MDRU
Mineral Deposit Research Unit

Geoscience BC

# Alkalic porphyry Cu-Au deposits: a BC speciality

Thomas Bissig, MDRU

Acknowledgements:
Dick Tosdal, Dave Cooke, Kirstie Simpson, Claire Chamberlain, Craig Hart, Janina Micko, Kevin Byrne, Heidi Pass, Meghan Jackson, Paul Jago, Adam Bath.
Geoscience BC and sponsors of the MDRU alkalic project

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# Outline

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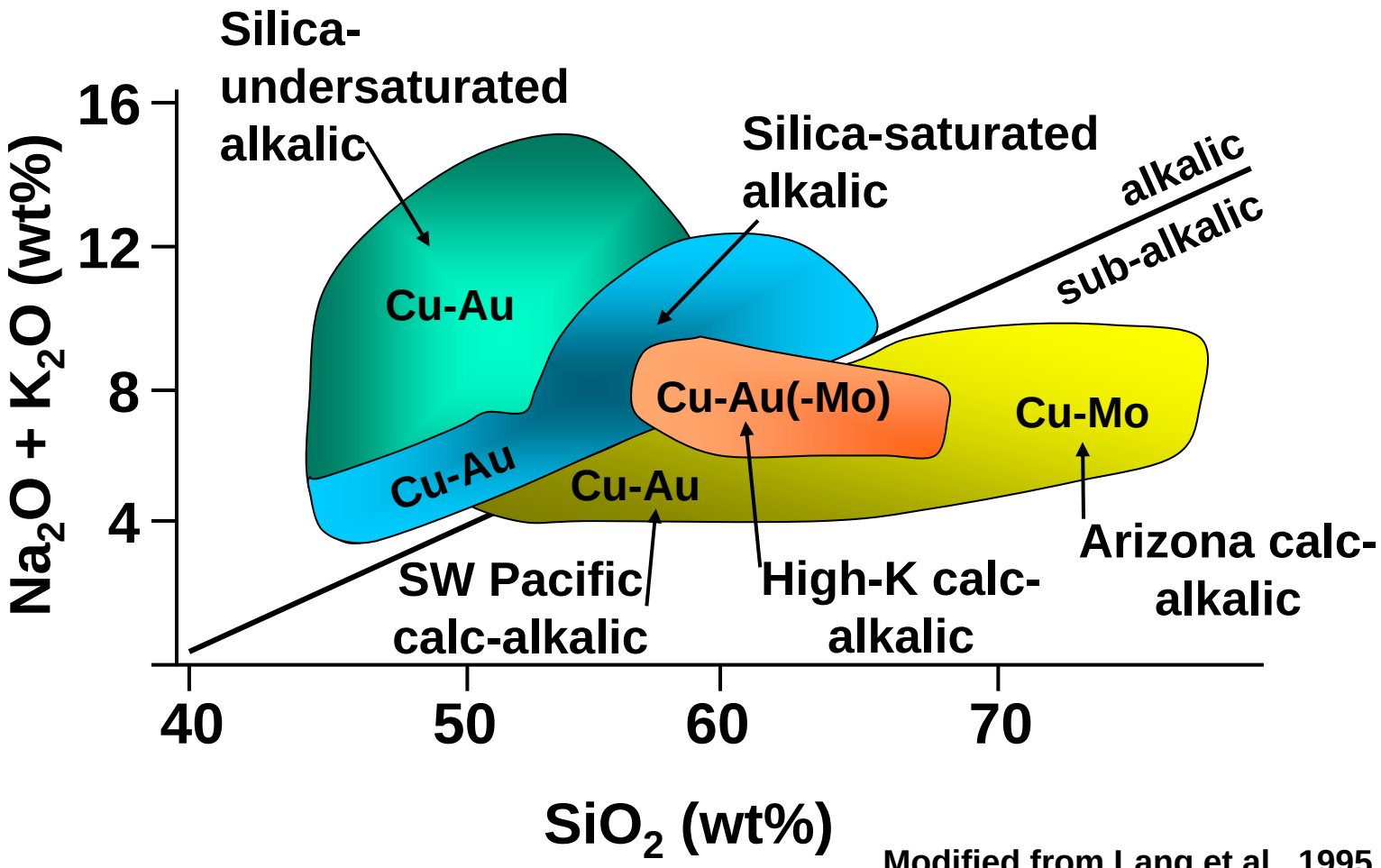
- What are alkalic porphyry deposits and how are they different from calc-alkalic ones?
- BC examples: Galore Creek (silica undersaturated) and Mount Milligan (silica saturated)
- Regional volcanic setting and characteristics of host rocks
- Conclusions

# Igneous Associations

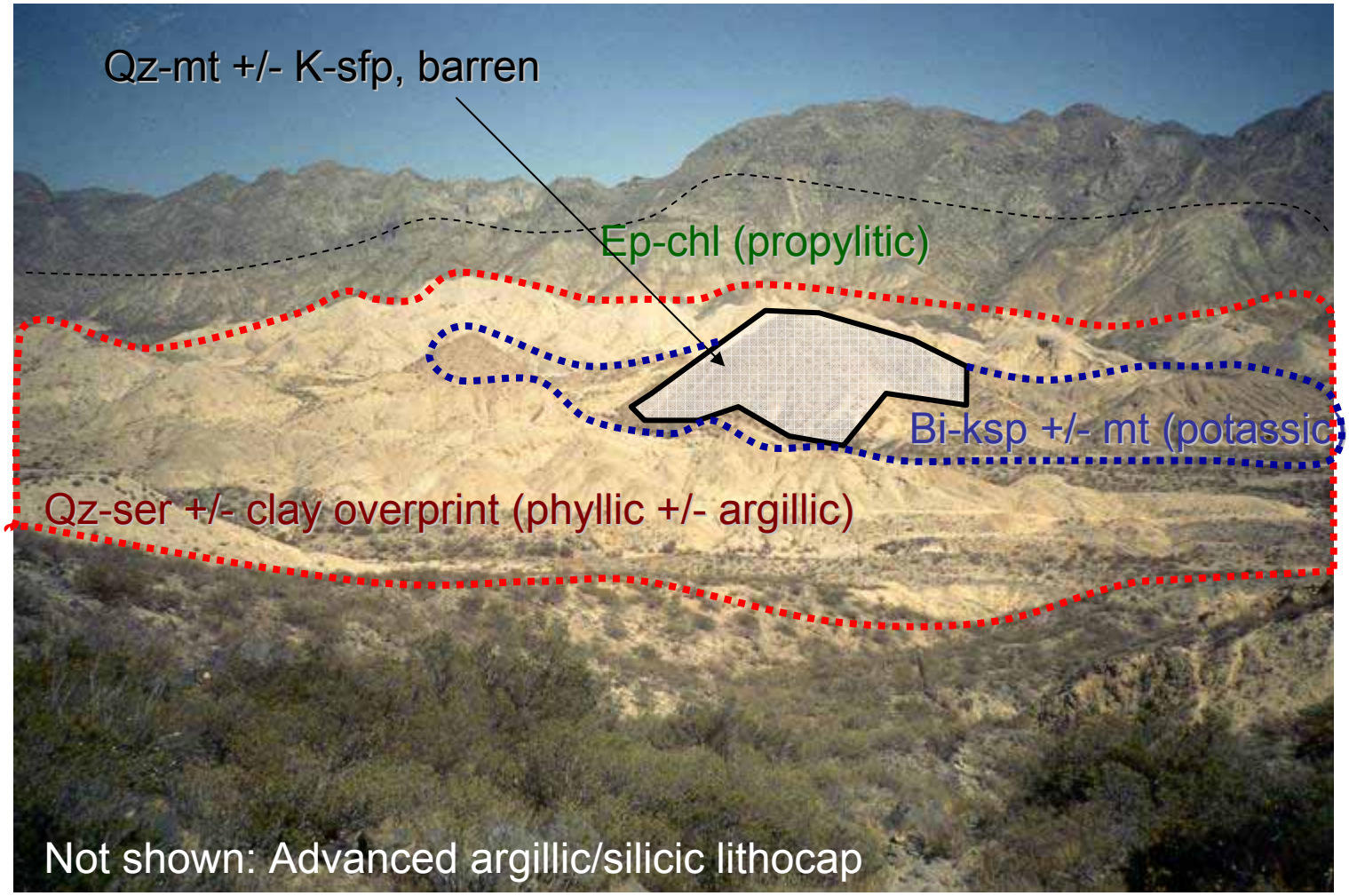
*Free gold in quartz-bornite vein, Ridgeway, NSW*

- **Porphyry Cu-Au-Mo deposit classification**




Modified from Lang et al., 1995

# General alteration model (calc alkalic type)



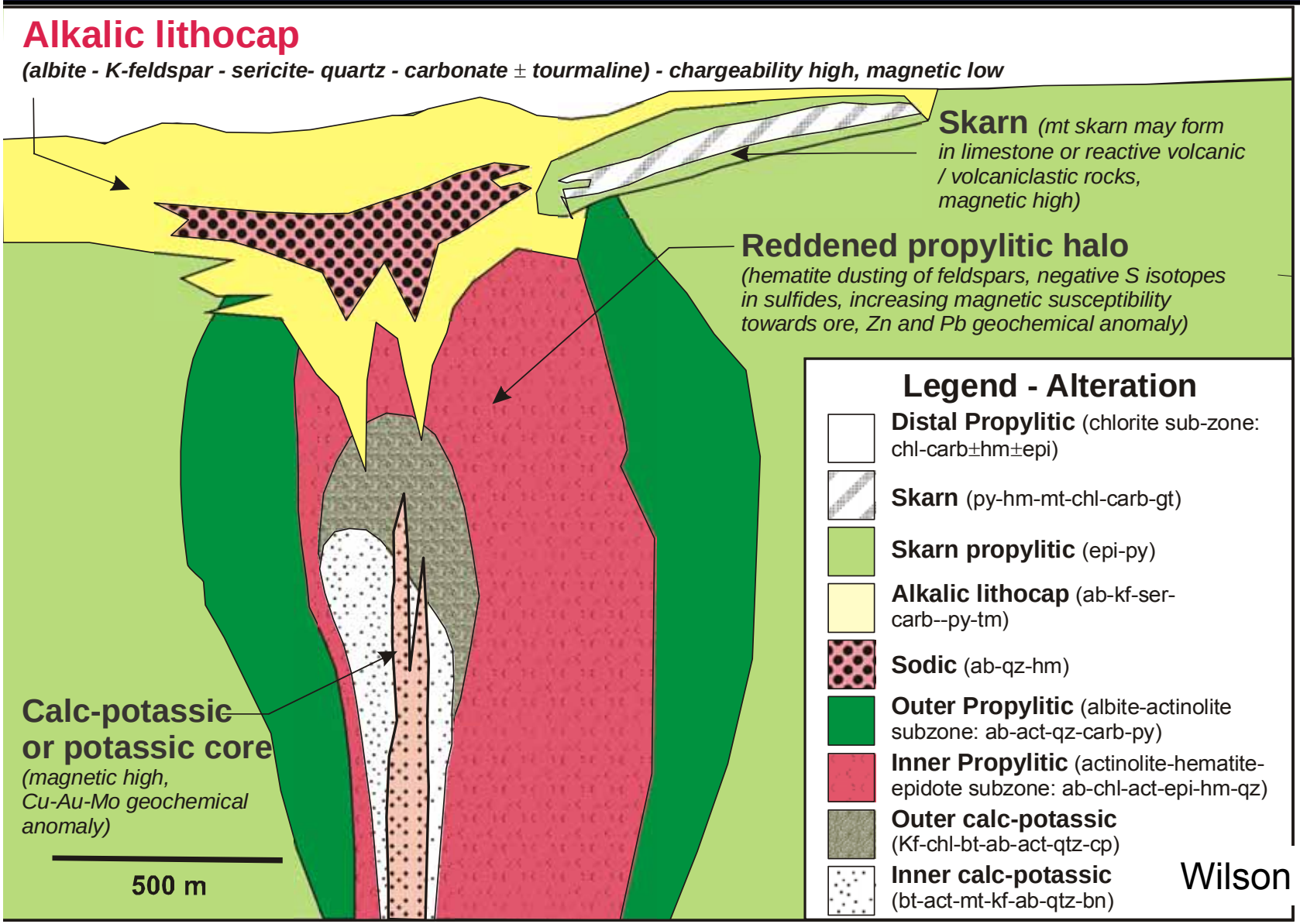

BAJO DE LA ALUMBRERA (1975, pre-mining)

