MDRU
Mineral Deposit Research Unit

UBC a place of mind

SeArch Phase 1 Mapping Project

Structural and magmatic controls on mineralization in the western Skeena Arch

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Rock Talk: Smithers, BC - February 22, 2017

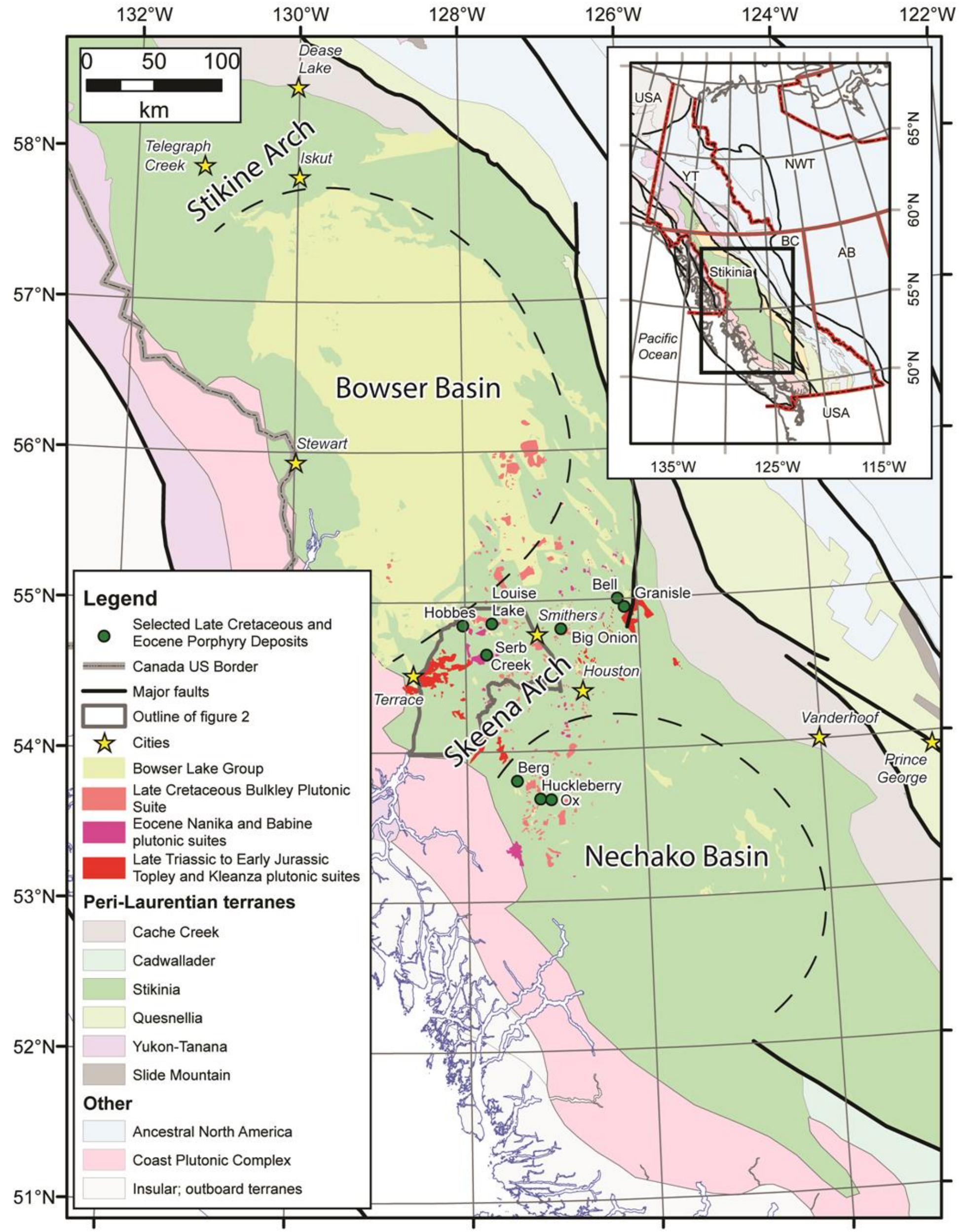
Geoscience BC

Outline

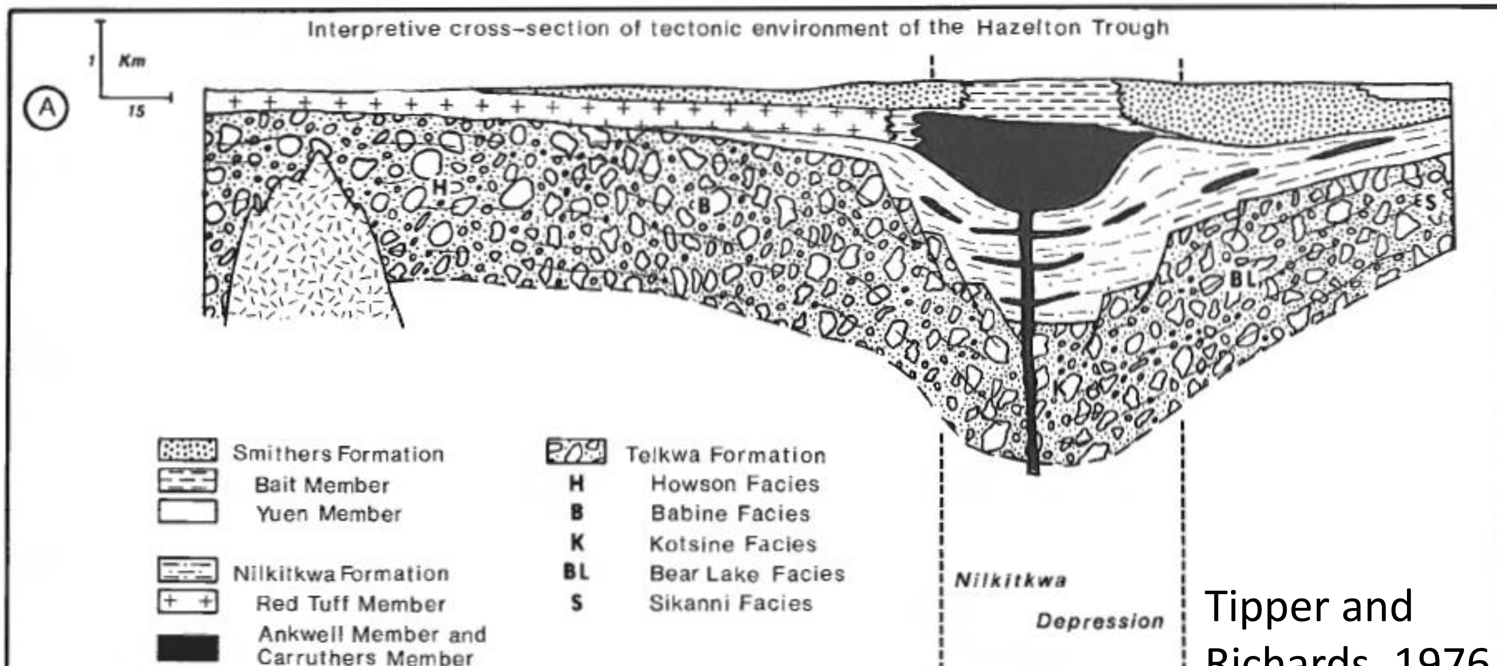
- What is the Skeena Arch?
- Structural framework of the Skeena Arch
- How did the Skeena Arch form?
- Geochemistry of intrusive suites
- Mineralization
- How did the Late Cretaceous BC porphyries form?

The Skeena Arch

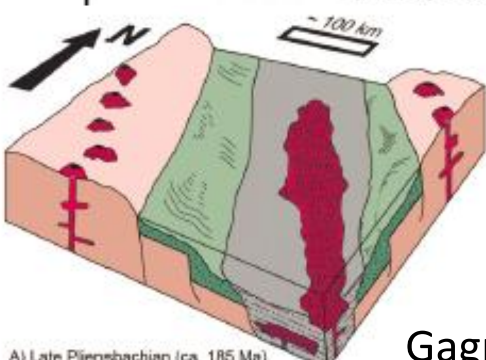
- NE-trending Middle to Late Jurassic topographic high
- Separates basins
- High mineral potential
  - Mostly associated with Late Cretaceous and Eocene intrusive suites



