

A multi-scale approach to controls on mineralization in the Fraser Zone, Western Australia



Geological Survey of
Western Australia



Curtin University

THE INSTITUTE FOR
GEOSCIENCE RESEARCH (TIGeR)



Many thanks to our partners

MRIWA

Creasy Group

Geological Survey of Western Australia

Curtin University

IGO

Legend Mining



Geological Survey of
Western Australia



Participants

- Katy Evans (lead CI, Curtin), and module 3: Controls on Tenor
- Chris Kirkland (co-CI, Curtin), leading module 1: Crustal architecture
- Tim Johnson (co-CI, Curtin), leading module 2: Petrochronology
- Mehrooz Aspandiar (co-CI, Curtin), leading module 4: Regolith
- Chris Clark (co-CI, Curtin)
- Raphael Quentin de Gromard (co-CI, GSWA, field support, structural insights)

- PhD students (Riley Rohrer, Katharina Kuper, Louisa Stokes)
- Postdoc: Ameen Mahbubul: Postdoc for Regolith module
- Curtin co-supervisors: Hugo Olierook, Alex Walker:
- With advice from: Dick England, petrographer, Steve Barnes (CSIRO)

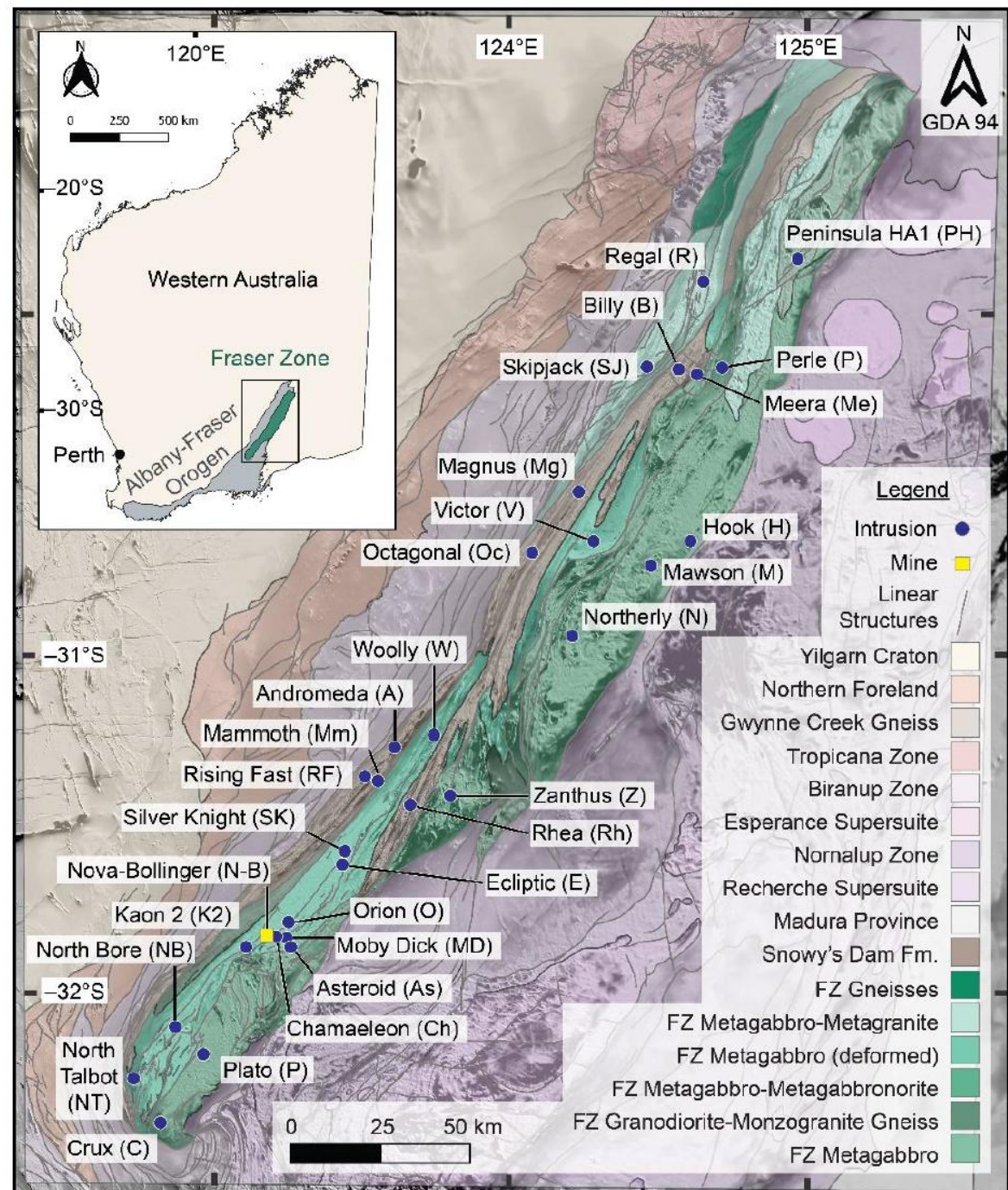
Project leads on from M470 (lead CI, Chris Kirkland)

- M470 focused on the whole Albany-Fraser Orogen, with modules focused on
 - Crustal Architecture
 - Petrochronology
 - Sulphur isotope systematics
- Developing a reliable chronostratigraphic and tectonothermal framework as a basis for mineral exploration.
- Known mineralization within the region was placed in a geological context using a mineral systems approach

Project objective and structure

- Objective was to apply a parallel, but targeted, approach to the Fraser Zone
- Four modules
 - Crustal architecture
 - Petrochronology (pressure–temperature–time structure)
 - Controls on Tenor
 - Expressions of mineralization within the regolith
- Each module was linked to a PhD studentship, except for the regolith module where a postdoctoral researcher was engaged for 15 months after the selected PhD student pulled out for Covid-related reasons.