Se also Ulrich and Heinrich, 2002)

# Alkalic porphyry Cu-Au: N-Parkes, NSW, Australia


**Alteration footprint is narrow, less evident than calc-alkalic cousins**

# Alkalic porphyry Cu-Au deposits: alteration model

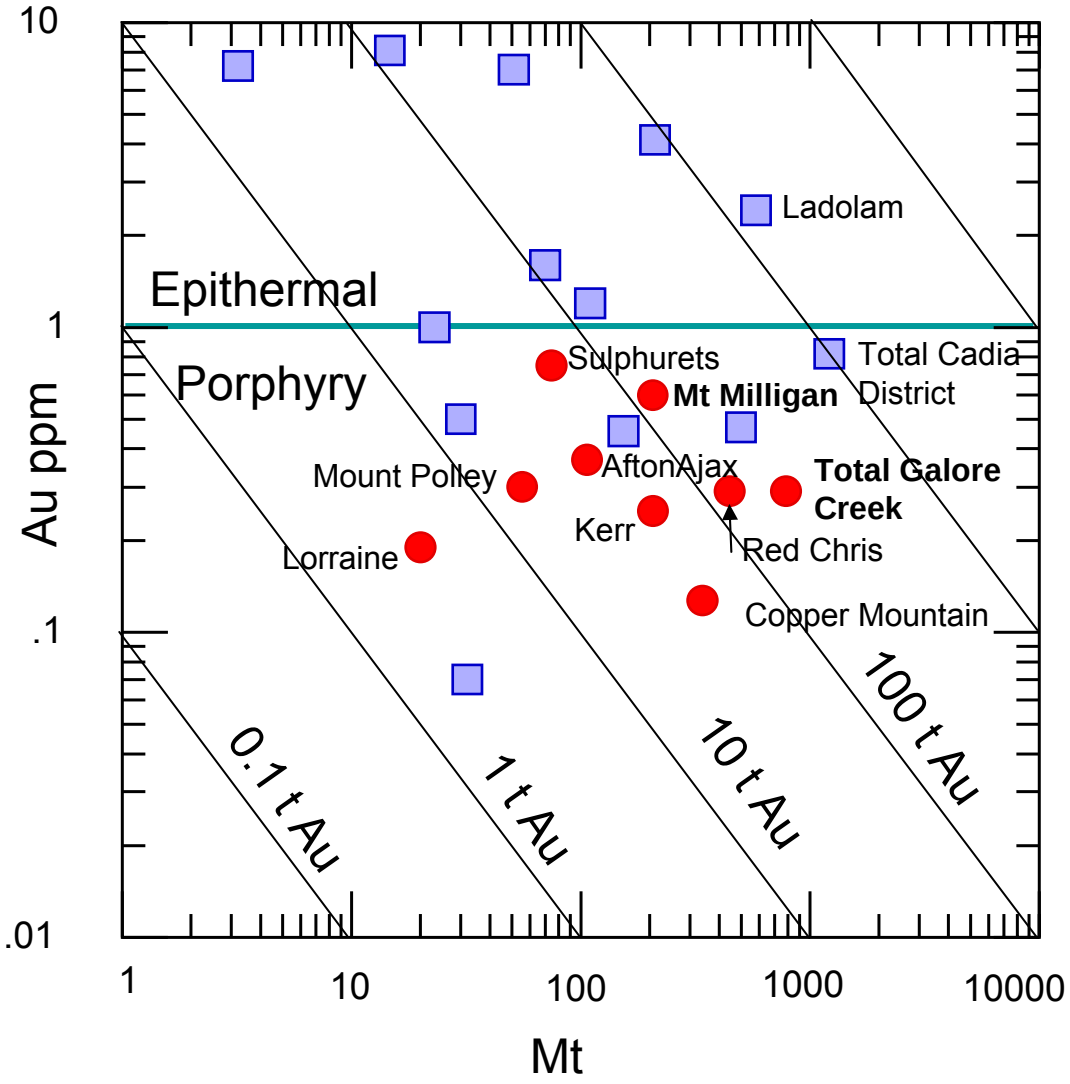



Wilson et al. 2003

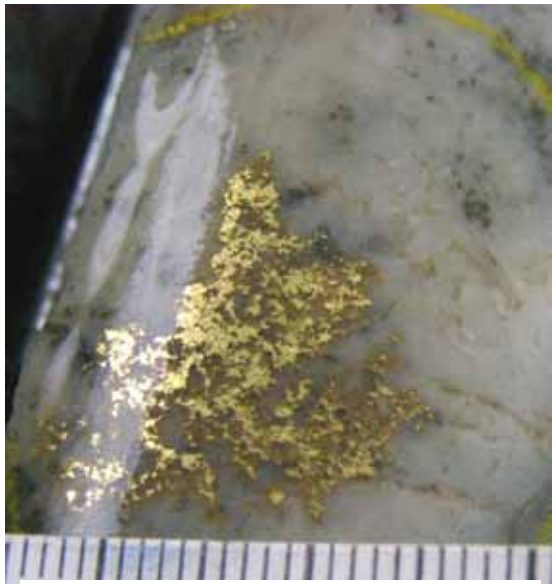
# Why target alkalic porphyry Cu-Au systems?

- **Cu-Au association**
- **Includes some of the highest gold grades in porphyry systems (Ridgeway, Cadia Far East)**
- **PGE enrichment in some systems (Copper Mountain, Afton, Lorraine)**
- **Magnetite locally very abundant (sold as Fe ore)**
- **Environmentally benign (low pyrite, high neutralization capacity of some host rocks)**
- **Untapped potential in BC and elsewhere**

# Grade and Tonnage- Alkalic systems




- BC porphyries
- Other locations

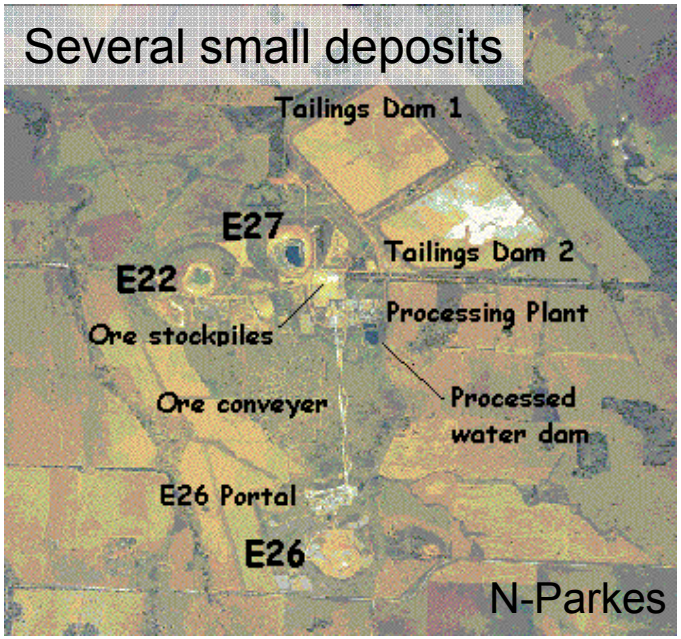


Au in alk. Epith. Deposit, Lk Cowal

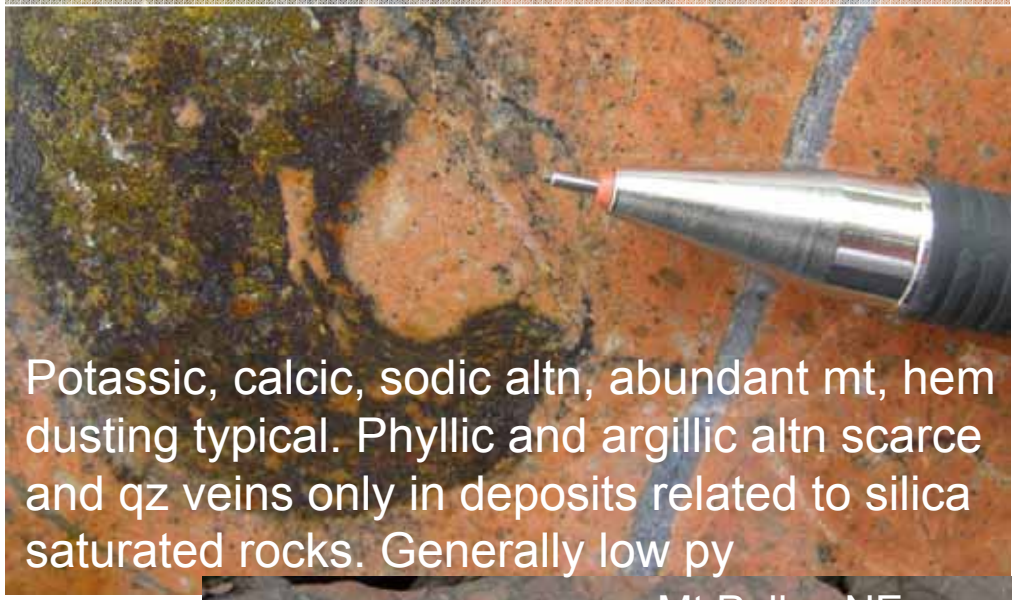
# Alkalic vs Calc-Alkalic

**Alkalic districts typically have…**

Several small deposits




Myarolitic cavity filled with Bn-cpy, N-parkes



Potassic, calcic, sodic altn, abundant mt, hem dusting typical. Phyllic and argillic altn scarce and qz veins only in deposits related to silica saturated rocks. Generally low py

Ab-ep-act-chl +/- carb alteration, Mt Milligan

Complicated and apparently small alteration footprint.