Early Jurassic Hazelton Trough



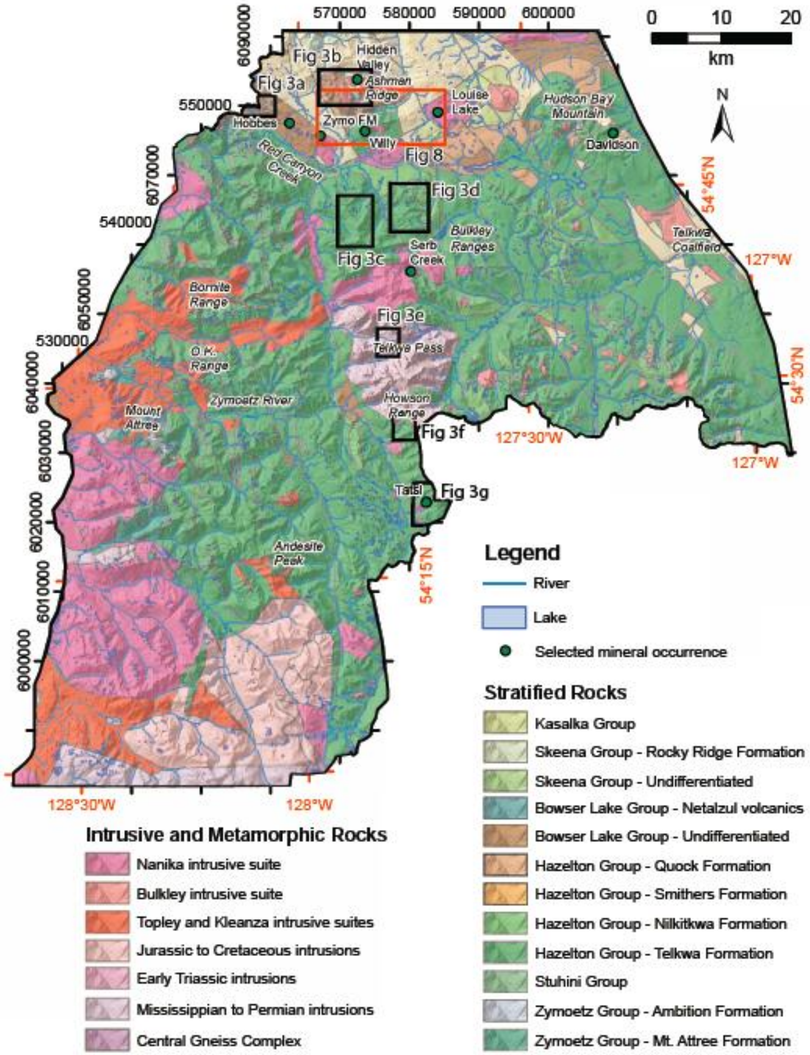
Tipper and Richards, 1976

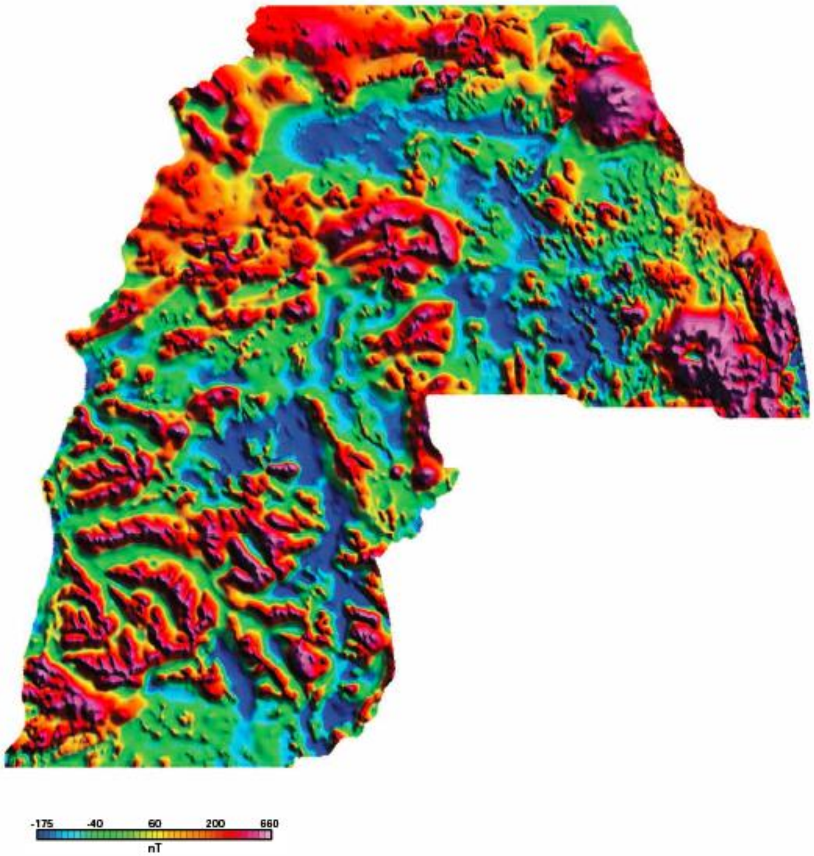


Gagnon et al., 2012

- Strong NW-trend in Early Jurassic

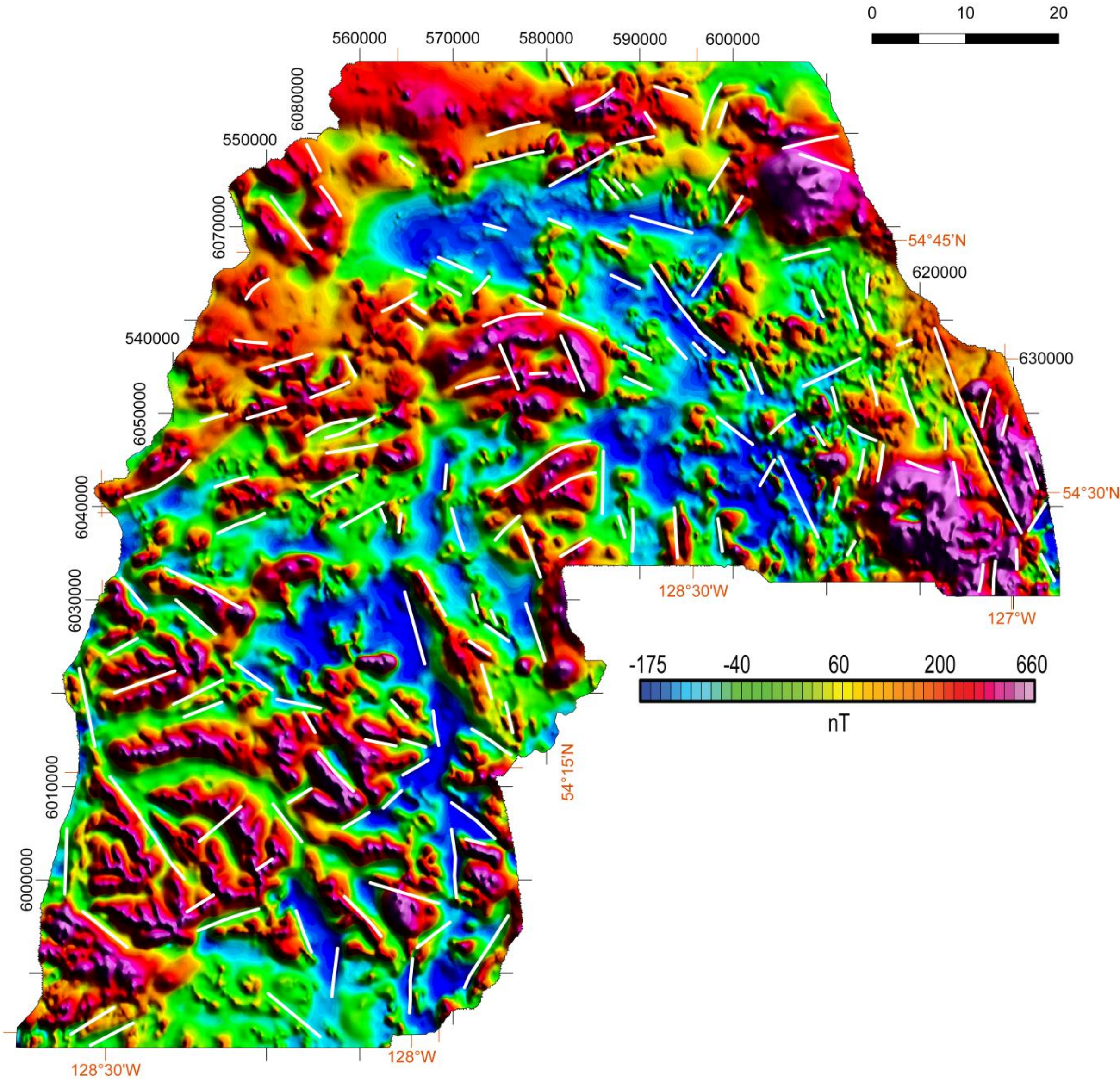
The SeArch Mapping Project





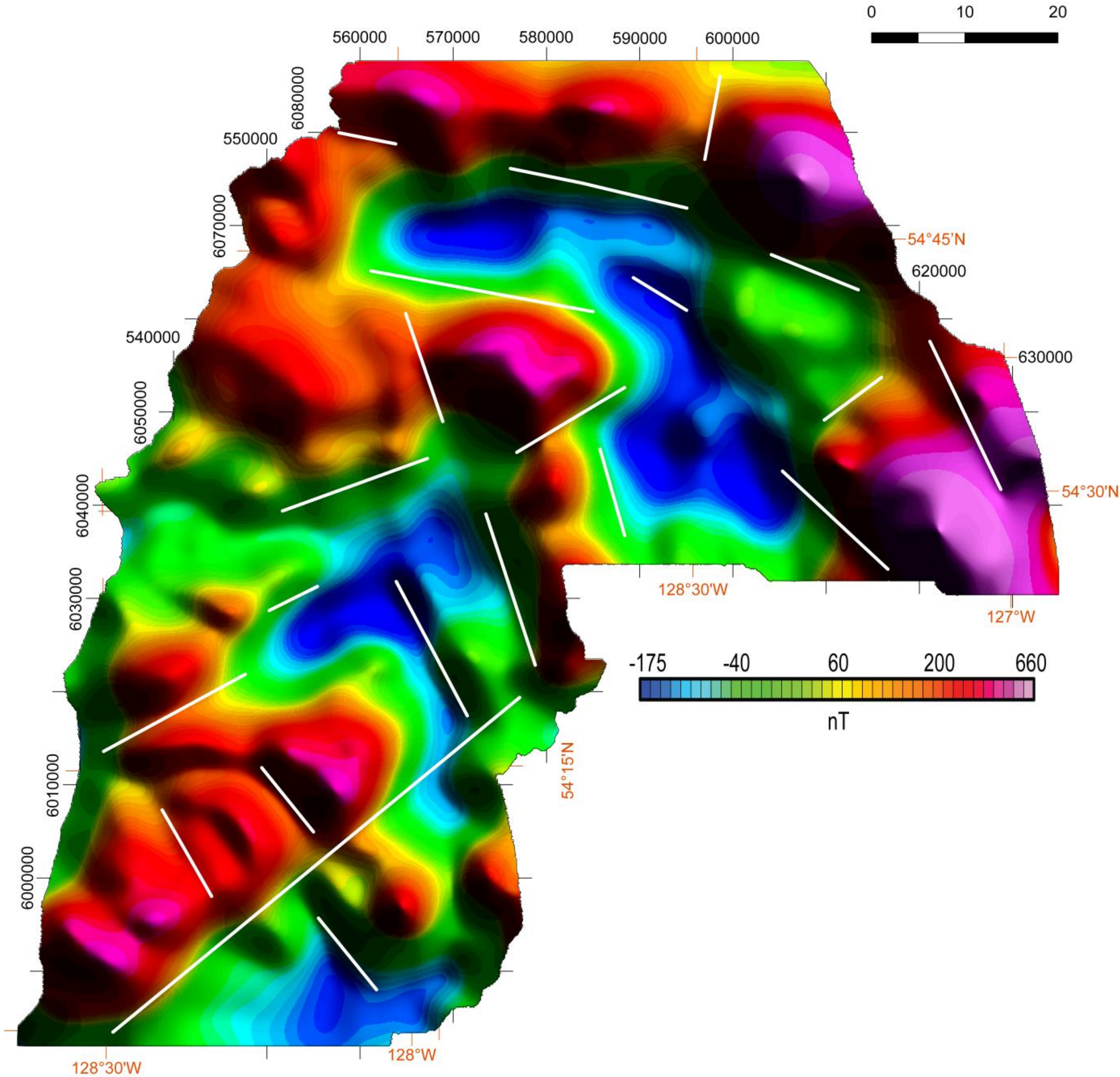
Magnetics

- 1^{st} VD and RTP
- Emphasizes shallow features
- High frequency minor features
- 3 dominant trends



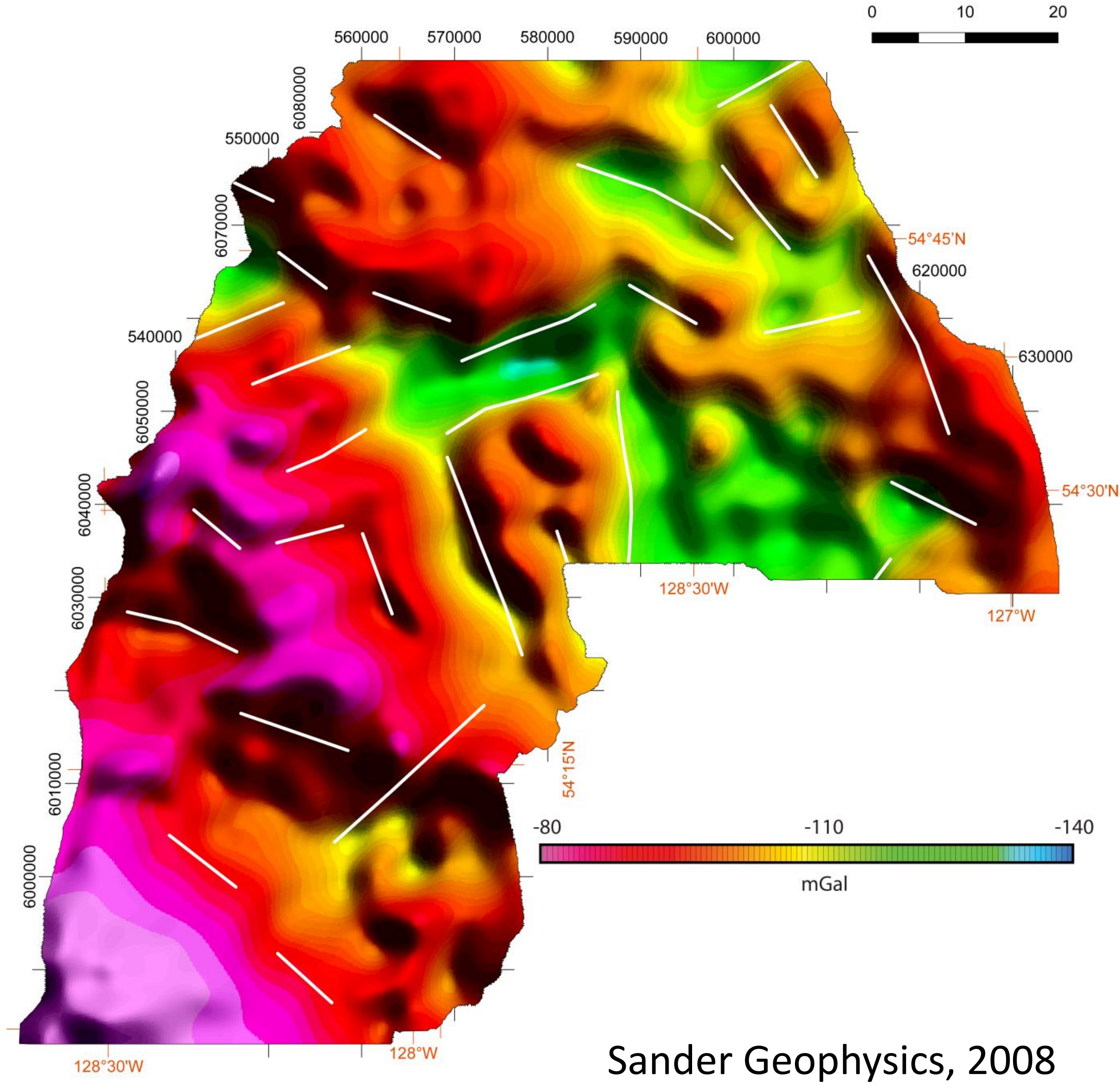
Magnetics

- 3000m Upward Continued RTP
- Emphasizes deep features
- 3 dominant trends



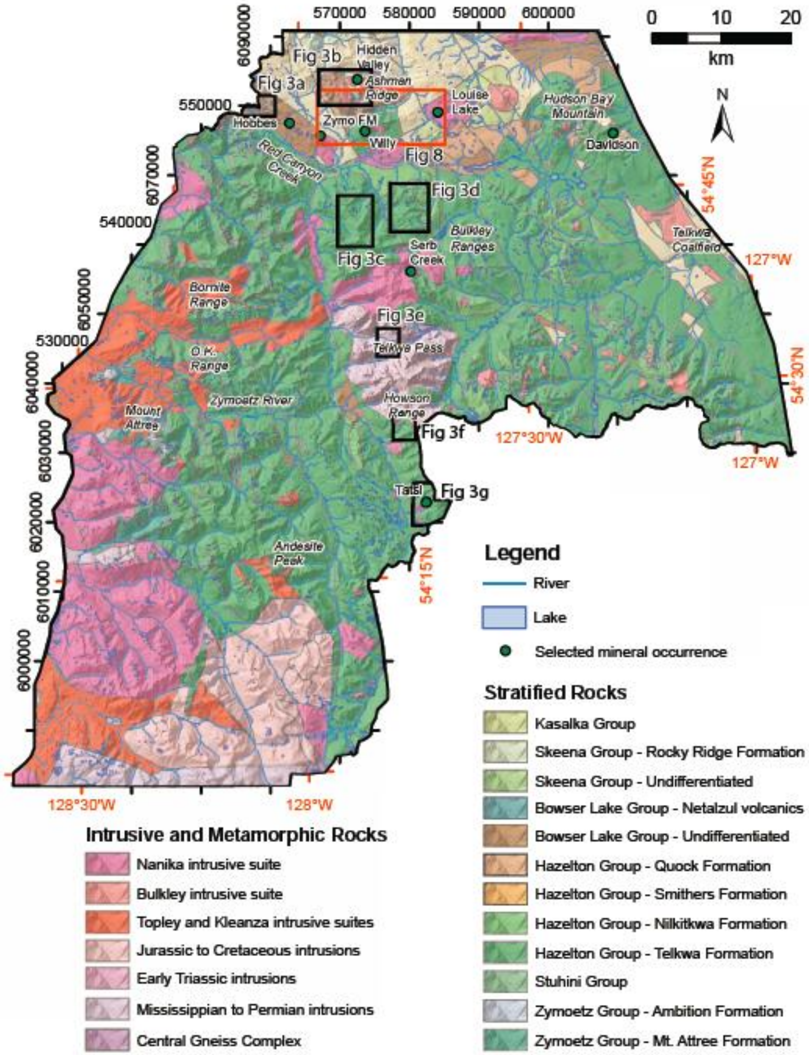
Gravity

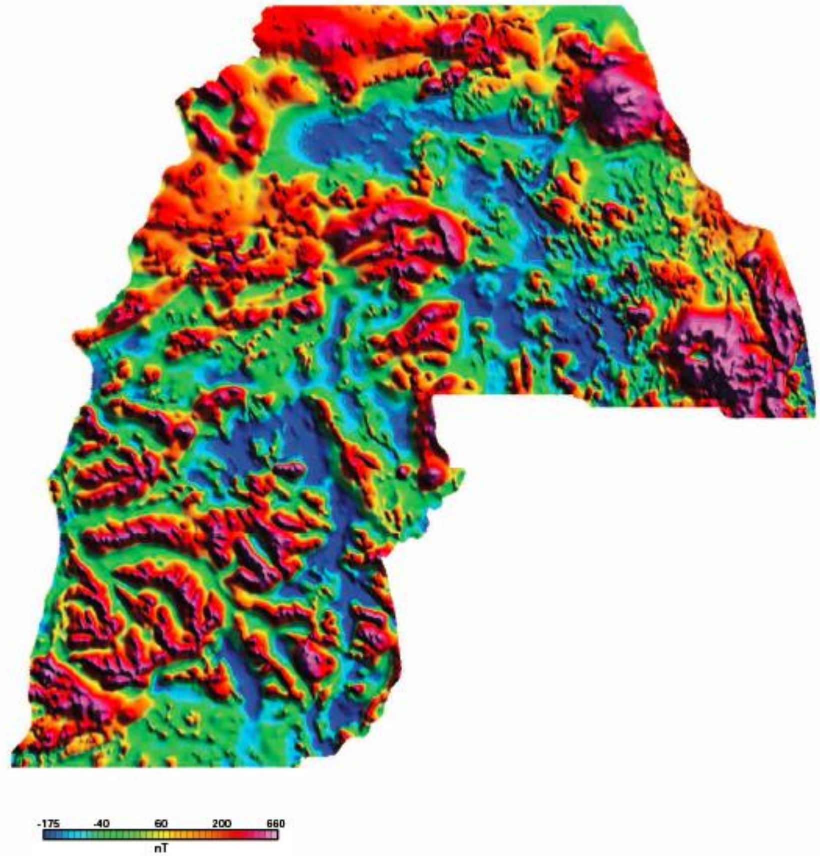
- Terrain corrected bouger
- Emphasizes deep features
- 3 dominant trends



