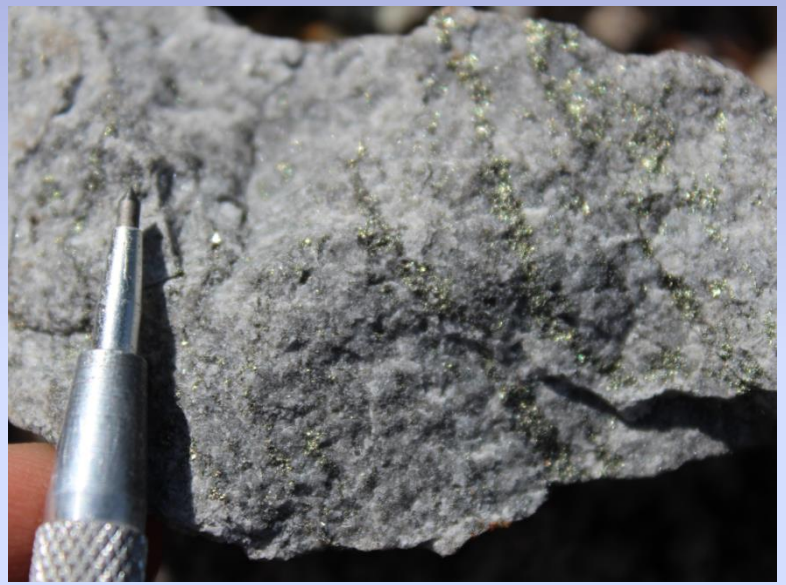
Montgomery Lake Cu-Au Prospect:

Potential for ISCG/IOCG mineralization in the Labrador Trough



GEOLOGICAL SURVEY
NEWFOUNDLAND AND LABRADOR
Celebrating 150 years

James Conliffe

Mineral Deposits Section

Newfoundland Labrador
Natural Resources

Overview

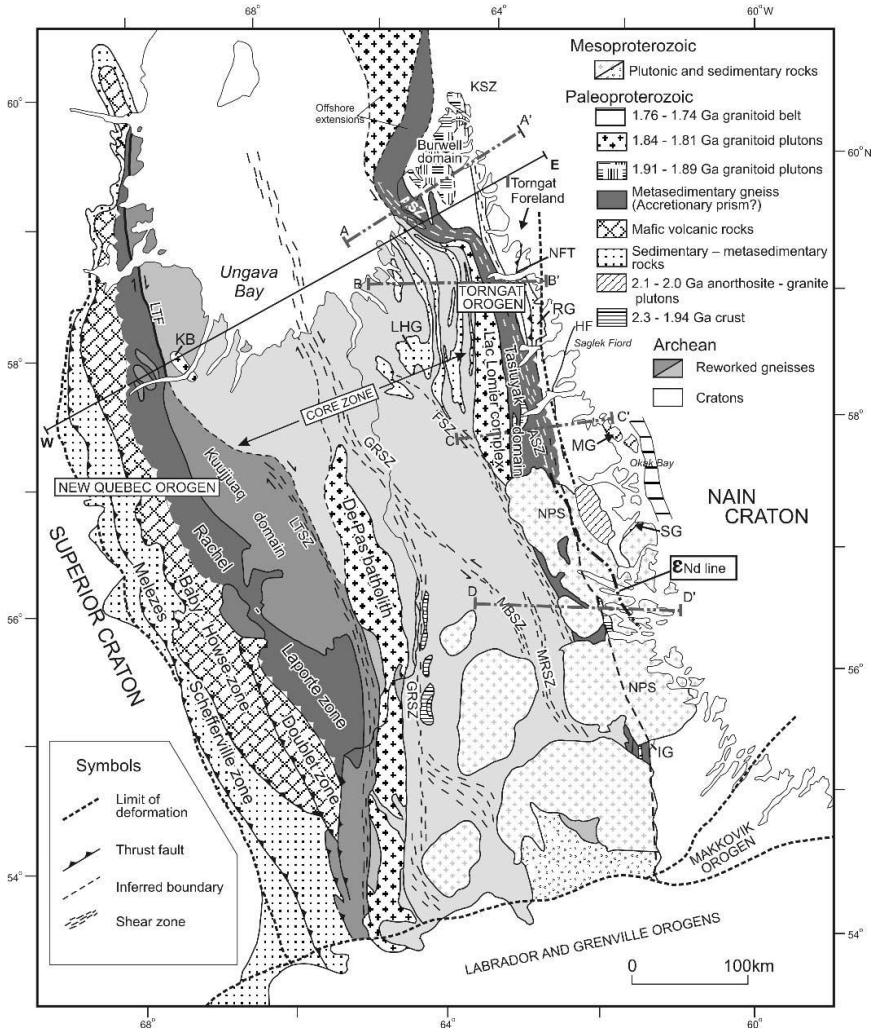
- Geological setting of Montgomery Lake prospect
- History of exploration
- Alteration and mineralization at Montgomery Lake Prospect
- IOCG mineralization and associated deposit types
  - Iron-sulphide copper gold subgroup
- Comparisons between Montgomery Lake prospect and ISCG Mineralization
- Exploration implications

Geological Setting

- Labrador Trough located in western Labrador and northeastern Québec
- Sequence of Paleoproterozoic (2.17 to 1.87 Ga) sedimentary and igneous rocks located between Superior Craton and Archean core zone

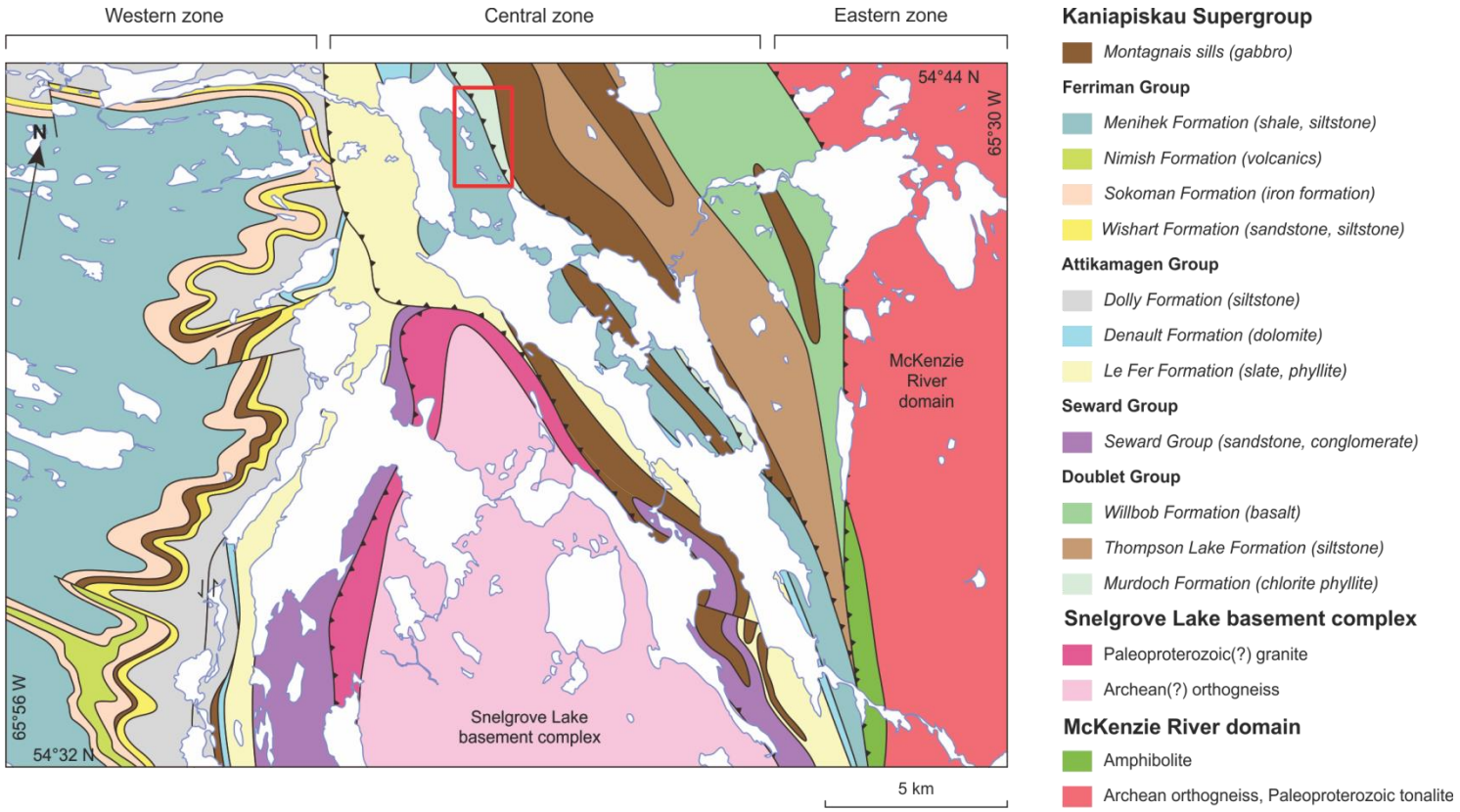
  Kaniapiskau Supergroup

- Subsequently deformed during New Québec Orogeny
  - *Foreland fold-and thrust belt*



