Porphyry Indicator Minerals (PIMS): A New Exploration Tool for Concealed Deposits in south-central British Columbia

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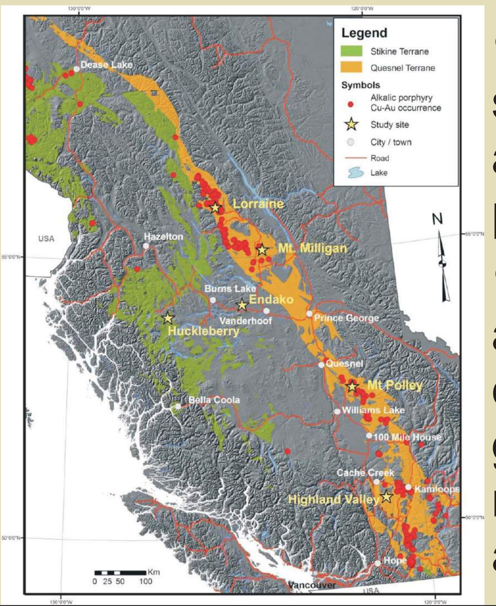
Why PIMS?

The common occurrence of resistate minerals as alteration products in BC porphyry copper deposits suggest that these minerals could be utilized as porphyry indicator minerals (PIMS) and potentially provide a new exploration tool for BC explorers. This research project has successfully recognized, characterized and documented the occurrence, types, relative abundances and compositions of selected resistate minerals in several BC porphyry deposits.

- Porphyry indicator minerals (PIMS), such as apatite, rutile, garnet and titanite, are associated with porphyry copper deposits and are resistant to weathering.
- PIMS display unique properties such as color, shape, luminescence and composition.
- Improved understanding of these minerals could provide a key tool to increase exploration targeting success, especially in glacial, fluvial and regolith terrains.

