PIMS - Porphyry Indicator Minerals from Alkalic Porphyry Cu-Au Deposits in British Columbia

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Introduction

The common occurrence of resistate minerals in mineralized and altered portions of British Columbia's alkalic porphyry copper deposits suggest that these minerals can be utilized as indicators of mineralization and used for exploration in terrains covered by glacial till.


North view of Copper Mountain Mine (2012).

Porphyry indicator minerals (PIMS) are chemically stable in weathered environments, have a high specific gravity, are sufficiently coarse-grained and display characteristic features that can directly link them to a porphyry-related alteration assemblage.

These minerals typically display unique physical properties such as color, size and shape that allow their presence to be used as a prospecting tool in a similar manner to which kimberlite indicator minerals (KIMS) are used.

Copper Mountain, Mount Milligan, Mount Polley and Lorraine alkalic porphyry deposits are selected sites for this study.

Objectives

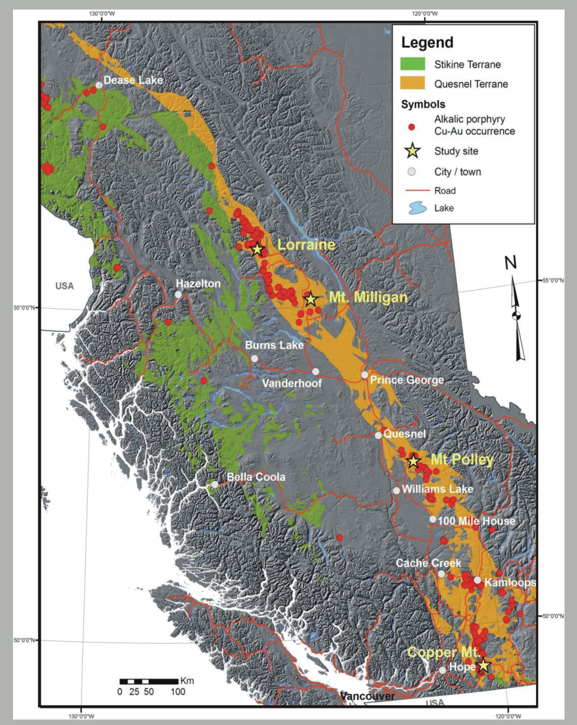
1. Determine assemblages and occurrence of indicator minerals within different alteration and mineralization types of selected BC alkalic porphyry Cu-Au deposits.
2. Determine the diagnostic physical parameters and chemical compositions of indicator minerals, particularly apatite, garnet, magnetite, rutile and titanite.
3. Evaluate abundance and size of PIMS in till sediments covering selected sites.
4. Establish criteria for use of resistate minerals as an exploration tool for alkalic porphyry deposits in south-central BC.

Alkalic Porphyry Deposits in BC

Alkalic porphyry deposits formed during two separate time intervals: Late Triassic to Middle Jurassic and Late Cretaceous to Eocene.

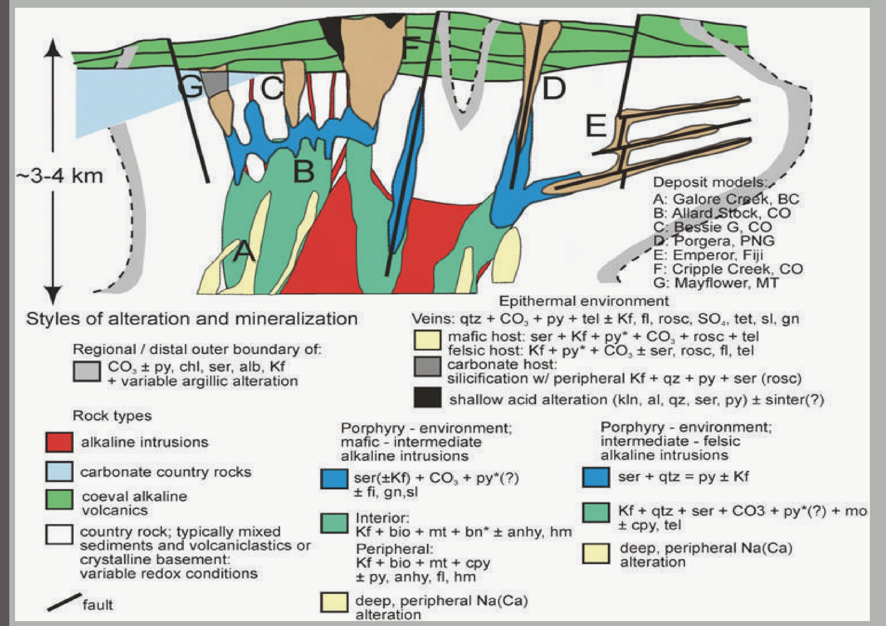
A Late Triassic to Early Jurassic magmatic arc formed prior or during the Quesnel and Stikine terranes accretion to the North American Continent. This arc defines two suites of alkalic intrusions, silica-saturated and silica-undersaturated, both hosting Cu-Au porphyry deposits in British Columbia.

