Development of an integrated 3D model and distal expression of the Highland Valley Copper System, south-central British Columbia

R.G. Lee

Roundup 2018

The Team

NSERC-CMIC FOOTPRINTS

- **Integrated expertise across multiple disciplines**

Site Leaders
Craig J.R. Hart – MDRU-UBC
Pete Hollings – Lakehead
Sarah Gleeson – Potsdam, Germany

Geologists
Guillaume Lesage – MDRU-UBC
Kevin Byrne – Alberta
Michael D'Angelo – Lakehead
Darius Kamal – MDRU-UBC

Site Geologists
John Ryan – Teck Resources Limited
Miguel Alfaro – Teck Resources Limited

Modeller
Julia King – Geoscience North

Surface soil/till:
Rachel Chouinard – MDRU-UBC
Peter Winterburn – MDRU-UBC
Andrea Reman – Waterloo
Martin Ross – Waterloo

Hyperspectral
Philip Lypaczewski – Alberta
Benoit Rivard – Alberta

Physical Properties
Randy Enkin – GSC Sydney B.C.

Geophysics
Reza Mir – University of Toronto
William Morris – McMaster University

Inversion Modelling
Marc Vallée – Memorial University

Objective – Integrating data to 3D model

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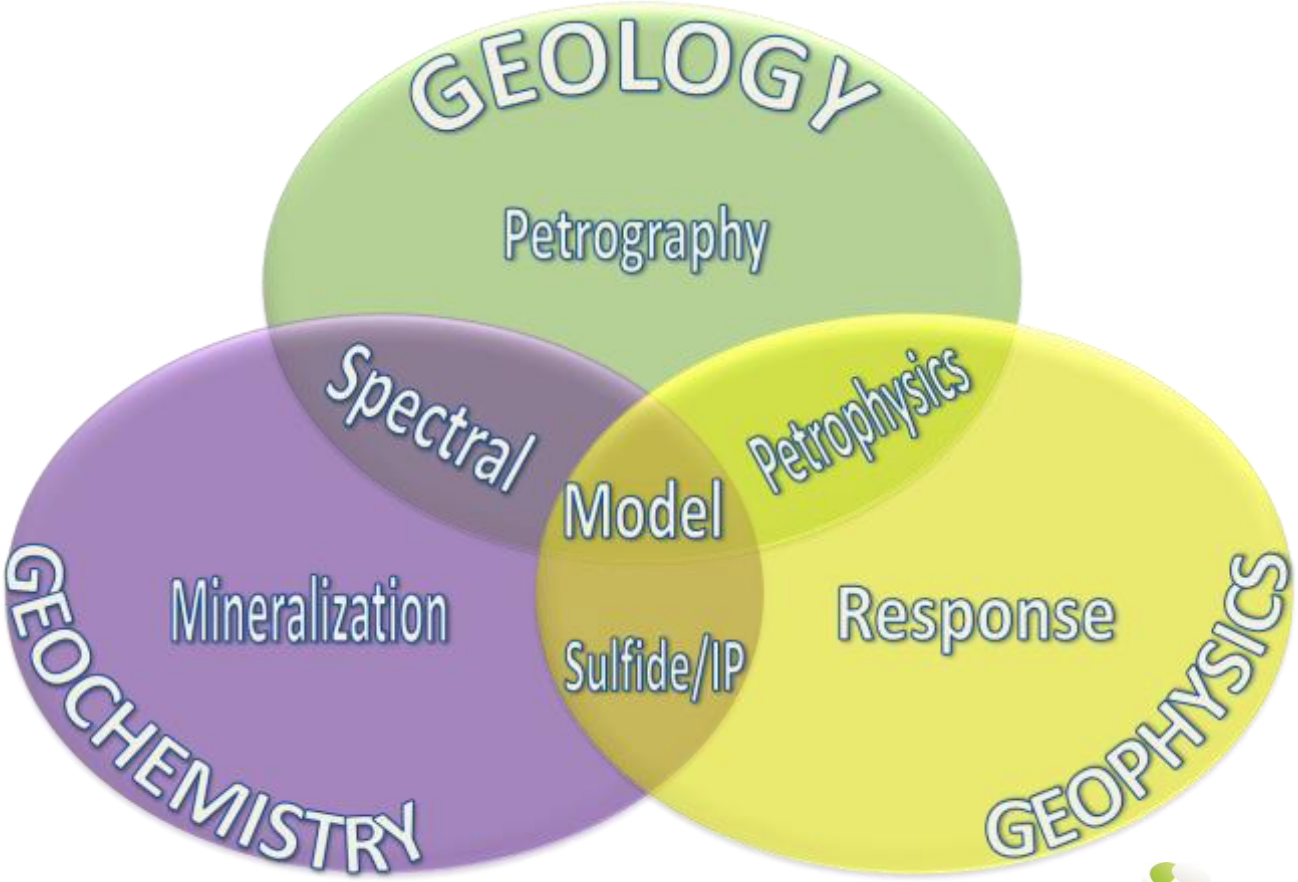

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Guichon Creek batholith – south-central B.C.
Highland Valley Copper (HVC)