BC Porphyry Copper Belts Undercover

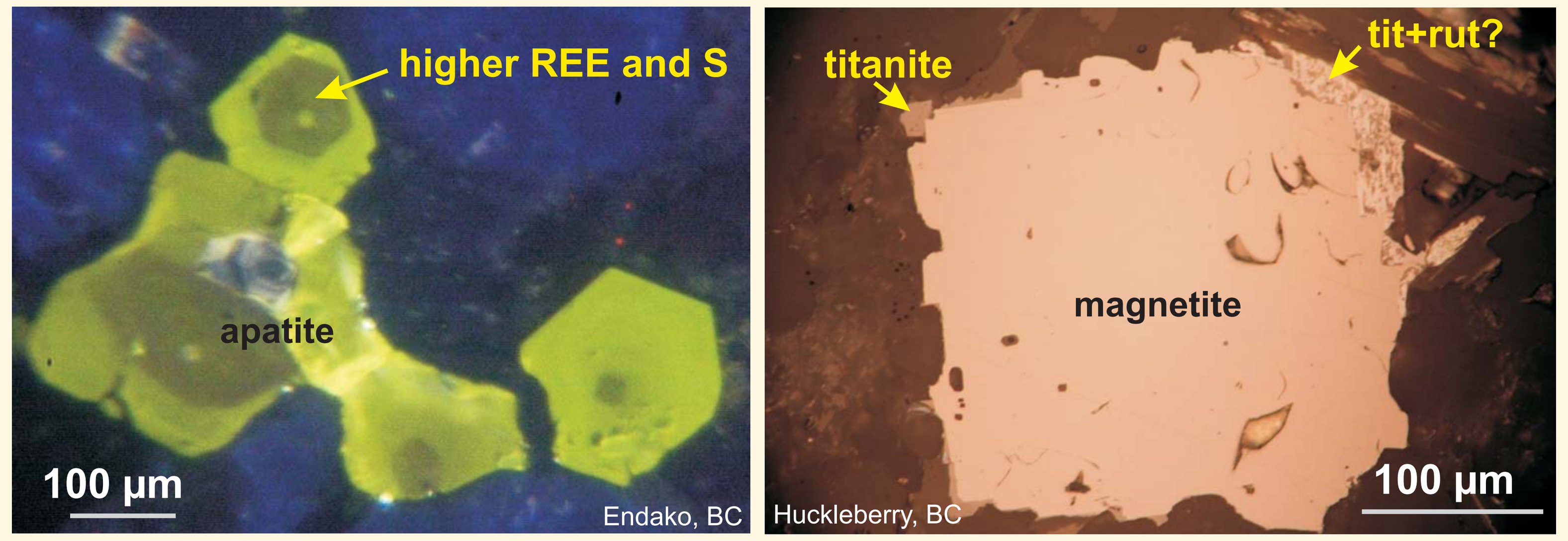


- The Quesnel and Stikine terranes in south-central BC host magmatic arcs, which are highly prospective for porphyry deposits.
- However, exploration success in this area has been limited due to extensive veneers of till and related glacial sediments especially in the region between the Mount Milligan and Mount Polley porphyry deposits.

Objectives

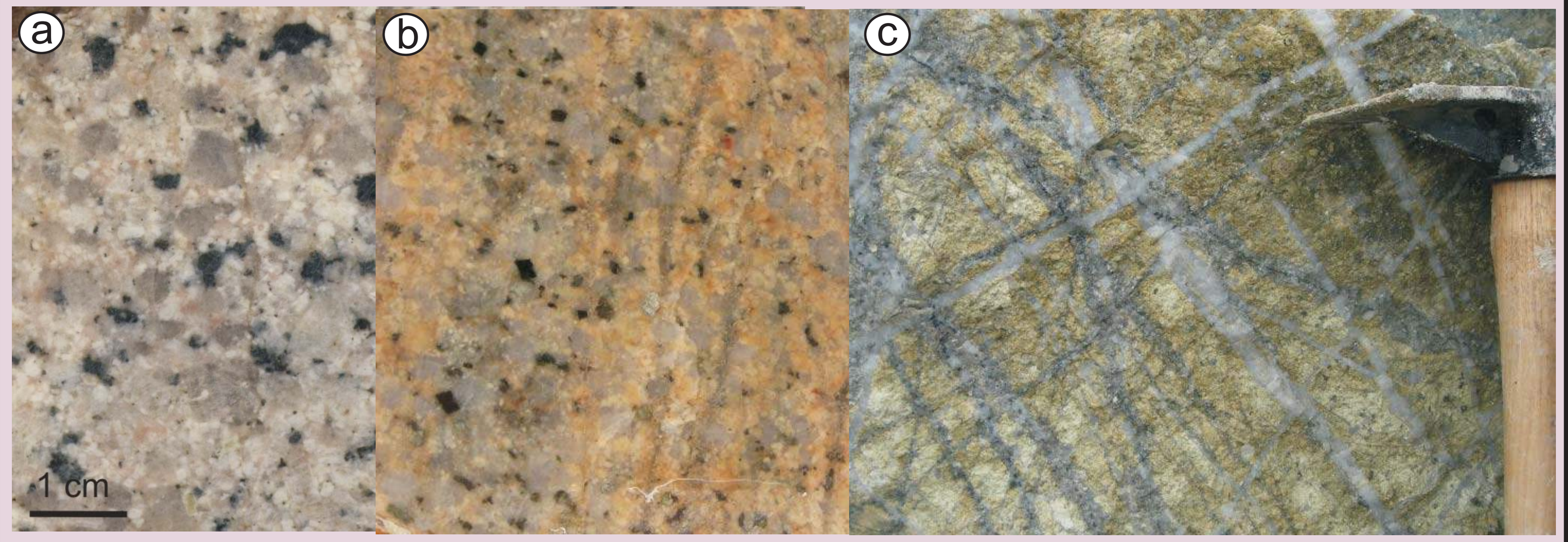
- Determine the occurrence and types of resistate minerals in various styles of alteration and mineralization in several central BC porphyry copper-gold deposits.
- Determine the diagnostic physical parameters and chemical compositions of resistate minerals.
- Identify important indicator minerals and establish physical properties to distinguish those resistate minerals that are directly associated with porphyry Cu-Au deposits
- Establish criteria for use of PIMS as an exploration tool.

Apatite and Magnetite in Porphyry Deposits



- Apatite is a common accessory mineral in porphyry host-rocks and also associated with K-silicate alteration.
- Apatite structure can incorporate transition metal, REE and anion impurity activators which in granitoid rocks commonly cause strong yellow-greenish luminescence.
- Apatite commonly shows characteristic zoning which are attributed to changes in melt composition, resulting from magma mixing, differentiation and oxidation state.
- Ti-Magnetite is an accessory mineral in both porphyry host-rocks and with K-silicate alteration commonly occurring with titanite and hematite.