Late Cretaceous to Eocene porphyry deposits formed in an intracontinental arc setting after the accretion and assembly of the Quesnel and Stikine terranes.

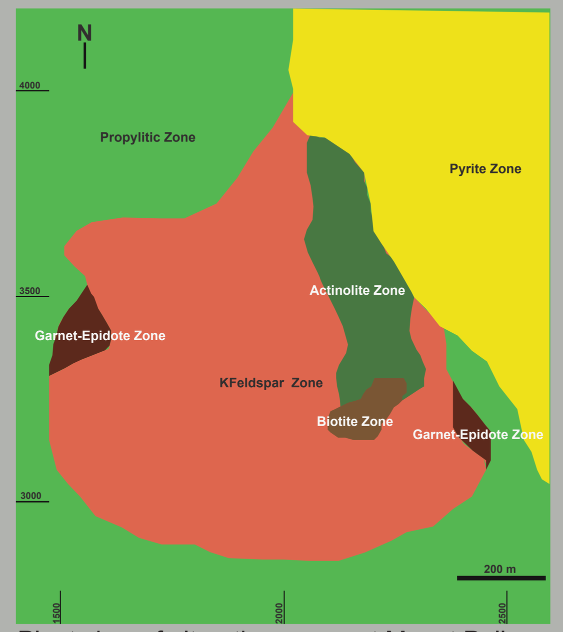


Hydrothermal Alteration Assemblages

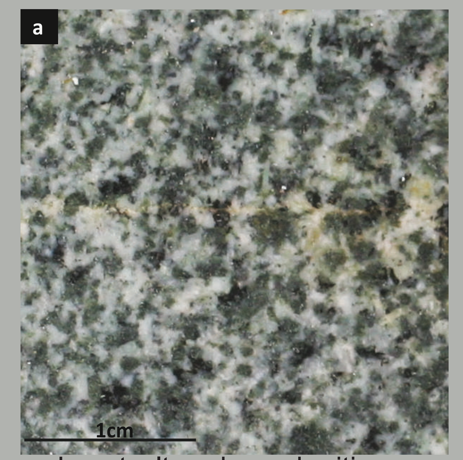
- Potassic alteration is characterized by K-feldspar + biotite + magnetite mineral assemblage, commonly displaying strong orange color. Potassic alteration can be pervasive, partially or totally obliterating original rock texture. It is also commonly associated with main event of hypogene mineralization.
- Propylitic alteration is defined by chlorite + epidote + albite + pyrite mineral assemblage and characterized by its green color.
- Locally, overprint of potassic by propylitic alteration is common. A clear evidence of this is green patches of propylitic over orange potassic alteration.
- Local smaller alteration zones characterized by garnet-epidote assemblage and actinolite are also common in alkalic porphyries of BC.

