



Australian Government
Geoscience Australia



Exploring for
the **Future**

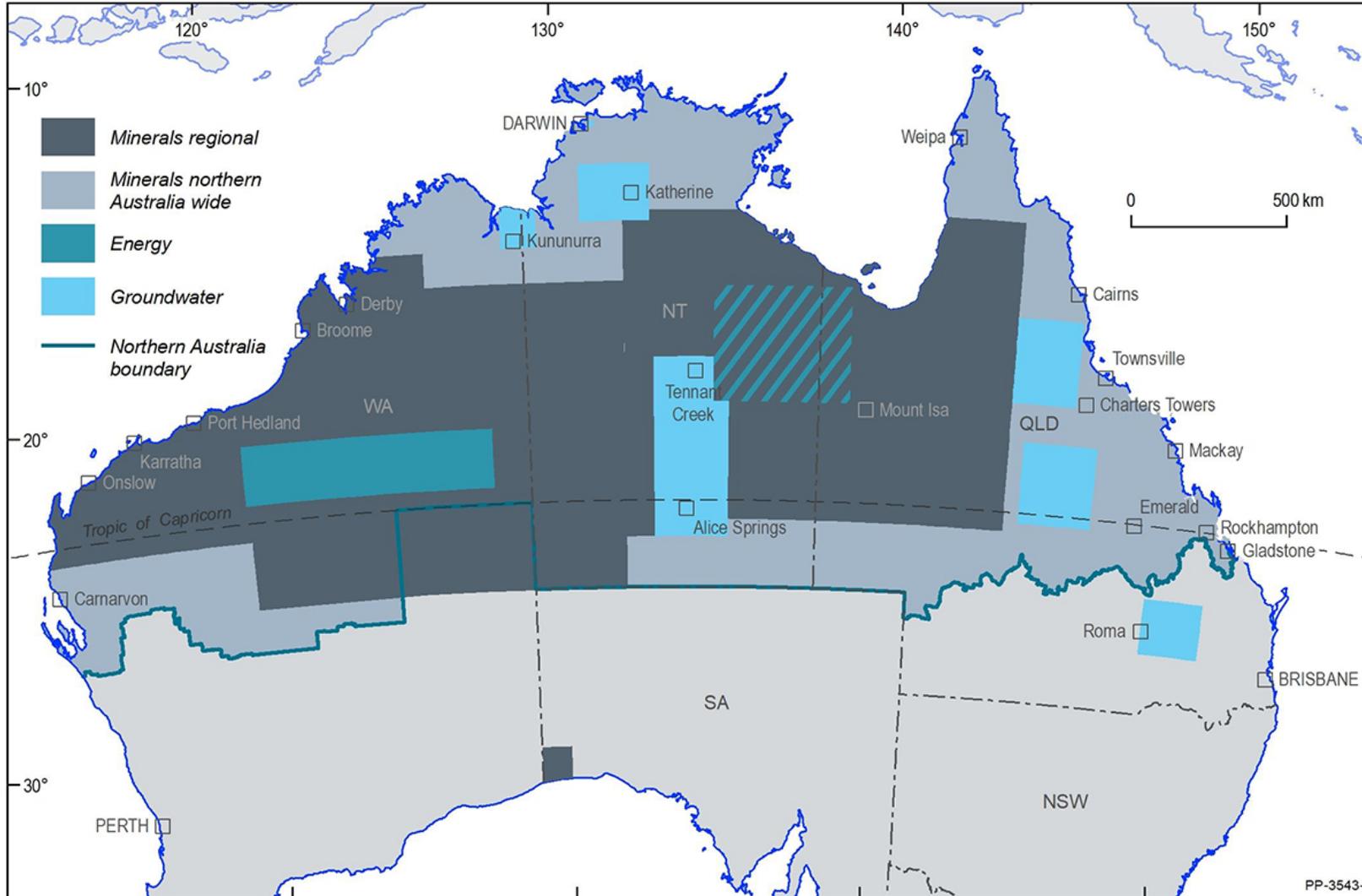
minerals | energy | groundwater

Exploring for the Future Expanded and Extended

Karol Czarnota on behalf of the Exploring for the Future Team

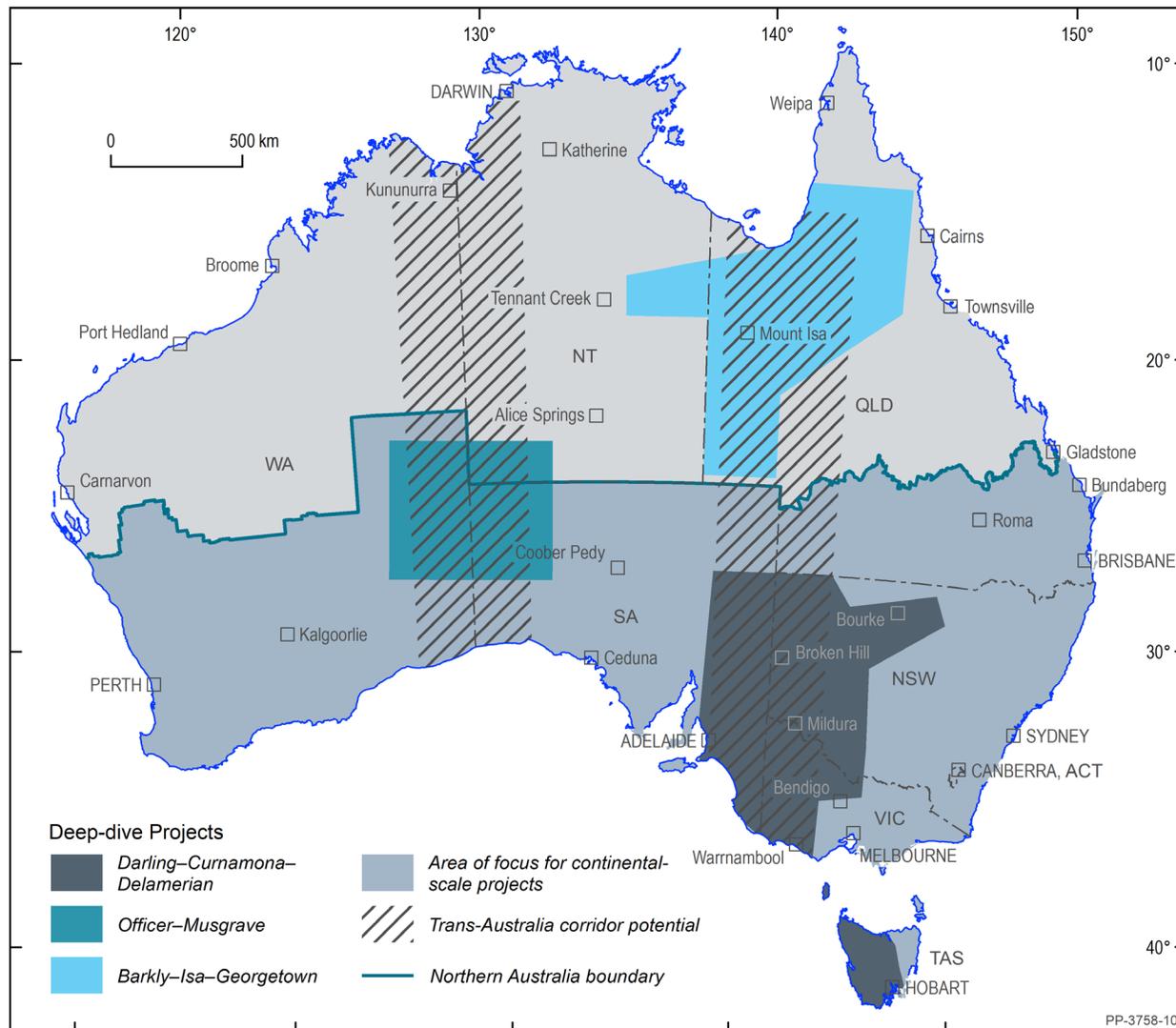


Exploring for the Future Phase One (2016-2020) – \$100 M



- Focused on Northern Australia
- National projects covered >2 M km²
- Focus areas:
 - Tennant Creek to Mount Isa
 - Kidson Sub-basin
 - Stuart Corridor
 - East Kimberly
 - Eastern Volcanic Provinces
 - Darwin
- 21 collaborative activities

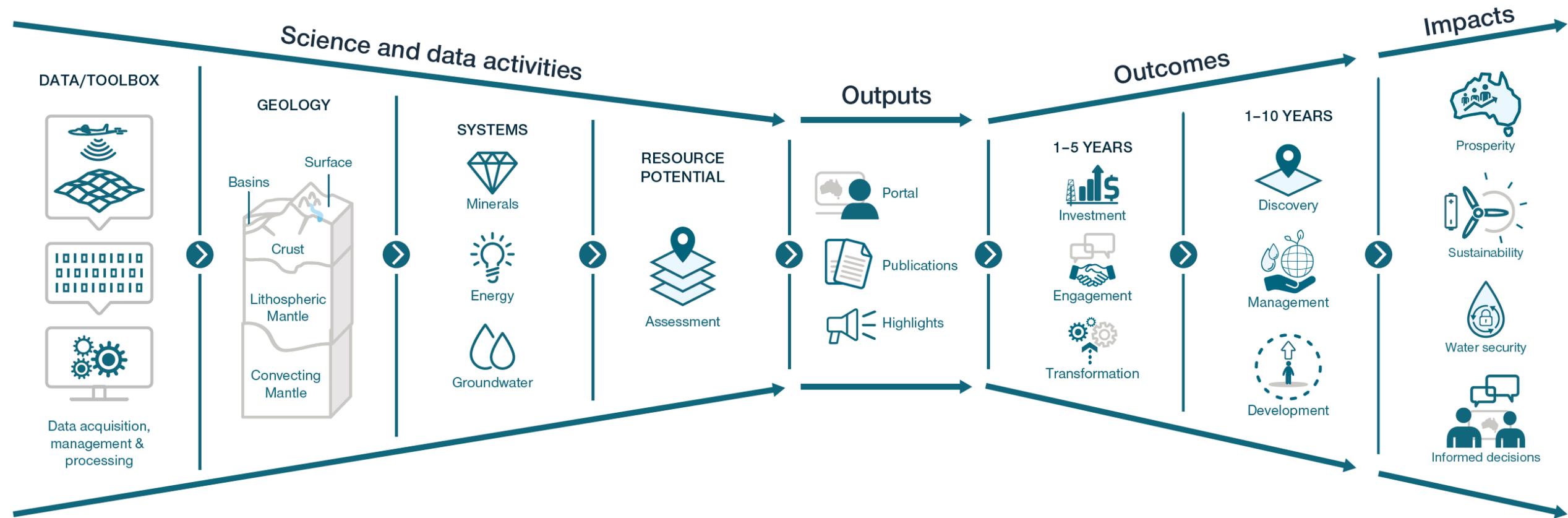
Exploring for the Future Phase Two (2020-2024) – \$125 M



- **3x Continental-scale projects** with a focus on southern Australia:
 - Australia's Resources Framework
 - Australia's Resource Energy Future
 - National Groundwater Systems
- **3x Deep-dive projects** in two trans-continental corridors
 - Darling-Curnamona-Delamerian
 - Barkly-Isa-Georgetown
 - Officer-Musgrave
- **2x program-support projects**
 - Enhanced data delivery
 - Geoscience knowledge transfer

A Pathway to Exploring for the Future

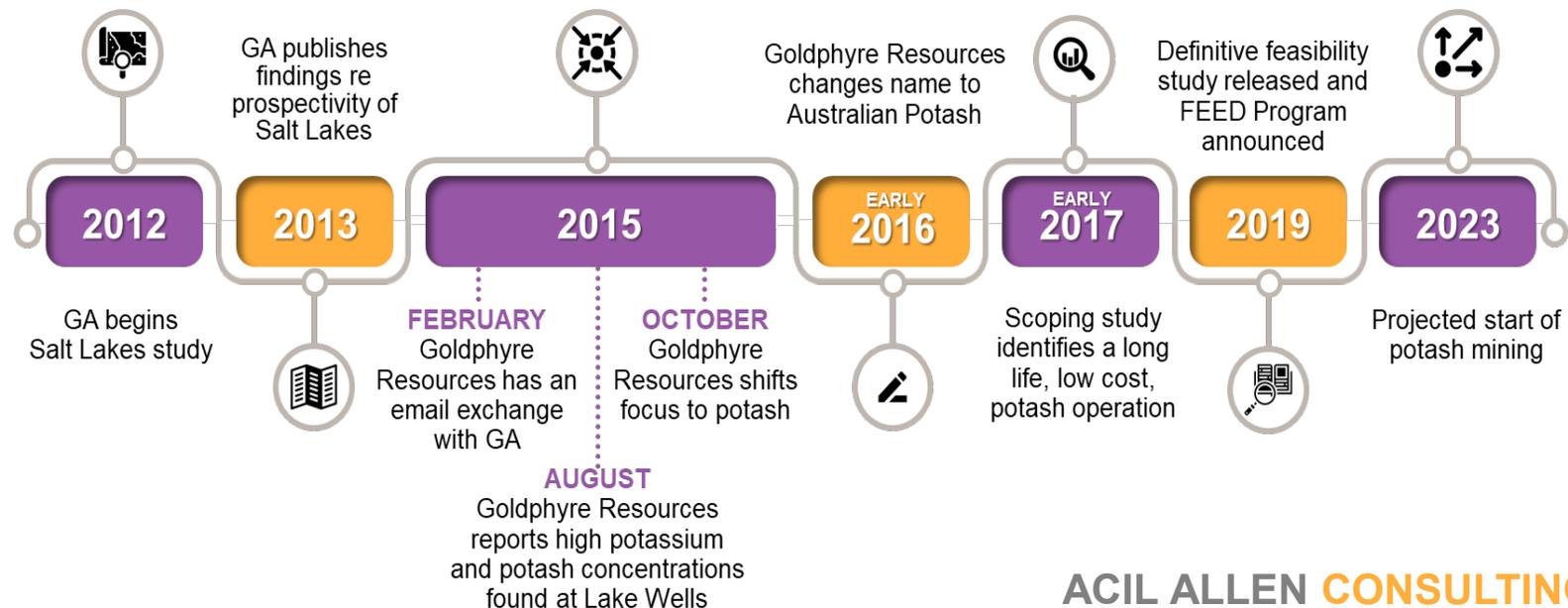
Vision: To support a strong economy, resilient society and sustainable environment for the benefit of Australians through an integrated geoscientific understanding of our mineral, energy and groundwater potential.



Impact (Prosperity) – Potash Example



GA start → Lake Wells potash mining ≈ 11 yrs

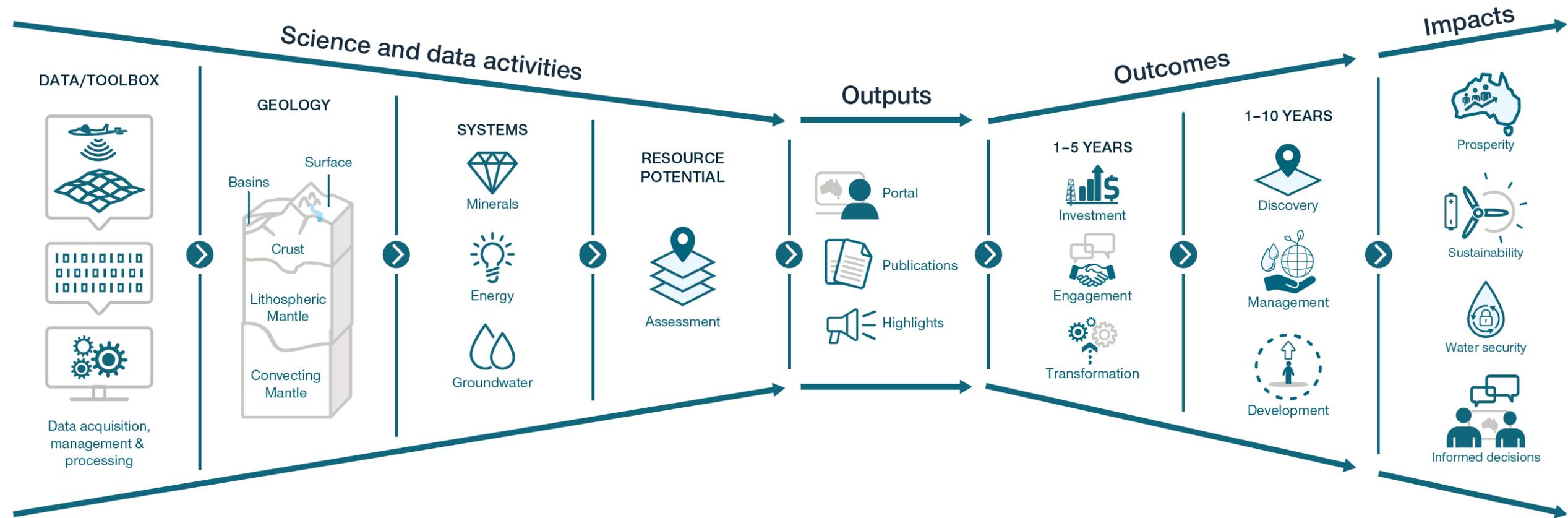


Expenditure (2 years) (2018 \$)		Net benefit for every \$ spent by GA (assuming Lake Wells deposit becomes a mine)	
GA	Partners	Australia	Comm. Government
\$2.7 m	-	\$1 : \$158 – \$254	\$1 : \$65 – \$93

<http://pid.geoscience.gov.au/dataset/ga/145195>

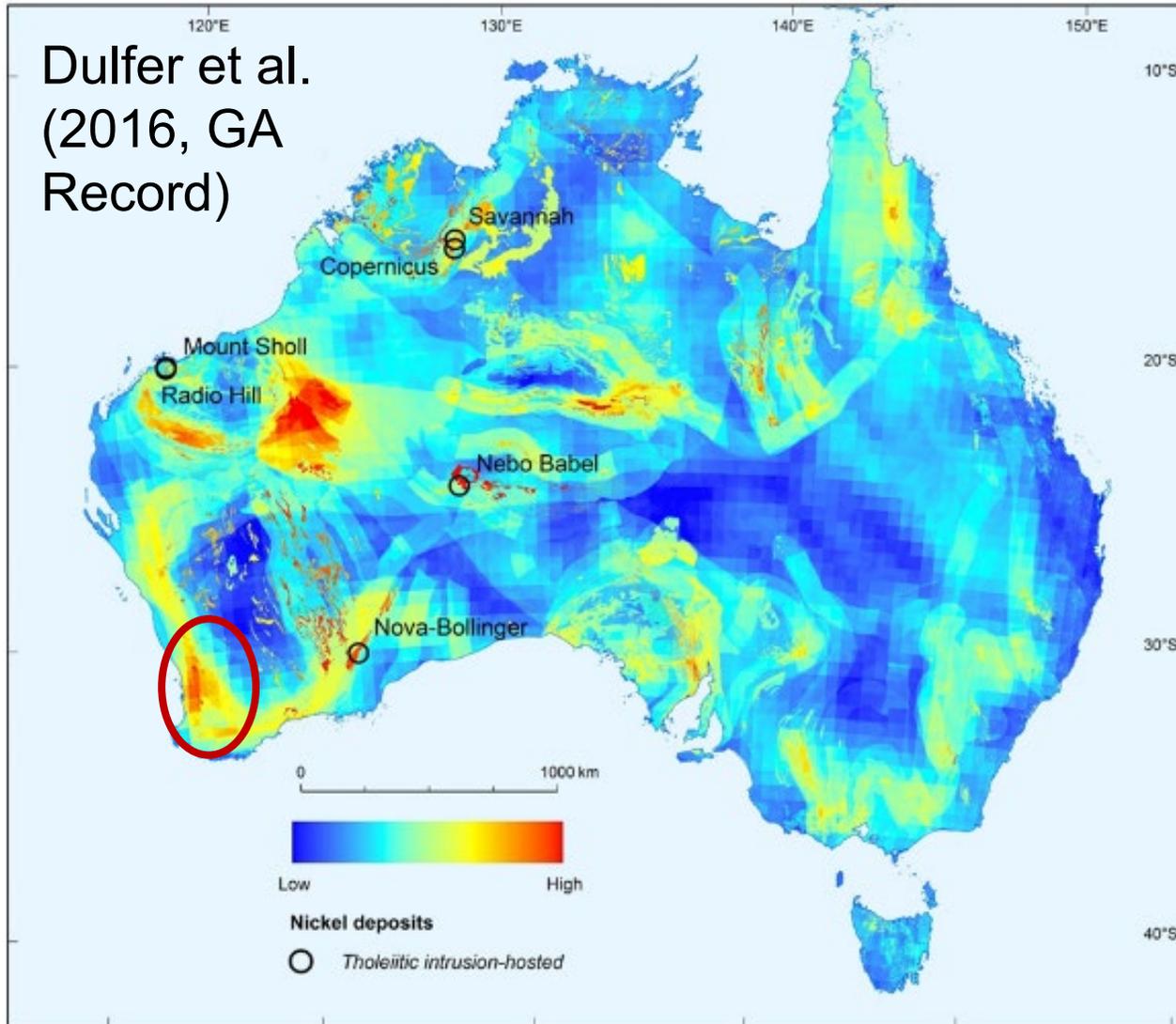
A Pathway to Exploring for the Future

Vision: To support a strong economy, resilient society and sustainable environment for the benefit of Australians through an integrated geoscientific understanding of our mineral, energy and groundwater potential.

