Southeast Zone (Cu-Mo) and Deerhorn (Cu-Au) Porphyry Deposits: Paragenesis, Alteration and their Possible Relationships, Woodjam Property, Central British Columbia

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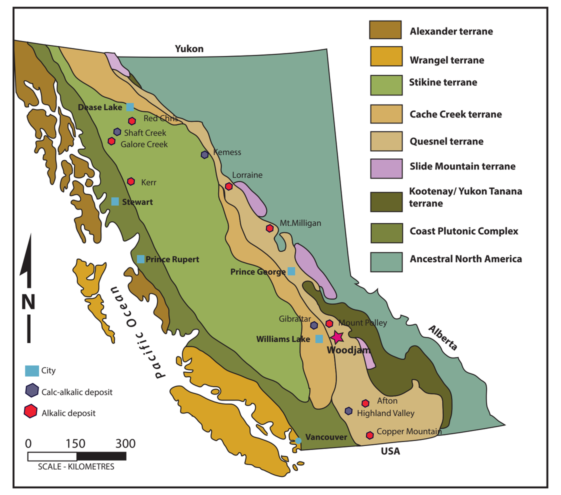
Introduction

The Woodjam property (93A/013, 93A/014, 93A/023, 93A/024, 93A/025, 93A/033, 93A/034, 93A/035), is part of the porphyry deposits of Late Triassic to Middle Jurassic age (216 to 183 Ma) located in the Quesnel terrane in central British Columbia.

It hosts several discrete porphyry deposits including the Megabuck (Cu-Au), Deerhorn (Cu-Au), Takom (Cu-Au), Southeast Zone (Cu-Mo) and the recently discovered Three Firs (Cu-Au).

These deposits display various styles and assemblages of alteration and mineralization. Whereas the Southeast Zone (SEZ) is comparable to calc-alkalic porphyry deposits, the nearby Deerhorn zone is mainly associated with alkalic porphyry intrusions.



Major tectonic terranes and associated porphyry deposits of the Canadian Cordillera in British Columbia (modified from McMillan et al., 1995)

View from the Southeast zone deposit

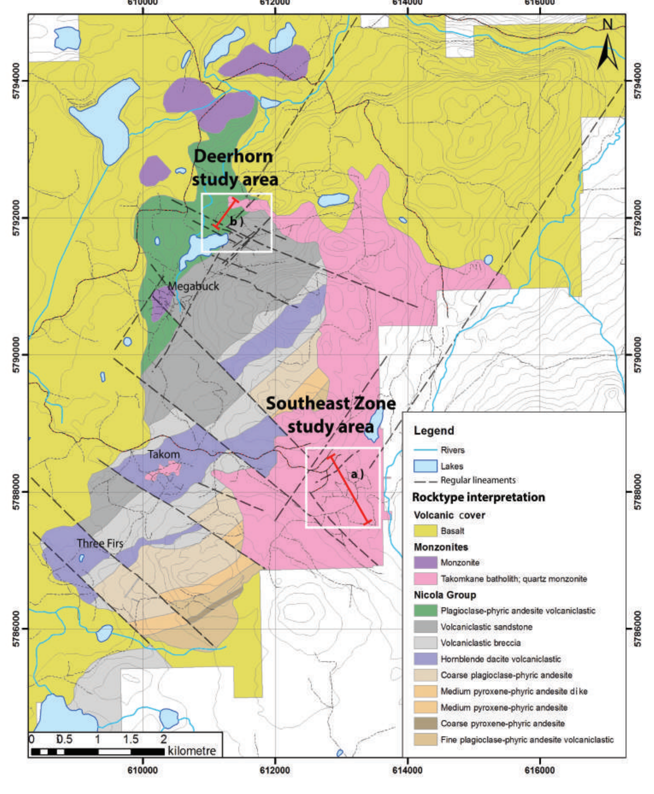
Recent exploration at the Deerhorn Cu-Au deposit has shown two contrasting alteration assemblages of K-feldspar + magnetite, typical of alkalic systems, and illite+ tourmaline and Mo mineralization typical of calc-alkalic system. The SEZ displays some features not typical of calc-alkalic deposits such a very low amount of quartz veining.

