# Geology of the Karouni Orogenic Gold Deposit: Guyana, South America

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# Today's Talk

- Guiana Shield
- Camp Scale
- Deposits
- Alteration
- Geochronology
- Implications for source

# Gold Mining in Guyana

- Gold discovered in 1850s, mined continuously since
- Two current producing mines (Aurora, Karouni) and one major former producer, Omai
- Substantial artisanal gold mining community, “Pork Knockers”

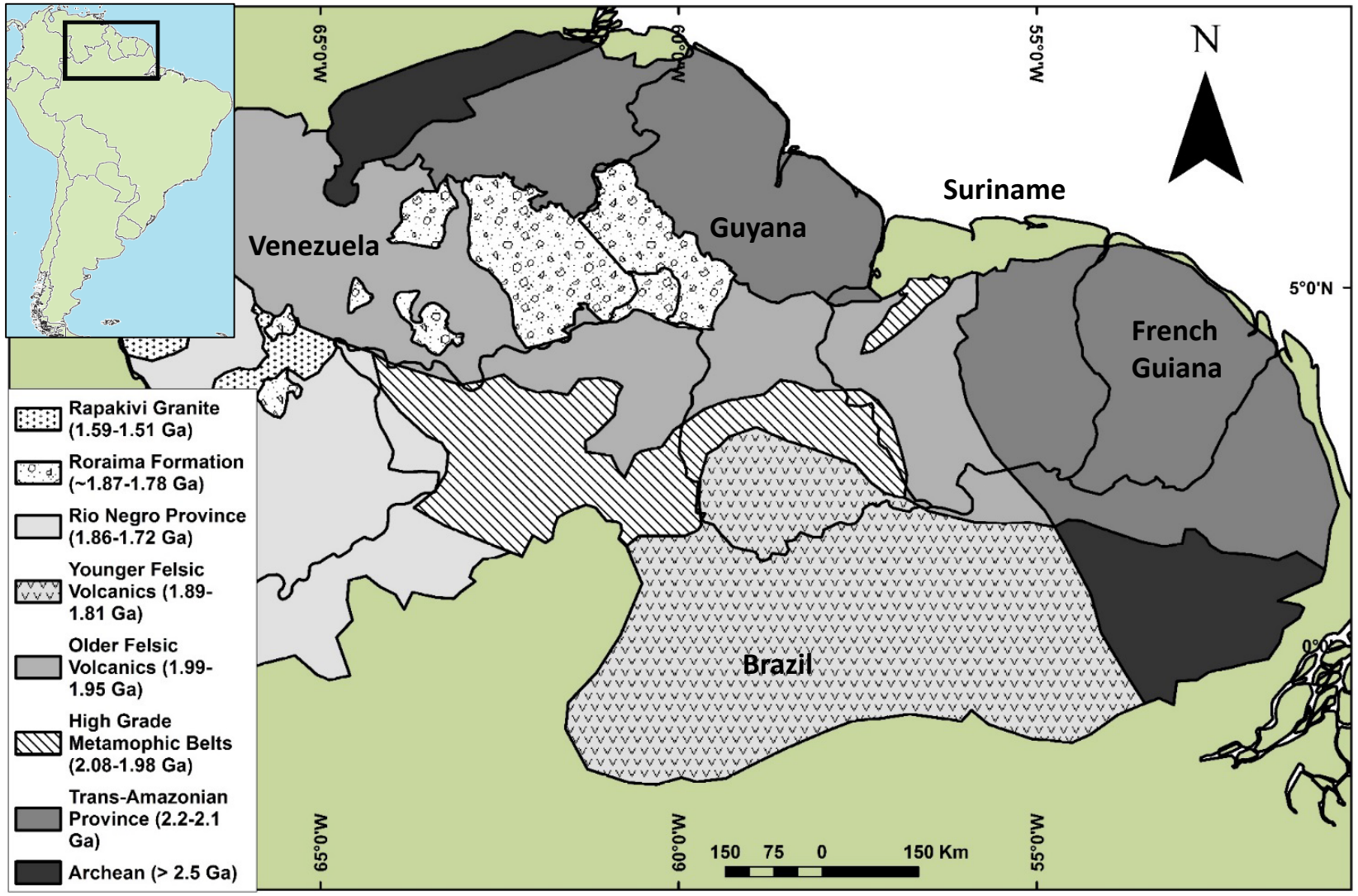
Aurora Mine: Photo Guyana Gold Fields

Karouni Mine

Omai Mine: Photo Mahdiagold.com

Pork Knockers at work

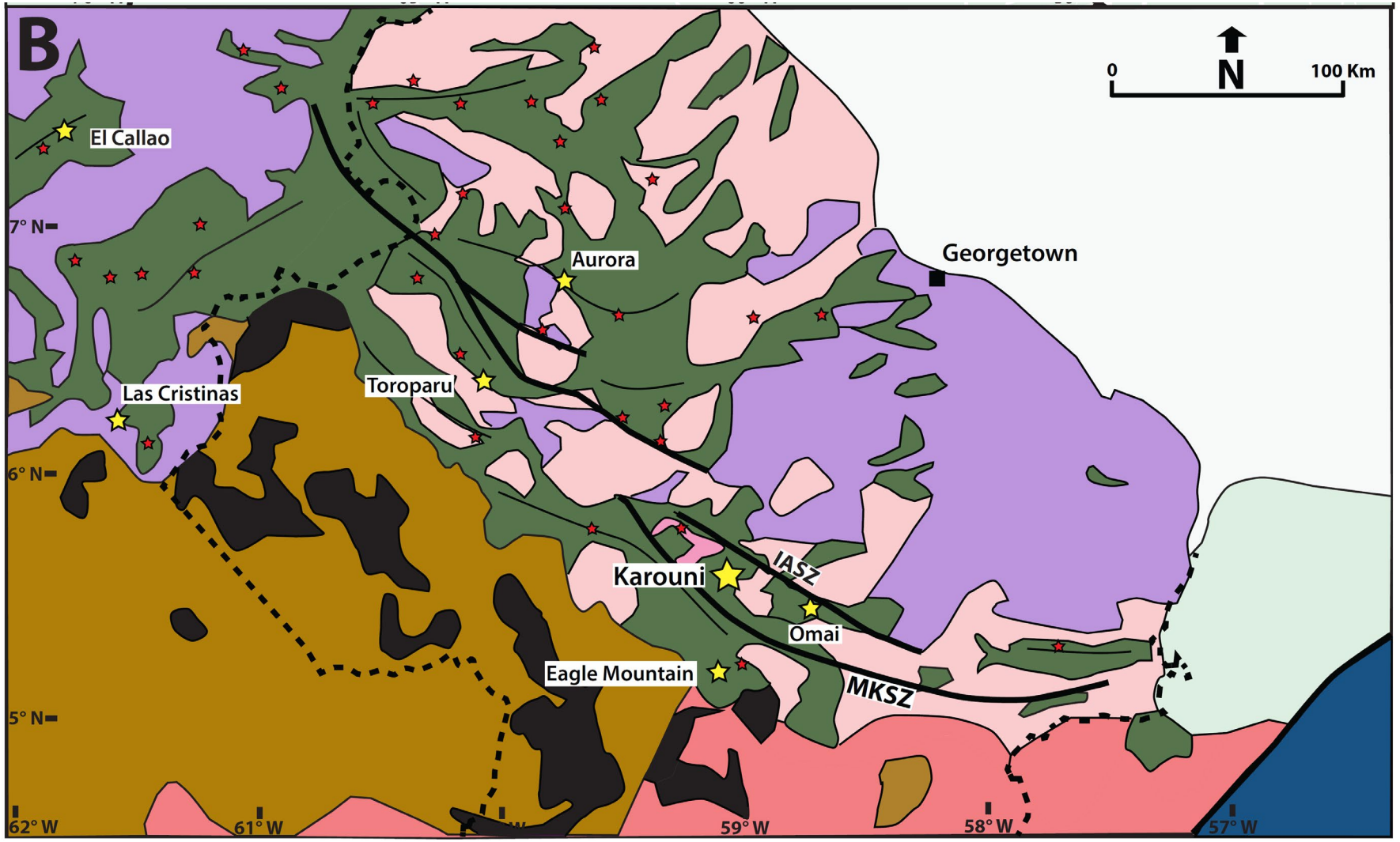
# Guiana Shield Geology




**Simplified geological province map of the Guiana Shield (modified from Kroonenberg et al., 2016)**

- **Northern portion of the Amazon Craton**
- **Trans-Amazonian Province (2.2-2.0 Ga)**
  - **granite-greenstone terrane**
  - **Host majority of Au deposits**
- **Younger belts to the SW (1.95-1.8 Ga)**