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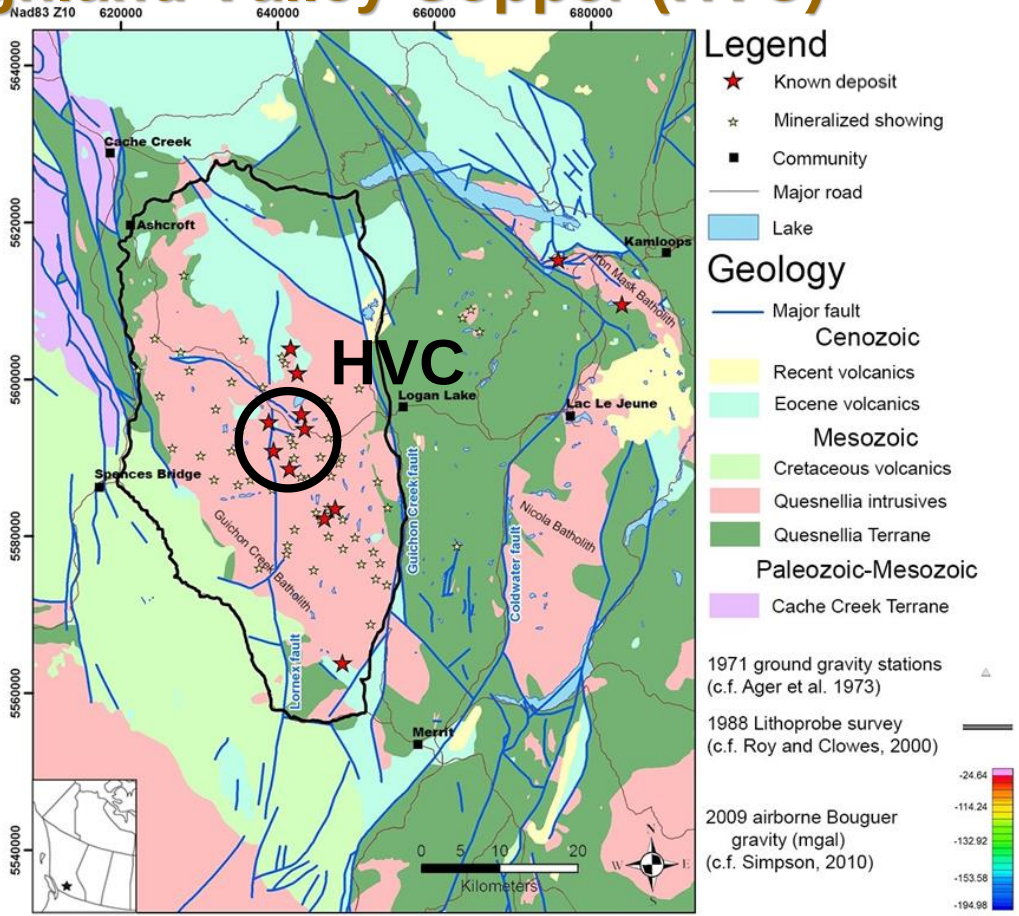

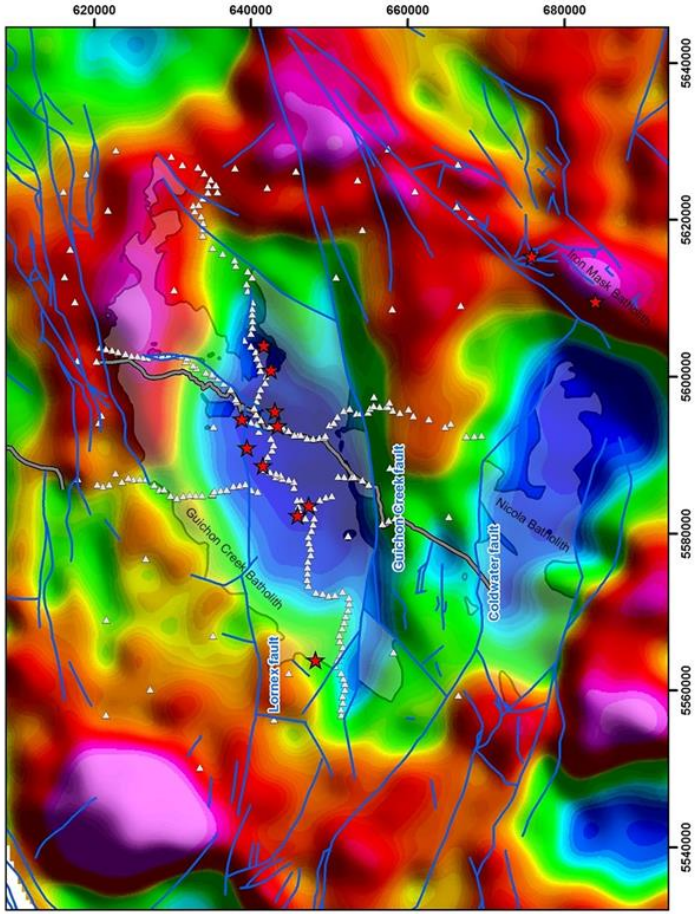

GCB & HVC

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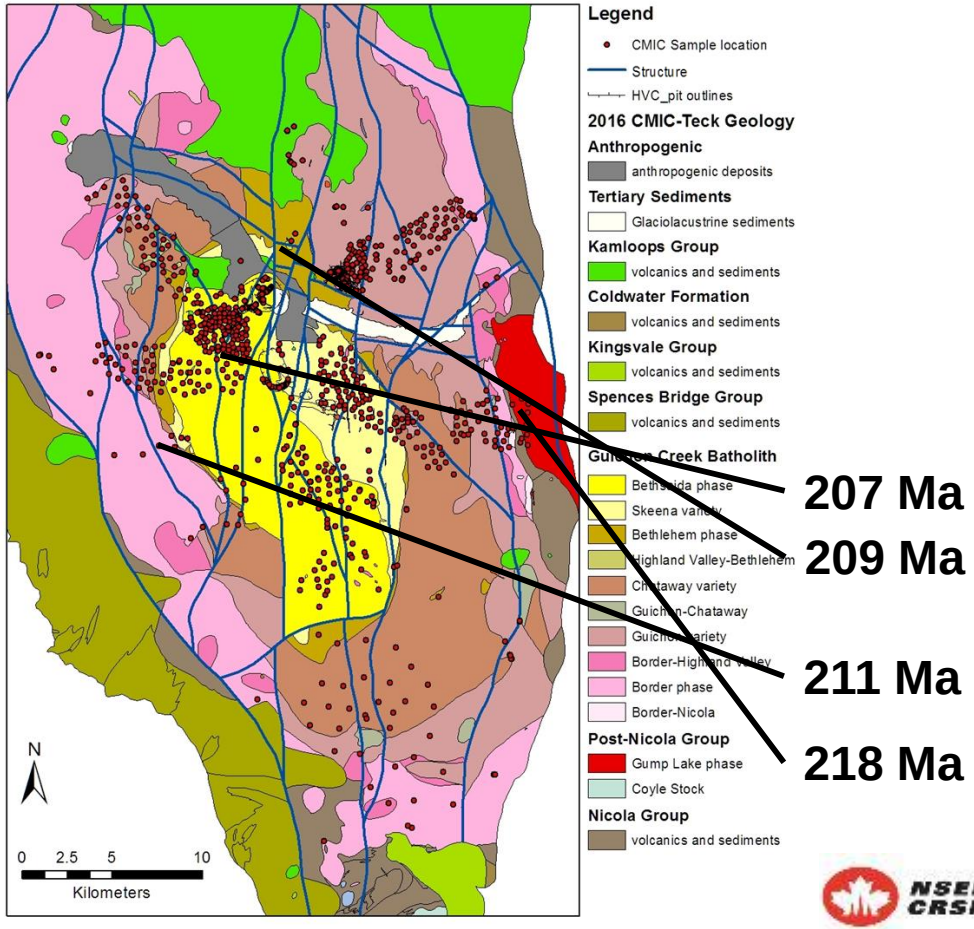
New geologic and structure map of region from five+ transects