The Fraser Zone, Western Australia



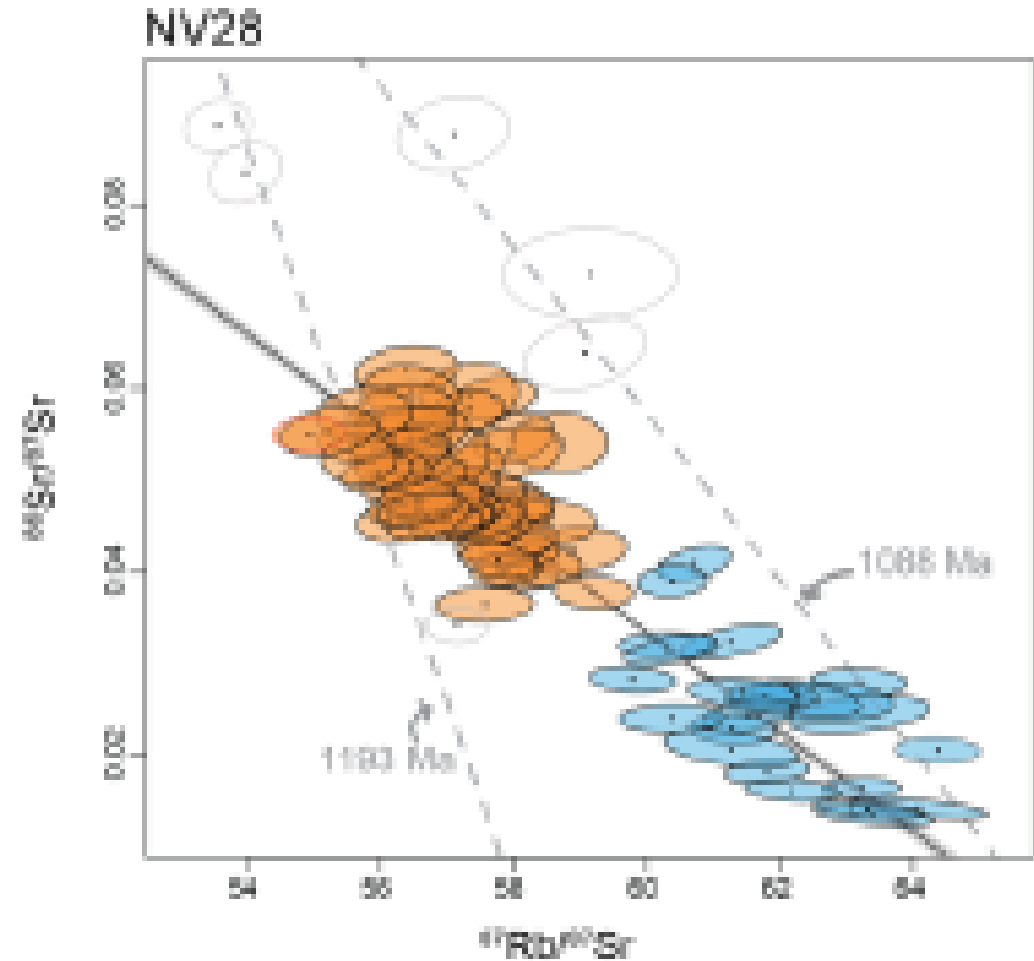
Module 1: Architecture and stratigraphy

- Through the lens of intrusive rocks
- Using multiple isotope systems and minerals to constrain the architecture, components, and evolution of the Fraser Zone



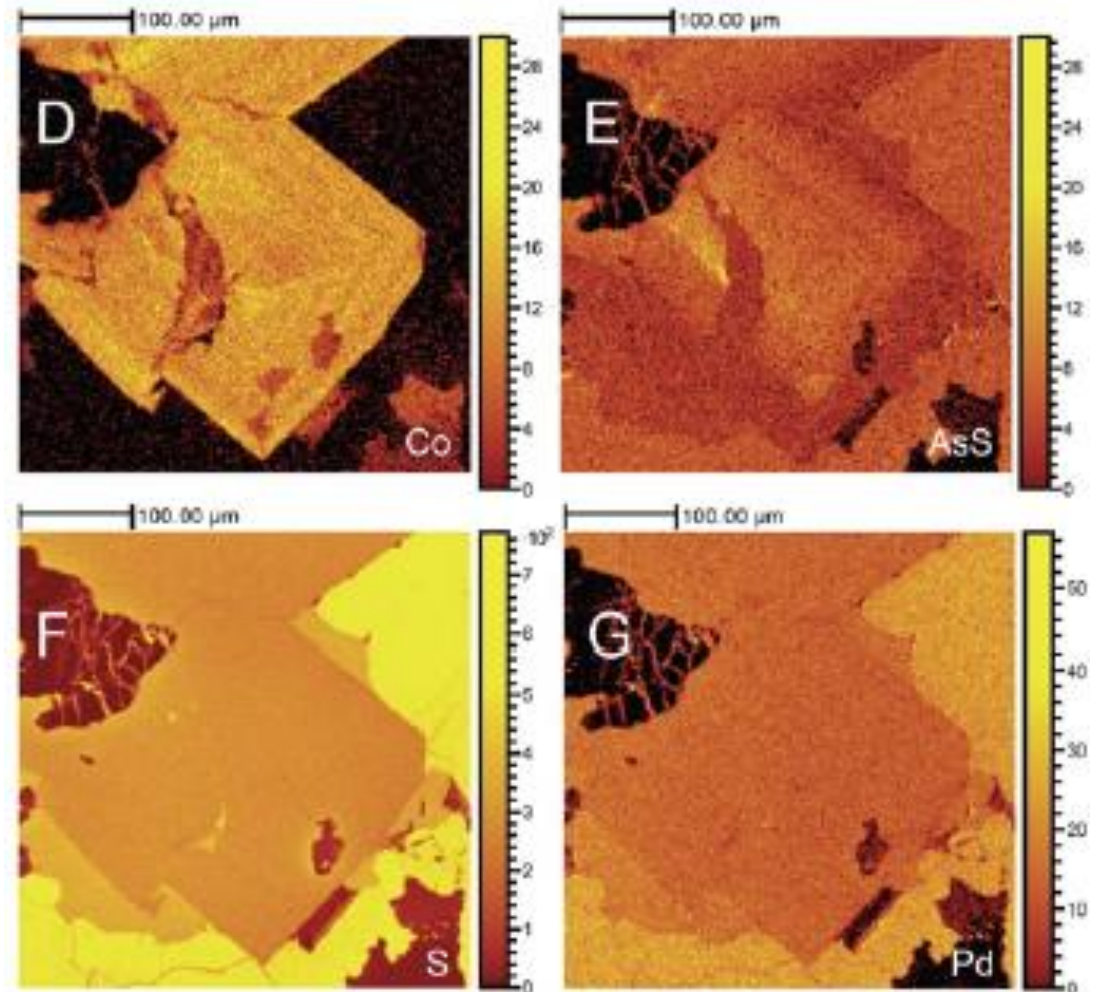
Module 2: Petrochronology

- Through the lens of metasediments, using thermobarometry and geochronology
- Determining the pressure, temperature and timing of metamorphism across the Fraser Zone, revealing ancient structures and gradients