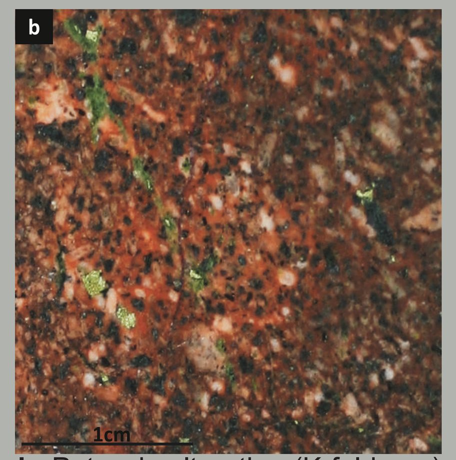


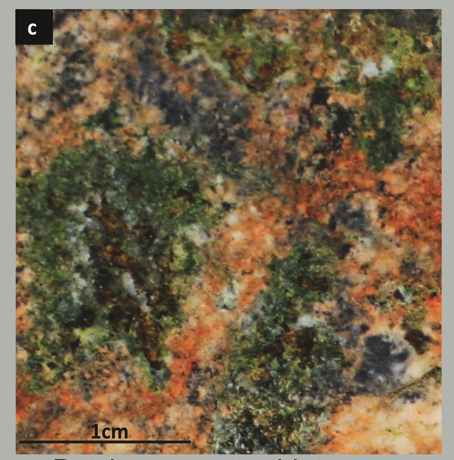
Schematic model of alkalic igneous complexes and associated ore deposit and alteration patterns (from Chamberlain et al., 2006)

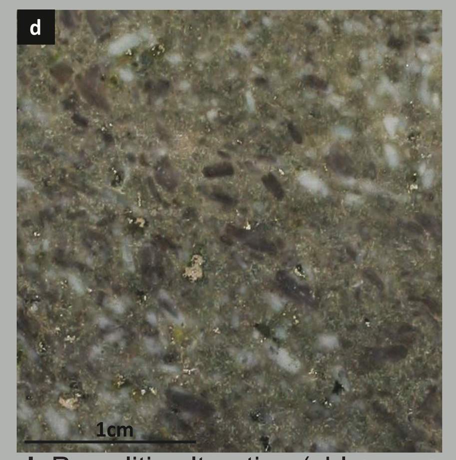


Plant view of alteration zones at Mount Polley (redrafted from Fraser et al., 1995)


a. Least altered porphyritic monzonite, Copper Mountain.

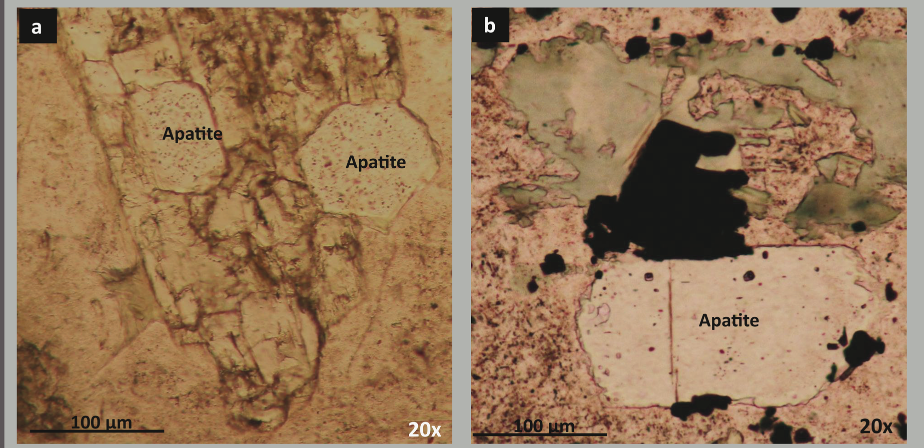

b. Potassic alteration (K-feldspar) in porphyritic monzonite, Copper Mountain


c. Patchy garnet-epidote assemblage overprinting potassic alteration, Mount Polley.

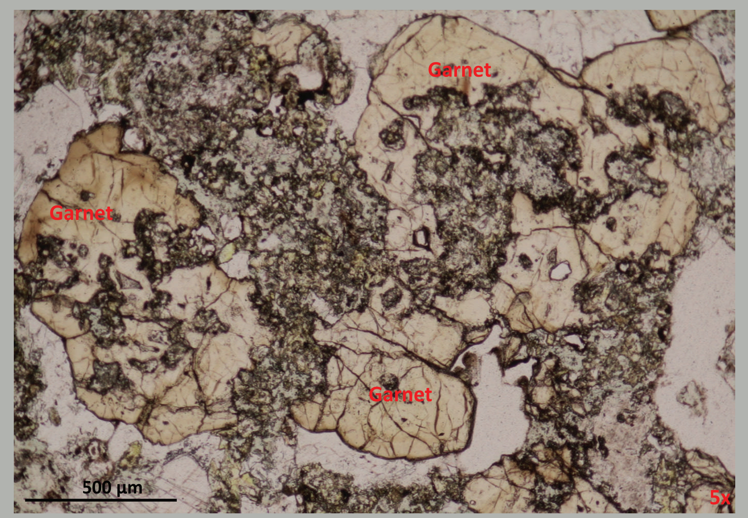

d. Propylitic alteration (chl + ep + alb + py) in porphyritic monzonite, Copper Mountain.