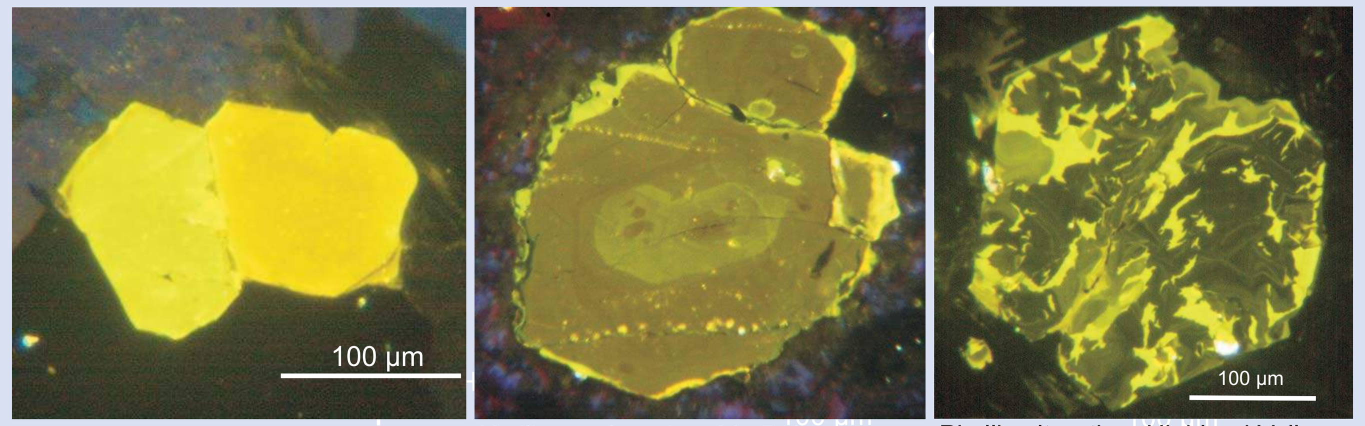
Hydrothermal Alteration Assemblages



Porphyry copper mineralization is commonly associated with felsic intrusive bodies and is overprinted by K-silicate alteration assemblages. Muscovite, e.g. phyllic alteration, occurs in clac-alkaline porphyry deposits such as Highland Valley:

- Fresh Bethsaida granodiorite, the main host-rock to mineralization at Highland Valley, with rounded quartz phenocrysts and biotite books (a).
- Stockwork of K-silicate alteration of K-feldspar and biotite overprting Bethsaida granodiorite (b).
- Intense green mica alteration and associated sulfide mineralization overprinting the Bethsaida granodiorite (c).

Apatite Characteristics



Fresh, Highland Valley — K-silicate alteration, Mt. Polley — Phyllic alteration, Highland Valley

Apatite in fresh host-rock:

- Displays strong luminescence of yellow to yellow-green and sometimes yellow-brown. No major internal structures were observed using either cathodoluminescence (CL) or SEM.

