Sulfur isotope compositions in the weathering profile of magmatic Ni-Cu deposits in SW Australia

EGU Conference | May 24, 2022

Kaj Sullivan*, Justin Drummond, Ben J. Cave, Paul Polito, Amanda Stoltze, Matthew I. Leybourne

Rationale

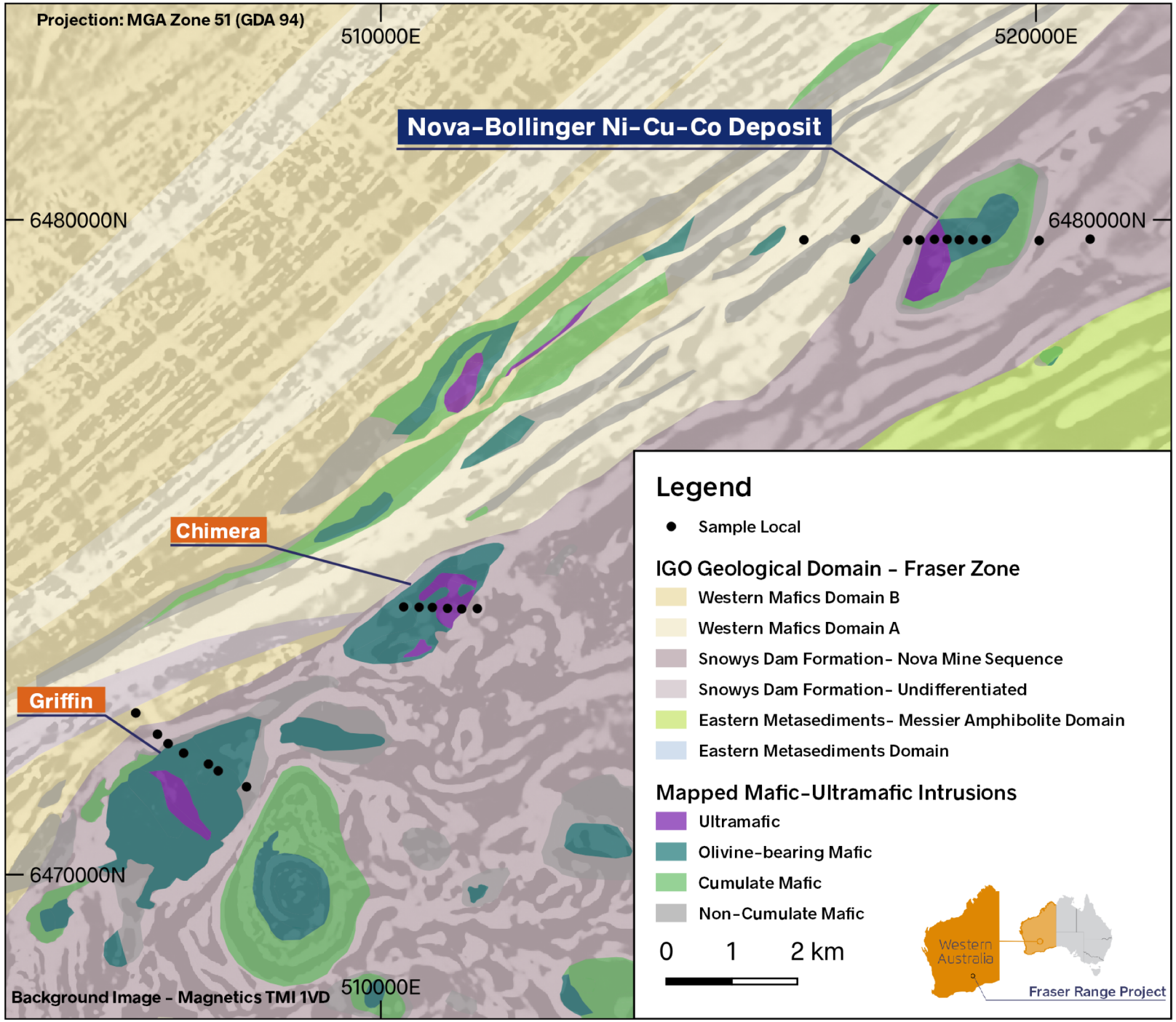
- **Post-mineral cover obscures prospective geological sequences**
- **Exploring for magmatic Ni-Cu deposits that are buried under post-mineral cover presents significant challenges**
- **Previously suggested that the S isotope signature ($\delta^{34}S_{CDT}$) of surficial sulfate in lakes and groundwaters provides an ideal baseline against which to base-metal or gold mineralization**