These observations suggest a temporal and paragenetic relationship between the two deposits may exist, thus providing a unique opportunity to study the relationship between alkalic and calc-alkalic deposits in BC.

Regional Geology

The Nicola Group (host of the Deerhorn Zone)

Late Triassic and Early Jurassic island arc volcanic and sedimentary strata, that is composed of submarine basaltic to andesitic augite ± plagioclase - phyric lavas, volcaniclastics and sedimentary units (Mortimer, 1987; Schiarizza et al., 2009; Vaca, 2012). This sequence extends throughout south-central British Columbia.



Geological map of the Woodjam district. Cross section line of drill holes relogged in this study are shown (red lines) for Southeast zone (a) and Deerhorn (b) deposits (from Gold Fields Exploration Canada, internal data 2012)

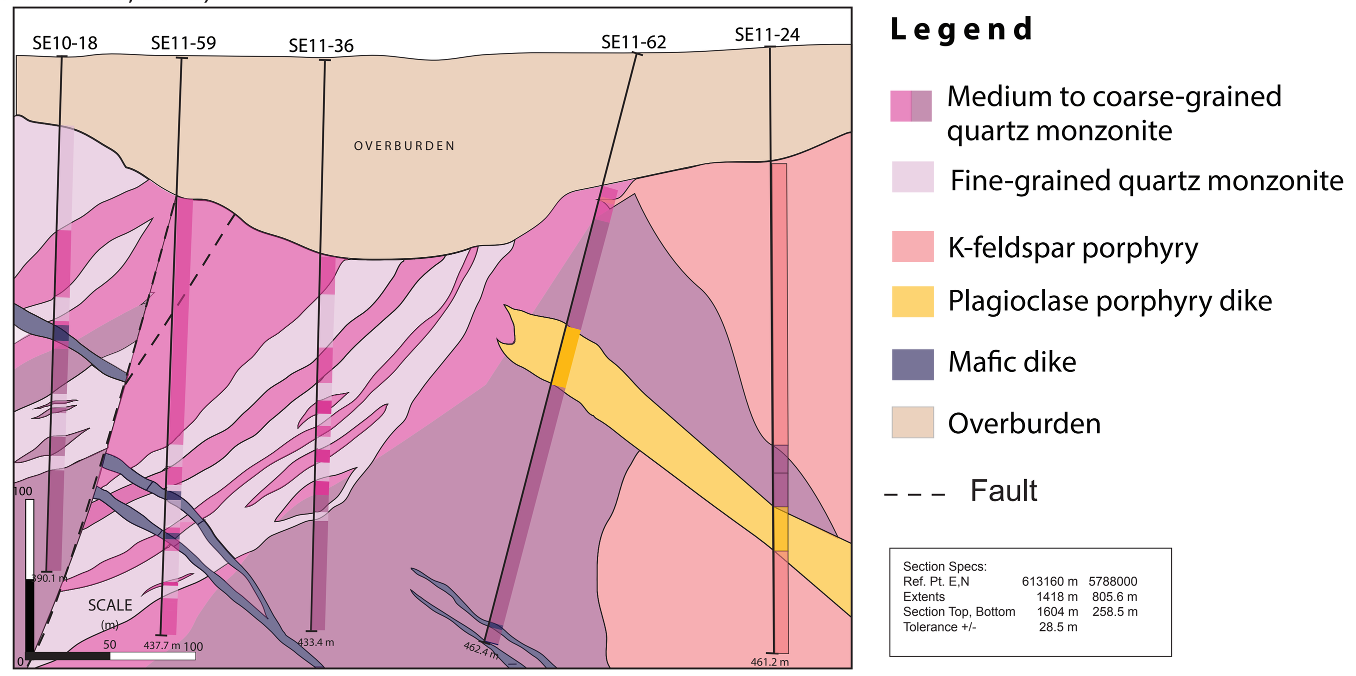
Takomkane batholith (host of the Southeast Zone deposit)

