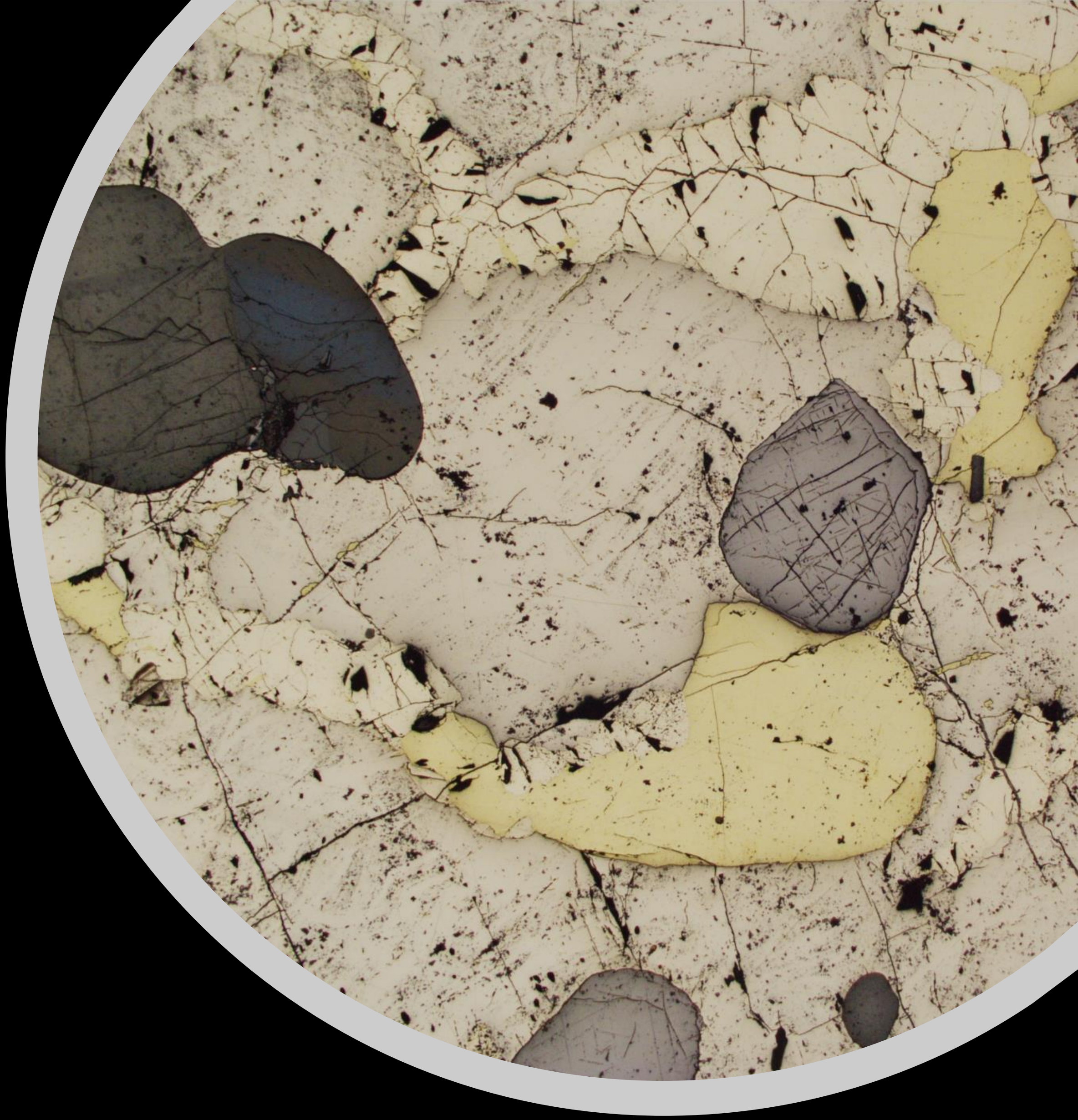
Sulfur sources and magmatic sulfide mineralization in the Fraser Zone

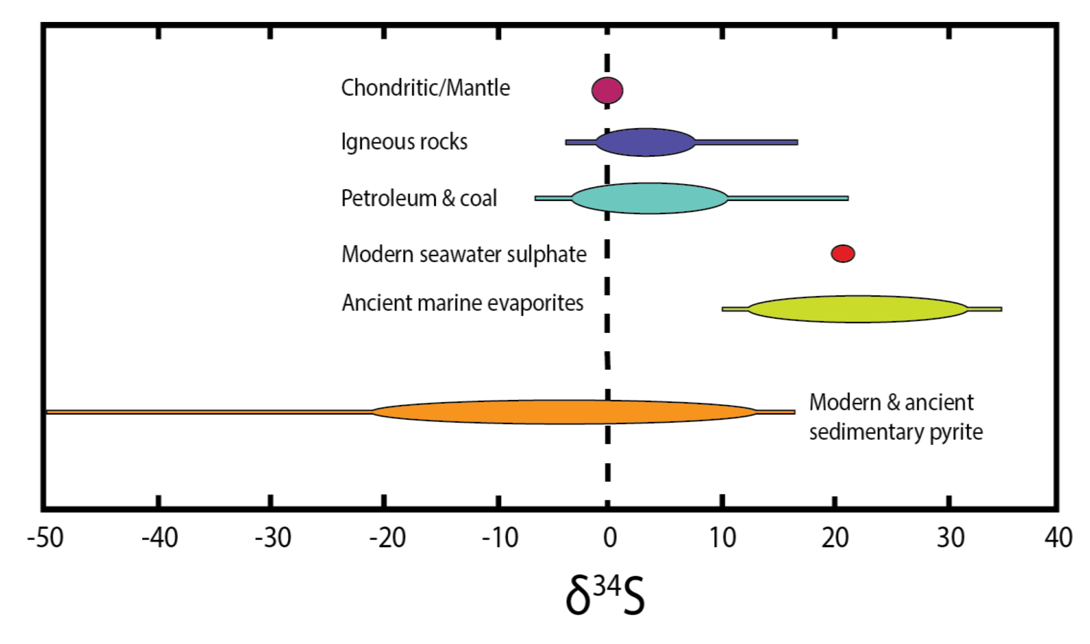
Alex Walker, Katy Evans, Christopher Kirkland

Magmatic sulfides and sulfur isotopes



- Sulfur isotopes allow tracing of sulfur through the Earth
- A powerful tool with which to fingerprint sulfur incorporated into mineral prospects
- Tracking of sulfur sources and fertility

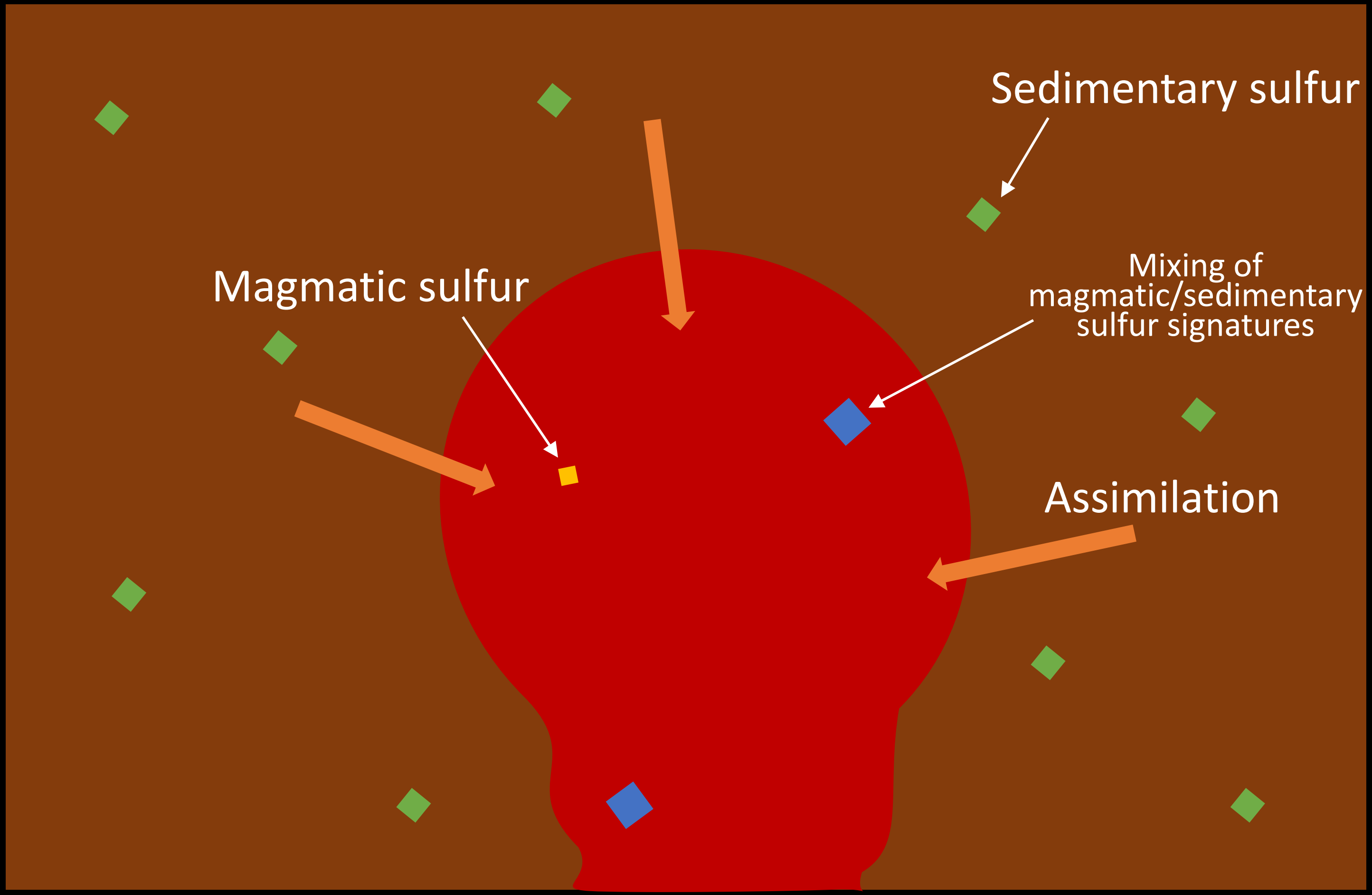
Sulfur Isotope 101



- Ratios of sulfur isotopes ^{32}S, ^{33}S, ^{34}S can be used to characterize sulfur reservoirs

- $$\delta^{34}S = \left\{\frac{(^{34}S/^{32}S)_{sample} - (^{34}S/^{32}S)_{reference}}{(^{34}S/^{32}S)_{reference}}\right\} x\ 1000$$