Study sites

Chimera: 6 drill holes across EW transect

Griffin: 8 drill holes across NW-SE transect

Nova: 11 drill holes across EW transect



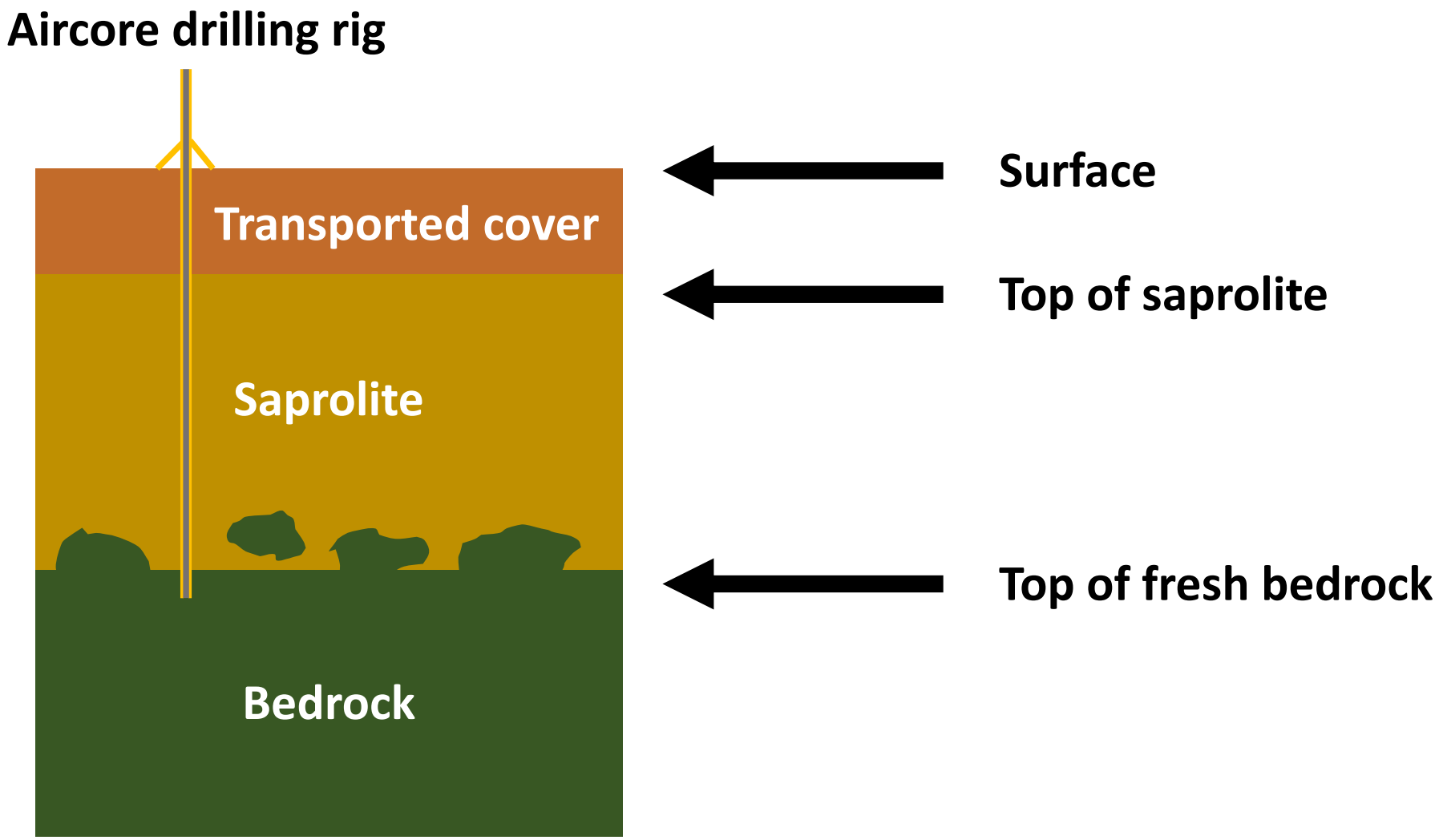
Methodology

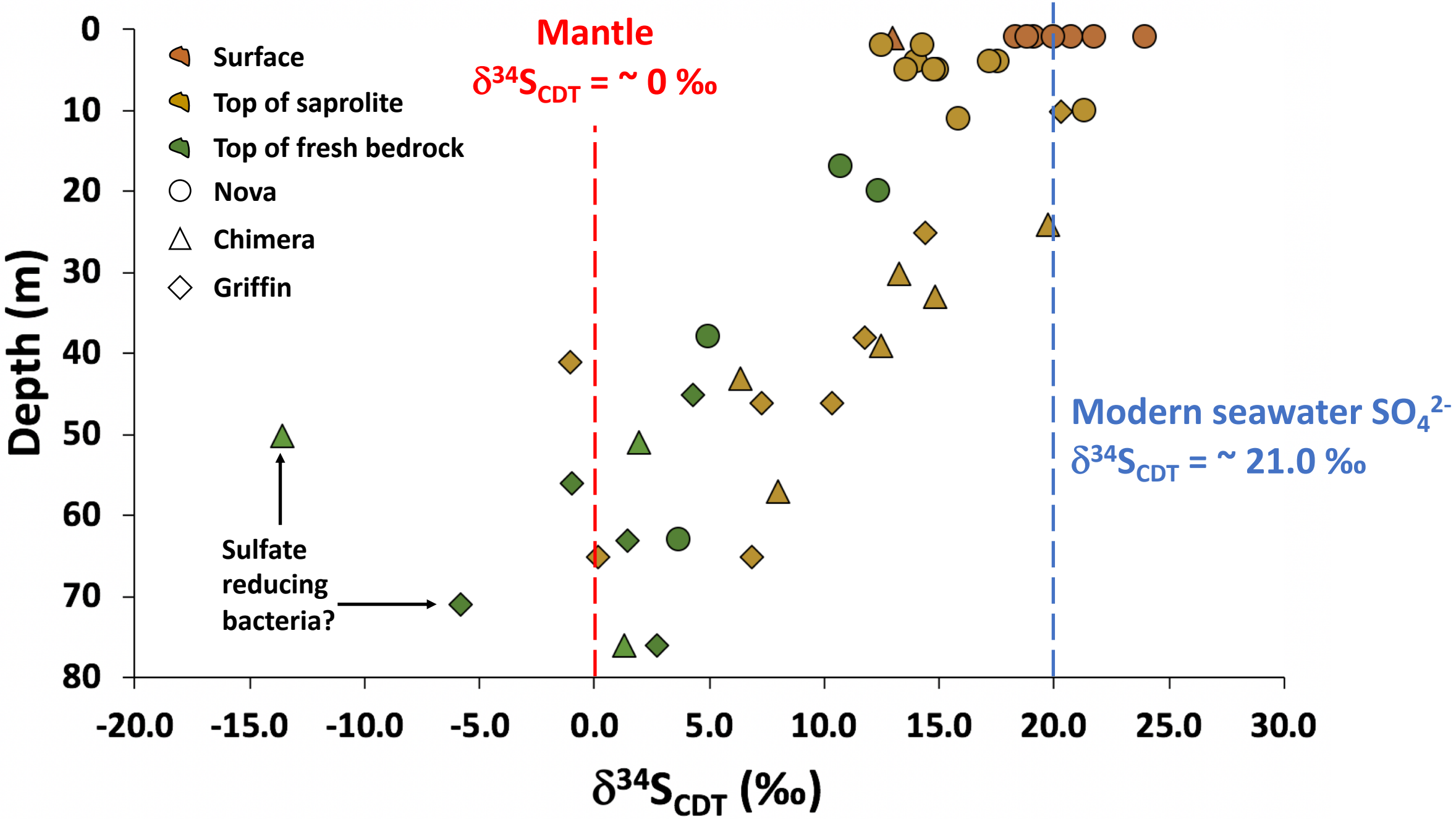
- **Samples provided from aircore**
- **Powdered samples**
- **XRD for mineralogy**