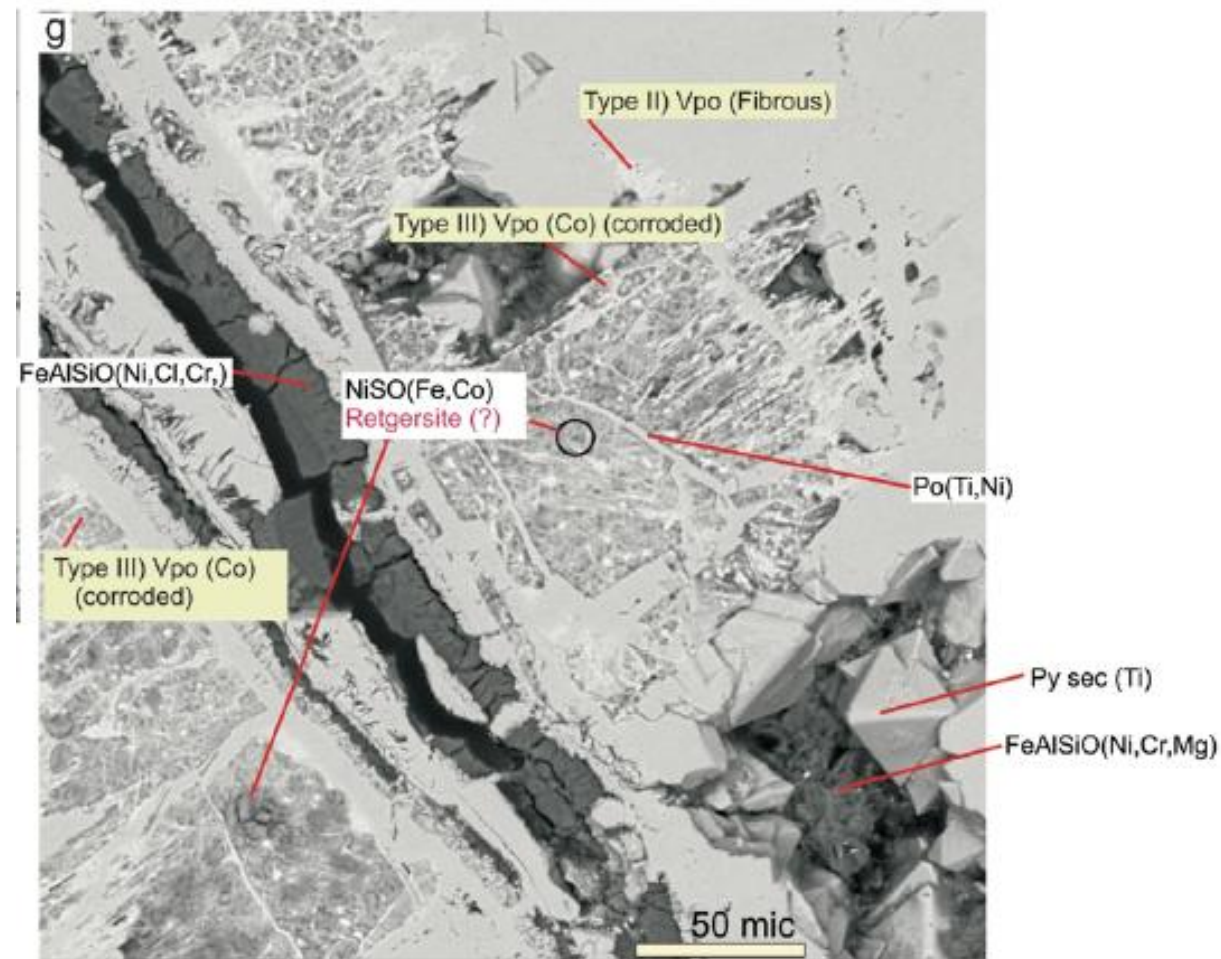
Module 3: Controls on tenor

- Through the lens of mineralized rocks, using sulfur isotopes and geochemistry
- What factors controlled the probability of mineral deposit formation within the Fraser Zone, and how do we recognize them?



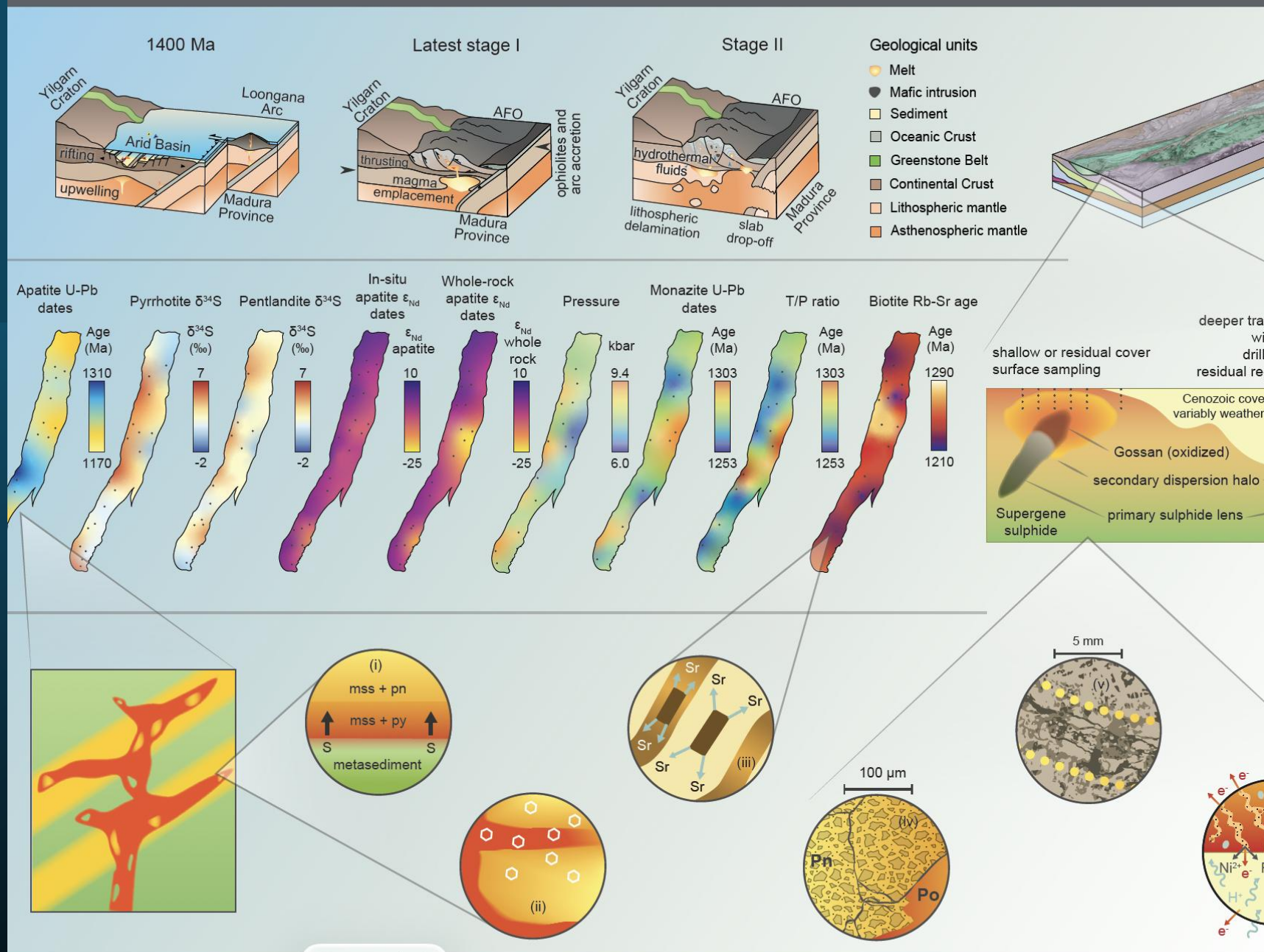
Module 4: Regolith

- Through the lens of weathered mineralized rocks
- What is the surface expression of a weathered magmatic Ni–Cu–Co magmatic sulfide mineral deposit within the ancient landscape of the Fraser Zone?