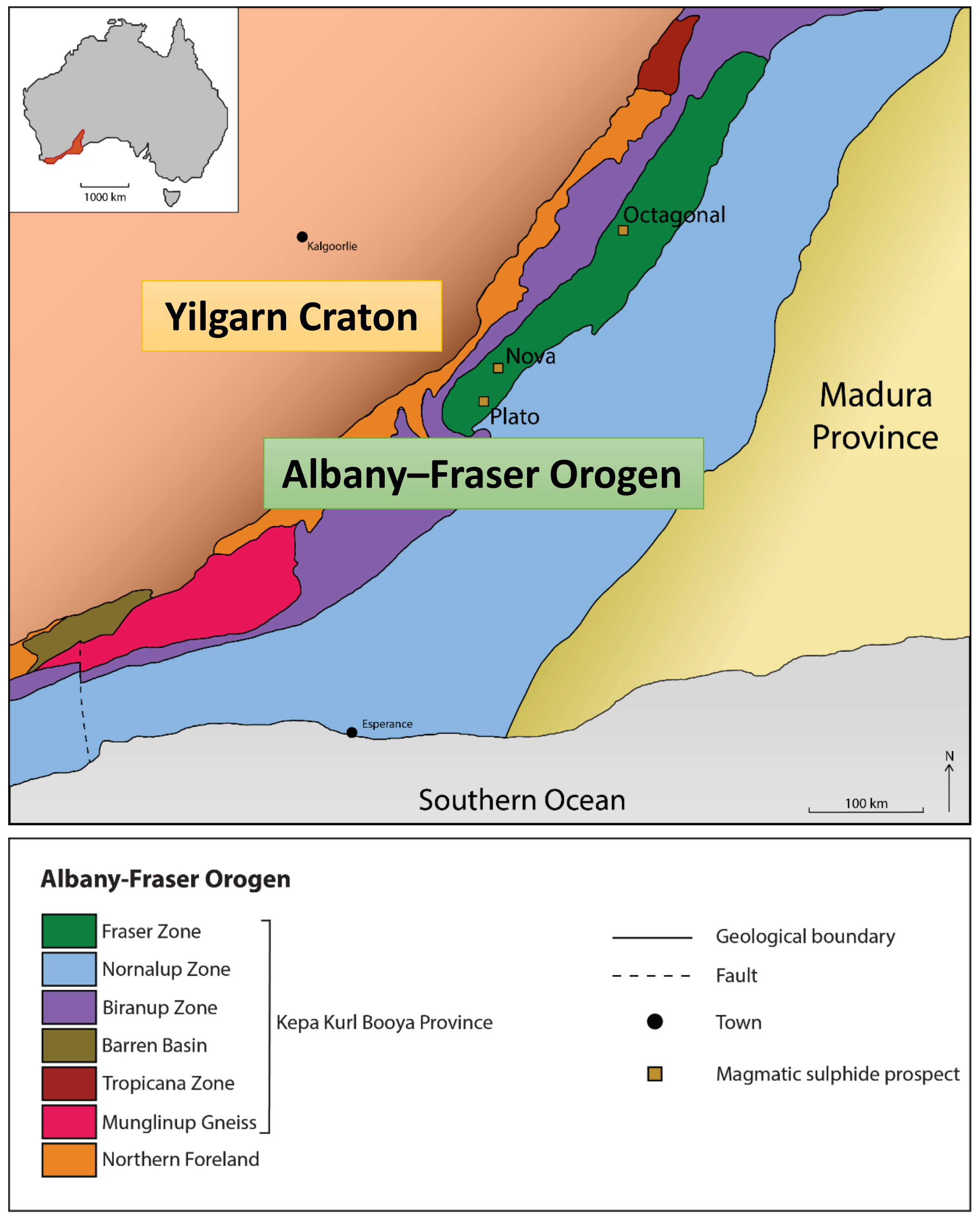
- Magmatic sulfide deposits sulfur isotopes:
  - characterize origin
  - degree of mixing between distinct sources
- Can be used to identify Archean input


Sedimentary sulfur
Magmatic sulfur
Mixing of magmatic/sedimentary sulfur signatures
Assimilation

[illegible]

Albany–Fraser Orogen

- Orogenic belt sandwiched between Yilgarn Craton and Madura Province
- Divided into Northern Foreland and Kepa Kurl Booya Province
- Reworked cratonic vs mixed cratonic and juvenile material



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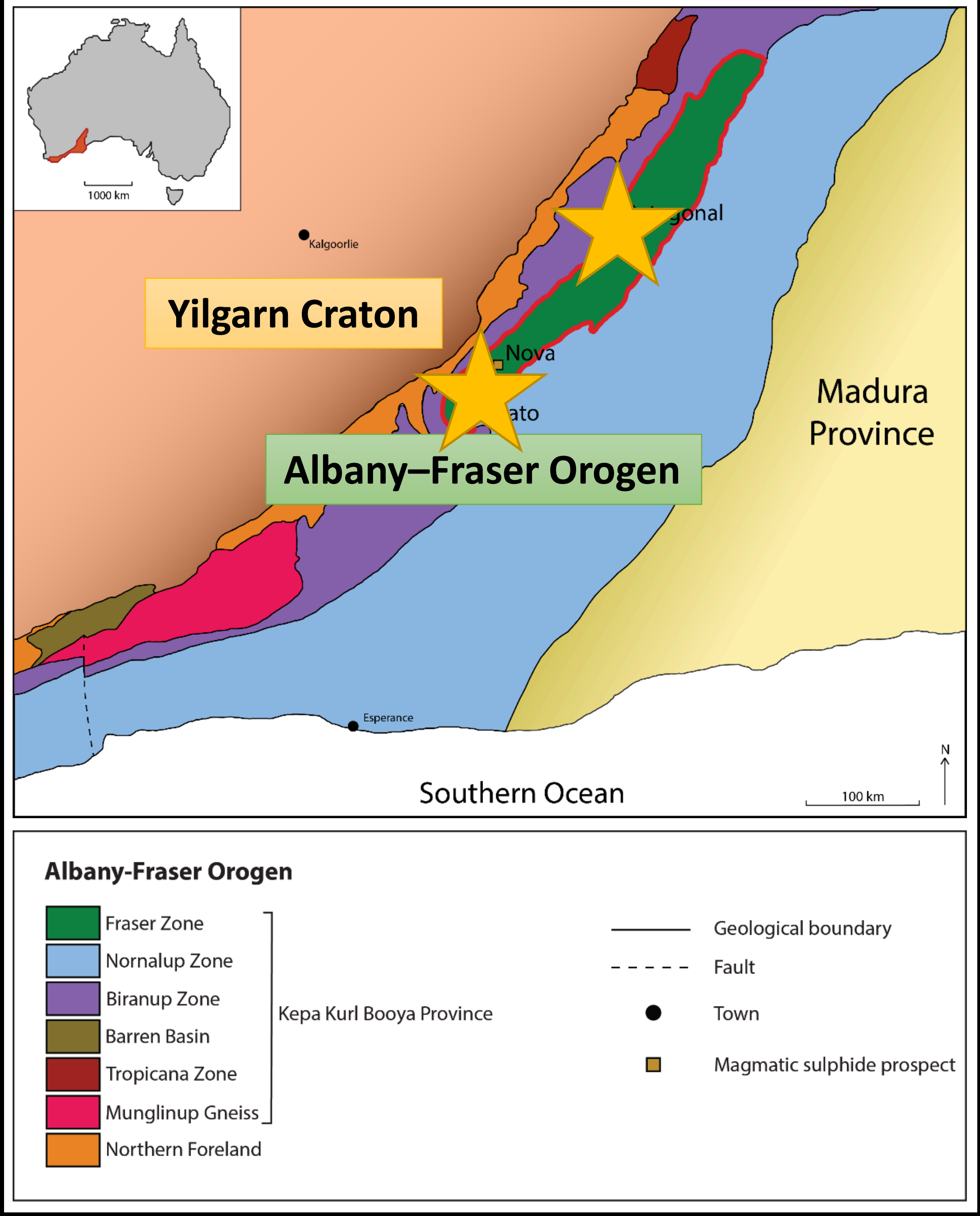
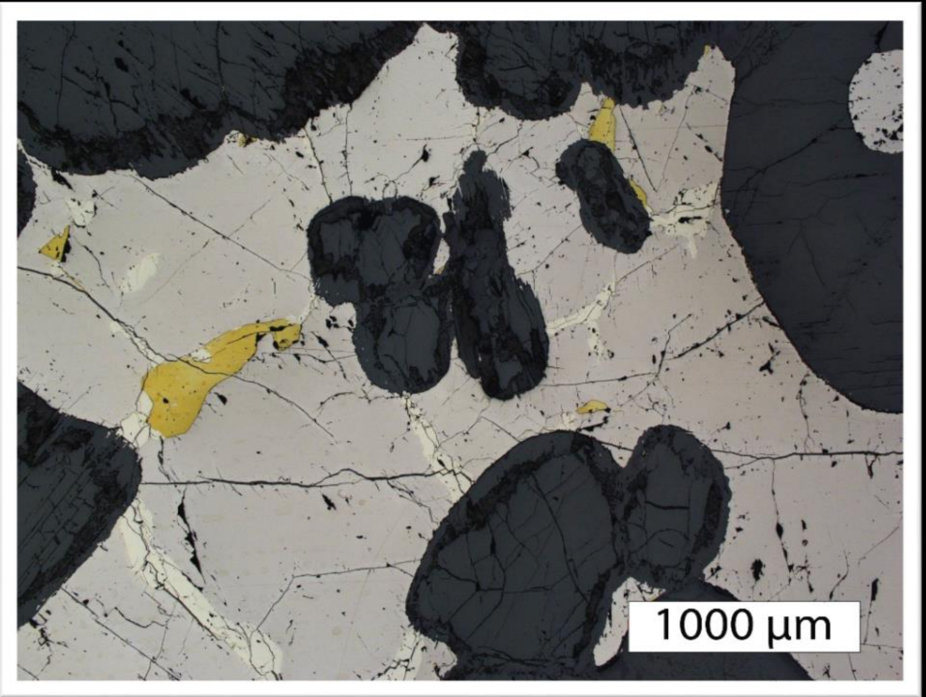
Fraser Zone

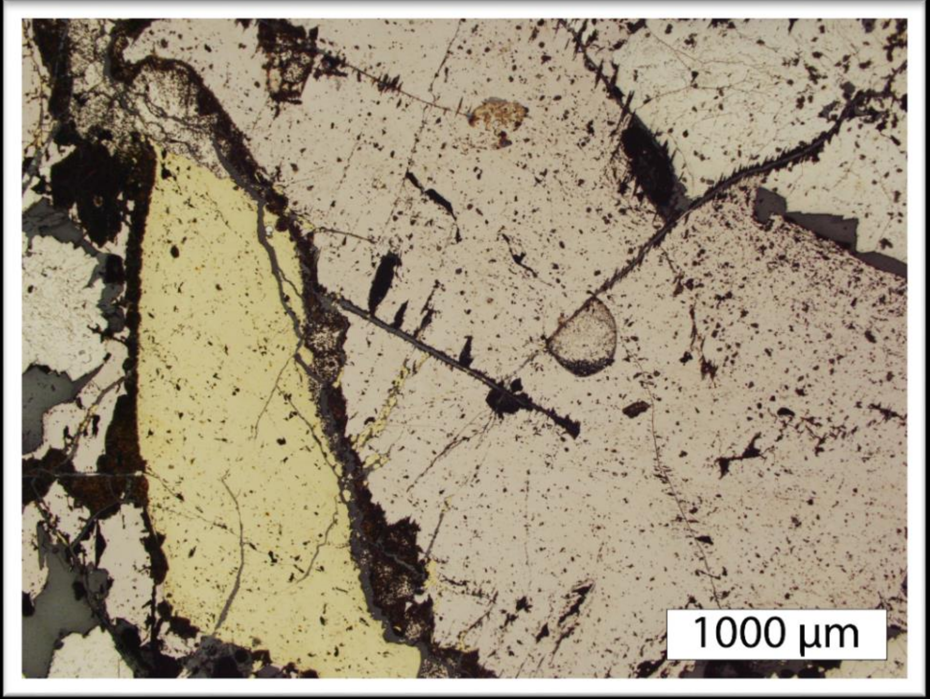
- Interpreted as mid-crustal hot zone formed by mantle upwelling
- Metagabbros/metagranites, ultramafics and metasediments
- Prospective for magmatic sulfide mineralization