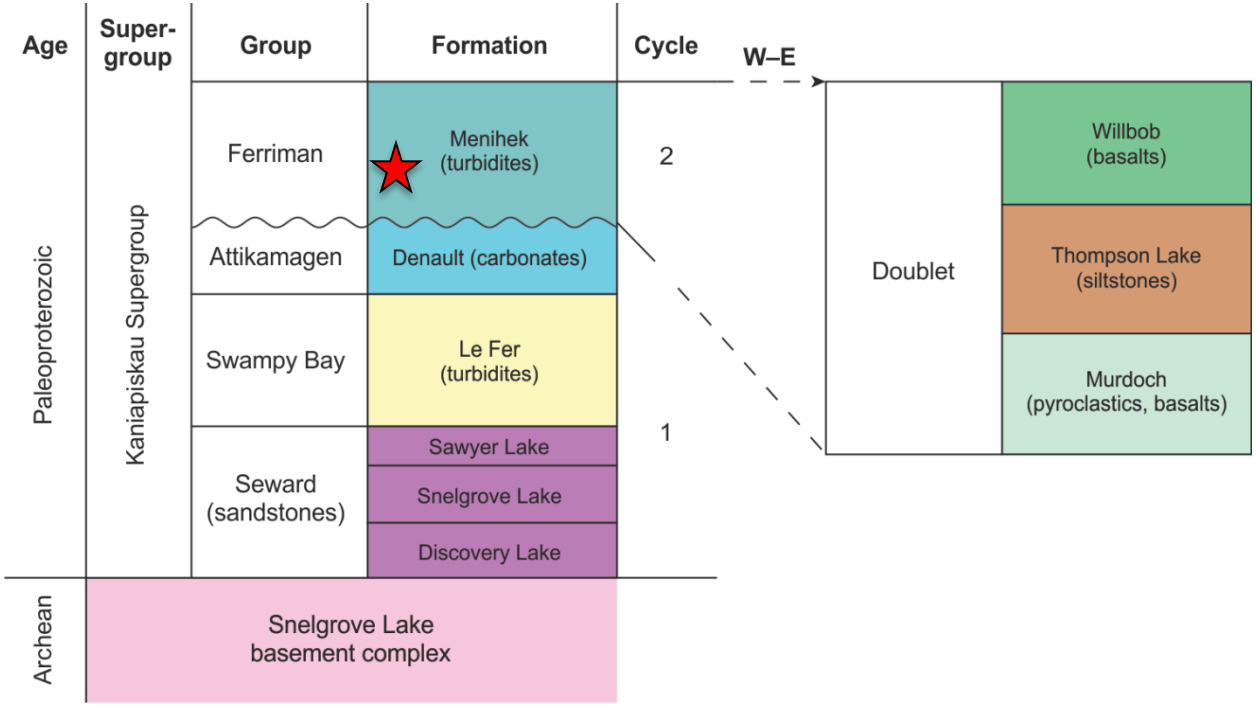
From Wardle et al (2002)

Andre Lake Map Sheet (23I/12)



- Recent geological mapping by GSNL (preliminary map in Butler, 2019)
- Montgomery Lake area located in central zone, close to Walsh Lake Fault

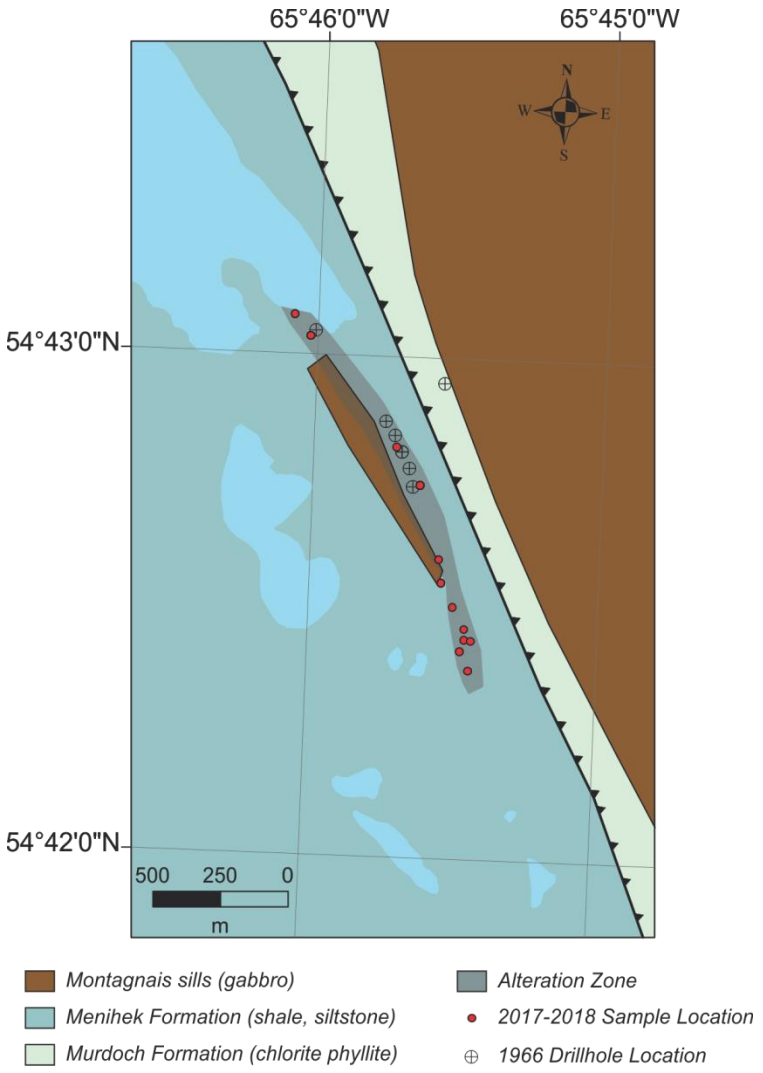
Andre Lake Map Sheet (23I/12)



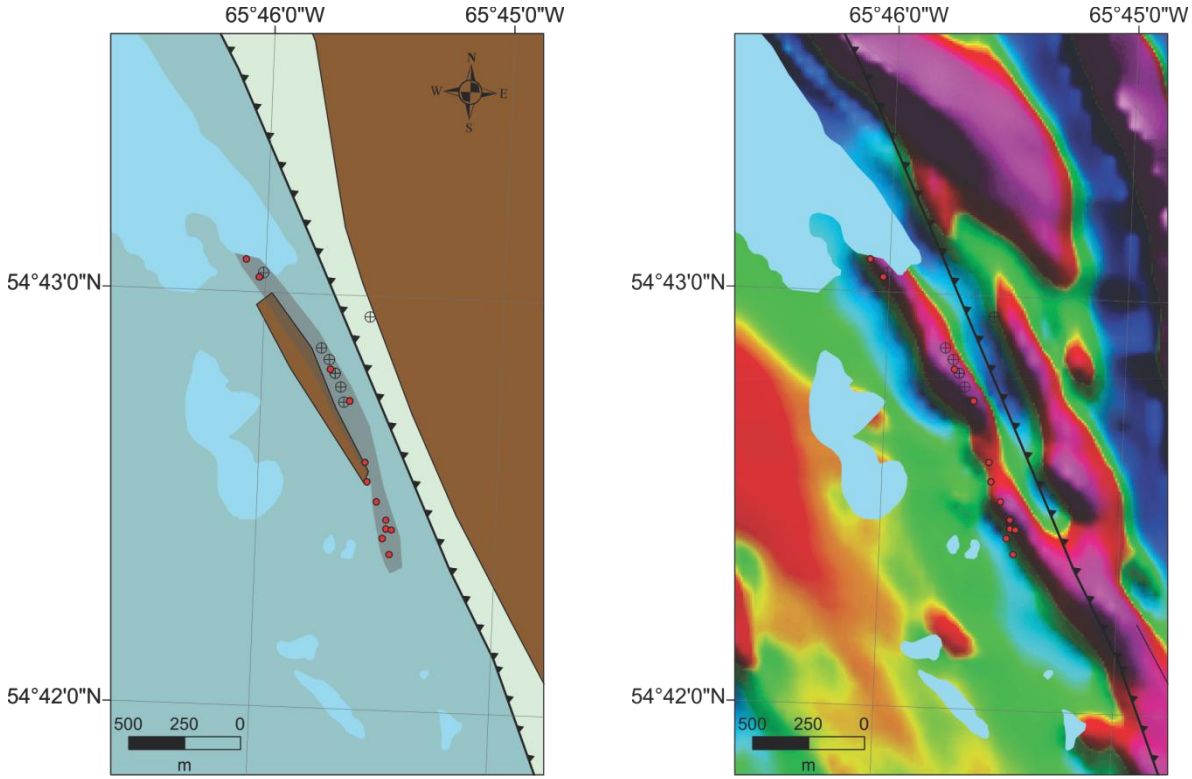
- Kaniapiskau Supergroup to west separated from Doublet Group to east by Walsh Lake Fault
- Metasedimentary units intruded by gabbro sills (Montagnais)
- Possible Paleoproterozoic granite at margin of Snelgrove Lake basement complex (Wardle, 1979; Butler, 2019)

Montgomery Lake Geology

- Regional geological mapping by Wardle (1979), detailed study by Swinden and Santaguida (1995)
- Strong alteration zone parallel to Walsh Lake Fault traced for more than 1.5 km
- Outcrop is poor and host lithologies generally strongly altered
  - Field relationships and diamond drilling indicates least altered protolith is graphitic shales intruded by gabbro sills



Montgomery Lake Geology



- Airborne magnetic data indicate geology significantly more complex than published geological maps

History of Exploration

1942: Prospect discovered by prospectors, stripping and trenching

- *24m channel sample at 0.59% Cu*

1943-1964: Prospecting, geophysical (EM, mag, gravity) and geochemical surveys

1966: Geophysical (EM, mag, gravity) and geochemical surveys, diamond drilling (1255m in 12 drillholes)

- *Highlights include 0.31% Cu over 14.5m, 0.17% Cu over 25.5m, 0.12% Cu over 36.1m, 1.0g/t Au over 1.5m, 9.2 g/t Ag over 1.5m*

1992-93: GSNL trench mapping and geochemical analyses

- *Grab samples from main trench up to 3.5% Cu and 424 ppb Au*
- *Suggest that mineralization is similar is style to orogenic gold deposits (Swinden and Santaguida, 1995)*

2003-2008: Prospecting

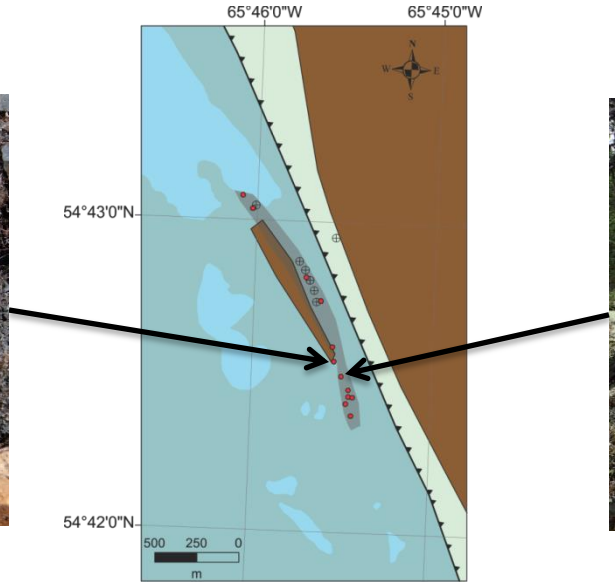
- *Grab samples from main trench up to 5.48% Cu*