Mt Polley NE zone

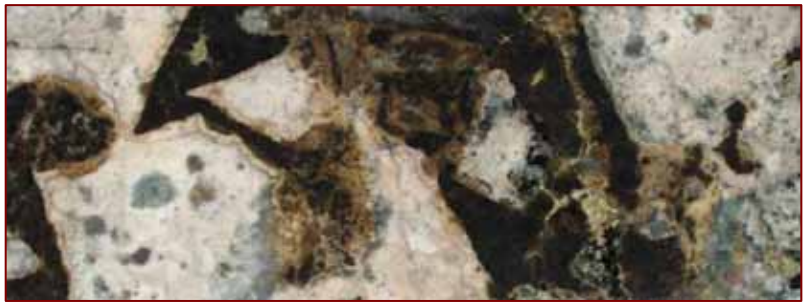
Breccias important in some deposits particularly in silica undersaturated types. May host high grade

# Features reminding of IOCG's, Skarns

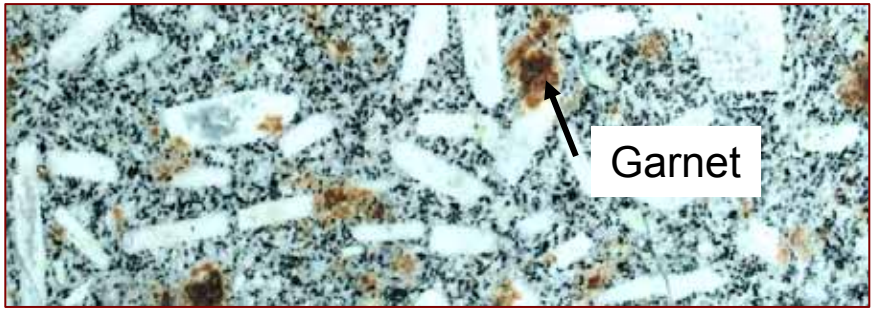
Magnetite-Apatite veins, Afton, BC


Pegmatite style K-fsp, coarse bi veins with late cpy, Copper Mountain, BC

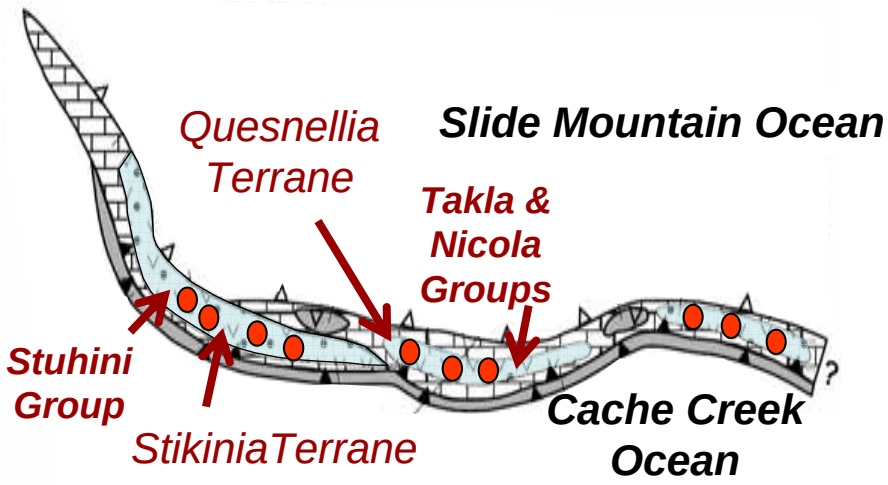
Gnt-diop-biot-cemented breccia, Galore Creek



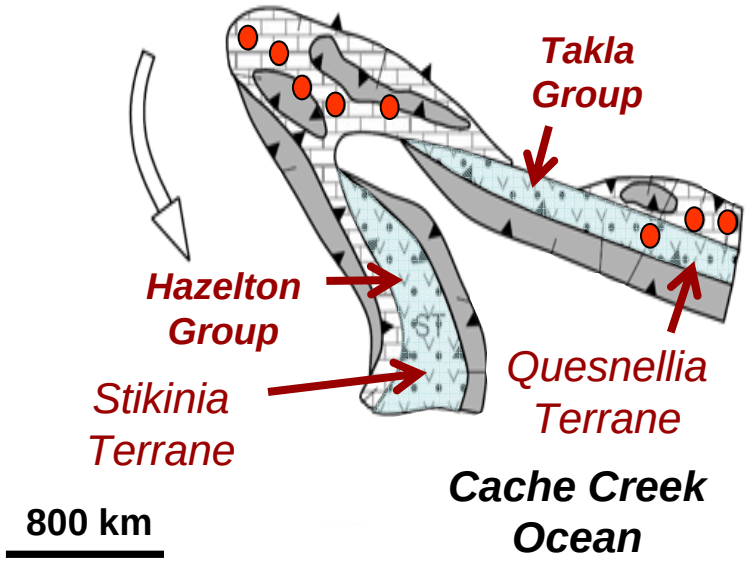
Megacrystic Or-plag-phyric monzonite, Galore Creek

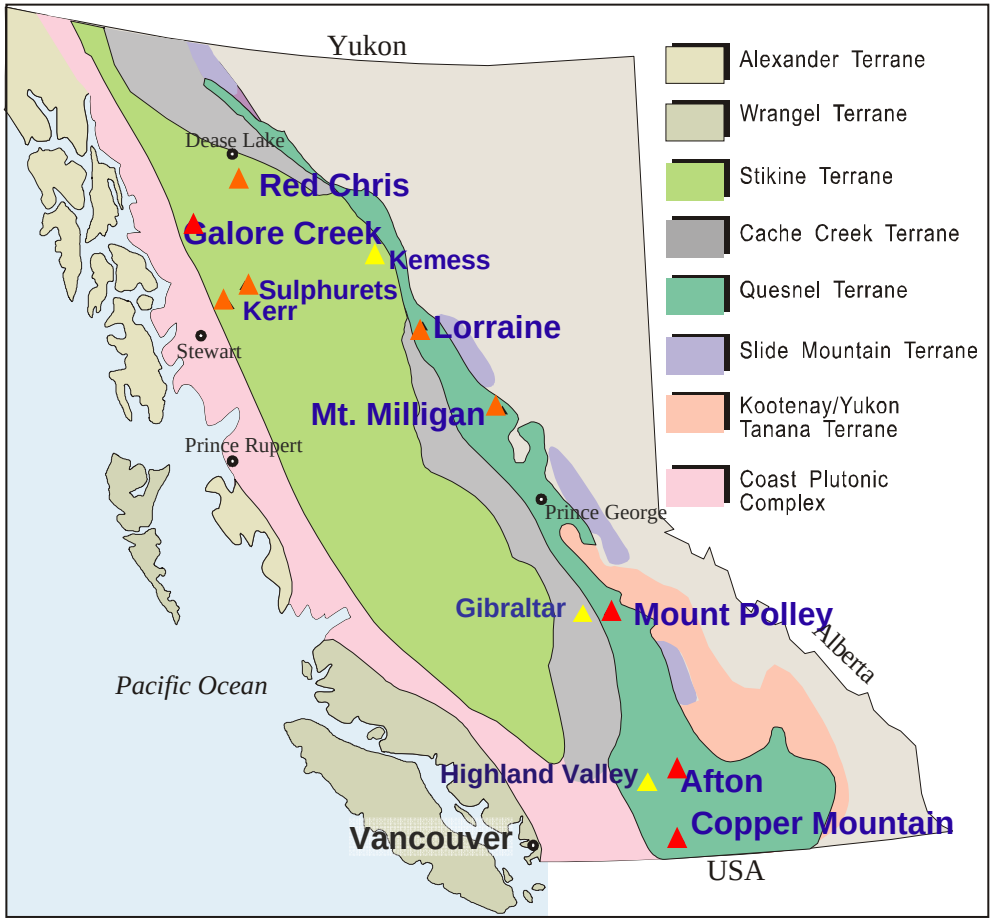


# Structural and Tectonic Environment of BC Alkalic Cu-Au Porphyry Deposits




***208-193 Ma: Mihalynuk et al., (1994)***




-Si ▲ +Si ▲ Alkalic Cu-Au porphyries

▲ Calc-alkalic Cu-Au porphyries

# The Galore Creek Project

**J. Micko, PhD candidate, K. Byrne MSc**

MDRU Mineral Deposit Research Unit

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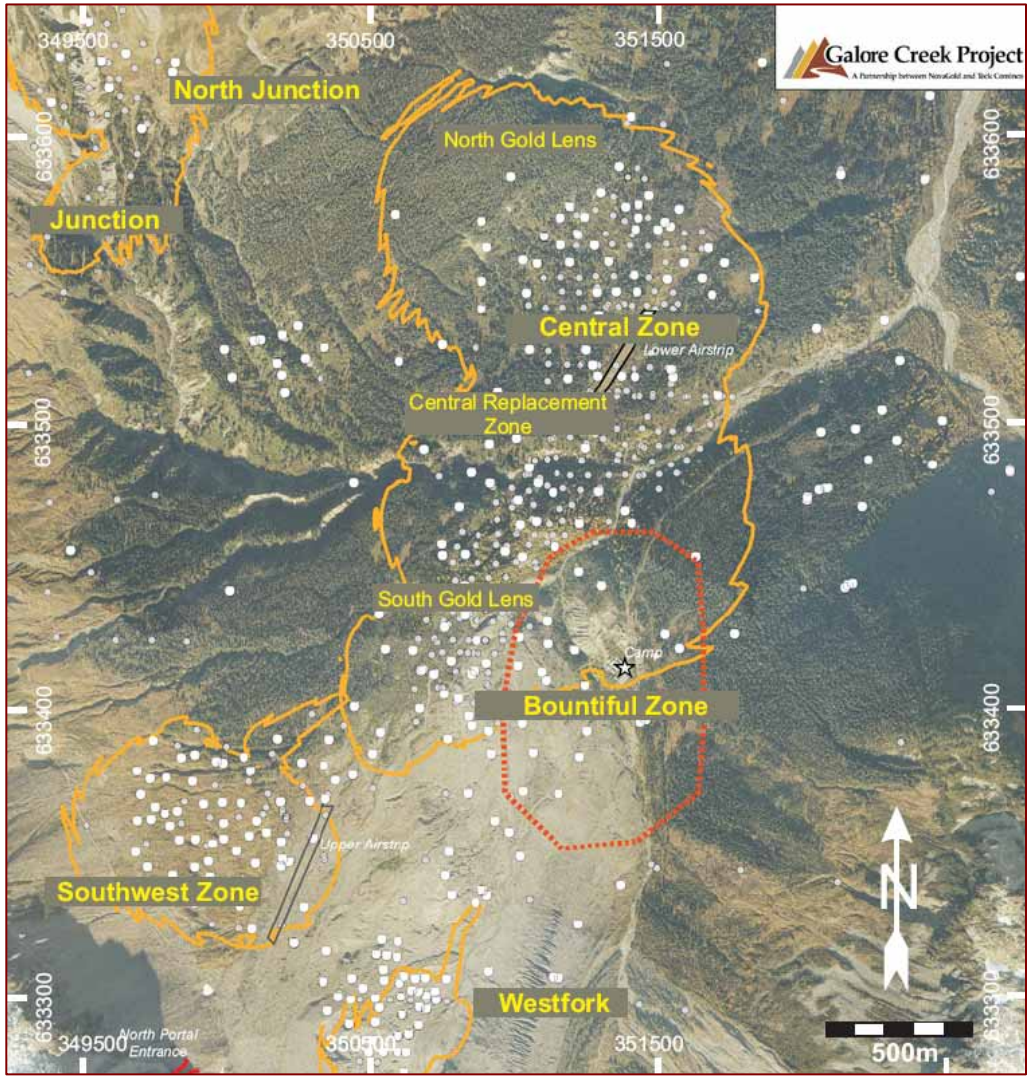
- The Galore Creek district contains *5 deposits* and *7 prospects.*