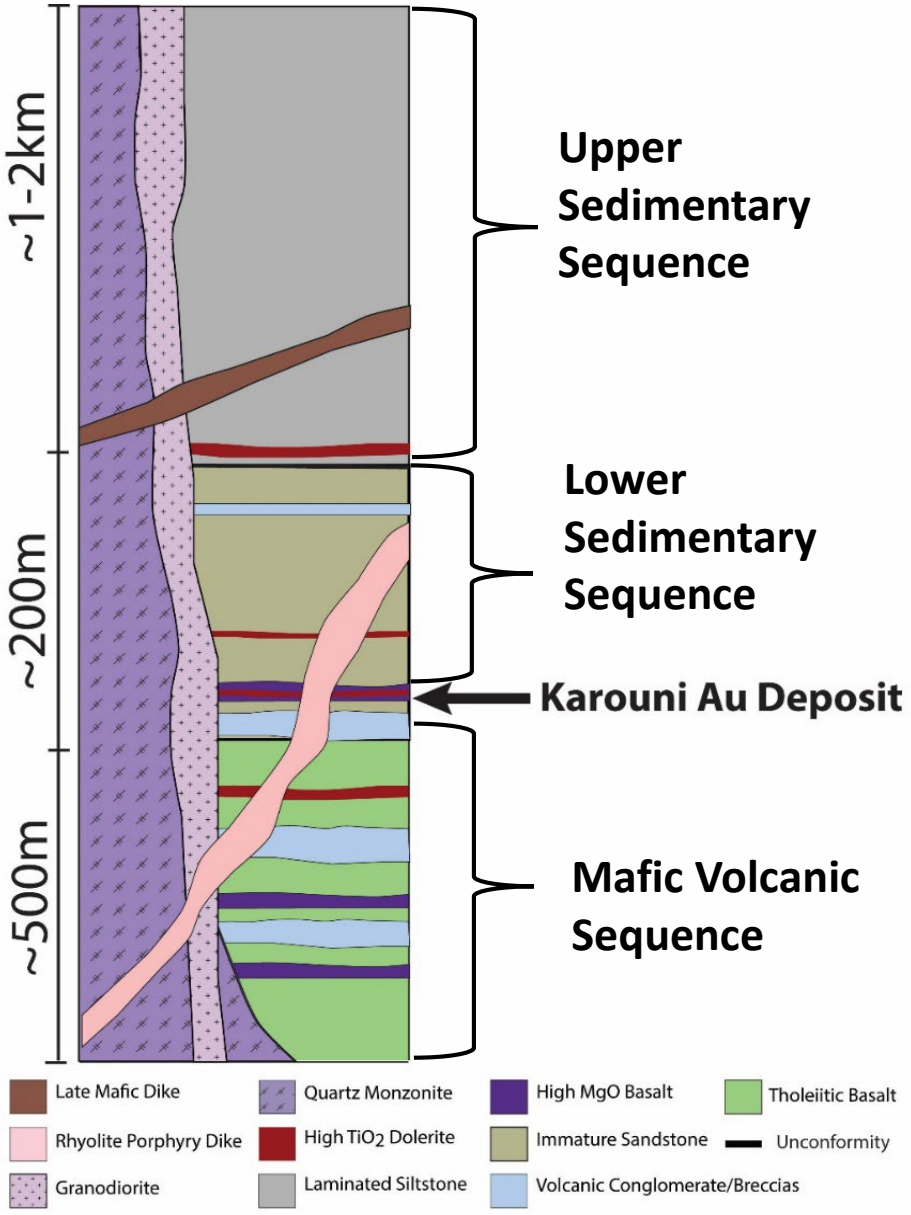
# Northern Guiana Shield Geology



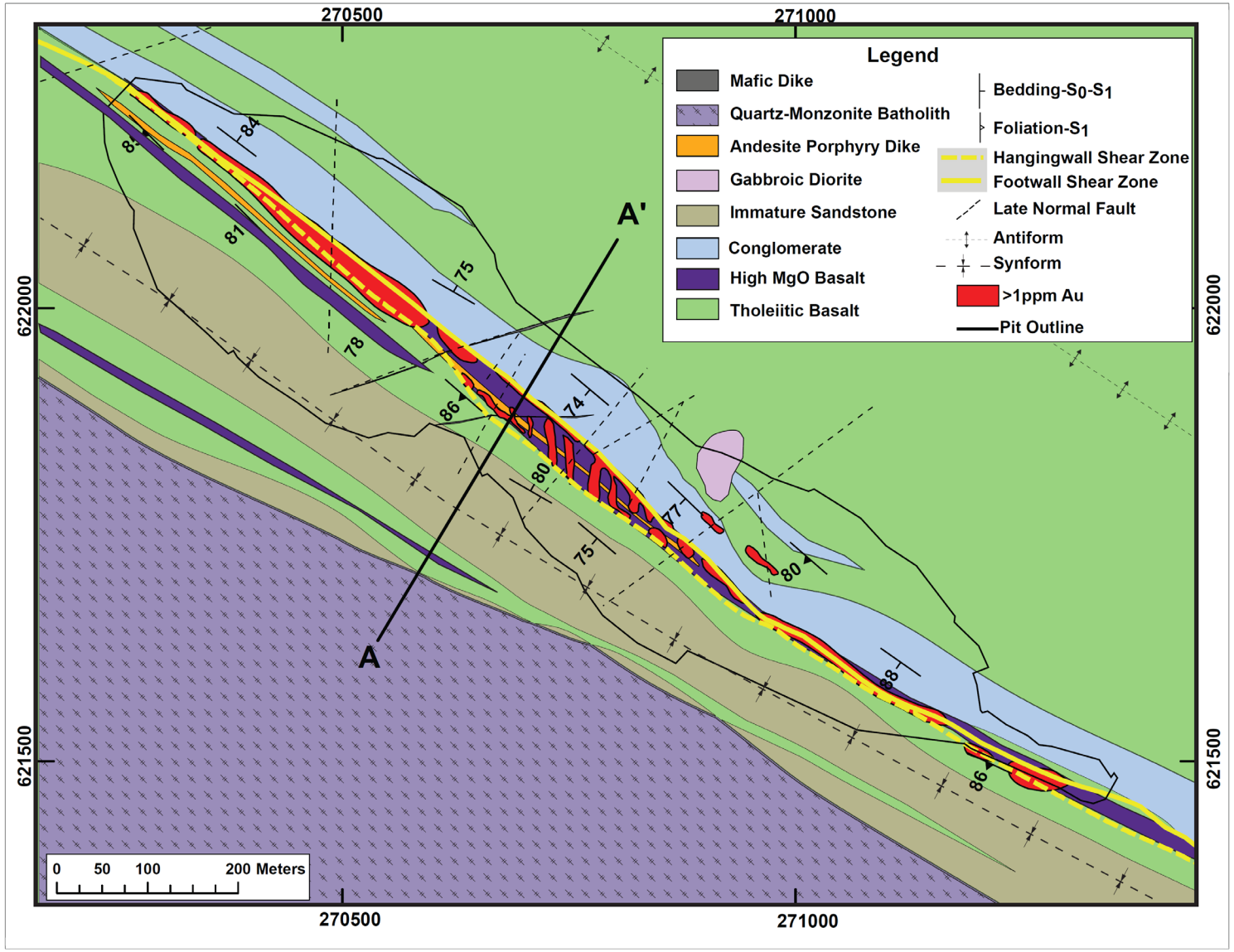

- Multiple world-class deposits >10 Moz (Las Cristinas, El Callao, Aurora, Rosebel)
- Major Au deposits hosted the greenstone belts in proximity to regional shear zones

Simplified map of the north-western Guiana shield, complied from the national geological maps of Guyana, Venezuela and Suriname. MKSZ= Makapa-Kuribrong Shear Zone, IASZ = Issano-Aparu Shear zone