Montgomery Lake Cu-Au Prospect

Fieldwork in 2013, 2017 and 2018 included visits to historic trenches, and sampling of altered and mineralized rocks in the Montgomery Lake area

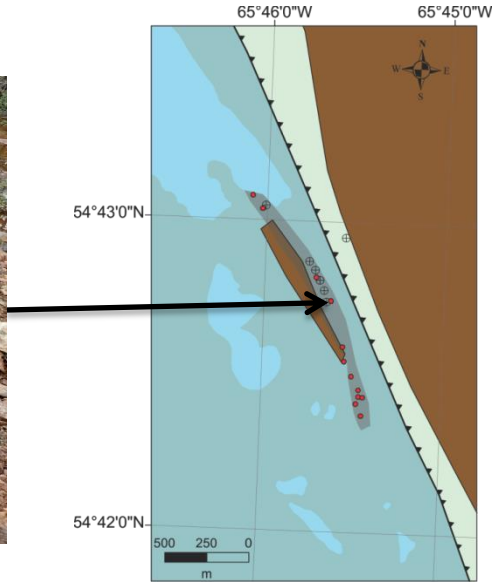
- *22 samples collected for geochemical and petrographic analysis*

Montgomery Lake Cu-Au Prospect: Least Altered Lithologies



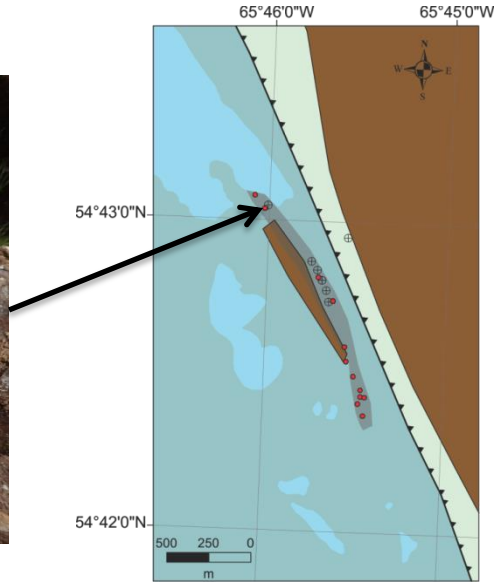
- Dark grey, finely laminated shale to siltstone, graphitic in places (Menihek Formation)
- Intruded by medium grained gabbro sills (Montagnais Gabbro)

Montgomery Lake Cu-Au Prospect: Historic Trenches



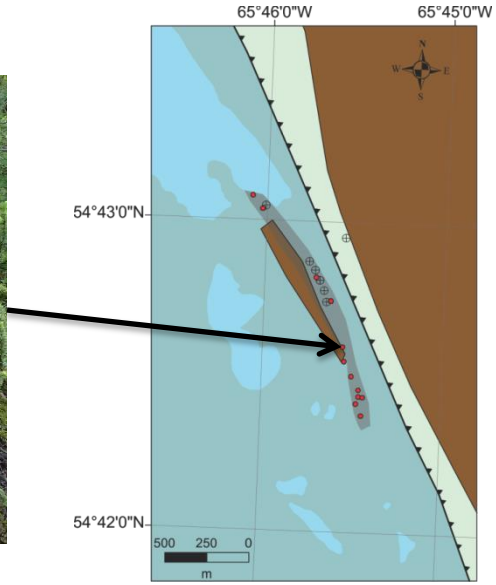
- Intensely altered units, host lithologies difficult to determine
- Alteration assemblages and mineralization variable
- Commonly brecciated with rounded to sub-angular clasts in fine-grained grey matrix

Montgomery Lake Cu-Au Prospect: Other showings/alteration



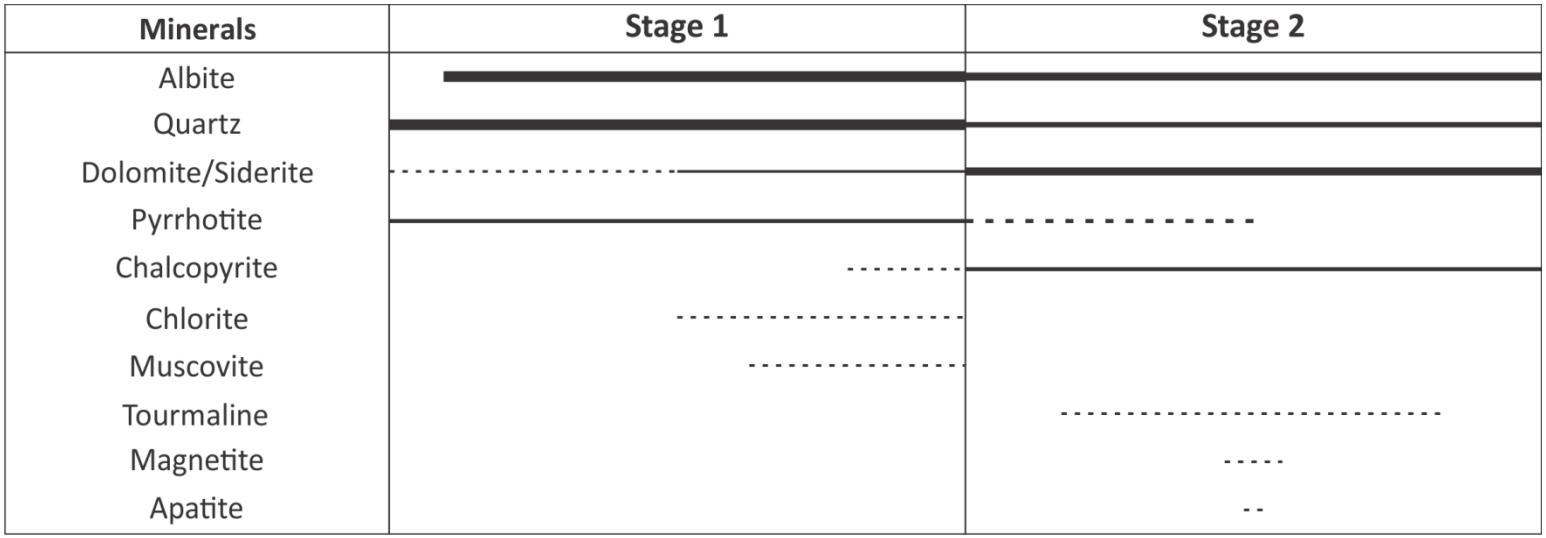
- Large mineralized boulders/subcrop located ~50 m south of Montgomery Lake
- Matrix supported breccia with rounded to angular clasts of fine-grained albite-quartz in medium-grained matrix
- Chalcopyrite in matrix and late fractures
- Similar to mineralization in historic trenches (~ 700 m to the southeast)

Montgomery Lake Cu-Au Prospect: Other showings/alteration



- Outcrops of chalcopyrite-pyrrhotite mineralization located ~ 300 m south of historic trenches
- Alteration zone traced for ~700 m south of historic trenches, with common sulphides (pyrrhotite, pyrite)

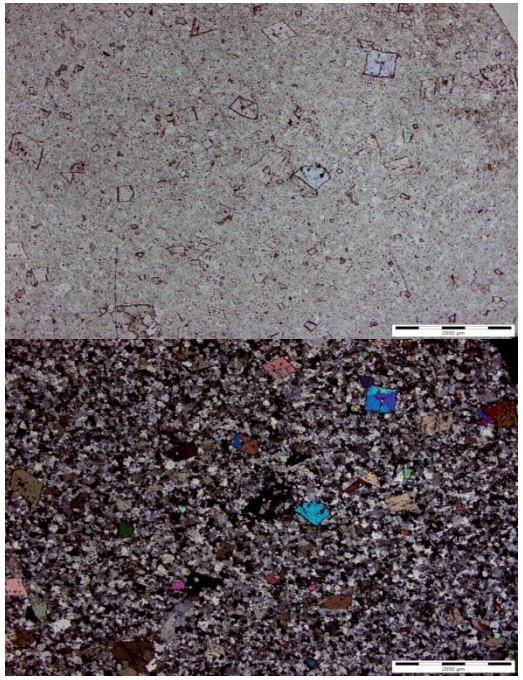
Montgomery Lake Cu-Au Prospect: Sample petrography



- Petrographic analysis of 21 thin sections, SEM-MLA analysis of two mineralized samples
- Two main phases of alteration
  - Stage 1: Early pervasive sodic alteration: ab-qtz-dol with minor po
  - Stage 2: Main mineralization stage: ab-dol-qtz-cpy-tour with minor po, mag, ap

Montgomery Lake Cu-Au Prospect: Stage 1 Alteration

Intense sodic alteration



Fine grained Stage 1 alteration (ab-qtz-dol)

Contact between altered “albitite” and unaltered siltstone

Sodic-silicic alteration

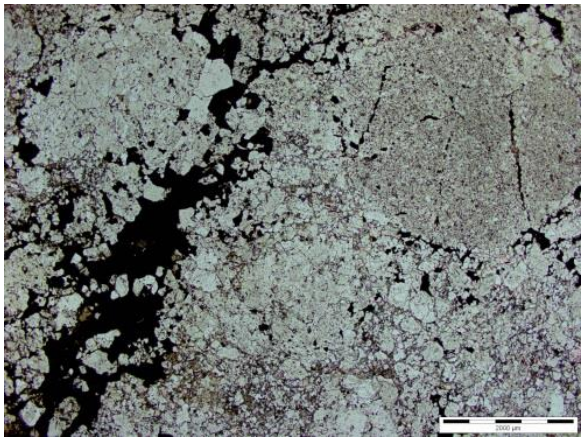
- Metasomatic rock consisting primarily of albite and quartz with < 10% carbonate – “Albitite”
- Pink to grey colour
- Previously described as quartzofeldspathic units (siltstones and sandstones)
  - Contact between alteration and unaltered siltstones and gabbros observed in the field