Sander Geophysics, 2008

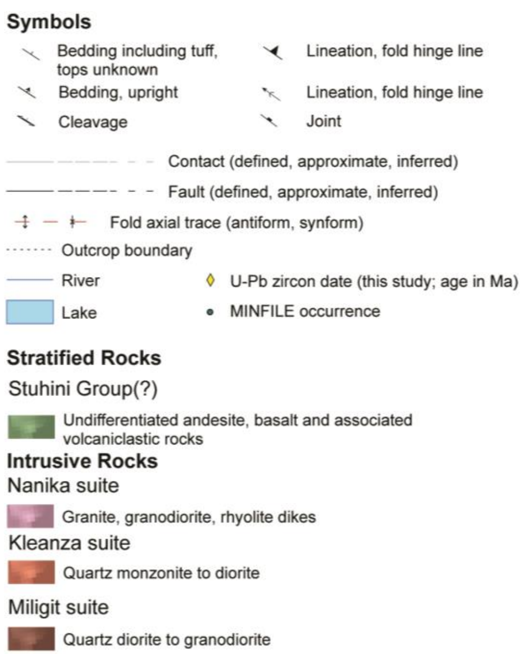
Ground Truthing

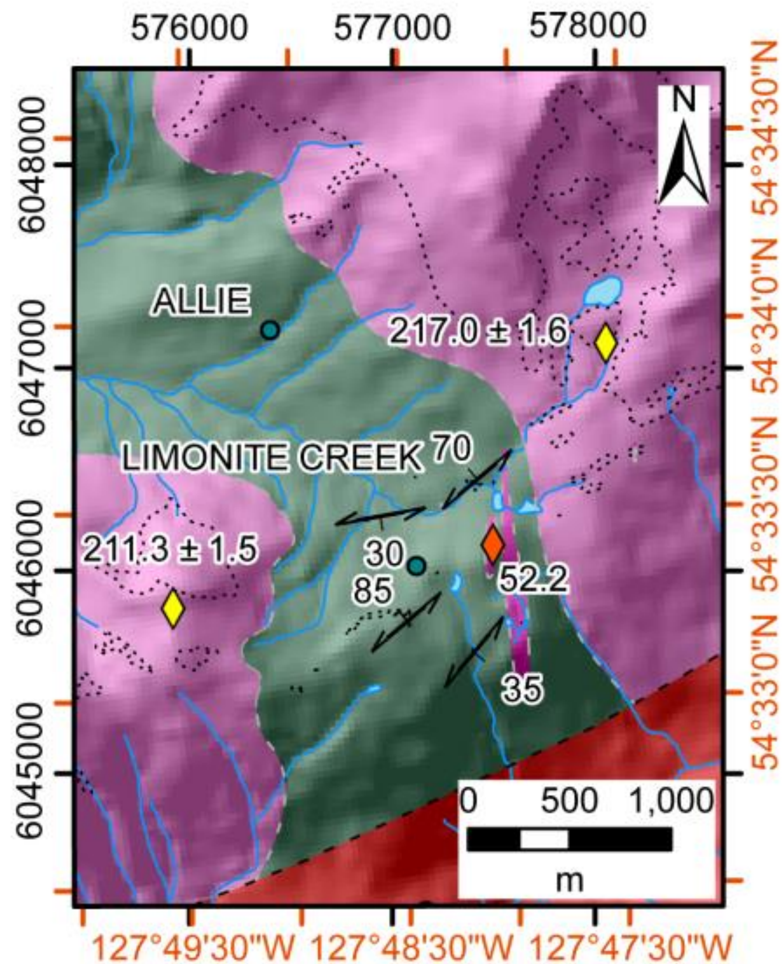




ENE-Trending Foliation

- Triassic (?) volcanics locally have strong foliation
- Crosscut by Late Triassic plutons and Eocene dykes



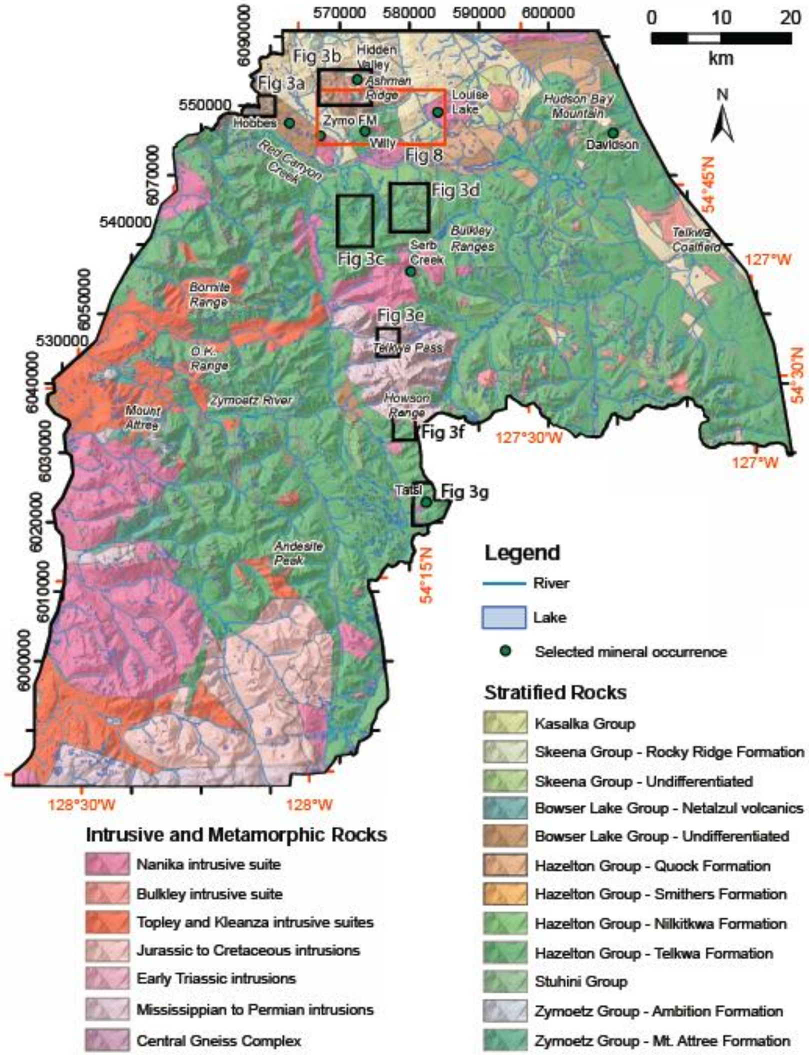


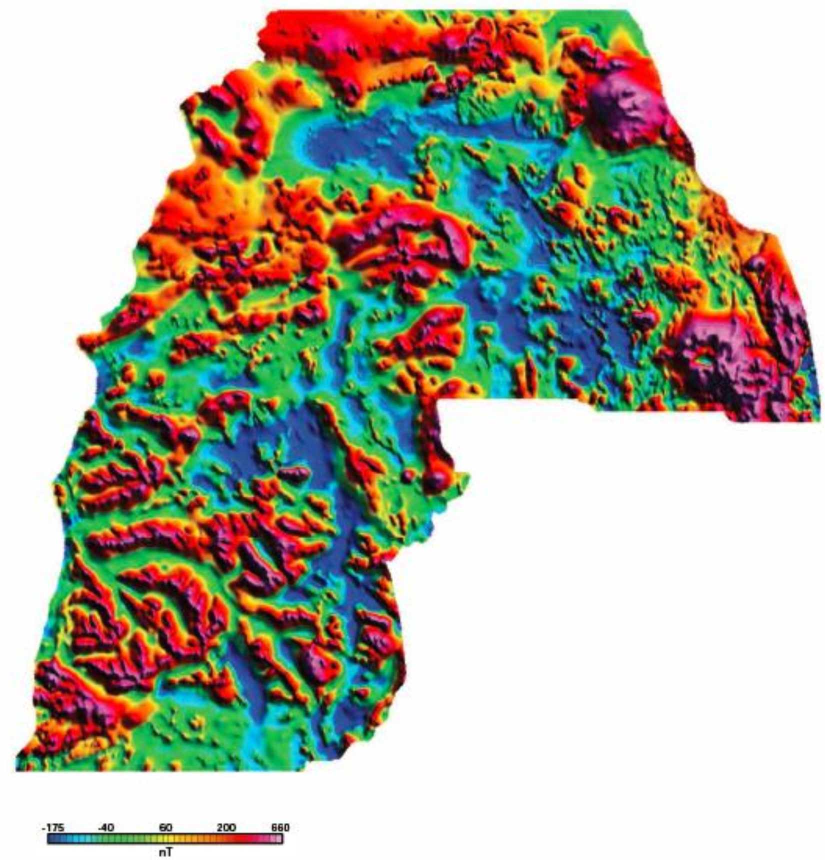
ENE-Trending Foliation

- Triassic (?) volcanics locally have strong foliation
- Local SC fabric but no consistent sense of shear or well developed lineation
- Crosscut by Late Triassic plutons

- Structural anisotropy is Late Triassic or older

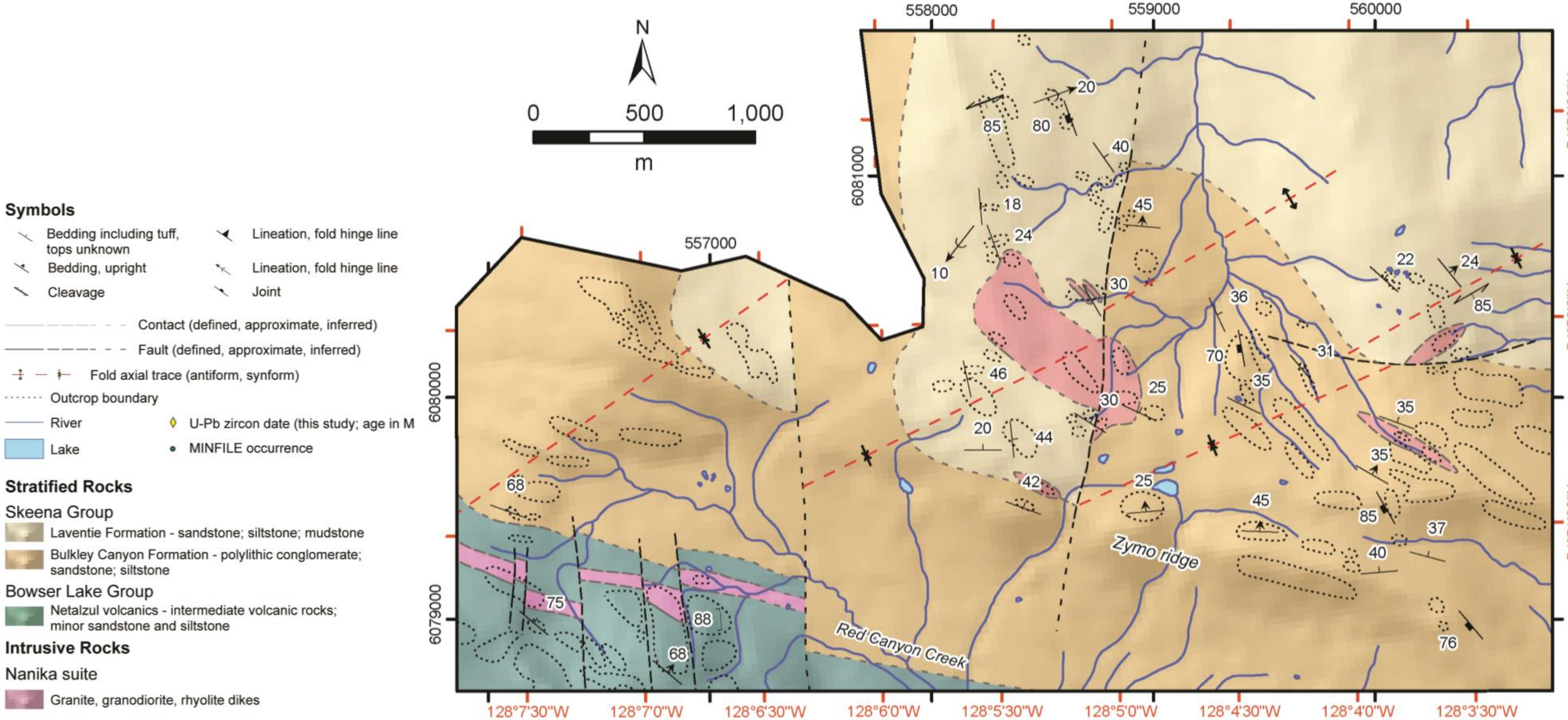
ENE-Trending Folds





ENE-Trending Folds

- Conformable transition from Bowser Lake Group to Skeena Group



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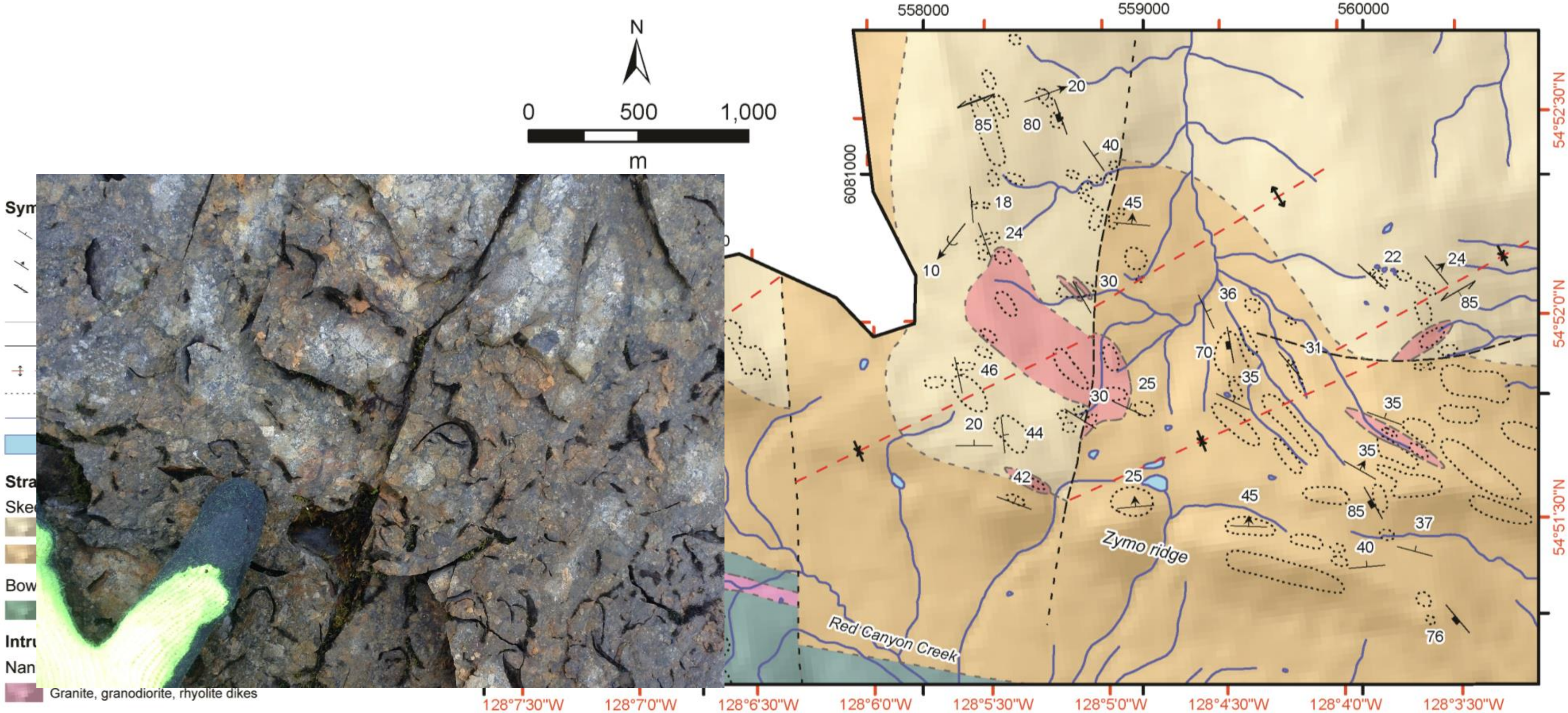

