Geochemical and mineralogical dispersal in till from the Mount Polley Cu-Au porphyry deposit, central British Columbia, Canada

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Abstract

Mount Polley Mine is an alkaline, silica-under saturated Cu-Au porphyry deposit owned by Imperial Metals Ltd. It is located 8 km southwest of Likely, within the Interior Plateau of British Columbia. This region was glaciated several times during the Quaternary and is predominantly covered by till. This makes it an ideal site to develop drift prospecting exploration methods for detecting buried mineralization. Glaciers are dynamic, eroding bedrock, and transporting and depositing the resulting debris as till in the direction of ice movement. If a glacier erodes mineralized bedrock, the resulting till will be enriched in elements and minerals derived from the mineralization. Porphyry mineralization and the associated alteration zones are spatially extensive, which may result in large dispersal trains in till. The objective of this research is to characterize the geochemical and mineralogical composition of till in the Mount Polley region in order to identify key indicators of porphyry mineralization in till, benefiting future exploration for porphyry deposits in areas of thick drift cover. This research is funded by the Geological Survey of Canada's Targeted Geoscience Initiative (TGI-4) program. Dominant ice flow in the Mount Polley region is to the northwest with an earlier west-southwestward flow. During the 2012 and 2013 field seasons, 87 till samples were collected up-ice, overlying and down-ice from the deposit based on these flow measurements. Elements and minerals associated with the mineralization show elevated content near the deposit, which progressively decreases towards the northwest (or down-ice direction). These include copper, silver (in the 2 µm fraction) and gold (in the 63 µm fraction), up to 1548 ppm, 503 ppb and 90.2 ppb, respectively. Gold grain content of up to 87 grains per 10 kg is observed in the silt-fine sand fraction. In the heavy mineral concentrates (s.g > 3.2), apatite (up to 0.5%), chalcopyrite (up to 98 grains per 10 kg), and epidote (up to 90%), observed in the 0.25 – 0.5 mm fraction. Gold grain, chalcopyrite, and epidote are excellent indicators of Mount Polley mineralization. However, apatite may not be a suitable indicator of Mount Polley mineralization in till.

Introduction & Objectives

- The Interior Plateau of British Columbia has been glaciated numerous times throughout the Pleistocene resulting in areas of thick glacial deposits that obscure the bedrock
- It hosts several economic porphyry deposits and also holds potential for undiscovered deposits
- It is an ideal region to test drift prospecting techniques because of gaps in knowledge of the surficial material and Quaternary history
- Drift prospecting utilizes a combination of field and laboratory methods including:
  - Surficial mapping to identify glacial sediments, geomorphic expression and till sampling locations
  - Till sampling and ice-flow measurement to determine direction of transport via glaciers
  - Geochemical analysis of the till matrix to determine element content and separation of the heavy mineral fraction to determine the mineral content
  - Analysis of geochemical, mineralogical and lithological results using spatial and statistical software to identify the location of mineralized bedrock
- This research project is part of the Geological Survey of Canada's Targeted Geoscience Initiative rogram (TGI-4), with the main objective of providing the mining industry with tools for effective exploration of buried mineralization in central British Columbia. This research project will contribute towards the mandate of the TGI-4 by:
  - Applying a refined approach to drift prospecting methods by incorporating unconventional methods such as till mineralogy (previously used in diamond exploration) with traditional till geochemistry, as well as taking advantage of the recent advances in analytical procedures, to identify the extent and characteristics of the geochemical and mineralogical dispersal in till from the Mount Polley deposit

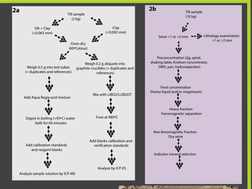
Methodology

- Sampling unweathered basal till (Fig. 1a, b, c) and identification of ice-flow indicators, such as rat tails, grooves and striations, on outcrops (Fig. 1d, e, f)
- The clay (<2 µm) and silt + clay (63 µm) sized fractions were separated from the 2 kg till samples (Fig. 2a) and submitted for geochemical analyses to Acme Analytical Laboratories Ltd. in Vancouver, BC
- The 10 kg samples were submitted for indicator mineral analyses to Overburden Drilling Management (ODM) in Ottawa, ON (Fig. 2b)