Petrography

- Mafic and metasedimentary rocks
- Sulfides analysed primarily pyrrhotite, pentlandite and chalcopyrite (± secondary pyrite)
- Breccias, disseminated, net textured and massive sulfides at Octagonal
- Disseminated and blebby sulfides at Plato

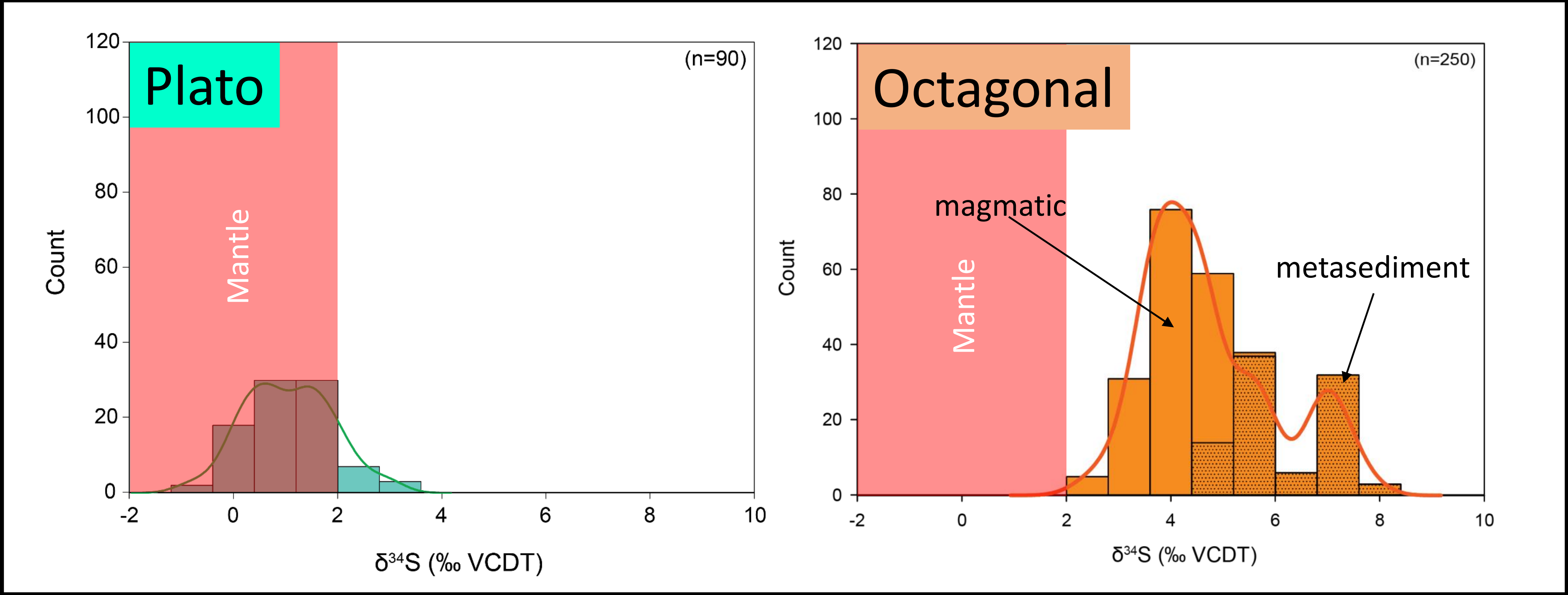




Methodology

- Petrography
- In-situ analysis via IMS1280
- Thin section 'pucks' embedded into epoxy
- Standard materials either embedded or mounted alongside

$\delta^{34}S$ isotope data



-0.87 – 3.11‰ range (1.05‰)

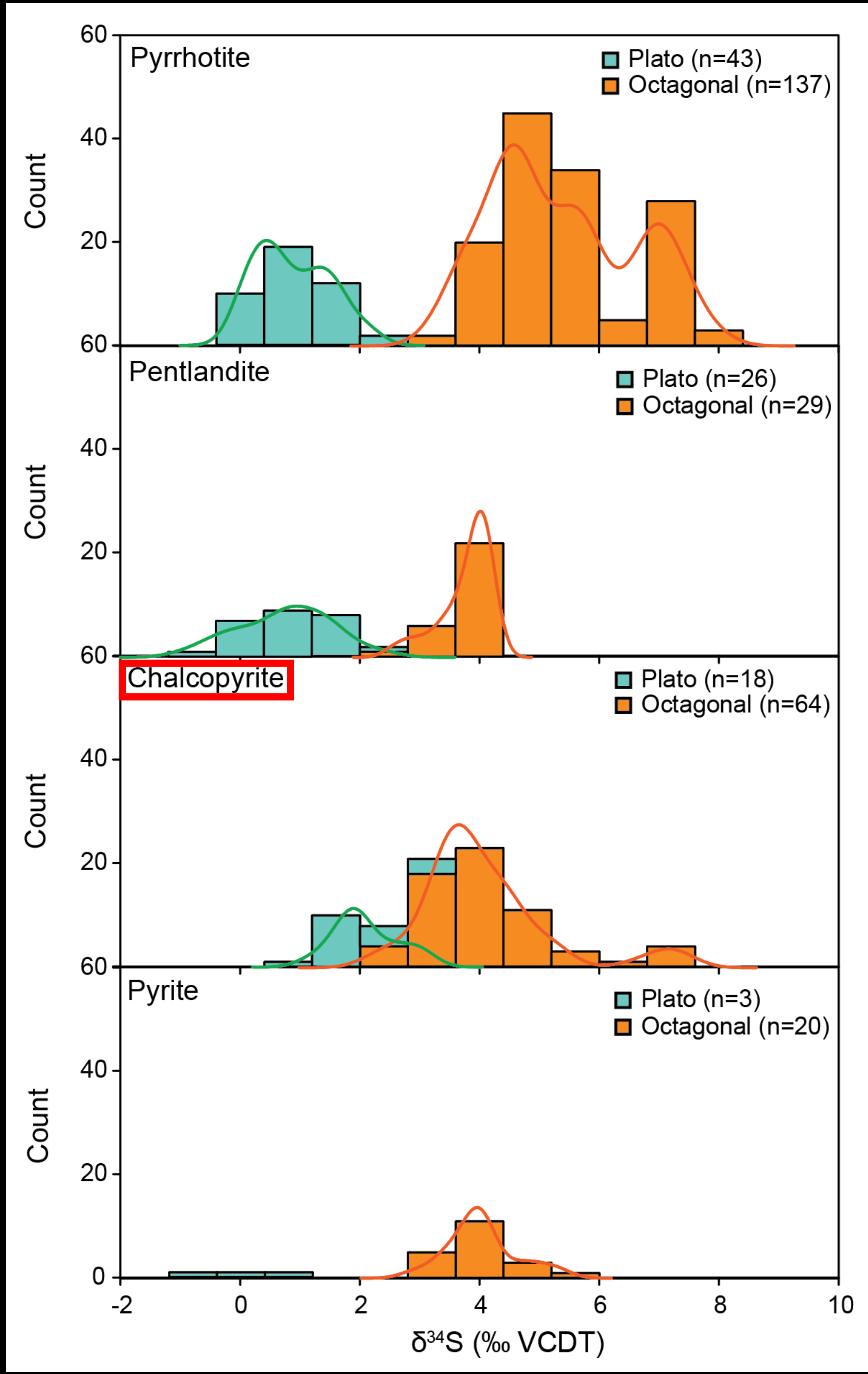
2.25 – 5.93‰ range (4.31‰)

4.44 – 7.88‰ range (6.12‰)

$\delta^{34}S$ isotope data

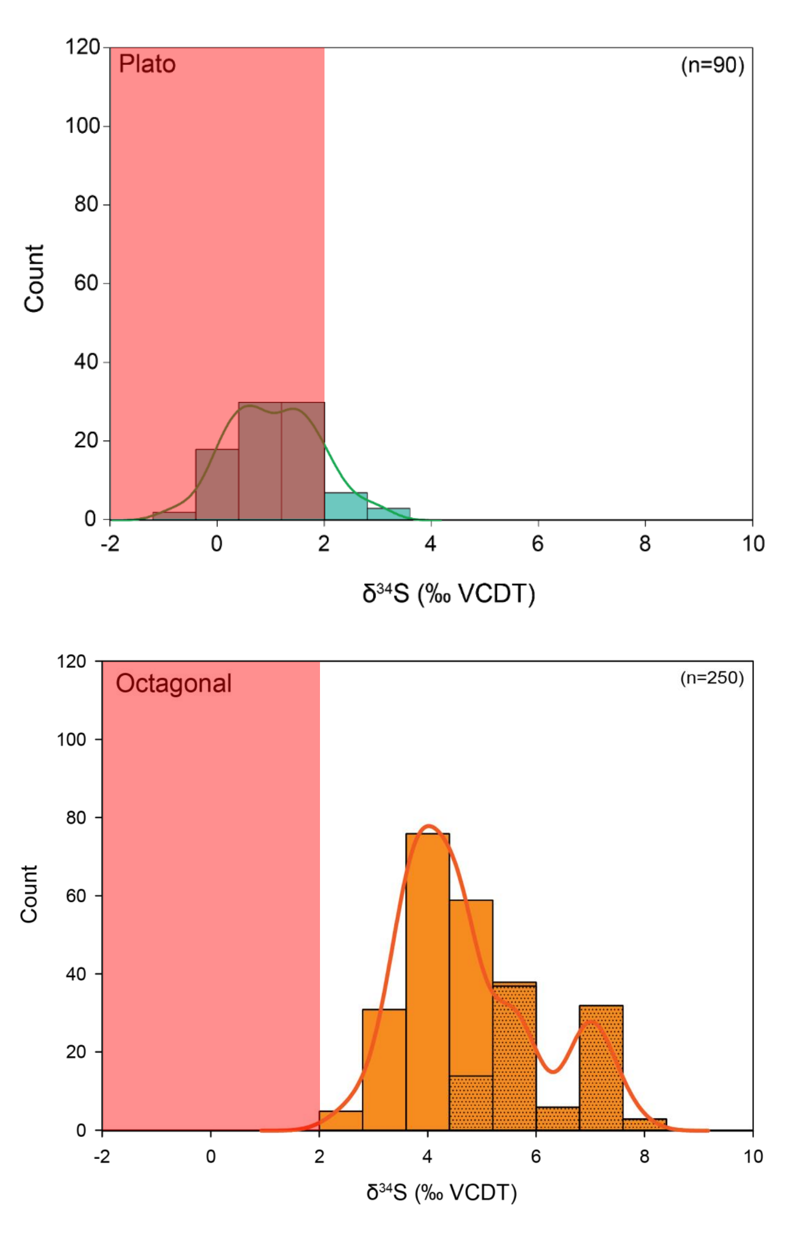
- Sulfides analysed primarily pyrrhotite, pentlandite and chalcopyrite (± pyrite)