1:5000 & 1:10,000

Over 1000 samples collected for project

- **Field measurements**
- **Field mag sus**
- **Rock (soil/till/vegetation)**

New U-Pb Age Dates
218 – 207 Ma



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Work Flow – 1000 samples

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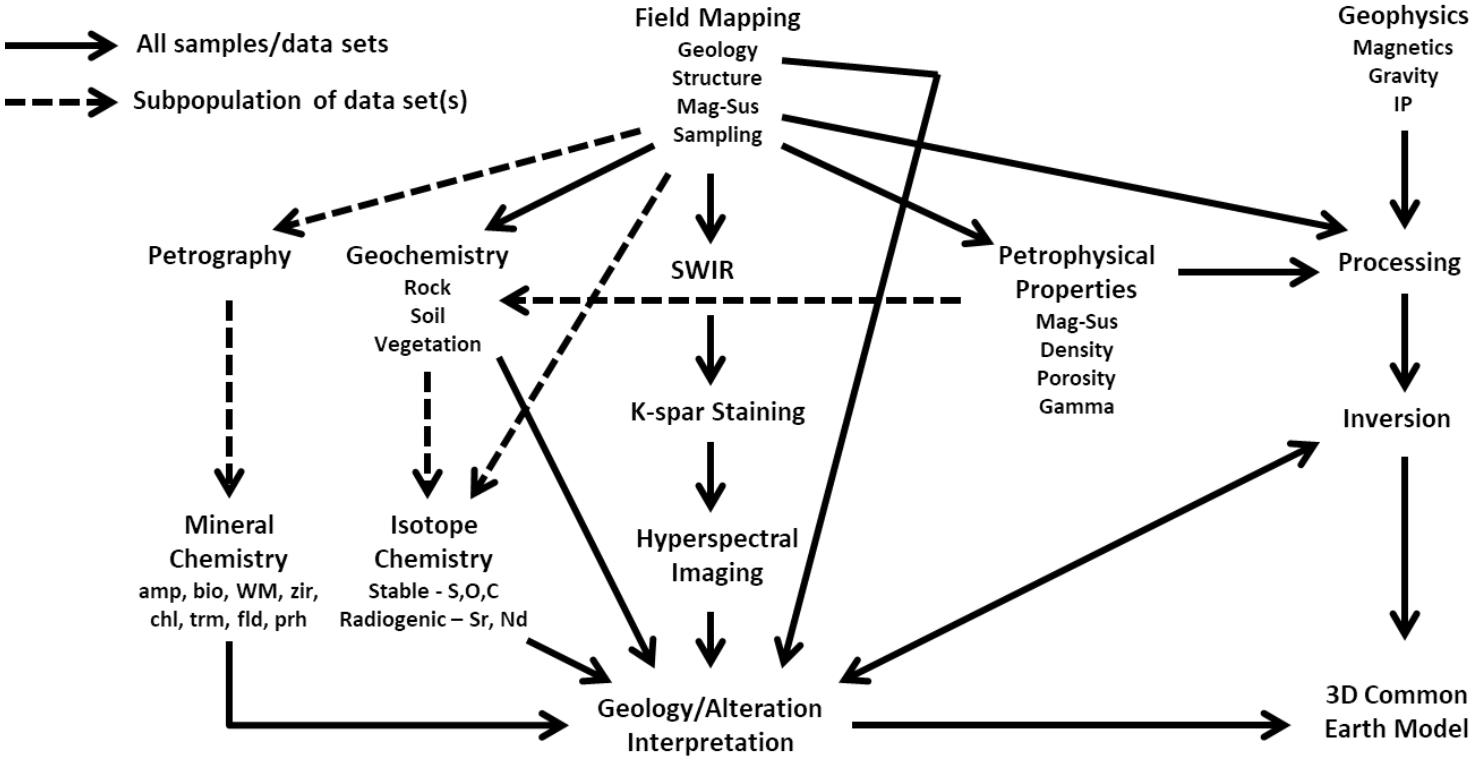

Deliverables – Lithology Model; Structural Model; Alteration Map; Integrated database

Petrography - Integration

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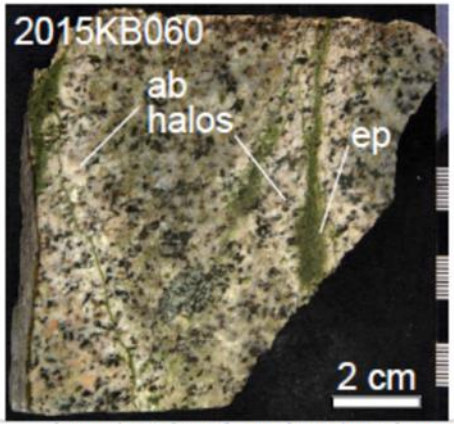
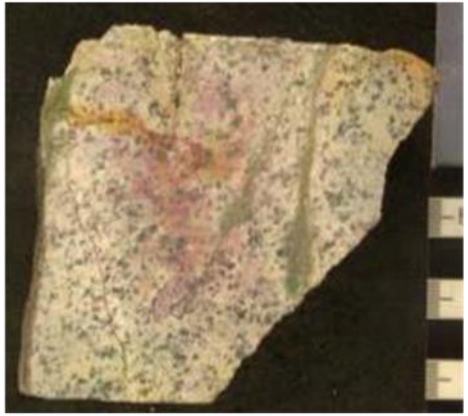
Petrography -> K-staining -> Spectral -> chemical composition