Integration

Time

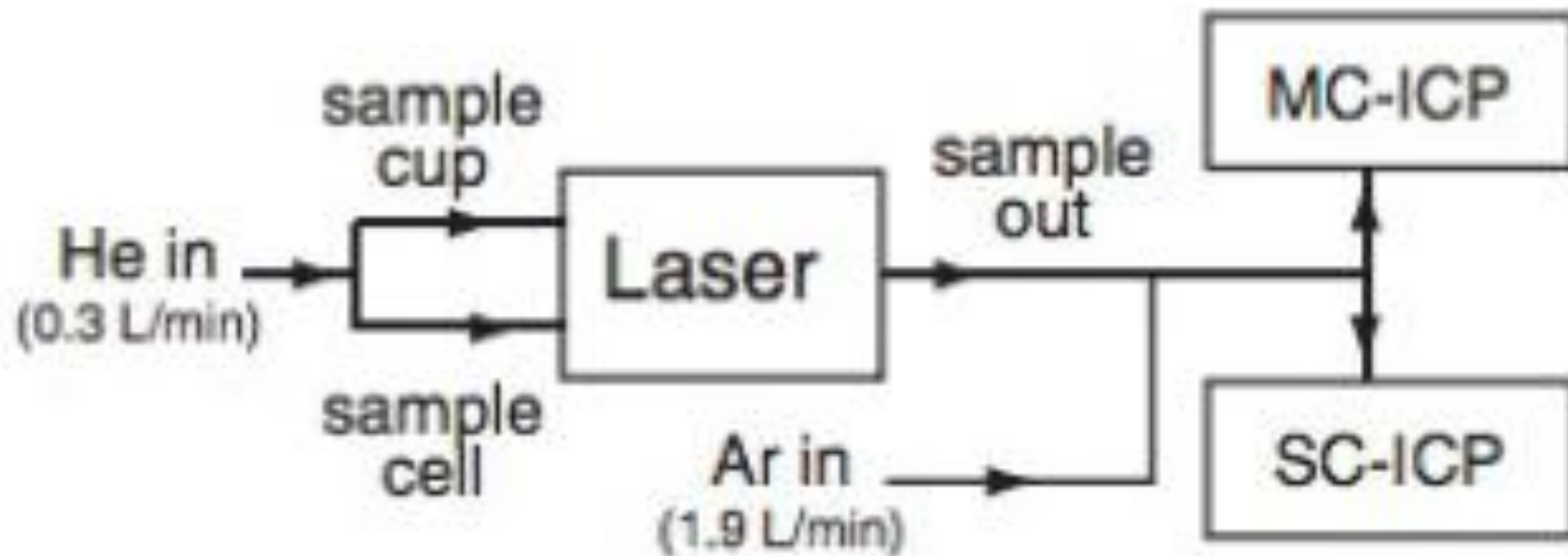


Screenshot

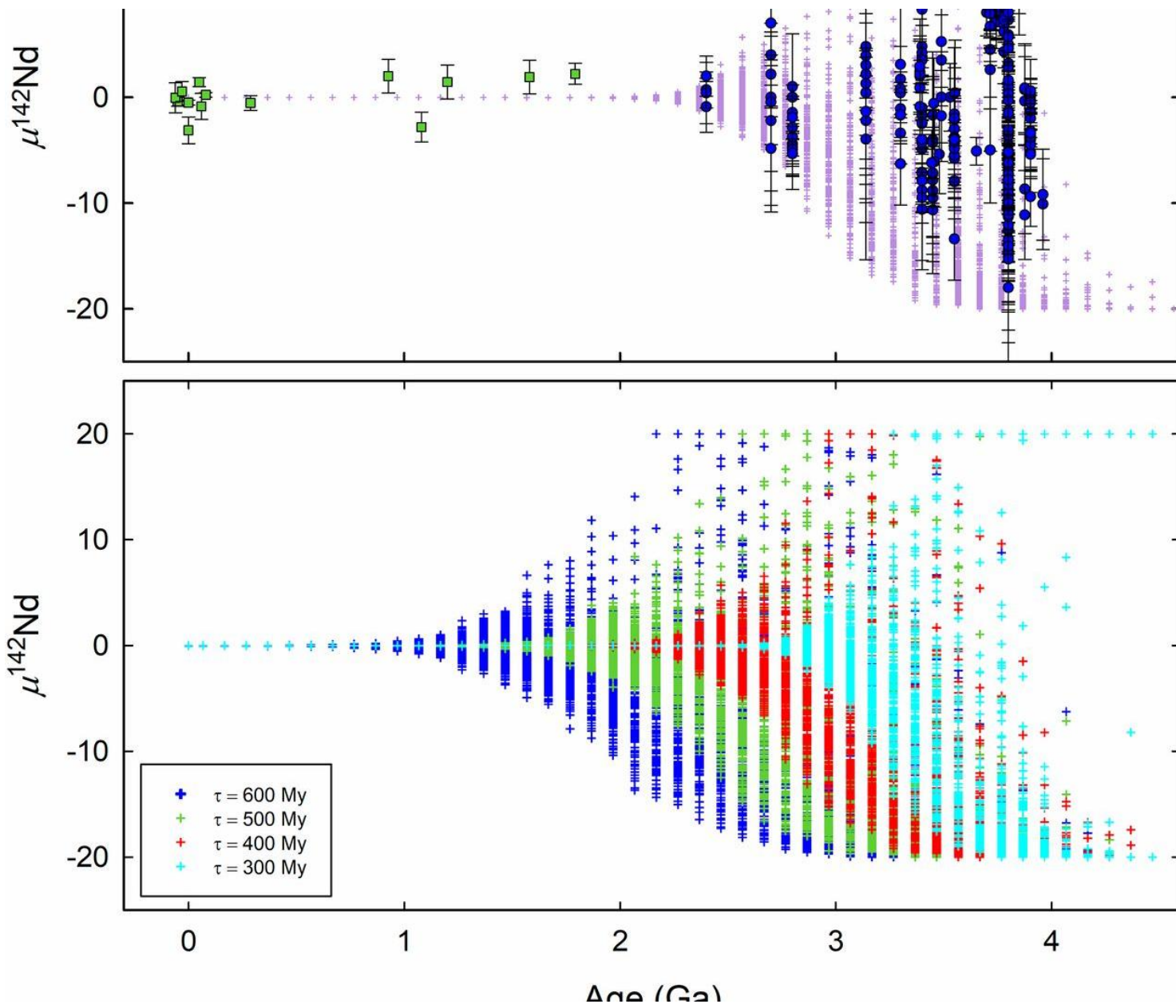


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Novelty: cutting-edge analytical techniques



Extinct isotopes

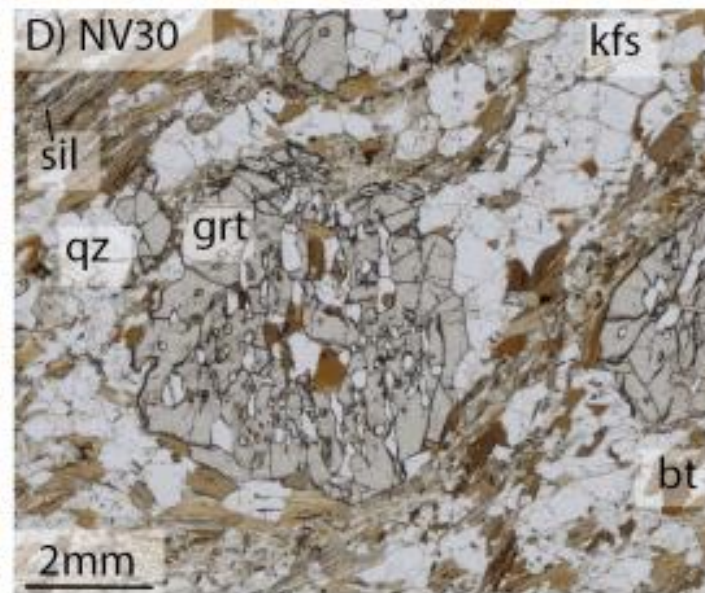
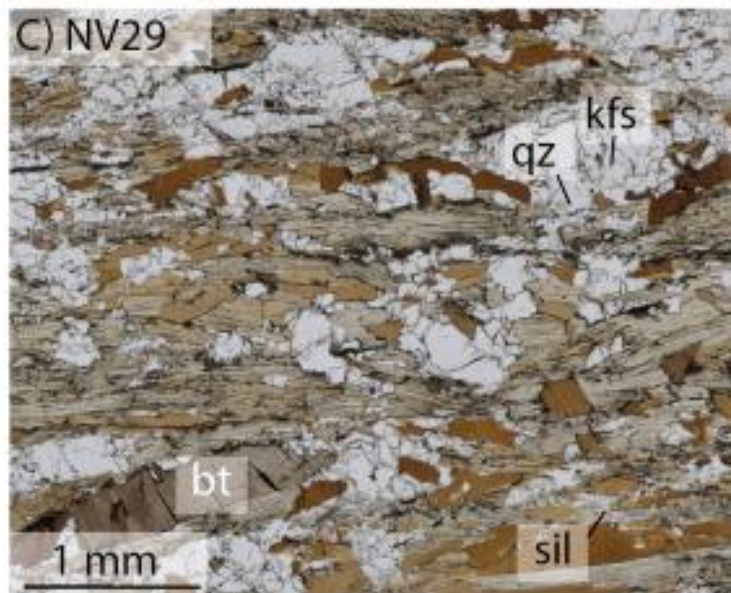
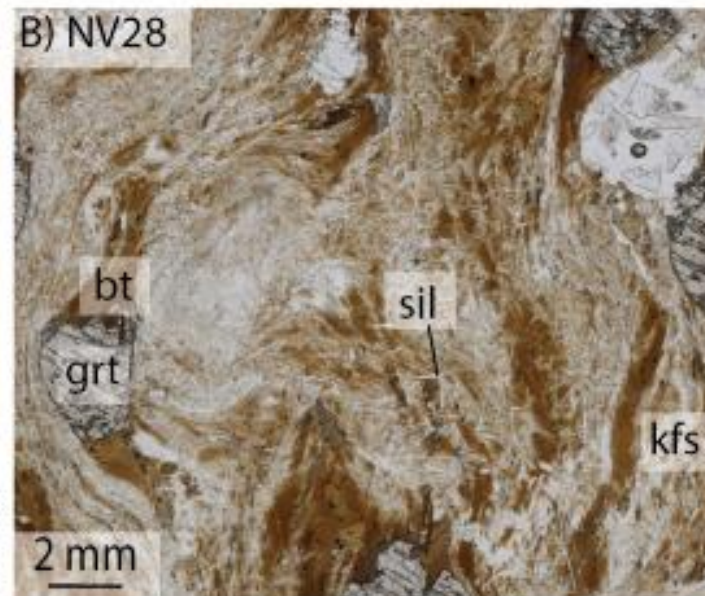
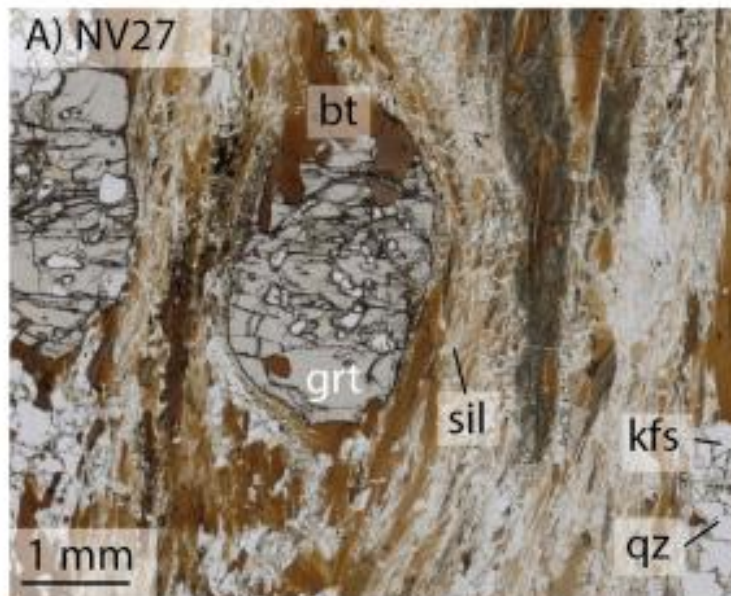