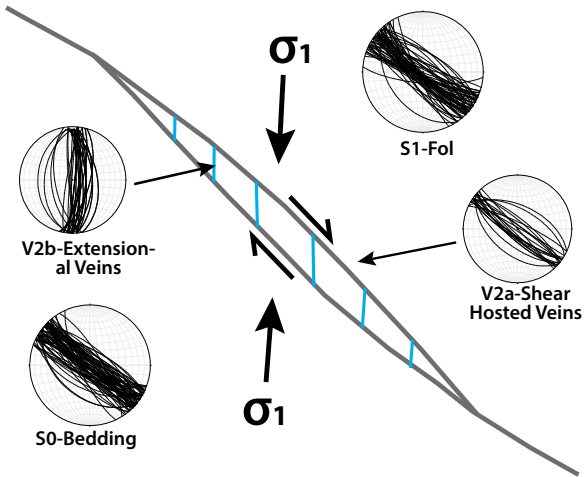
# Karouni Camp Scale

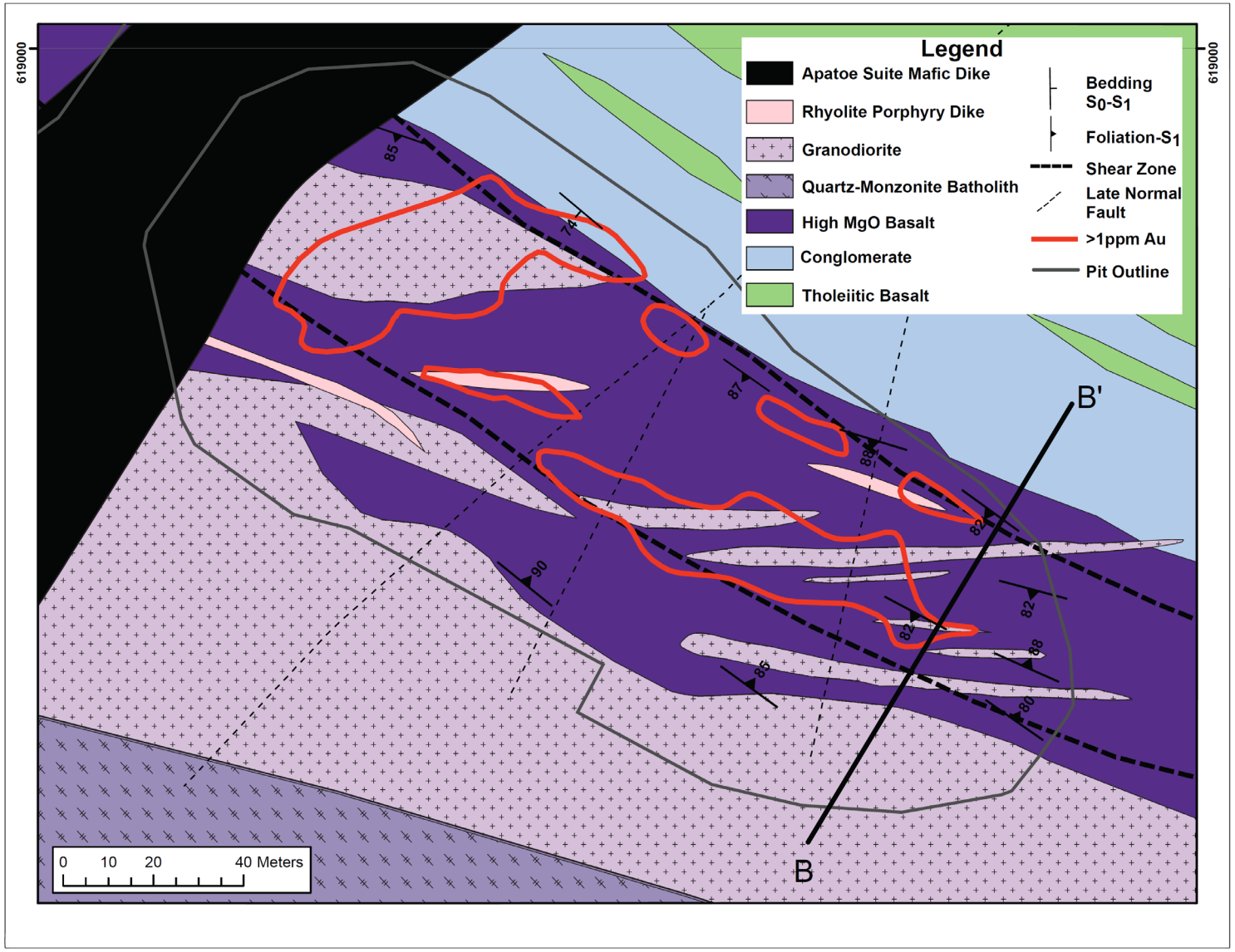
# Smarts Deposit




- NW-SW trending Smarts-Hicks Shear zone hosted ductile High MgO basalt
- Single shear zone diverges into multiple shear zone segments at a 15° change in strike
- Mineralization:
  - $V_{2a}$ NW-SE shear zone hosted veins
  - $V_{2b}$ N-S extensional veins between the shear zones

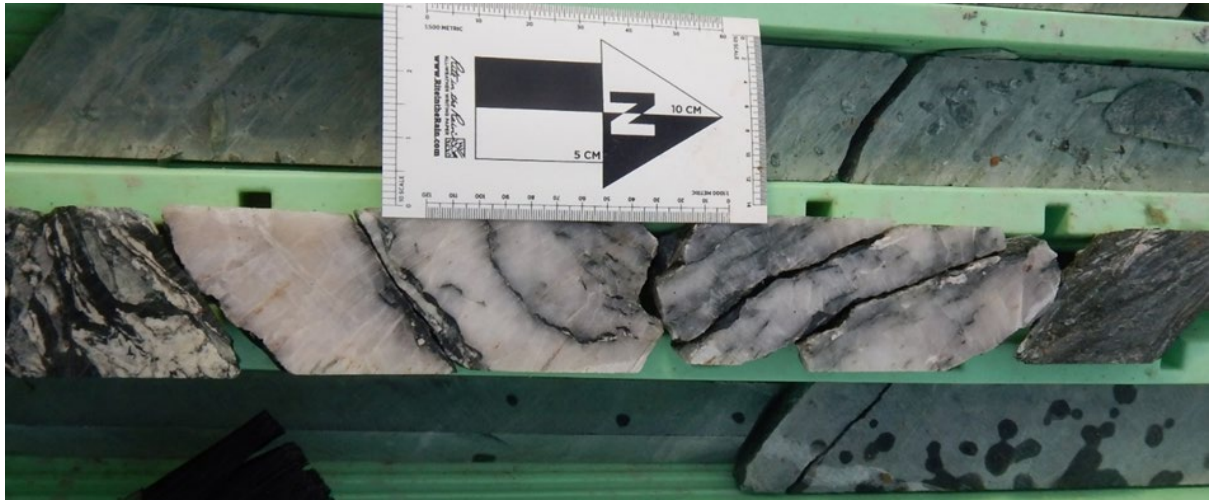


# Hicks Deposit

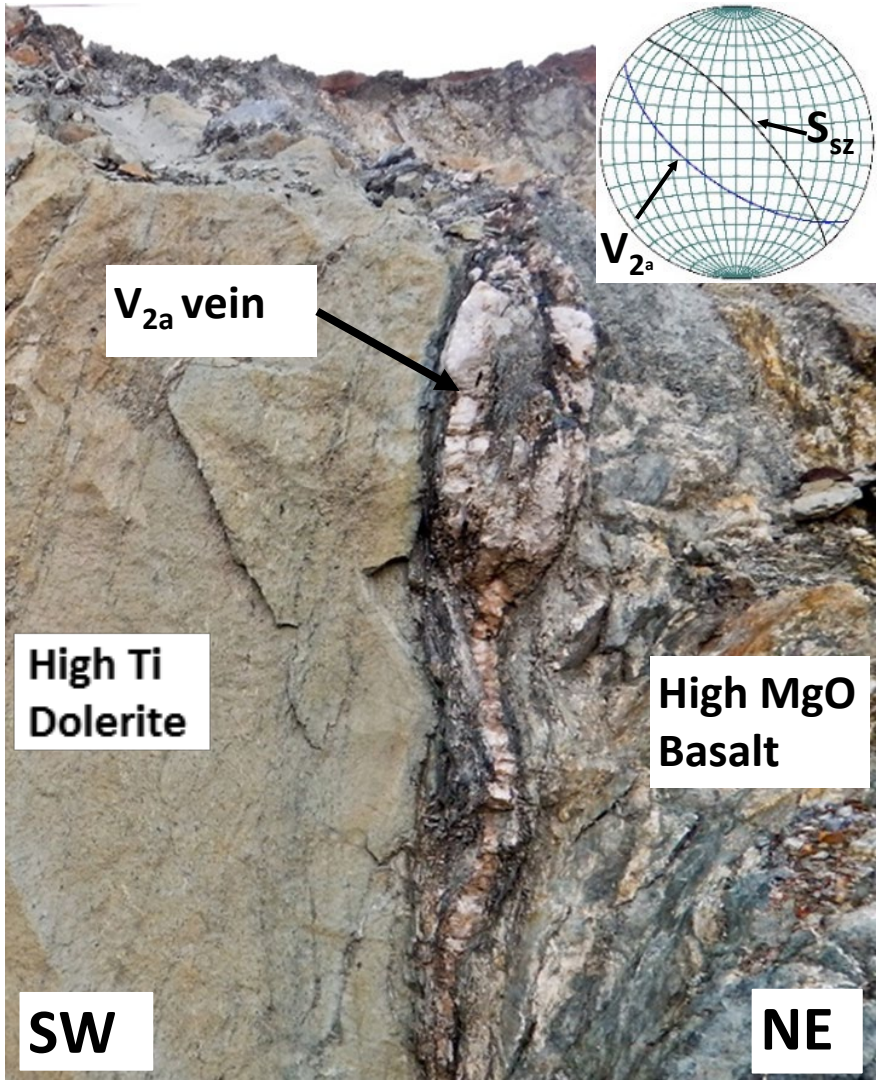



- Granodiorite/rhyolite porphyry and High MgO basalt host rocks
- Shear zones locally cut and offset dikes (1-2m)
- Same N-S and NW striking Qtz-Cal-Py veins
- Rheology is key for localizing veins