- Silica undersaturated class, age roughly between 210-203 Ma

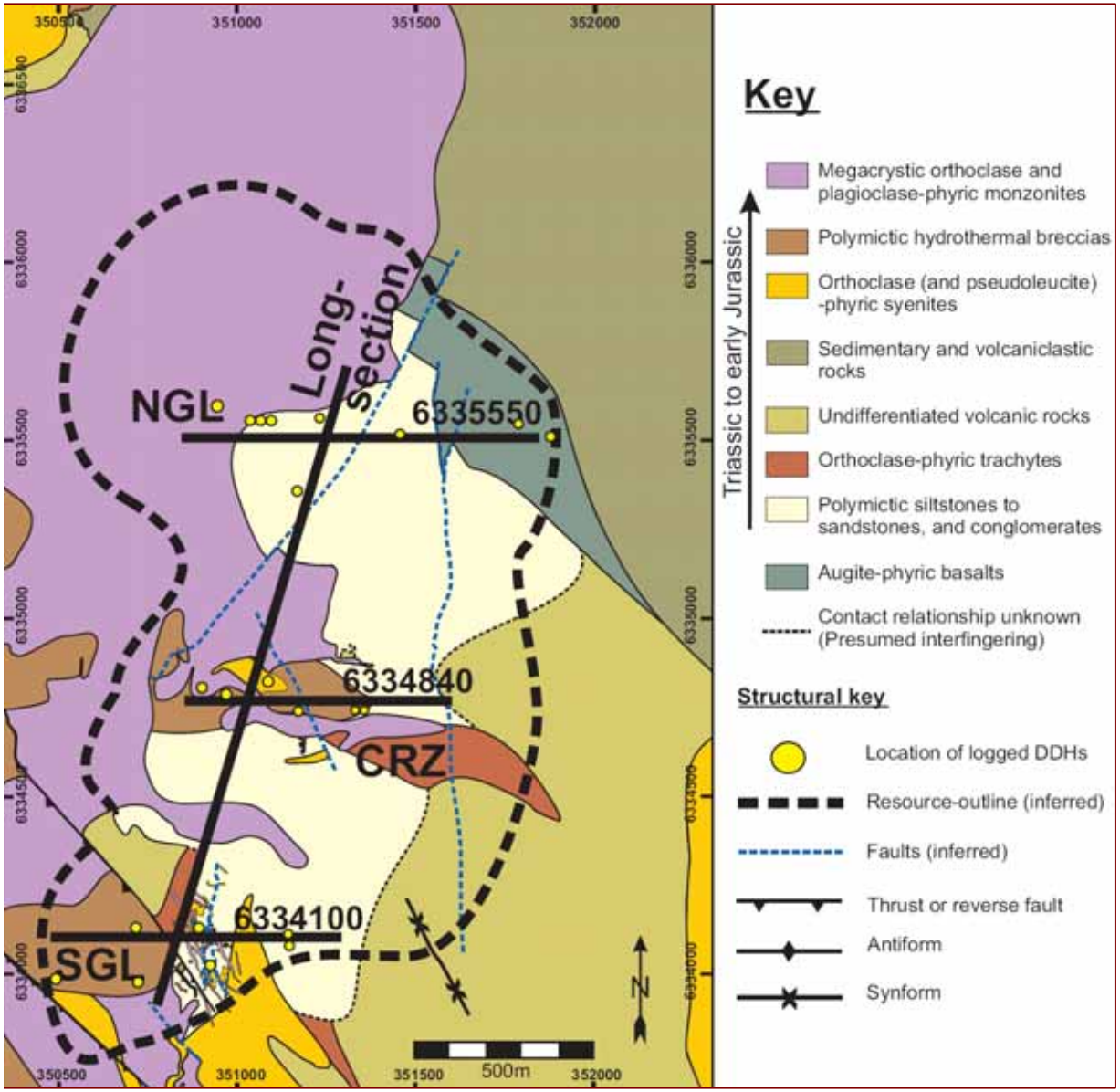
- The overall measured and indicated resource is estimated at *785.2 million tonnes* grading at *0.52% Cu, 0.29g/t Au and 4.87 g/t Ag*
*(NovaGold Resources Inc; press release June, 2008).*

Currently owned by *"Galore Creek Mining Company" (GCMC),* a 50:50 joint venture between NovaGold Resources Inc. and Teck Cominco Ltd.



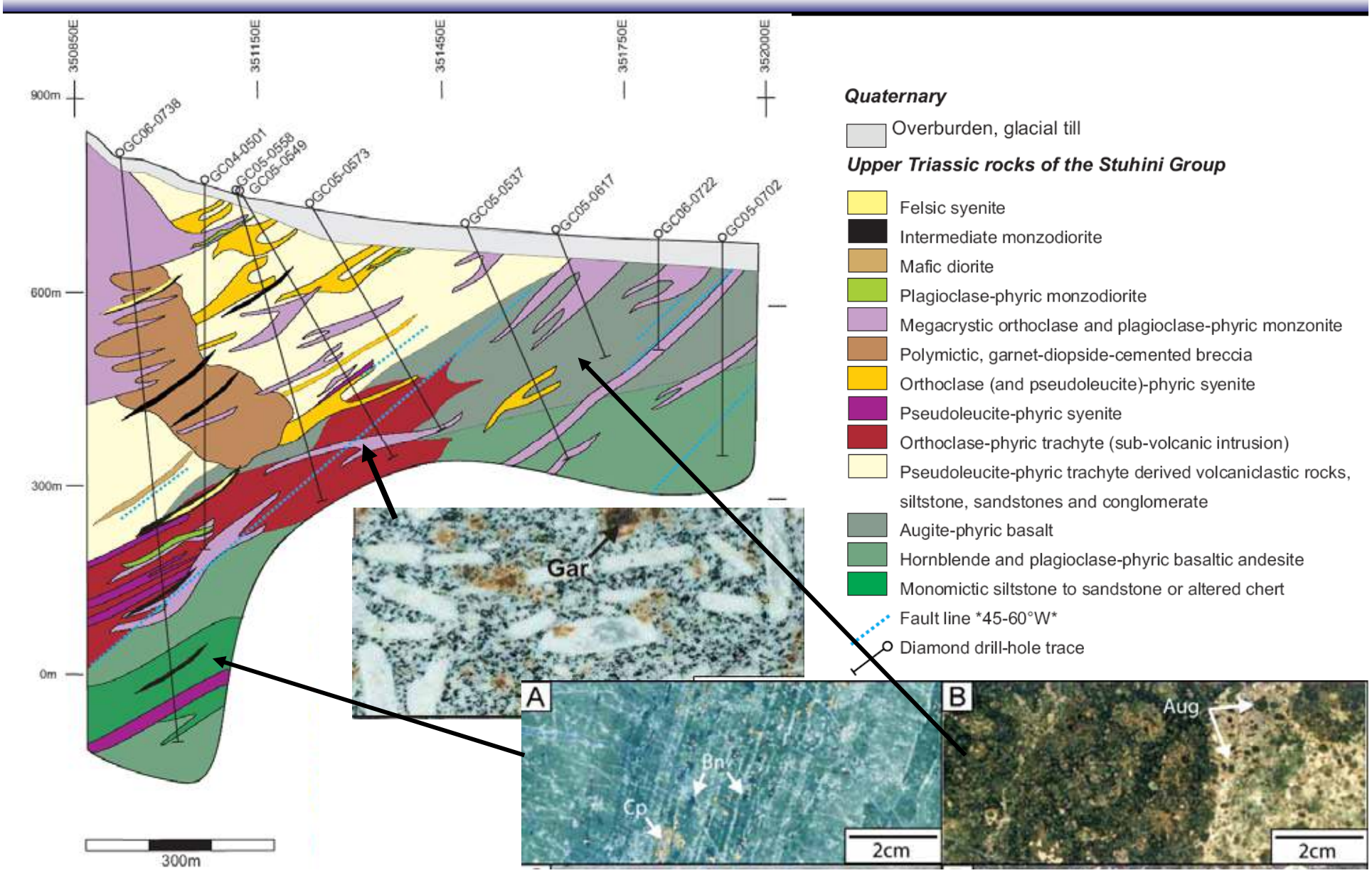

*The Galore Creek district -*
*(after NovaGold Resources Inc., 2007)*

# Galore Creek- Geology

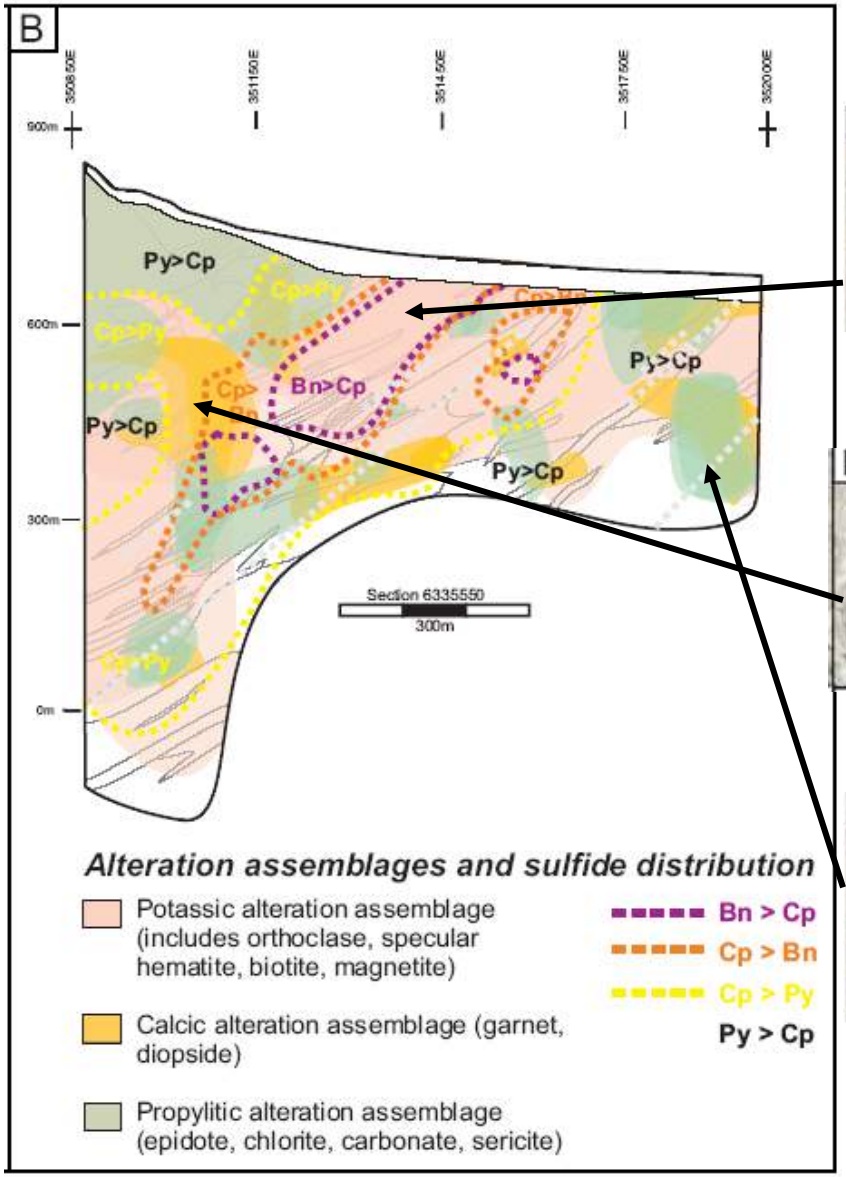



Micko, in prep.