- Element content was determined using:
  a) Aqua regia digestion and ultratrace ICP-MS analysis and
  b) Lithium borate tetraborate, HNO_3 digestion and ICP-ES analysis (Fig. 2a) for 48 elements and compounds
- The coarse fraction (<2 mm) are processed using density concentration methods (Fig. 2b) followed by examination for porphyry indicator minerals (PIMs)

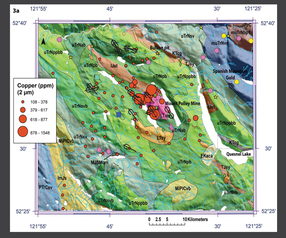
Figure 1: (a) Typical road cut till section, (b) Till sample, (c) Profile sampling of a till section within the WX Zone at Mount Polley, approximately 8 m high. Ice-flow indicators measured on bedrock outcrops in the Mount Polley region. White arrows points in the direction of ice-flow. Azimuths are given above the arrows (d) Rat tails and striations, (e) Rat tail, (f) Striations and grooves.

Figure 2: (a) Geochemical analysis done on till fractions at Acme Analytical Laboratories Ltd., (b) Heavy mineral separation procedure conducted at ODM.

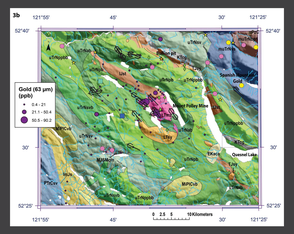


Results: Proportional dot maps generated for elements and minerals of interest

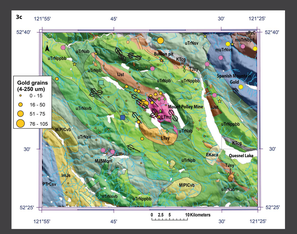
Copper (2 µm; Aqua Regia digestion, ICP-MS)



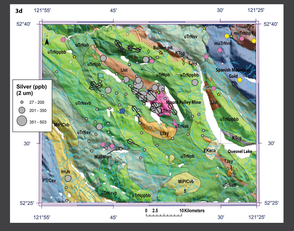
Gold (63µm; Aqua Regia digestion, ICP-MS)



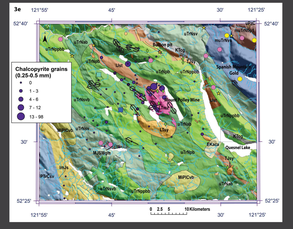
Gold grains (4-250 µm, normalized to 10 kg bulk till)



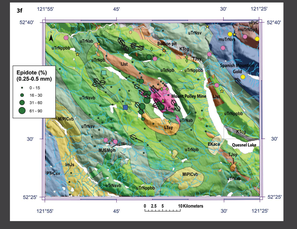
Silver (2 µm; Aqua Regia digestion, ICP-MS)



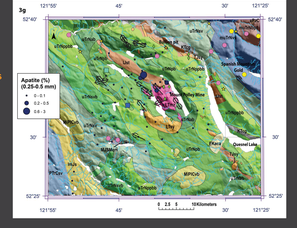
Chalcopyrite grains (0.25-0.5 mm fraction, normalized to 10 kg bulk till)



Epidote % (0.25-0.5 mm)



Apatite % (0.25-0.5 mm)



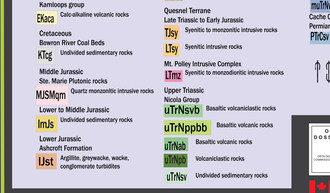


Figure 3: Dot proportional plot for (a) Copper, (b) Gold, (c) Gold grains, (d) Silver, (e) Chalcopyrite, (f) Epidote, (g) Apatite.