Apatite

- Apatite is ubiquitously distributed in both fresh and altered rock types.
- Apatite crystals are typically colorless, with euhedral short prismatic shape and 100 to 150 µm average size. Inclusions, specially in altered rocks, are frequent and can be a diagnostic feature.
- Apatite usually occurs as inclusion or next to mafic minerals such as amphibole and pyroxene but can also be singularly disseminated in the groundmass.

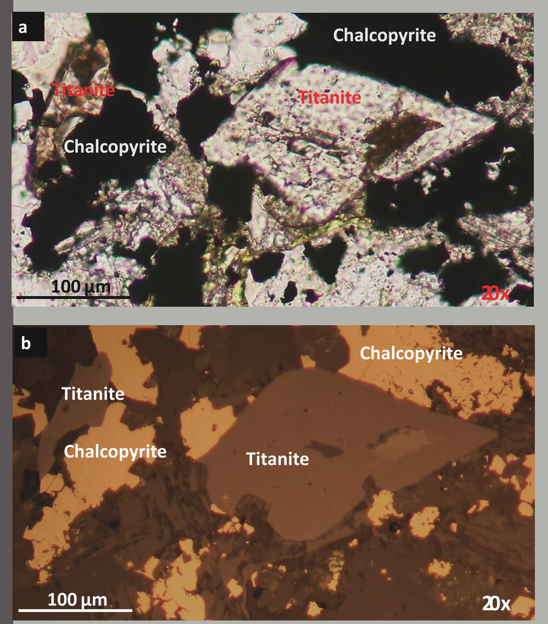


Garnet



- Garnet grains are massive, up to 2000 µm, and display a typical pale yellowish color in transmitted light.
- Garnet grains are typically subhedral octahedral shape and are highly fractured.
- Garnet + epidote mineral assemblage is a characteristic feature in margins of potassic alteration zone at Mount Polley.