# Alteration and Mineralization: $V_{2a}$ Veins

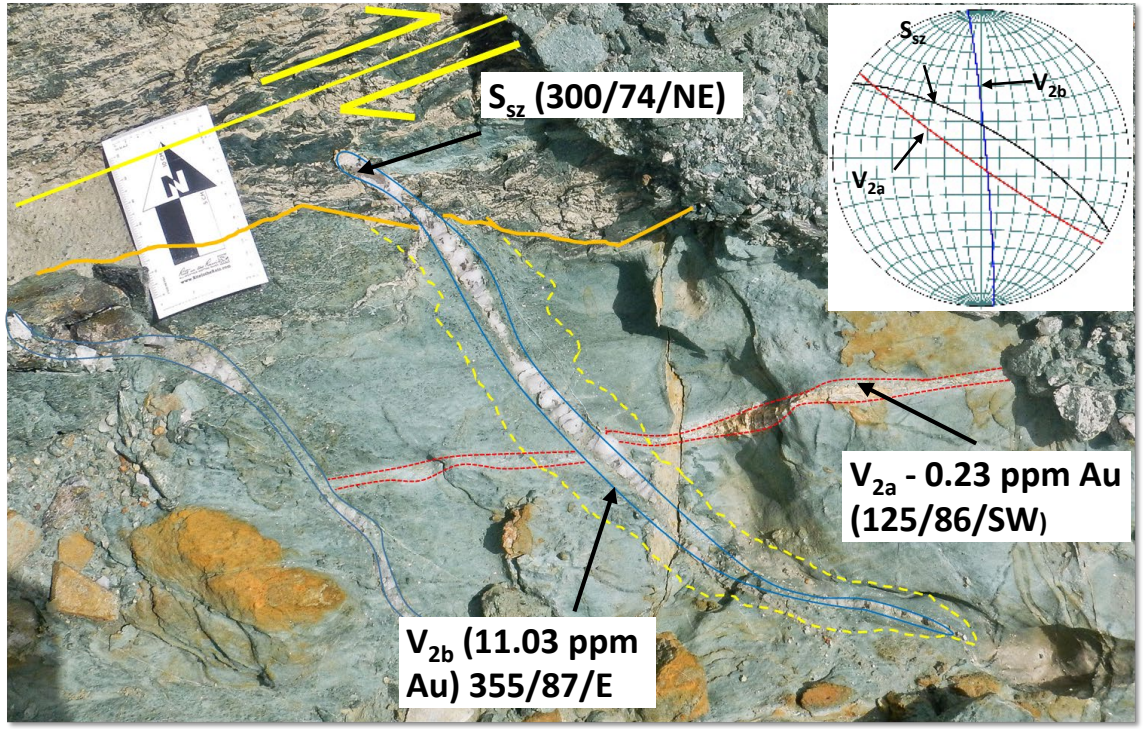


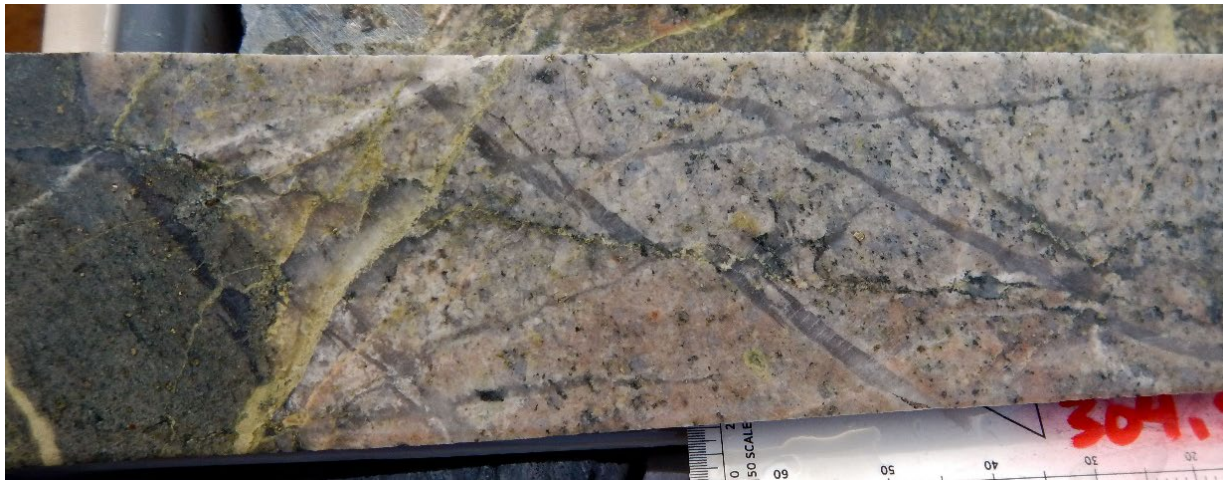

- Shear zone hosted, NW Strike, steep dip
- Hosted in high MgO Basalts
- qtz-cal-chl ±py, Au
- Laminated, crack-seal textures, folded, boudinaged
- Variable grades 0.2 to >20 g/t



# Alteration and Mineralization: $V_{2b}$ Veins

- N-S strike, steep dip
- Brittle lithologies, pinch out in ductile rocks
- Sigmoidal wings indicate dextral movement
- Qtz-cal-chl ± py-tourm-Au
- Sharp, brittle vein walls, cut foliation, perpendicular mineral fibers
- High Grade, up to 100 g/t, average 5-20 g/t, up to 20 g/t in the py halo



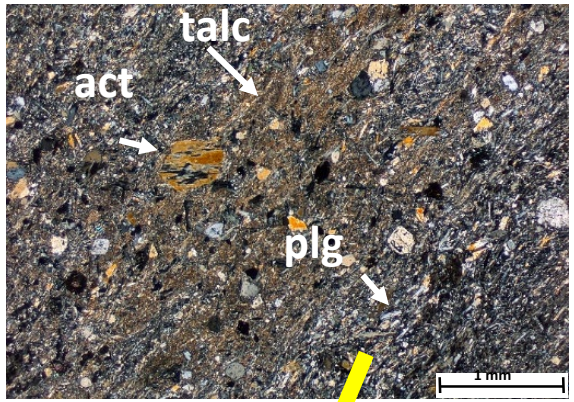



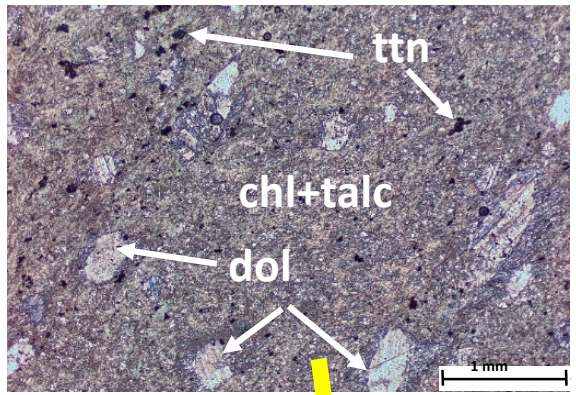
# Hydrothermal Alteration: High MgO Basalt