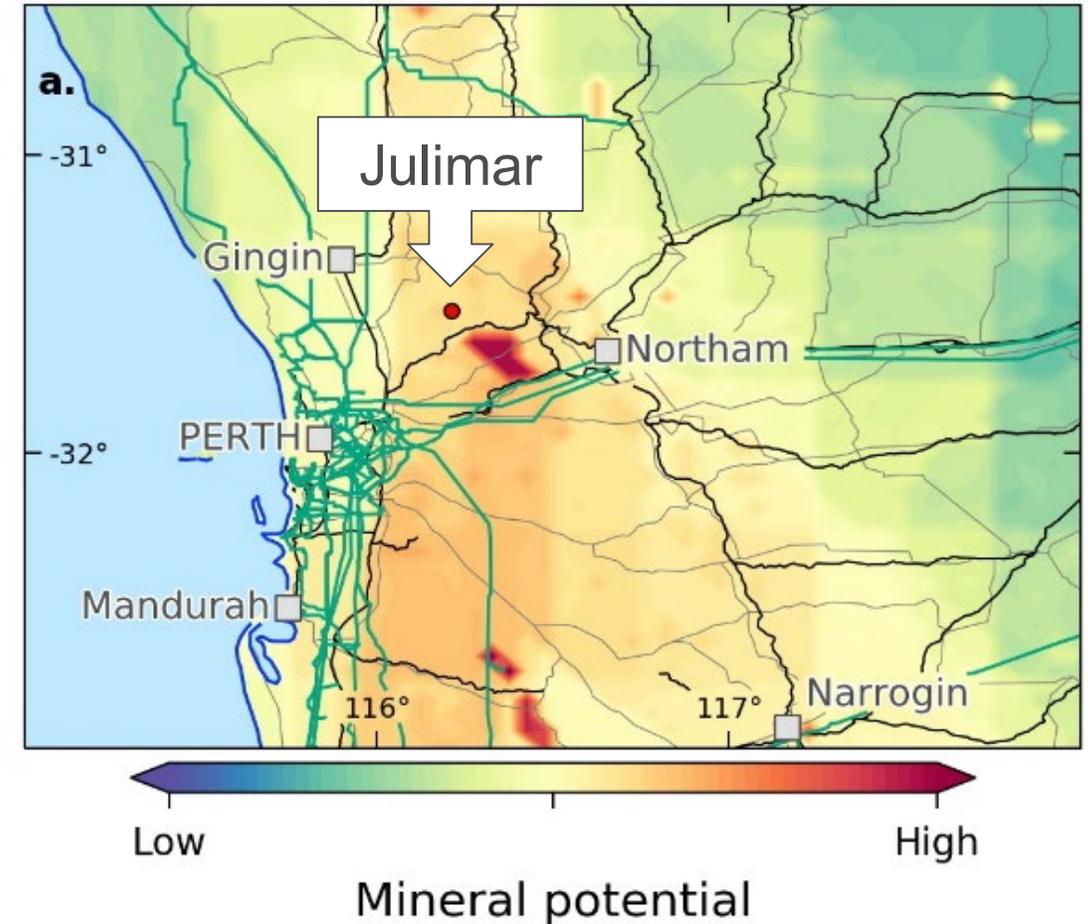


Outcome (Discovery) – Ni-Cu-PGE Discovery Example

Dulfer et al.
(2016, GA
Record)

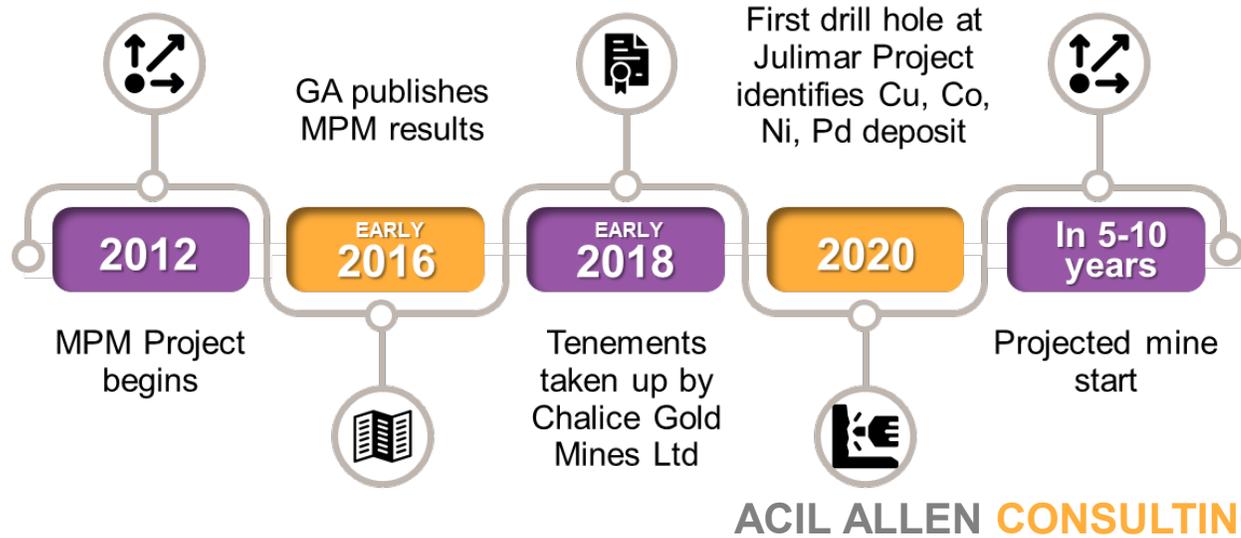


Mineral potential map for
PGE-Ni-Cu sulfide deposits



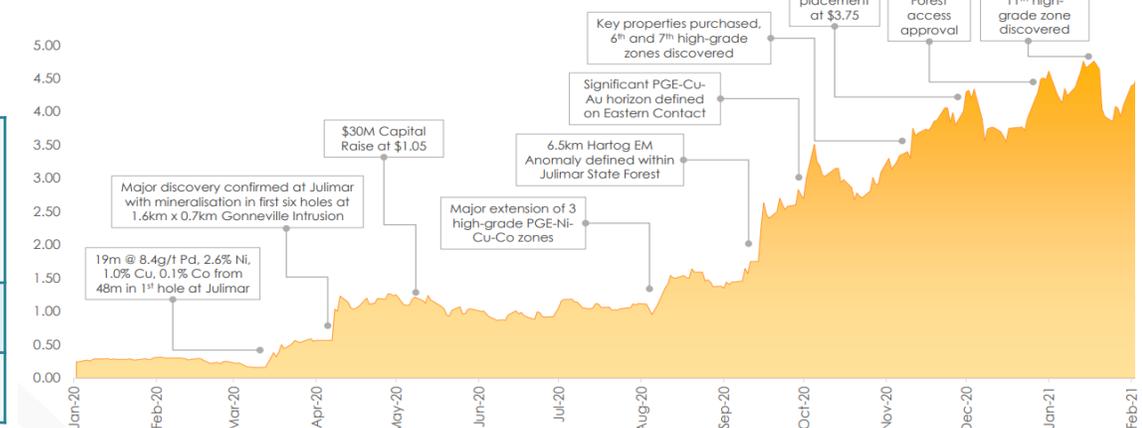
Outcome (Discovery) – Ni-Cu-PGE Discovery Example

GA start → PGE-Ni-Cu-Co-Au mine ≈ 13–18 yrs



Expenditure (4 years) (2018 \$)		Net benefit for every \$ spent by GA (assuming Julimar prospect becomes a mine)	
GA	Partners	Australia	Comm. Government
\$1.6m	-	\$160 – \$525	\$49 – \$157

CHN Share Price Chart (A\$/share)

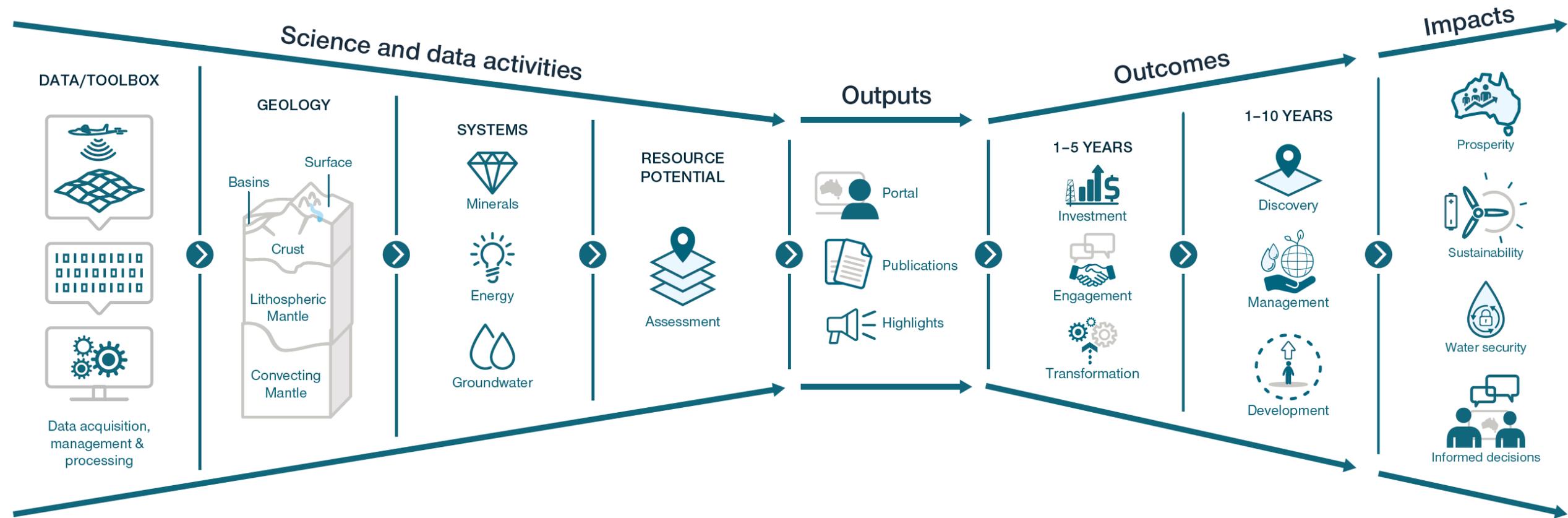


>2,000% Total Shareholder Return since January 2020

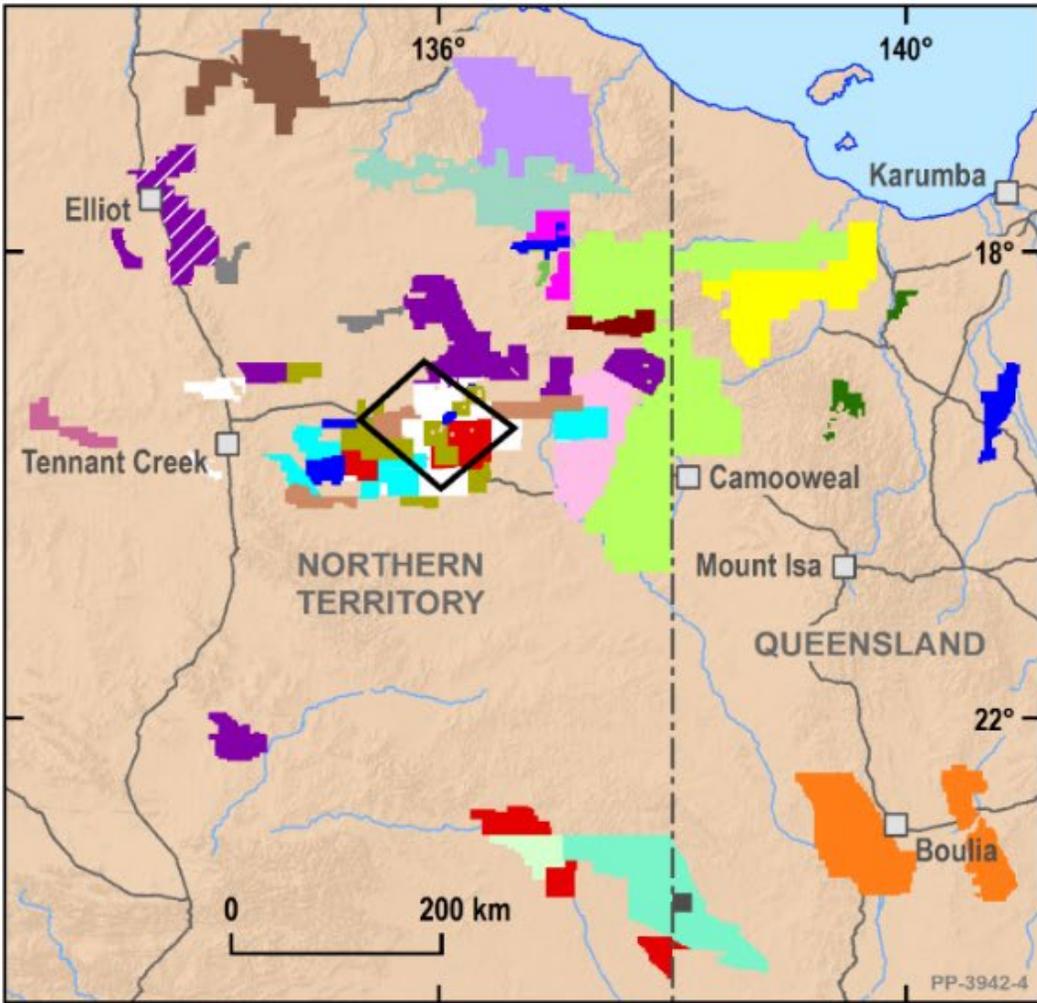
chalicemining.com

A Pathway to Exploring for the Future

Vision: To support a strong economy, resilient society and sustainable environment for the benefit of Australians through an integrated geoscientific understanding of our mineral, energy and groundwater potential.



Outcome (Investment) – Tenement Uptake (2016-2020)



- Anglo American Exploration Pty Ltd**
- Armour Energy Ltd**
- Middle Island Resources Ltd**
- Baudin Resources Pty Ltd/ BHP joint venture**
- Baudin Resources Pty Ltd**
- Brema Resources Pty Ltd**
- B.S.T. Explorations Pty Ltd**

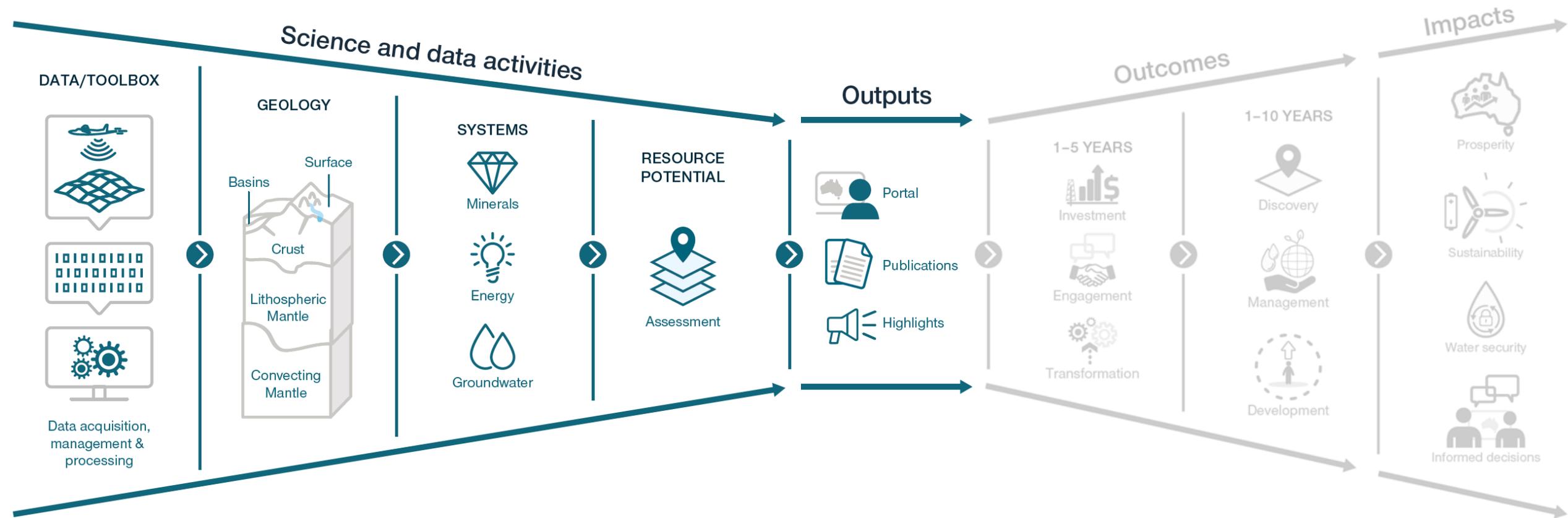
- Castillo Copper Ltd**
- Cedar Resources Pty Ltd**
- Cientifica Pty Ltd**
- Harkiss Mineral Discovery Pty Ltd**
- Hartz Rare Earths Pty Ltd**
- Inca Minerals Ltd**
- Knox Resources Ltd**
- Liberation Resources Pty Ltd**
- Minerals Pty Ltd**
- Newcrest Operations Ltd**
- Pennant Resources Pty Ltd**
- Pinnacle Gold Pty Ltd**

- Plutonic Ltd**
- Redbank Operations Pty Ltd**
- Santos Ltd**
- Strategic Energy Resources Ltd**
- Teck Australia Pty Ltd**
- East Tennant region**
- Major road**
- Watercourse**
- Town/location**

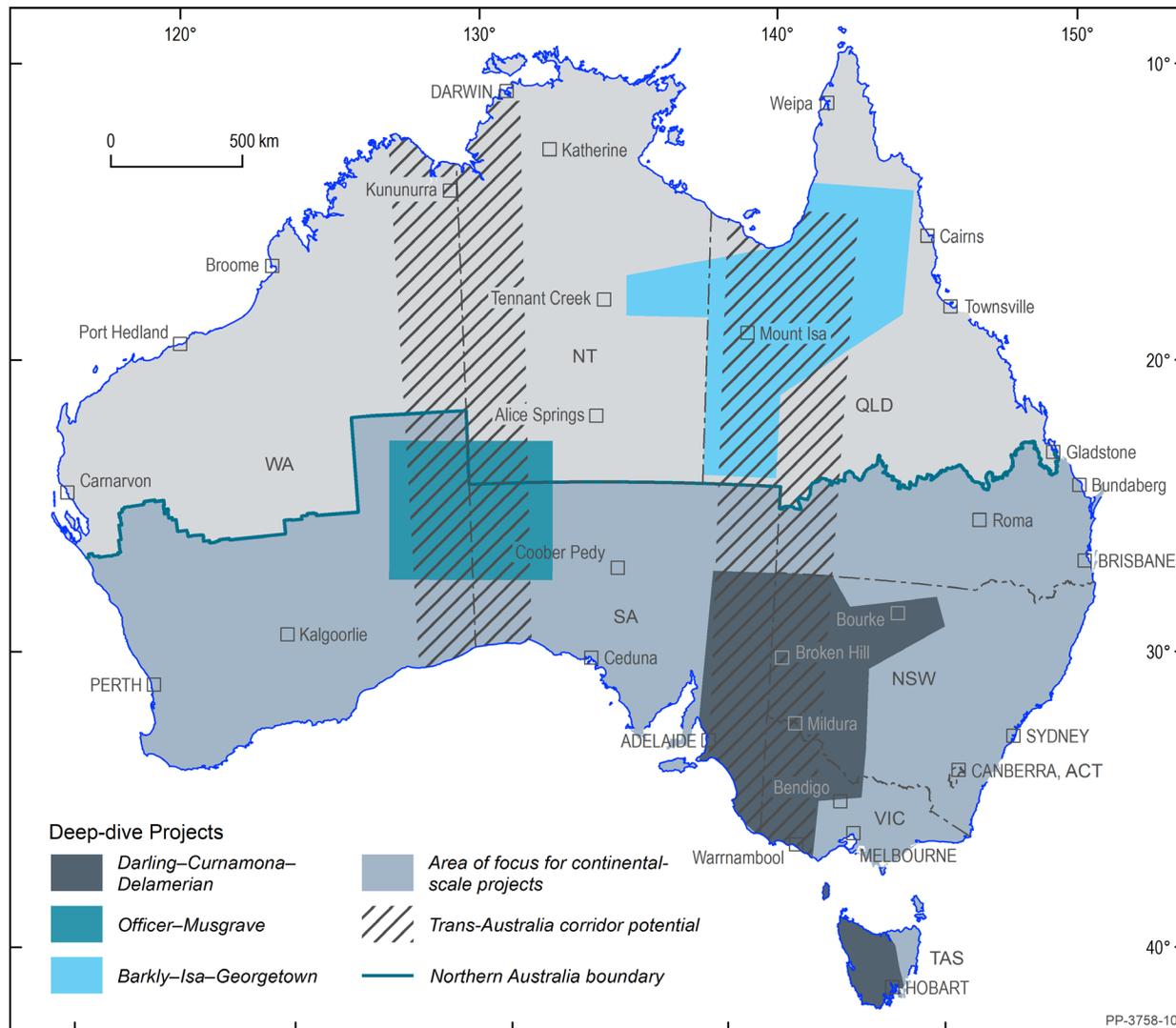
Current as at March 2021. Total area of tenements granted and under application exceeds 120 000 km²

A Pathway to Exploring for the Future

Vision: To support a strong economy, resilient society and sustainable environment for the benefit of Australians through an integrated geoscientific understanding of our mineral, energy and groundwater potential.