$$\delta^{34}S\ (‰) = \left(\frac{R^{34/32}_{Sample}}{R^{34/32}_{CDT}} - 1 \right) \cdot 1,000$$

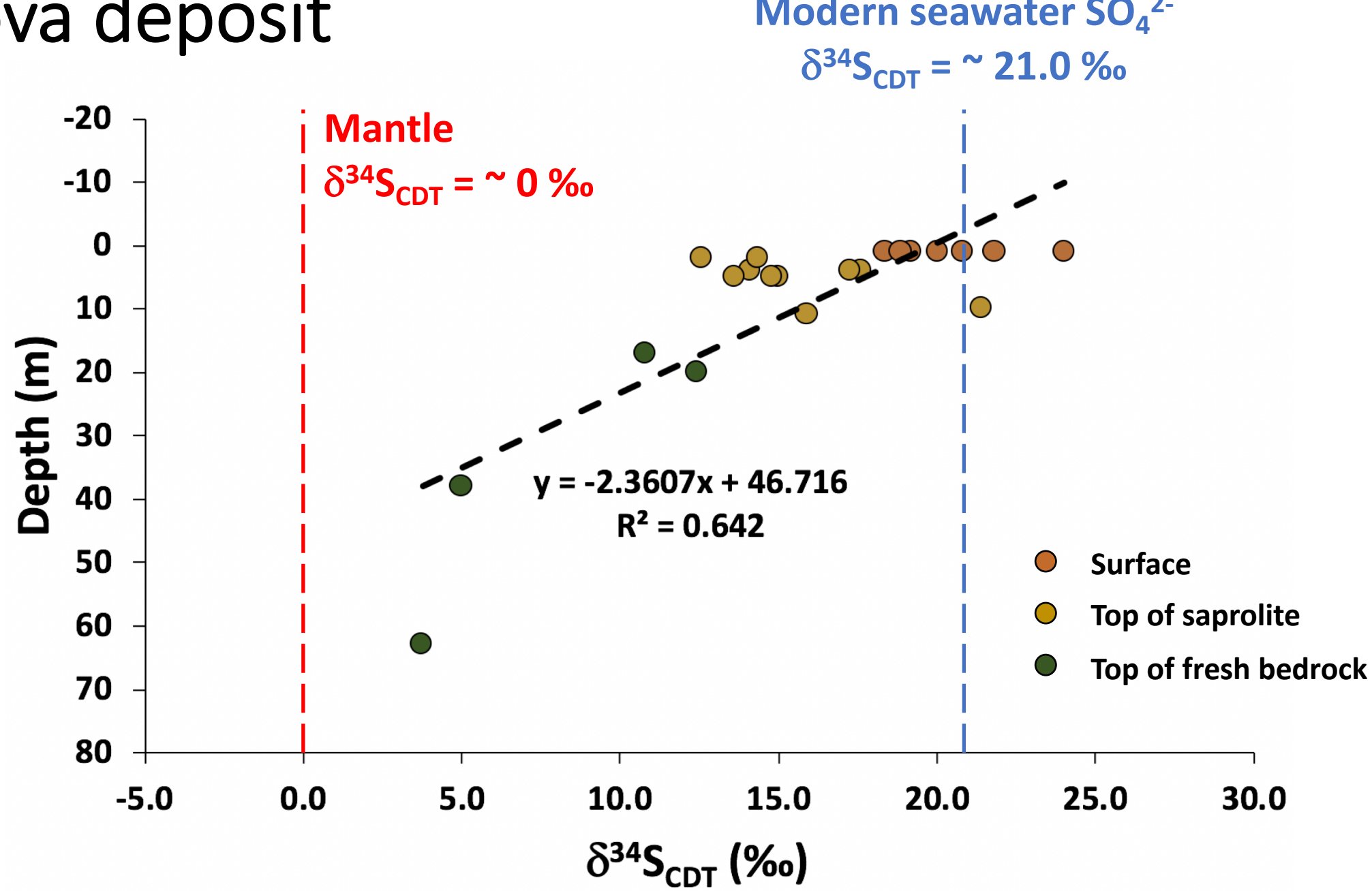
- **Sulfur isotopic analysis determined from powdered samples by CF-EA-IRMS**
- **Trace element concentrations determined by 4A/ICP-MS**