Time-of-flight secondary ion mass spectroscopy




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Petrography



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Outcomes, insights and integration



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Collaborative outcomes

- Continuation and extension of collaboration between Curtin University, Creasy Group, and the Geological Survey of Western Australia, deepening and broadening the collaboration to include new topic areas, such as the regolith work;
- New collaborations with IGO and Legend Mining. IGO holds a huge volume of data from the study area, and this collaboration has benefited greatly from access to those data, to the expertise within IGO.
- Intensive collaborations between the three PhD students and staff at the partner organisations. These students have had valuable opportunities to interact with and learn from the project sponsors during site visits and regular meetings.



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Data Science

- The rapid-flow through analytical techniques (TIMA, LASS) produced large datasets
- The PhD students attended workshops where tools used to explore large datasets
- For example: Data Mosaic Workshop: Automating the Geological Interpretation of Drill Hole Data, Perth WA.
- The students used a range of statistical techniques to test the validity of their conclusions and to interpolate their data onto maps.



Research training

- Geological and geochemical training for research students in the application of science to industry needs
- Established and exploited advanced analytical infrastructure and human resources in WA
- Provided WA-based exploration teams with high-level “in-house” analytical and interpretive expertise (and vice versa)
- Leveraged research benefits from the financial investment into research infrastructure from State and Federal governments, and WA-based institutions (Curtin, UWA, GSWA, CSIRO).

New datasets

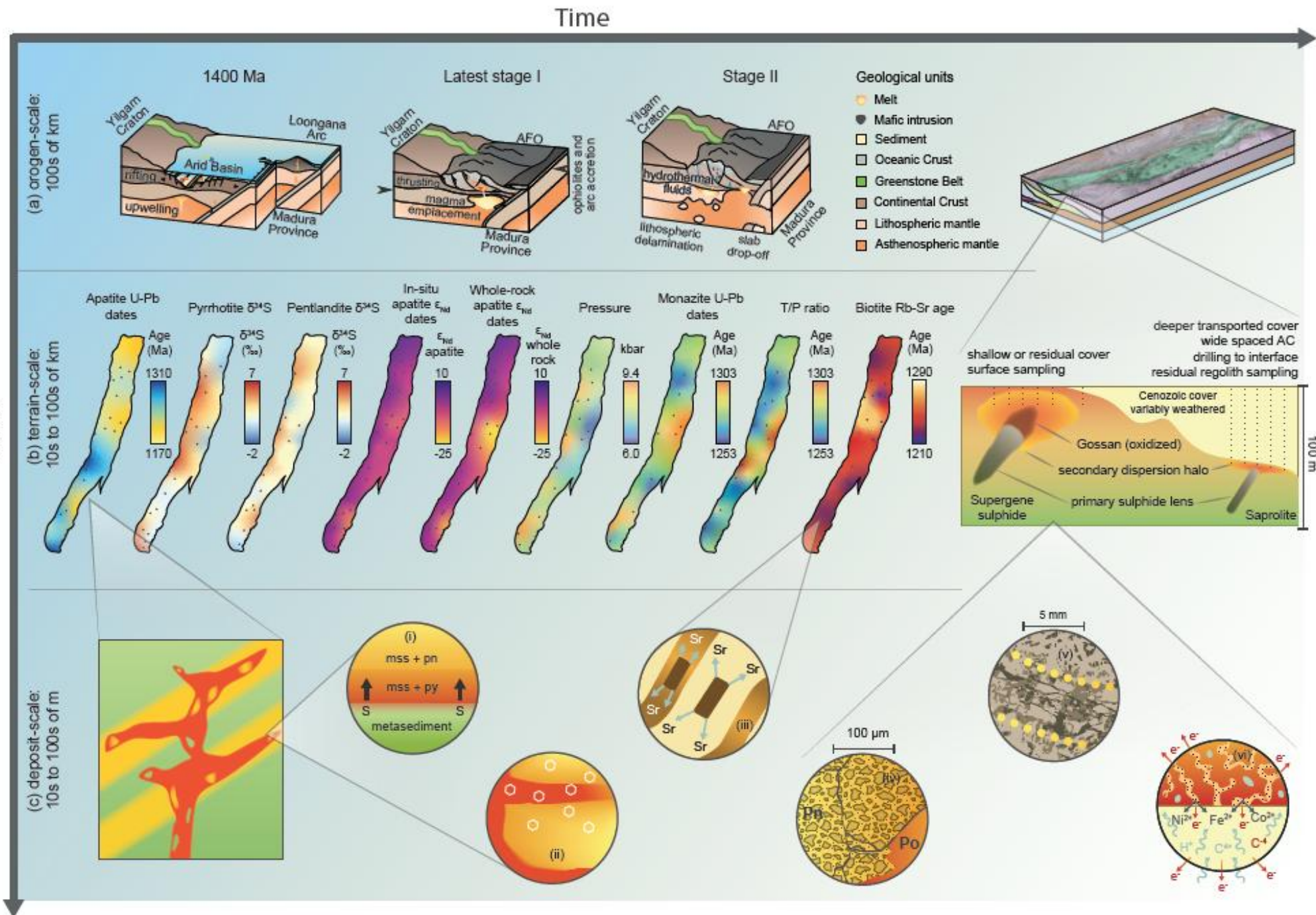
- Research outputs have been available to the project partners through reports and presentations throughout the project
- Research data documented in the three publicly available theses as well as the final report.
- The final datasets will be available publicly via MRIWA and, where applicable, GSWA databases
- Principal results have been, or will be, be released as publications in academic journals.
- Results and interpretations have been presented at academic and industry conferences.



A 3D rendering of a red puzzle piece with the word "Integration" written on it in white. The red piece is the central focus, surrounded by several white puzzle pieces. The pieces are arranged in a grid-like pattern, with some pieces missing, creating a sense of a puzzle being solved or in progress. The lighting is soft, highlighting the edges and the glossy surface of the pieces.