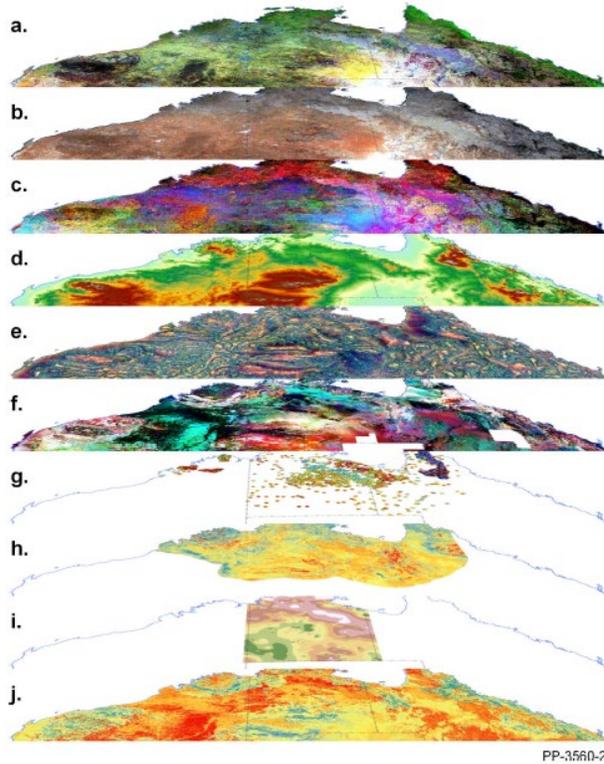
Exploring for the Future Phase Two (2020-2024) – \$125 M



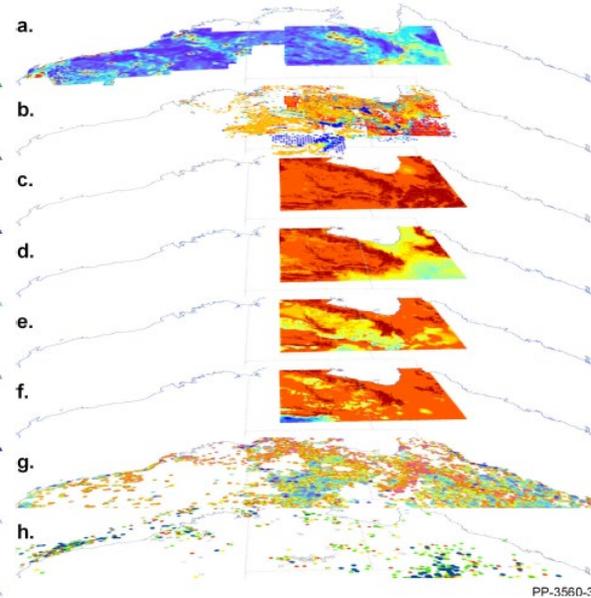
- **3x Continental-scale projects** with a focus on southern Australia:
 - Australia's Resources Framework
 - Australia's Future Energy Resources
 - National Groundwater Systems
- **3x Deep-dive projects** in two trans-continental corridors
 - Darling-Curnamona-Delamerian
 - Barkly-Isa-Georgetown
 - Officer-Musgrave
- **2x program-support projects**
 - Enhanced data delivery
 - Geoscience knowledge transfer

Australia's Resources Framework (ARF) Project

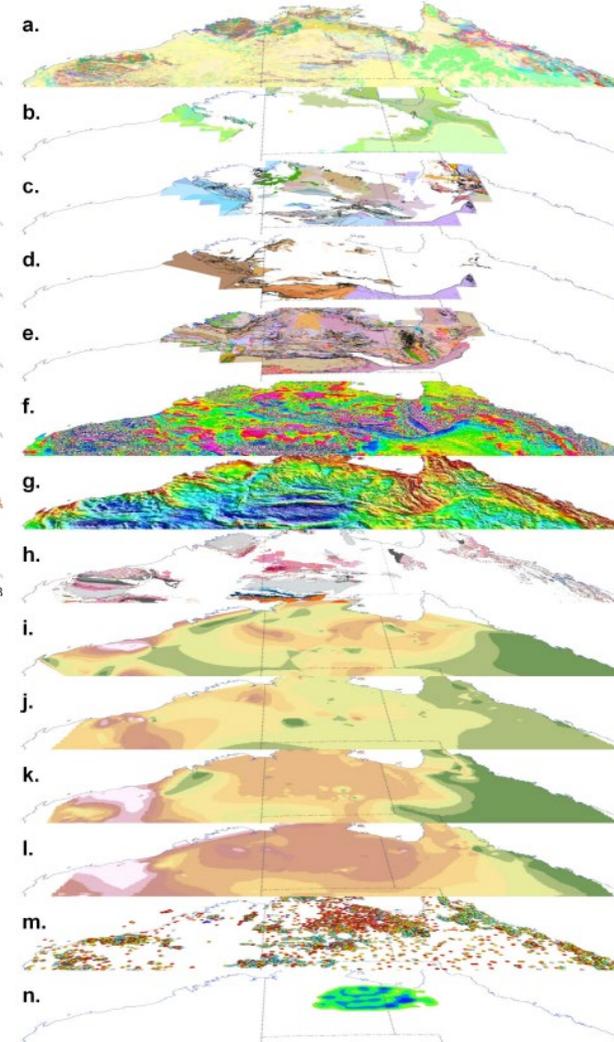
Surface



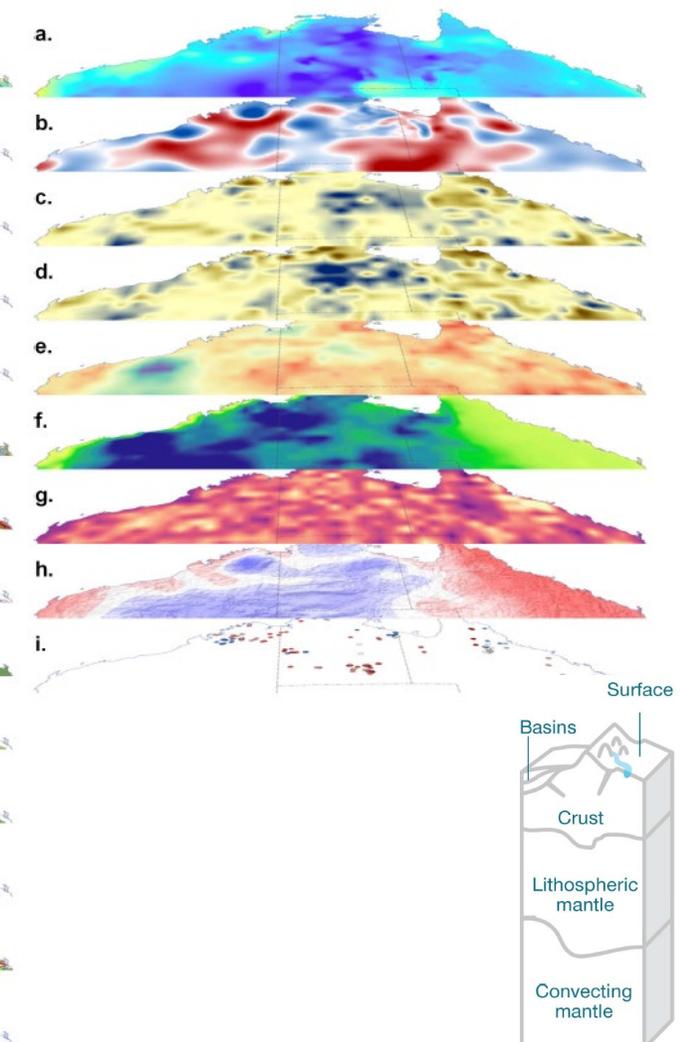
Basins



Crust

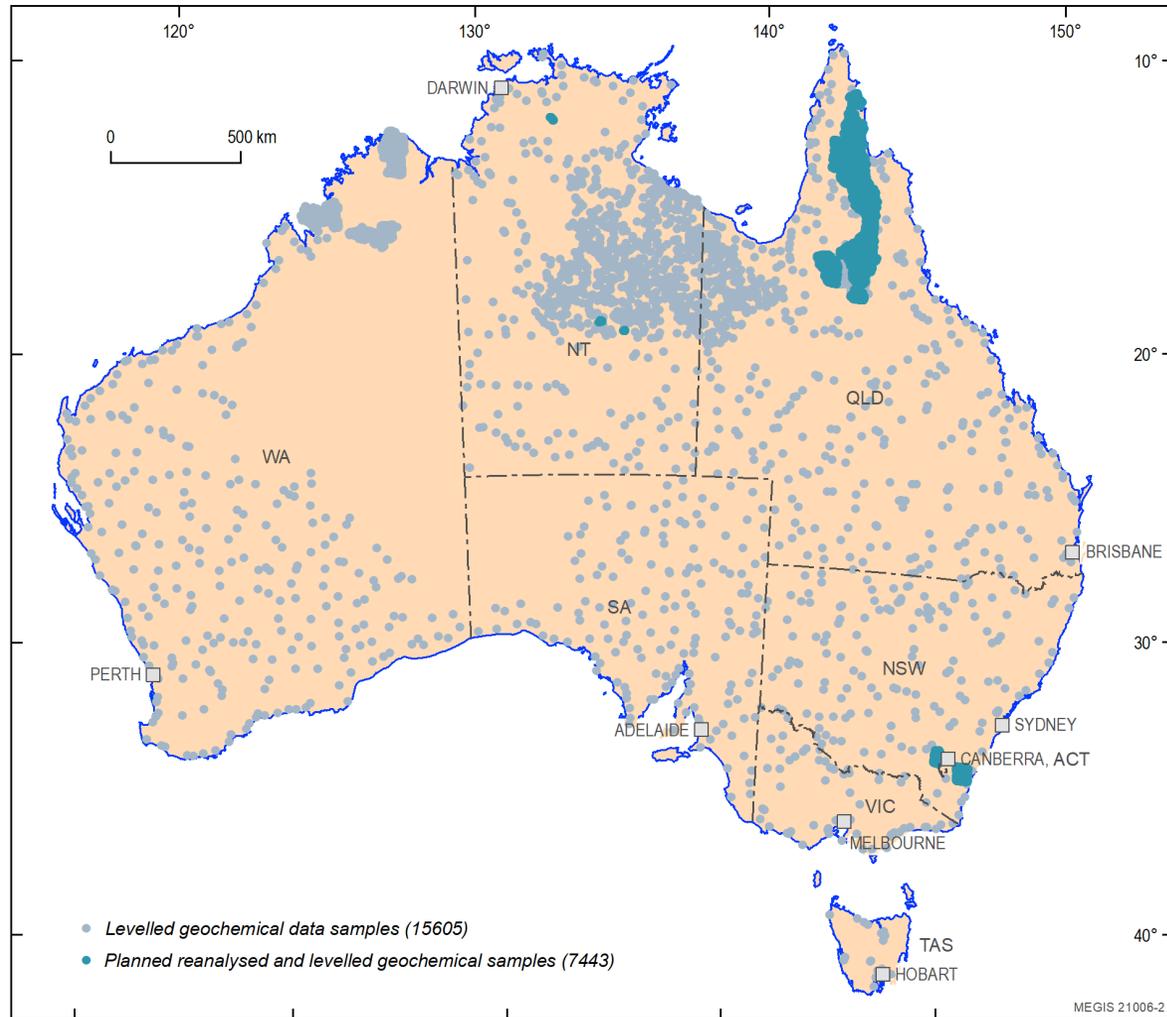


Mantle

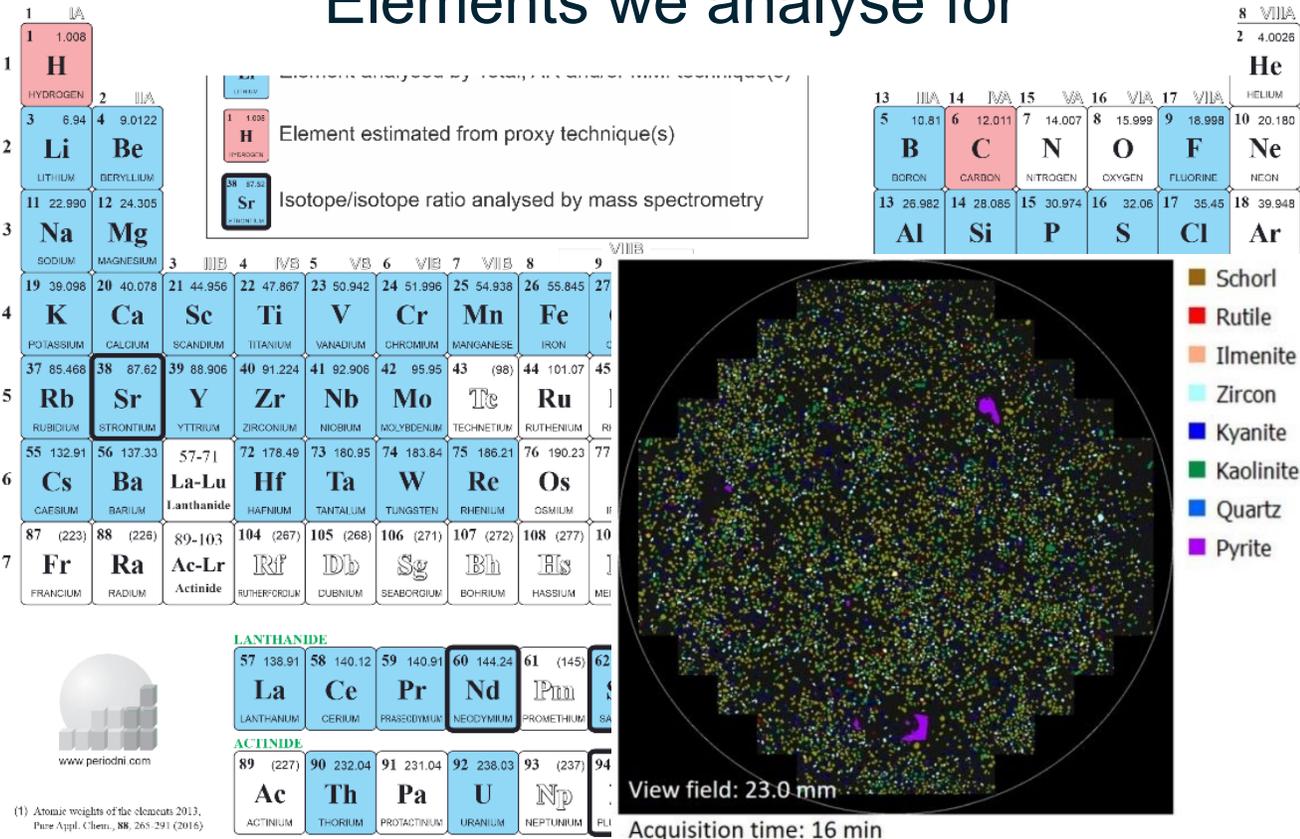


Czarnota et al. (2020);
Exploring for the Future Extended Abstracts
<https://www.ga.gov.au/eff/extended-abstracts>

ARF: Soil Geochemistry



Elements we analyse for



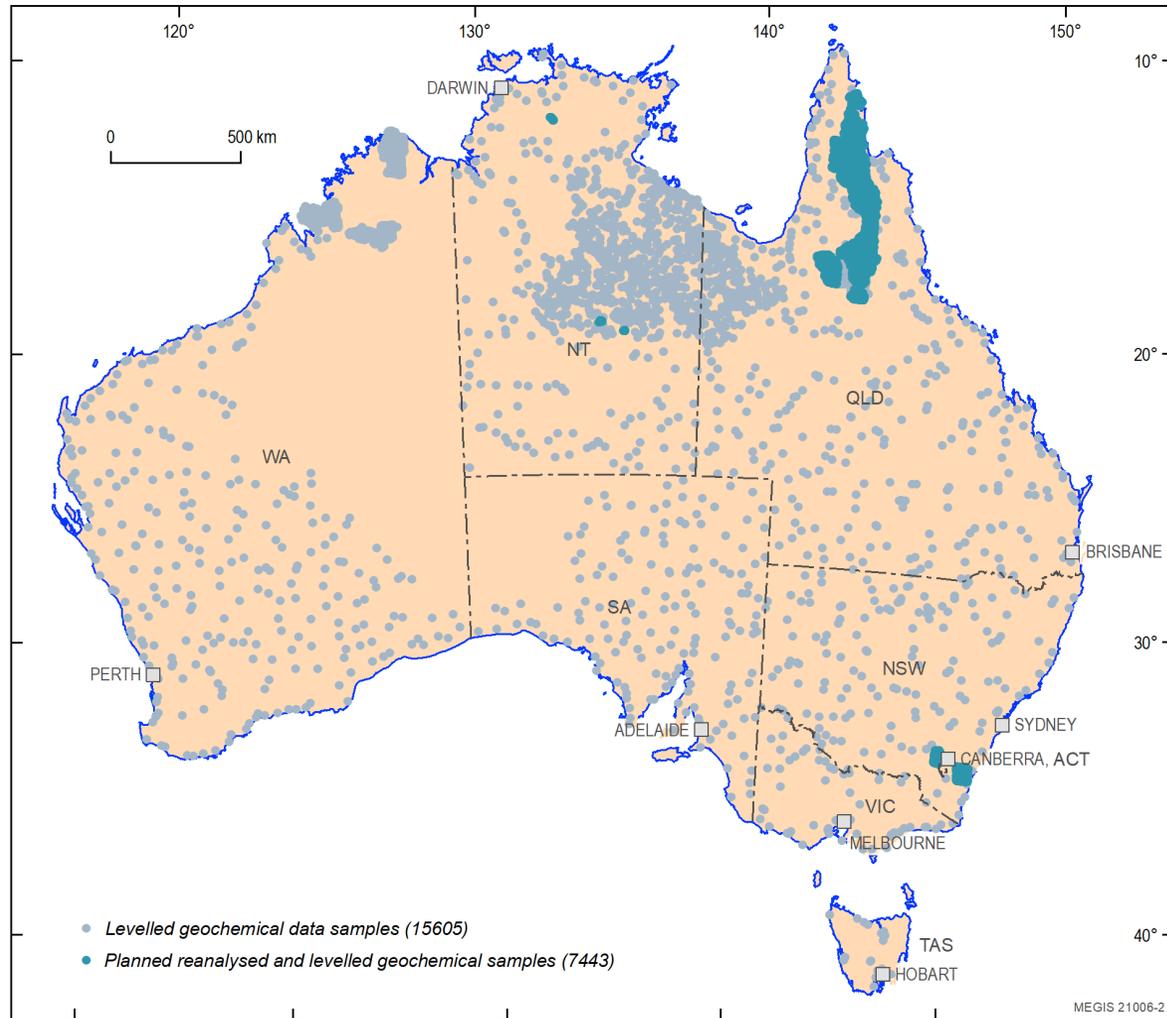
(1) Atomic weights of the elements 2013, Pure Appl. Chem., 88, 265-291 (2016)

Modern GA samples analysed for >60 elements
Legacy samples analysed for about a dozen elements

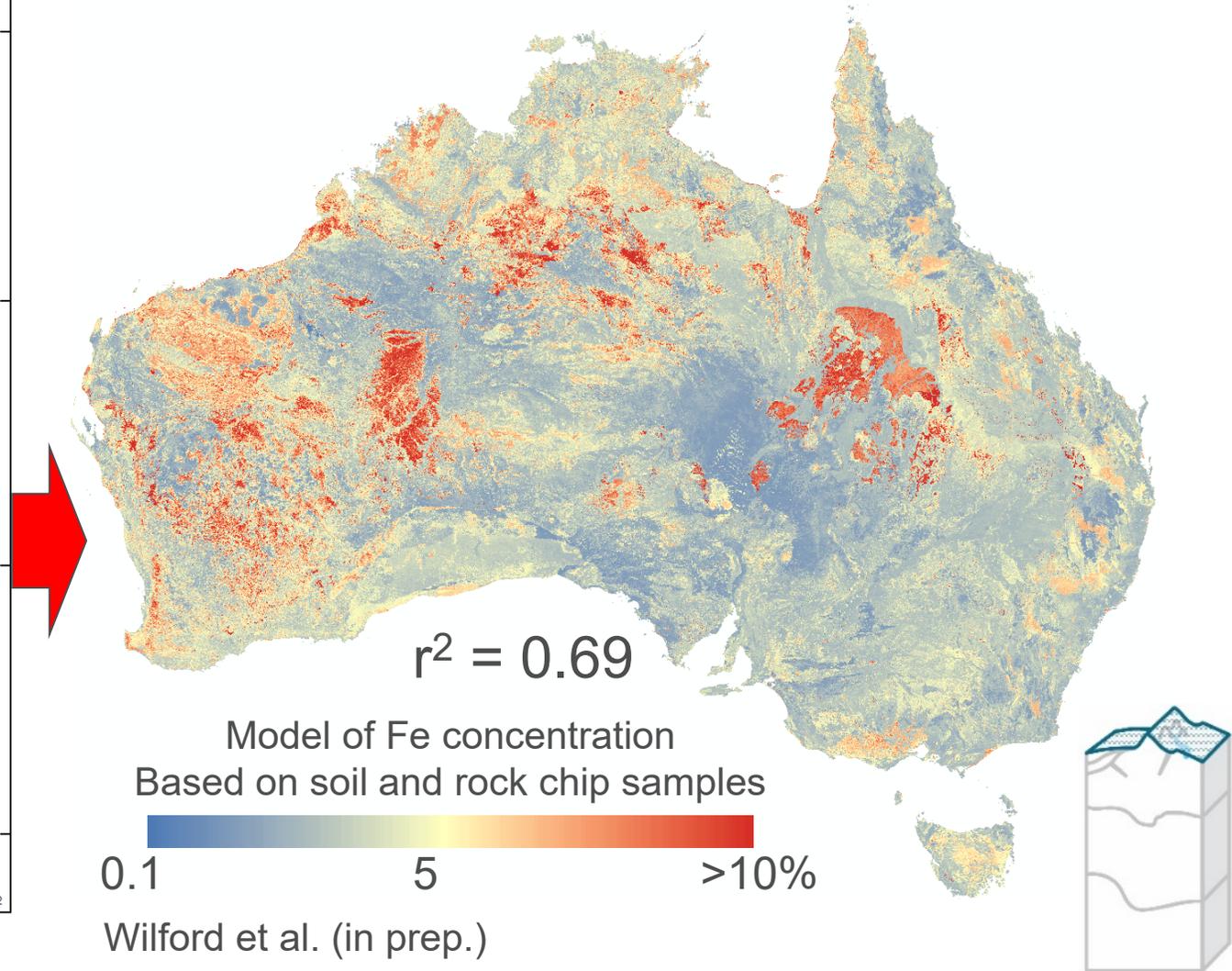
De Caritat et al. (2020)

National geochemical survey of Australia to be analysed for heavy mineral concentrates

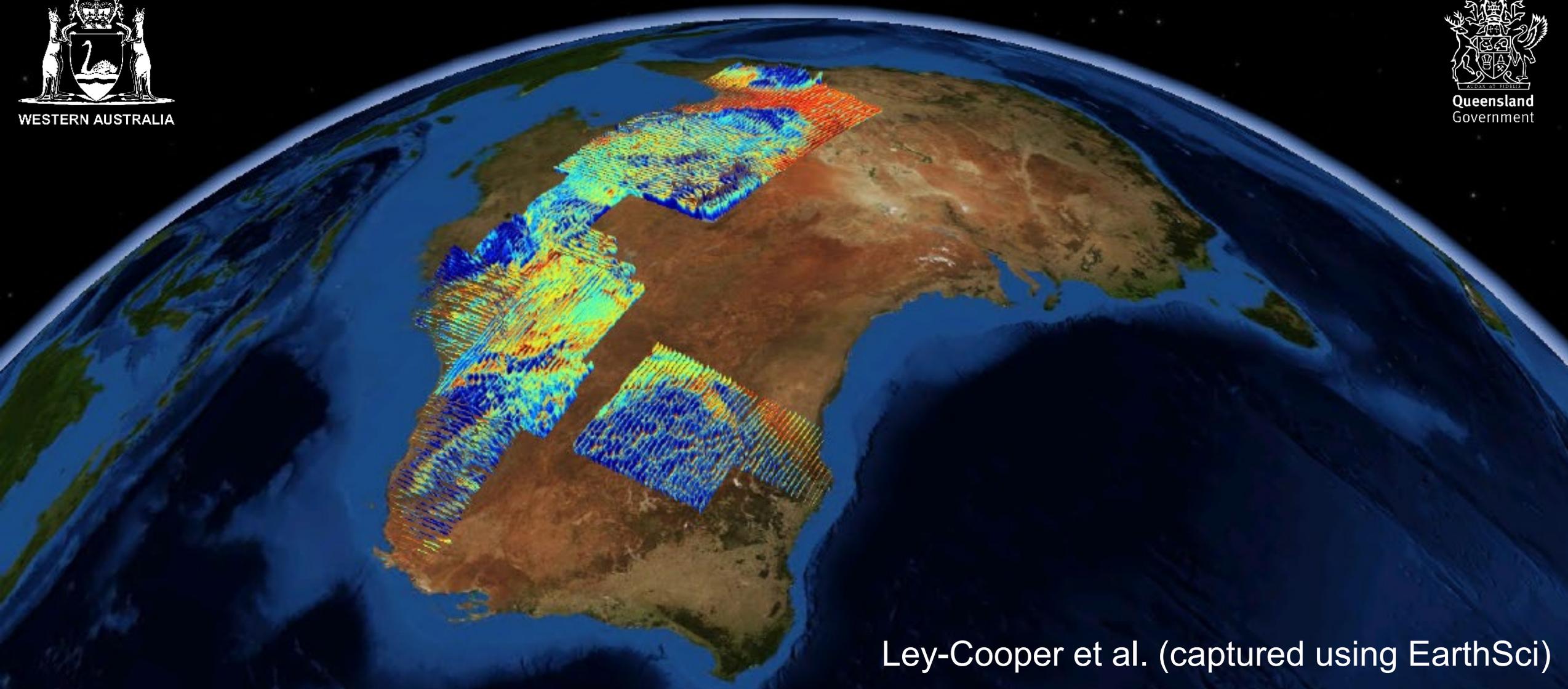
ARF: Soil Geochemistry to National Grids



Main et al. (in prep.)