Montgomery Lake Cu-Au Prospect: Stage 2 Alteration and Mineralization

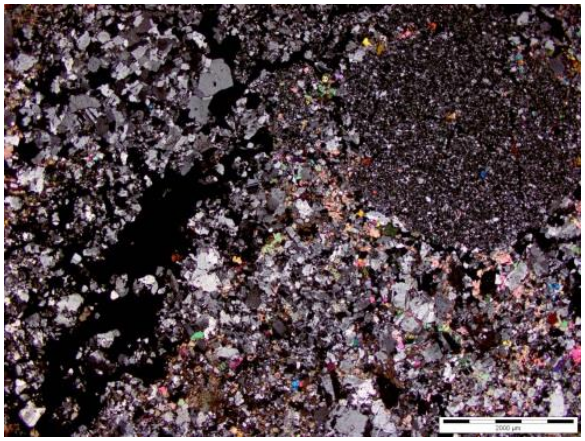
Newfoundland Labrador

Historic trenches

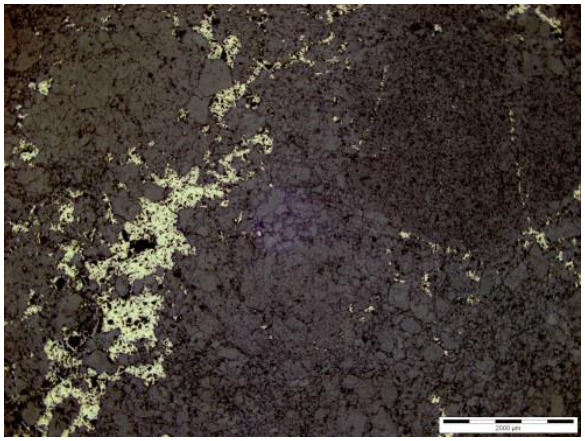
- Rounded clasts of Stage 1 alteration in matrix of albite-dolomite-quartz-tourmaline
  - Chalcopyrite in matrix and late-stage fractures, minor pyrrhotite and pyrite
- Hydraulic breccia, previously described as pebble conglomerate
- Minor Fe-oxides (magnetite?) and apatite recorded in matrix



Transmitted light, PPL



Transmitted light, XPL



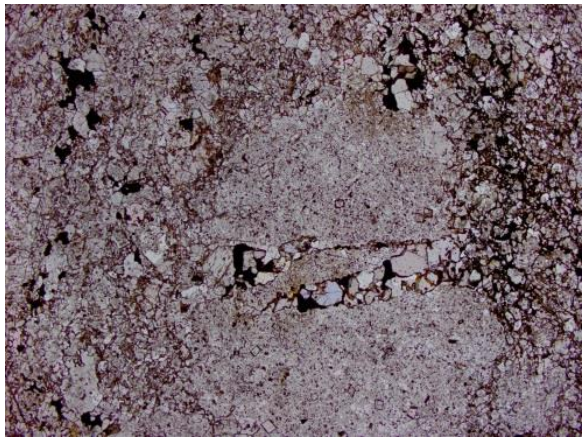
Reflected light

Montgomery Lake Cu-Au Prospect: Stage 2 Alteration and Mineralization

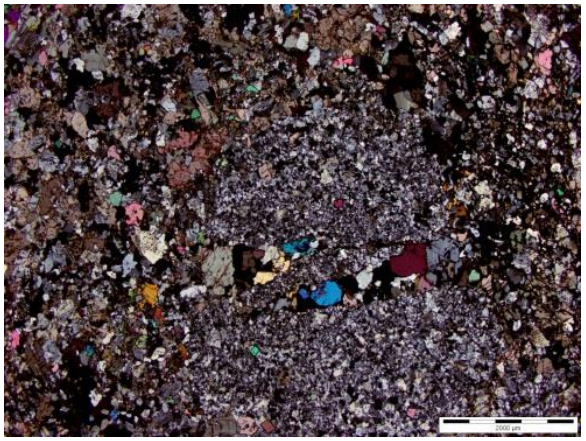
Newfoundland Labrador

Mineralized boulders

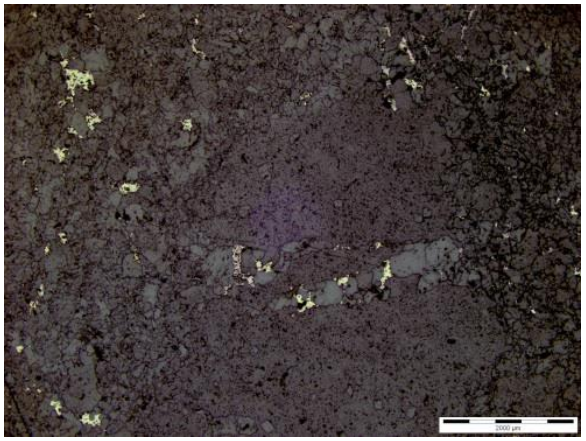
- Rounded clasts of Stage 1 alteration in matrix of albite-dolomite-quartz-tourmaline
  - Chalcopyrite in matrix and late-stage fractures, minor pyrrhotite and pyrite
- Hydraulic breccia, previously described as pebble conglomerate
- Minor Fe-oxides (magnetite?) and apatite recorded in matrix



Transmitted light, PPL



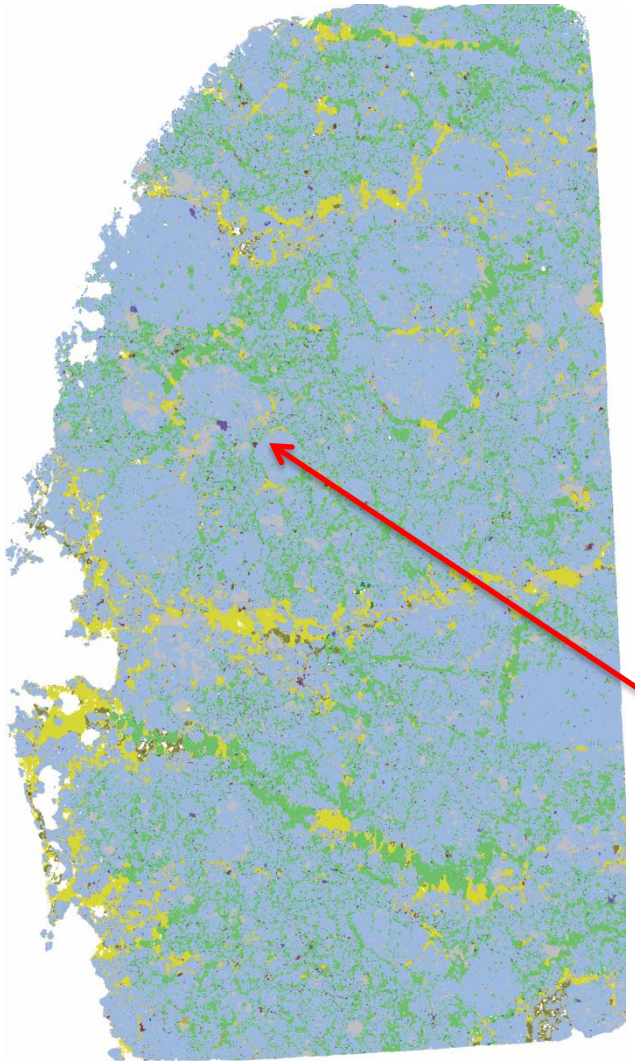
Transmitted light, XPL



Reflected light

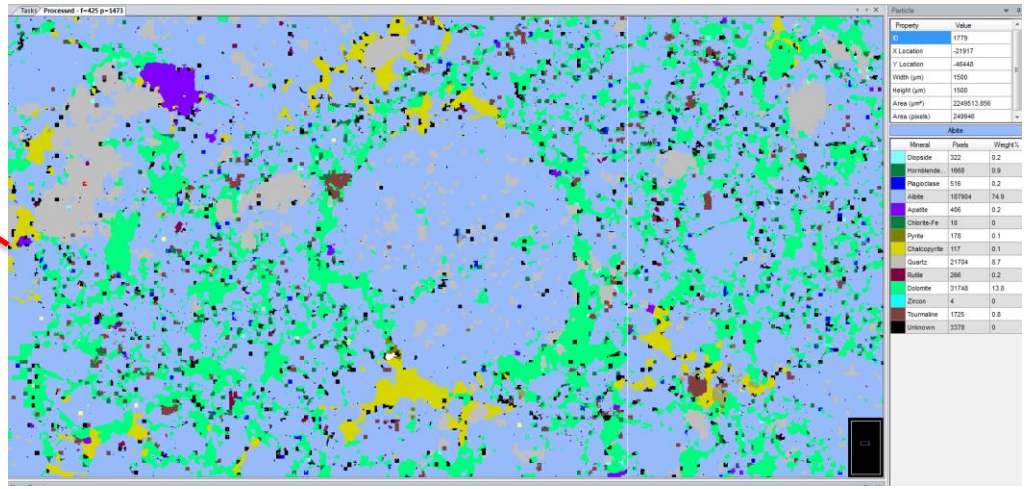
Montgomery Lake Cu-Au Prospect: SEM-MLA Analysis

Newfoundland Labrador



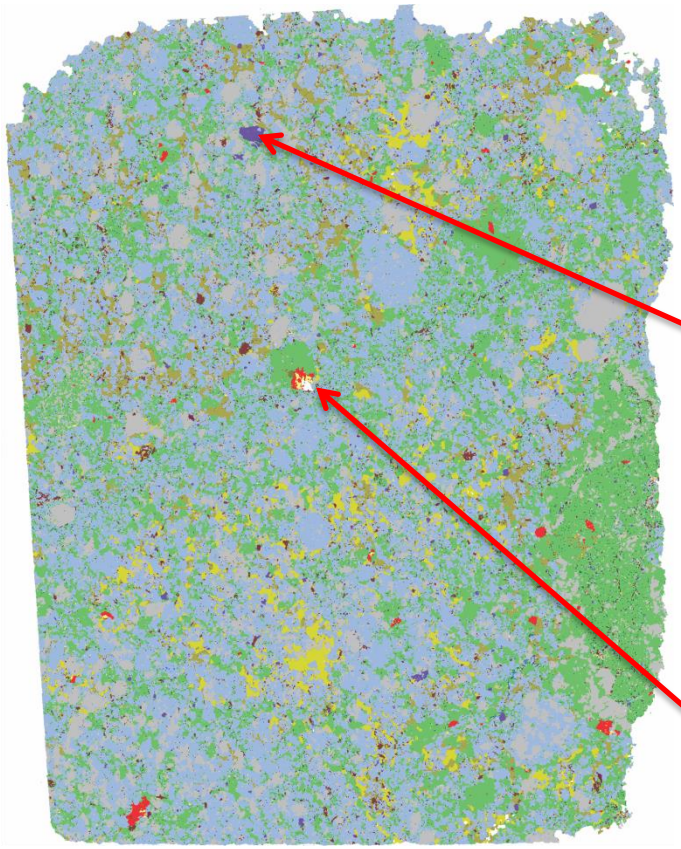
Sample 18JC001A01 (Historic Trenches)

- Dominantly albite (62.5%), dolomite (17.8%), chalcopyrite (9.9%) and quartz (4.4%)
- Minor hornblende, tourmaline, apatite and rutile
- Rare gold grains observed associated with chalcopyrite?