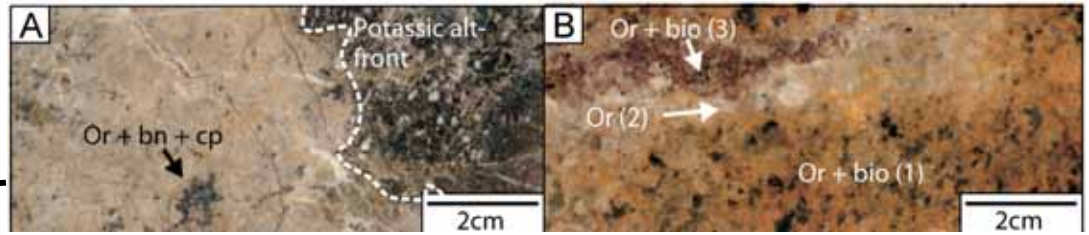
# Geology of the NGL



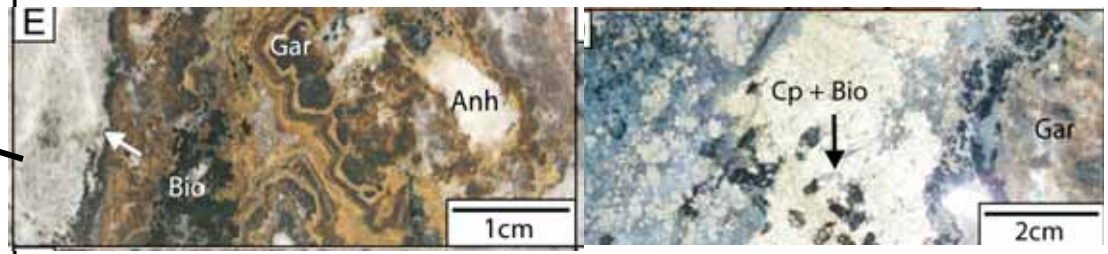
# Hydrothermal alteration and mineralization (NGL)



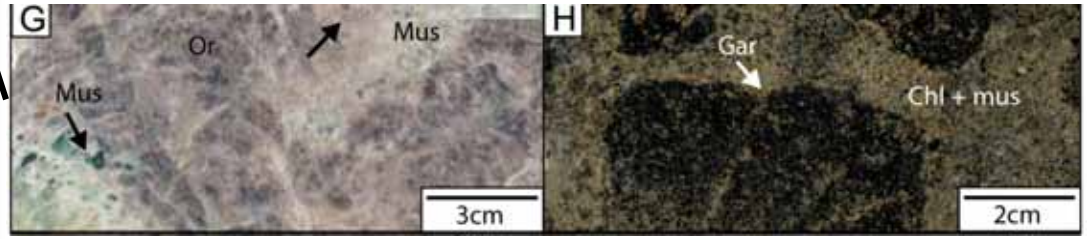

Potassic (orthoclase, biotite, magnetite ± hem)




Calcic (Garnet, diopside ± anhydrite )

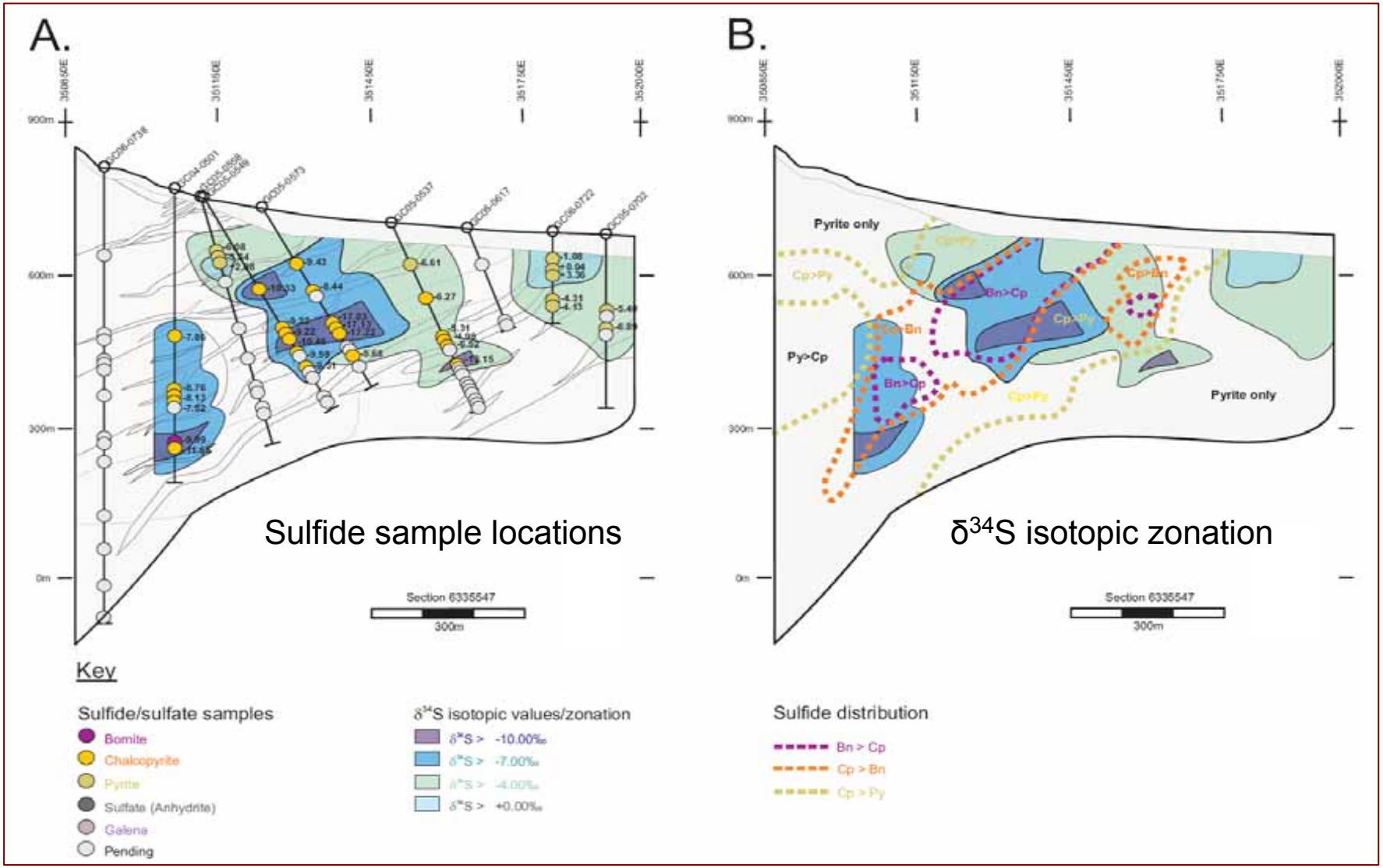



Propylitic (chlorite, epidote, carb. ± muscovite)




From Micko, in Prep

# Sulfur isotopes distribution (NGL)




From Micko, in Prep

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# Mt Milligan

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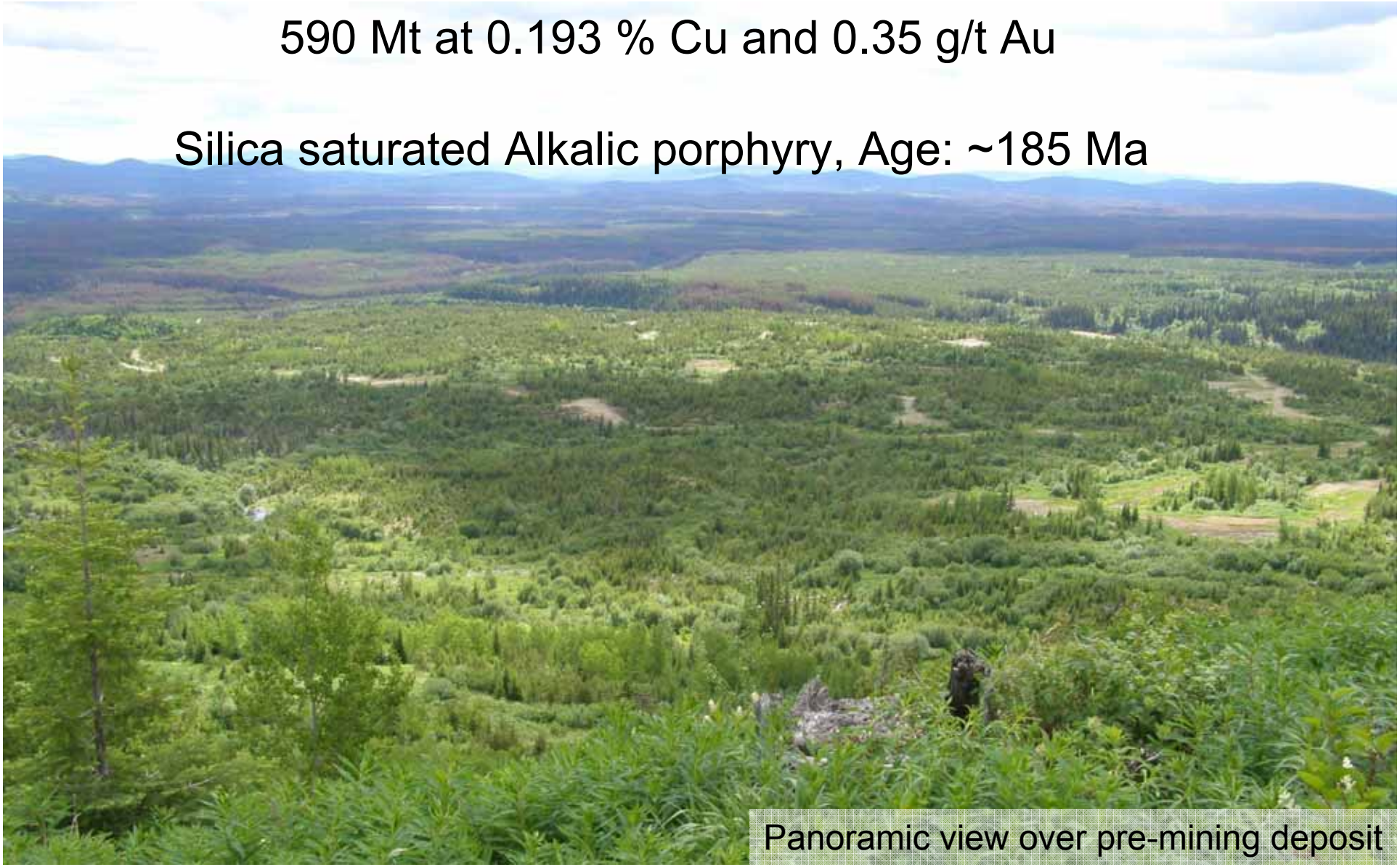
590 Mt at 0.193 % Cu and 0.35 g/t Au