Lithochem -> petrophysical properties -> proxies for model

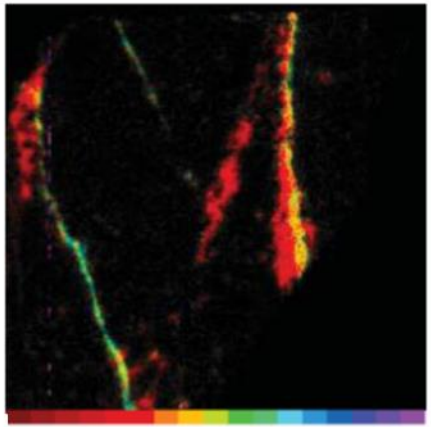
Data combined with field observations to define alteration maps



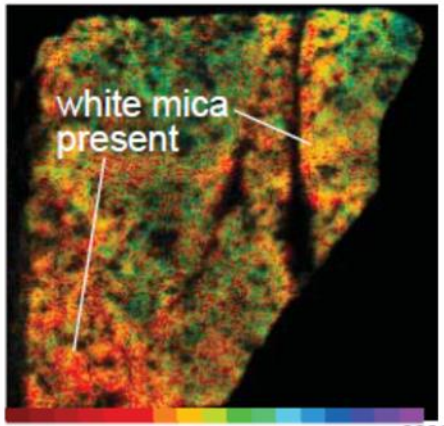
	Al/Ti	Ca/K	Na/K	Na/Ba	Sr/Ba	K/Th	Rb/Ti
stg. Na	26.7	10.0	9.3	3.9	4.4	0.1	28.0
least alt.	24.8	2.8	1.9	0.6	1.0	0.4	82.6



Feldspar staining



1540nm Epidote composition 1556nm



2190nm Al-OH variation 2220nm

Litho & mineral chemistry

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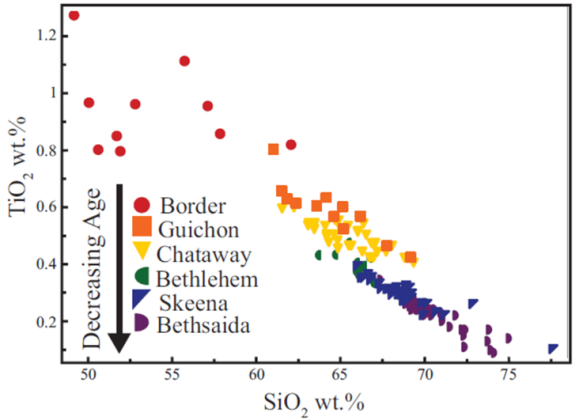
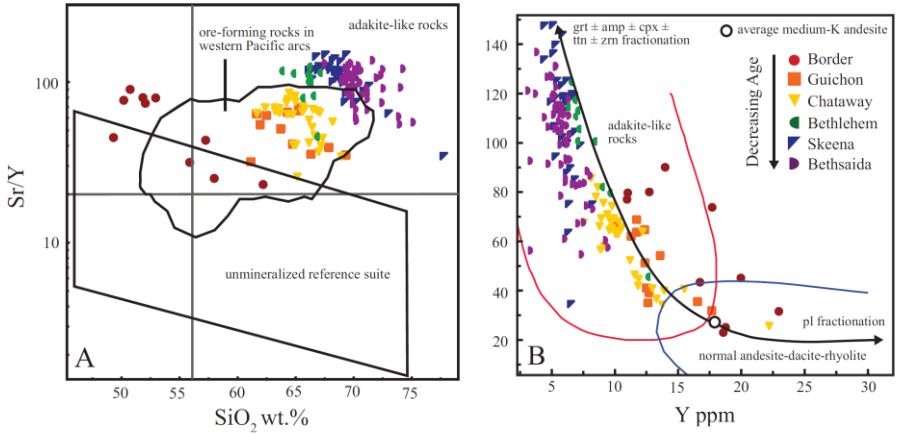
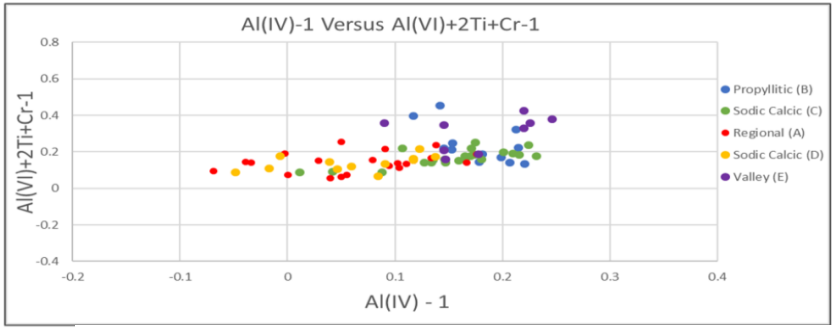
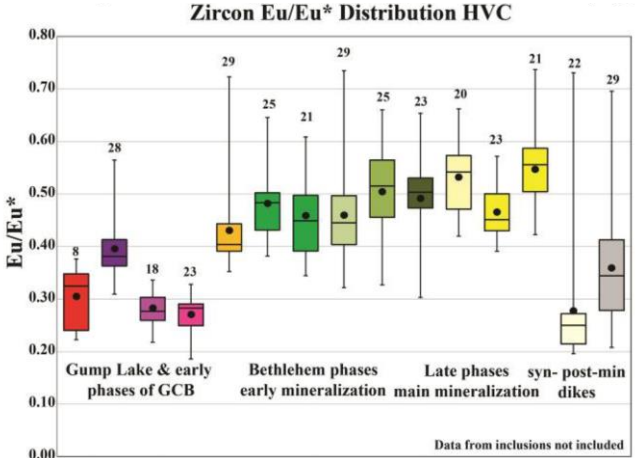
D'Angelo et al. 2017 SEG December issue