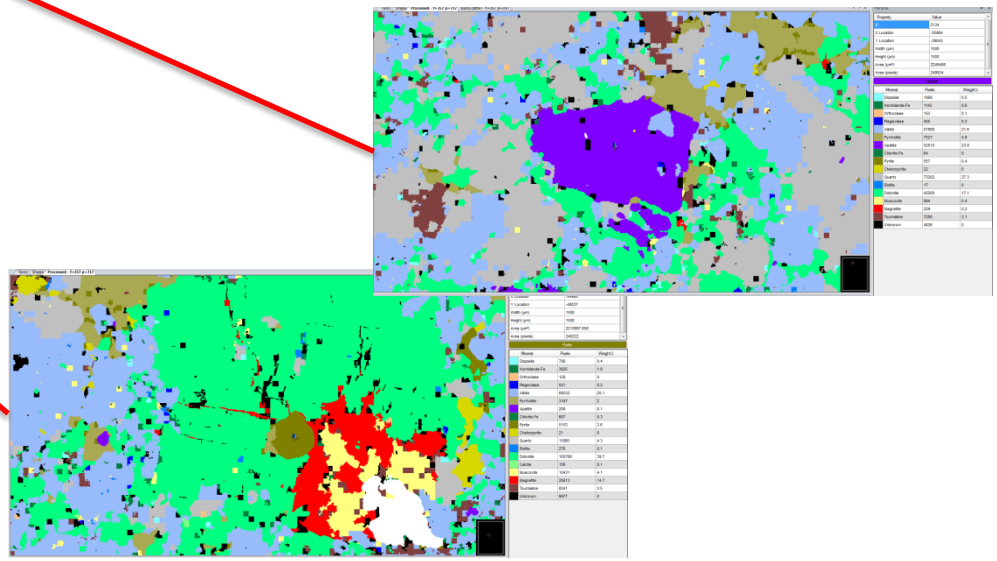
Montgomery Lake Cu-Au Prospect: SEM-MLA Analysis

Newfoundland Labrador

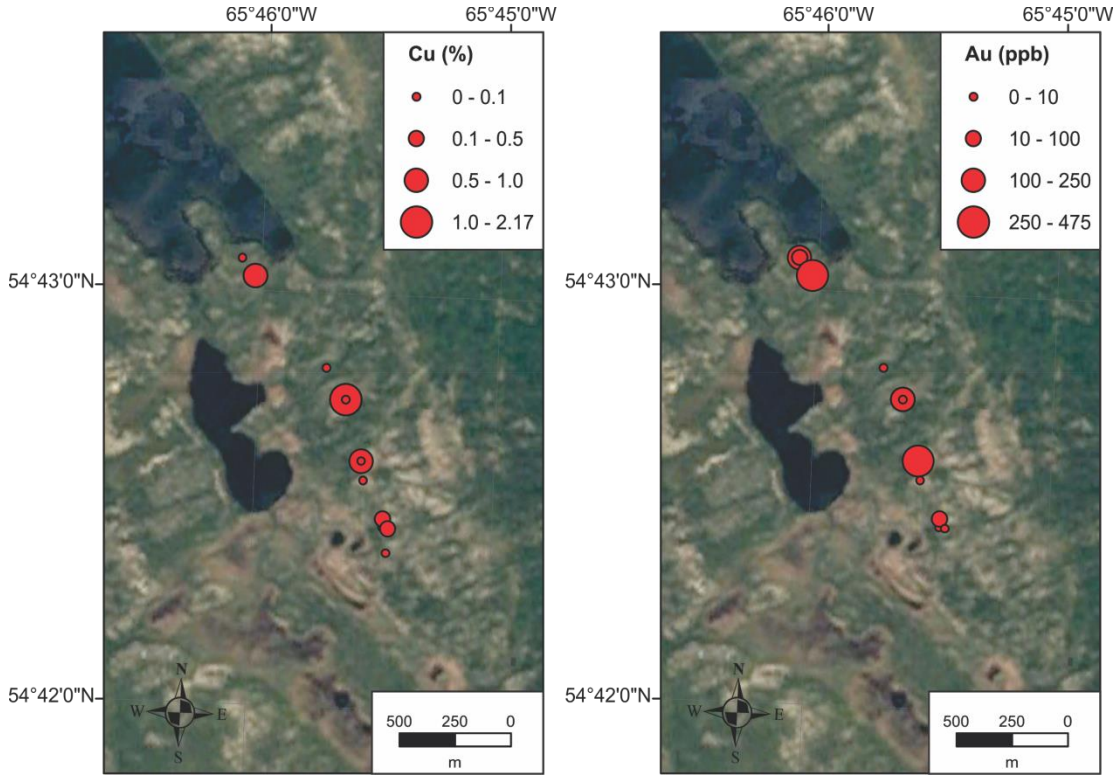


Sample 18JC006A01 (Mineralized Boulder)

- Dominantly albite (39.3%), dolomite (26.4%), quartz (12.9%), pyrrhotite (7.9%), chalcopyrite (9.9%) and tourmaline (2.5%)
- Minor hornblende, magnetite, muscovite, apatite and rutile



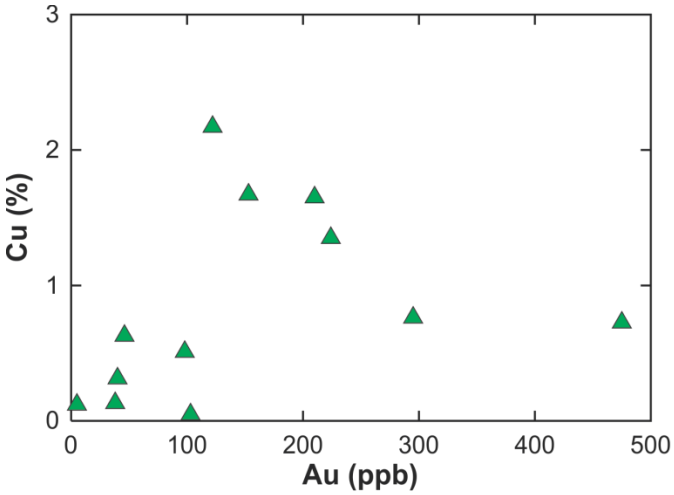
Montgomery Lake Cu-Au Prospect: Geochemistry

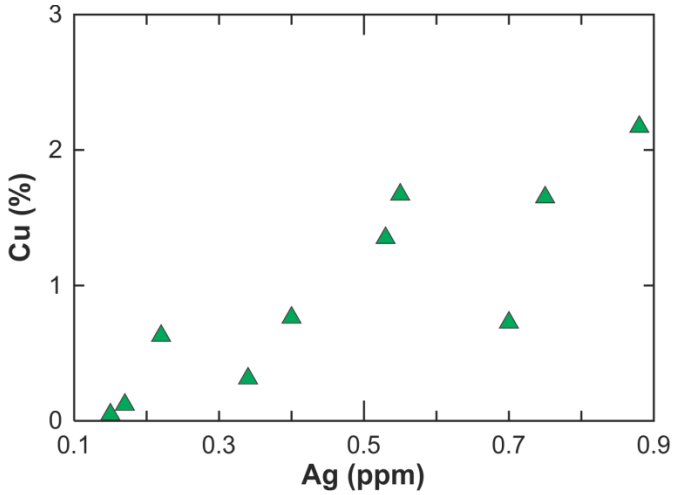


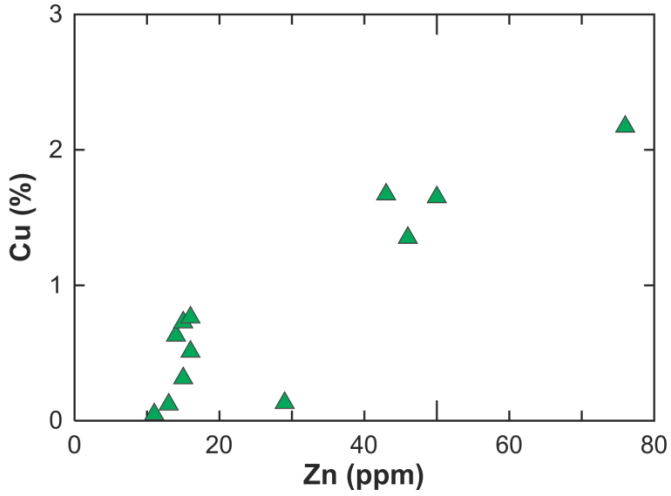
- Anomalous Cu (> 0.1% Cu) and Au (> 100 ppb) grades in grab samples over 1.4 km strike length
  - Maximum values of 2.17% Cu and 475 ppb Au

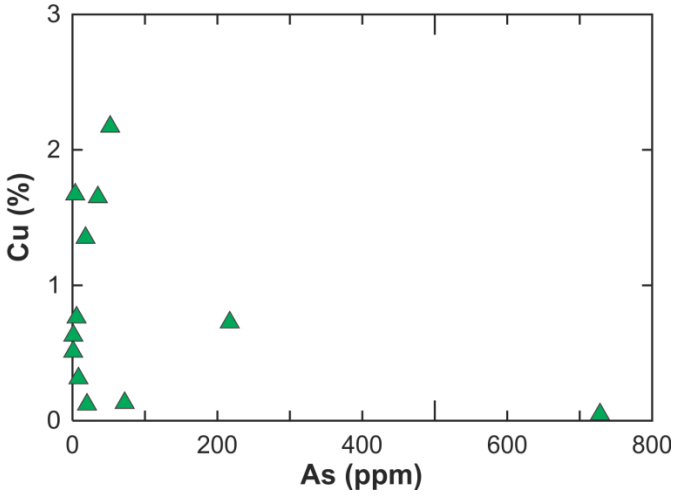
Montgomery Lake Cu-Au Prospect: Geochemistry