- Minimal fractionation – likely coeval formation



$\delta^{34}S$ isotope data

- Plato
  - -0.87 – 3.11‰ range (1.05‰)
- Octagonal
  - 2.25 – 5.93‰ range (4.31‰)
- Assimilation of external sulfur



Increasing metasedimentary component

(7.07‰)

δ34S isotope data

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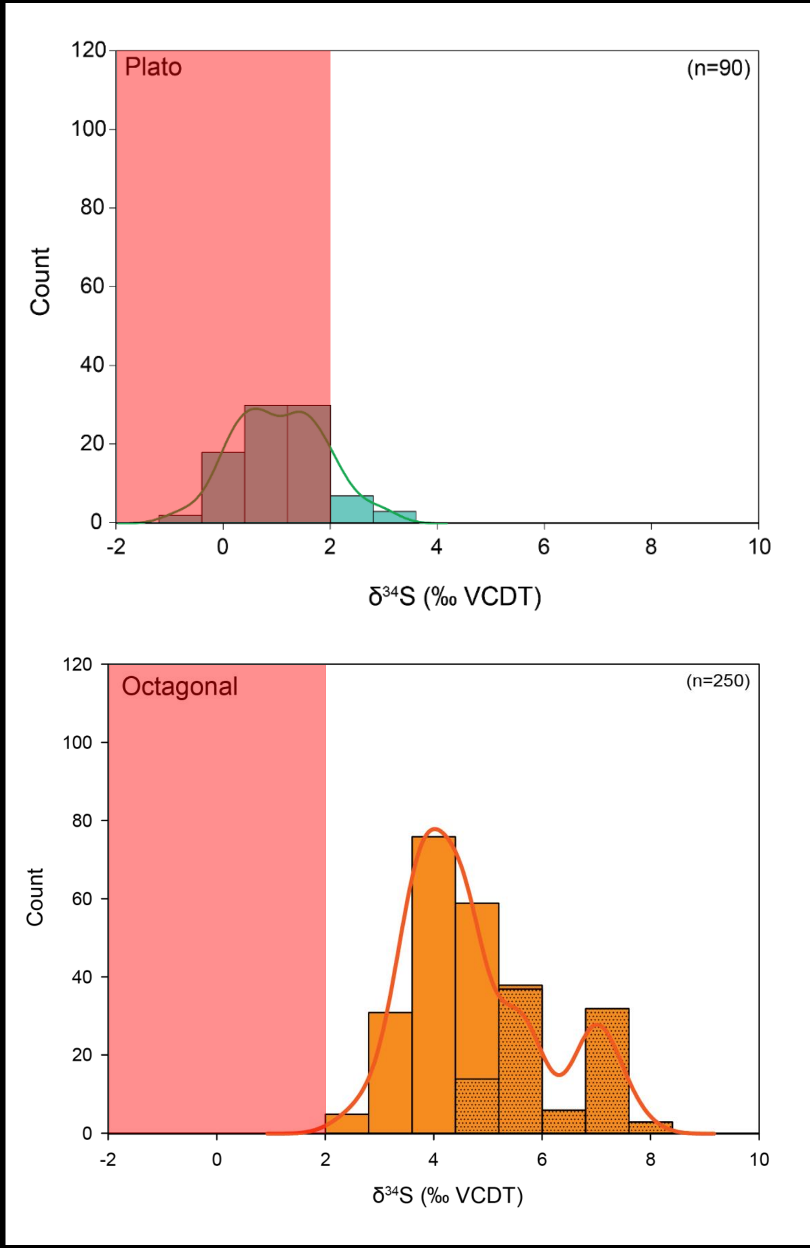
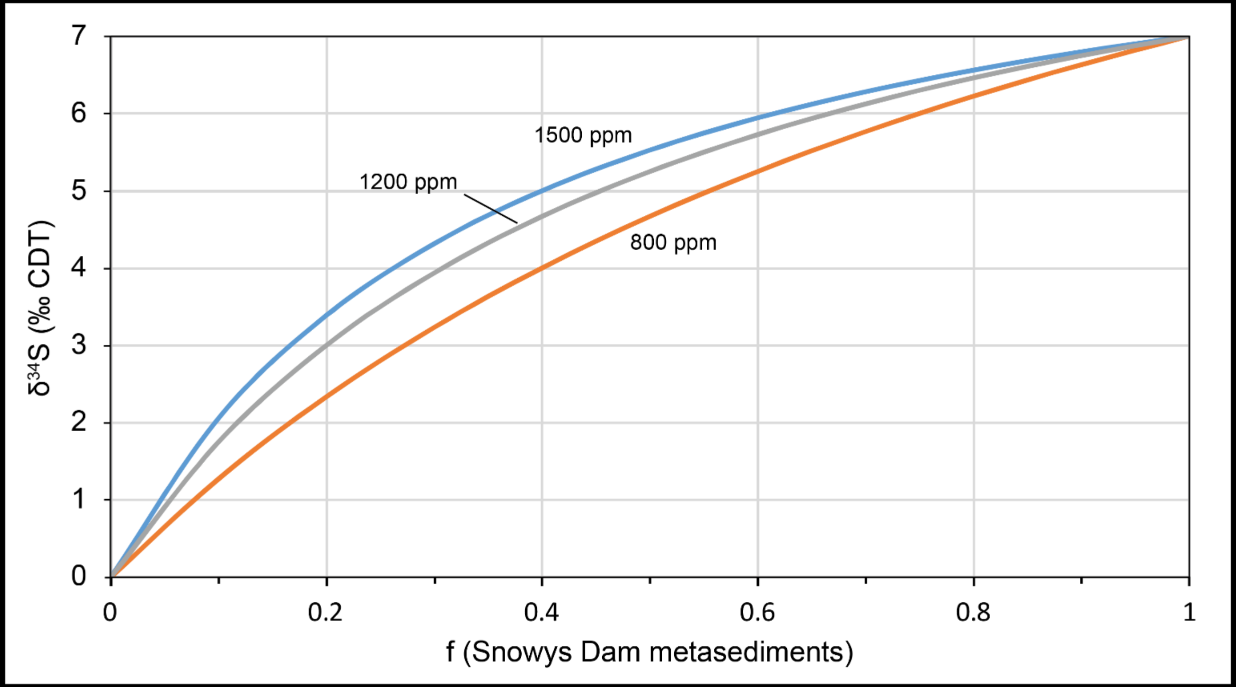


Increasing metasedimentary component

(7.07‰)

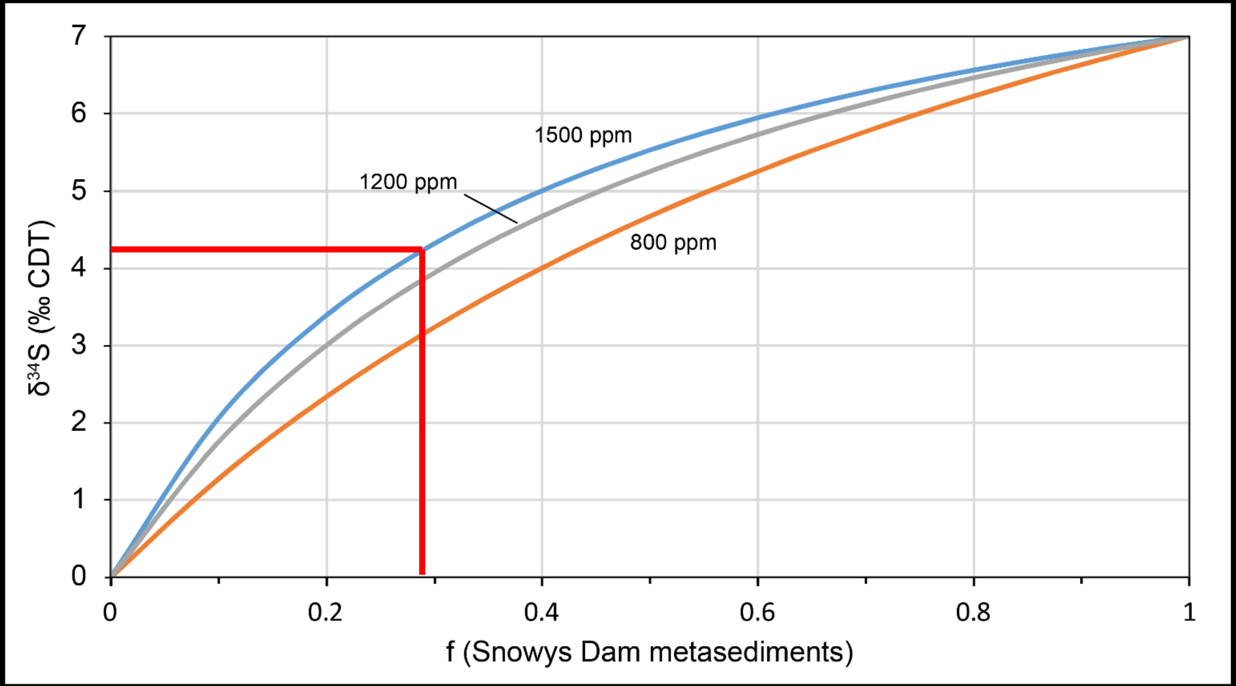
How much?