Chlorite chemistry; Kamal 2017 UBC BSc



Zircon; Lee et al. 2017 SGA

Alteration

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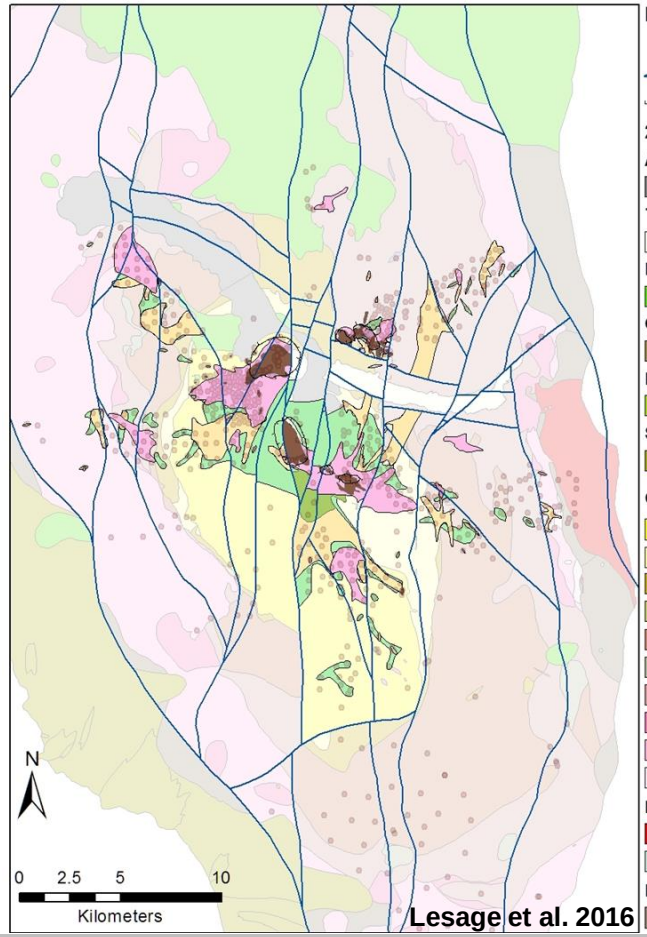
New alteration map defining fluid pathways and footprint vectors

Distribution of mapping and sampling extends ~30km east-west and ~20km north-south

Structural bound

Alteration mineral assemblage

- Fracture-controlled Ms-Qz+-Ccp+-Bn
- Fracture-controlled Kfs+-bt+-Qtz+-Ccp+-Bn
- Pervasive Ab-Chl-Act+-Grt+-Di
- Fracture-controlled Ab-Chl-Ep
- Fracture-controlled WM-Chl-Prh



Lesage et al. 2016

Legend

- CMIC Sample location
- CMIC-Teck Structure
- HVC_pit outlines

2016 CMIC-Teck Geology

Anthropogenic
- anthropogenic deposits

Tertiary Sediments
- Glaciolacustrine sediments

Kamloops Group
- volcanics and sediments

Coldwater Formation
- volcanics and sediments

Kingsvale Group
- volcanics and sediments

Spences Bridge Group
- volcanics and sediments

Guichon Creek Batholith
- Bethsaida phase
- Skeena variety
- Bethlehem phase
- Highland Valley-Bethlehem
- Chataway variety
- Guichon-Chataway
- Guichon variety
- Border-Highland Valley
- Border phase
- Border-Nicola

Post-Nicola Group
- Gump Lake phase
- Coyle Stock

Nicola Group
- volcanics and sediments

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Petrophysical properties

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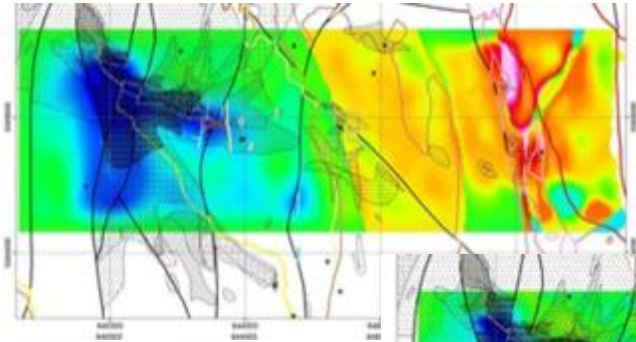
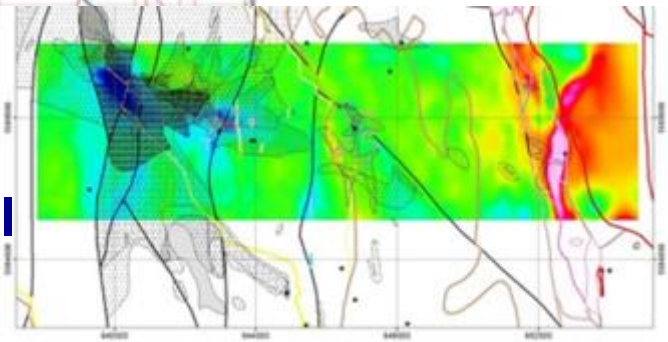
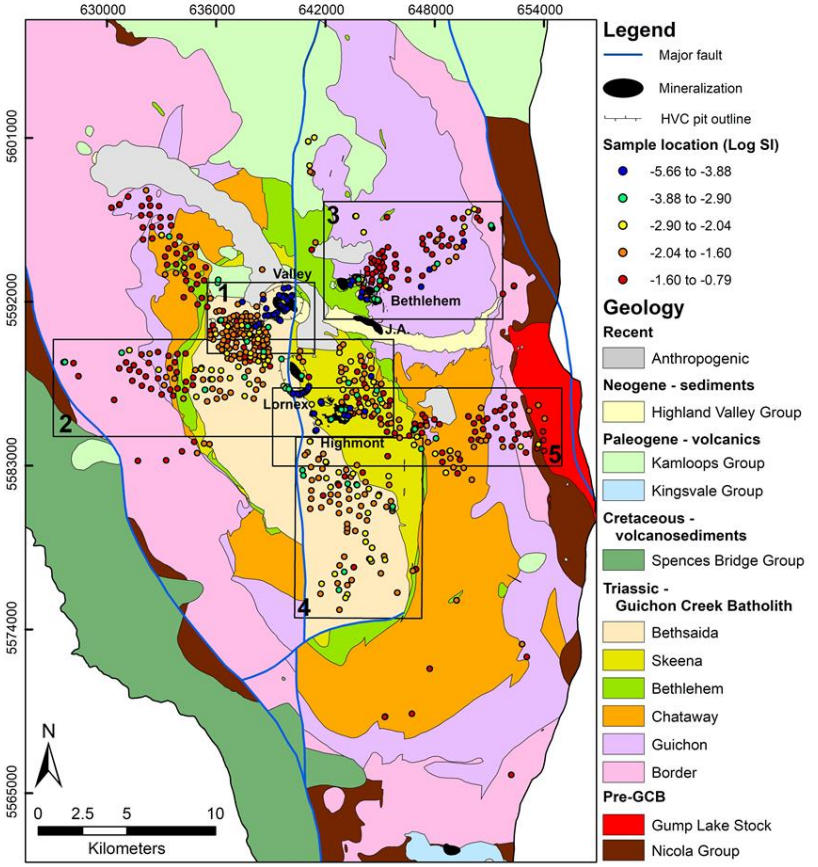
- Magnetic susceptibility
- Tie between geophysics and bedrock
- Sample density and sample type dependant