Newfoundland Labrador

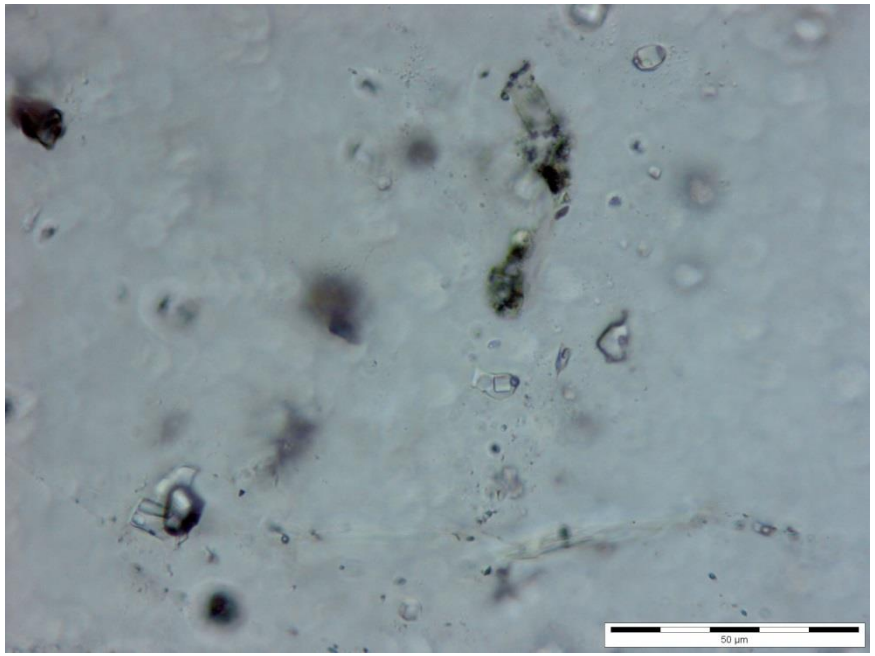


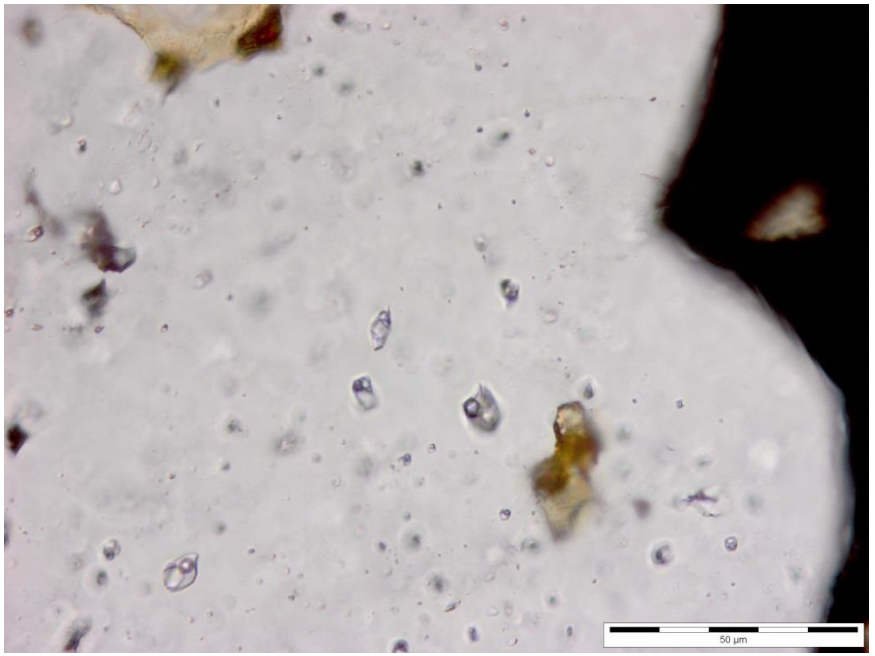






Montgomery Lake Cu-Au Prospect: Fluid Inclusions





- Petrographic analysis highlight presence of abundant hypersaline (salt bearing) fluid inclusions
- Full fluid inclusion analysis in progress

Montgomery Lake Cu-Au Prospect: Genetic model

Newfoundland Labrador

- Swinden and Santaguida (1995) proposed that Montgomery Lake prospect represented mesothermal (orogenic) Au mineralization
  - Location of mineralization proximal to major crustal structure
  - Abundant carbonate alteration, possible local fuchsite

BUT: Different from typical mesothermal Au deposits

  - Strong regional sodic alteration (albitization)
  - High Cu:Au ratios
  - Lack of associated quartz veining
  - High salinity fluids associated with mineralization

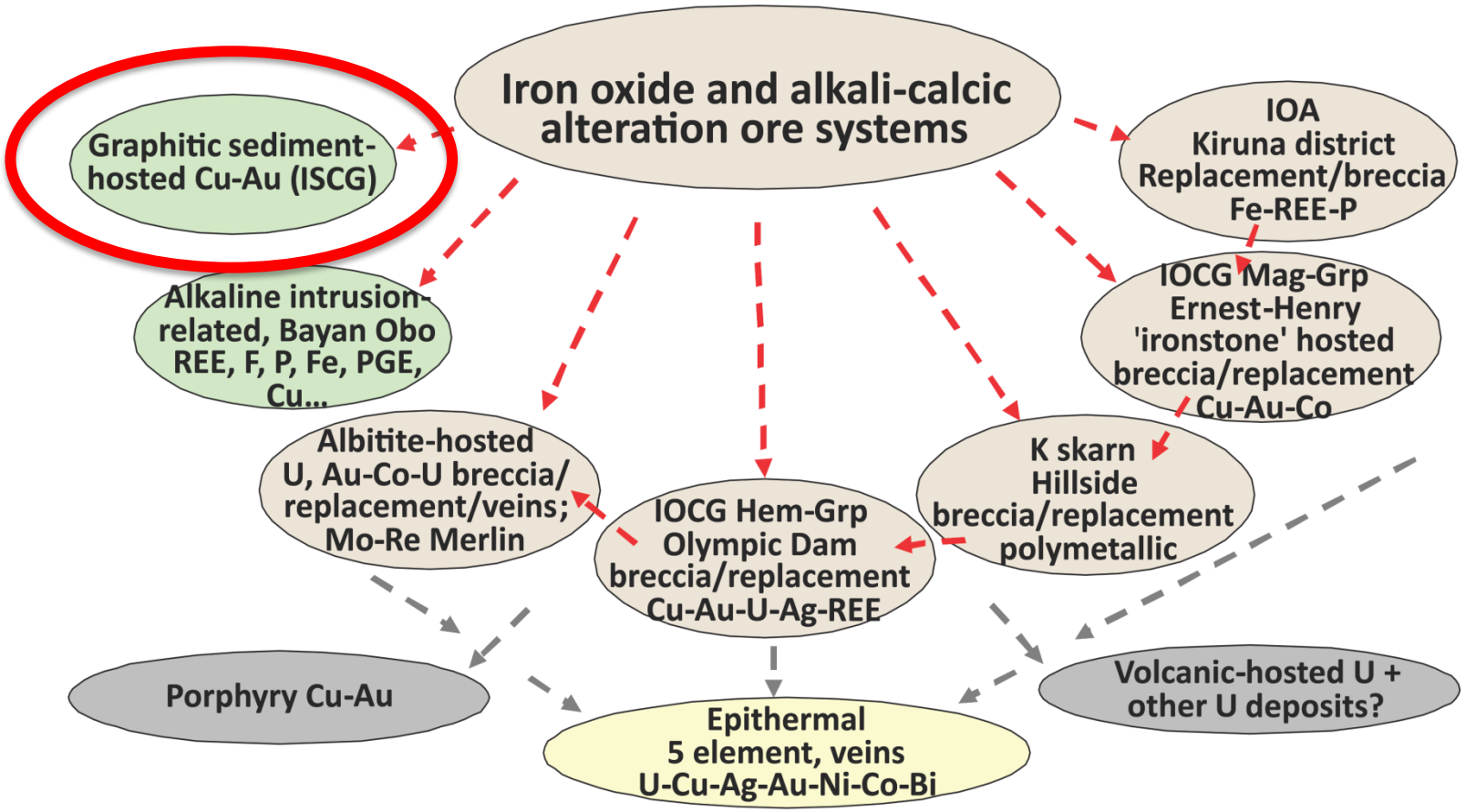
A new genetic model required

- Iron Oxide-Copper-Gold (IOCG) mineralization
  - Where is all the IO?

IOCG Mineralization

Newfoundland Labrador

Deposit spectrum and continuum



From Corriveau et al. (2017)