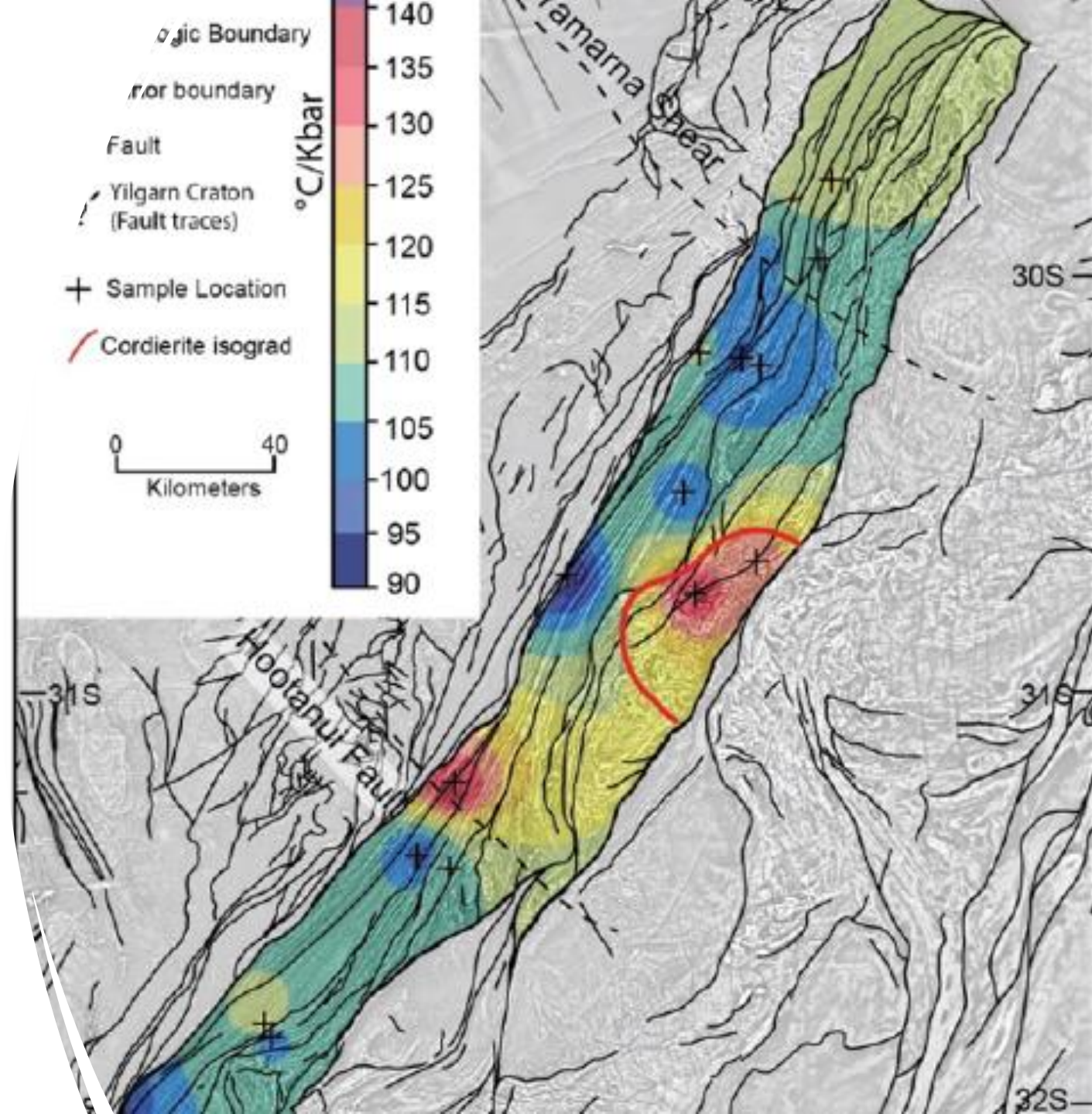
Integration

Regional Scale

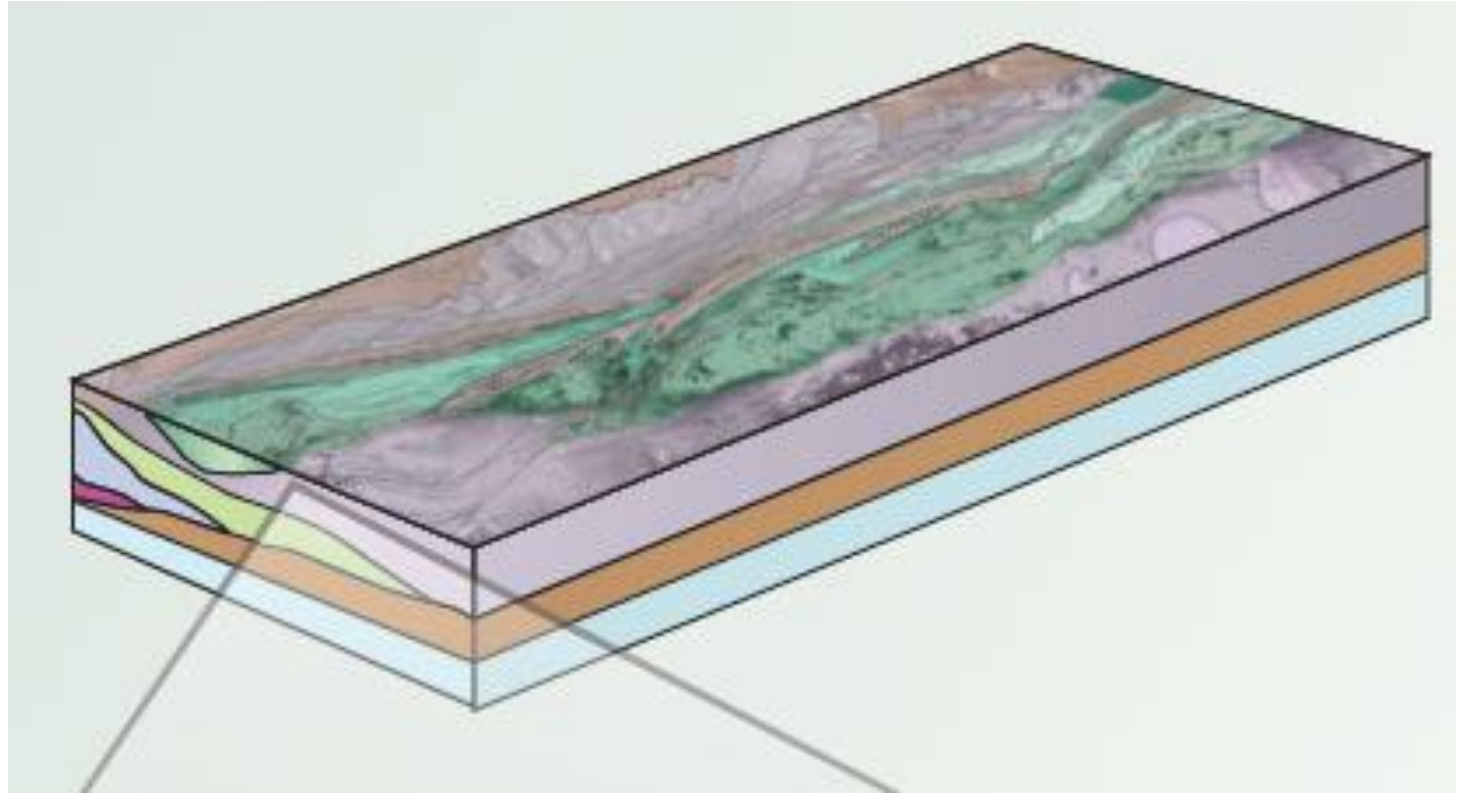


Regional scale patterns in thermobarometry

- Low pressures around the Mawson Deposit, where the oldest ages for metamorphic cooling and exhumation are also recorded
- Boundaries, broadly speaking, align with faults such as the Yamarna Shear Zone, that divide the ancient Yilgarn into its main structural blocks,