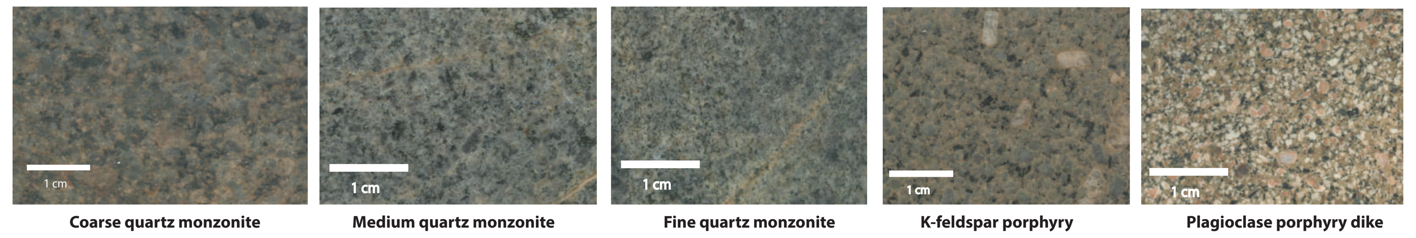
A large composite calc-alkalic batholith, of largely granitoid composition with a surface expression of approximately 40 × 50km, intrudes the Nicola Group. The Woodjam Creek unit of the Takomkane batholith occurs in the Woodjam district and is composed of granodiorite, monzogranite and quartz-monzonite (Schiarizza et al., 2009).

Nicola and Takomkane units are overlain by the Early Miocene to Early Pleistocene basalt of the Chilcotin Group.

Southeast Zone lithology

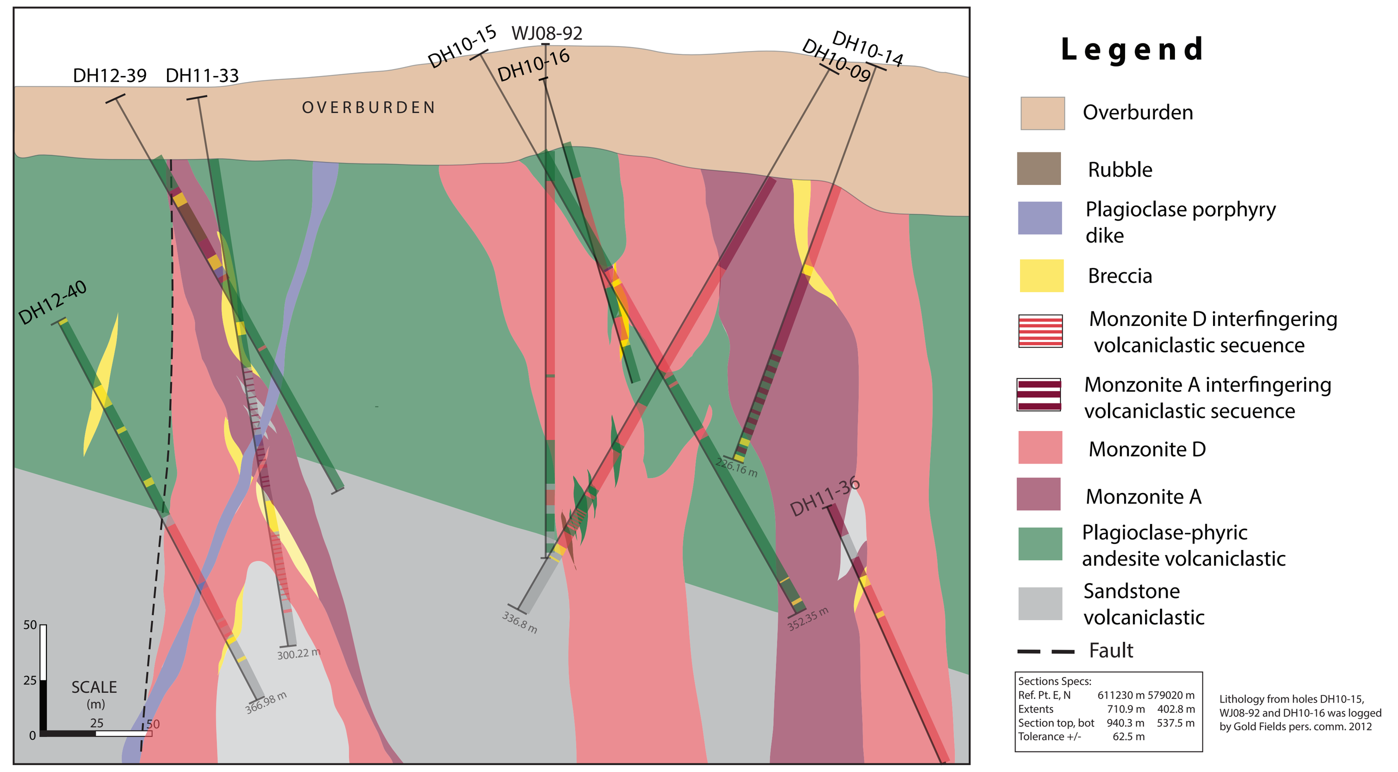
- Hosted by a series of texturally variable quartz monzonite intrusive bodies divided texturally into fine, medium and coarse grained units (Rainbow, 2010). All quartz monzonites are intruded by K-feldspar porphyry body.
- Quartz monzonites were emplaced pre- to syn- mineralization and are affected by intense alteration, whereas the K-feldspar porphyry was probably emplaced during the final stages of hydrothermal activity (Rainbow, 2010; Sherlock et al., 2012).

