Magnetite as a Porphyry Copper Indicator Mineral in Till

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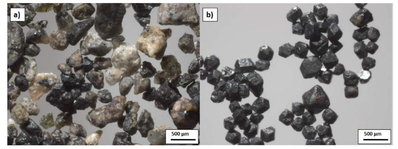
Objectives

- Prospective Mesozoic calcalkaline and alkaline intrusive igneous rocks for porphyry Cu-Au deposits in the Canadian Cordillera are often overlain by a thick glacial sediment cover – a major hindrance for exploration
- Magnetite (Fe_3O_4) is a ubiquitous mineral in porphyry systems and is resistant to weathering and glacial transport
- We want to determine if the trace element signature of magnetite in till can provide a unique exploration vector for identifying mineralized porphyry systems in glaciated terrain
- Using the Mount Polley porphyry Cu-Au deposit, south-central British Columbia, the composition of magnetite in basal till is examined as a function of distance to the deposit

Methodology

- 74 till samples were provided by the TGI-4 program covering an area of ~700 km² surrounding the Mount Polley porphyry Cu-Au deposit
- Magnetite is separated from heavy mineral concentrates for each till sample, and 100-125 magnetite grains per sample are randomly selected, mounted in epoxy and polished for analysis



- **Reflected light microscopy and the scanning electron microscope (SEM)** identifies different exsolution and alteration phases, as well as mineral inclusions present in some grains
- **Laser-ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS)** is performed on 50 magnetite grains per till sample
  Sc, Ti, V, Mn, Cr, Co, Ni, Cu, Zn, Ga, Nb, Mo, Sn, Ta, W
- **Electron microprobe (EMP)** is primarily used to identify the concentration of the internal standard (^{57}Fe) used in LA-ICP-MS trace-element analysis
  Mg, Al, Si, Ca, Ti, V, Cr, Mn, Fe, Ni
- As part of a concurrent study, the trace element composition of magnetite has been determined for various porphyry deposits in British Columbia, including Mount Polley
- With a large enough database of till magnetite chemistry, the next step will be to use discriminant functions as a possible quantification method for 'scoring' magnetite provenance

Acknowledgements

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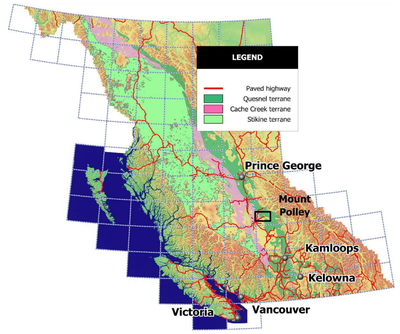
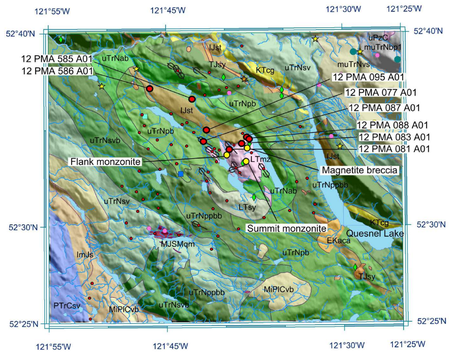
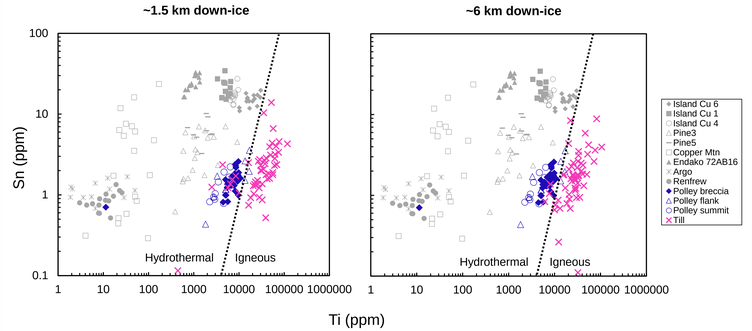
Mount Polley Porphyry Cu-Au Deposit





Magnetite Chemistry: Till vs. Mount Polley



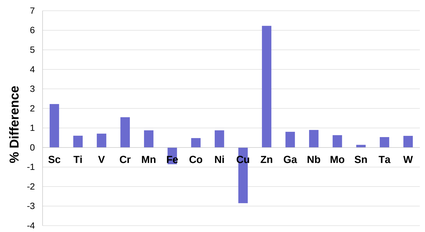
- Hydrothermal magnetite from various porphyry deposits in BC have a unique trace-element signature that differs from magnetite in igneous rocks (Grondahl, 2014)
- The proportion of magnetite grains with the Mount Polley signature is detectable to a distance of ~6 km down-ice (northwest) of the deposit

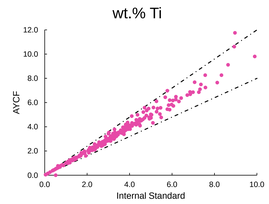
AYCF Method: Standardless LA-ICP-MS Analysis

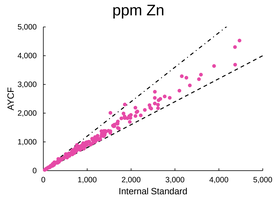
- **Ablation Yield Correction Factor Method*:** normalization of the sum of all cations to 72 wt.%
- Corrects the matrix-dependent absolute amount of material ablated
- No internal standardization → no further analysis by EMPA required

$$AYCF = \frac{72}{\sum_{j=1}^{N}\left(cps_{sam}^{j} x l^{j}\right)}$$

AYCF Method vs. Internal Calibration





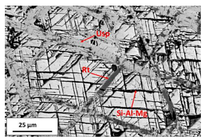


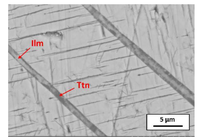
Left: Average % differences between element concentrations calculated by internal standardization versus the AYCF method (n=259).

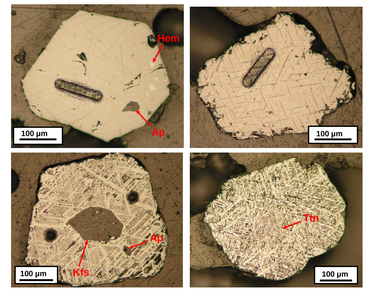
Above: Element concentrations for all data show that the AYCF method is accurate well within +/- 20% (dashed lines).

* Liu, Y. et al. *Chemical Geology* **257**, 34-43 (2008).

Petrography



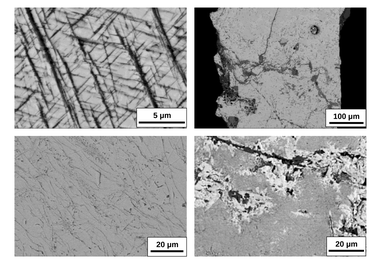




Right: Variety of habits, textures, inclusions and alteration types is observed in magnetite from till (reflected light images).

Above: Exsolution lamellae are identified as either ulvöspinel or ilmenite (BSE images).

Below: Alteration to titanite (sphenitization) occurs on exsolution lamellae, along preferred crystallographic planes or disseminated randomly throughout grains (BSE images).



Sphenitization