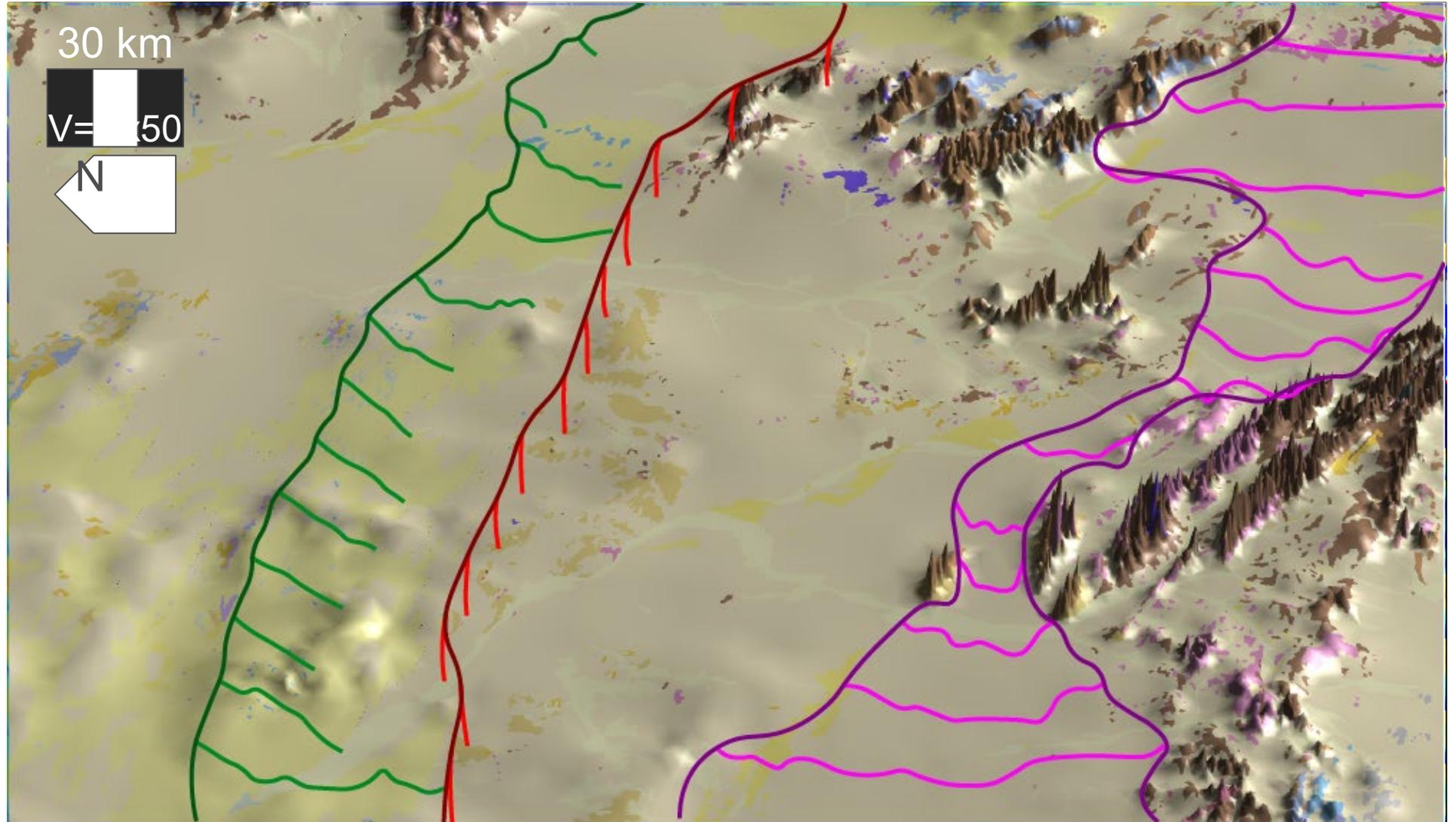
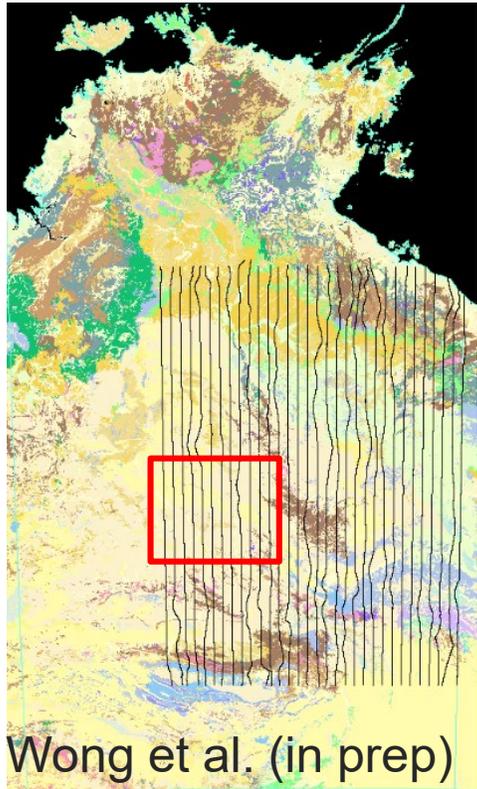
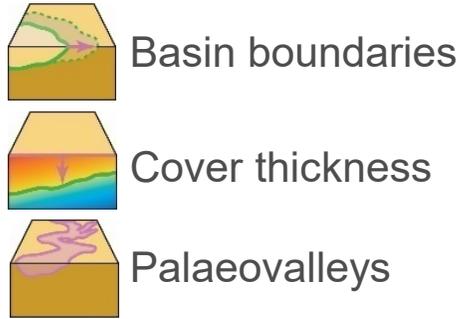
Example: Australian Airborne Electromagnetics (AusAEM)



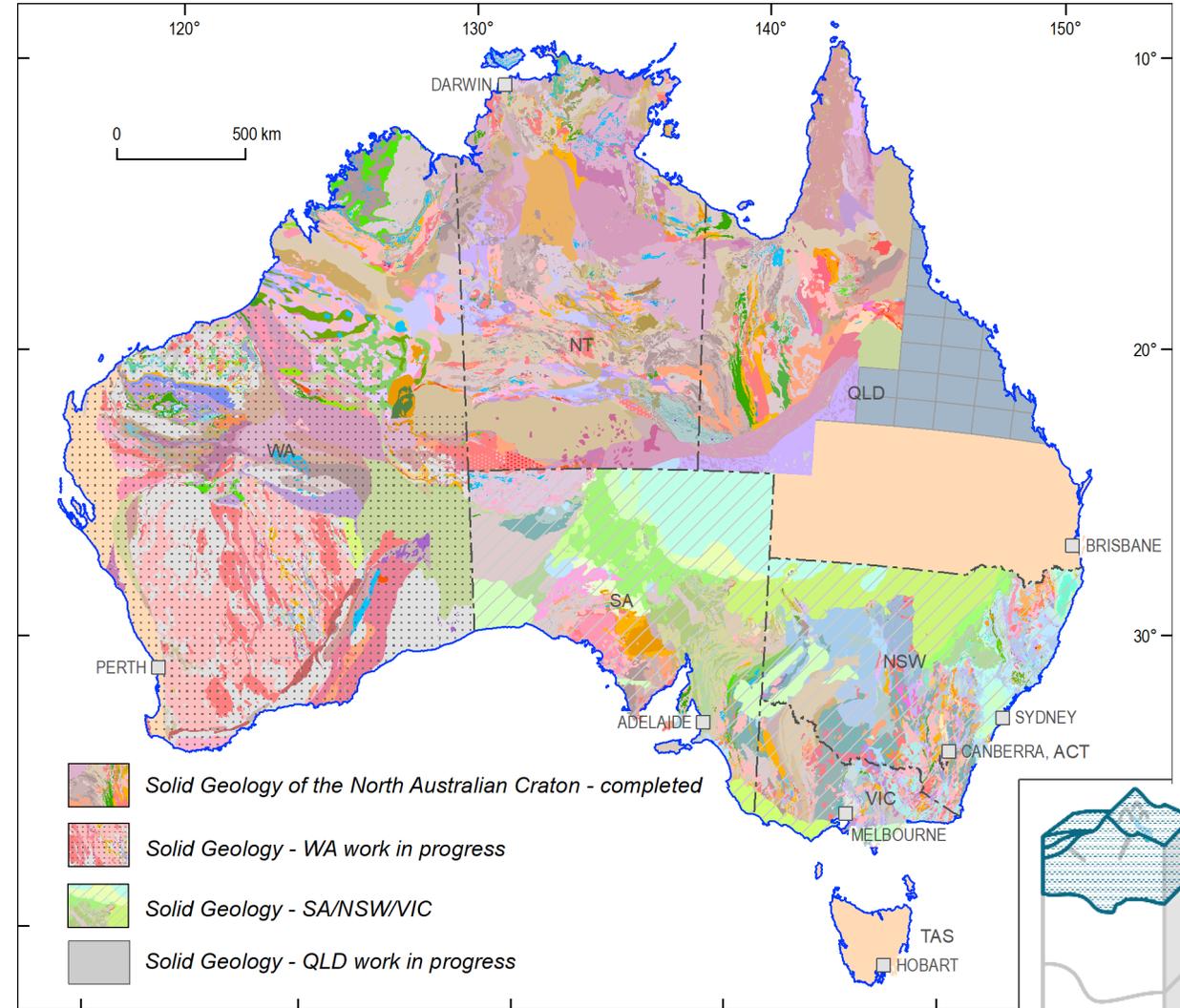
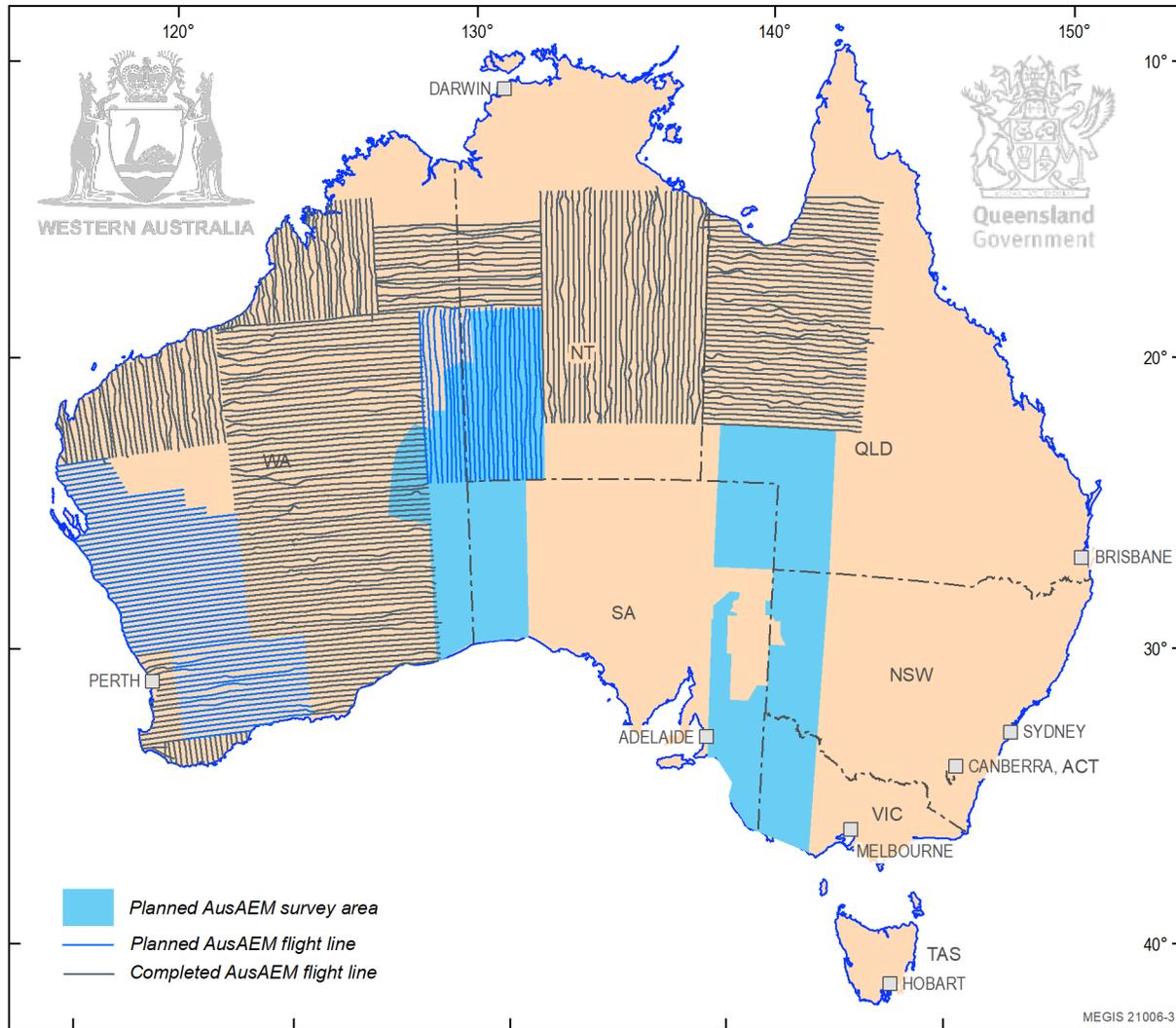
Ley-Cooper et al. (captured using EarthSci)



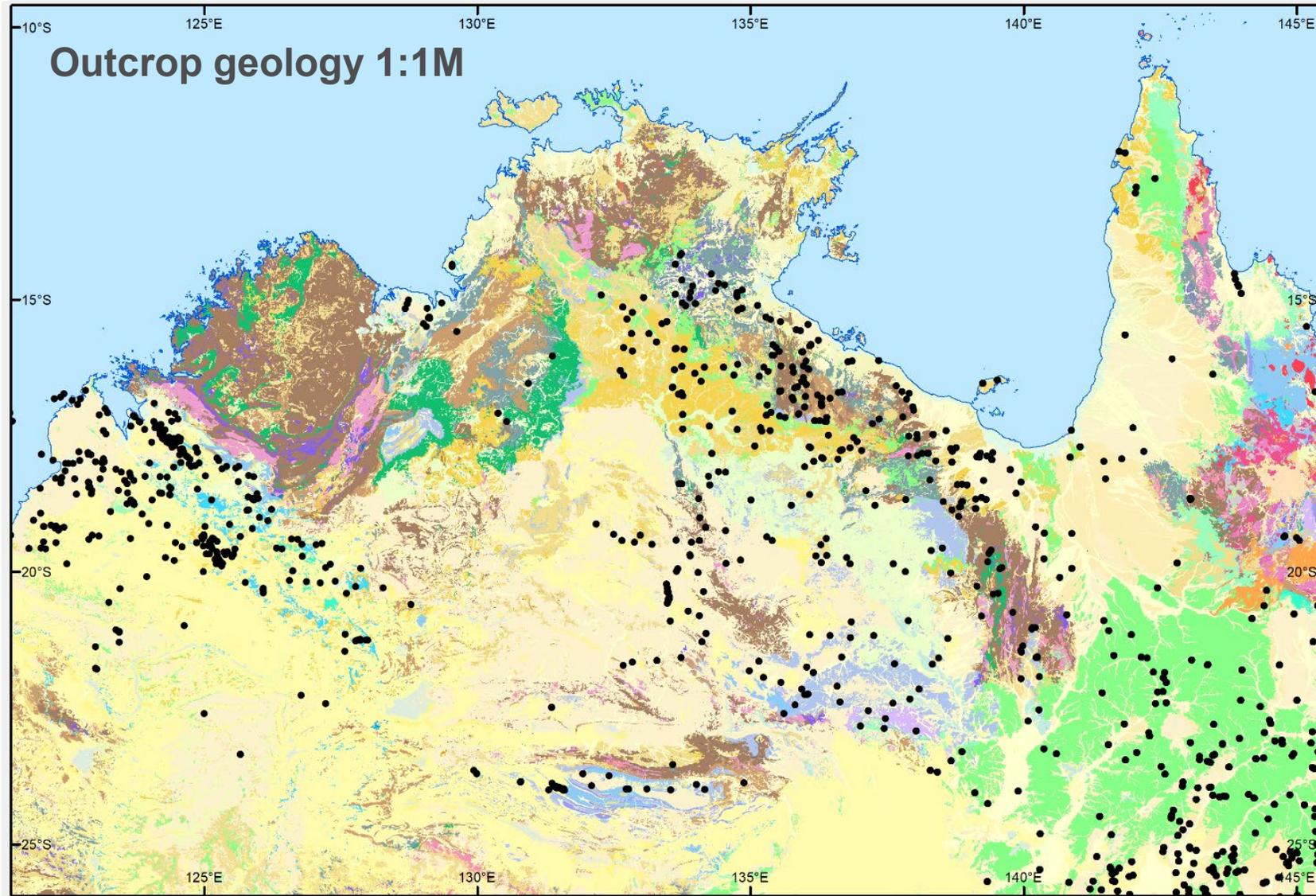
Example: Willowra Suture, Lander Trough, and palaeovalleys