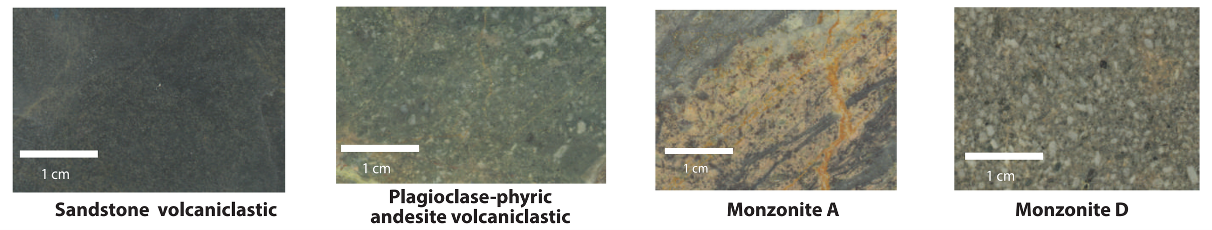




Deerhorn Zone lithology

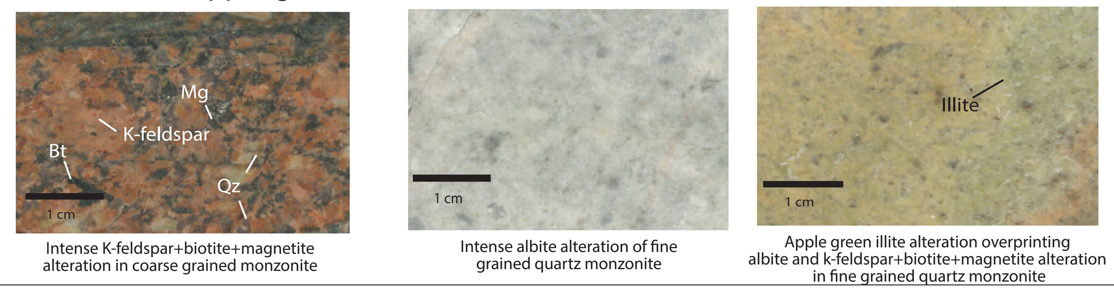
- **Nicola Group** stratigraphy consists of volcaniclastic sandstone, overlain by a plagioclase-phyric andesite with local clast breccia facies (Blackwell et al., 2012).
- **"Monzonite A"** occurs as "pencil" shaped intrusive bodies, which intrude the volcano-sedimentary rocks of the Nicola Group (Blackwell et al., 2012).
- **"Monzonite D"** is characterized by plagioclase and hornblende phenocrysts and occurs as dikes with sharp contact that cross-cut Monzonite A and Nicola Group stratigraphy (Blackwell et al., 2012).