ENE-Trending Folds

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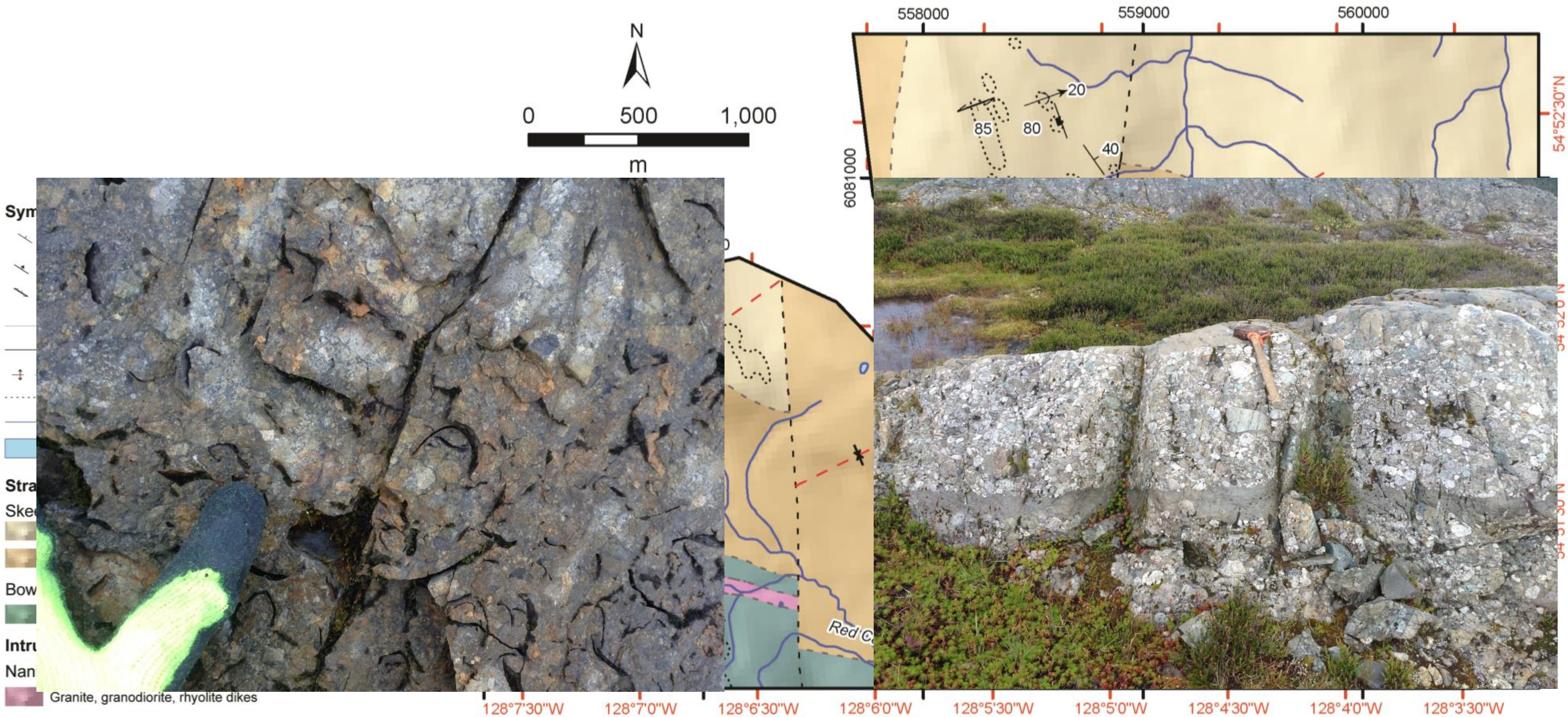
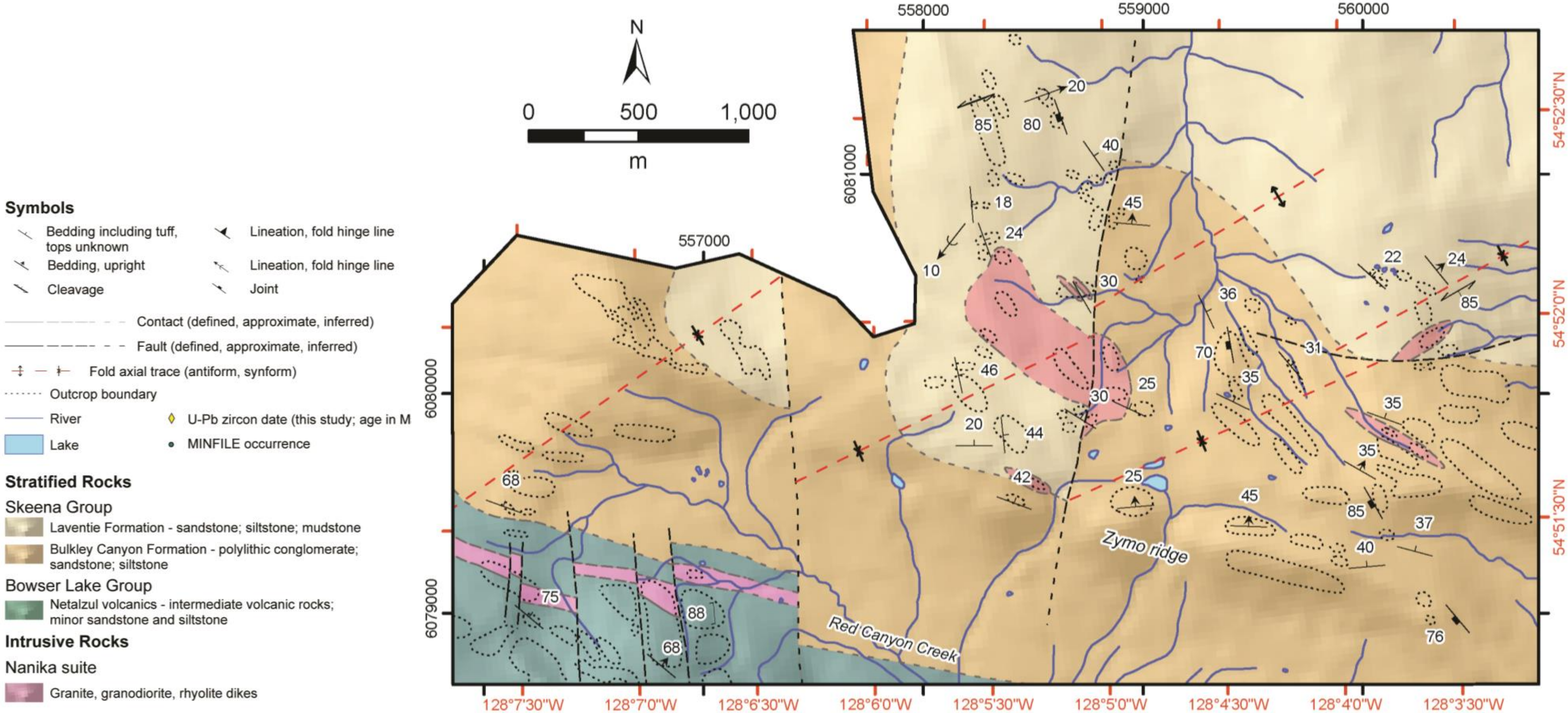


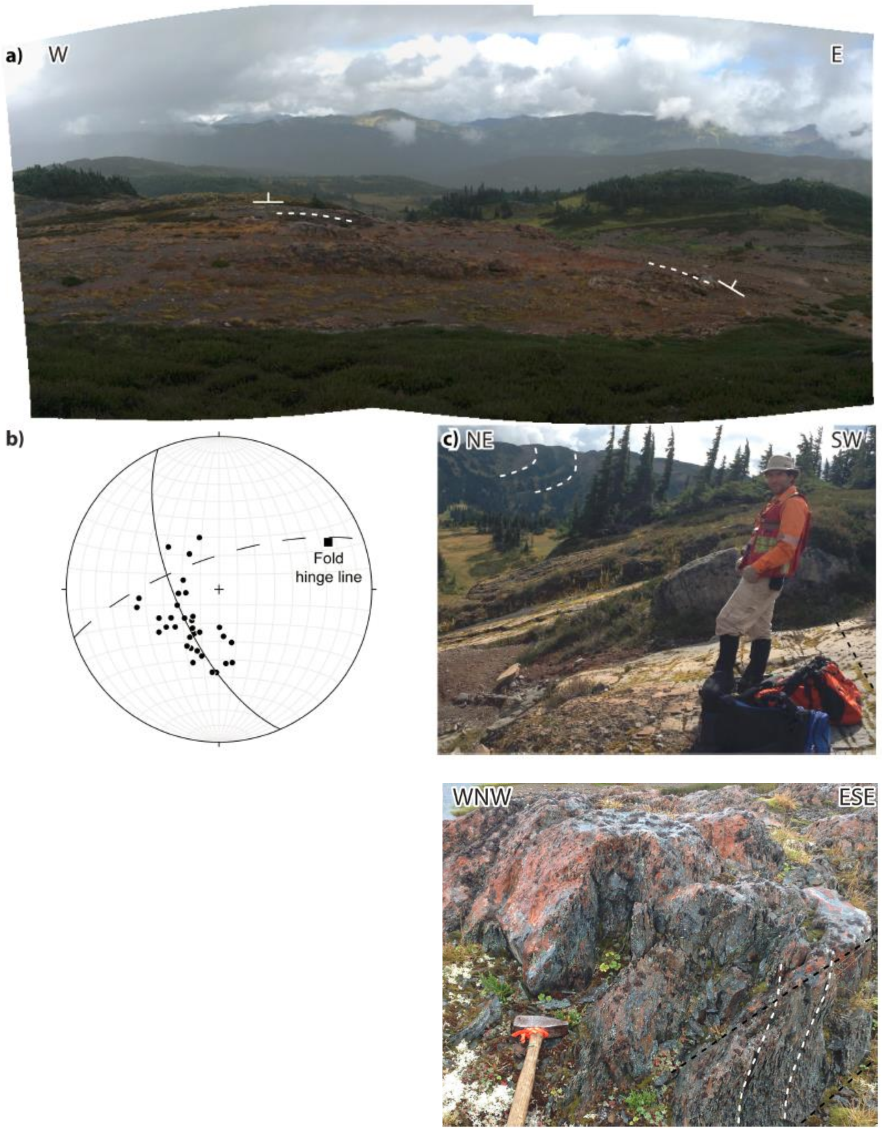
ENE-Trending Folds

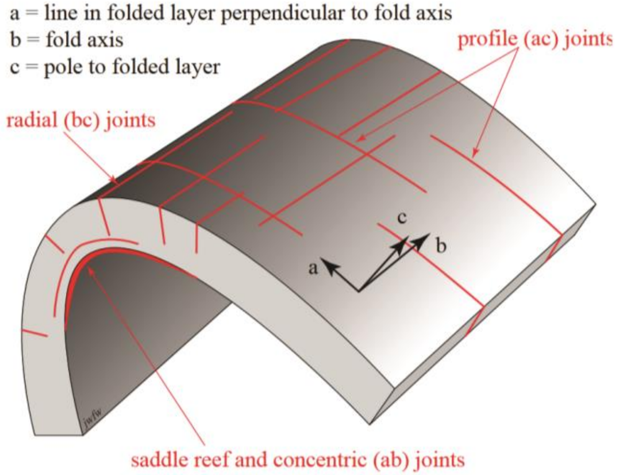
- Open, northeast plunging folds developed in Skeena Group
- Steep axial planar cleavage



ENE-Trending Folds

- Zymo ridge map area

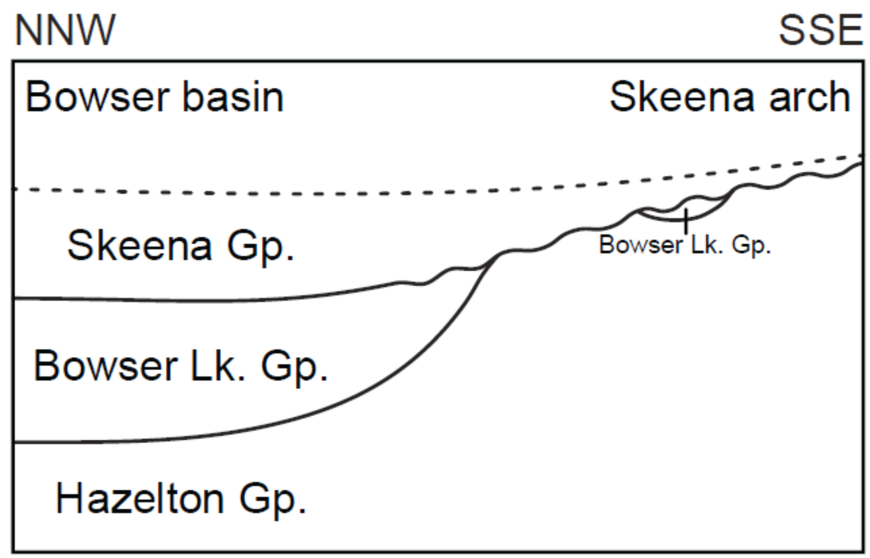




Waldron, 2017

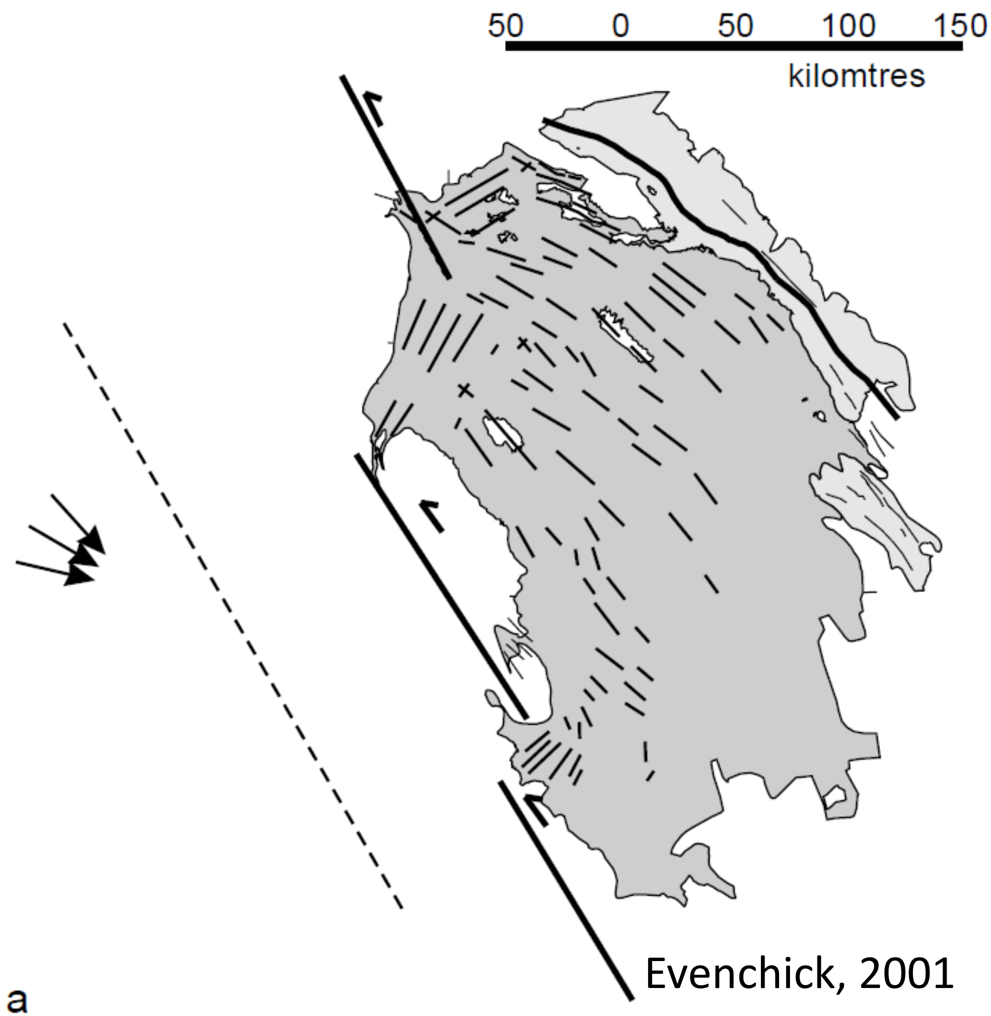
Origin of the Skeena Arch

- Continuous deposition along the northern margin of the Skeena Arch from Smithers Fm to Skeena Gp (Gagnon et al., 2012; Smith and Mustard, 2005).
- Unconformity below Skeena Group to the south (Palsgrove and Bustin, 1991)
- Significant influx of coarse volcanic and locally plutonic clasts at base of Skeena Group may record continued uplift of arch