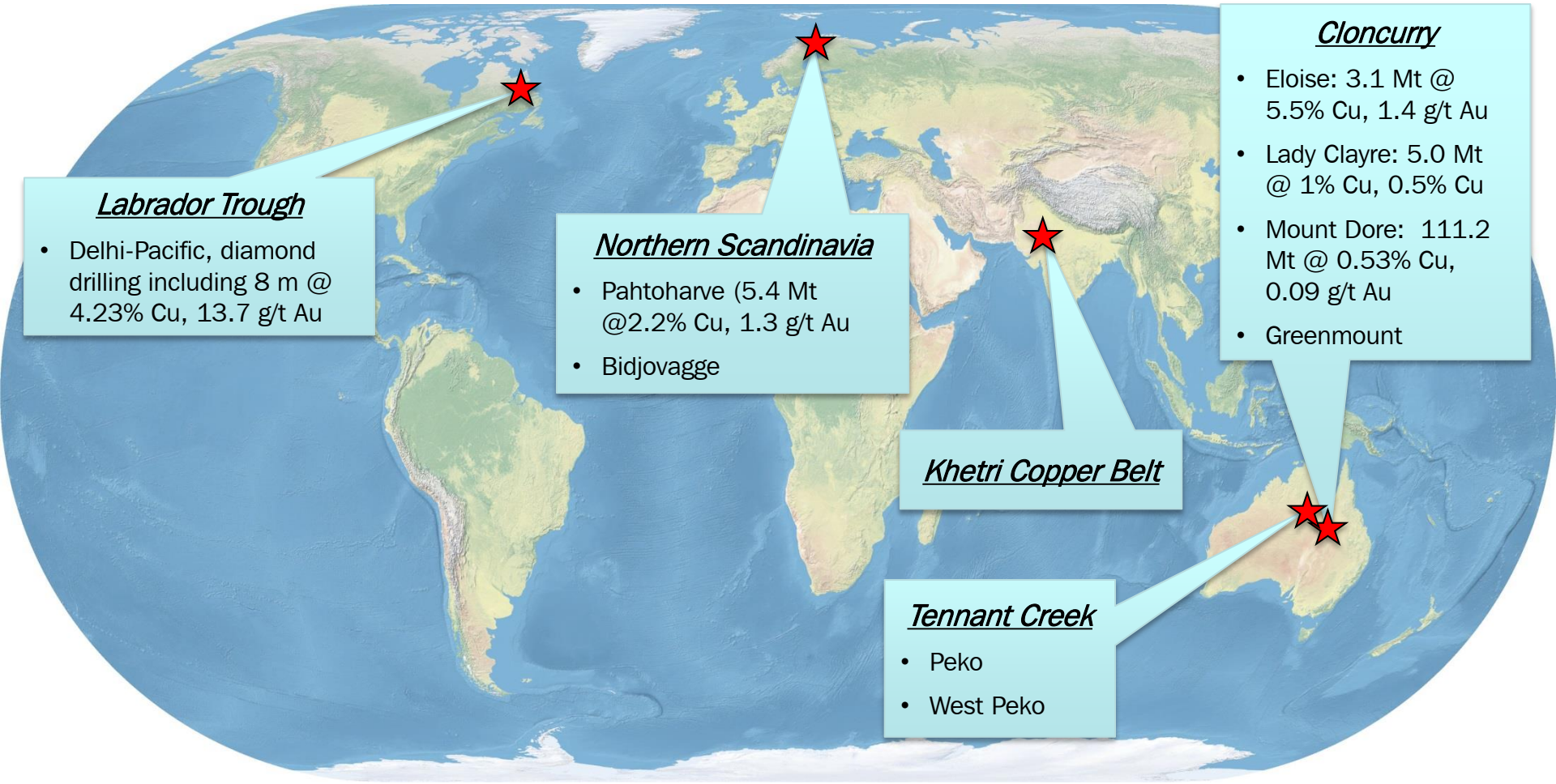
Iron Sulphide Copper Gold (ISCG): Graphitic Sediment Hosted Cu-Au

Newfoundland Labrador

- Several IOCG districts contain Cu-Au deposits which contain little or no Fe oxides
  - Can also occur as zones within larger deposits
- Mineralization style related to IOCG style mineralization
  - Sodic-calcic alteration, strong structural control on mineralization
  - Fe in form of pyrrhotite or pyrite
- Sulphide deposition under conditions too reduced to stabilize Fe-oxides (Mark et al., 2006; Williams, 2010a)
  - Interaction between the mineralizing fluids and the host rocks (carbonaceous and graphitic shales)

Iron Sulphide Copper Gold (ISCG): Graphitic Sediment Hosted Cu-Au

Newfoundland Labrador



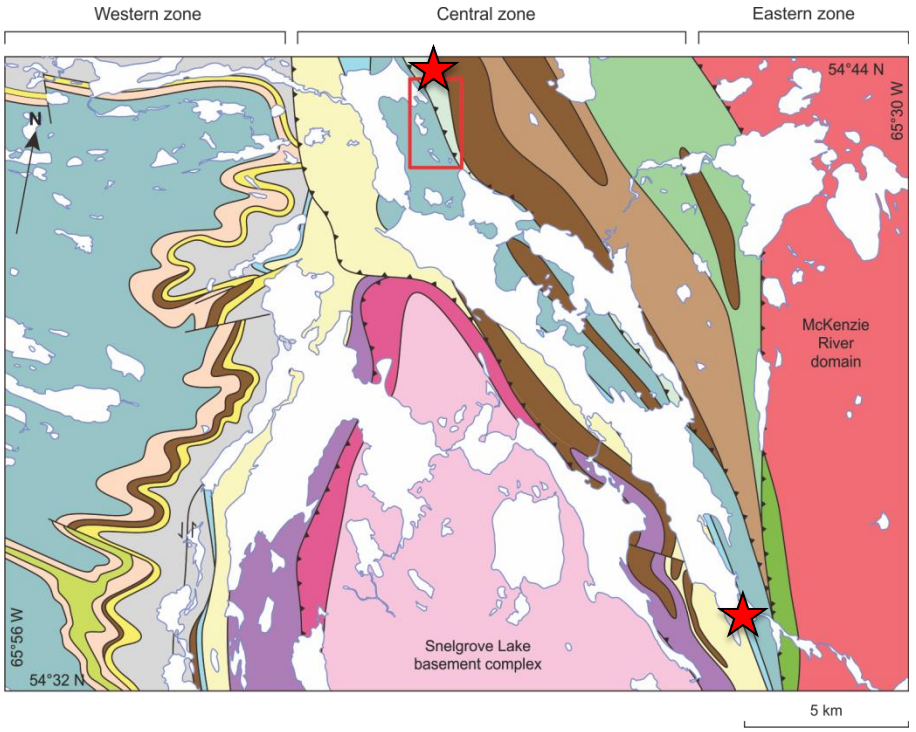
Montgomery Lake Cu-Au Prospect: Possible ISCG style mineralization

Newfoundland Labrador

- ✓ Strong structural control near major crustal structure (Walsh Lake Fault)
- ✓ Hosted in graphitic sedimentary sequence (reducing)
- ✓ Early sodic alteration (regional)
- ✓ Late mineralization and brecciation
  - ✓ Predominantly chalcopyrite and pyrrhotite mineralization
  - ✓ Tourmaline, apatite and minor magnetite associated with mineralization event
- ✓ Anomalous Cu and Au grades (grades and Cu/Au ratios similar to other ISCG deposits)
- ✓ Presence of hypersaline fluids?
- ✓ Possible association with mafic (Montagnais) and felsic (Paleoproterozoic granite?) magmatism?

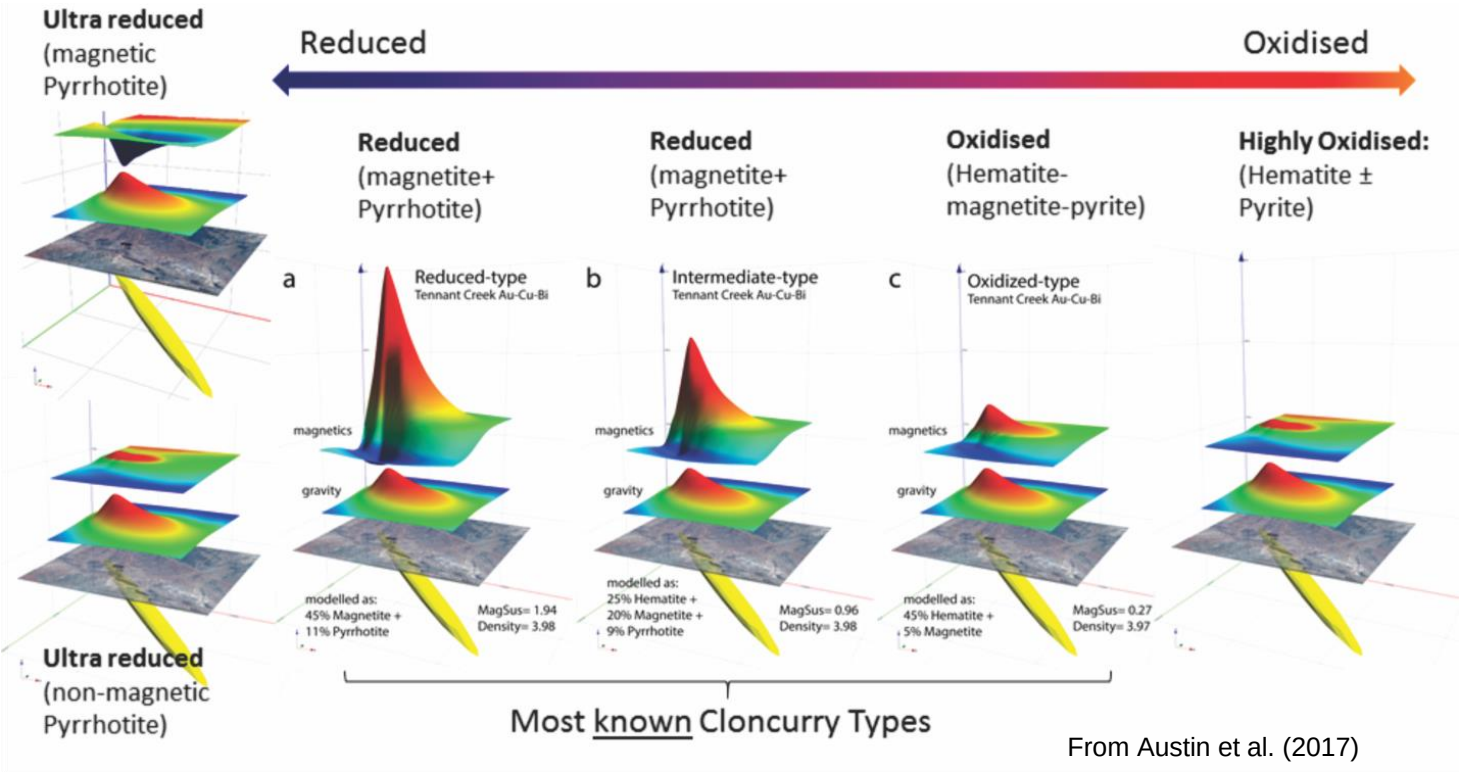
Exploration for ISCG/IOCG mineralization

- ISCG mineralization usual associated with other IOCG type deposits
  - e.g. Cloncurry district (Ernest Henry, Osborne)
- Potential for further exploration in eastern Labrador Trough using IOCG exploration model
  - Possible similar alteration reported from southern end of Andre Lake (Kozela, 1960)