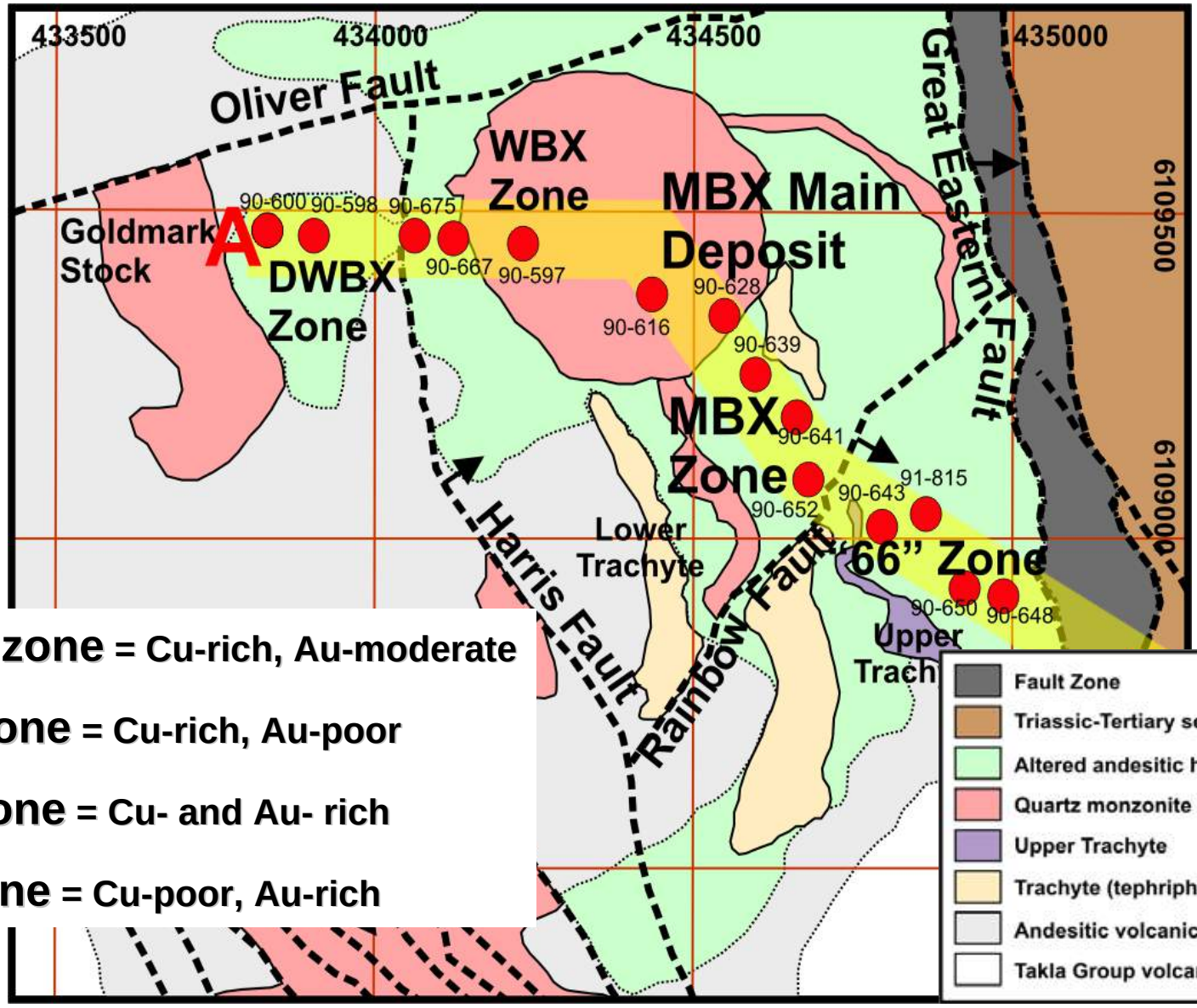
Silica saturated Alkalic porphyry, Age: ~185 Ma



Panoramic view over pre-mining deposit

# Mount Milligan

P. Jago, MSc




Plan provided by Placer Dome Inc.

- **DWBX zone** = Cu-rich, Au-moderate
- **WBX zone** = Cu-rich, Au-poor
- **MBX zone** = Cu- and Au- rich
- **"66" zone** = Cu-poor, Au-rich

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# Mount Milligan rocks

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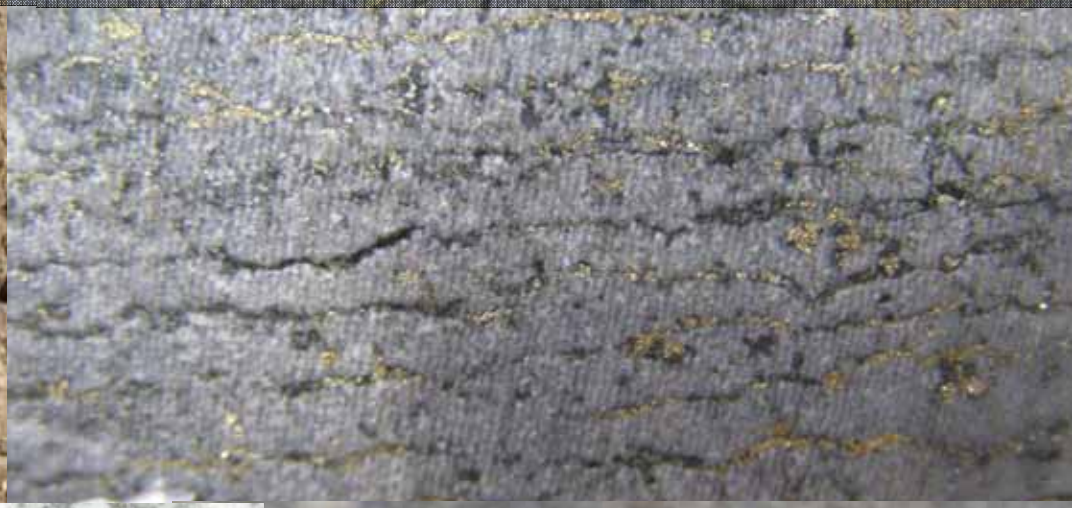
Volcanic host rocks, strong bi +/-mt altn, augite phenos replaced by sulfides

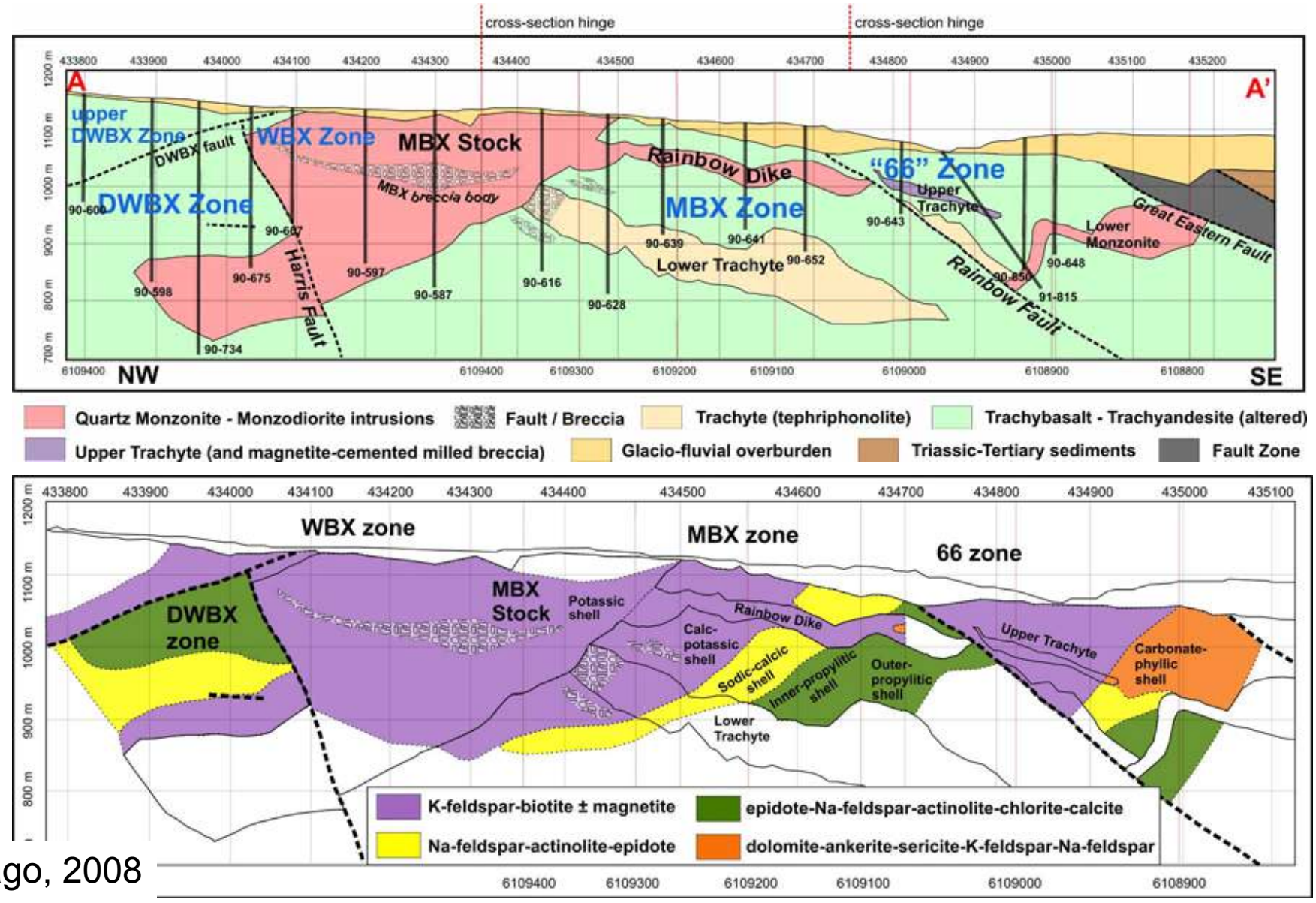
Flow-banded rainbow dyke. Sulfides in flow bands. K-spar +/- bi alteration



Ab-ep-act-chl +/- carb alteration (inner propylitic)

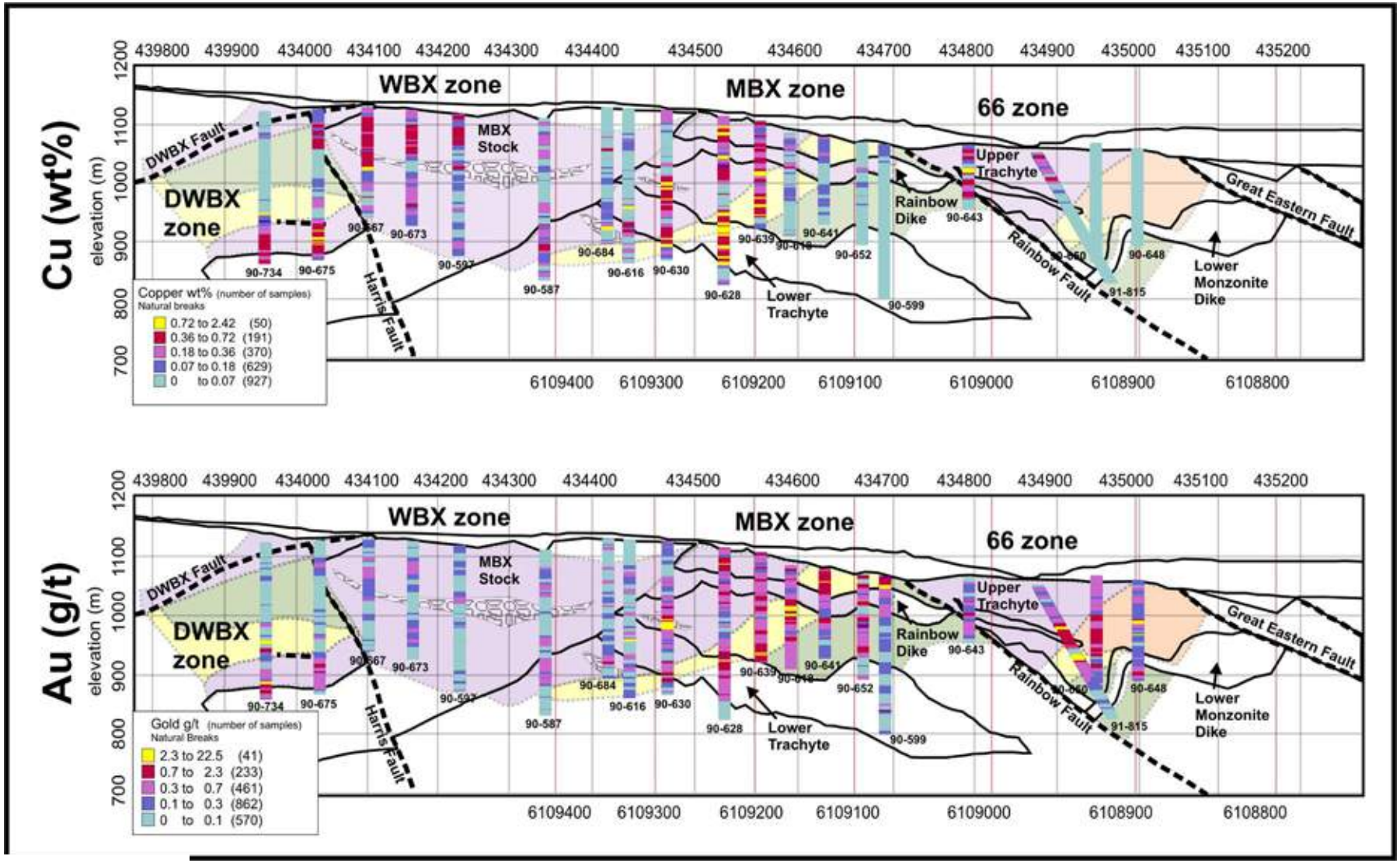
Thin fracture controlling sericitization of feldspars, upper trachyte