Sulfur mixing models



- Simple mixing model between mantle derived magmas and Snowys Dam Formation metasediments
- Mineralized material ~4.25‰
- Assimilation of component equal to ~30% mass of sulfur in magma
- Incongruent melting

Sulfur mixing models



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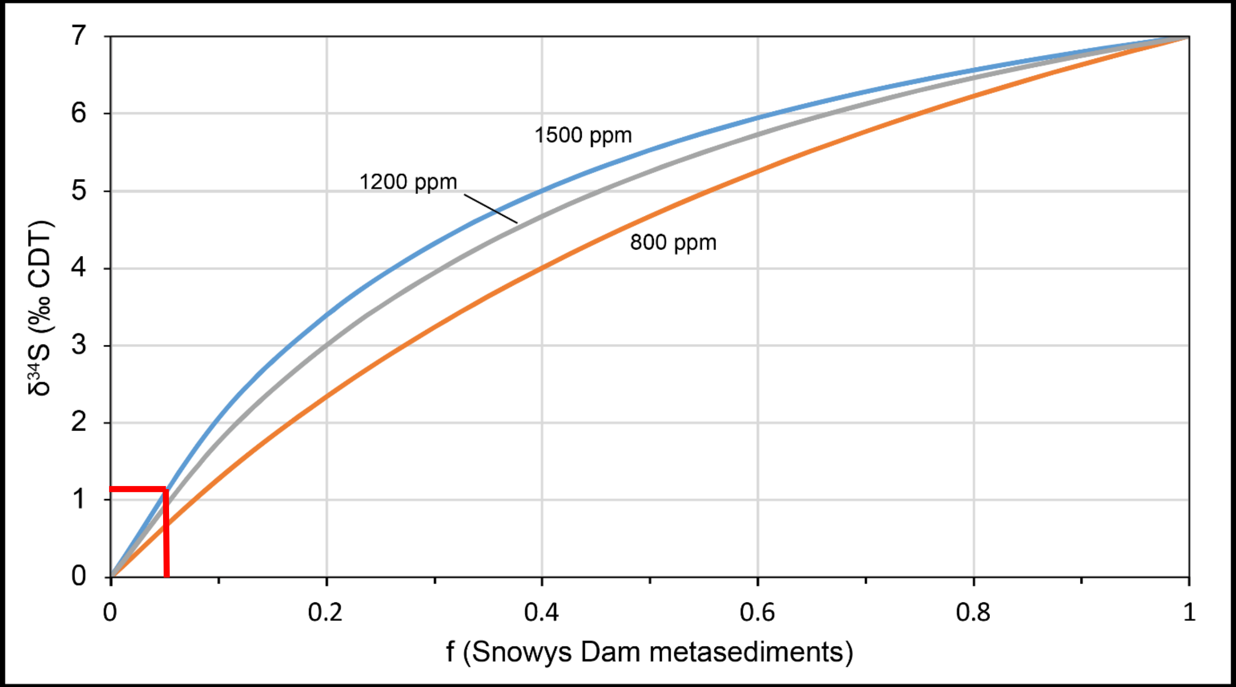
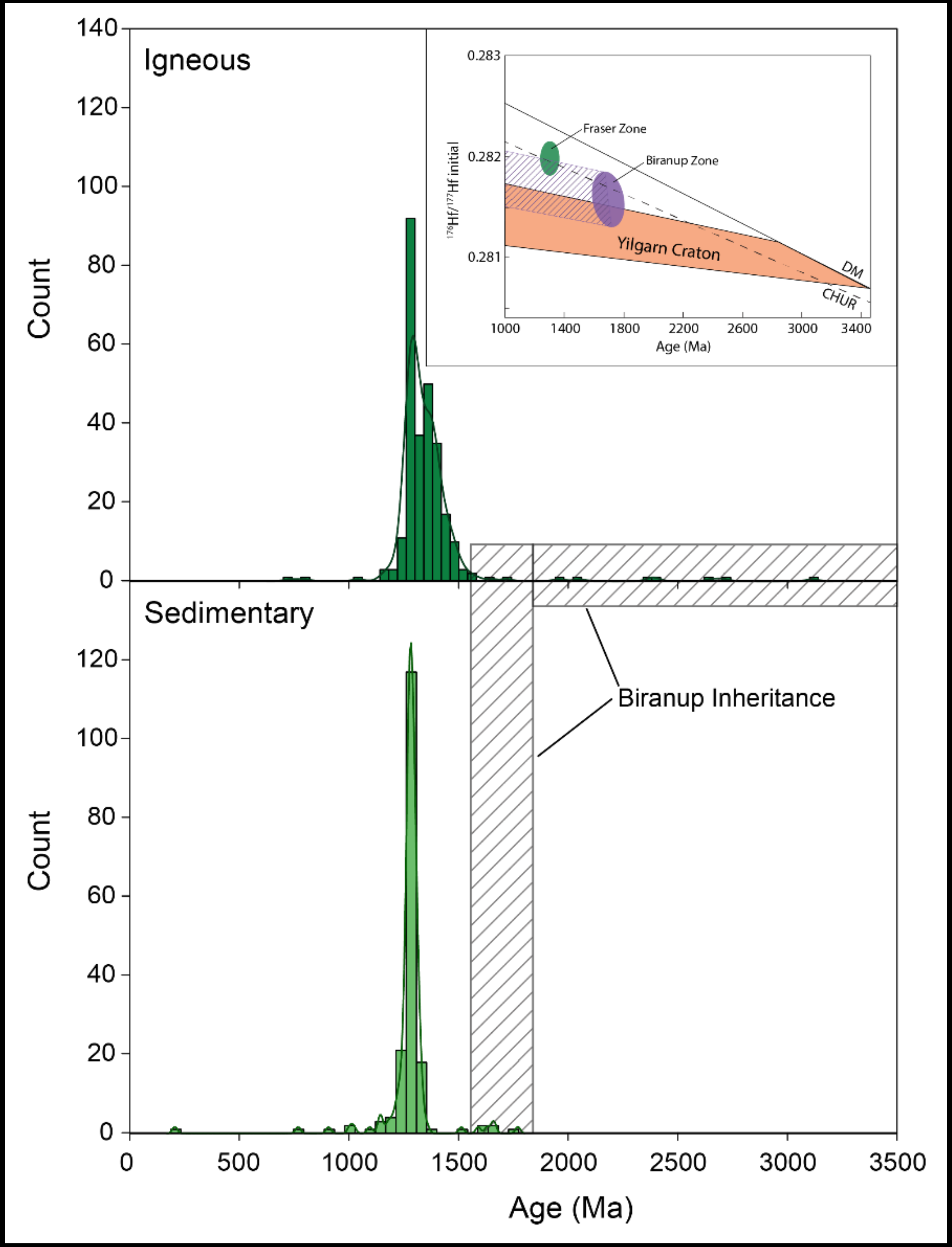
Sulfur mixing models



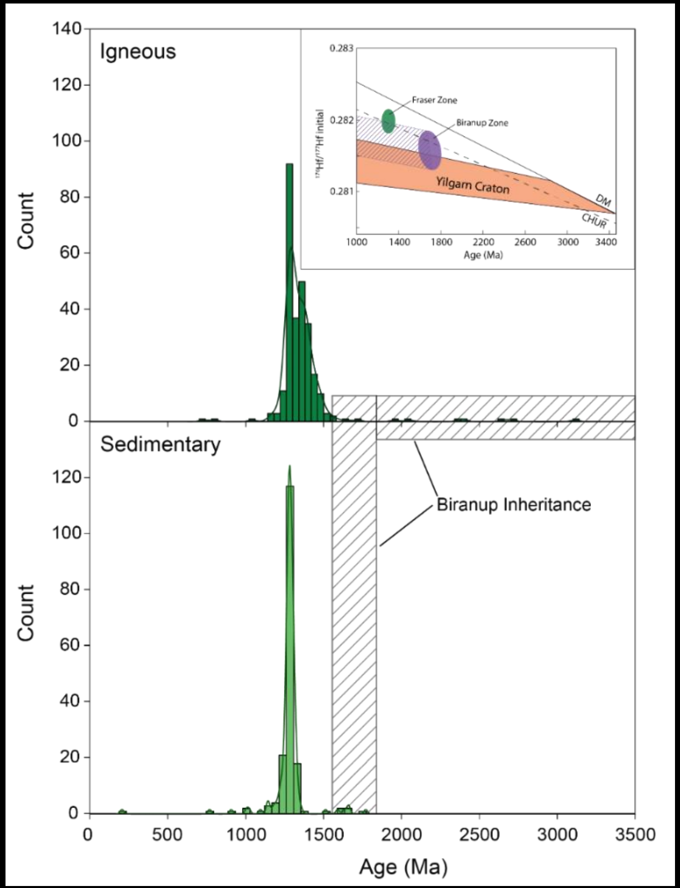
- Simple mixing model between mantle derived magmas and Snowys Dam Formation metasediments
- Plato material ~1.05‰
- Assimilation of component equal to ~5% mass of sulfur in magma

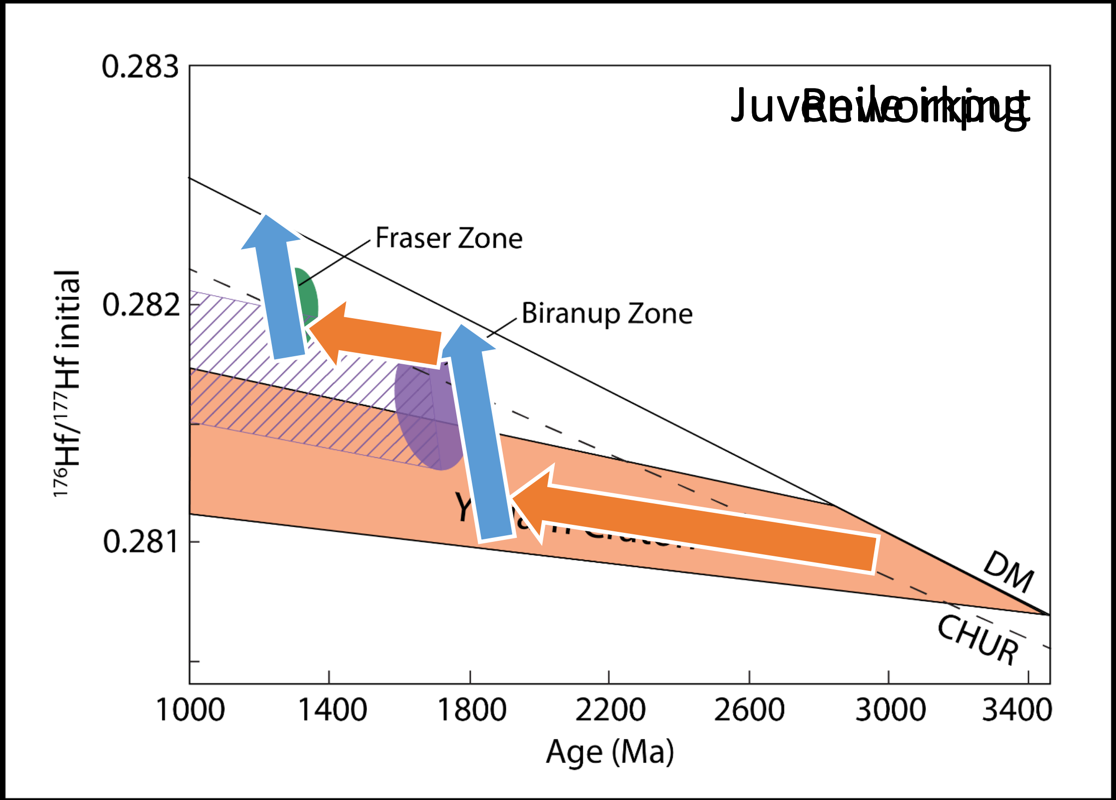
Archean component in the Fraser Zone

- Whole rock geochemistry, Hf and Nd isotopes and dated inherited zircon grains establish a Biranup basement to Fraser Zone
- Biranup is itself reworked Archean lithologies
- Arid Basin includes sparse pre-1500 Ma detrital zircons



Archean sulfur in the Fraser Zone





Archean sediment (and Biranup basement material) assimilated by the Fraser Zone magmas during emplacement; also present in Snowys Dam metasediments