- The results were plotted in ArcGIS to determine the dispersal length and pattern for the elements and minerals
- The proportional dot maps depict the glacial dispersal train in till for elements and minerals derived from the mineralization at Mount Polley

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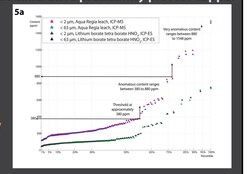
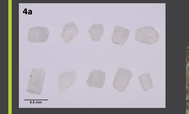
Discussion

- Ice-flow measurements indicate two dominant phases of ice-flow movements: a first phase generally to the west-southwest followed by a dominant northwestward flow
- The dot proportional and cumulative frequency curves (Fig. 5a, b, c) provide regional background values of approximately 380 ppm, 20 ppb and 200 ppb for copper, gold and silver, respectively
- Anomalous content values for elements and minerals associated with the Mount Polley porphyry deposit are dispersed at least 4.9 km (Ag and gold grains), 3.8 km (Au), 3 km (Cu), 2.4 km (apatite), 2.4 km (epidote) and 840 m (chalcopyrite) to the northwest and 2.5 km (epidote) to the southwest
- Spatial variations in gold (element and mineral) data suggests other gold sources (both unknown and known), such as the Bullion Placer deposit, which may be contributing to the anomalous geochemical and mineralogical signal in till
- Of the two fractions (clay (<0.002 mm) and silt + clay (<0.063 mm) analyzed for element content, the clay fraction showed higher content values for copper and silver, whereas the silt + clay fraction showed higher content values for gold (Fig. 5)
- There was no significant variation in copper content between the two analyses packages; however, the anomalies are slightly more pronounced using Aqua Regia digestion and analysis by ICP-MS
- This slight difference may help to identify subtle dispersal plumes from porphyry mineralization
- Anomalous content values for copper in both the 2 µm and 63 µm fractions and both analyses packages start at approximately the 60th percentile (Fig. 5a)
- Anomalous content values for gold in the 2 µm and 63 µm fraction start at approximately the 55th and 75th percentile, respectively (Fig. 5b)
- Similarly, anomalous content values for silver in the 2 µm and 63 µm fraction start at approximately the 55th and 60th percentile, respectively (Fig. 5c)

Cummulative probability plot for copper





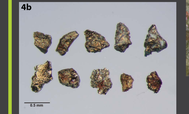
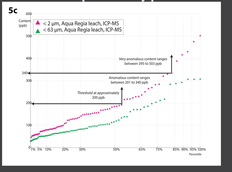
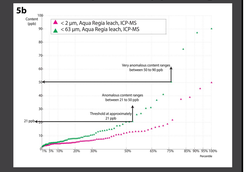


Figure 4: Heavy mineral fractions recovered from till samples (a) Apatite, (b) Chalcopyrite, (c) Epidote.

Cummulative probability plot for silver



Cummulative probability plot for gold



Conclusions

- Drift prospecting methods are well suited for porphyry deposits because the target area is large and the geochemical and mineralogical signature dispersed in till is widespread
- Based on themineralogical and elemental content of till, glacial dispersal to the northwest, related to the second phase of ice flow, is predominant. Dispersal of epidote southwest and northwest of the mine could be related to the first and second phases of ice movements, respectively. If that is the case, dispersal of epidote to the southwest represents a palimpsest dispersal train, i.e. a train partly re-entrained during the second phase of ice movement
- Epidote, derived from the propylitic alteration found in bedrock west and south of deposit, is an effective indicator mineral for the Mount Polley deposit because of low regional background content of epidote in regional lithologies
- Apatite content in till near the mineralization is slightly higher than background regions (where the content values are slightly lower but not nil) and does not progressively decrease down-ice from the mineralization; therefore, it may not be well suited as an indicator of porphyry mineralization in till for the Mount Polley deposit

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