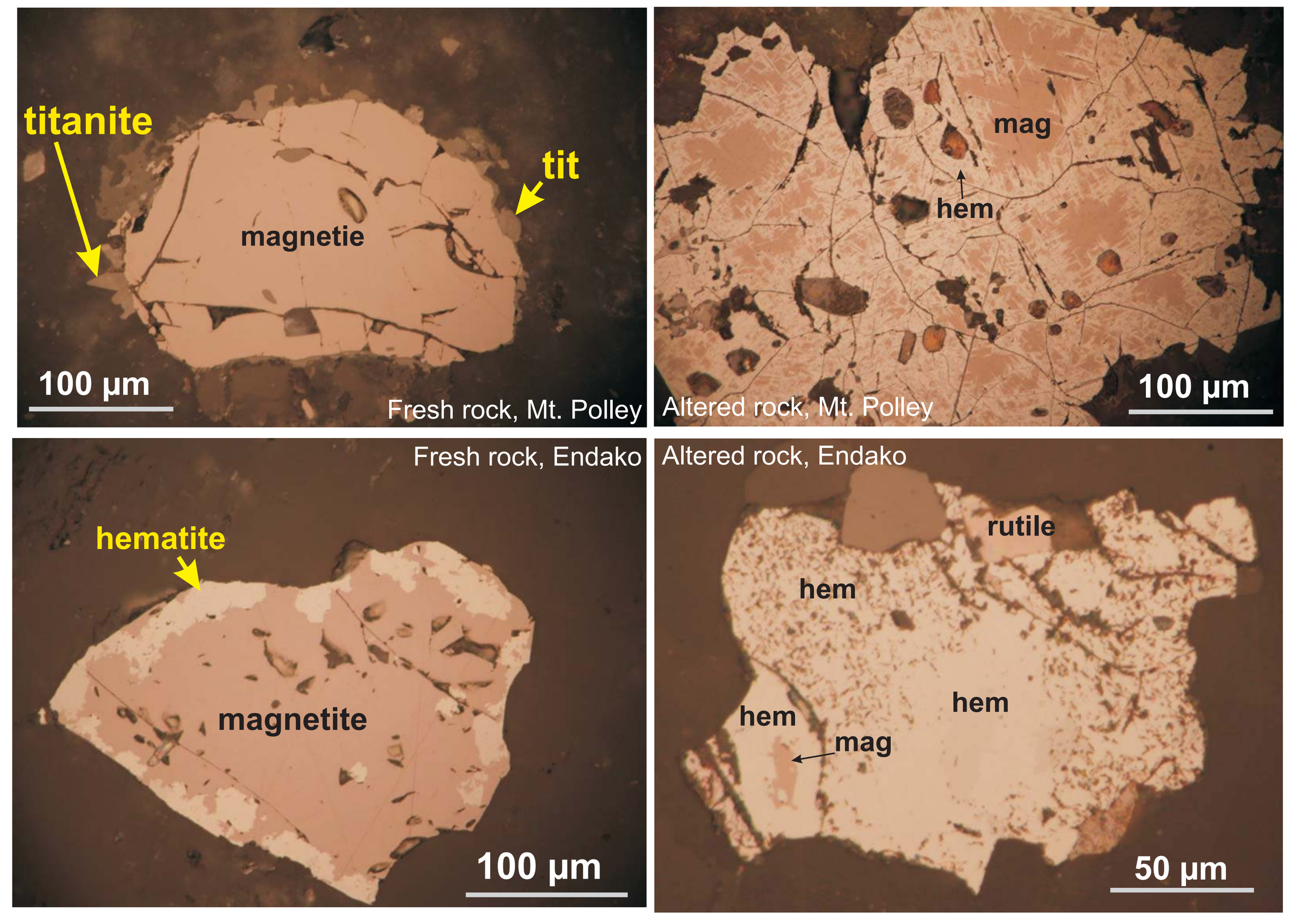
Apatite in K-silicate altered host-rock:

- Displays yellow-green luminescence due to varying proportion of Mn/Fe.

Apatite in muscovite altered host-rock:

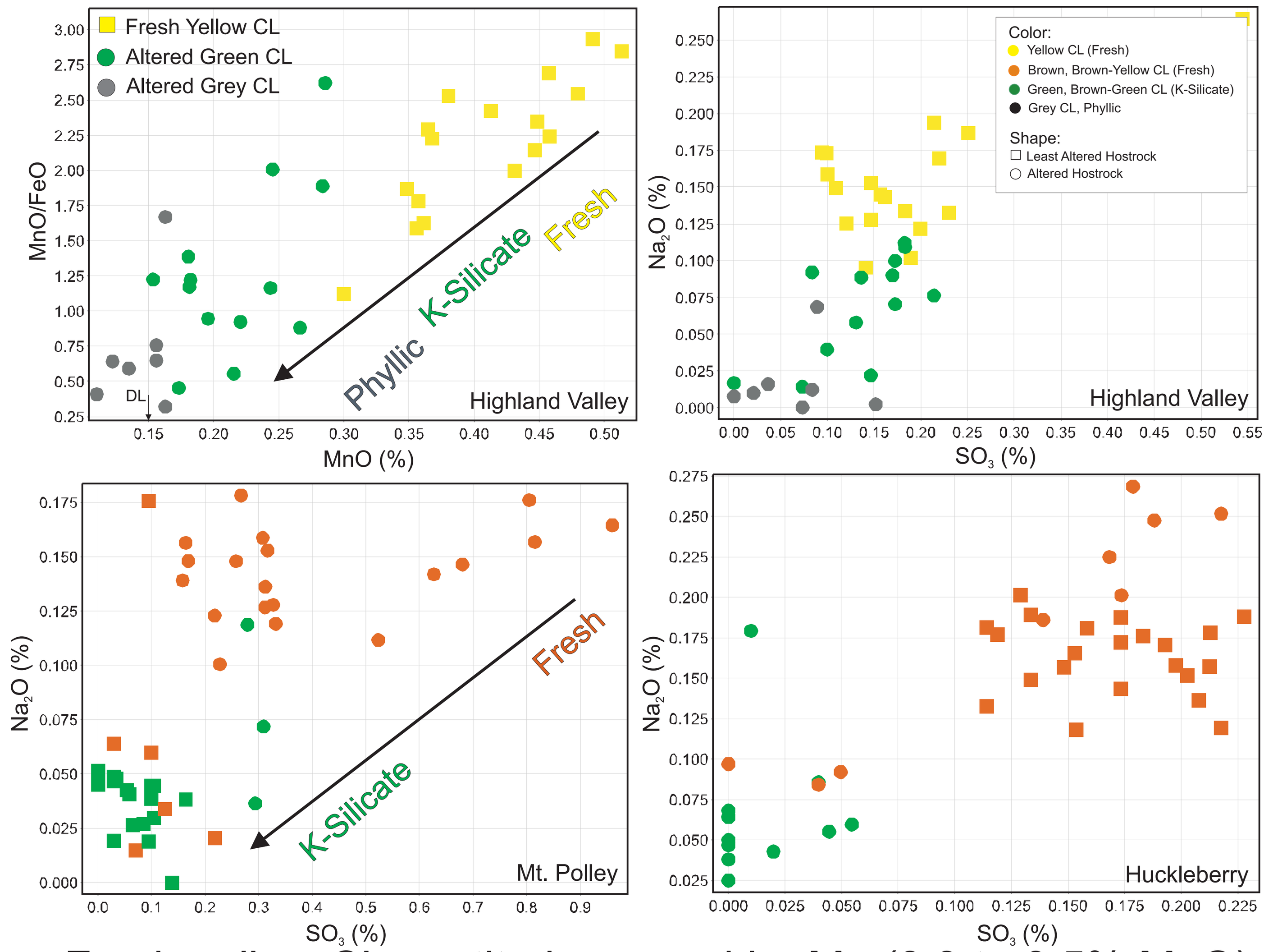
- Displays a unique green luminescence and in strongly altered host-rock is overprinted by a complex network and bodies of dark-green to grey-luminescent domains.

Magnetite Characteristics



- Magnetite in fresh host-rocks displays uniform pink color of titanomagnetite and commonly has a rim of hematite or titanite.
- Magnetite in altered host-rocks has remnant of pink Ti-magnetite replaced by hematite. Spongy hematite cemented by hydrothermal quartz occurs with more advanced alteration stages of magnetite.

Apatite Chemistry



- Fresh yellow CL apatite is caused by Mn (0.3 to 0.5% MnO). The Mn content of brown-luminescent apatite is low (<0.2 MnO) and other trace elements, such as REE, probably contributed to the brown luminescence.
- Green luminescent apatite of K-silicate alteration is caused by lower Mn/Fe ratio. Other trace elements such as Cl, Na and S are also depleted from apatite during the K-silicate alteration.
- Grey luminescent apatite associated with muscovite alteration is caused by a significant loss of Mn during phyllic alteration. Such fluids were not developed in alkalic porphyry deposits.

Conclusions

- Apatite grains with altered host-rocks have green and grey CL color and have lost many to their trace components such as Mn, Na, Cl, S and REE.
- Magnetite grains with altered host-rocks have remnant of pink Ti-magnetite replaced by hematite indicating that the oxidation state of the system progressively increased during the transition from K-silicate to sericite/chlorite alteration. The released Ti commonly forms rutile lamella or grains.
- Porphyry-altered apatite and magnetite can be easily recognized visually and geochemically.

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