# Mount Milligan



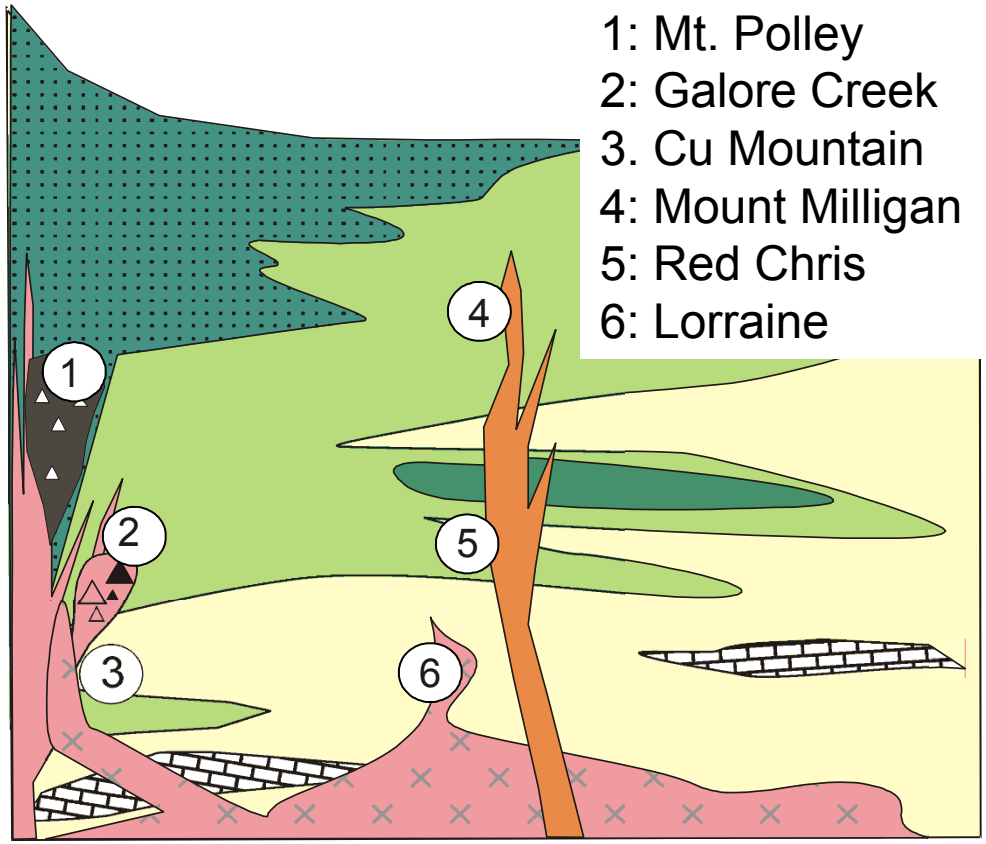

Jago, 2008

# Alteration geometry with ore grade




Jago, 2008

# General volcanic setting for BC porphyry Cu-Au deposits




1: Mt. Polley
2: Galore Creek
3. Cu Mountain
4: Mount Milligan
5: Red Chris
6: Lorraine

Nicola, Takla, Stuhini groups

Proximal Basalts
*Magnetite rich*
Medial facies basalts
Fine grained basinal facies
Carbonate rocks

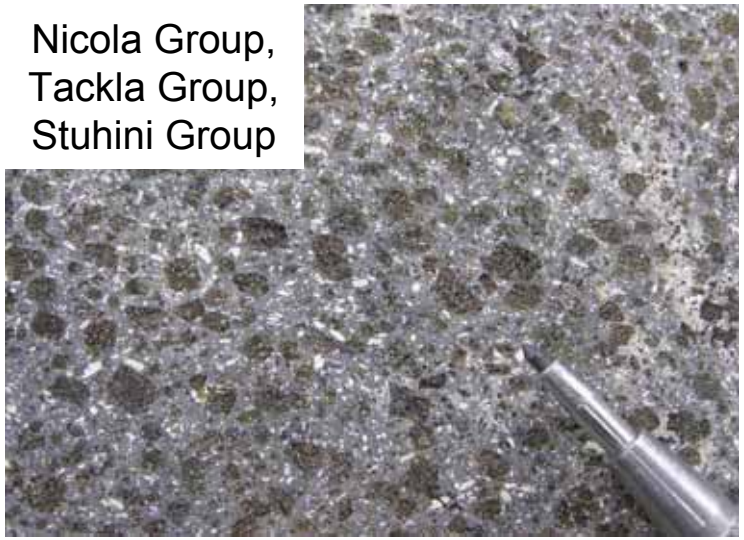
Intrusive rocks

Silica saturated monzonite
Silica undersaturated monzonite

~500 m

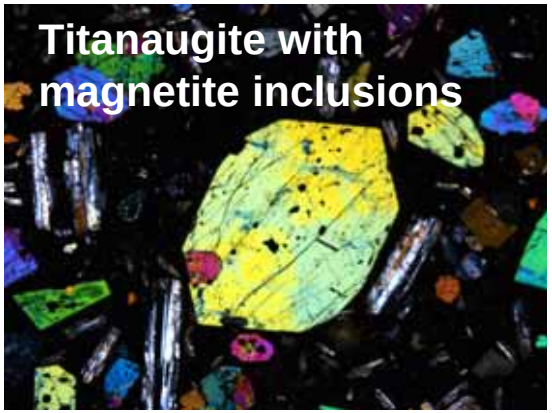
Subaqueous pyroxene phyric basalts

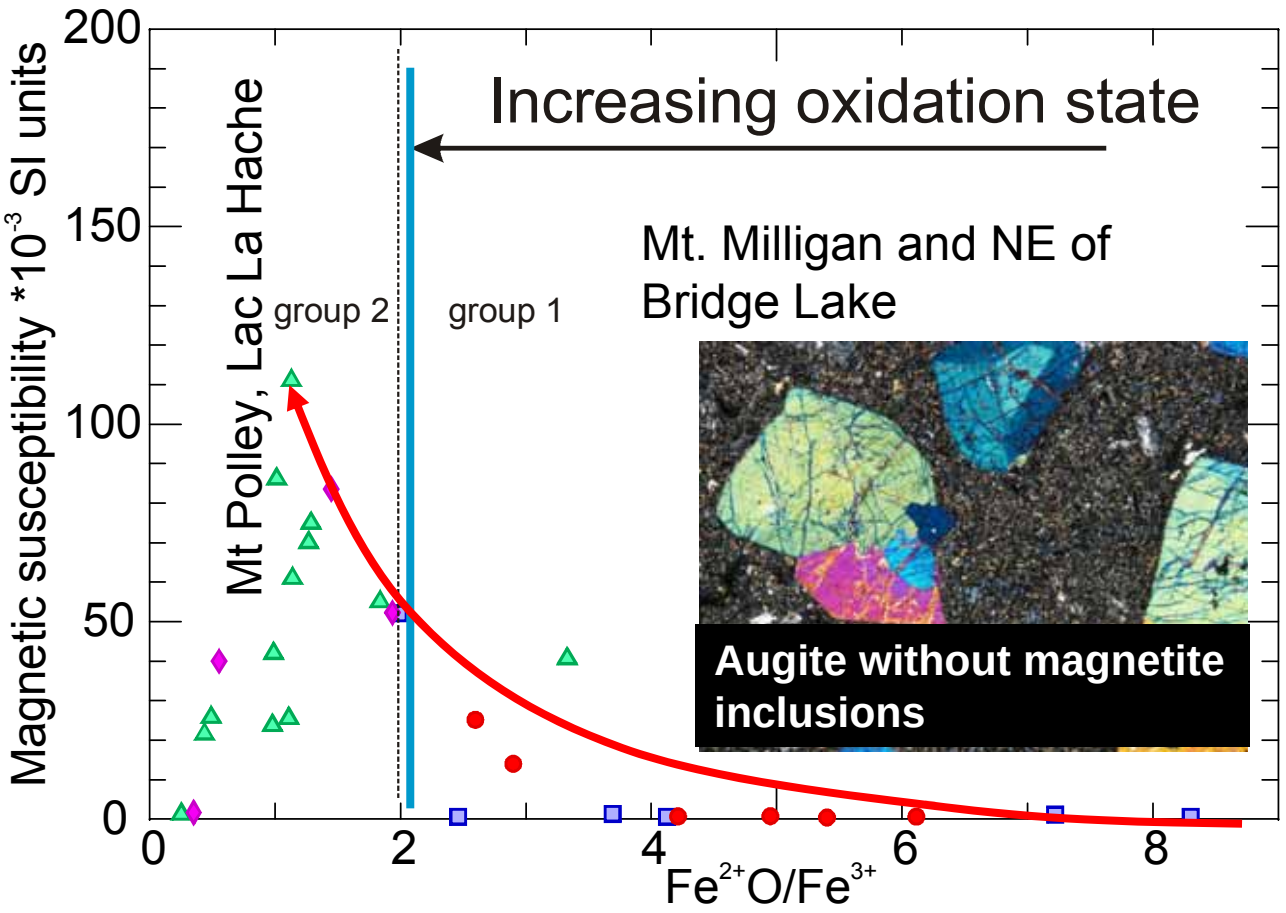
Nicola Group,
Tackla Group,
Stuhini Group



# Magnetic Susceptibility as Proxy for Oxidation State

Highly oxidized parts of the arc are more likely to host a Mt. Polley
Oxidized rocks tend to be more alkalic