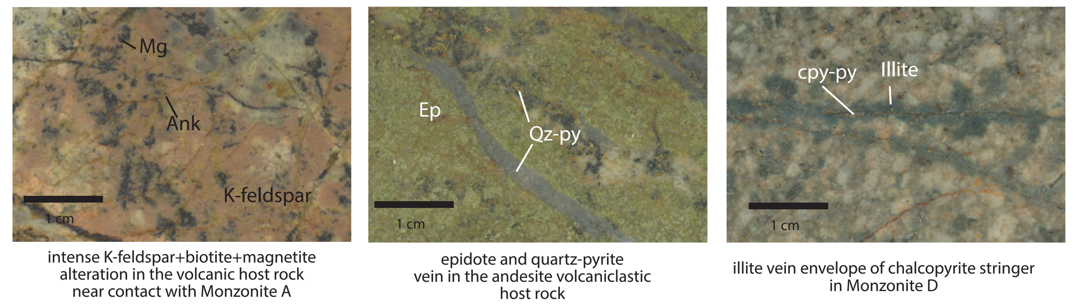
Alteration Southeast Zone

- **K-feldspar + biotite + magnetite** is the earliest alteration, occurs as pervasive mineral replacement
- **Albite** alteration is recognized at the northern extent of the deposit
- **Chlorite ± epidote ± pyrite** intensity is higher at the margins of the deposit.
- **Illite** occurs as three visually and possibly paragenetically distinct types: dark green illite, white illite and apple-green illite.



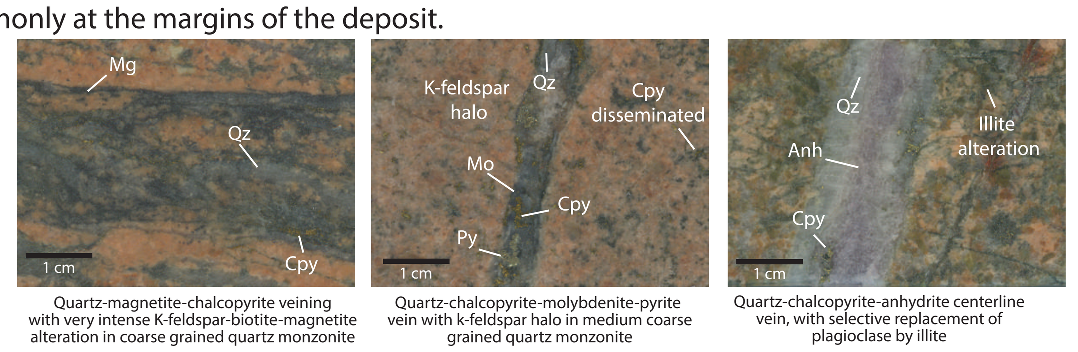
Alteration Deerhorn Zone

- **K-feldspar + biotite + magnetite** alteration is very intense in Monzonite A and in the volcanic rocks surrounding these intrusions.
- **Chlorite ± epidote ± pyrite** alteration occurs mainly in Monzonite D and in the surrounding volcanic host rocks.
- **Ankerite and calcite** veinlets occur throughout all lithologies.
- **Illite** occurs mainly as vein envelope overprinting vein K-feldspar halos