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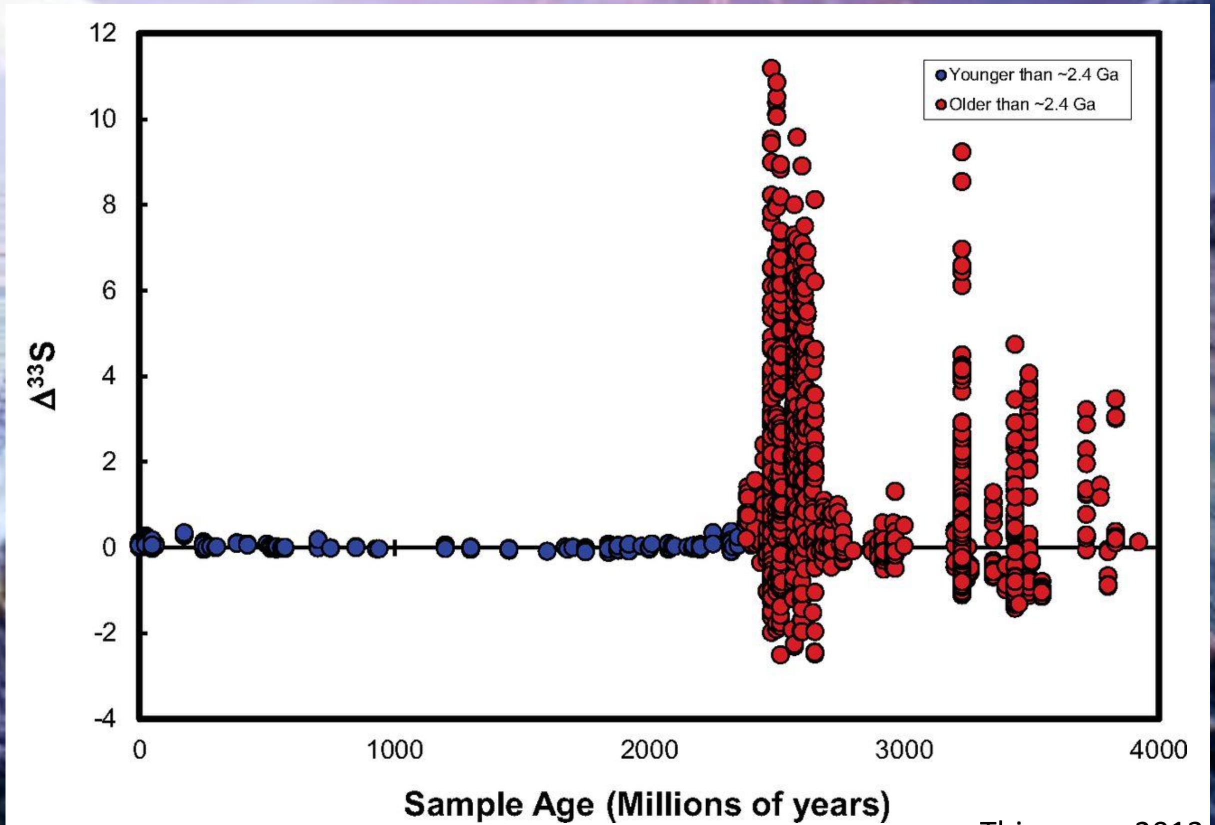
Archean sulfur and $\Delta^{33}S$

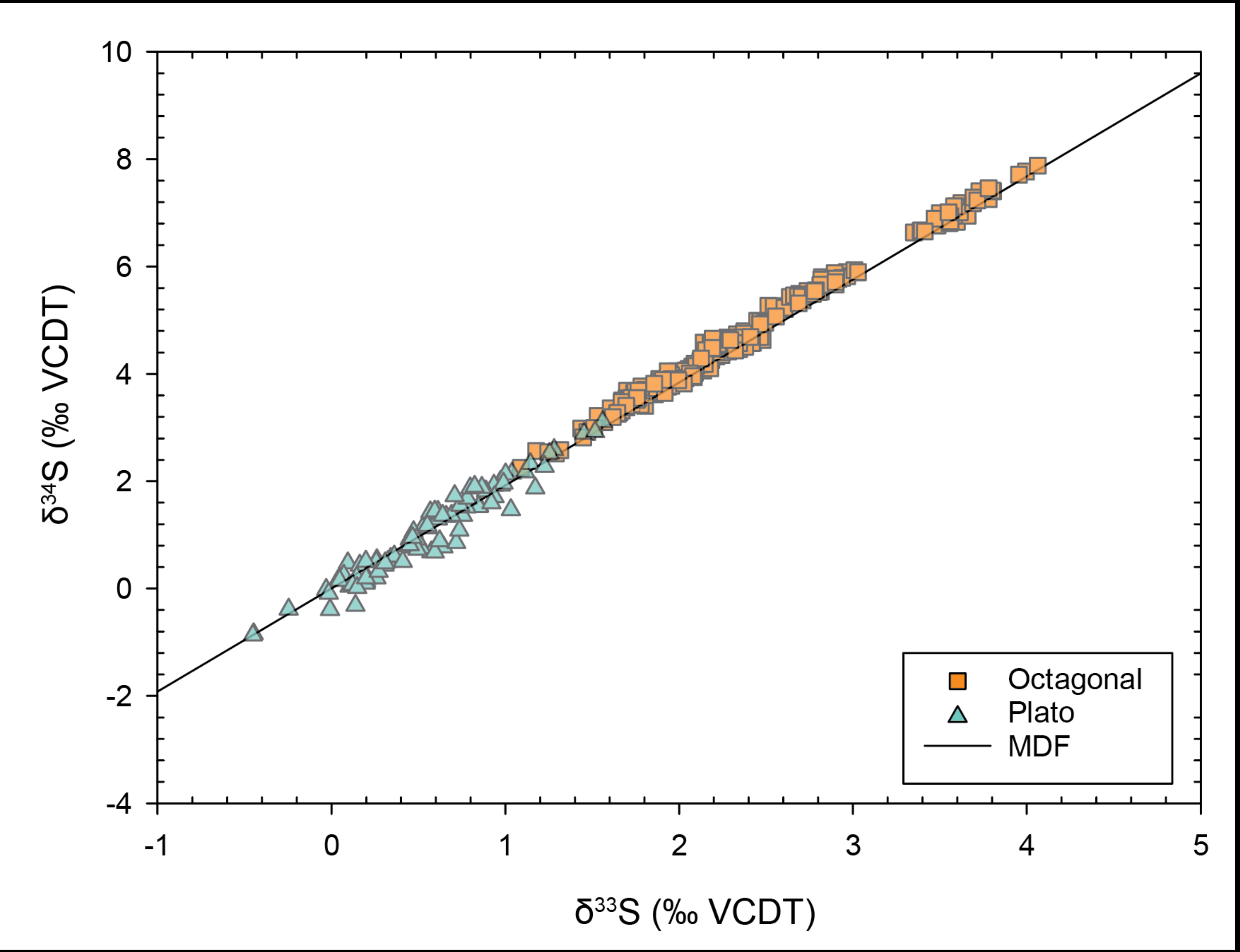


Thiemens, 2013

Peter Sawyer

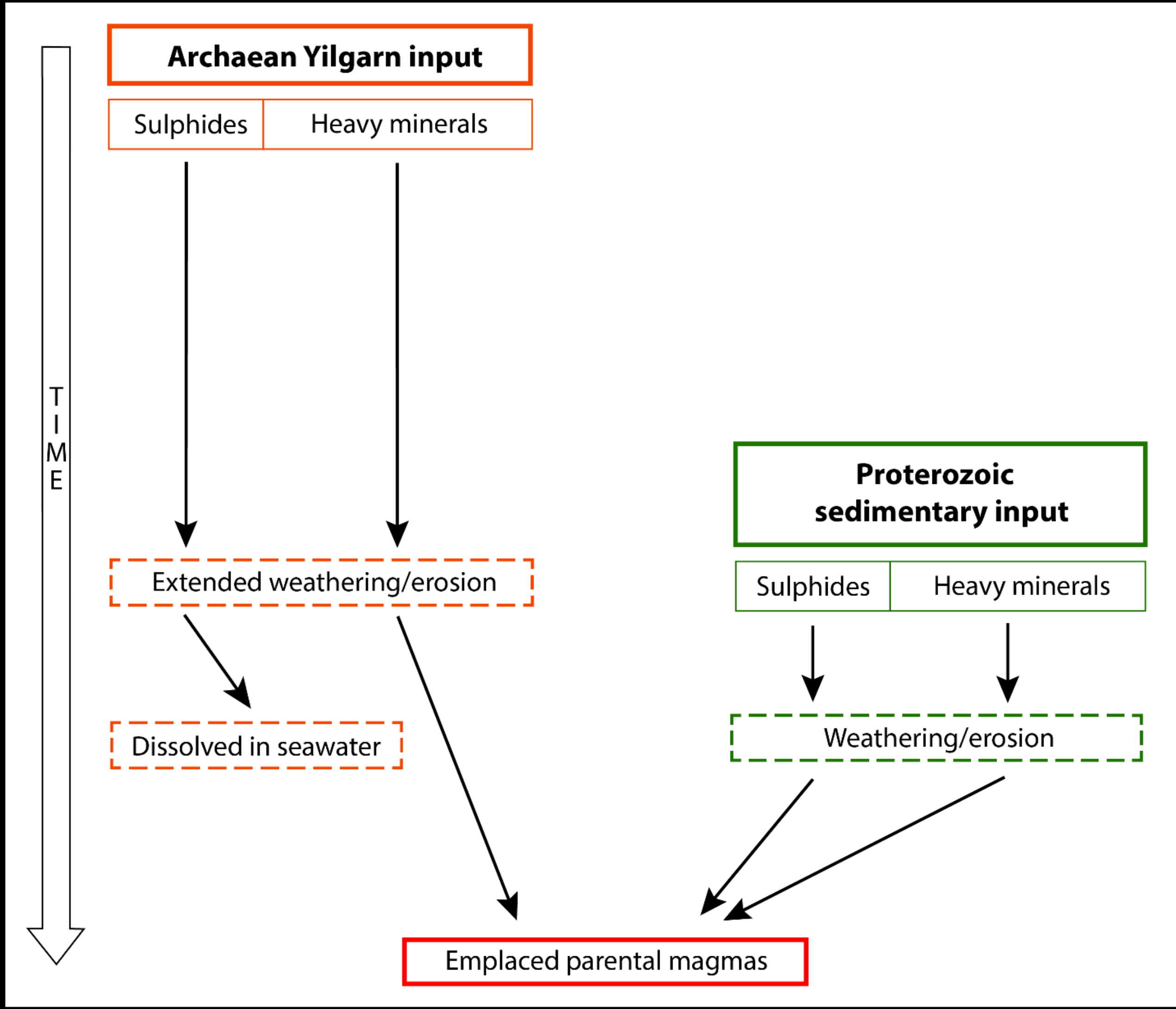
Archean sulfur in the Fraser Zone

- Archean sulfur may be identified via MIF signature
- Deviation from MDF line reflects MIF; $\Delta^{33}S$
- Collected data indicates overall $\Delta^{33}S$ signature of $-0.03 \pm 0.08‰$