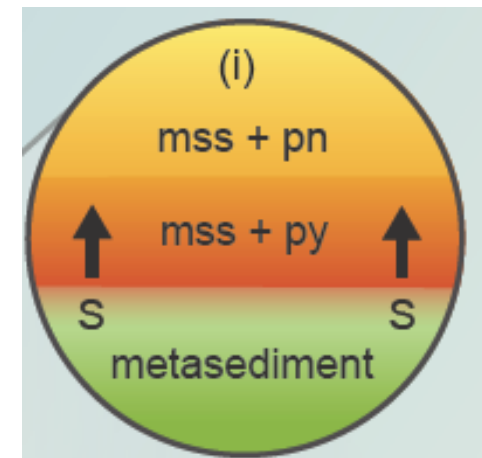
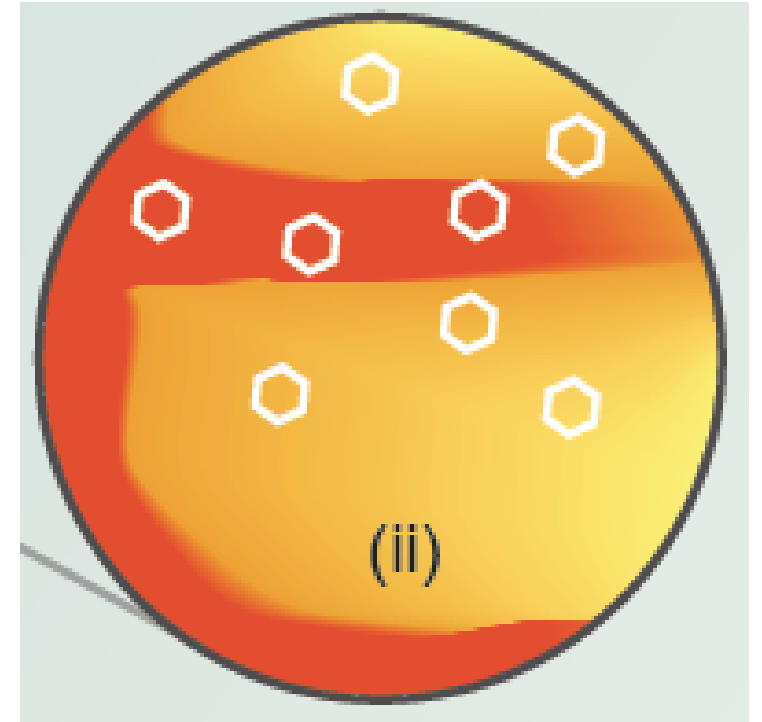
East-west variation



- the ϵ_{Nd} map and biotite model-age map reveal east–west variation across the Fraser Zone
- This may relate to variations in crustal thickness and the presence of ancient fragments of Yilgarn Craton beneath the eastern Fraser Zone
- Consistent with geophysical models

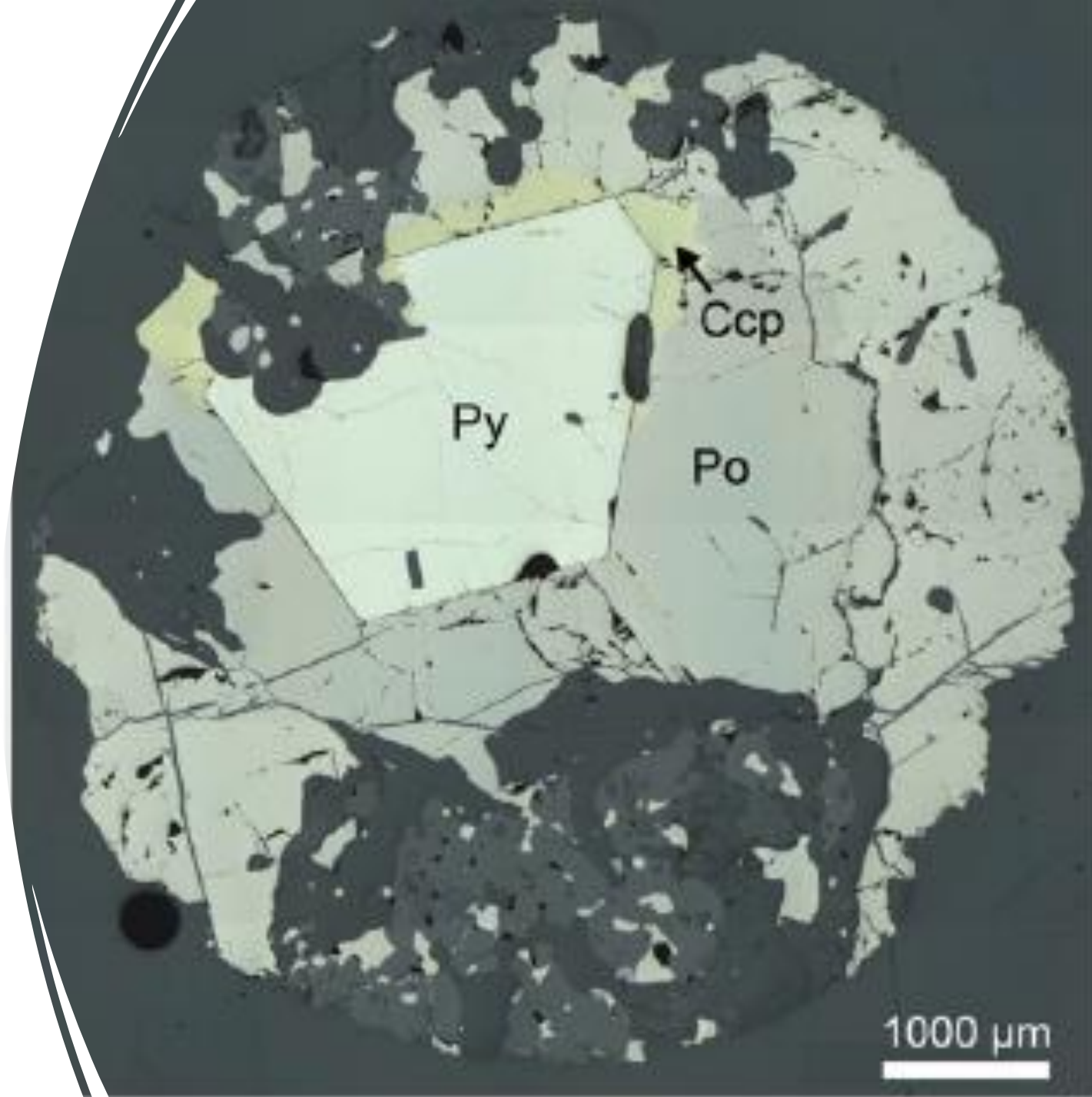
Deposit Scale

- Lu–Hf and U–Pb isotopic ratios, and petrochronological characteristics from a single prospect are relatively consistent – deep processes homogeneous
- S isotope ratios and ϵ_{Nd} show variation on the deposit scale and length-scales smaller than the deposit scale, highlighting shorter length-scales of local mixing and incomplete homogenization