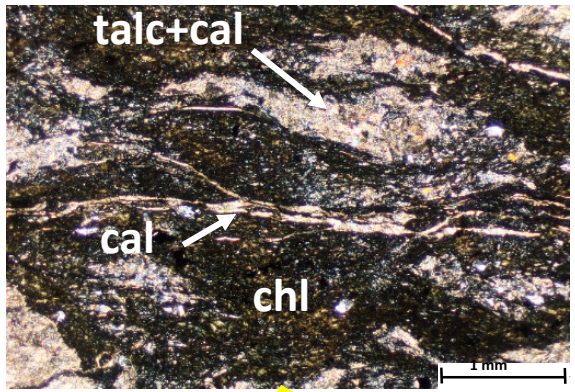
Cpx-Act-Plg → Talc-Chl-Dol-Ttn

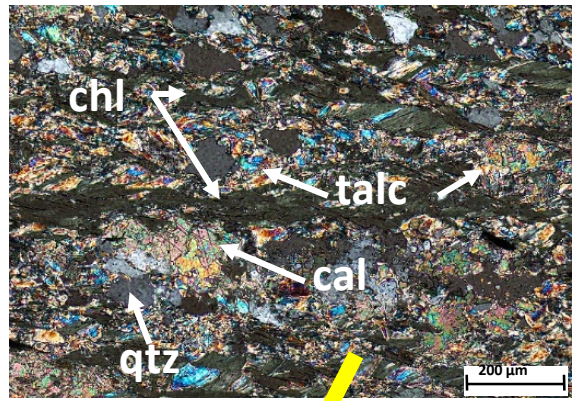
Dol → Cal

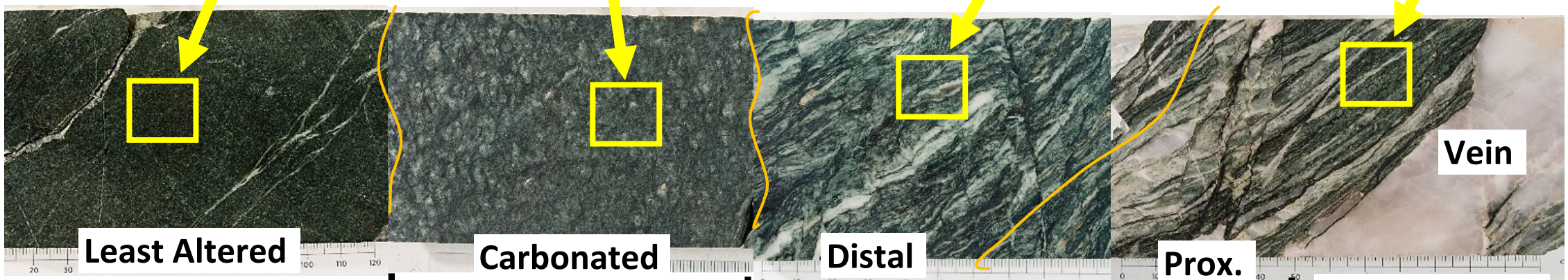
+ Qtz-Py



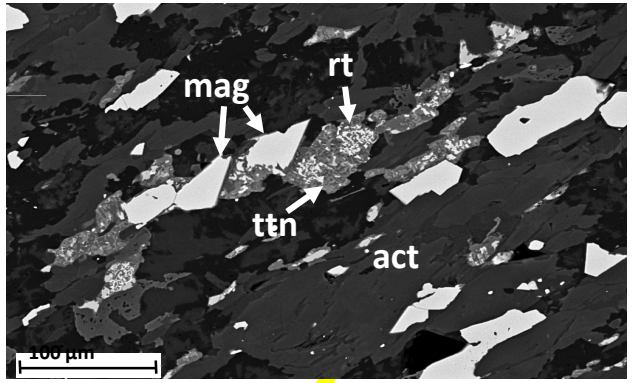

5m-1m

1m-20cm

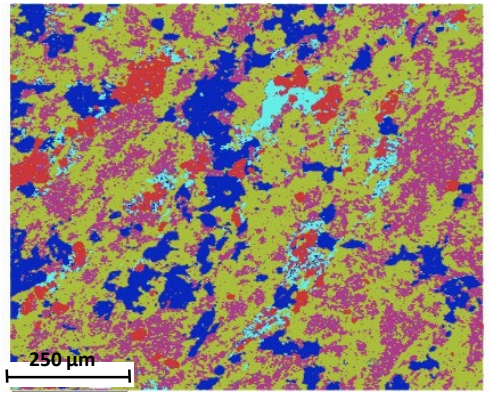
>1cm-2 m

# Hydrothermal Alteration: High $TiO_2$ Dolerite

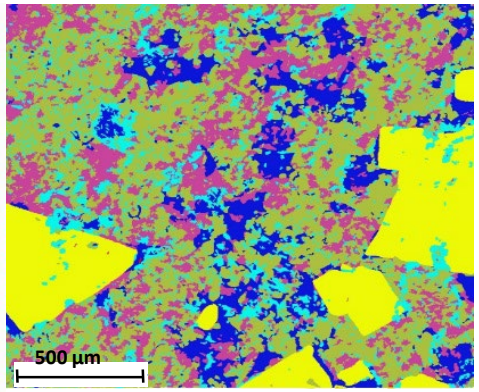
Ilm → Rt - Ttn



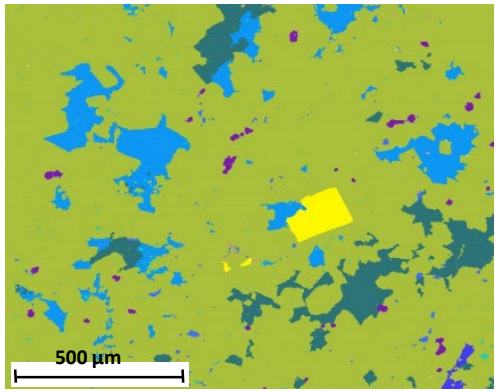

Act-Epi-Plg → Alb-Cal-Chl



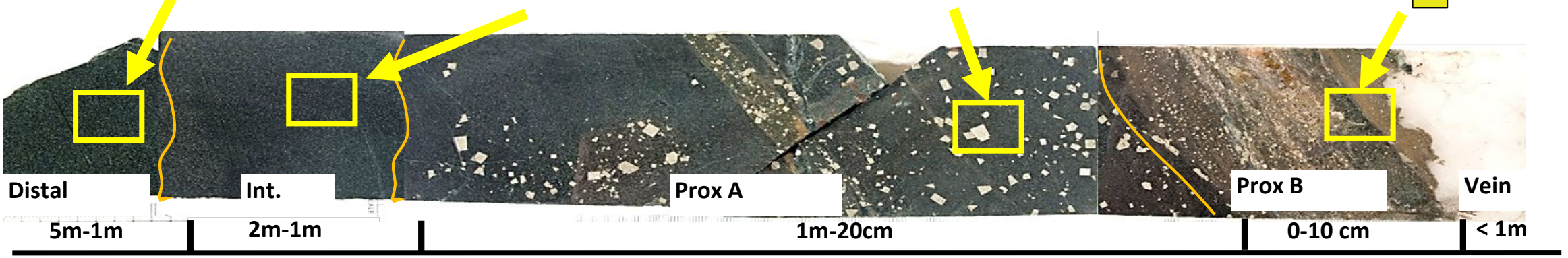

Mag → Py



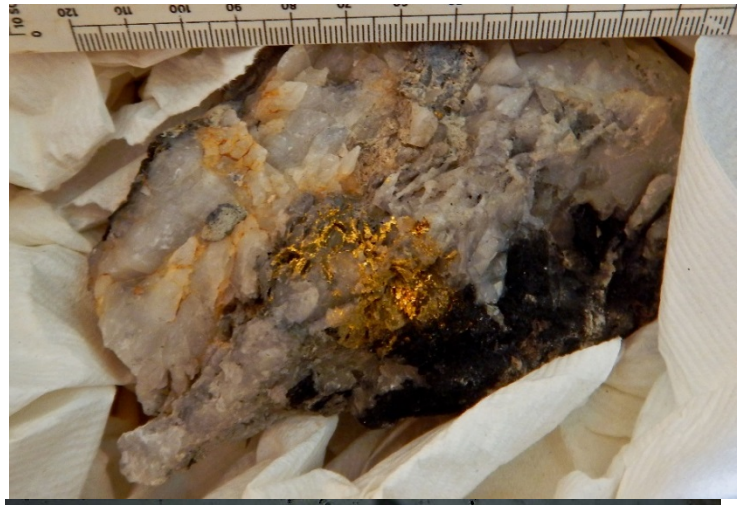

Cal-Rt → Alb- Ttn- Qtz

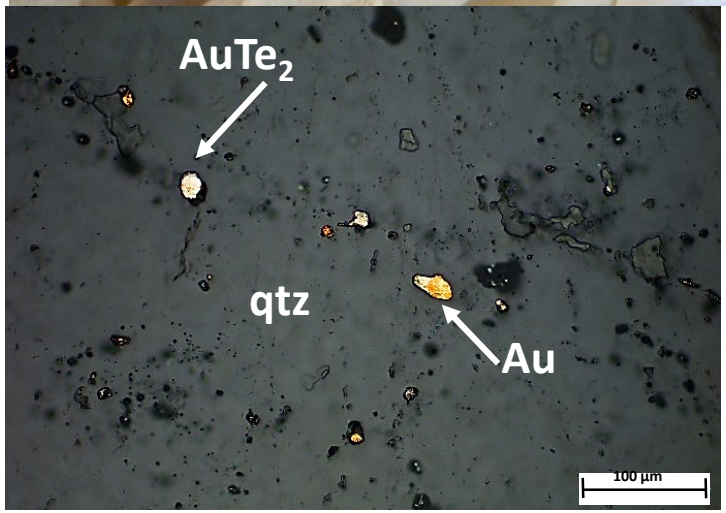



- Albite
- Chlorite
- Calcite
- Rutile
- Quartz
- Titanite
- Magnetite
- Pyrite



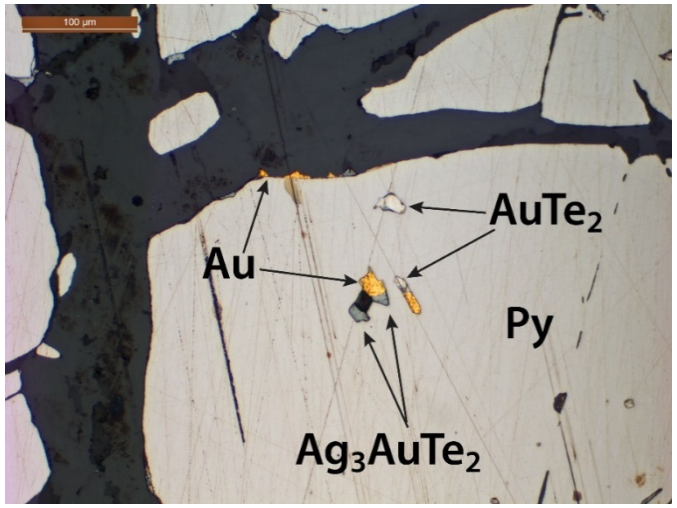
# Au Mineralization

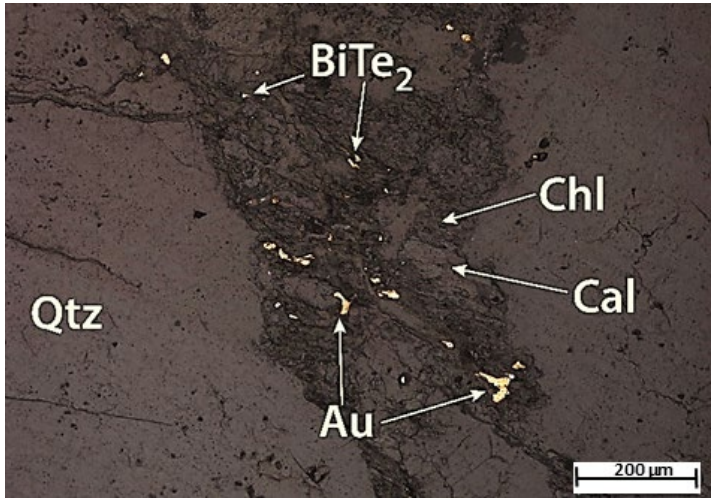





- **Vein hosted: Coarse native gold in both $V_{2a}$ and $V_{2b}$ veins**
  - **Fracture fills and inclusions in quartz**

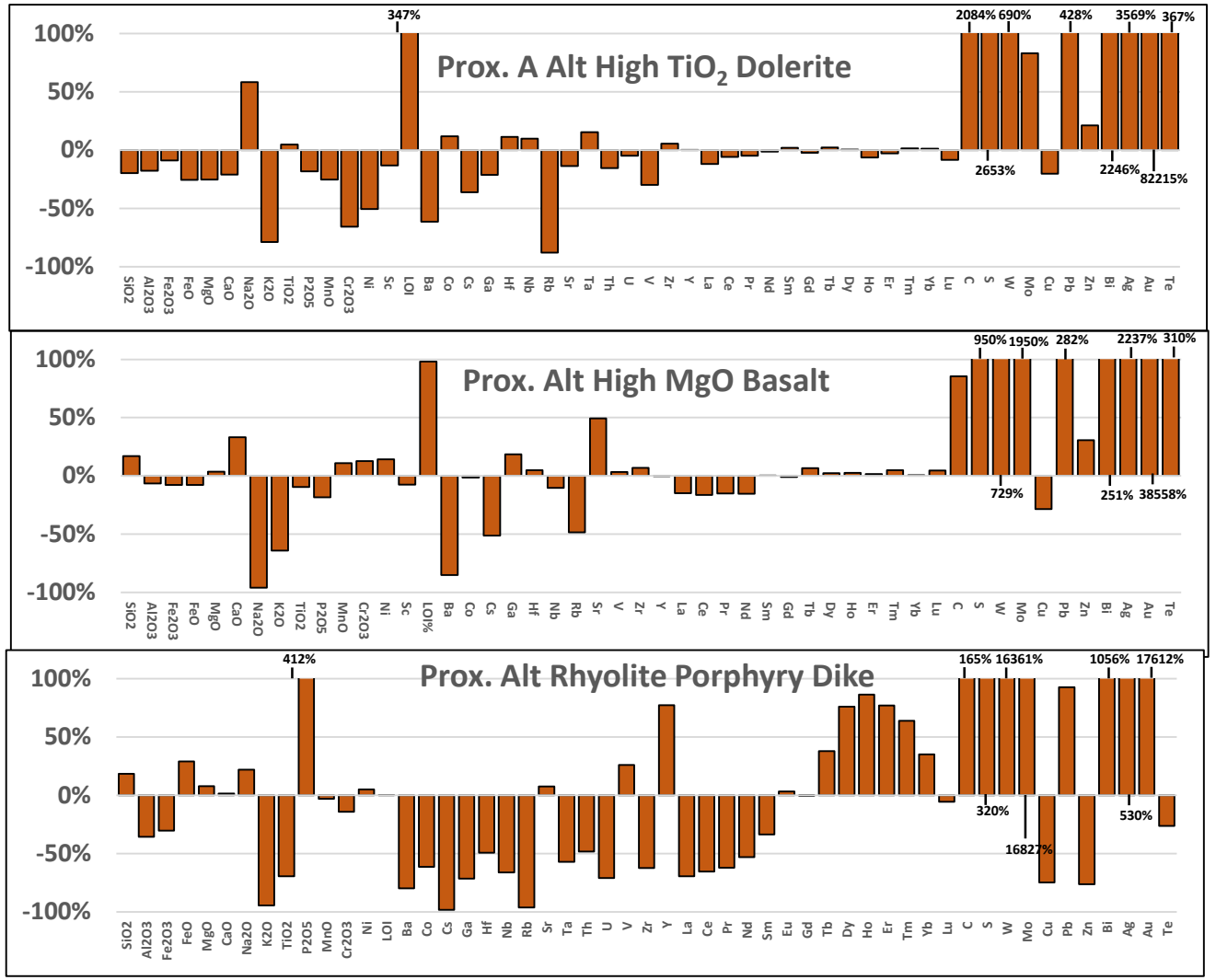
- **Wall rock hosted: native gold, Au bearing tellurides, calaverite ($AuTe_2$) and petzite ($Ag_3AuTe_2$) in pyrite**
  - **Inclusions and fracture fills**