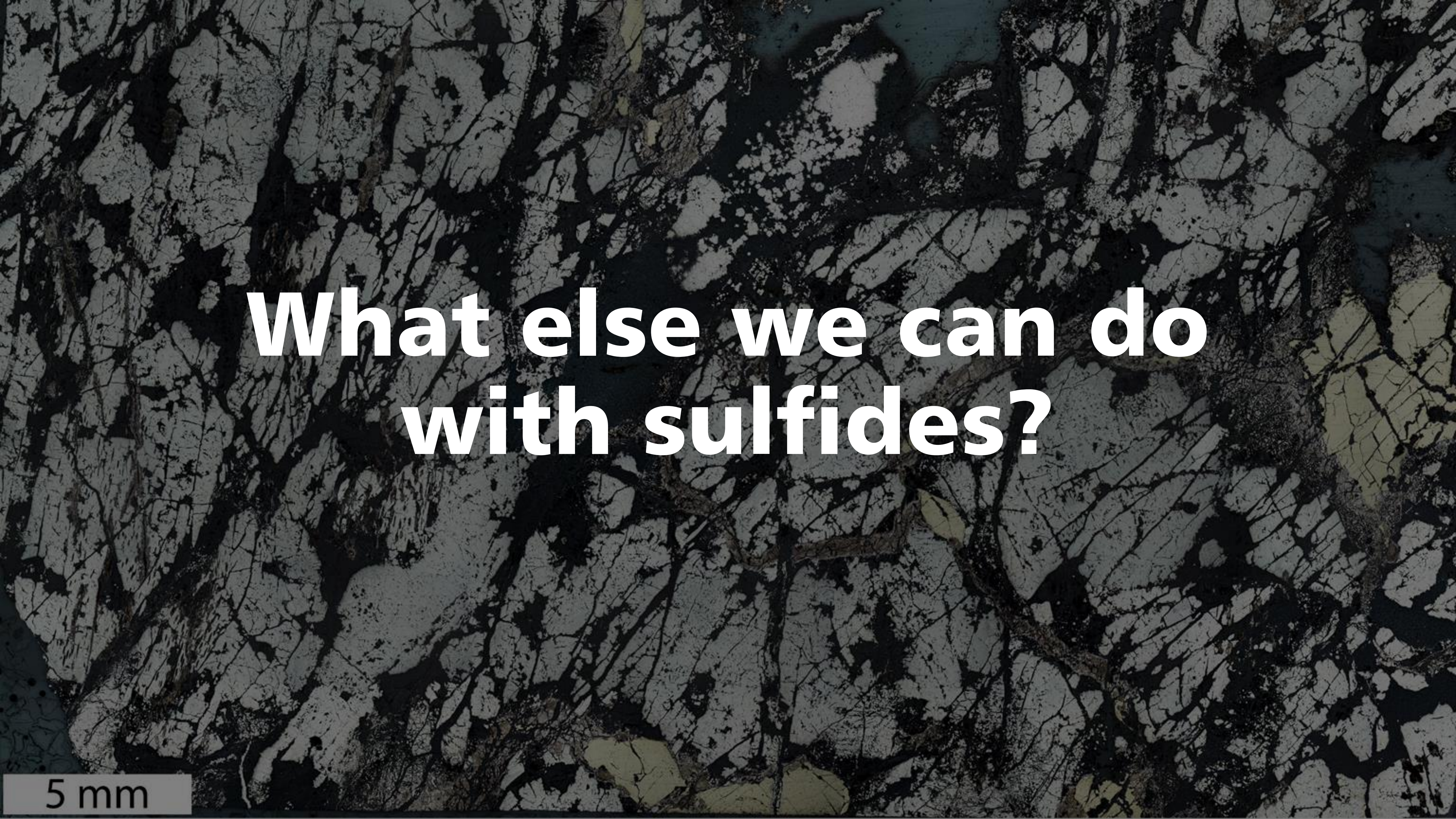


Archean sulfur in the Fraser Zone

- Modelling suggests dilution not the answer
- Likely stripping of sulfides from material via sedimentary processes
- Phases more resistant to weathering (e.g. zircon) survive

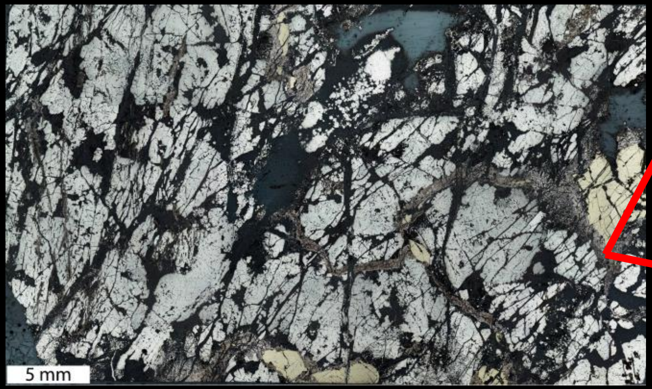


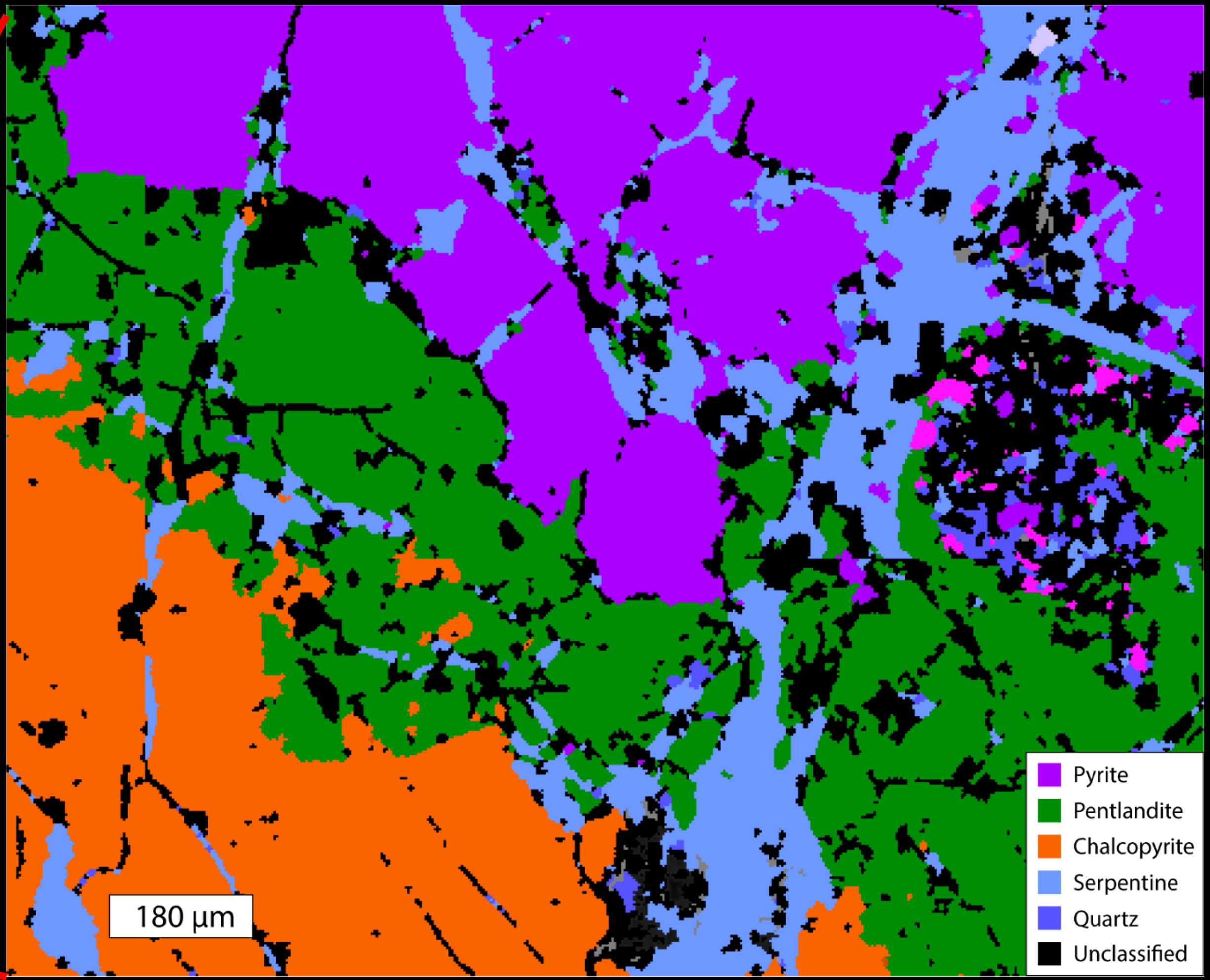
What else we can do with sulfides?



Sulfide mapping

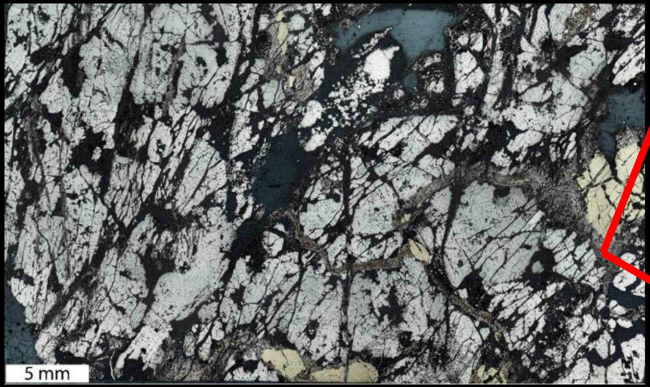
- TIMA analysis: identification/quantification of mineralogy