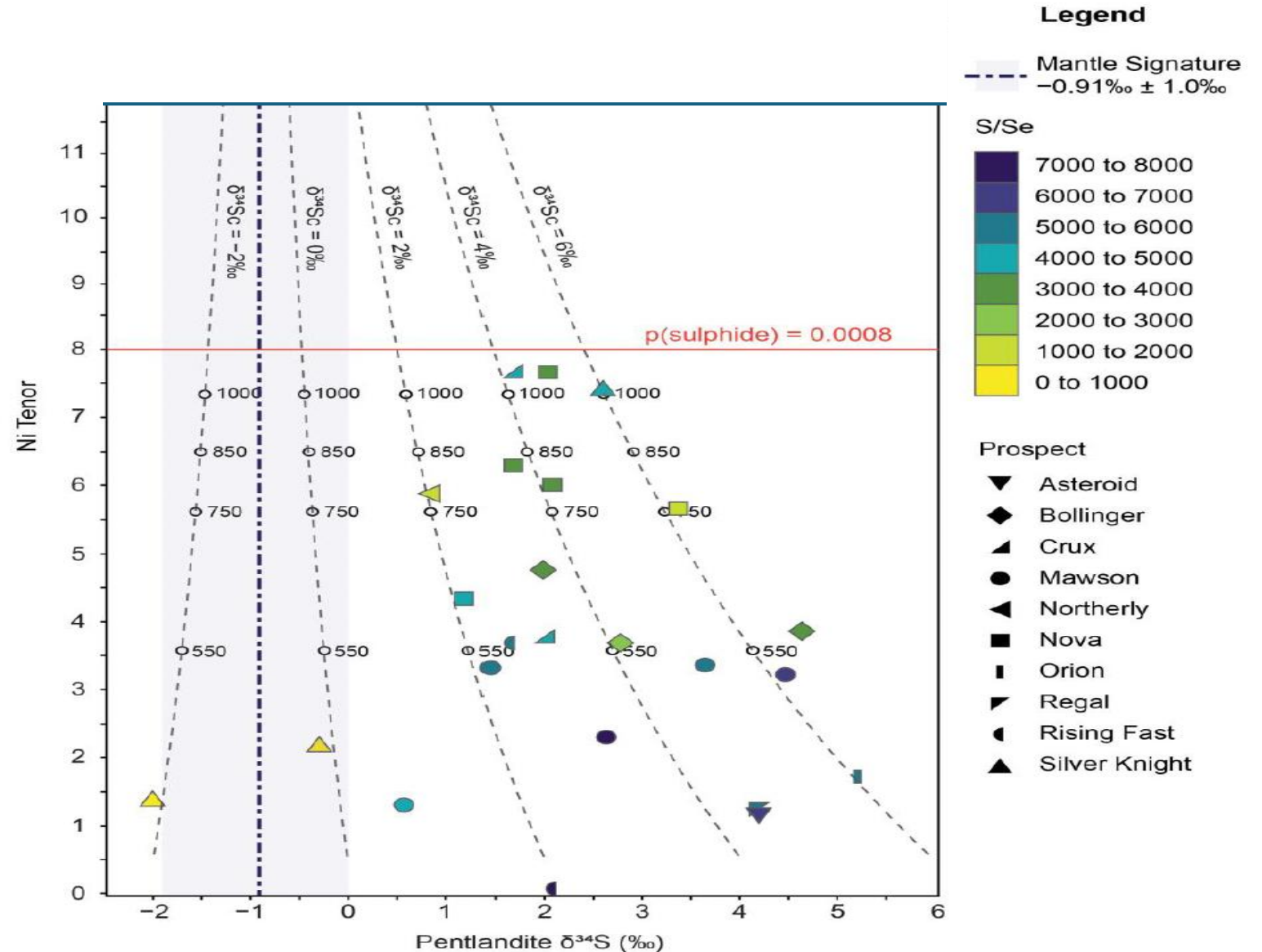
Thin section to micrometre scale

- Multiple indicators of limited length-scale equilibrium
 - S isotopes
 - Whole-rock versus apatite ϵ_{Nd} values
 - Petrographic controls on Rb–Sr biotite ages
 - Pyrite formed at high temperatures
 - Oscillatory Y zoning in garnet, and complex zoning in monazite



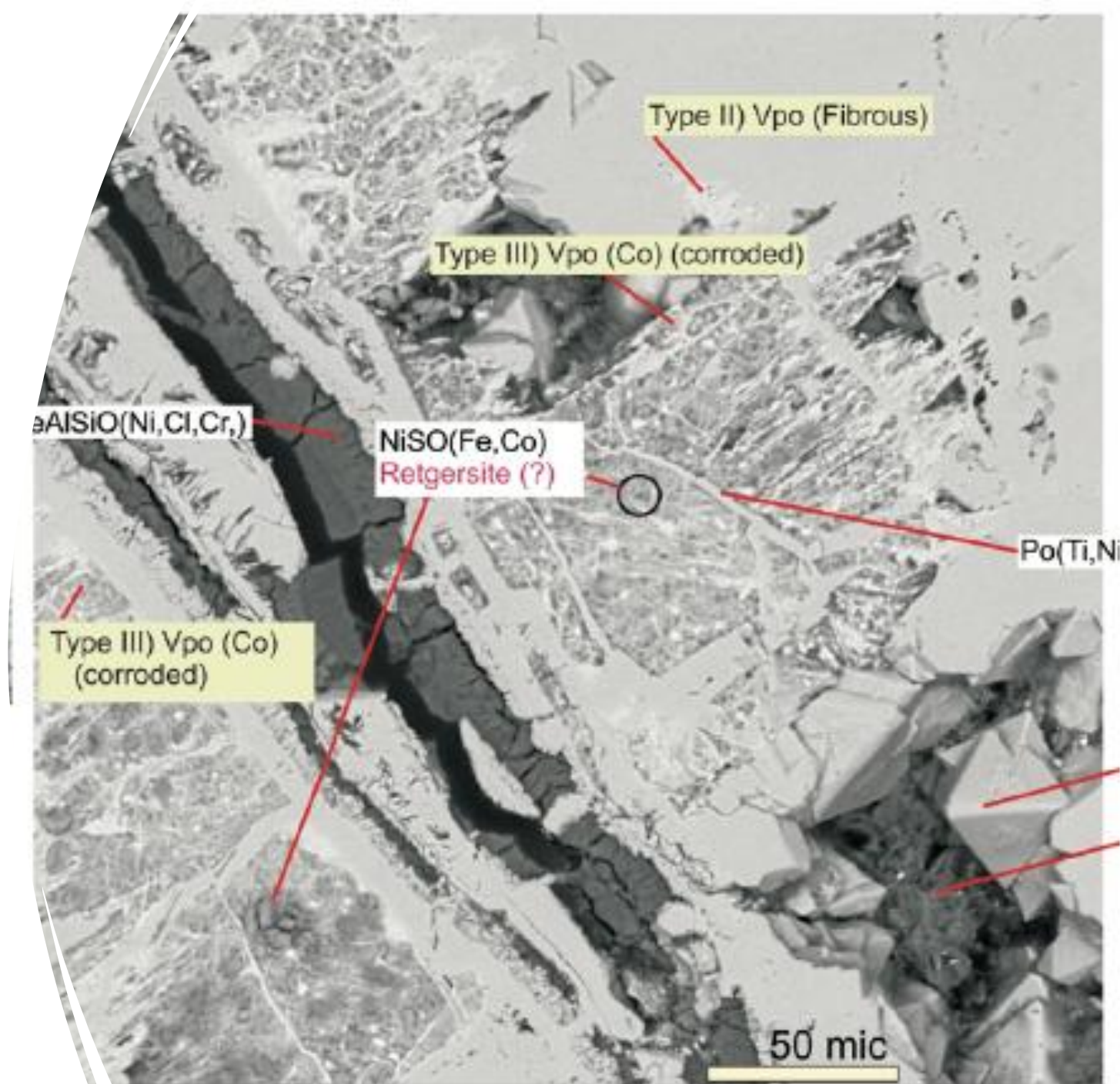
Implications for mineralisation

- Inferred thinning of the wedge-shaped Fraser Zone towards the west implies a greater contribution of juvenile material to the west
- S isotope vs. tenor curves indicate that there may be a sweet spot for sediment assimilation, although further work is needed to investigate this
- Incomplete mixing may record a systems that were cut short before they had fully evolved – potentially by changes in geodynamic setting



Regolith findings - implications

- Regolith studies provide the first characterization of gossans formed above magmatic Ni–Cu–Co-sulphide mineralisation
- Ni- and Cu-bearing minerals such as atacamite, retgersite, and chalcantite are preserved within the in-situ regolith
- Regolith characteristics are the product of complex environmental evolution over millions of years





Thank you!



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