Exploration for ISCG/IOCG mineralization: Geophysics

Newfoundland Labrador

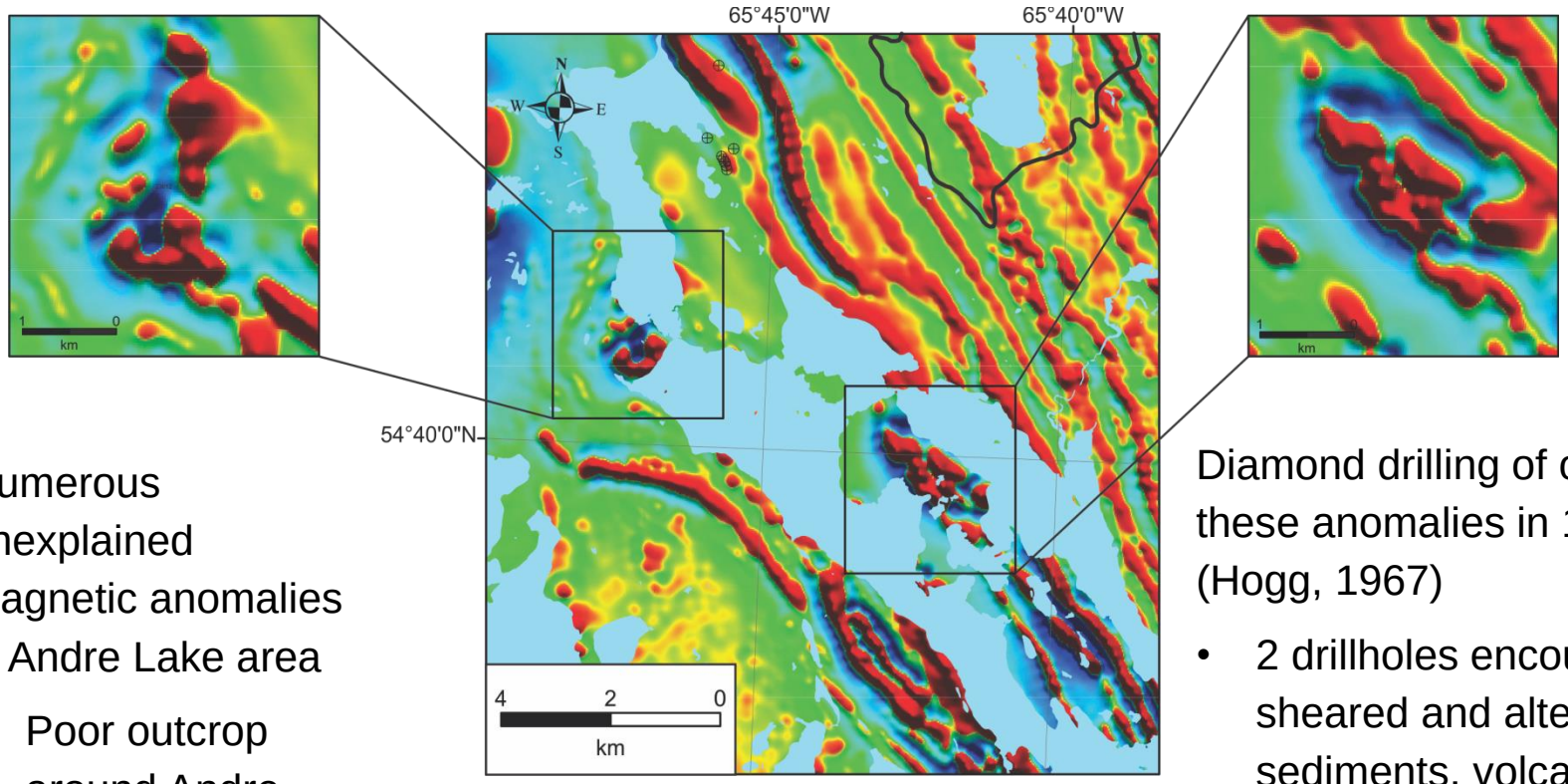


From Austin et al. (2017)

- IOCG: Associated with magnetic and/or gravity anomalies
- ISCG: Weaker magnetic and gravity signatures, EM useful

Exploration for ISCG/IOCG mineralization: Geophysics

Newfoundland Labrador



Numerous unexplained magnetic anomalies in Andre Lake area

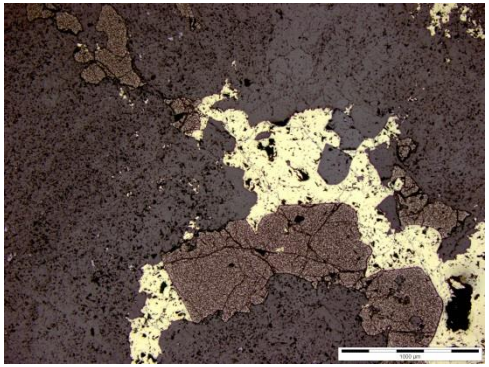
- Poor outcrop around Andre Lake
- Mapped as shale/siltstone

Diamond drilling of one of these anomalies in 1967 (Hogg, 1967)

- 2 drillholes encountered sheared and altered sediments, volcanics and gabbro
- Intervals of pyrrhotite and magnetite rich units with trace chalcopyrite

Conclusions

- The Montgomery Lake Cu-Au prospect is associated with a 1.5 km alteration zone with anomalous Cu (up to 2.17%) and Au (up to 475 ppb) along the trend
- Multiple alteration events with early sodic alteration and later mineralization event associated with brecciation of host rocks
- Prospect tentatively classified as ISCG type (subset of IOCG deposits)
- ISCG mineralization commonly associated with other IOCG-type deposits: Potential for future exploration in Andre Lake area



References

Austin, J (2017) Geophysical, Structural and Mineralogical Signatures of the Cloncurry Mineral System.

Butler, J P (2019) New observations from the Andre Lake area (NTS 23I/12), western Labrador: Tectonic relationships in the Hinterlands of the New Québec Orogen. In Current Research, Compiled and Edited by C. P. G. Pereira and D. G. Walsh, Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 19-1, pages 131-146.

Butler, R, Jr and Churchill, R A (2004) First year assessment report on prospecting and geochemical exploration for licences 9559M-9560M on claims in the Montgomery Lake and Martin Lake areas, western Labrador. Altius Resources Inc. Newfoundland and Labrador Geological Survey, Assessment File LAB/1395, 2004, 27 pages.

Corriveau, L, Nadeau, O, Montreuil, J –F, Desrochers, J -P (2014) Report of activities for the Core Zone: Strategic geomapping and geoscience to assess the mineral potential of the Labrador Trough for multiple metals IOCG and affiliated deposits, Canada. Geological Survey of Canada, Open File 7714, 12 pages.

Corriveau, L (2017) Iron-oxide and alkali-calcic alteration ore systems and their polymetallic IOA, IOCG, skarn, albitite-hosted U±Au±Co, and affiliated deposits: a short course series. Part 1: introduction. Geological Survey of Canada, Scientific Presentation 56, 2017, 80 pages.

Hogg, G M (1964) Report on geological, geochemical and seismic surveys in Labrador base metal areas-Colville Lake, Montgomery Lake, Pep Lake. Labrador Mining and Exploration Company Limited. Newfoundland and Labrador Geological Survey, Assessment File LAB/0297, 111 pages.

Hogg, G M (1968) Report on the drilling programme of April 1967 in the Andre Lake area, Labrador. Labrador Mining and Exploration Company Limited. Newfoundland and Labrador Geological Survey, Assessment File 23I/0022, 22 pages.

Kozela, F J (1960) Report on geological, geochemical and geophysical exploration in the Andre Lake area, Labrador. Labrador Mining and Exploration Company Limited. Newfoundland and Labrador Geological Survey, Assessment File 23I/0009, 20 pages

Love, H D (1967) Report on diamond drilling, geochemical and geophysical surveys of lease block No 135 in the Montgomery Lake area, Labrador. Labrador Mining and Exploration Company Limited. Newfoundland and Labrador Geological Survey, Assessment File 23I/0015, 127 pages.

Labonte, J and Kieley, J W (2009) Second and sixth year assessment report on compilation, geophysical interpretation, prospecting and geochemical exploration for licences 9559M-9560M, 13522M-13533M, 13538M, 13542M, 13785M, 13793M-13794M, 13850M-13853M, 13855M-13858M, 14596M, 15146M-15148M, 15893M-15898M, 16366M-16369M and 16535M-16544M on claims in the Howse Lake to Wet Lake area, western Labrador, 2 reports. Altius Resources Incorporated, Cornerstone Resources Incorporated and Turpin, A J. Newfoundland and Labrador Geological Survey, Assessment File LAB/1531, 113 pages.

Labonte, J, Kieley, J W and Wilton, D (2009) First and second year assessment report on geological, geochemical and geophysical exploration for licences 9559M-9560M, 13522M-13533M, 13538M, 13542M, 13785M, 13793M-13794M, 13848M-13858M, 14319M-14323M, 14589M-14597M and 15142M-15148M on claims in the Howse Lake to Wet Lake area, western Labrador, 3 reports. Cornerstone Resources Incorporated and Altius Minerals Corporation. Newfoundland and Labrador Geological Survey, Assessment File LAB/1483, 308 pages.

Mark G, Oliver N H S, and Carew M J (2006) Insights into the genesis and diversity of epigenetic Cu–Au mineralisation in the Cloncurry district, Mt. Isa Inlier, Northwest Queensland. Australian Journal of Earth Sciences, Volume 53, pages 109–124.

Swinden, S and Santaguida, F (1995) The Montgomery Lake prospect, western Labrador: Cu[±Au?] mineralization related to the Walsh Lake thrust. In Current research, Compiled and Edited by C. P. G. Pereira and D. G. Walsh, Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 95-01, pages 205-219.

Wardle, R J (1979) Geology of the eastern margin of the Labrador Trough. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 78-09, 27 pages.

Wardle, R J, James, D T, Scott, D J and Hall, J (2002) The southeastern Churchill Province: synthesis of a Paleoproterozoic transpressional orogen. Canadian Journal of Earth Sciences, vol. 39 no. 5, pages 639-663.

Williams P J (2010a) Classifying IOCG Deposits. Geological Association of Canada Short Course Notes, vol. 20, pages 23–38.

Williams P J (2010b) 'Magnetite-Group' IOCGs with Special Reference to Cloncurry (NW Queensland) and Northern Sweden: Settings, Alteration, Deposit Characteristics, Fluid Sources and Their Relationship to Apatite-Rich Iron Ores. Geological Association of Canada Short Course Notes, vol. 20, pages 23–38.

Thanks to

- Jared Butler, Andrew Smith, John Hinchey, and Ben MacDougall
- Wayne Tuttle (logistics)
- McGill Sub-Arctic Research Centre
- Canadian Helicopters
- Chris Finch (geochemistry) and Gabriel Sindol (SEM-MLA)
- Louise Corriveau

Newfoundland Labrador
Natural Resources

GEOLOGICAL SURVEY
NEWFOUNDLAND AND LABRADOR
Celebrating 150 years