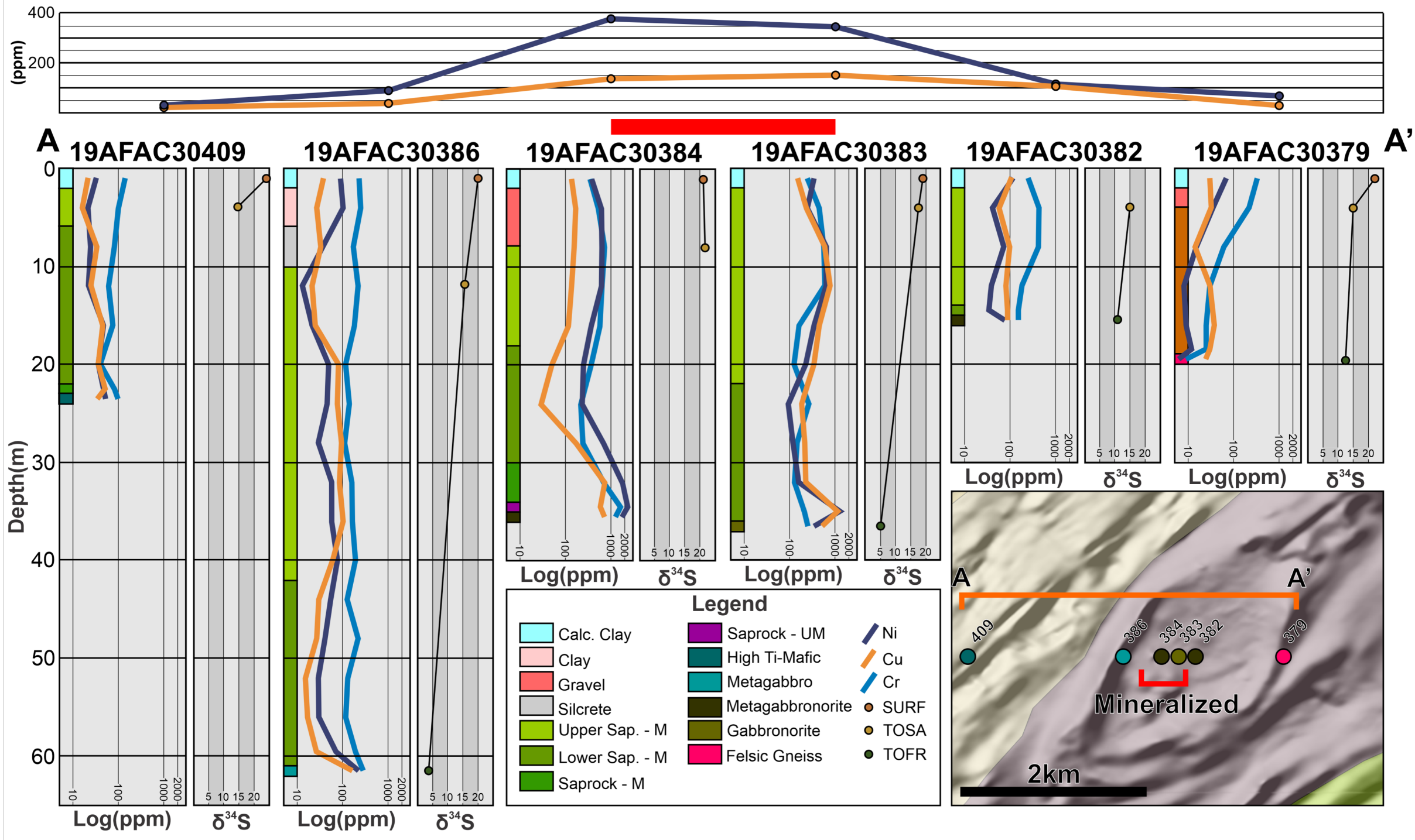
Sections measured for $\delta^{34}S_{CDT}$