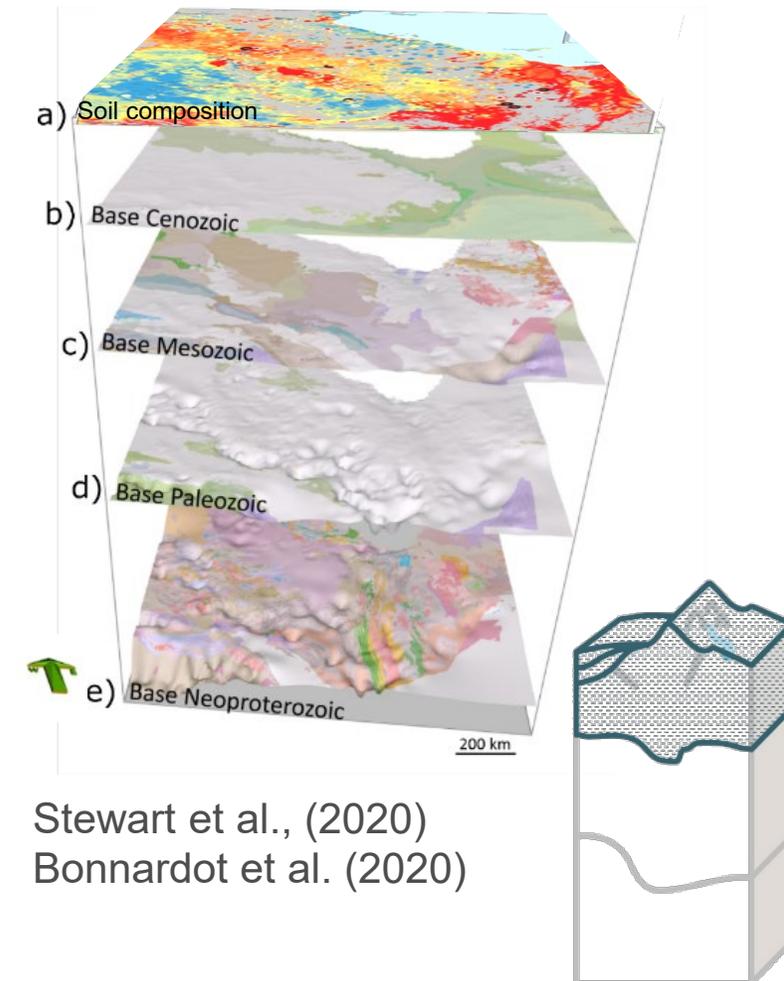
ARF: AusAEM & Solid Geology



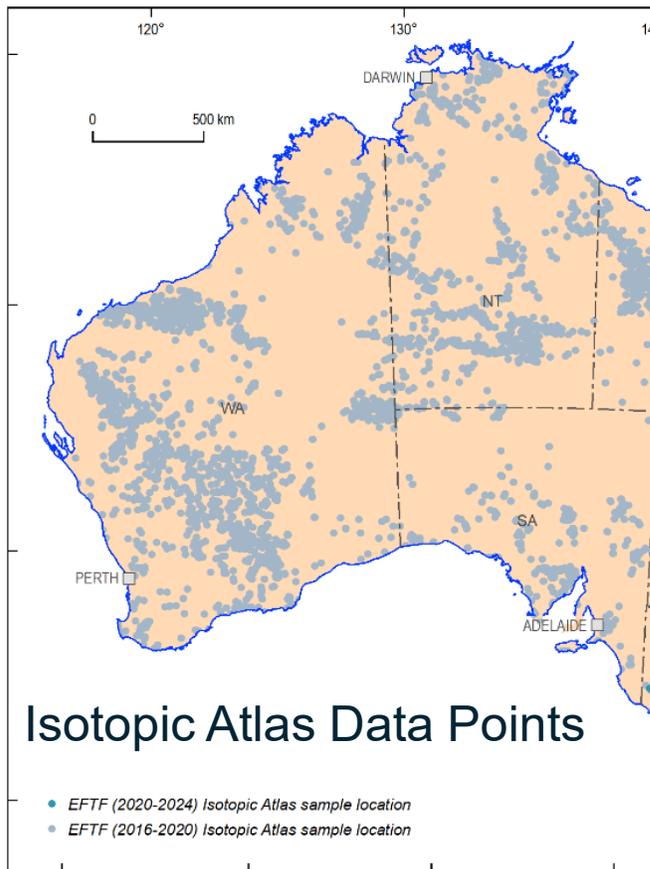
ARF: Basins/Crust – Solid Geology Mapping



3D Integrated cover model



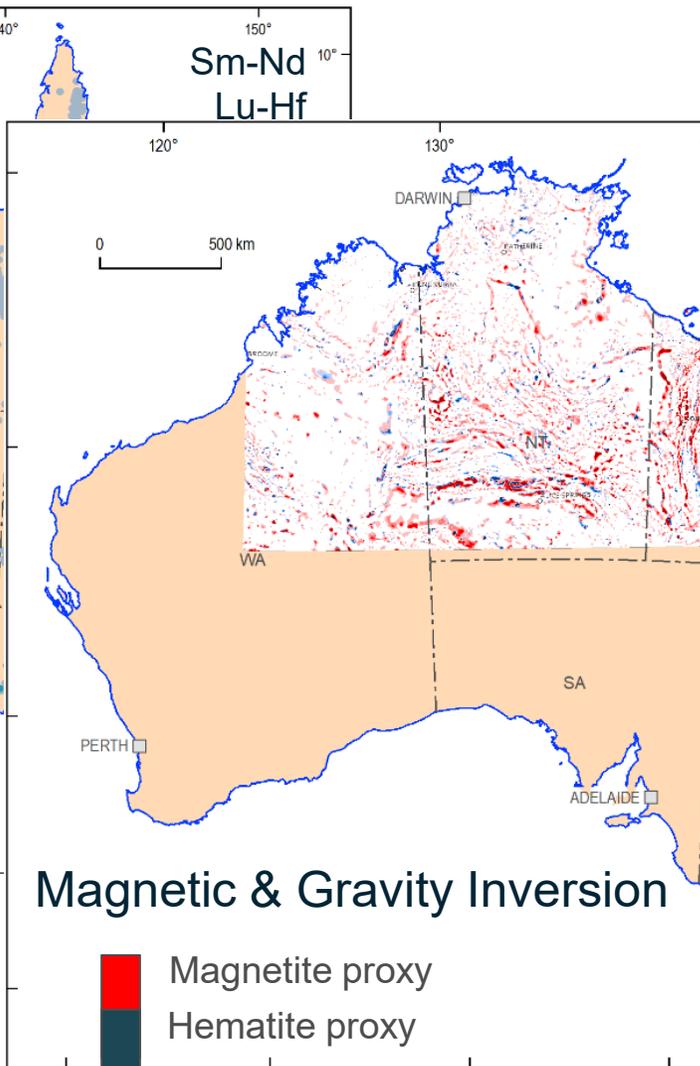
ARF: Crust



Isotopic Atlas Data Points

• EFTF (2020-2024) Isotopic Atlas sample location
• EFTF (2016-2020) Isotopic Atlas sample location

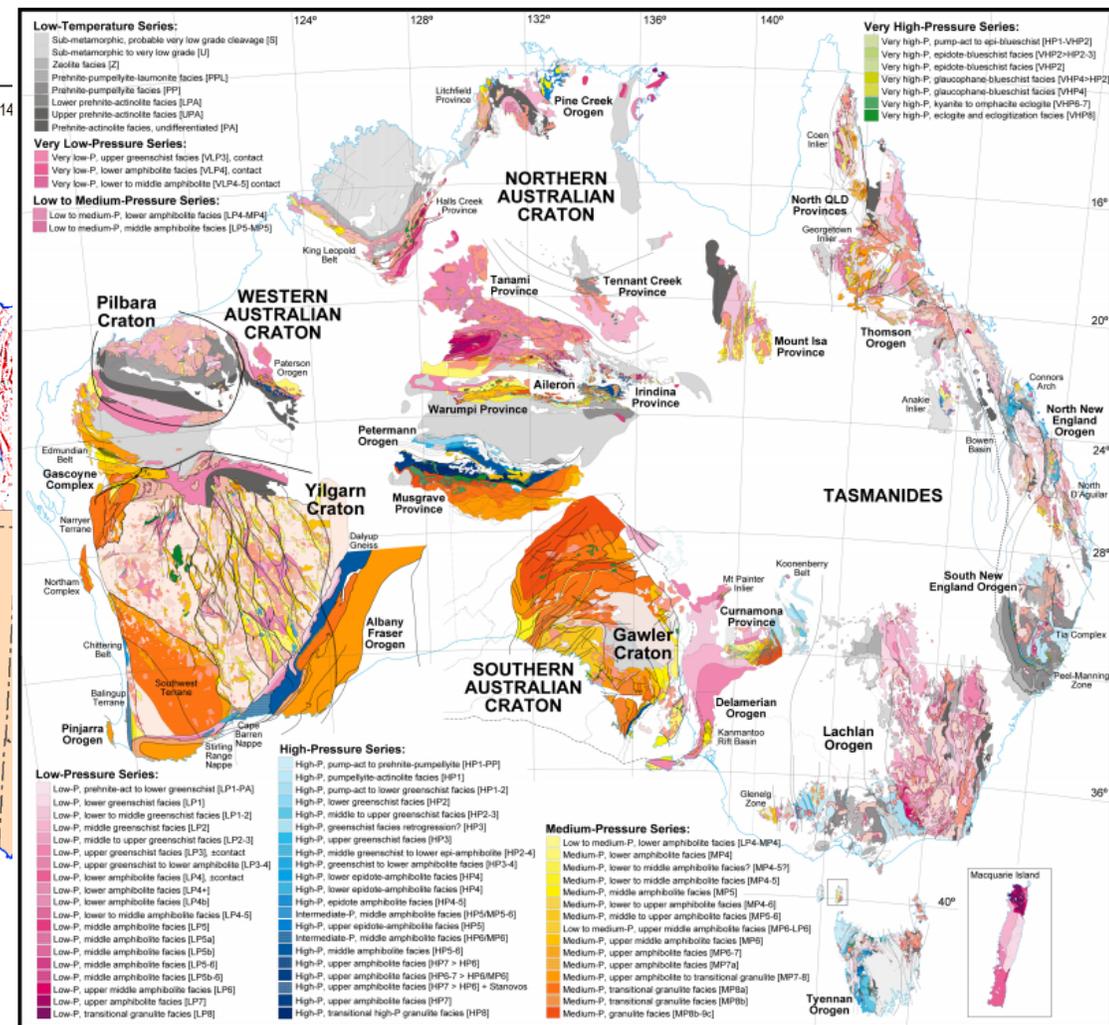
Fraser et al. (2020)



Magnetic & Gravity Inversion

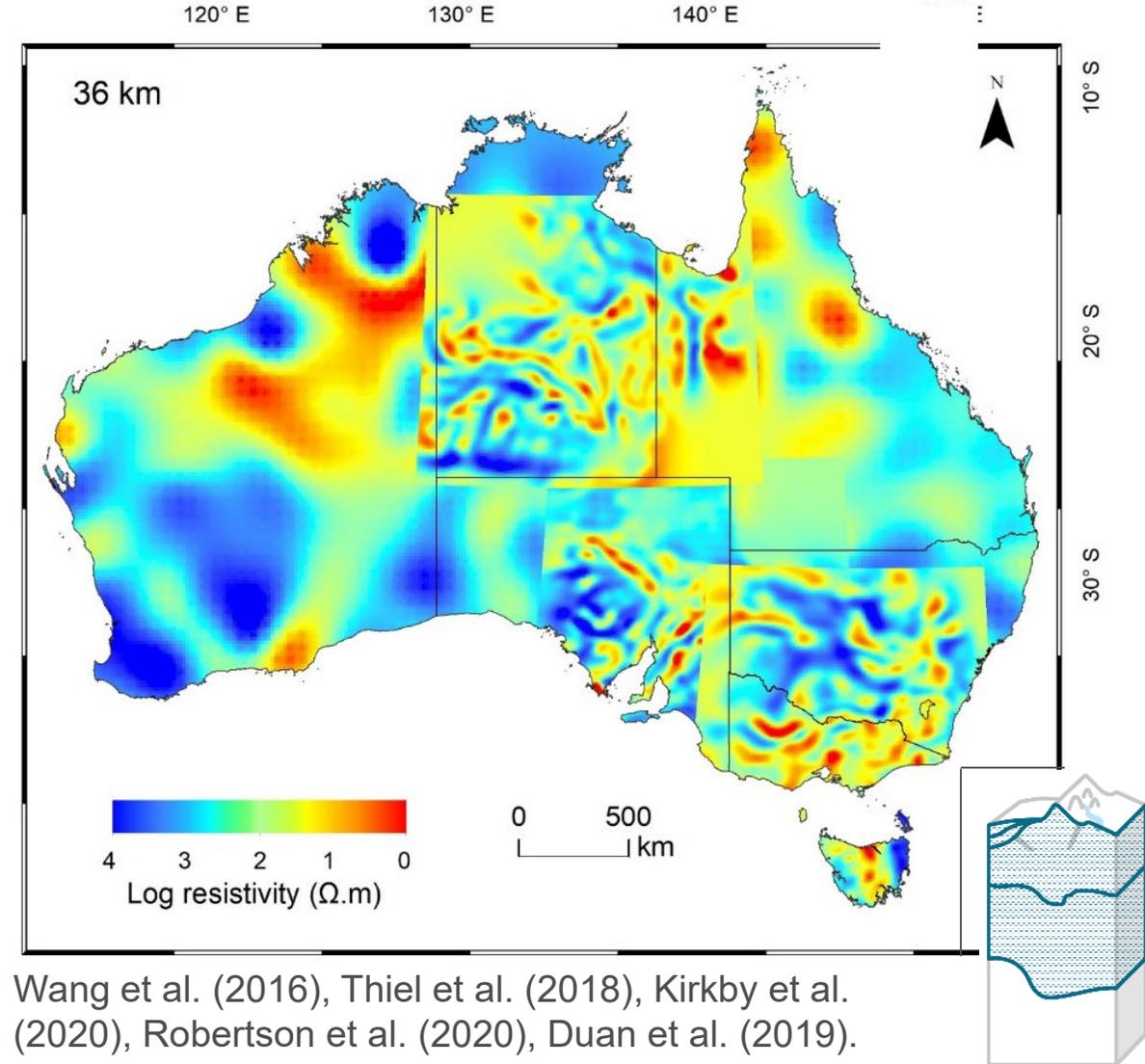
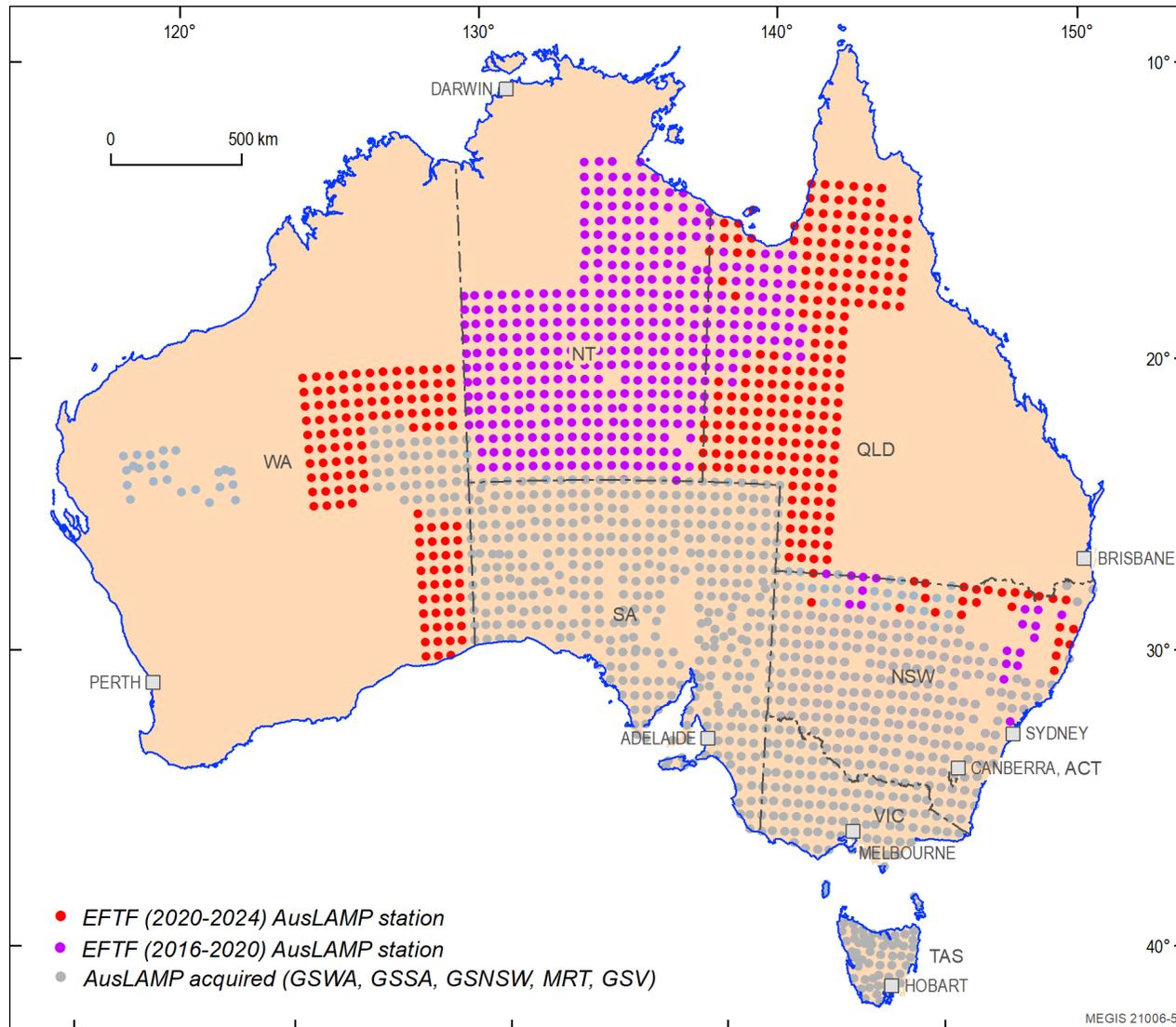
■ Magnetite proxy
■ Hematite proxy

Goodwin et al. (2020)

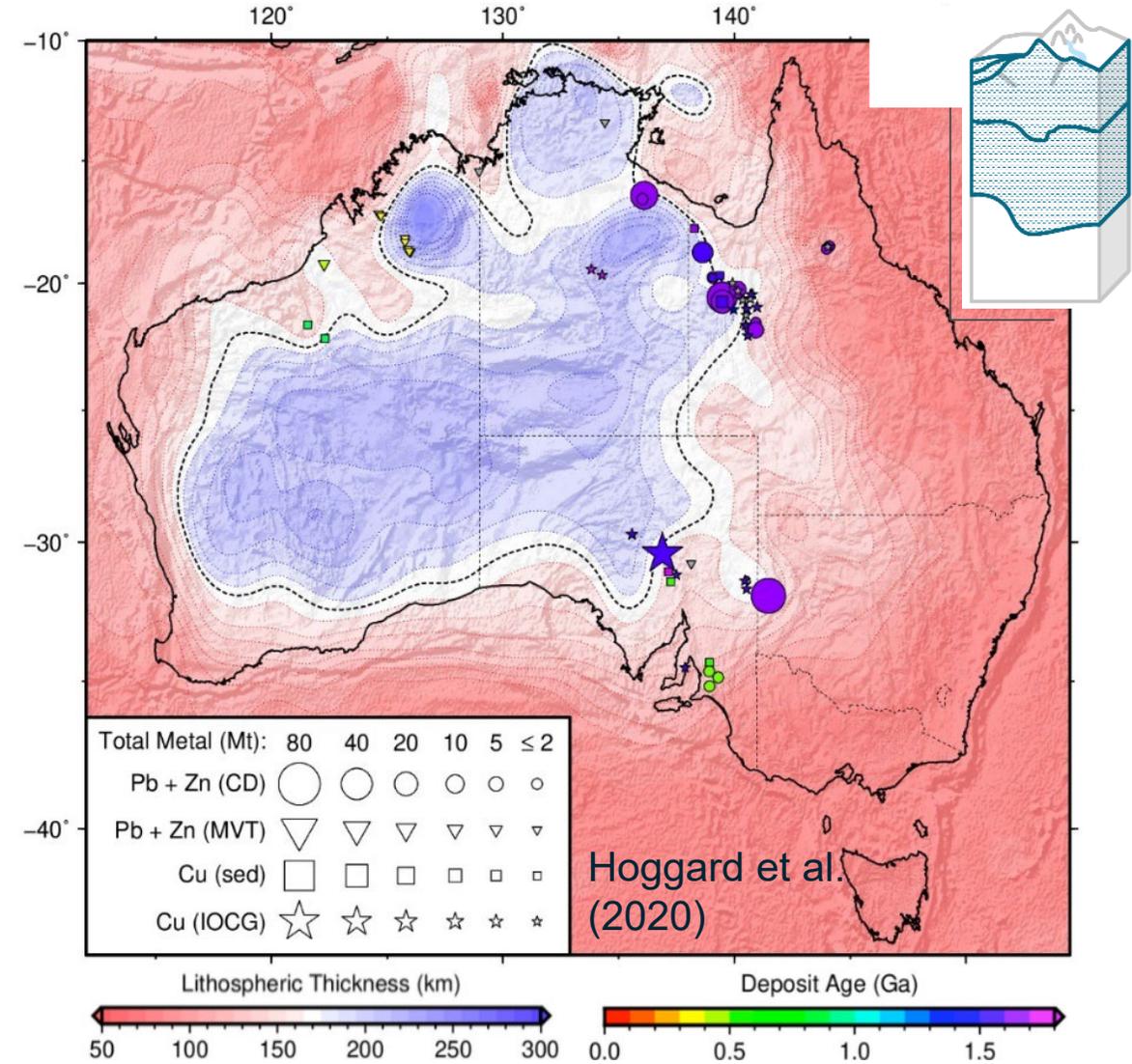
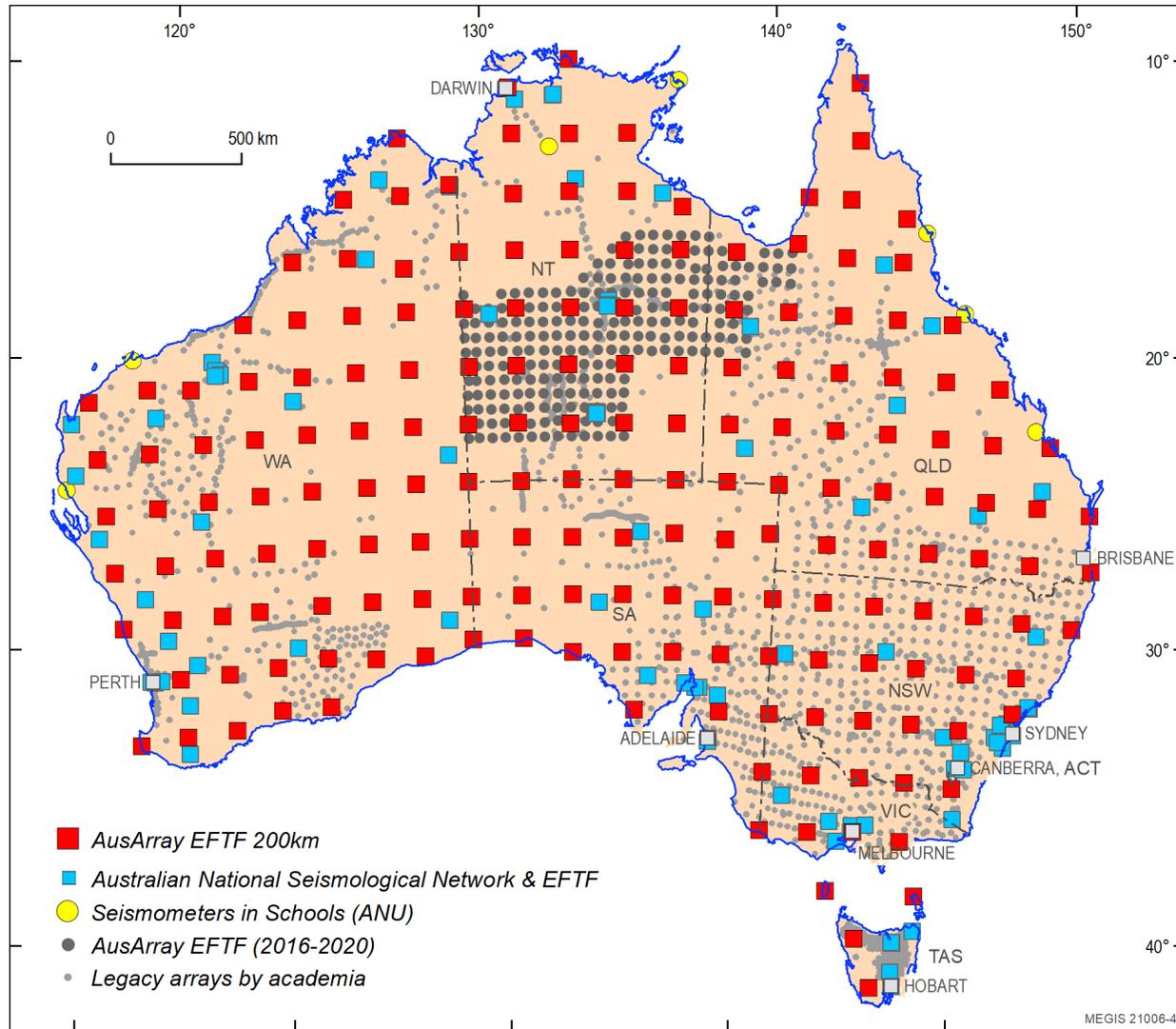