Block 5 Inversion



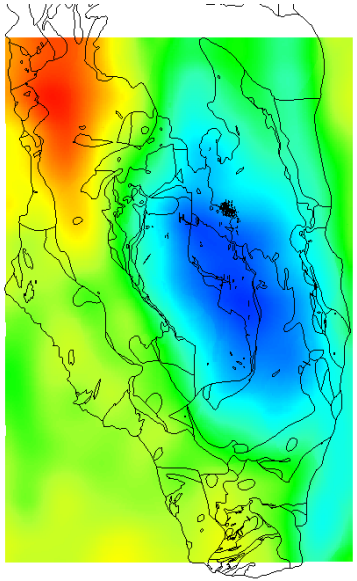
Forward Model

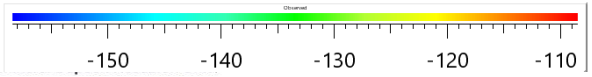


Vallée et al. 2017 SEG Houston '17

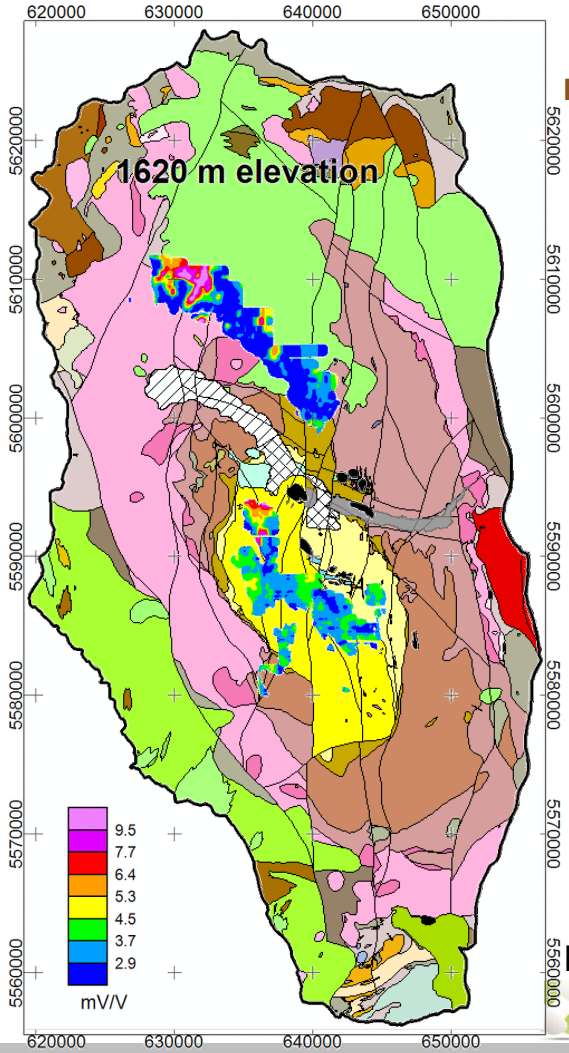
Geophysics

Geophysical compilations of legacy and recent IP, gravity, and magnetic data





Gravity (mgal)



Chargeability depth slices

Mir et al. in prep

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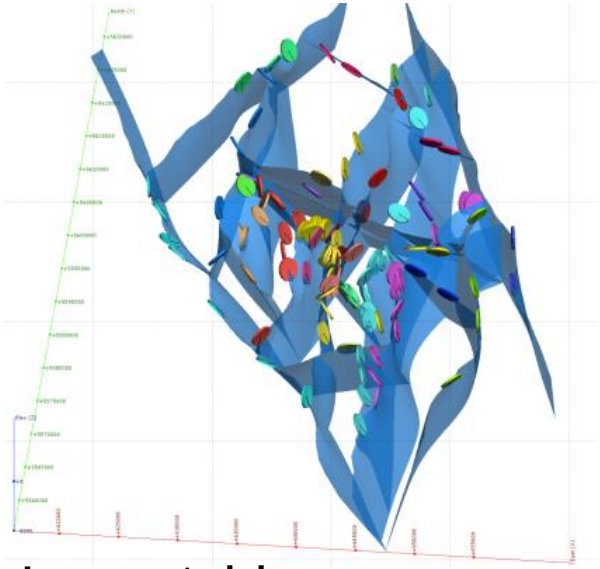
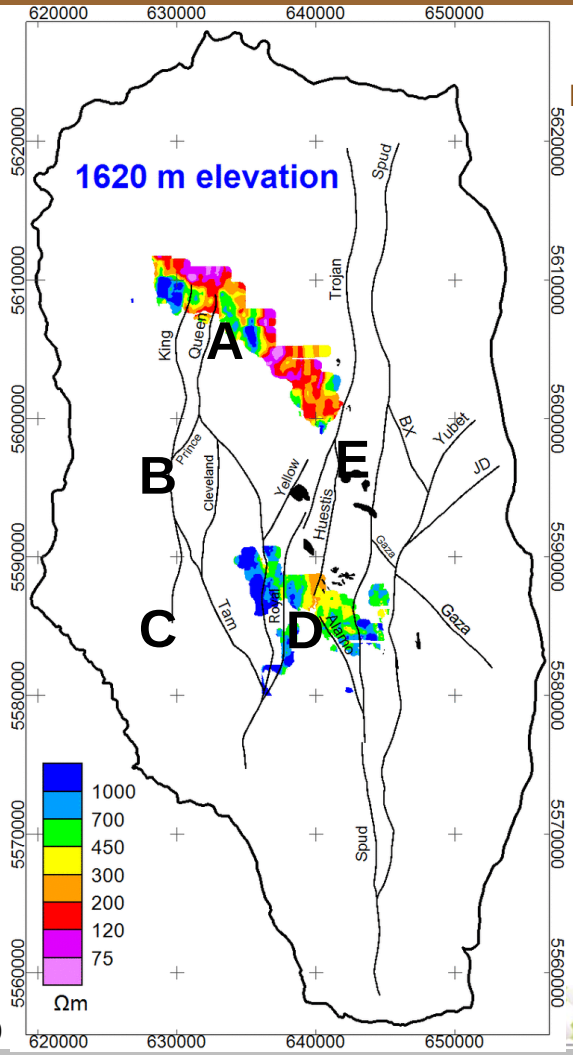
3D processing – Resistivity-Structure



Lesage et al. in prep



Mir et al. in prep

Depth slices in resistivity with syn-mineralization faults.