Origin of the Skeena Arch

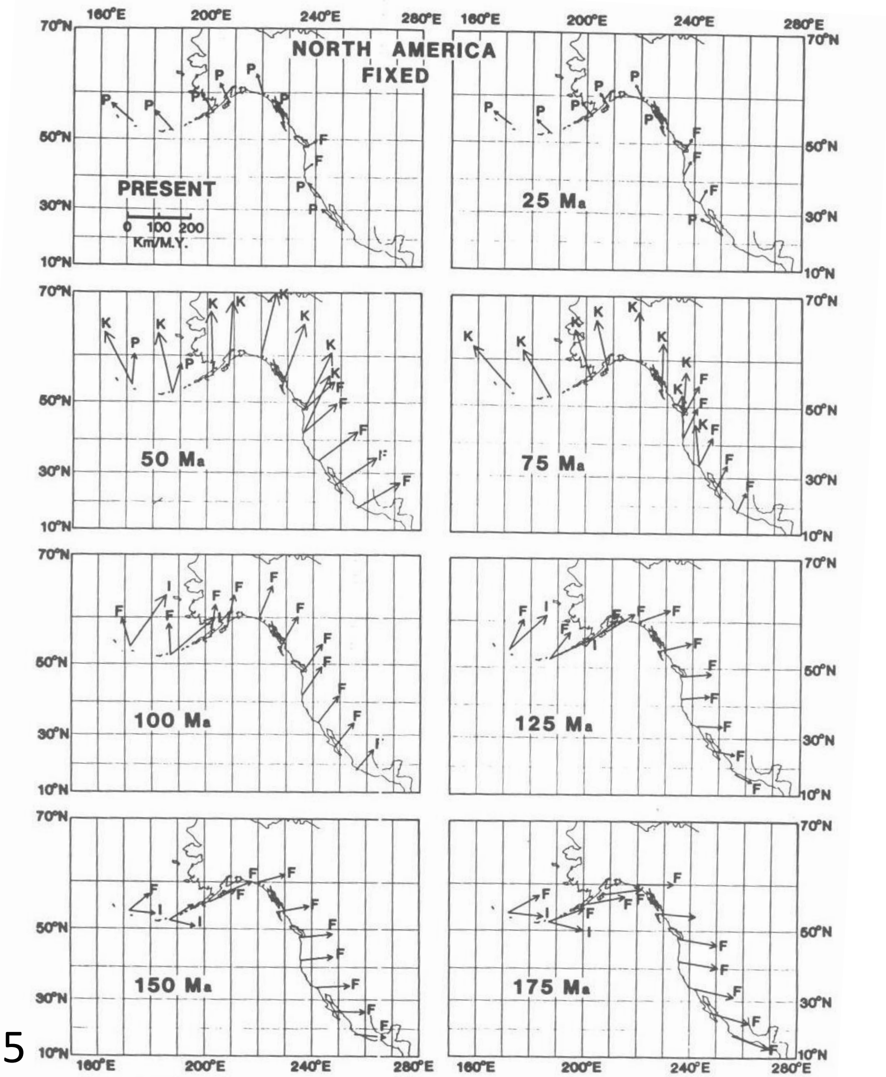
- NE-trending folds documented as early deformation in Skeena Fold Belt
- Cause of folding is sinistral oblique subduction
- Problem: Orientation of folds inconsistent with origin from oblique subduction alone
  - Pre-existing anisotropy?



Evenchick, 2001

Origin of the Skeena Arch

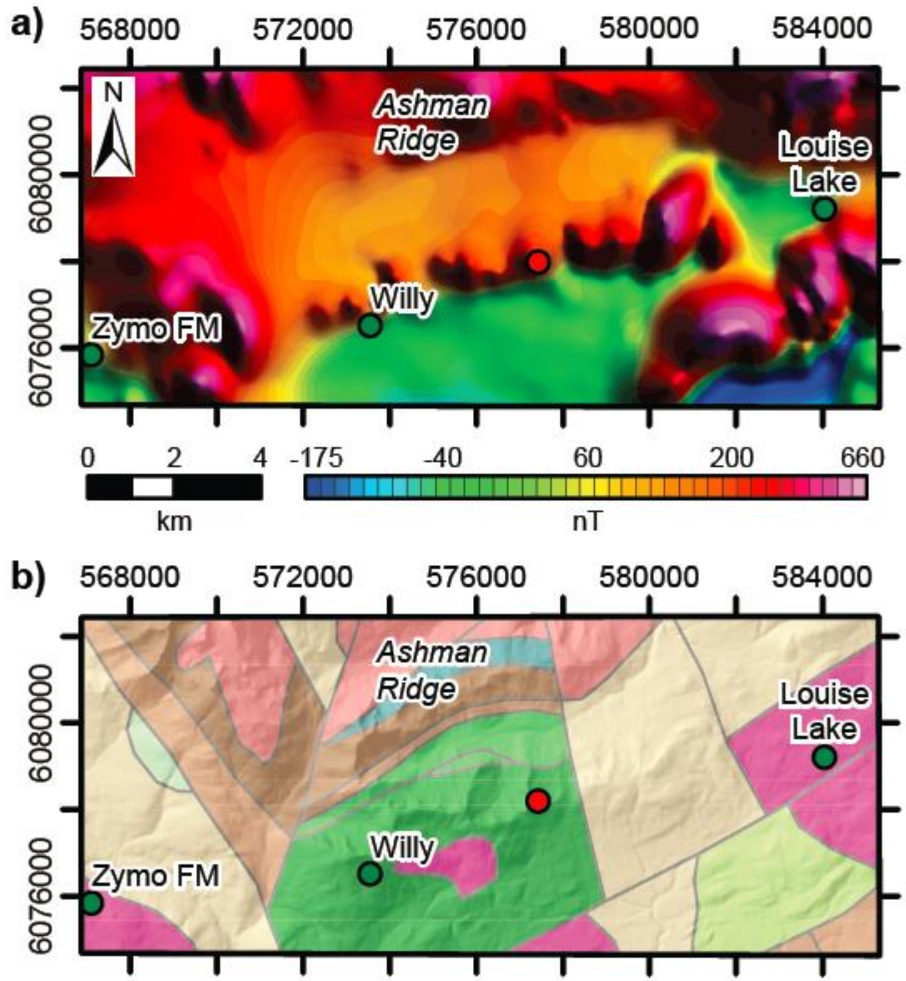
- Cause of folding is sinistral oblique subduction
- Sinistral component to convergence from Late Jurassic to mid Cretaceous
- Potentially long lived event?



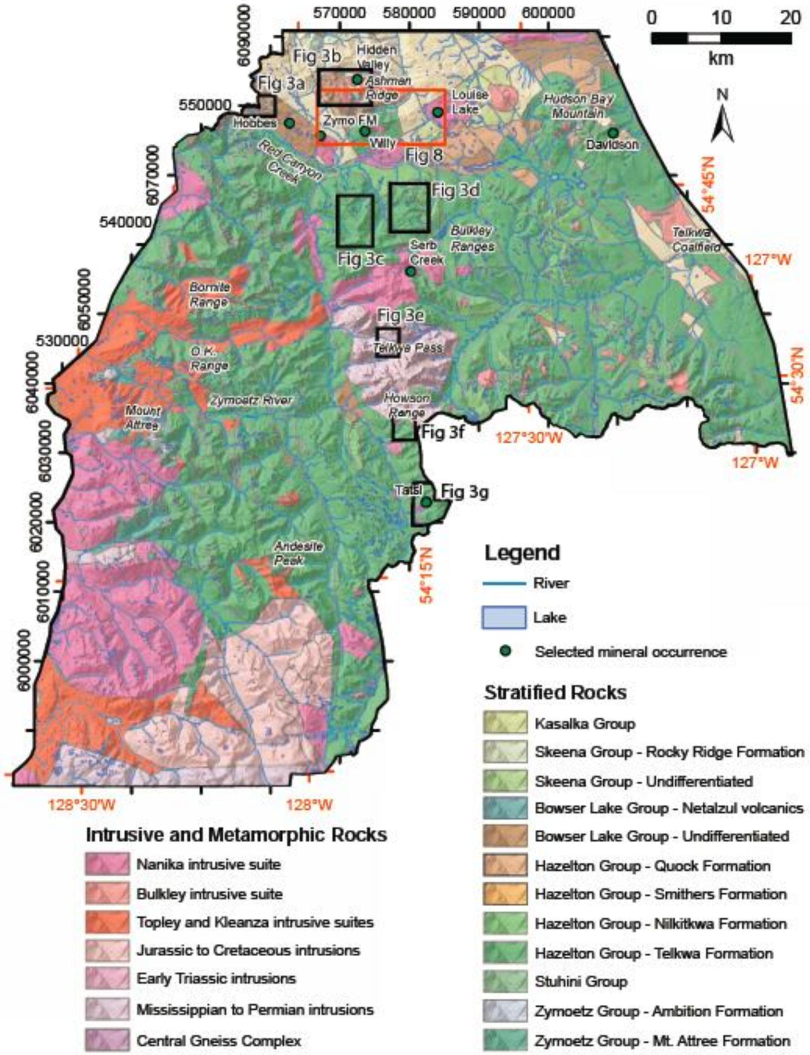
Engebretson et al., 1985

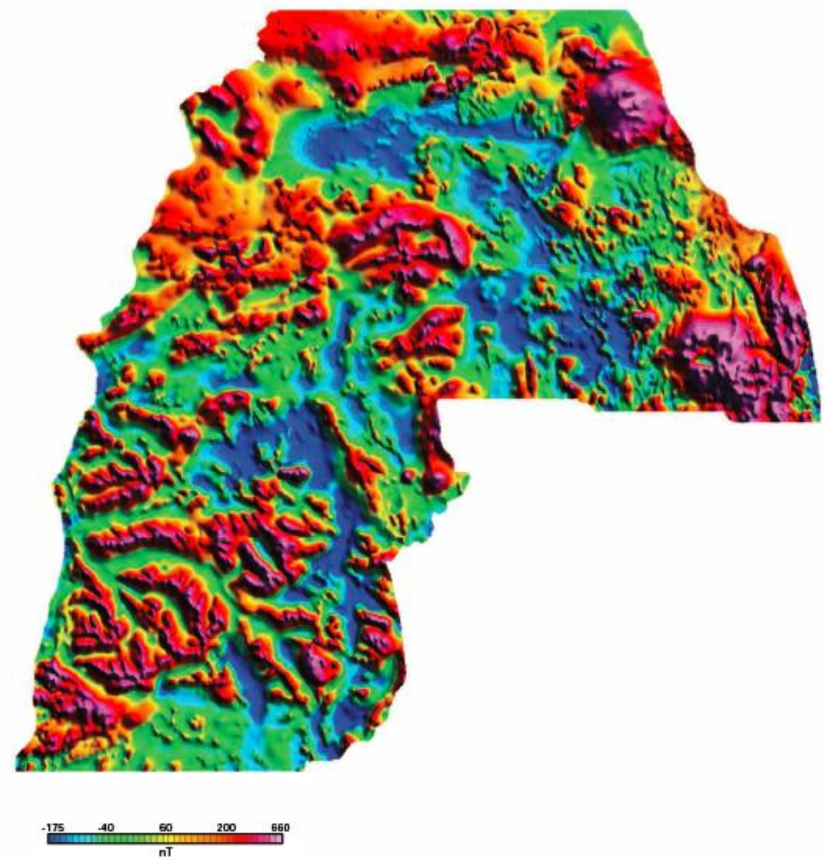
Significance of ENE-Trending Structures

- Strong local control on Late Cretaceous magma
- ENE trend of mag highs
- Correspond to plagioclase porphyry plugs
- 3 known mineral occurrences



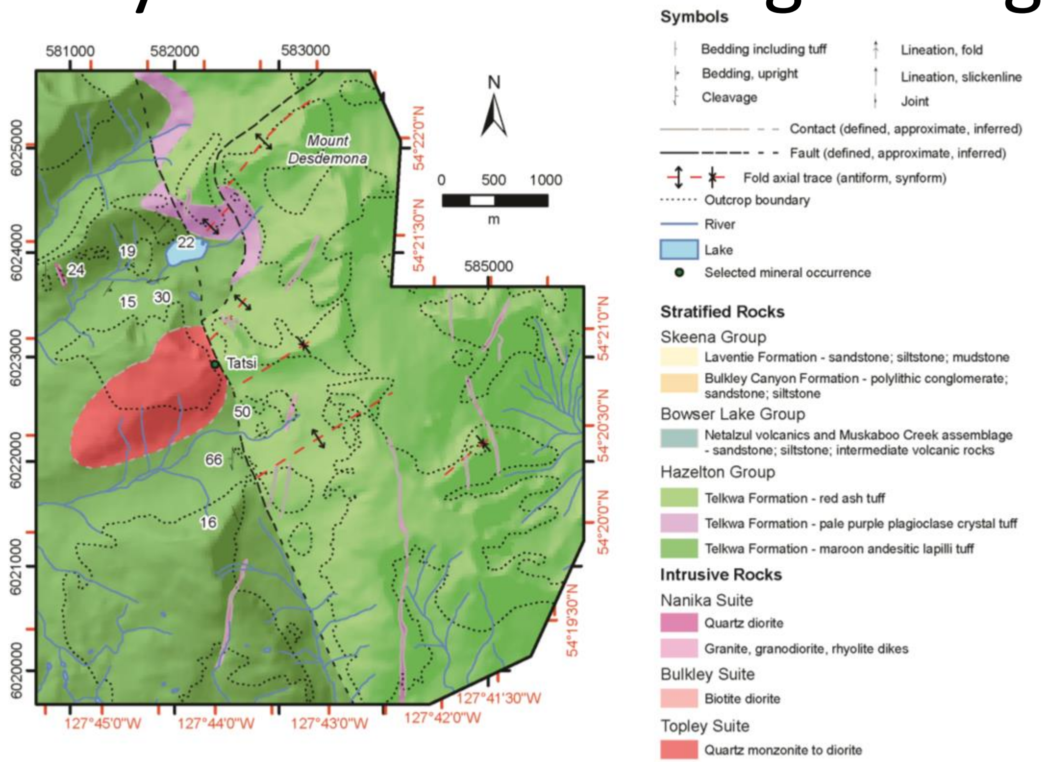
SSE-Trending Structures





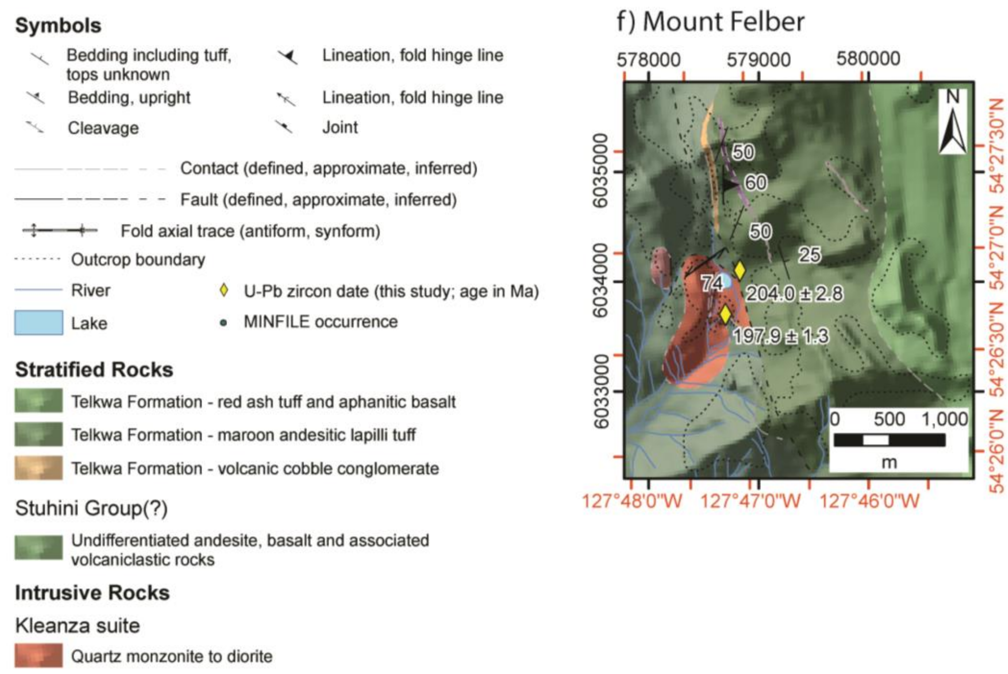
SSE-Trending Grabens

- NNW-striking, steeply dipping normal fault
- Eocene dykes localized along strong joint set