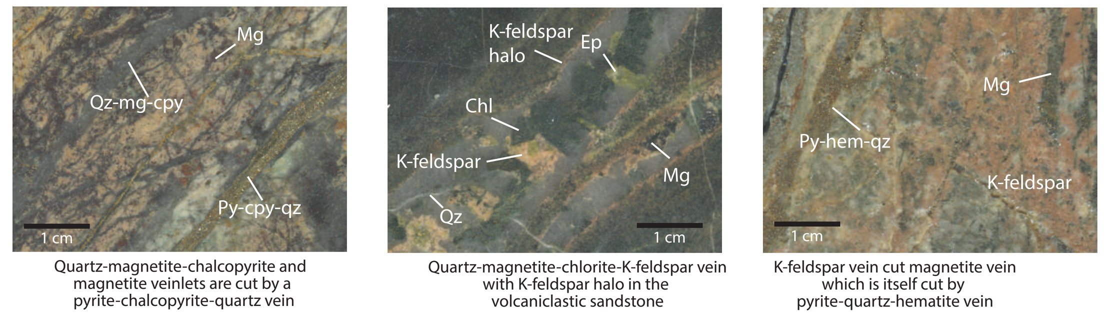
Southeast Zone Veining

- **Rare magnetite stringers and quartz ± chalcopyrite ± magnetite veins** occur locally in the core of the porphyry.
- **Quartz ± chalcopyrite ± pyrite ± molybdenite ± anhydrite (±bornite) veins with K-feldspar halos** occur in the deep central and marginal areas.
- **Pyrite ± epidote ± chlorite veins with epidote ± hematite ± illite halos** occur commonly at the margins of the deposit.