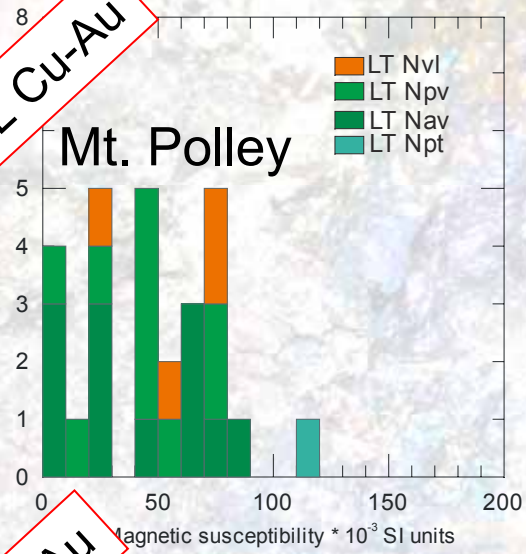

Ongoing MDRU research; Bissig et al. 2010

# Magnetic Susceptibility, Host rocks

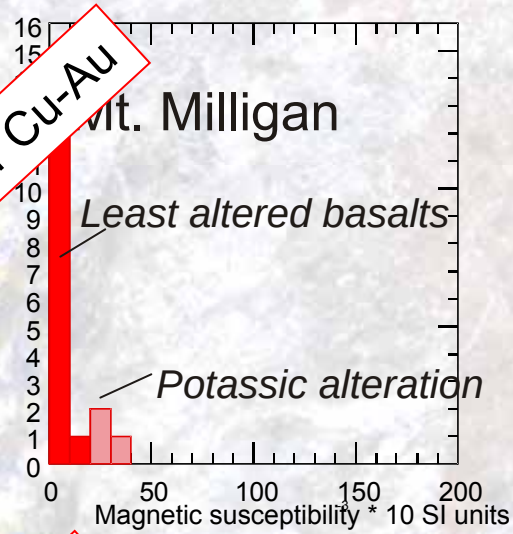
**Magnetic susceptibility generally high (>20*10$^{-3}$ SI)**

**Magnetic susceptibility generally low (>10*10$^{-3}$ SI)**

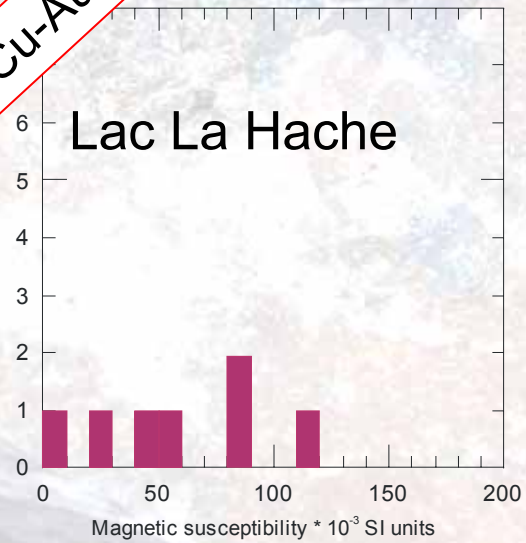
COEVAL Cu-Au



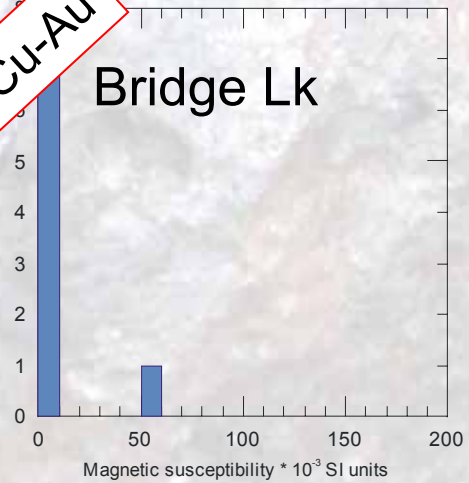

20 Ma younger Cu-Au




COEVAL Cu-Au



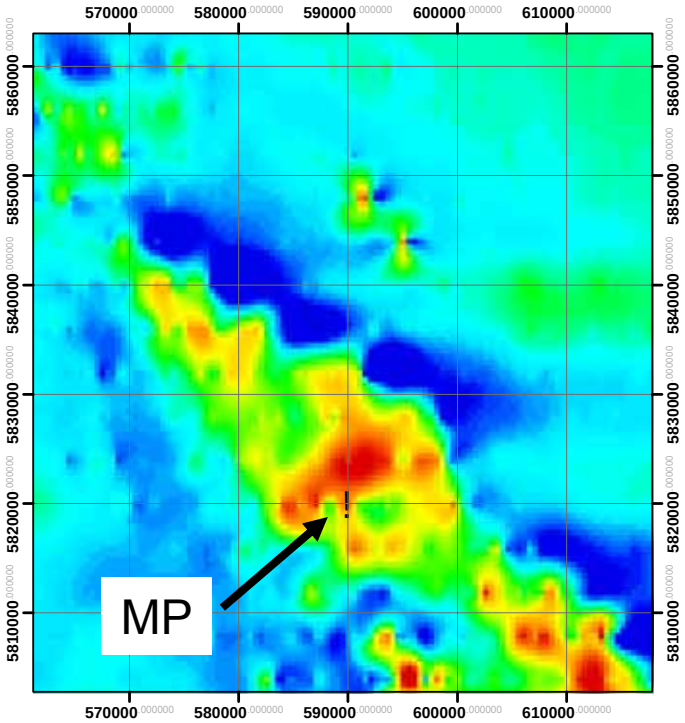

No Cu-Au

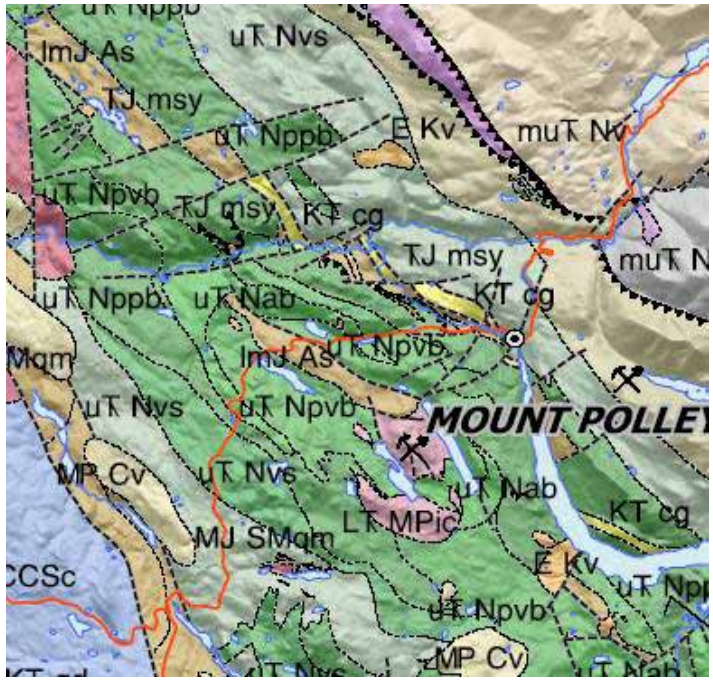



Ongoing MDRU research; Bissig et al. 2010

# QUEST Aeromagnetic Signatures

**Mount Polley:** Relatively high magnetic intensity in Nicola Gr. volcanic rocks



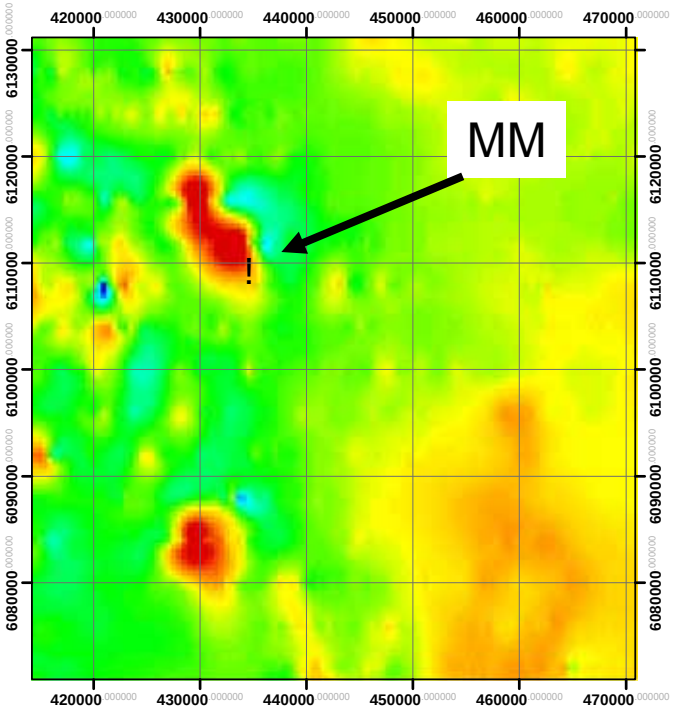




Logan et al., 2010

Ongoing MDRU research; Bissig et al. 2010

# QUEST Aeromagnetic Signatures

**Mount Milligan:** Generally subdued magnetic intensity in volcanic units. Mag high corresponds to mid Jurassic (169 Ma) intrusion



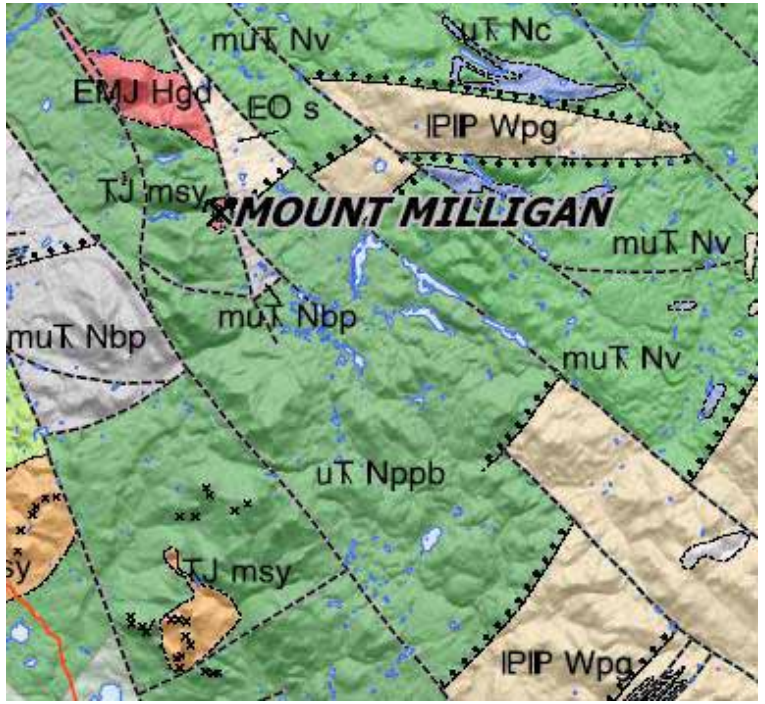

**Legend**

**Mag2_Main.grd**

**Value**

High : 62759.687500

Low : 55648.089844




Logan et al., 2010

Ongoing MDRU research; Bissig et al. 2010

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# Summary

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- Most BC porphyry deposits have been tilted
- Negative sulfur isotopes in sulfides vector to mineralization
- Magmatic-hydrothermal breccias are important hosts
- Porphyries represent a variety of volcanic and igneous settings but host rocks to all are subaqueous basaltic rocks and K-spar megacrystic monzonite porphyries are commonly found in proximity to mineralization
- In most districts several discrete mineralized centers with varied Cu:Au ratios are present

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# Additional information

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**Geoscience BC - www.geosciencebc.com**

**MDRU - www.mdru.ubc.ca**