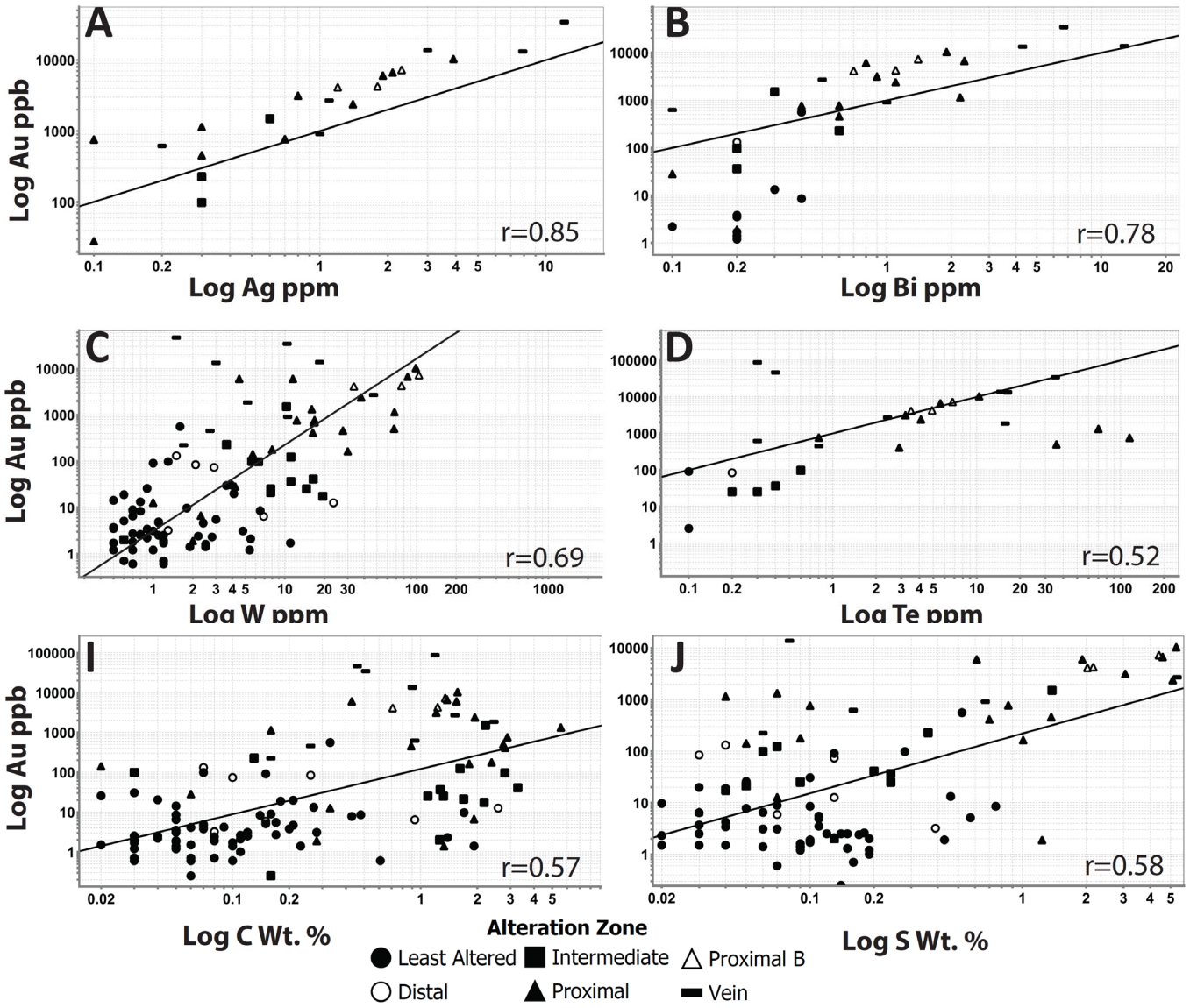
# Mass Balance Modeling of Alteration

- **Strong enrichment of Au, Ag, Bi, W, Pb, Te, Mo**
- **Enrichment of Na, C and S**
- **Depletion of alkalis, Ba, Rb, Cs**