Mantle
$\delta^{34}S_{CDT}$ = ~ 0 ‰
Surface
Top of saprolite
Top of fresh bedrock
Nova
Chimera
Griffin
Sulfate reducing bacteria?
Modern seawater SO_4^{2-}
$\delta^{34}S_{CDT}$ = ~ 21.0 ‰
Depth (m)
0
10
20
30
40
50
60
70
80
-20.0
-15.0
-10.0
-5.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
$\delta^{34}S_{CDT}$ (‰)

Nova deposit




400
200
(ppm)
A
A'
19AFAC30409
19AFAC30386
19AFAC30384
19AFAC30383
19AFAC30382
19AFAC30379
Depth(m)
0
10
20
30
40
50
60
Log(ppm)
δ34S
Legend
Calc. Clay
Clay
Gravel
Silcrete
Upper Sap. - M
Lower Sap. - M
Saprock - M
Saprock - UM
High Ti-Mafic
Metagabbro
Metagabbronorite
Gabbronorite
Felsic Gneiss
Ni
Cu
Cr
SURF
TOSA
TOFR
409
386
384
383
382
379
Mineralized
2km

Conclusions

- **Near-surface $\delta^{34}S_{CDT}$ values above Nova, Griffin, and Chimera appear to be mostly related to seawater-derived sulfate**

- **At depth, $\delta^{34}S_{CDT}$ shows a clear relationship between the mixing of seawater sulfate and magmatic S weathering into the environment**

- **Cu and Ni isotope systems could potentially help de-risk exploration for magmatic Ni-Cu deposits**

References

Barnes, S. J., Taranovic, V., Miller, J. M., Boyce, G. & Beresford, S. Sulfide Emplacement and Migration in the Nova-Bollinger Ni-Cu-Co Deposit, Albany-Fraser Orogen, Western Australia. *Economic Geology* **115**, 1749–1776 (2020).

Chivas, A. R., Andrews, A. S., Lyons, W. B., Bird, M. I. & Donnelly, T. H. Isotopic constraints on the origin of salts in Australian playas. 1. Sulphur. *Palaeogeography, Palaeoclimatology, Palaeoecology* **84**, 309–332 (1991).

Rees, C. E., Jenkins, W. J. & Monster, J. The sulphur isotopic composition of ocean water sulphate. *Geochimica et Cosmochimica Acta* **42**, 377–381 (1978).

Thode, H. G., Monster, J. & Durford, H. B. Sulphur isotope geochemistry. (1961).

Maier, W. D. *et al.* Petrogenesis and Ni–Cu sulphide potential of mafic–ultramafic rocks in the Mesoproterozoic Fraser Zone within the Albany–Fraser Orogen, Western Australia. *Precambrian Research* **281**, 27–46 (2016).

Seal, R. R., II. Sulfur Isotope Geochemistry of Sulfide Minerals. *Reviews in Mineralogy and Geochemistry* **61**, 633–677 (2006).

Marini, L., Moretti, R. & Accornero, M. Sulfur Isotopes in Magmatic-Hydrothermal Systems, Melts, and Magmas. *Reviews in Mineralogy and Geochemistry* **73**, 423–492 (2011).

Questions?

Reach me at kaj.sullivan@ugent.be