SSE-Trending Grabens

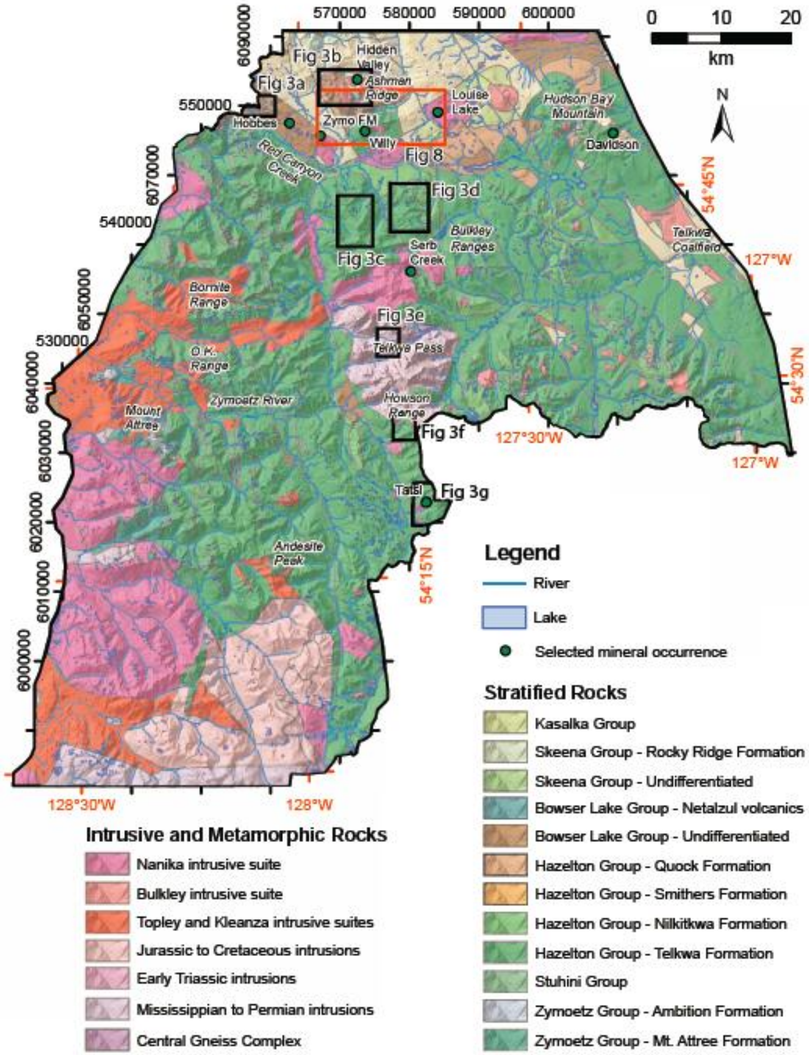
- NNW-striking, steeply dipping normal fault
- Exposure of the base of the Hazelton Group

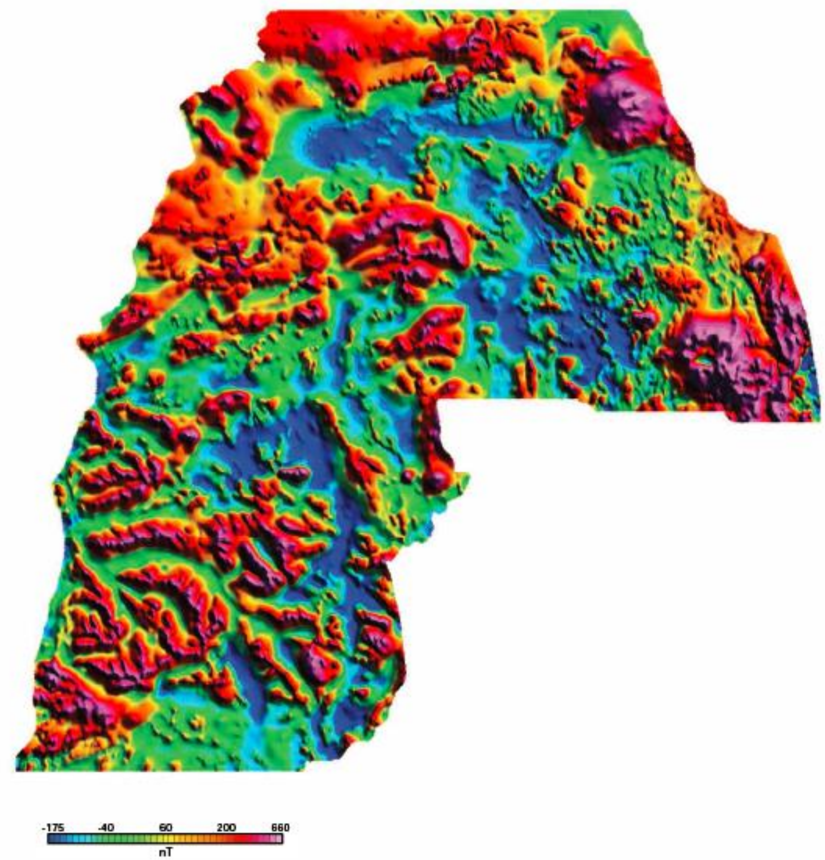


Timing of SSE-Trending Grabens

- Foliation associated with Kitsumkalum-Kitimat graben crosscuts Paleocene pluton
- Joints localize Eocene magmas
  - Dykes locally
  - Porphyry stocks near Babine Lake
- Eocene extension

ESE-trending structures





ESE trending

- Add mag again
- Not evident in the field
- Strong low frequency feature evident in mag and gravity
- Parallels a feature evident in TREK area where it marks a northeastward thickening wedge of BLG interpreted as a basin bounding fault.
- Small panel of BLG south of feature may reflect similar geometry

Intrusive Suites

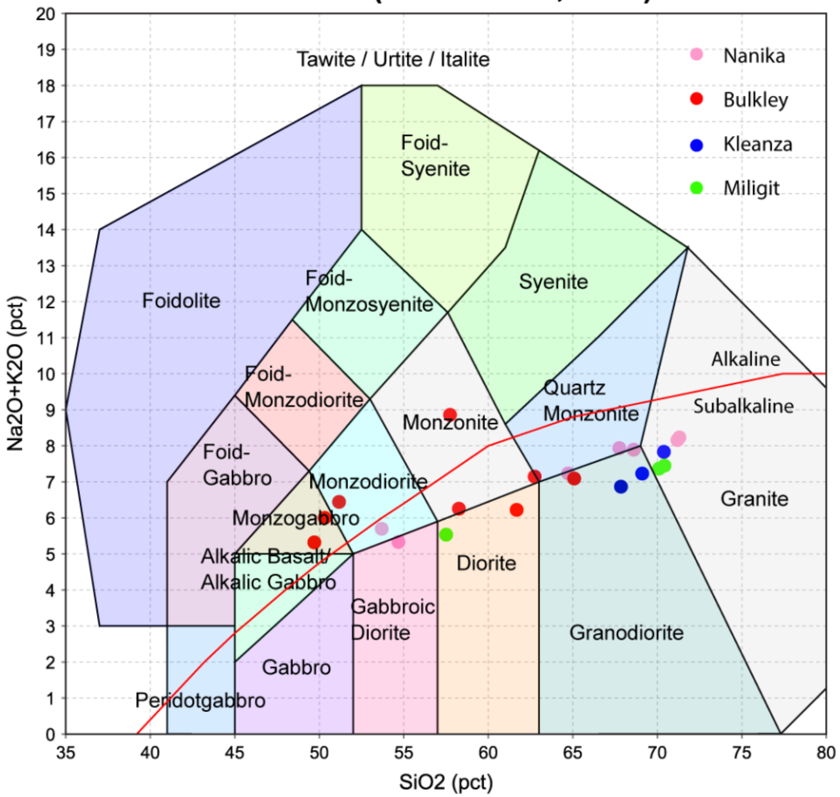
- Eocene Nanika Suite
  - Biotite + hornblende + plagioclase ± k-spar ± quartz porphyritic granodiorite, granite, minor equigranular monzodiorite
- Late Cretaceous Bulkley Suite
  - Biotite ± hornblende ± plagioclase porphyritic monzogabbro to granodiorite
- Early Jurassic Kleanza Suite
  - Hornblende granodiorite to granite locally (very heterogeneous overall)
- Late Triassic Miligit Suite
  - Biotite, hornblende ± pyroxene bearing diorite to granite



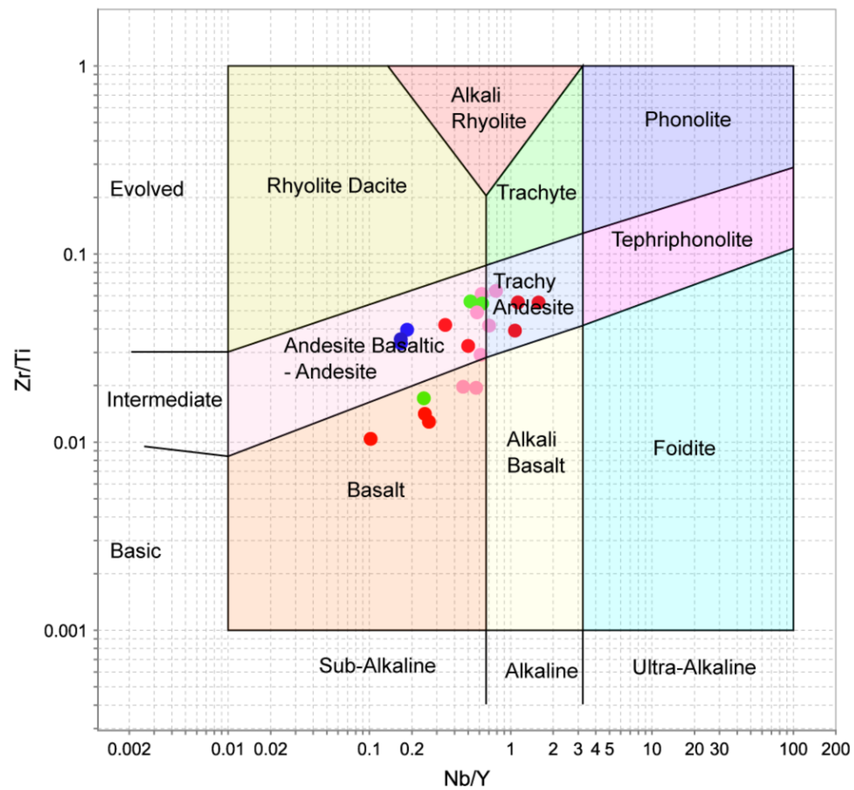

Whole Rock Geochemistry

- All subalkaline except Bulkley Suite

TAS Plutonic (Middlemost, 1994)



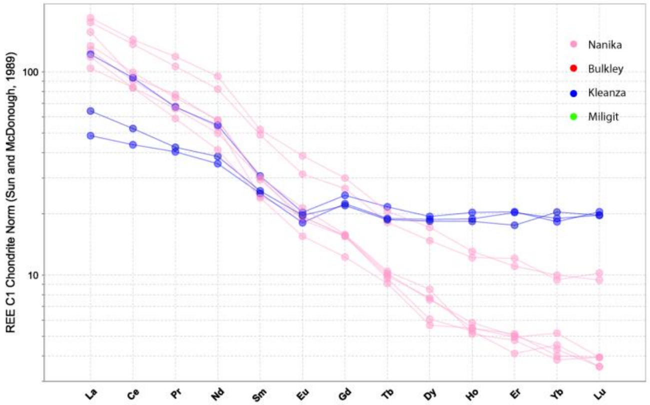
Volcanic Rocks Modified (Pearce 1996)

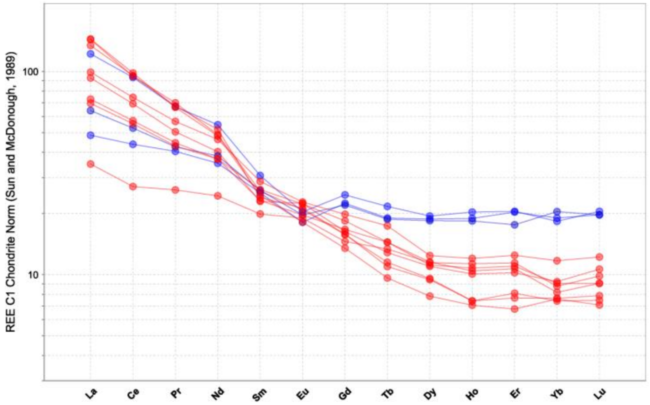


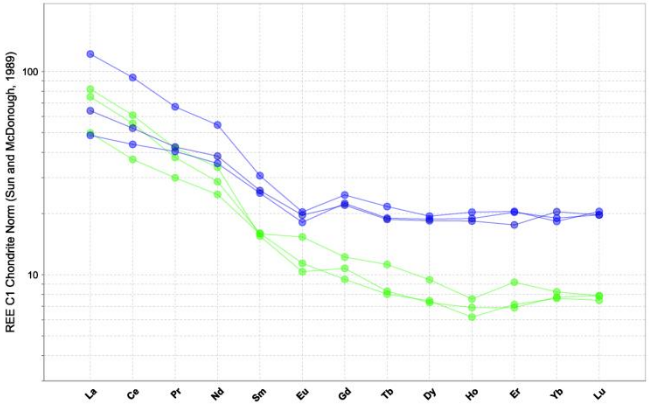
Whole Rock Geochemistry

- Kleanza is only suite with negative Eu anomaly – Plagioclase fractionation
  - Supported by Sr
- All have listric shape – amphibole or pyroxene fractionation
- Nanika suite has increased fractionation of HREE vs MREE – garnet fractionation

- Plagioclase is suppressed under high H_2O and high pressure (4-8 wt % H_2O at 40km depth: Richards, 2011; Alonzo-Perez et al., 2008)
- Garnet stabilized at higher H_2O or higher pressure (>8 wt % H_2O at 40km depth: Alonso-Perez et al., 2008; <50km depth: Atherton and Petford, 1993)