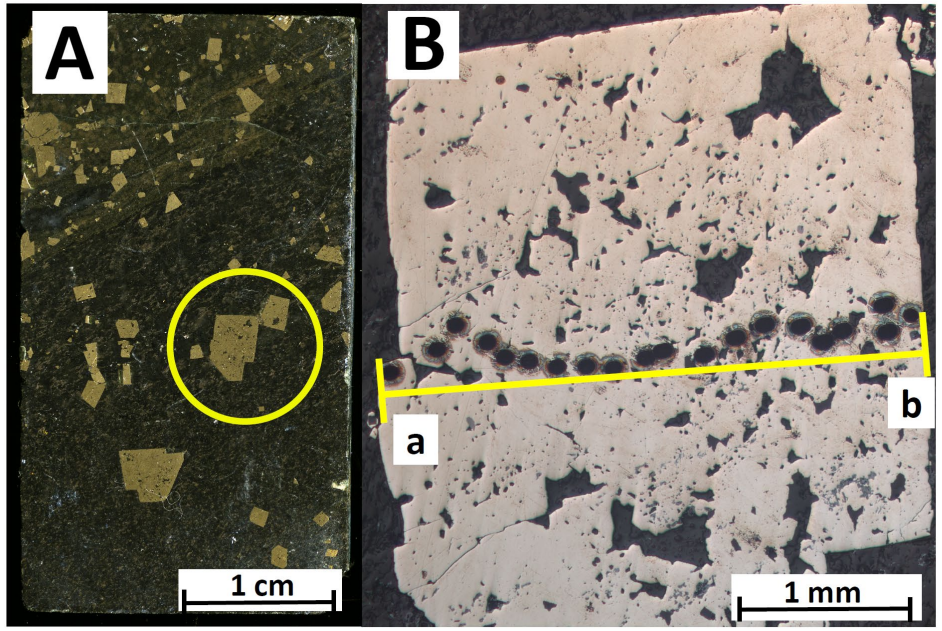


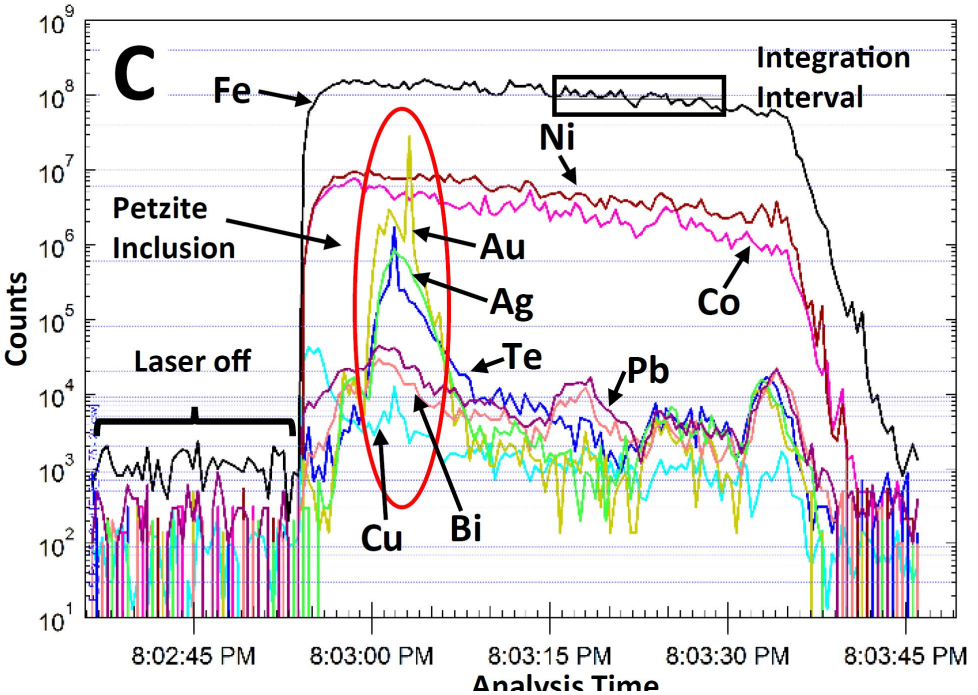
# Correlations to Au

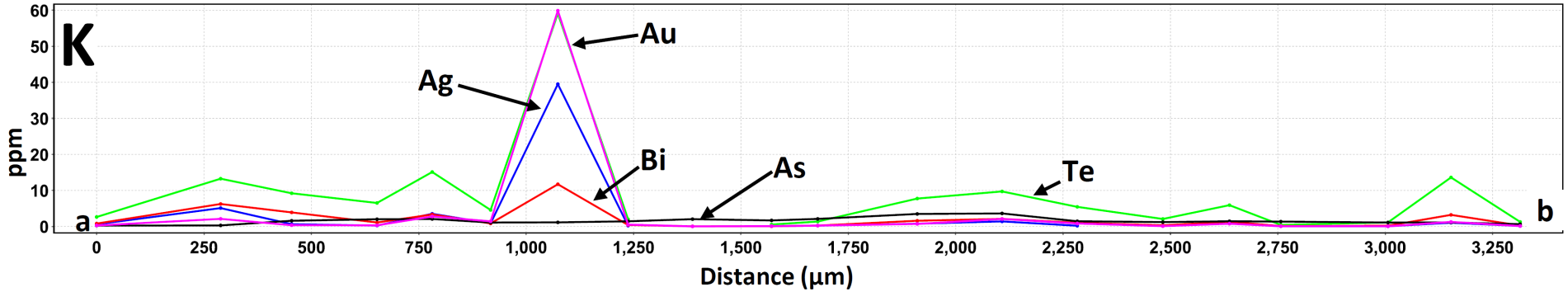
- W, Ag, Te and Bi
- C and S
- Ag, Te and Bi have very low values compared to Au
- W is the only useful pathfinder



# LA-ICP-MS Geochemistry: Pyrite

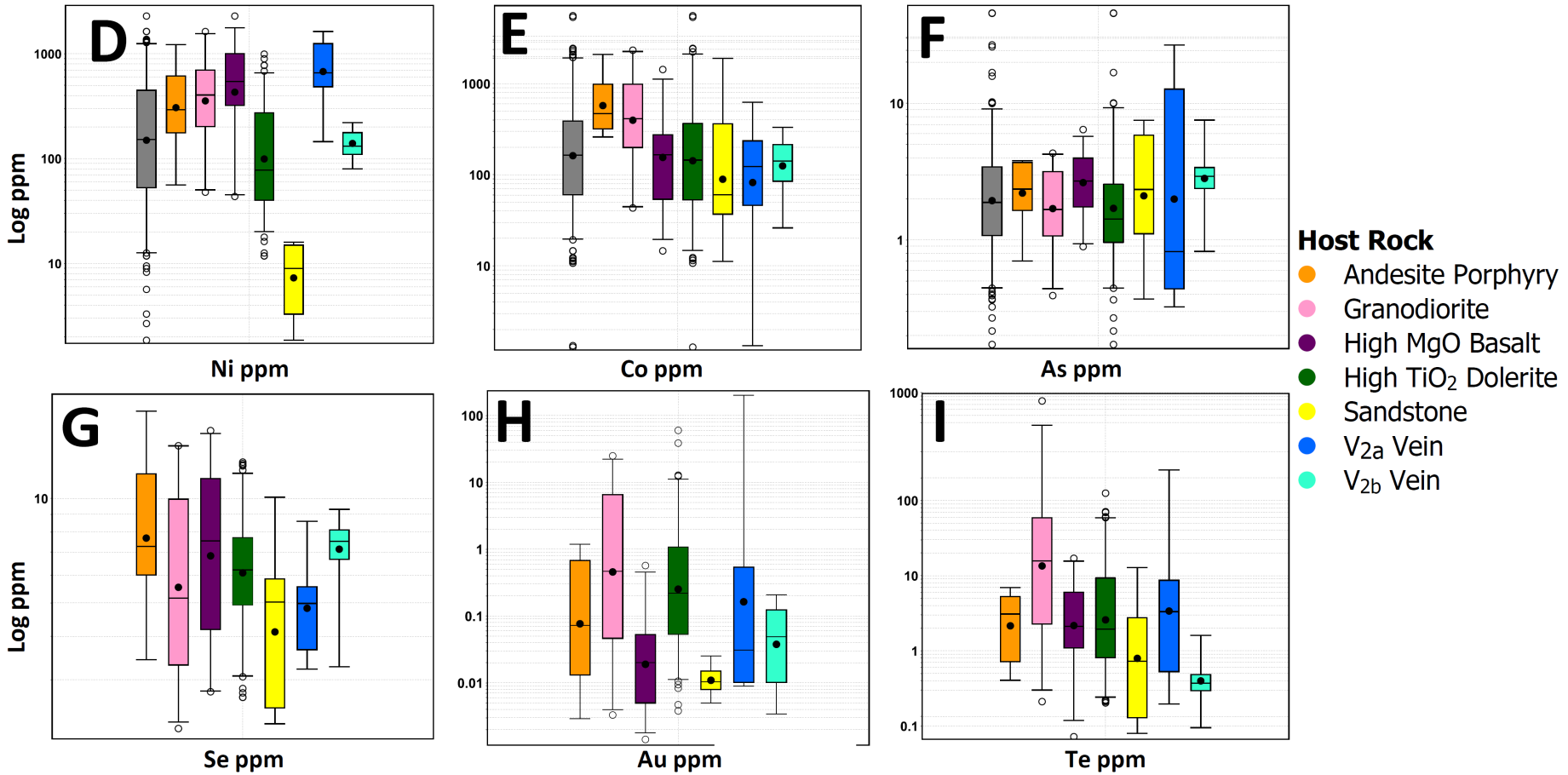



**Most trace elements are a function of inclusions**

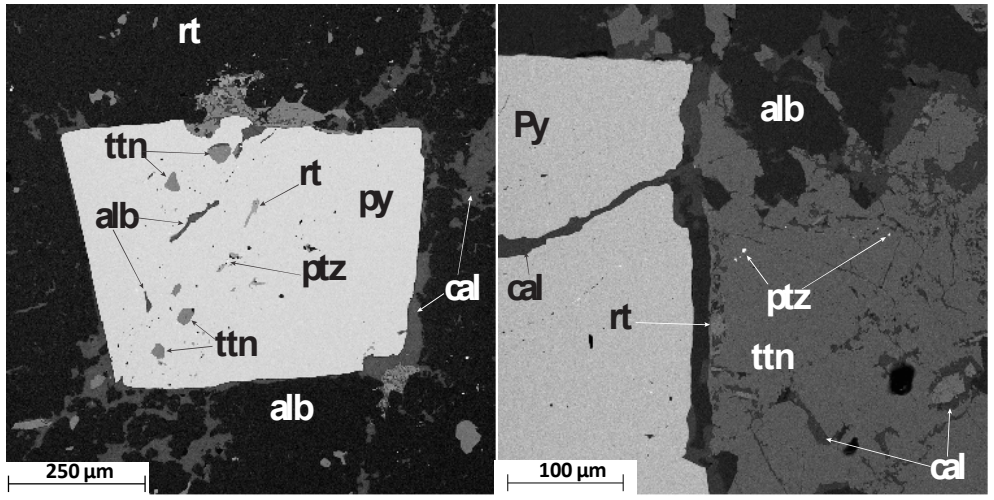
# LA-ICP-MS Geochemistry: Pyrite

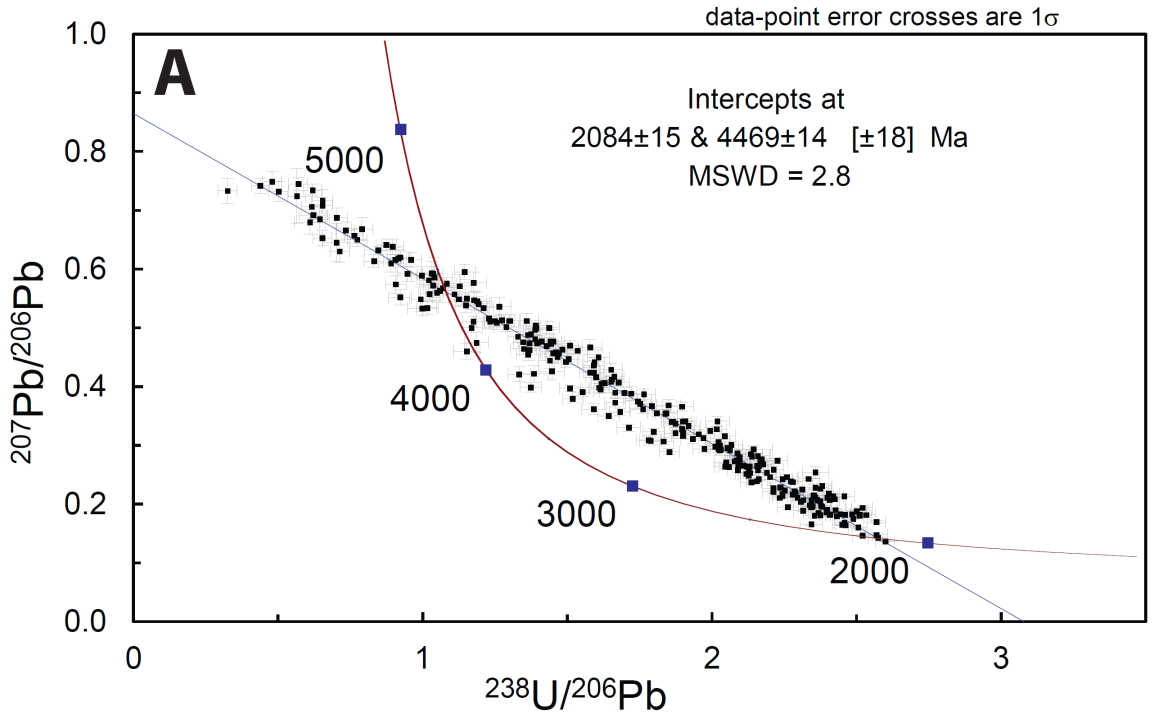



- No As, No Au
- Trace elements content (Ni, Co) a function of wall rock composition
- Consistent in both vein types (V2a and V2b), one pulse of fluid