Interpretative metamorphic map. Goscombe et al. (2020)

ARF: Lithospheric Mantle - AusLAMP

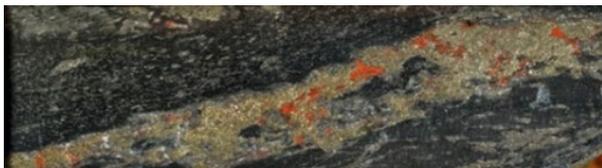
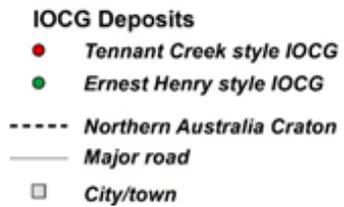
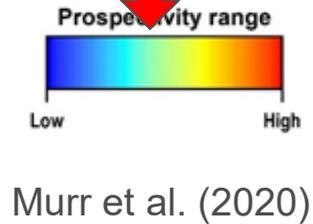
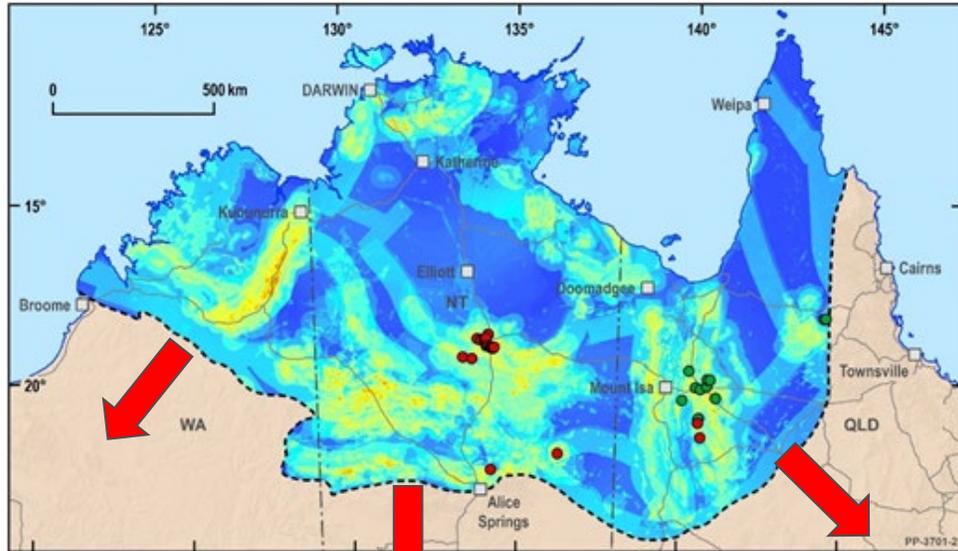


ARF: Lithospheric Mantle – AusArray & LitMod



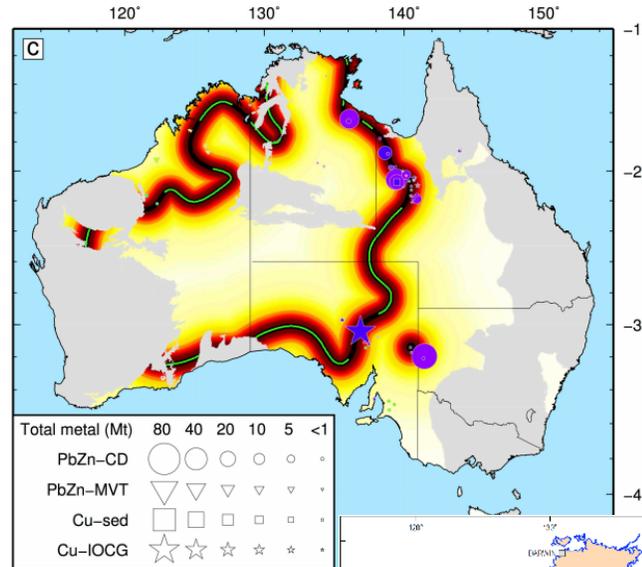
ARF: National Mineral Systems Assessments

1. Expand iron oxide-copper-gold assessment



Tested model by drilling in East Tennant NDIBK04

2. Improve Sediment-hosted base metal assessment

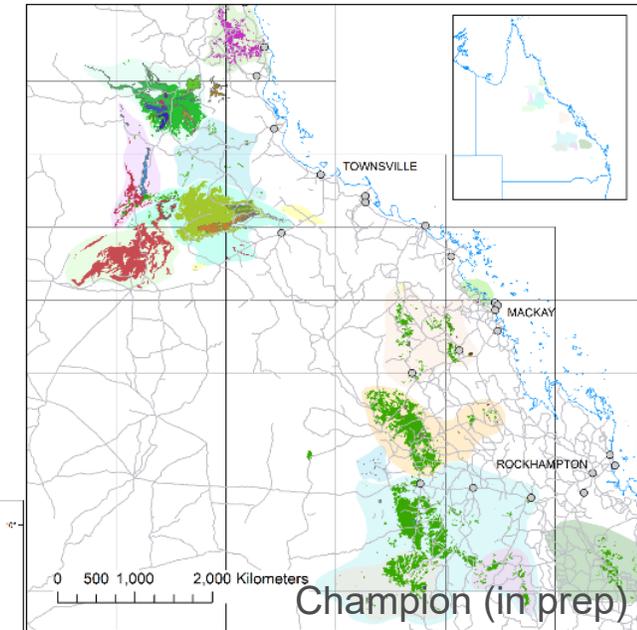


Czarnota et al. (2020)

Detailed geochemical studies

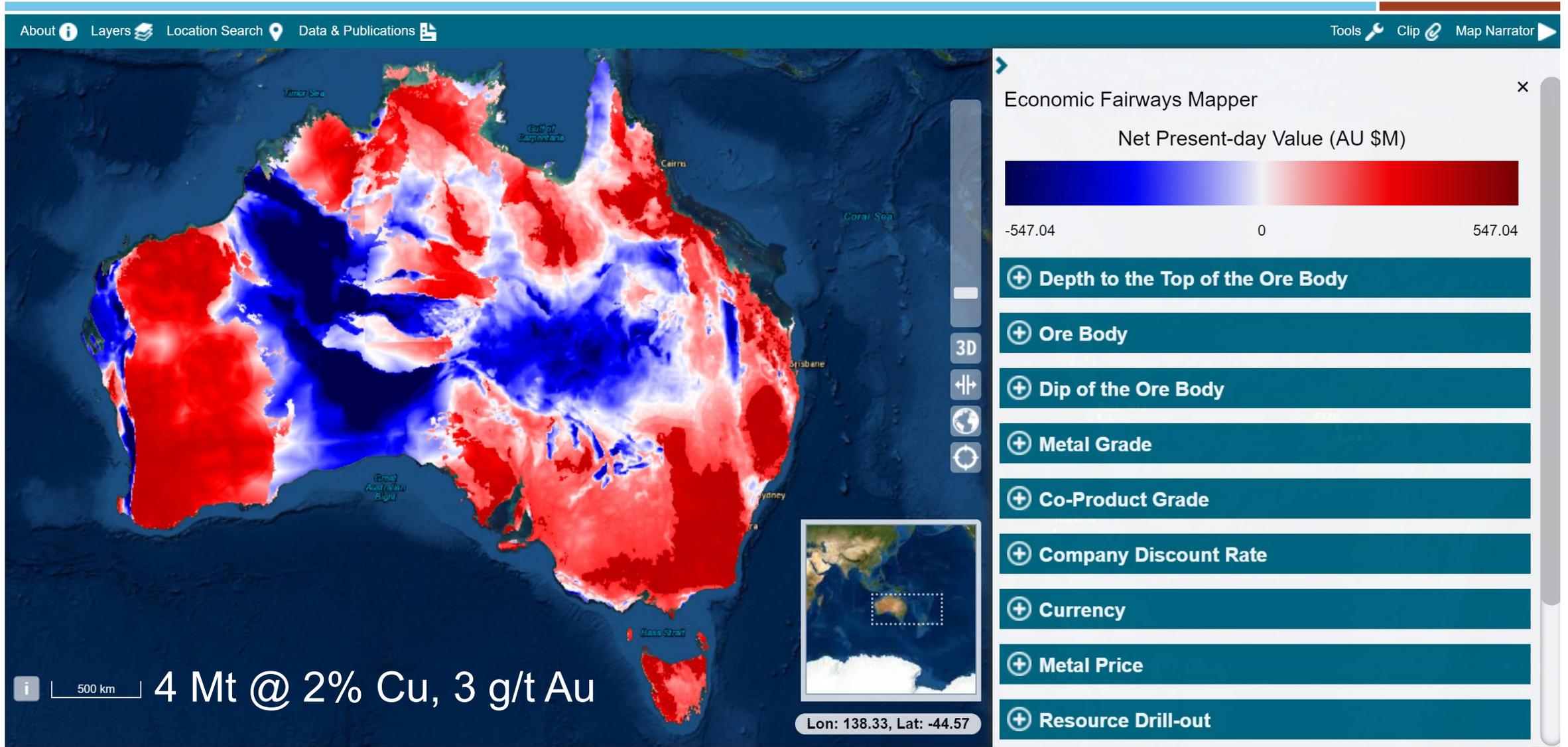


3. Alkaline rocks & related minerals

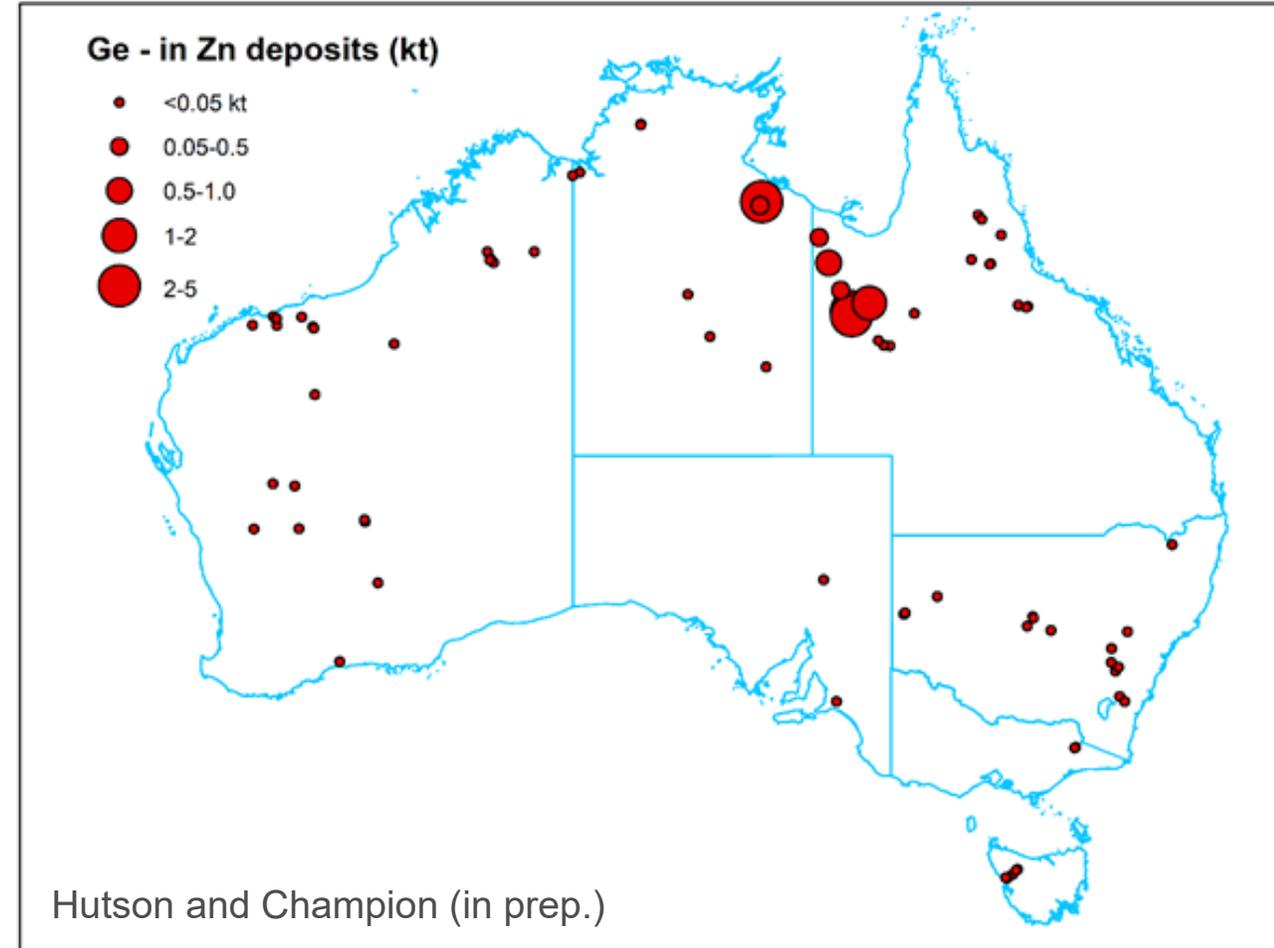
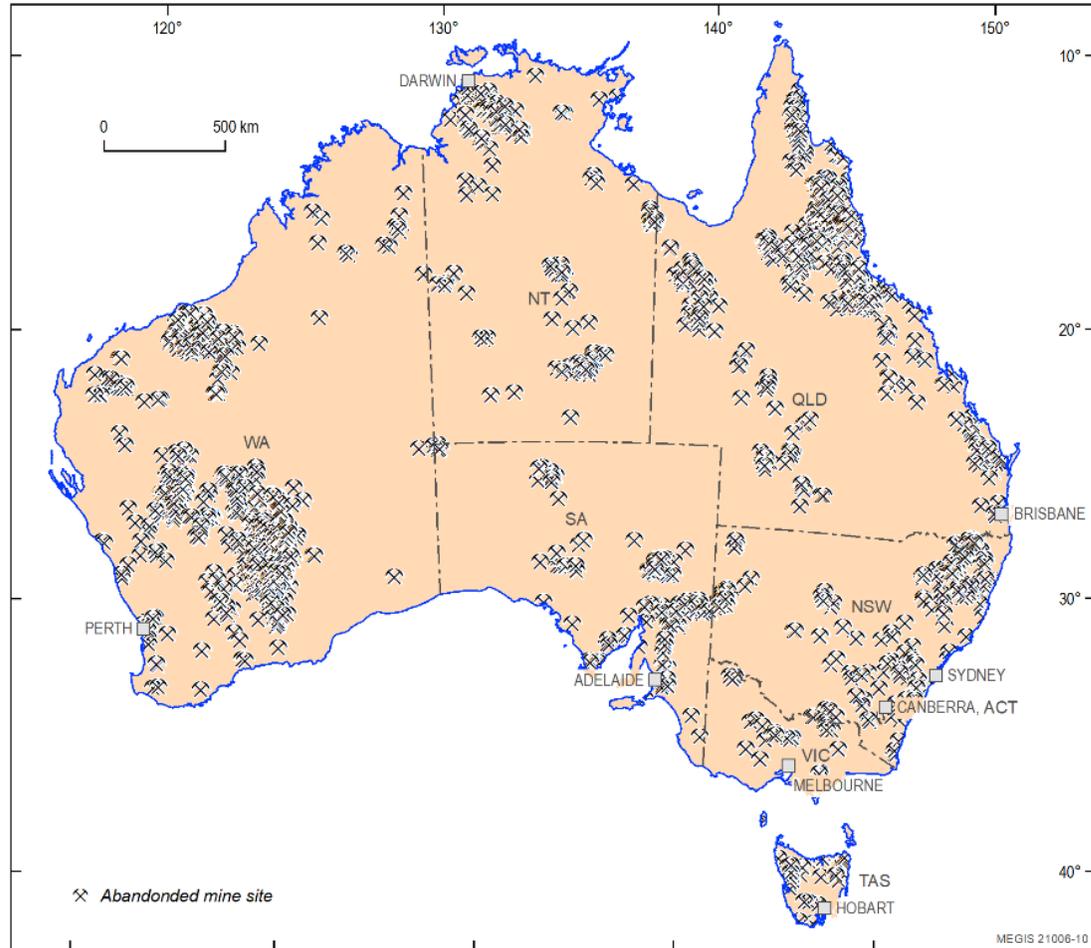


- a. Compile national distribution
- b. Undertake assessment for critical minerals

Economic Fairways Tool

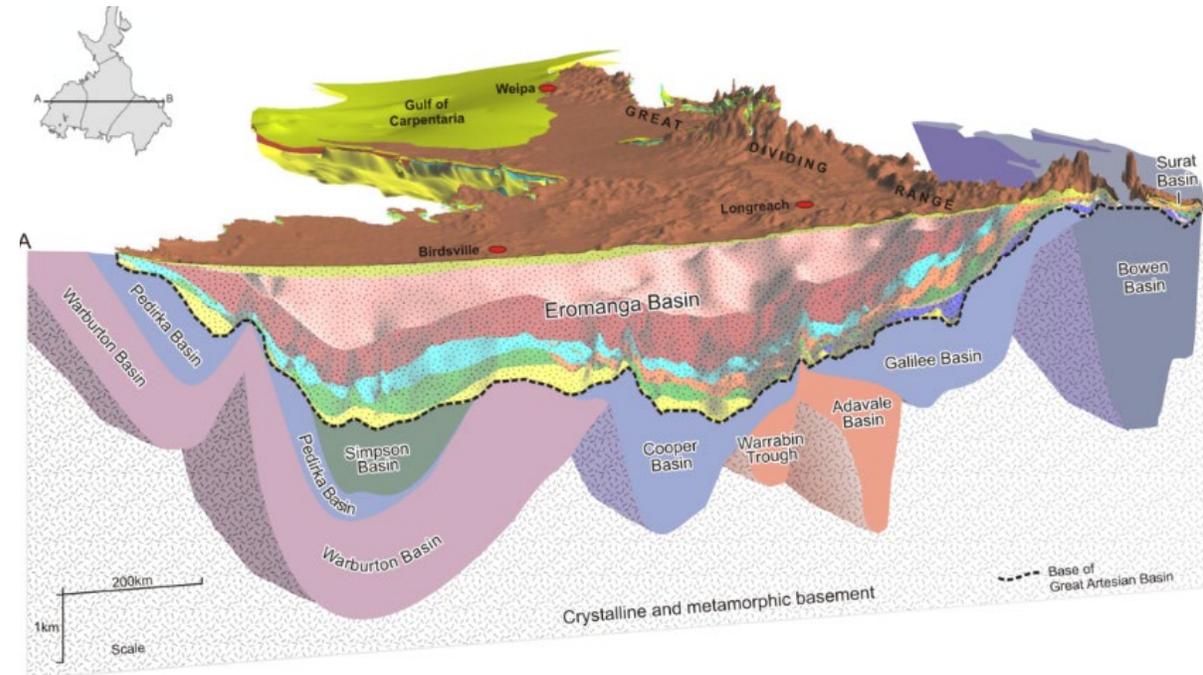
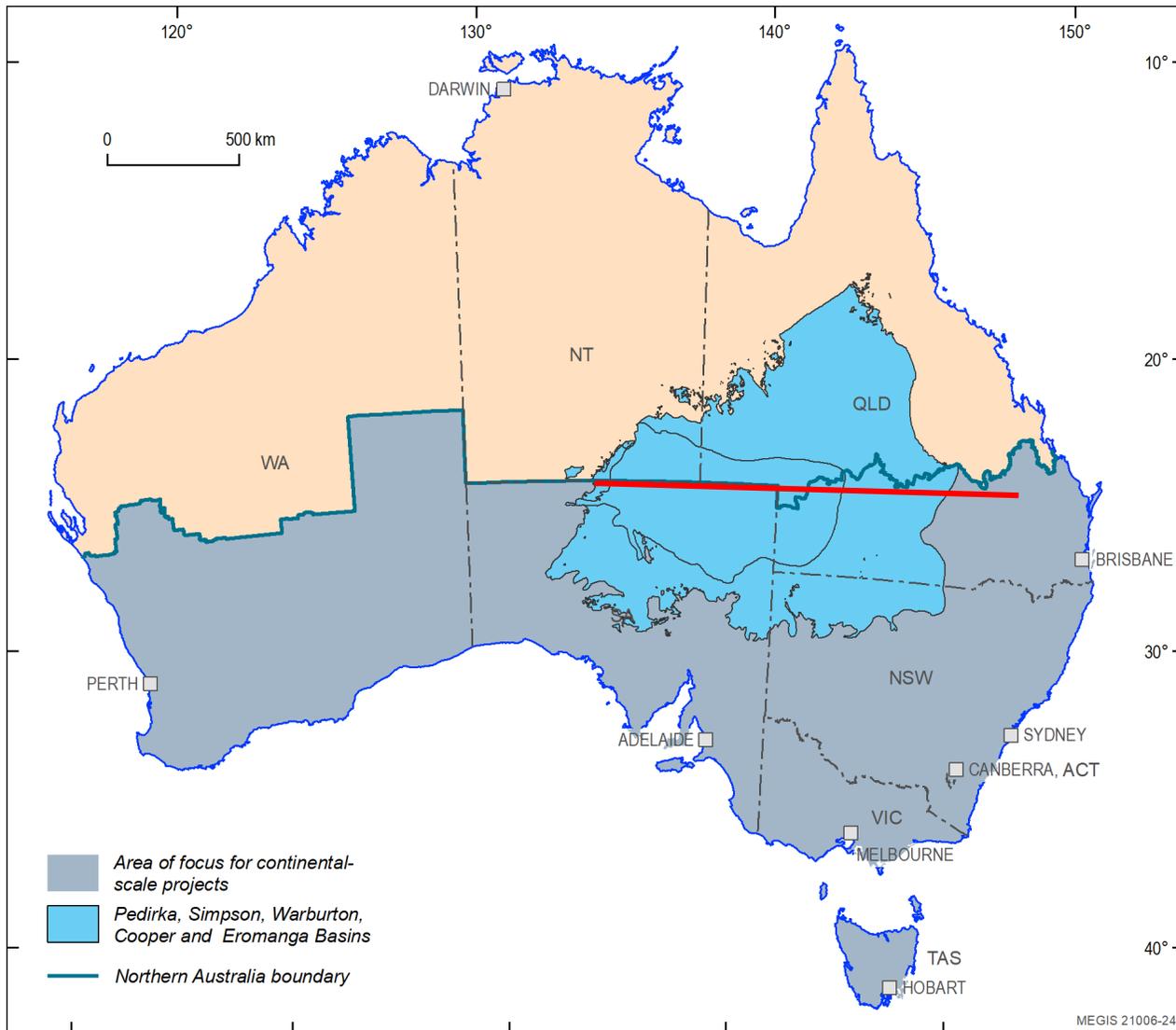


ARF: New opportunities in existing mines and mine waste



NB these results must be considered indicative only and require testing to confirm

Australia's Future Energy Resources Project



Key Questions:

- What is the hydrocarbon resource potential of Australia's central eastern basins under a variety of economic scenarios?
- Where are the fairways for low/non-hydrocarbon resources (hydrogen, enhanced oil recovery with carbon capture and storage, deep groundwater)?