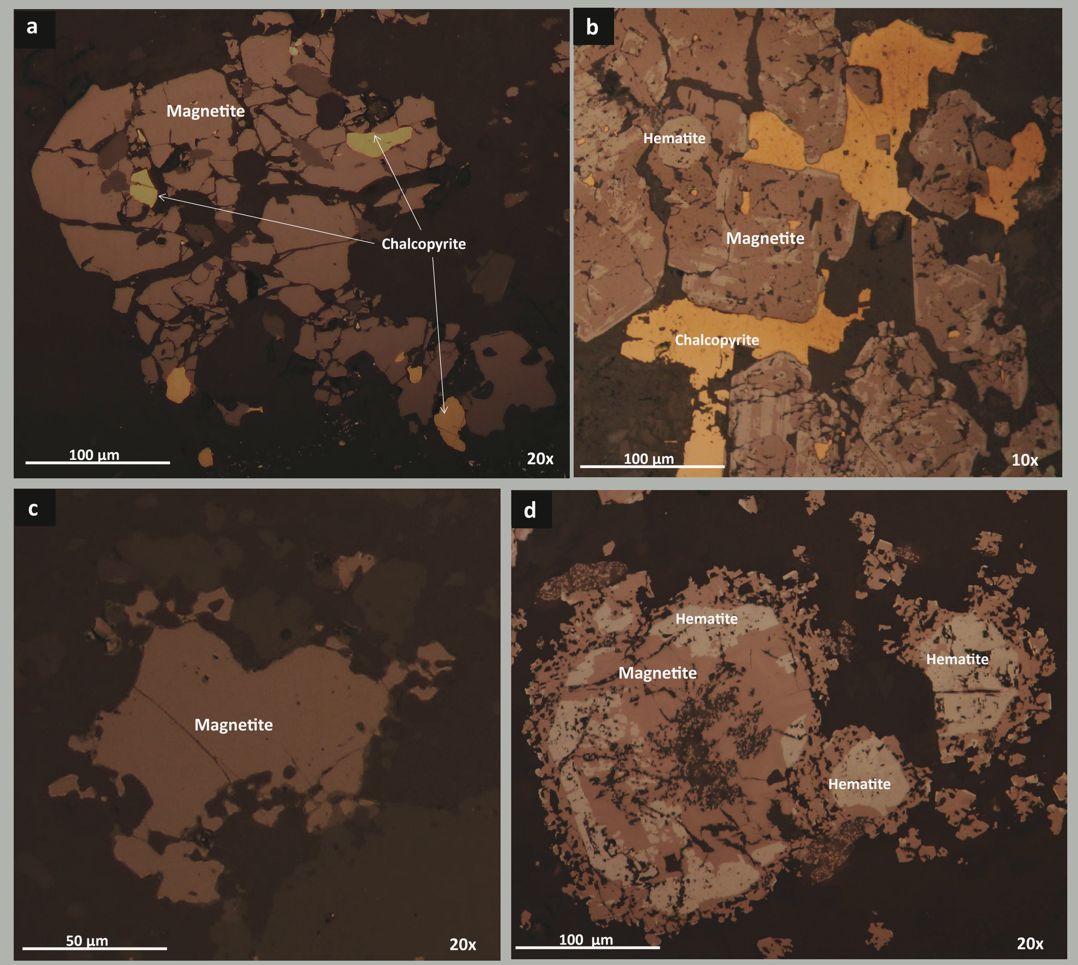
Titanite



- Titanite grains occur commonly in potassic zone overprinted by propylitic alteration.
- Pale brown color in transmited light (a) and dark grey in reflected light (b) are diagnostic features, as well as typical euhedral rhombohedral shapes to wedge shapes with size up to 200 µm.
- Intergrowth with chalcopyrite is common and is evidence of titanite formation during the main event of hypogene mineralization.