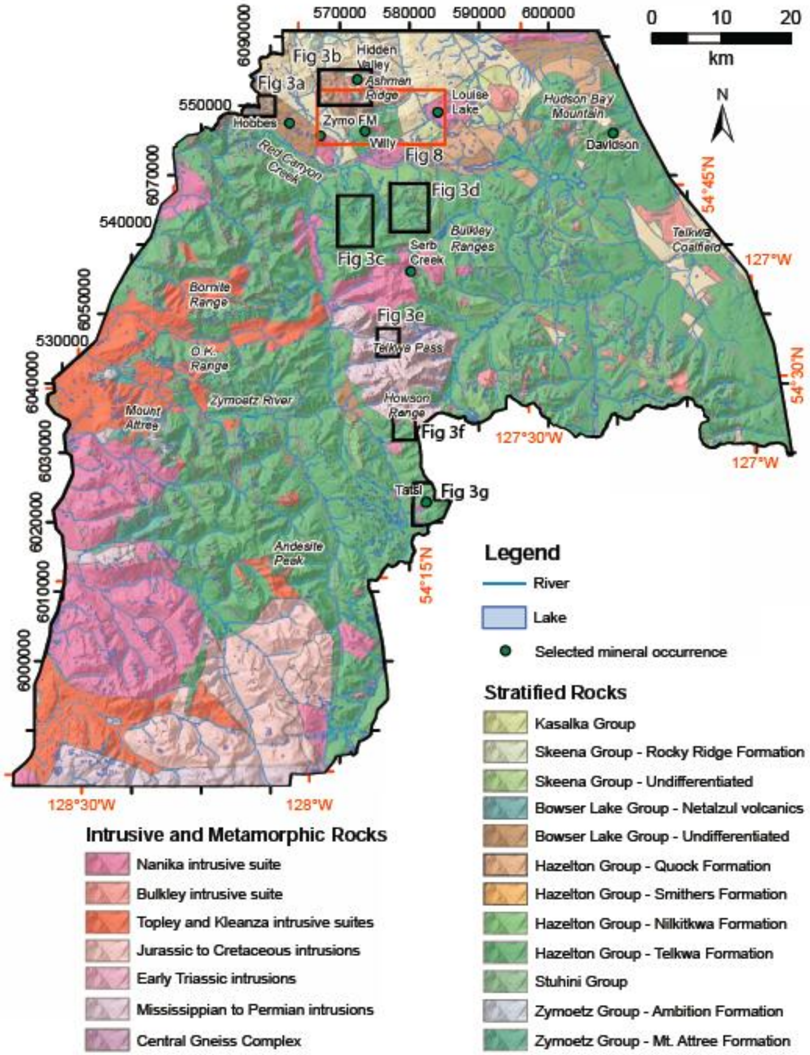


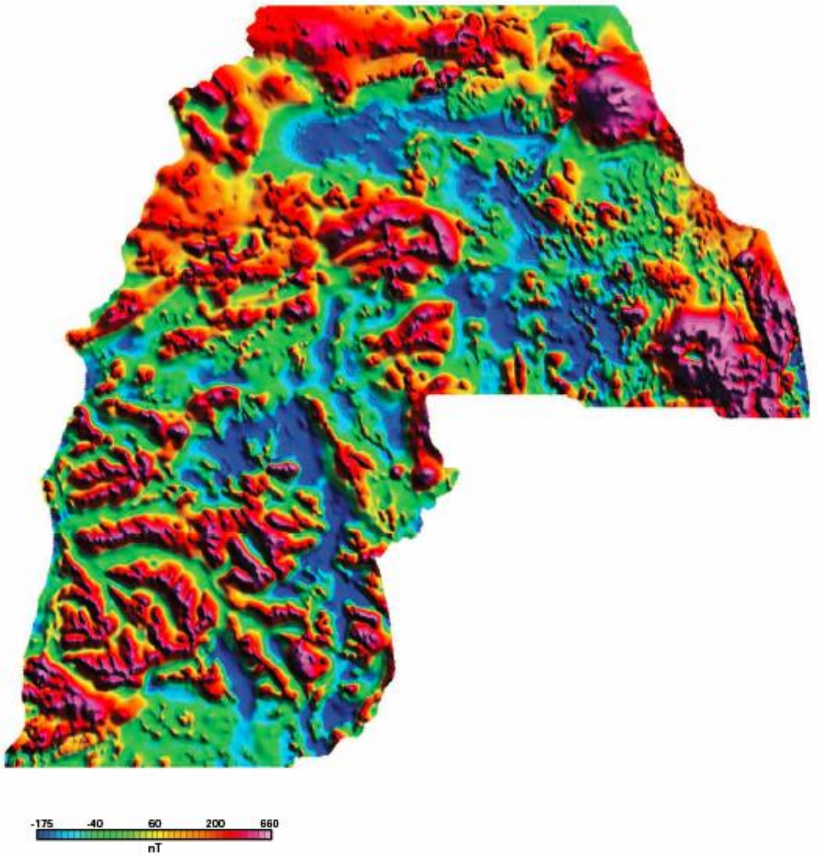


Whole Rock Geochemistry Based Prospectivity

- Bulkley, Nanika, and Miligit geochem suggest high water content
  - Prospective for hydrothermal systems
- Kleanza geochem suggests low water content
  - Less likely to form significant hydrothermal systems

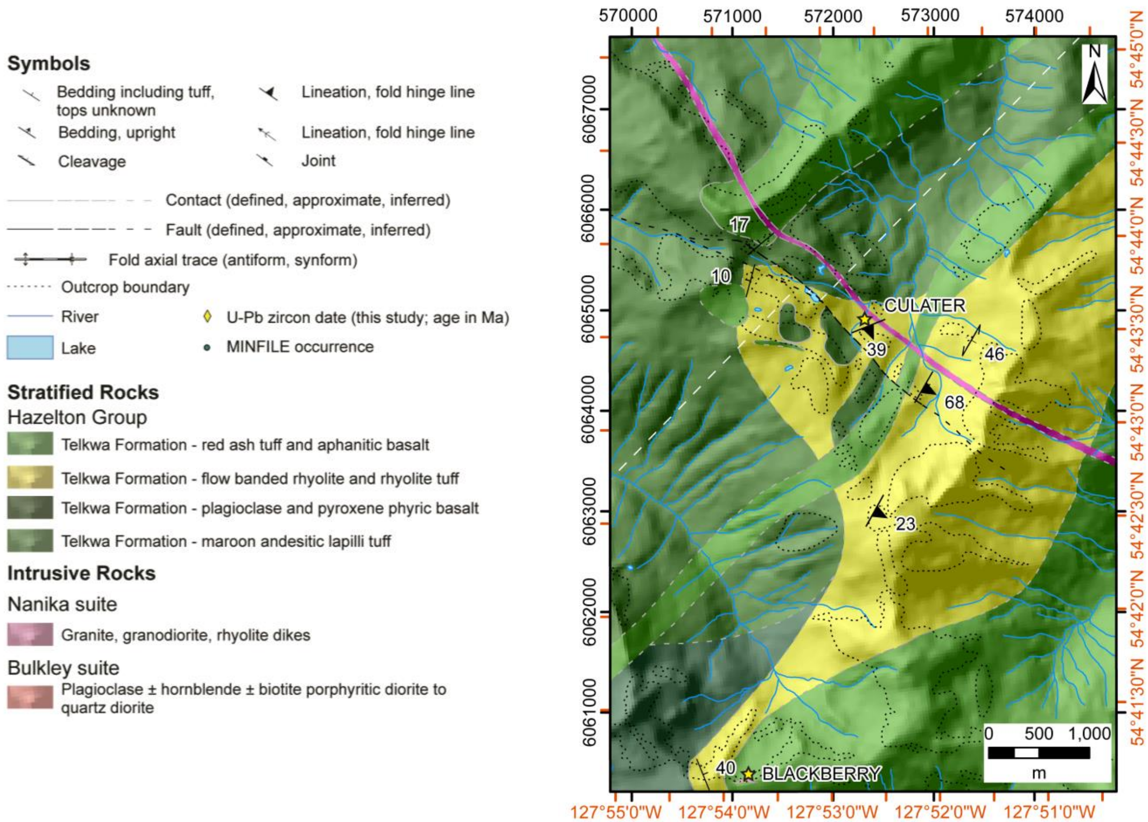
New Mineralization





Ventura Peak Area

- Two new mineral occurrences near Ventura Peak
  - CuLater
  - Blackberry



CuLater

CuLater

- Quartz, barite, carbonate veins and fine grained dioritic dyke
- Rhodochrosite and rhodonite: IS epithermal

>1% Cu, 25.5 ppm Ag

0.8% Cu, 0.1% Zn, 39.6 ppm Ag, 247.4 ppb Au

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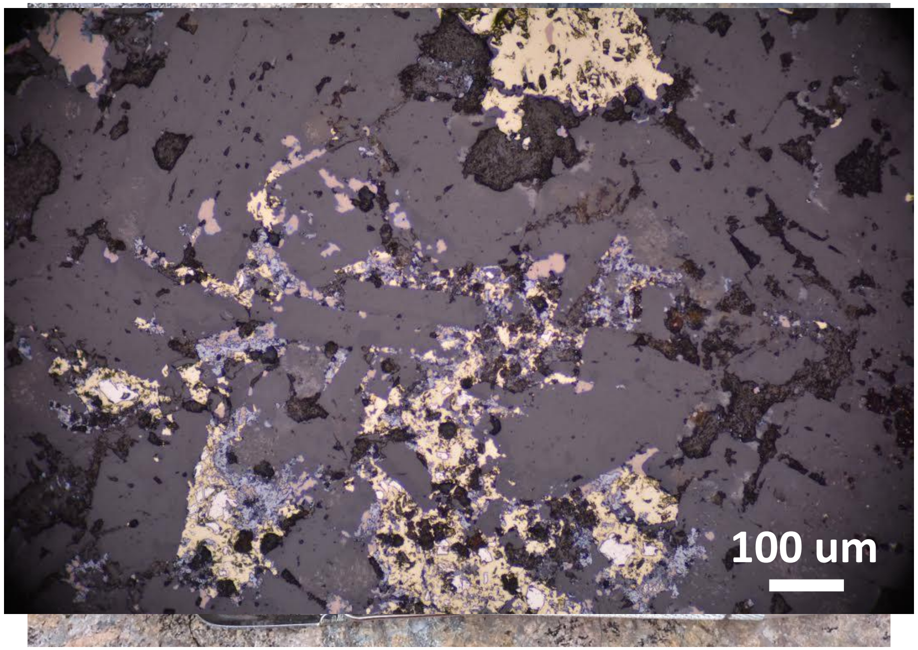


0.8% Cu, 0.1% Zn, 39.6 ppm Ag, 247.4 ppb Au

Blackberry

- Coarse chalcopyrite
- Strongly associated with plagioclase porphyritic diorite dyke
- No mineralization in Telkwa Formation
- 0.38% Cu, 16.1 ppb Au

CuLater and Blackberry

- Tourmaline + quartz ± rhodonite ± epidote alteration nearby

Late Cretaceous Mineralization

- Zymo, Hobbes, Louise Lake, Hidden Valley, etc.

Hobbes (c/o Eastfield Resources)

Hidden Valley

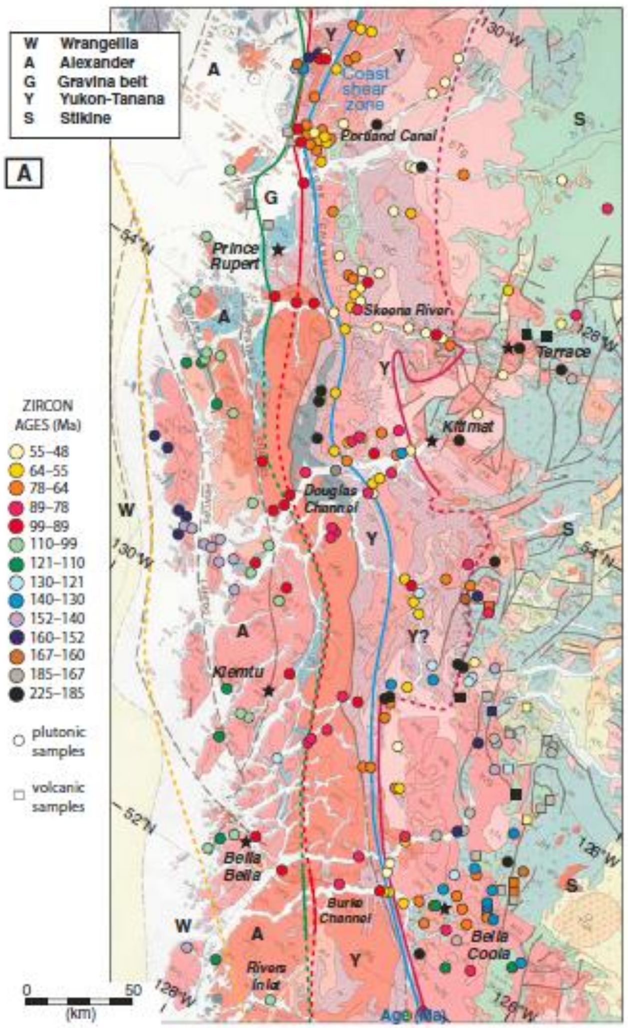
Late Cretaceous Mineralization

- Why?

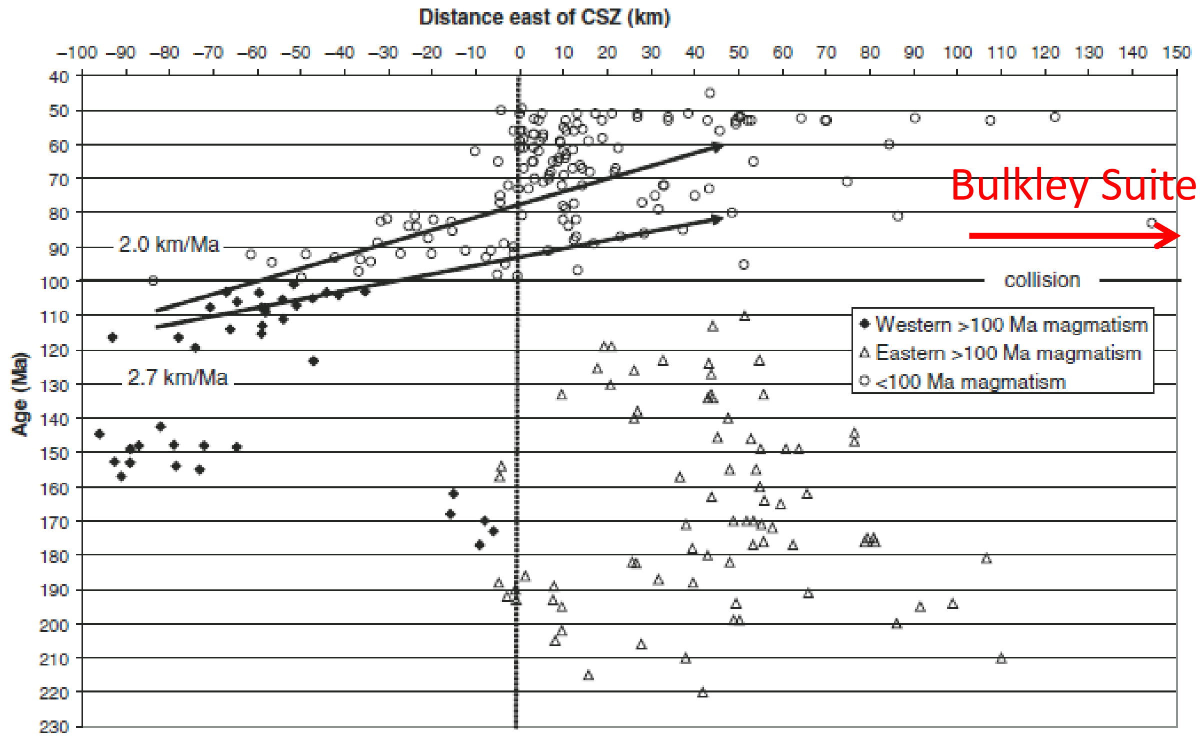
Hobbes (c/o Eastfield Resources)

Hidden Valley

Tectonic Setting of Bulkley Suite (Magmatic)