Alteration strongly controlled by district structures

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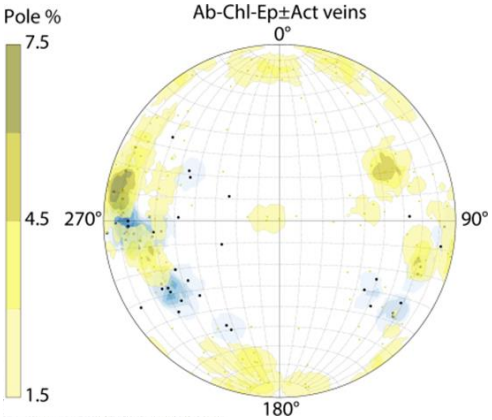
3D processing -
Correlating Alteration

Ab-Chl-Ep ± Act veins

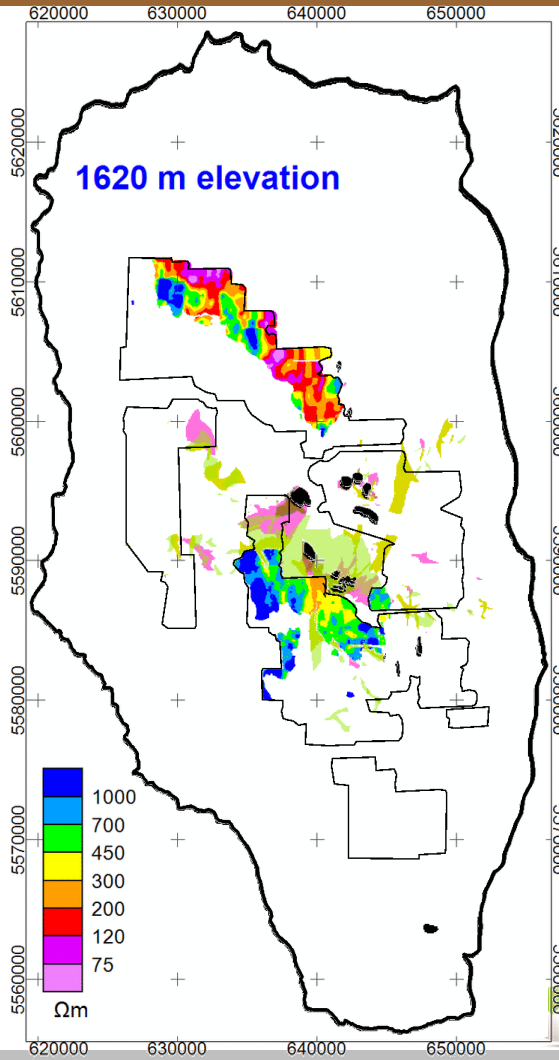
Magmatic fluid pressure wanes following early Kfs ± Bt ± Qz ± Ccp ± Bn veins

External fluids brought into the system

Lesage et al. in prep



Good match between vein orientations and syn-mineralization faults



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Alteration layer and IP data.

Fracture-controlled Albite-Chlorite-Epidote is associated with consistent decrease in resistivity at depth (< 500 Ωm).

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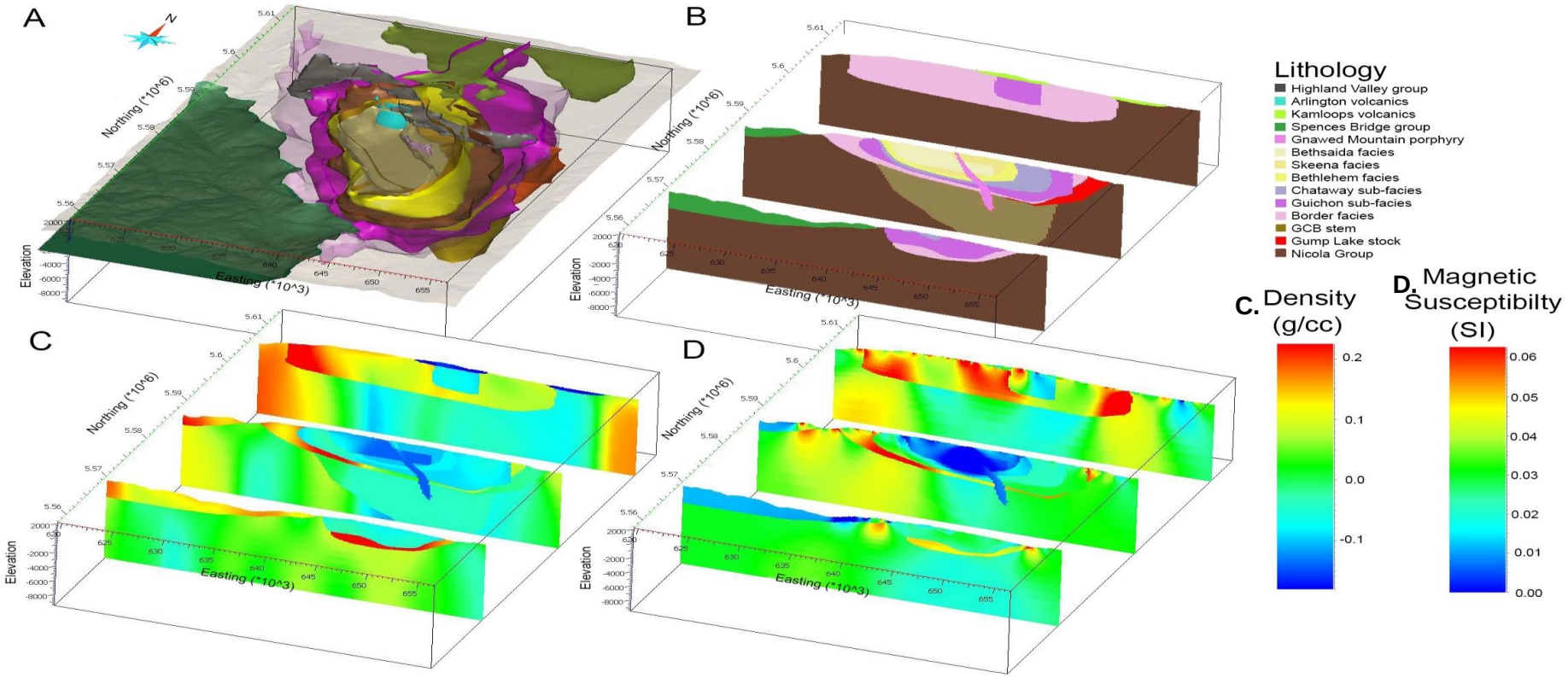
Results – 3D model