Key challenges:

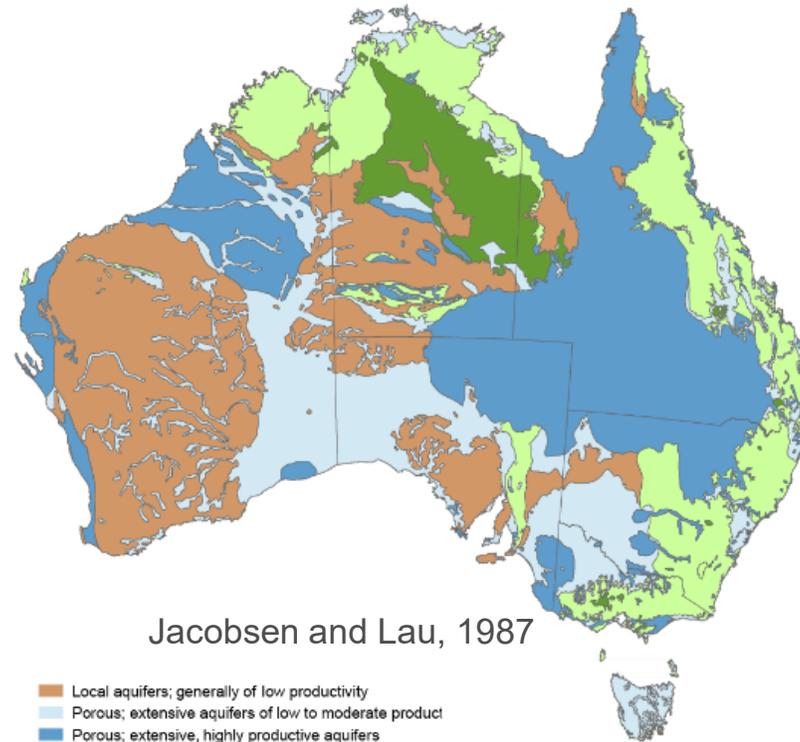
- Growing need for a cohesive national groundwater understanding to inform management.

Key science questions:

- Where are groundwater resources and what are their associated hydrogeology characteristics?
- Which regions most require improved groundwater system understanding?
- What is the best-practice approach to undertaking groundwater sampling, analysis and assessments?

Planned activities:

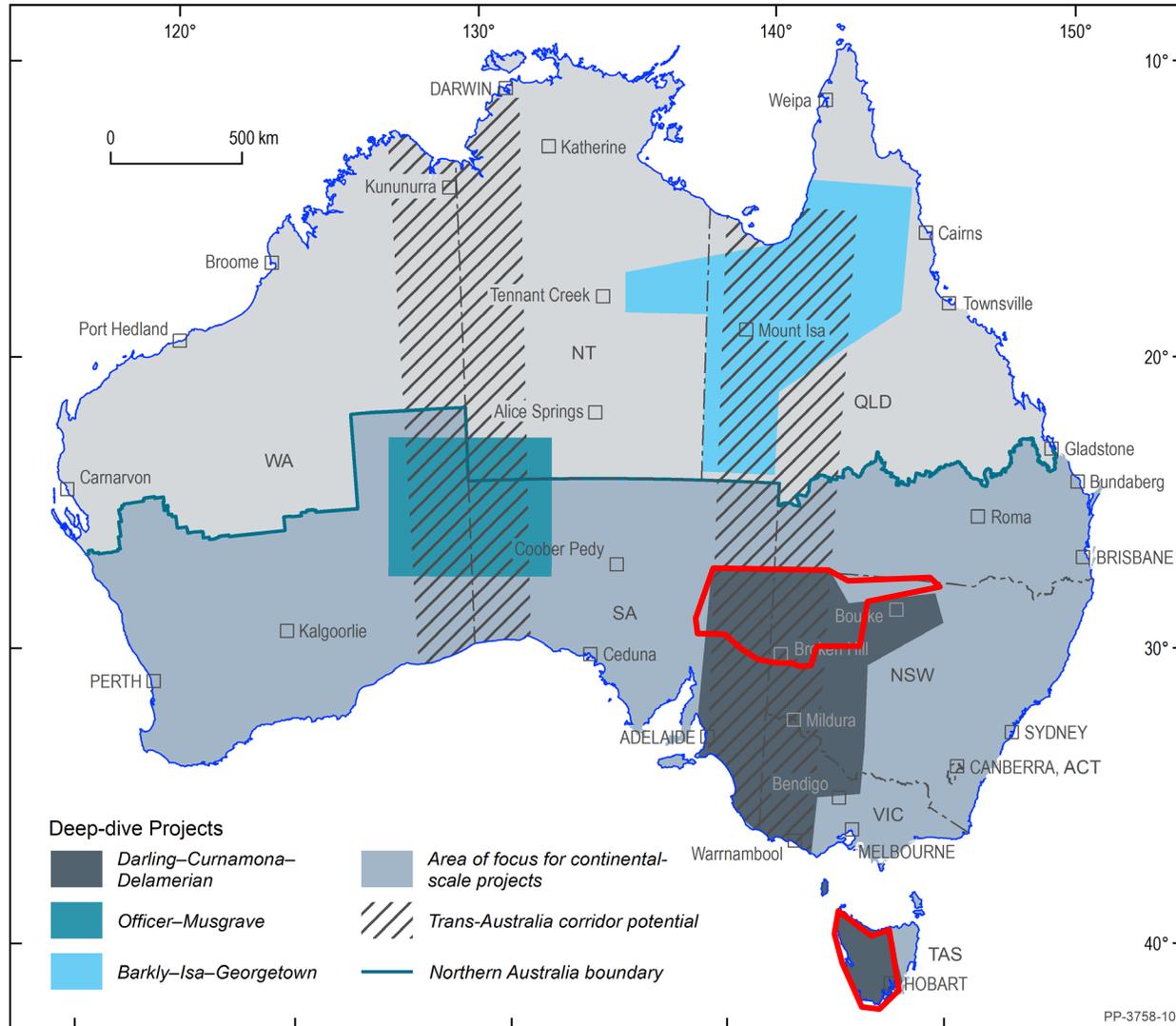
- Develop a phased geoscientific inventory for Australia's groundwater systems
- National Aquifer Framework harmonised with GA geology
- Develop understanding of Indigenous groundwater perspectives
- Prepare best practice groundwater guidelines inc. workflows



Principle hydrogeology of Australia

- Fractured or fissured; extensive aquifers of low to moderate productivity
- Fractured or fissured; extensive, high productivity aquifers
- Local aquifers; generally of low productivity
- Porous; extensive aquifers of low to moderate productivity
- Porous; extensive, highly productive aquifers

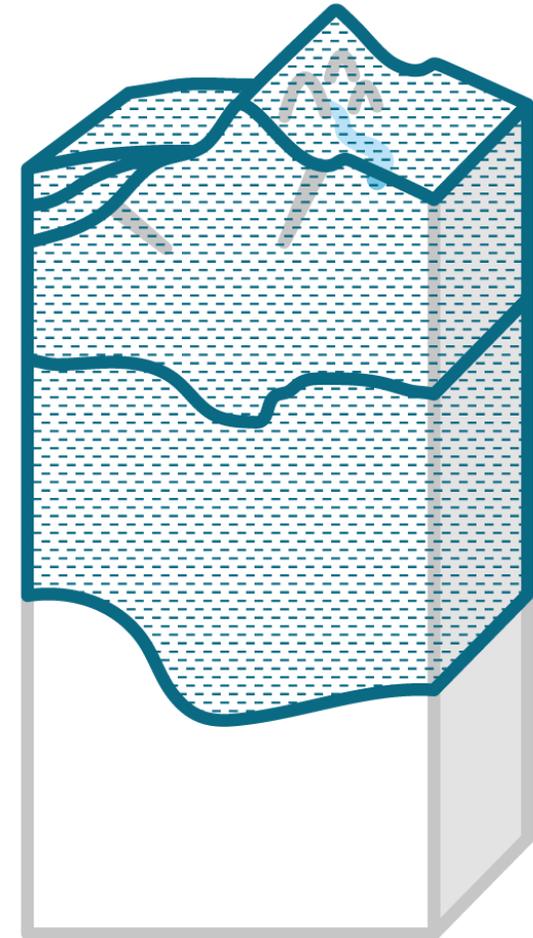
Darling-Curnamona-Delamerian Project



Systems



Geology



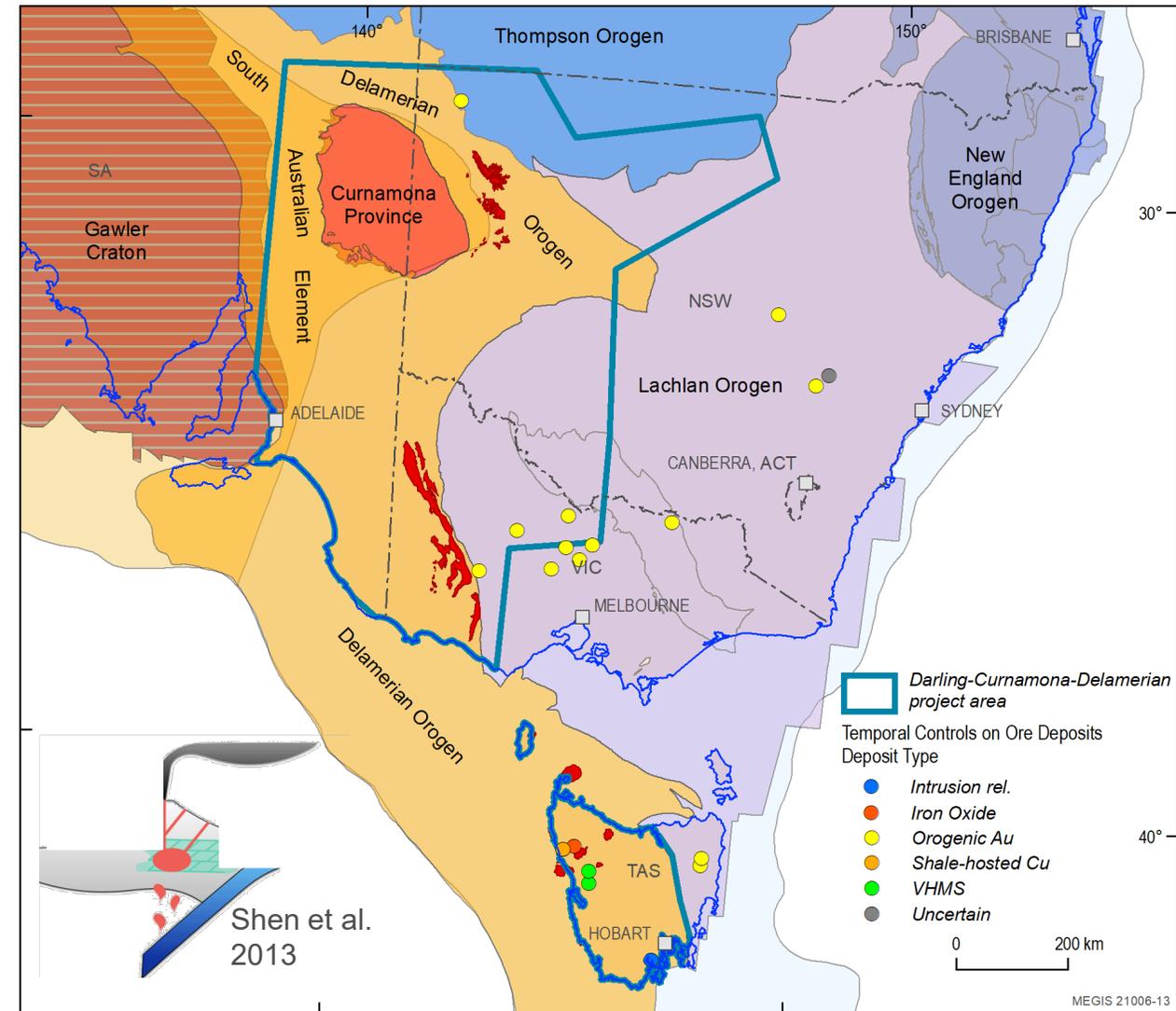
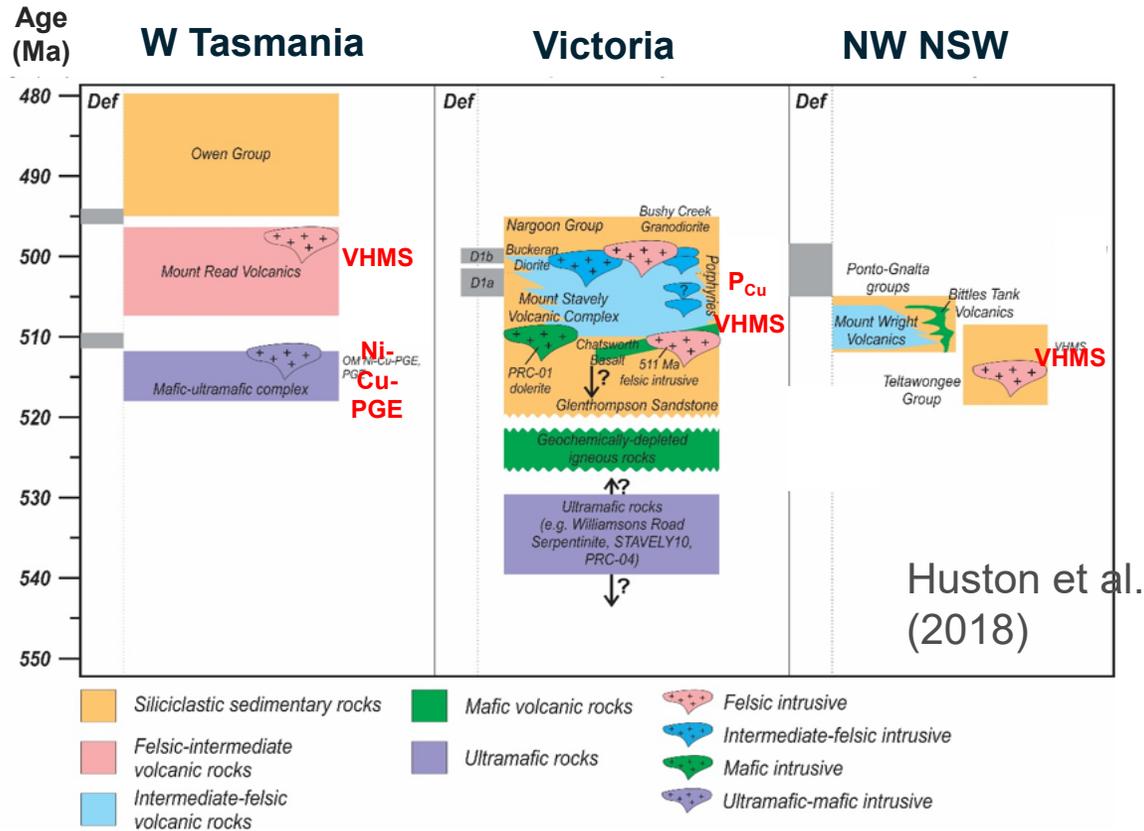
Darling-Curnamona Delamerian Project - Approach



Minerals

Key challenges:

- Is the Delamerian arc prospective for large convergent margin mineral systems under cover?
- What is the best way to target exploration undercover in the Curnamona and Delamerian arc?



Darling-Curnamona Delamerian Project - Approach



Minerals

Key challenges:

- Is the Delamerian arc prospective for large convergent margin mineral systems under cover?
- What is the best way to target exploration undercover in the Curnamona and Delamerian arc?

Key science questions:

- Extent, nature & variability of the Delamerian arc?
- Depth and nature of cover?
- Which tools are best applied to mineral exploration undercover?

Planned activities:

Delamerian & Curnamona

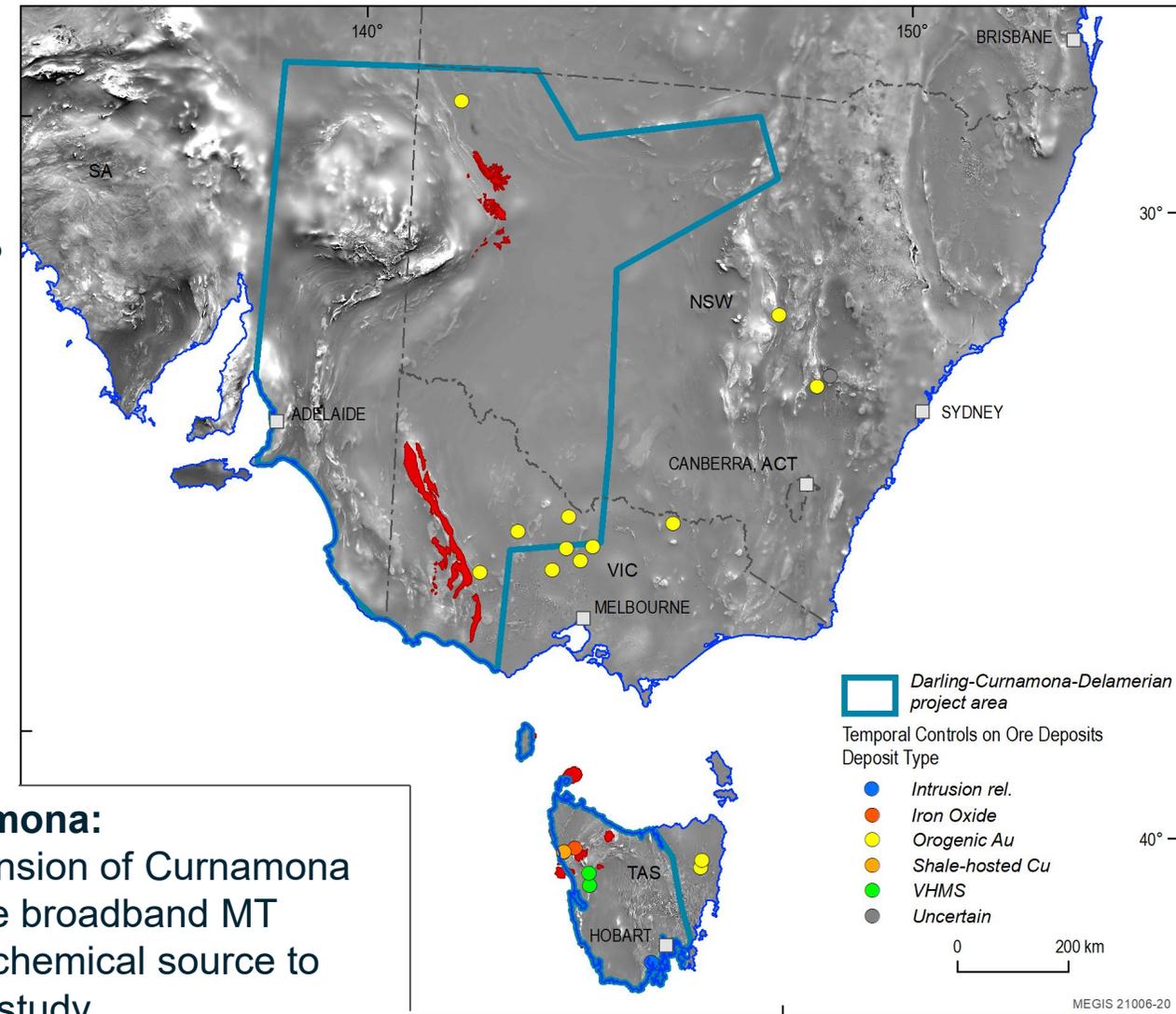
- A geodynamic synthesis of the region
- Airborne Electromagnetics ≤ 20 km

Delamerian:

- Deep reflection seismic
- Sampling and analysis of legacy core
- Drilling program?

