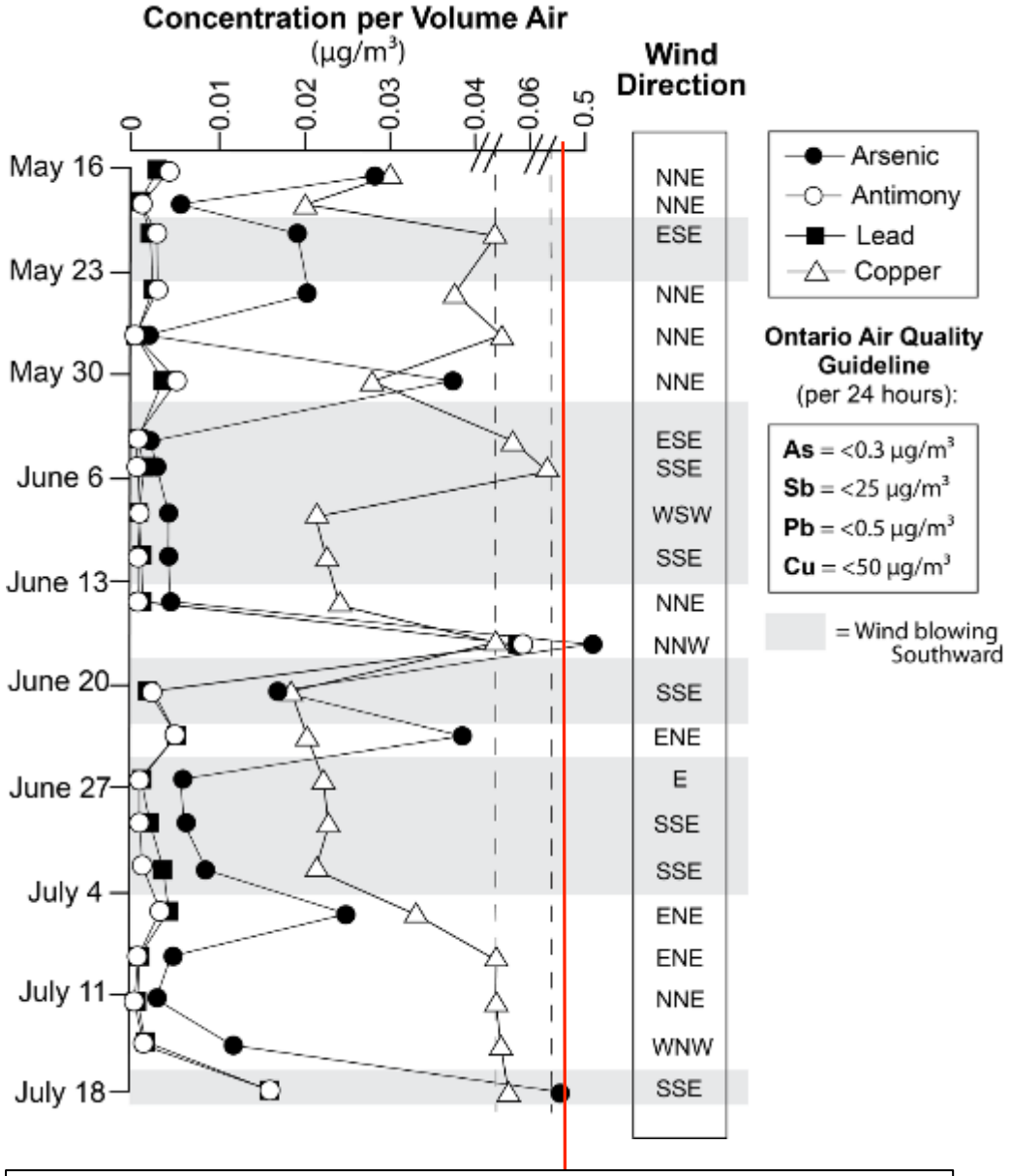
4. Results



0.3µg/m³ As = Ontario's Ambient Air Quality Criterion (AAQC)