Results – Gocad model

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Results - vectors

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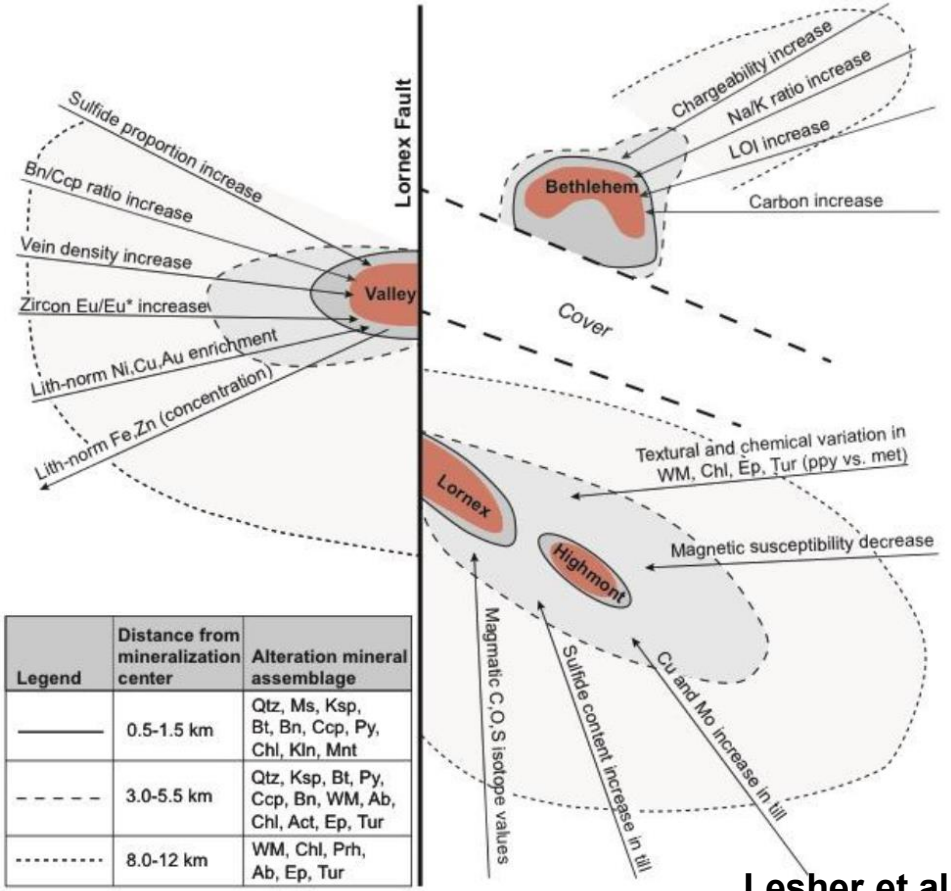

Legend	Distance from mineralization center	Alteration mineral assemblage
———	0.5-1.5 km	Qtz, Ms, Ksp, Bt, Bn, Ccp, Py, Chl, Kln, Mnt
- - - - -	3.0-5.5 km	Qtz, Ksp, Bt, Py, Ccp, Bn, WM, Ab, Chl, Act, Ep, Tur
----------	8.0-12 km	WM, Chl, Prh, Ab, Ep, Tur

		0-0.5 km Mineralized	0-0.5 km Proximal	1.5-6 km Medial	3-15 km Distal	>15 km Fresh	Method(s)
Whole Rock	Cu-Ni-Au-Mo	←	←	←	←	⋯	ICP-OES/FA
	Fe-Mg-Zn-Pb	←	←	←	←	→	ICP-OES
	$\delta^{13}C$	←	←	←	←	→	CF-IRMS
White Mica	Abundance	←	←	←	⋯	⋯	Petrography
K-feldspar	Abundance	←	←	←	⋯	⋯	Petrography/Staining
Sulfide	Abundance	←	←	←	⋯	⋯	Petrography
	Bn-Ccp	←	←	⋯	⋯	⋯	Petrography
	Py	⋯	←	←	←	⋯	Petrography
	$\delta^{34}S$	⋯	⋯	⋯	→	⋯	IRMS
Chlorite	Abundance	⋯	⋯	⋯	→	⋯	Petrography
Albite	Abundance	⋯	⋯	→	⋯	⋯	Petrography/Staining
Prehnite	Abundance	⋯	→	⋯	→	⋯	Petrography/SWIR
Carbonate	Abundance	←	←	→	⋯	⋯	Petrography
	$\delta^{13}C$	←	←	→	⋯	⋯	CF-IRMS
Zircon	Eu/Eu*	←	←	←	←	→	LA-ICP-MS
	Ti-temp	←	←	←	←	→	LA-ICP-MS
Petrophysics	Mag Susc	←	←	→	⋯	⋯	Susceptibility Meter

Mineral proportion
Physical properties
Chemical composition
Observable data up to 12 km from centre of system

Lesher et al. 2017 Exploration '17

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Summary

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- Guichon Creek batholith is long-lived (11 m.y.) system which hosts Highland Valley Copper (546 Mt Cu)
- New regional lithological and structural model based on geology and constrained geophysical interpretation
- Distal and proximal alteration mineral assemblage maps
- Integrated database with multiple parameters including: lithochemistry; mineral chemistry; SWIR; petrographic imaging; petrophysical properties; processed geophysical datasets
- New parameters for porphyry ore vectoring in large-scale regional settings

Sponsors/Collaborators

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Collaborators: GSC TGI4 Program
MERN Québec
Saskatchewan Geol Survey
BC Geological Survey

Supporters: Fullagar Geophysics
UBC Geophysical Inversion Facility