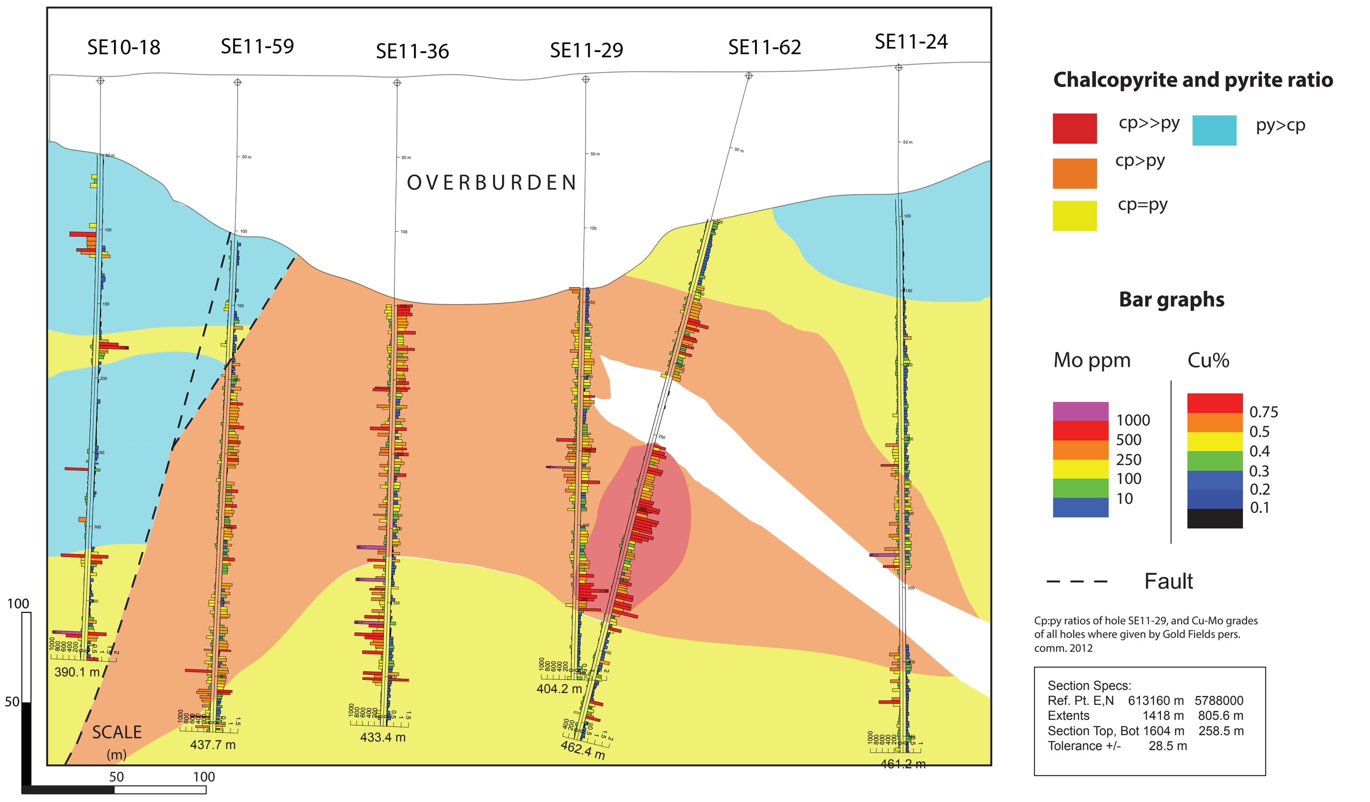
Deerhorn Zone Veining

- **Magnetite stockwork and gold bearing quartz-magnetite ± hematite ± sulphide veins** occur in Monzonite A and adjacent volcanic host rocks.
- **Quartz-magnetite-chlorite–K-feldspar veins** occur in the volcanic host rock.
- **Pyrite –quartz ± hematite ± epidote ± tourmaline veins** with a white illite halo occur throughout all rock units as well as **pyrite – chlorite ± calcite ± ankerite veins.**