Curnamona:

- Extension of Curnamona Cube broadband MT
- Geochemical source to sink study



Darling-Curnamona Delamerian: Barwon-Darling River

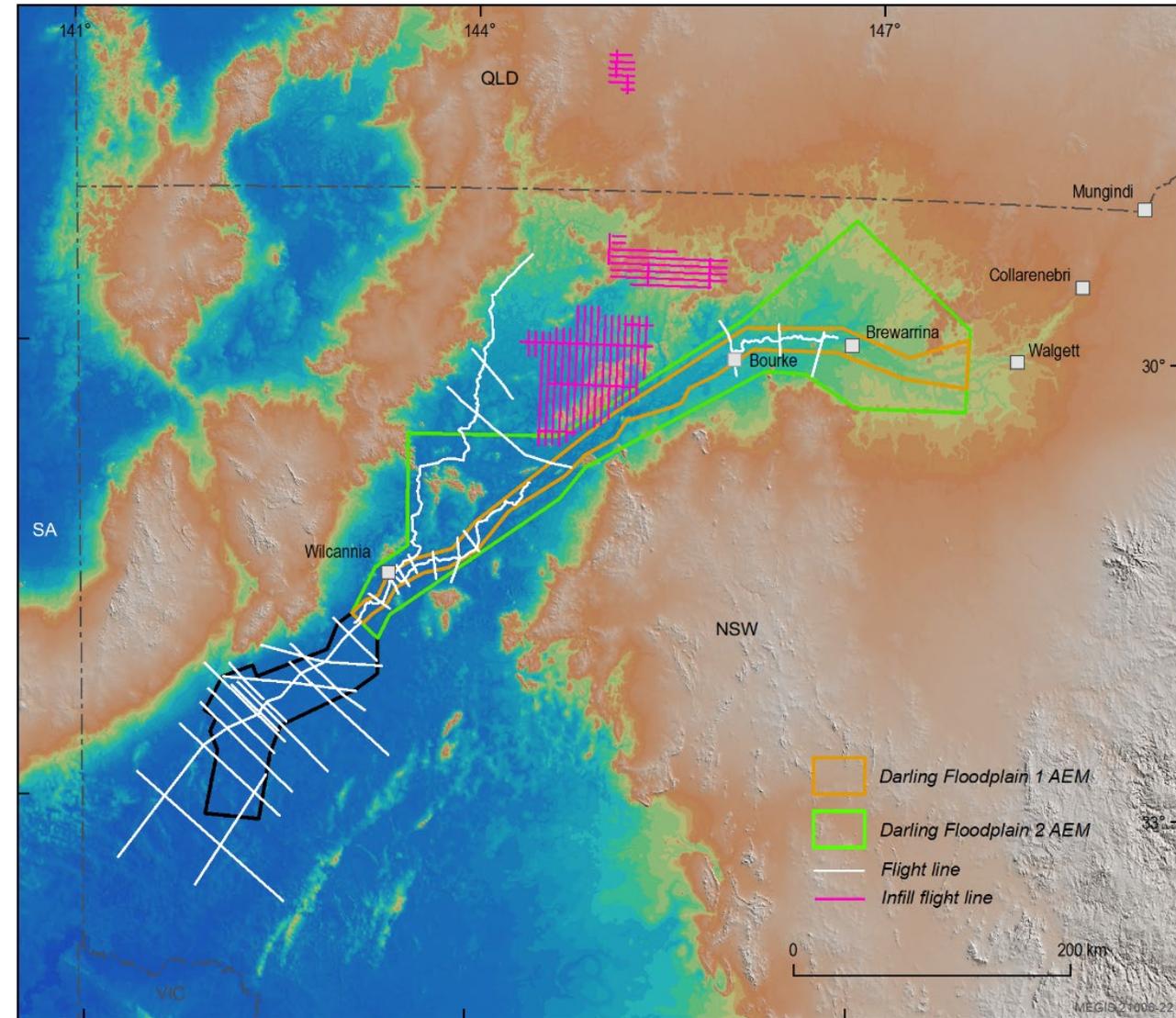
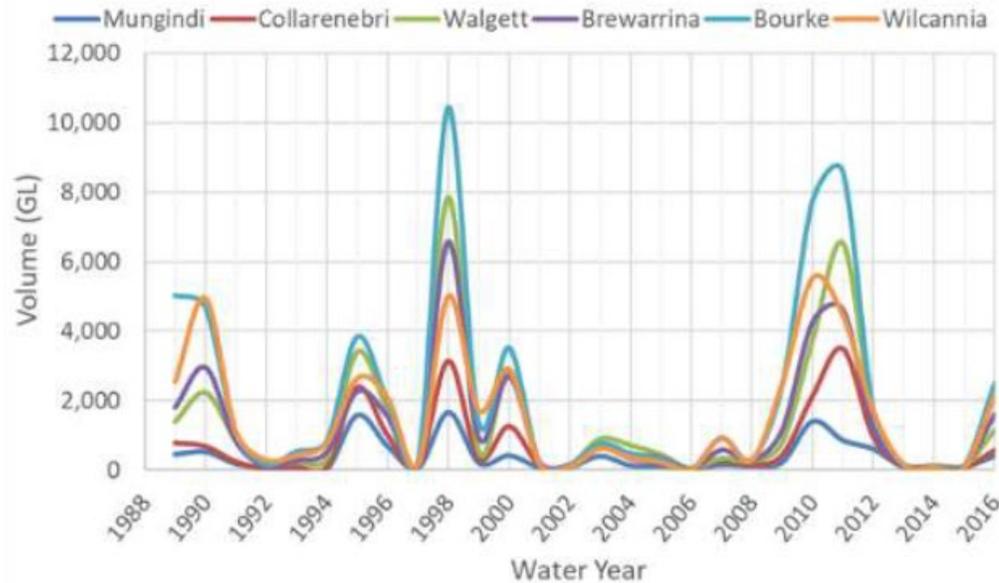


Groundwater

Key challenges:

- Water to support communities and industries
- Shallow saline groundwater in the region is actively managed to reduce risk to river health.
- During dry periods potable water supply to some towns in the region is scarce.

Annual Barwon-Darling River water volume



Darling-Curnamona Delamerian: Barwon-Darling River



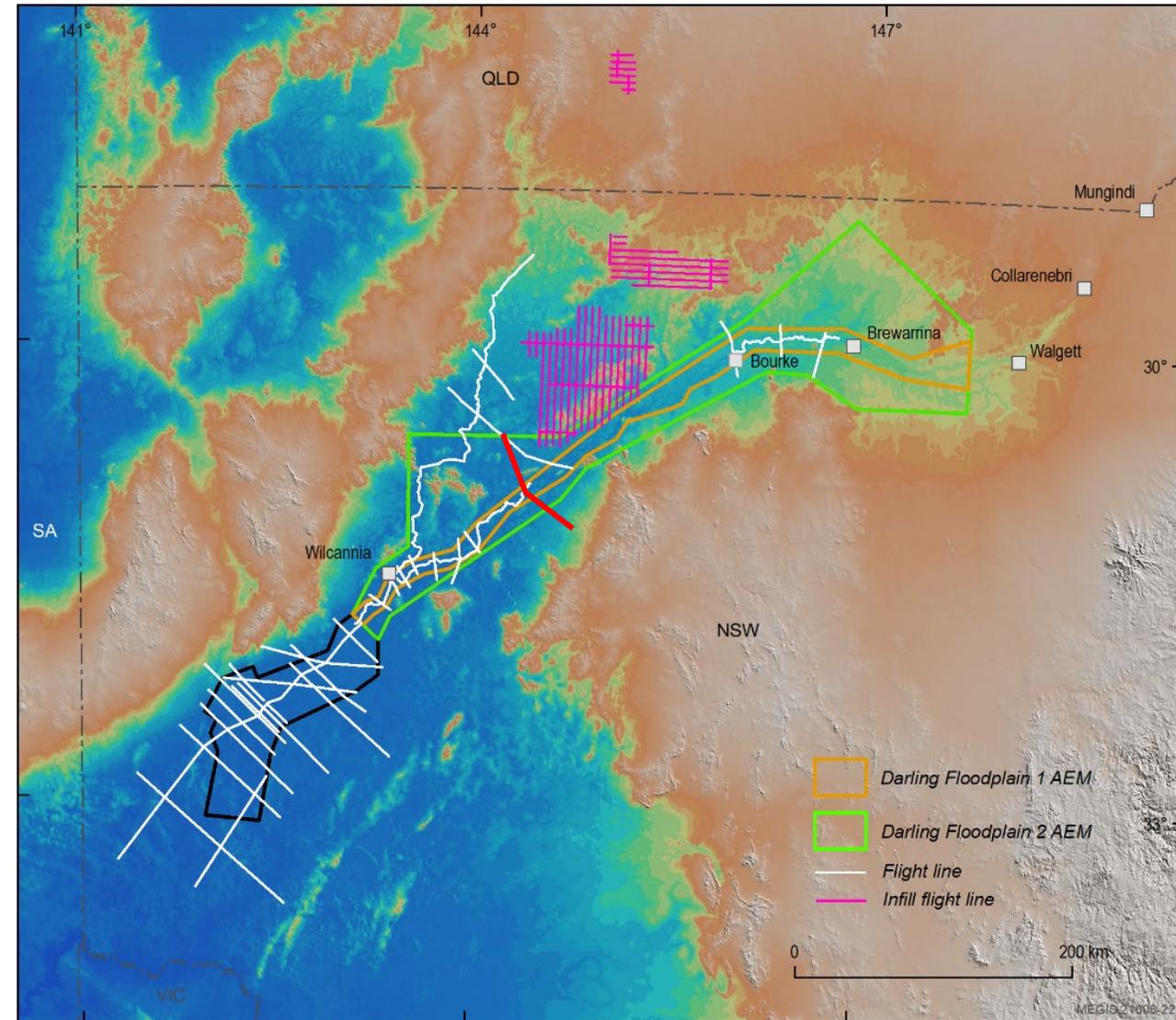
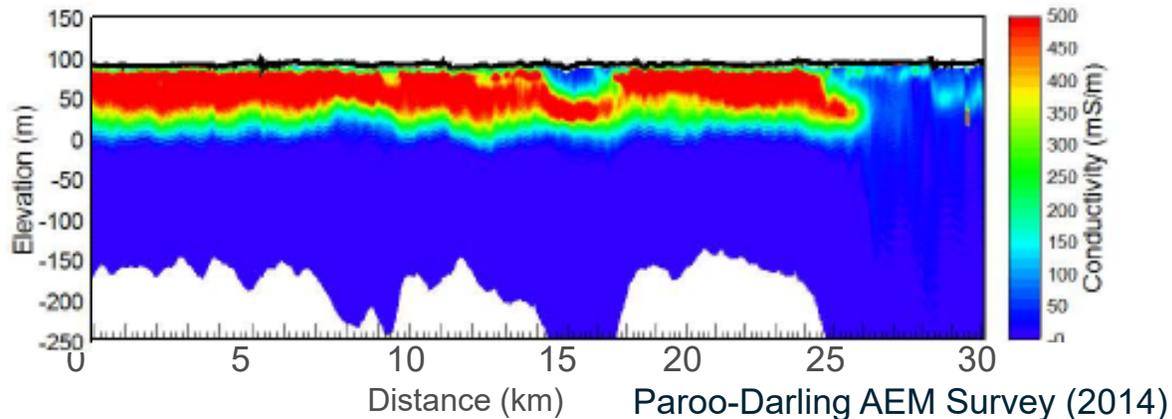
Groundwater

Key challenges:

- Water to support communities and industries
- Shallow saline groundwater in the region is actively managed to reduce risk to river health
- During dry periods potable water supply to some towns in the region is scarce.

Key science questions:

- Can salt interception schemes be improved?
- What are the facies controls on groundwater?
- Are there unknown groundwater resources & potential for storage?



Darling-Curnamona Delamerian: Barwon-Darling River



Groundwater

Key challenges:

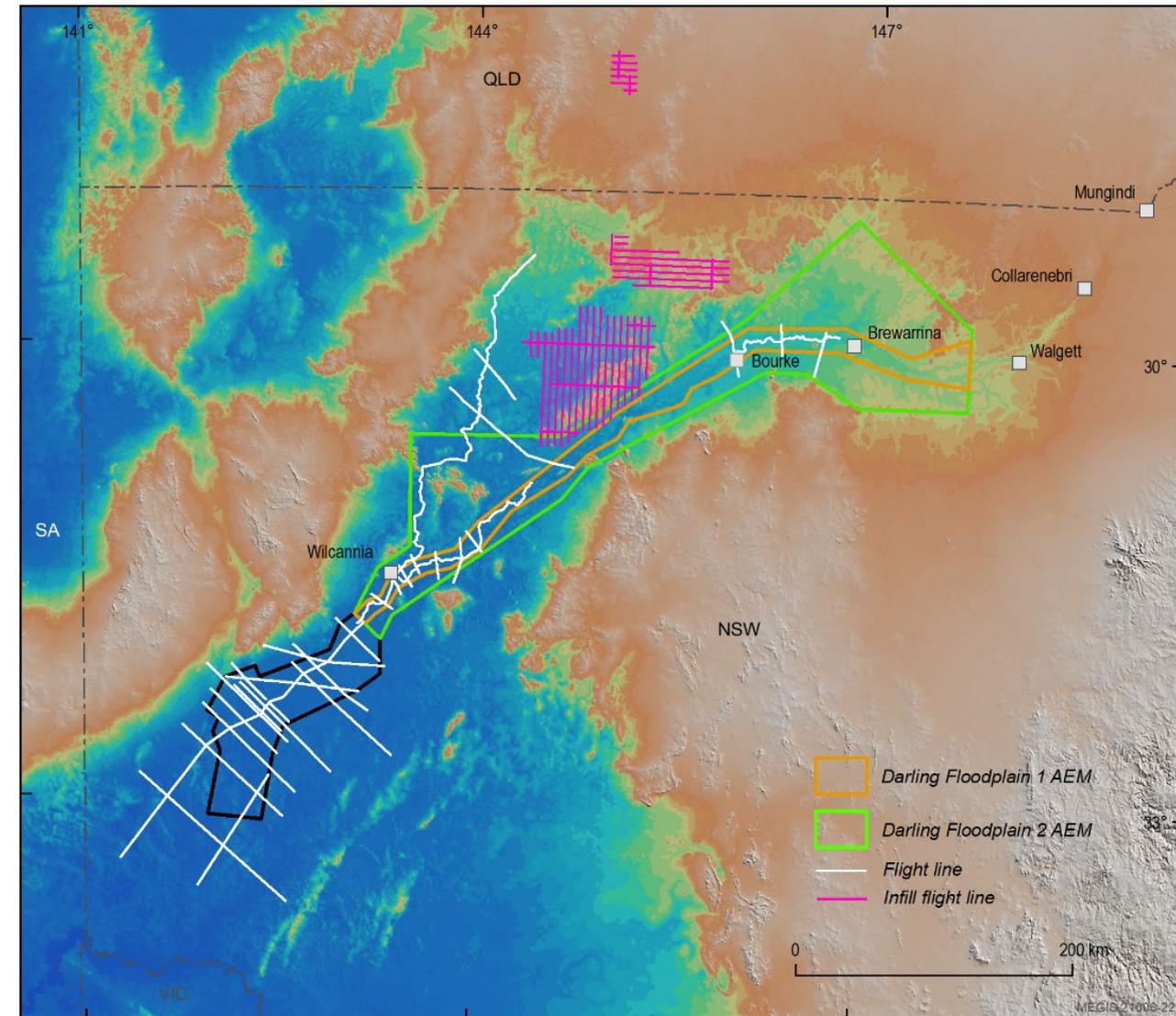
- Water to support communities and industries
- Shallow saline groundwater in the region is actively managed to reduce risk to river health.
- During dry periods potable water supply to some towns in the region is scarce.

Key science questions:

- Can salt interception schemes be improved?
- What are the facies controls on groundwater?
- Are there unknown groundwater resources & potential for storage?

Planned activities:

- A scale reduction approach to data collection:
 - Airborne electromagnetics in the corridor
 - Surface magnetic resonance surveys
 - Sonic drilling of 8 new paired bores
 - Hydrogeochemistry and dating



Enhanced Data Delivery – <https://portal.ga.gov.au>



Geoscience Australia Portal



About Layers Location Search Data & Publications

Tools Clip Map Narrator

Layers

Map Layers

3D Layers

Ground Opacity 23%

Show Stars On

Auto Rotate Direction Speed Slow Off

Vertical Exaggeration Model x1

Terrain x1 Link

Search

Airborne Electromagnetic (AEM)

Boreholes

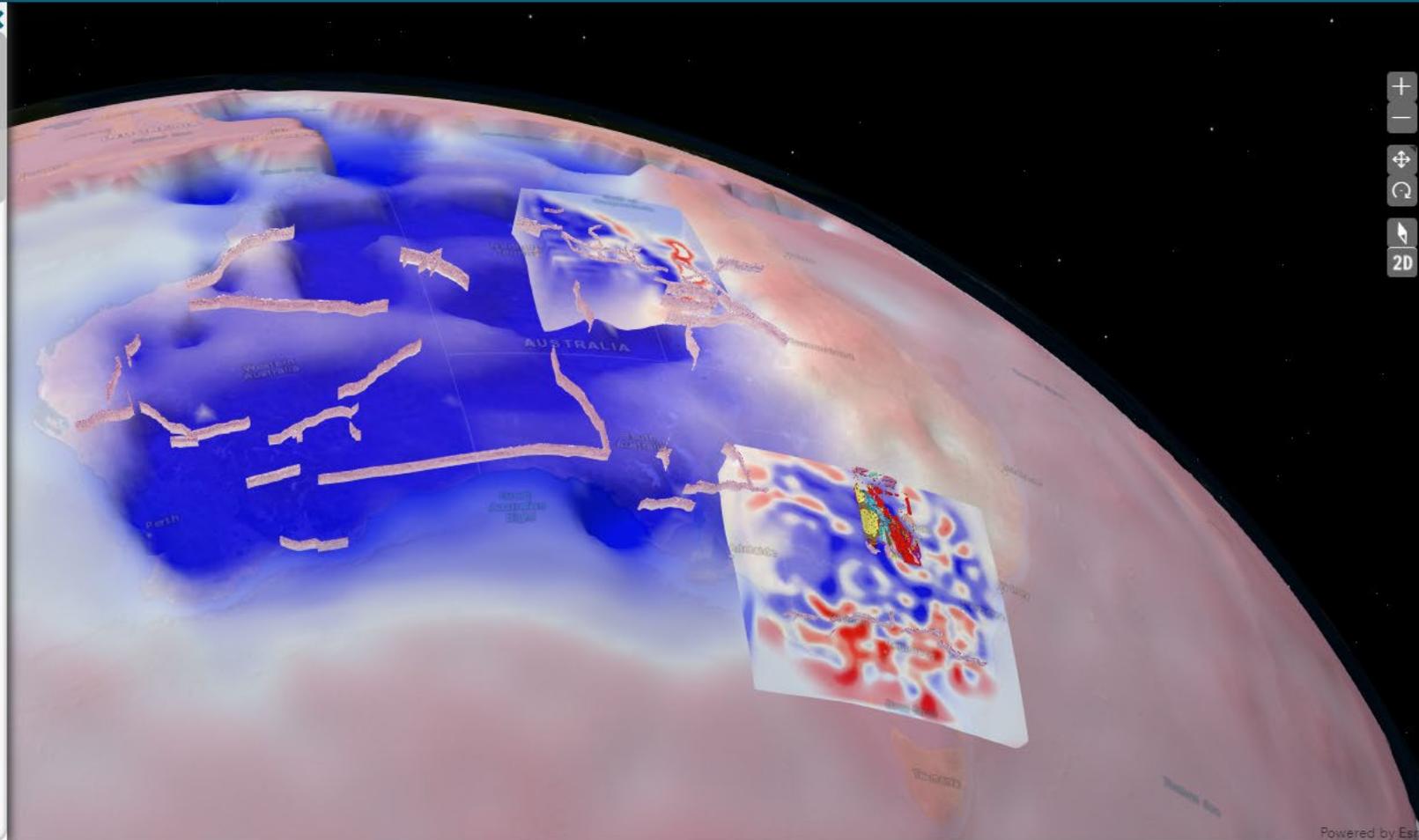
Cobar 3D Model

Earthquakes

Geology

Geophysics

Great Artesian Basin



Copyright Disclaimer Privacy Accessibility Information Publication Scheme Freedom of Information Contact us Provide Feedback

GEOSCIENCE AUSTRALIA



© Commonwealth of Australia (Geoscience Australia) 2021

karol.czarnota@ga.gov.au

Exploration in the Gallery

4 May 2021

Keep in touch



Access material:

- Program information – <https://www.ga.gov.au/efft>
- Portal – www.portal.ga.gov.au



Let us know what you think:

- Email – efft@ga.gov.au



Tuned in:

- Sign up for our monthly newsletter here – <https://communication.ga.gov.au/subscribe-efft>



Newsletters

Our government collaborators



Australian Government
**Department of Industry,
Innovation and Science**



Australian Government
Bureau of Meteorology



Australian Government
Department of the Environment and Energy



**Department of
Primary Industries**



**Geological Survey of
Western Australia**



**Planning &
Environment**



**GEOLOGICAL
SURVEY OF
South Australia**



Our collaborators from academia



Australian
National
University



MONASH University



THE UNIVERSITY
of ADELAIDE



THE UNIVERSITY OF
SYDNEY



MACQUARIE
University

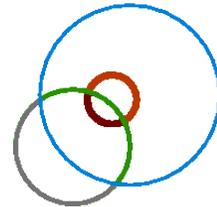


THE UNIVERSITY OF
WESTERN AUSTRALIA

HARVARD
UNIVERSITY



UNIVERSITY OF
CAMBRIDGE



LAMONT-DOHERTY
EARTH OBSERVATORY
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY



UNSW
SYDNEY



UNIVERSITY *of*
TASMANIA