# Age of Mineralization: Hydrothermal Titanite

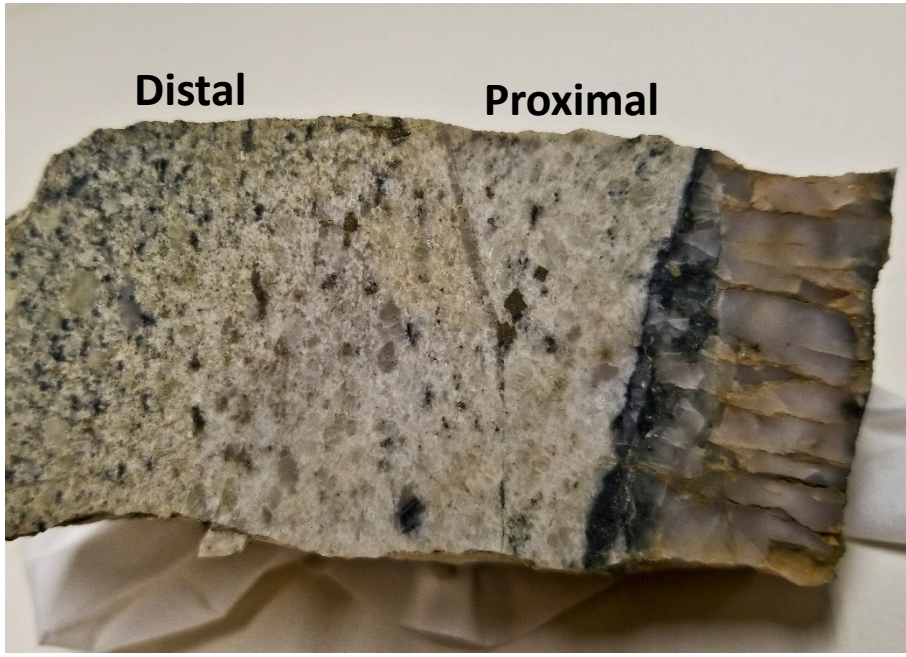
- In-Situ U/Pb LA-ICP-MS of titanite in Prox. B alteration
  - >1mm grains
- Petrogenetic link between titanite and gold
- Common Pb mixing line, 350 spots
- Regression shows a mineralization age of 2084±15 Ma

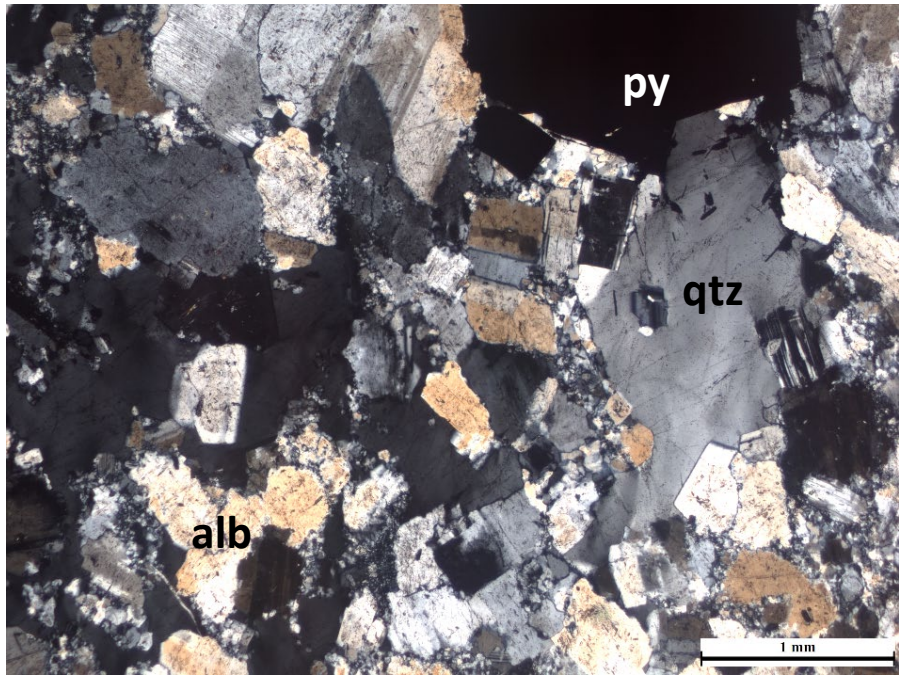


# Nature of ore fluids

- No potassic alteration, sodic dominant
  - No K in fluid? Depleted in altered zone
- Enrichment in W, Bi, Te, Ag, Mo, Pb
- No As, Sb; depletion in alkalis other than Na
- Neutral pH, moderately reducing (no hematite or pyrrhotite)
- Temp 270°-320° (chl geothermometry)
- Sulfidation reactions key for Au deposition



# Classic Orogenic gold deposit?

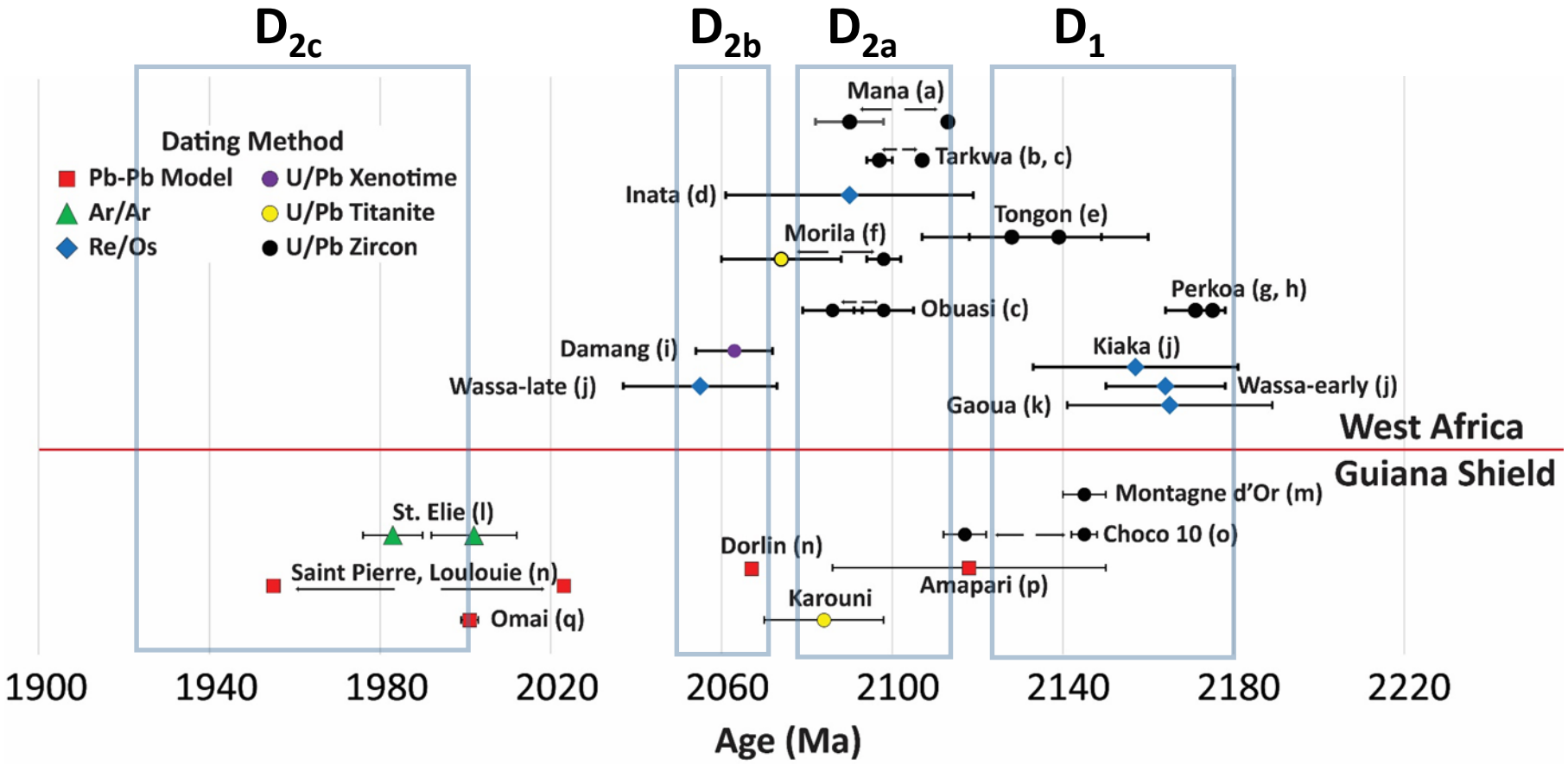
- Magmatic association?
  - Error margins overlap with rhyolite porphyry dikes (2088 ± 14 and 2089 ± 11 Ma)
  - Bi, W, Mo, Te element association
  - Dikes outside ore zone are un-mineralized, no element zoniation or fluid exsolution textures

- Classic Orogenic?
  - Greenschist facies host rocks, Strong structural control
  - Shear veins, quartz-carbonate vein arrays + albite alteration
  - late in deformation history

- But different
  - Lack of potassic alteration, As, Sb enrichment
  - Dominance of proximal calcite over ankerite/dolomite
  - Metamorphic fluids from a different source?

# Age Comparisons: Guiana Shield and West Africa

- Deposits dated with robust techniques are older, match deformation history
- Likely several gold events and more than just orogenic gold
- Similar to ages from West Africa



Sometimes there is a pot of gold at the end of the Rainbow…..

**Thank You!**

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