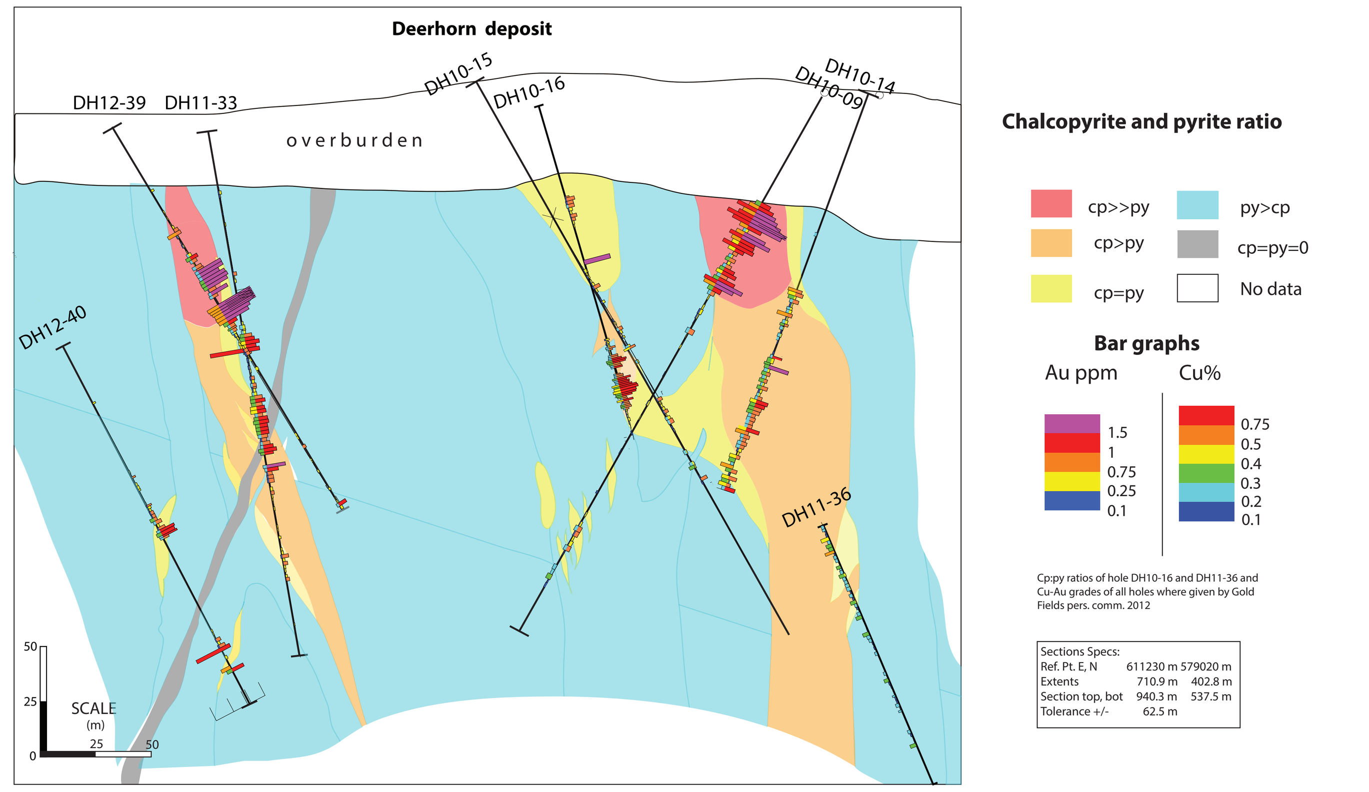
Mineralization Southeast Zone

- Copper occurs dominantly in **chalcopyrite** with subordinate **bornite** as disseminations and more commonly in veins.
- **Molybdenite** is mainly observed in veins.
- Areas of high copper grades (ca. 0.5% Cu) are characterized by dense stockworks of thin veins and with abundant disseminated chalcopyrite in the host-rock.
- Sulphide zoning at SEZ consists of chalcopyrite ± bornite (±pyrite) assemblage in the core of the deposit which changes upward and outward to chalcopyrite ± molybdenite ± pyrite and finally a pyrite dominated assemblage in the periphery of the deposit.



Mineralization Deerhorn Zone

- Has significantly **higher Au grades** than the SEZ, that are associated with **Cu mineralization** (up to ≤1.5 ppm Au and <0.75% Cu).
- Mineralization is hosted dominantly in Monzonite A and the adjacent volcanic host rocks and occurs as disseminated, in the early quartz-magnetite-chalcopyrite veins and in later quartz-sulphide veins.
- Monzonite D hosts lower grades of copper mineralization (~0.1-0.3% Cu) but does not host significant gold. Trace amounts of **molybdenite** have been observed in the later-stage quartz sulphides veins in Monzonite D.
- Sulphide ratios in the deposit depend of the lithology, consisting of higher cpy:py ratio in Monzonite A and lower in Monzonite D and the volcanic host rock.



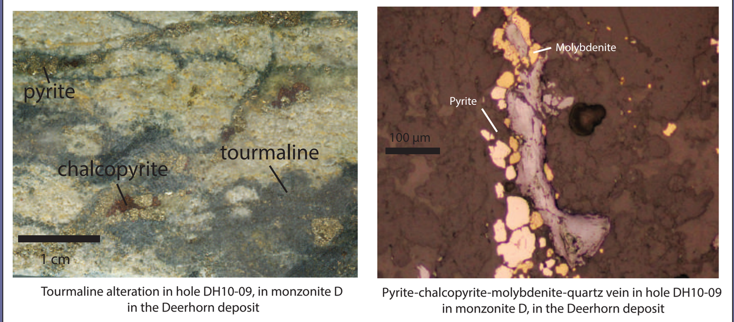
Conclusions and future work

The SEZ deposit presents mainly calc-alkalic characteristics. However the low abundance of quartz veining is not a typical feature of this type of deposit.

The K-feldspar +/- biotite +/- magnetite alteration assemblage and the vein stages observed at the Deerhorn deposit, illite+ tourmaline and Mo mineralization are consistent with characteristics of Cu-Au and Cu-Mo calc-alkalic porphyry systems (Sillitoe, 2000; Sillitoe 2010); however, the "pencil" shape intrusive host rock lacking modal quartz is consistent with characteristics of Cu-Au alkalic porphyry systems (Holliday et al., 2002).

The close proximity as well as the similar alteration and vein stages at the SEZ and Deerhorn deposits suggest that they could be related and may represent a transition from the alkalic to calc-alkalic environment. At the Deerhorn zone Monzonite D hosts Cu-Mo mineralization similar to that of the SEZ, suggesting also that alkalic-stage (in Monzonite A) occurs first and the calc-alkalic stage occurs second.

The next stage of this project will focus on the geochemistry and magmatic-hydrothermal evolution of these deposits in the Woodjam district, using detailed petrography and geochemical analyses.



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