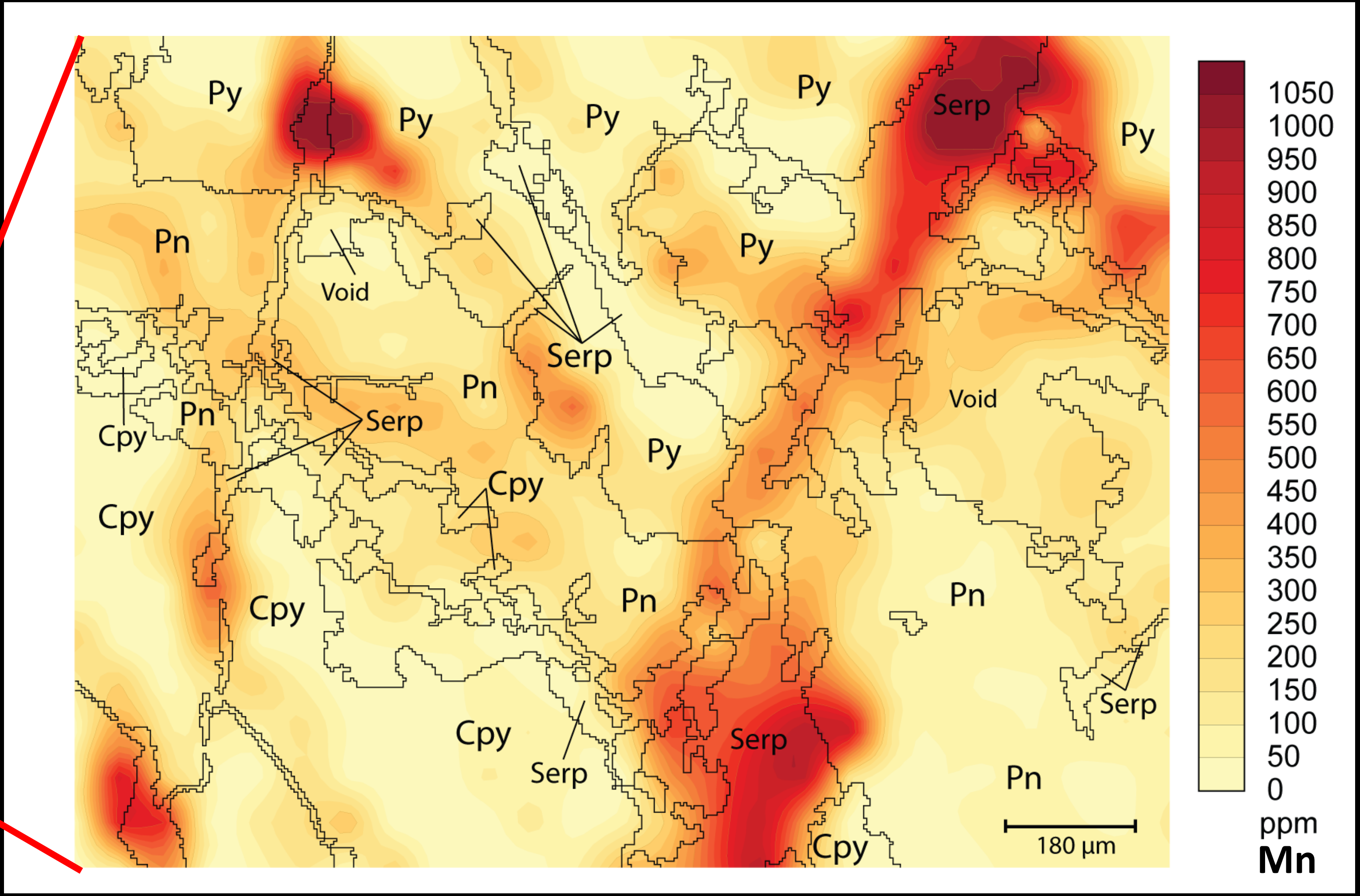




Sulfide mapping

- Elemental mapping of sulfide surfaces via laser ablation



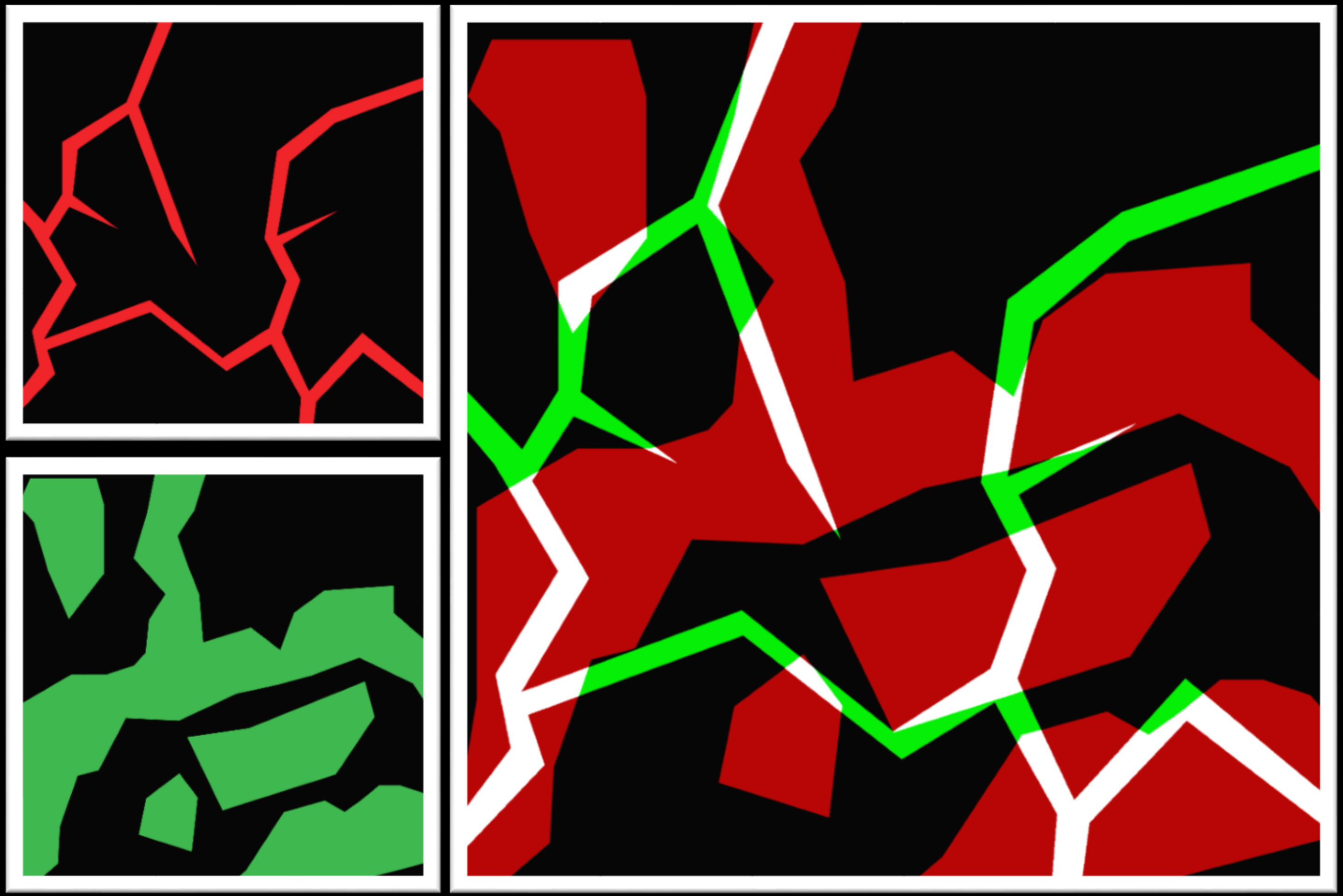


Testing of spatial relationships

r = 0.45

M1/M2 = 0.95/0.27

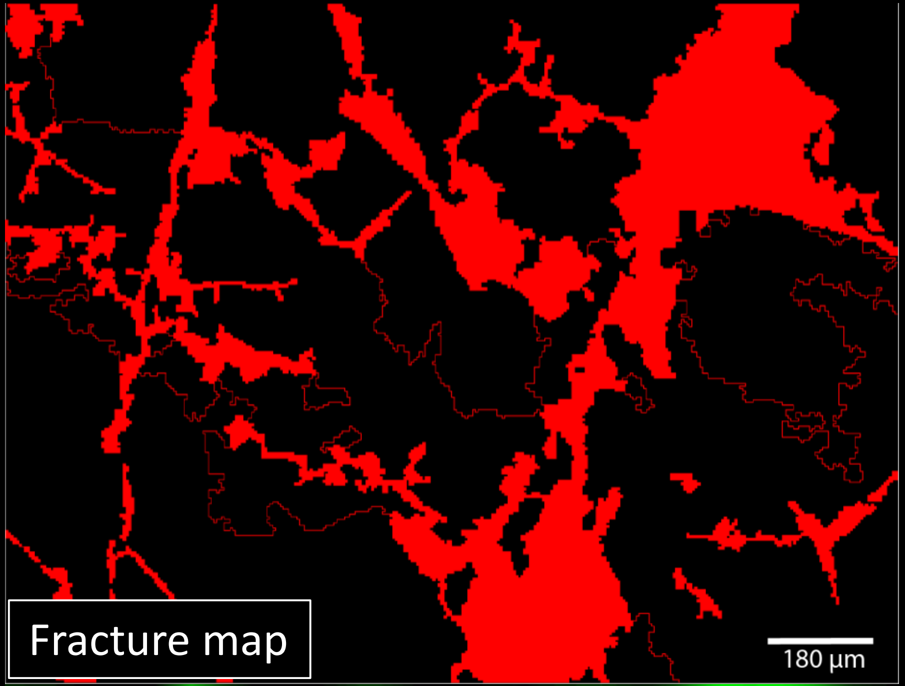
- Test images were used to assess how this technique can be applied and whether results are realistic

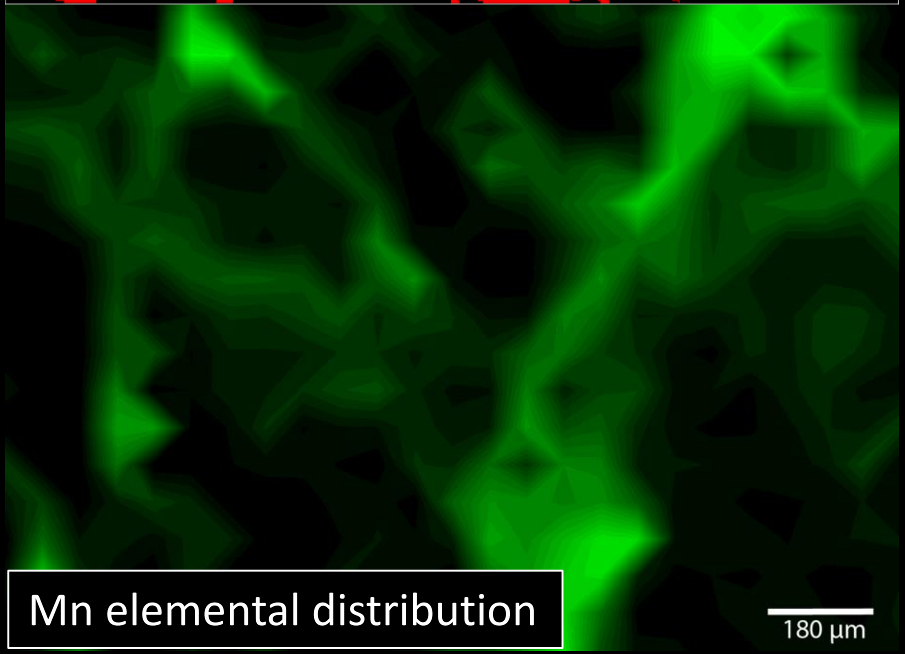


Colocalization analysis

- Statistically significant relationship between distributions of fractures and Mn

- Fluid flow and remobilization of metals via fracture networks is a means by which mineral deposits may be upgraded or destroyed





r = 0.30

M1/M2 = 0.85/0.34

Conclusions

- More positive sulfur isotopic signature at mineralized Octagonal relative to poorly mineralized Plato
- Mineralization linked to greater degree of country rock sulfur assimilation
- Absence of Archean sulfur within the Fraser Zone
- Laser ablation elemental mapping of sulfides
- Development of technique to quantify spatial relationships
  - Metal remobilization may upgrade or destroy mineralization