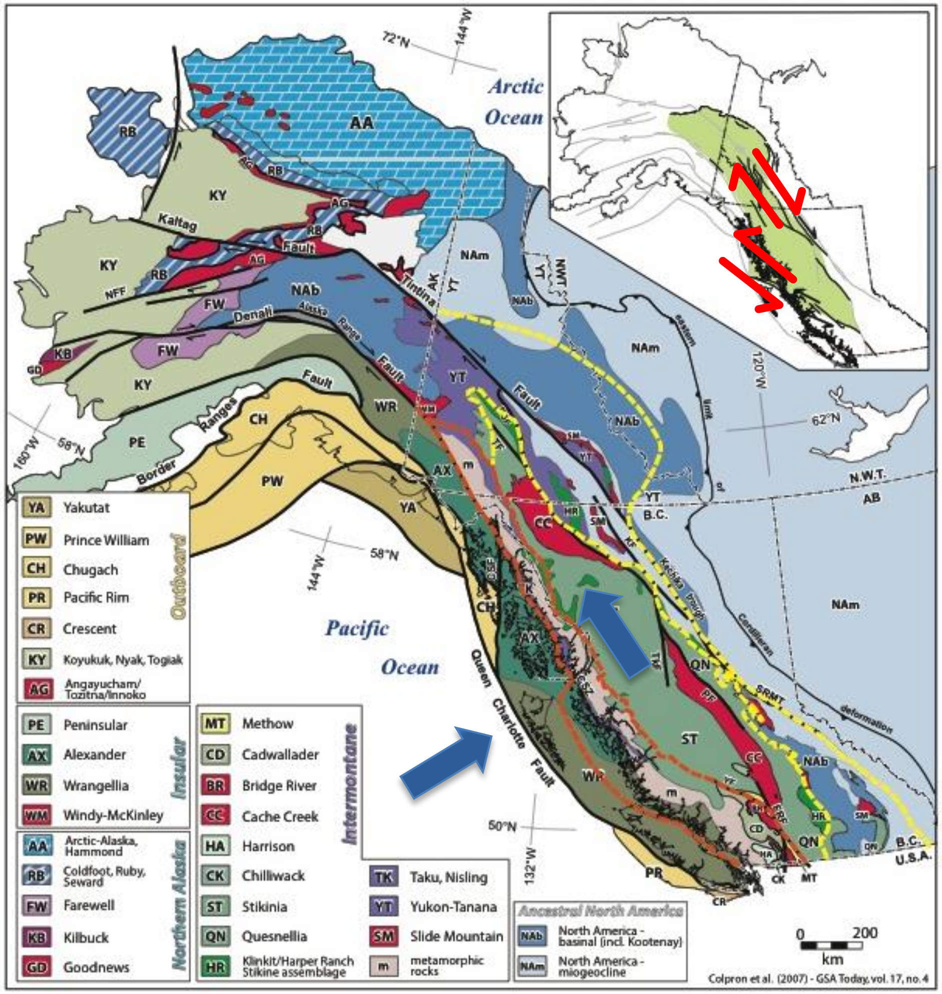


- Bulkley Suite is well east of arc axis



Gehrels et al., 2009

Tectonic Setting of Bulkley Suite (Structural)



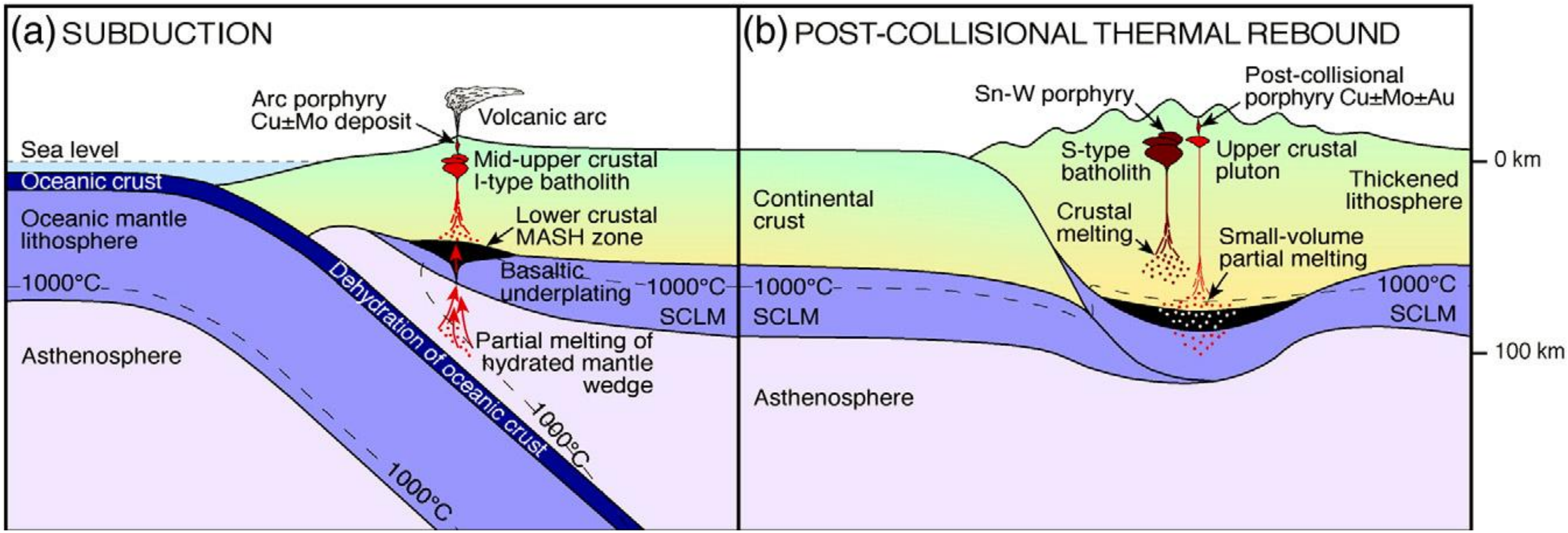
- Bulkley suite is late during a major orthogonal shortening event
  - Well developed fold and thrust deformation (thickening of crust)
  - Conjugate sinistral and dextral shear zones indicating tectonic escape (product of thickened crust)

Colpron et al., 2007; 2011;
Monger et al., 1982

Why Late Cretaceous Mineralization?

- Bulkley suite
  - Is well east of the arc axis
  - Emplaced late during a major compressional event
  - Calc-alkalic to mildly alkaline
  - Fractionation under moderately high pressure and water content (thickened crust)
  - Hosts (relatively) small porphyry Cu±Mo±Au deposits

Why Late Cretaceous Mineralization?

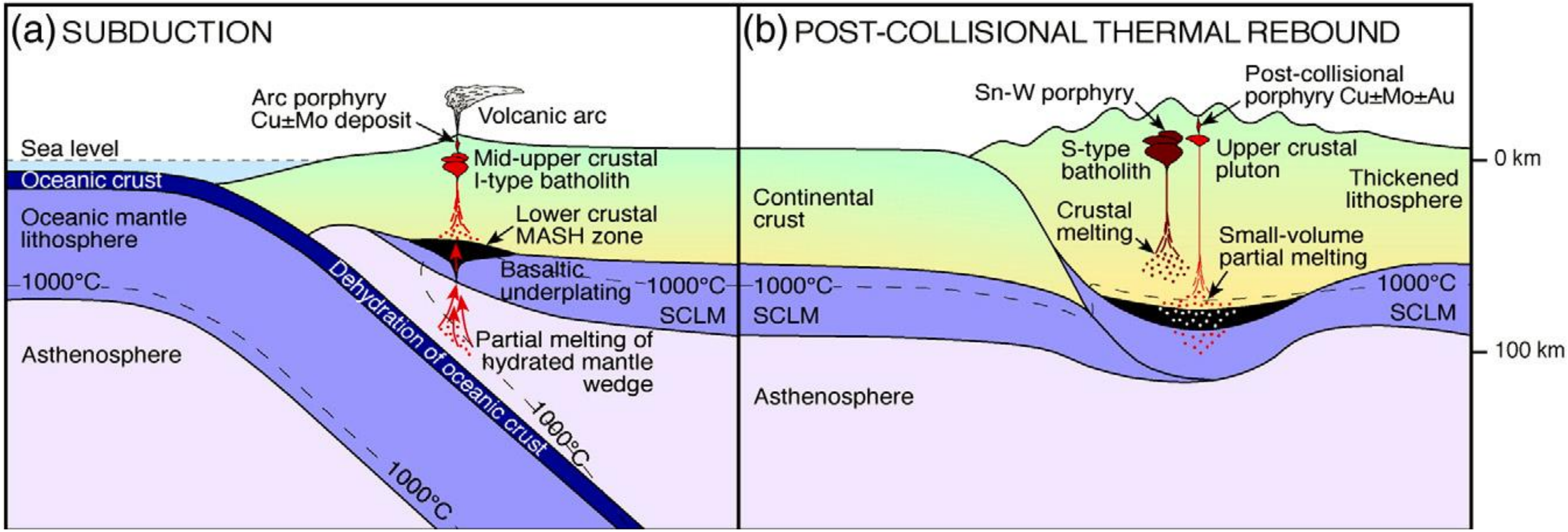


Richards, 2011

Why Late Cretaceous Mineralization?

- Bulkley suite
  - Is well east of the arc axis: location due to thickened crust not dewatering of slab
  - Emplaced late during a major compressional event: thermal equilibration expected within 20 My of thickening (Vanderhaeghe and Teyssier, 2001)
  - Calc-alkalic to mildly alkaline: due to low degree partial melt?
  - Fractionation under moderately high pressure and water content: melting of hydrous cumulates in thickened lithosphere
  - Hosts (relatively) small porphyry deposits: low degree partial melt = smaller volcanic centres
  - Cu±Mo±Au mineralization: stripping of cumulate sulfides

Why Late Cretaceous Mineralization?



Richards, 2011

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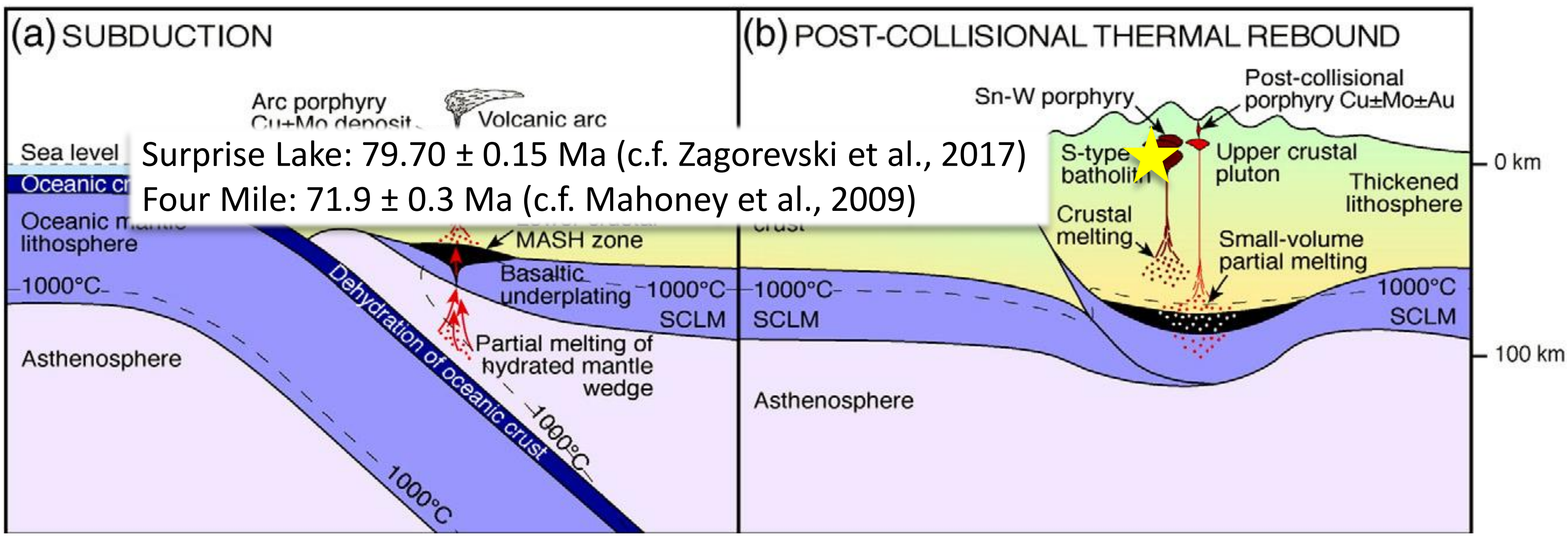
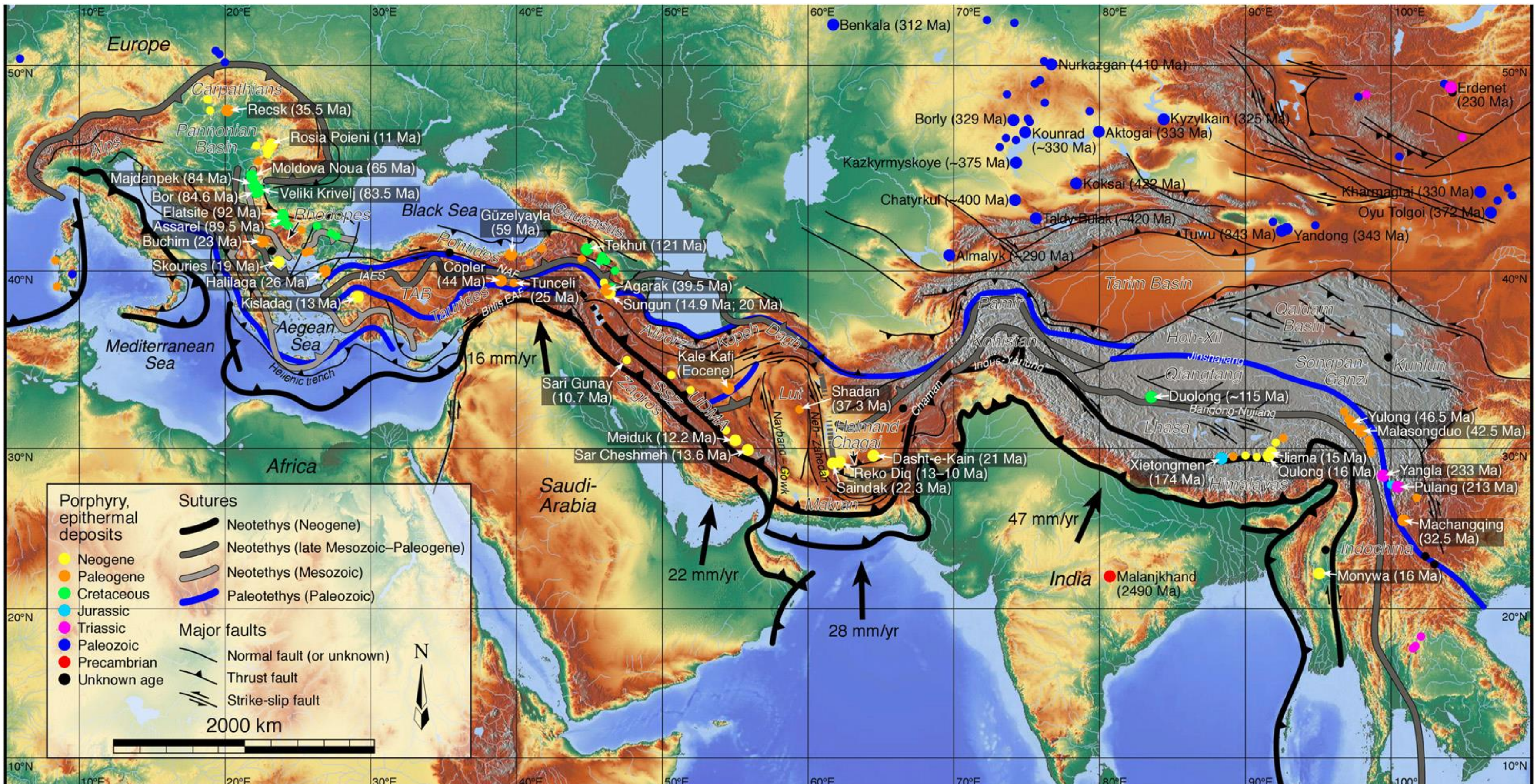


Surprise Lake: 79.70 ± 0.15 Ma (c.f. Zagorevski et al., 2017)
Four Mile: 71.9 ± 0.3 Ma (c.f. Mahoney et al., 2009)

Richards, 2011

Correlation with Tectonic Escape?



Richards, 2015

Important Conclusions

- Northeast trend of the Skeena Arch reflects a structural anisotropy present since the Triassic
  – Accommodated sinistral oblique convergence to form northeast-trending folds
  – Localized Early Jurassic through Eocene intrusions
- SSE-trending Eocene grabens have exposed the Triassic-Jurassic 'Red Line' boundary
  – HS epithermal Limonite Creek
- Late Cretaceous porphyries in BC are a product of mid-Cretaceous crustal shortening and thickening?

Thank You!