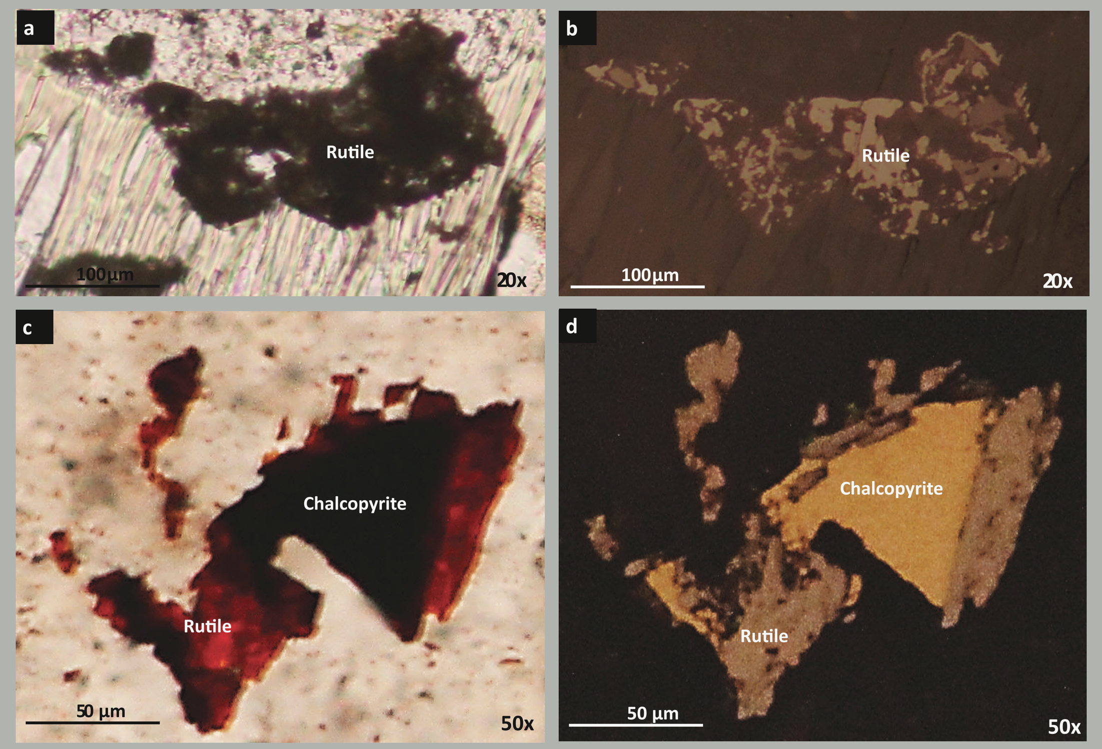
Magnetite

- Magnetite in potassic alteration (a and b) are 300 µm to massive grains up to 1500 µm. Subeuhedral octahedral shapes are characteristic feature. Intergrowth with chalcopyrite are evidence of magnetite formation during the main event of hypogene mineralization. Hematite lamellae are frequent.
- Magnetite grains in propylitic alteration (c and d) are 100 µm in average size. Anhedral to subrounded shapes with desintegrated edges are characteristic features. Abundant exsolution texture with hematite and absence to chalcopyrite intergrowth are also diagnostic features of magnetite within propylitic alteraion and fresh rock.



Rutile

- Rutile grains in propylitic alteration (a and b) display a typical skeletal texture and average size between 100 and 150 µm and about 2% modal abundance. Association with amphibole phenocrysts is very common.
- Rutile grain colour in mineralized potassic alteration is typically red in transmitted light (c) and light grey in reflected light (d). Very fine grains, up to 40 µm, of needle like shape is also diagnostic feature.
- Occasional intergrowth with chalcopyrite is evidence of rutile formation during the main event of hypogene mineralization.



Conclusions

1. Apatite is **colorless** and **ubiquitous** in fresh and altered rock. Three types of apatite can be recognized according to their size and shape. **Euhedral short prismatic crystals**, **100 to 200 µm size**, occurring as inclusion or next to mafic minerals are related to main event of hypogene mineralization.

2. Magnetite is mostly restricted to **potassic alteration**, with less occuring in propylitic alteration and fresh rock. Magnetite grains in potassic alteration have **subhedral octahedral shapes** to massive grains up **1500 µm**. **Intergrowths with chalcopyrite and bornite** are evidence of magnetite association with main event of hypogene mineralization.
As moving outwards to **propylitic alteration**, magnetite **grain size decreases** **(100 to 150 µm)**, shapes become **anhedral to subrounded** with **desintegrated edges**. **Exsolution texture with hematite** is very common and can completely replace magnetite.

3. Rutile is **ubiquitous** in fresh and altered rocks. Rutile crystals in **potassic alteration** display a typical **red color** in transmited light due to **high copper content** (Williams and Cesbron, 1977). Very **fine grains up to 40 µm** with **needle like shapes** are also characteristic. **Intergrowth with chalcopyrite** is evidence of rutile formation during the main event of hypogene mineralization. On the other hand, rutile crystals in **propylitic alteration** are mainly associated with amphibole phenocrysts and display a characteristic **skeletal texture** and no red color. Grain size can be up to **150 µm**.

4. Titanite grains can be up to **200 µm** and display **euhedral rhombohedral to wedge shape** in potassic alteration overprinted by propylitic alteration, where **abundance** can be high up to **3%.** Association with main event of hypogene mineralization is evidenced by common **intergrowths with chalcopyrite**.

5. Massive andradite **garnet** grains up to **2000 µm** in size and **7%** in abundance are restricted to a **garnet-epidote alteration zone** at Mount Polley. Both **size** and **local occurence** are features that suggest garnet can be used as PIM.

Future work

- Further detailed petrographic description of resistate minerals using SEM (Scanning Electron Microscope), cathodoluminescence (CL) and X-ray diffractometry (XRD).
- Study of heavy mineral separation of till sediments and rock samples to evaluate size and abundance of PIMS.
- Determine those diagnostic physical parameters and chemical compositions that will characterize indicator minerals in alkalic porphyry systems by using techniques such as Mineral Liberation Analyzer (MLA) which provides information on mineral species abundance, grain size distribution, grain shape and composition.
- Analyse trace elements of selected mineral separates by laser ablation ICP-MS (LA-ICP-MS).
- Determine correlations between the abundance of PIMS and till composition by performing whole rock geochemistry of till samples. This could be used as a proxy to reduce the number of heavy mineral concentrate samples.

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