

Using MT to understand the Mount Isa Province

Janelle Simpson



Acknowledgements

First Nations Peoples across Queensland

Seismic interpretation project – Karen Connors, Dominic Brown

2018 Cloncurry MT modelling – Liejun Wang, Jingming Duan

Cloncurry Depth to basement project – Hoel Seille

Data funded under various QLD Government and Geoscience Australia initiatives including New Economy Minerals Initiative, Exploring for the Future, Strategic Resources Exploration Program

Geophysical contractors – Moombarriga Geoscience, Zonge Engineering, Quantec

Naser Meqbel, Wenping Jiang, Darren Kyi, Russel Korsch, Michael Doublier, Paul Donchak, Sasha Aivazpourporgou, Courteney Dhnaram, Roger Cant, Matthew Greenwood and many others

MT community for publicly available inversion codes including but not limited to Occam 2D, ModEM3D

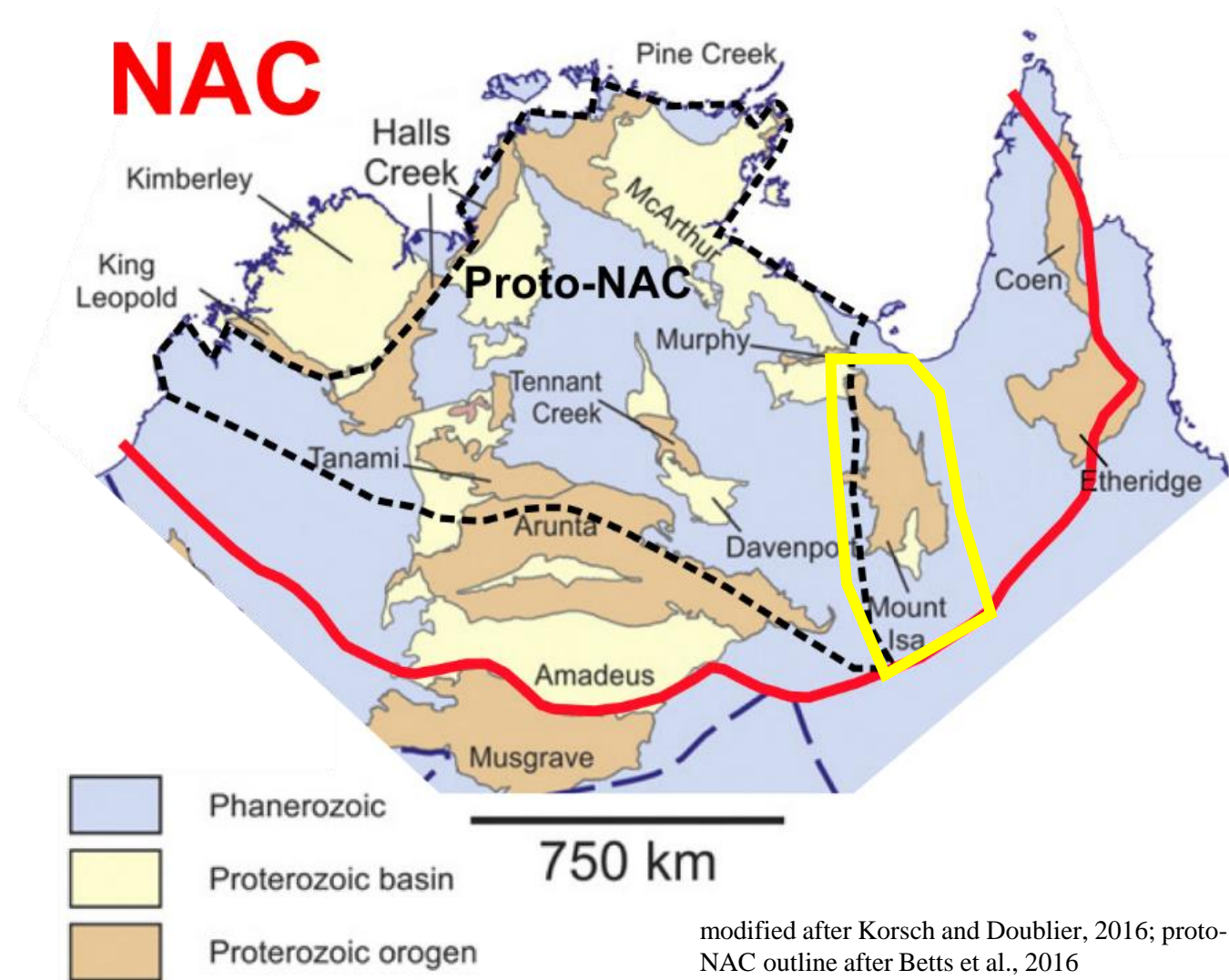
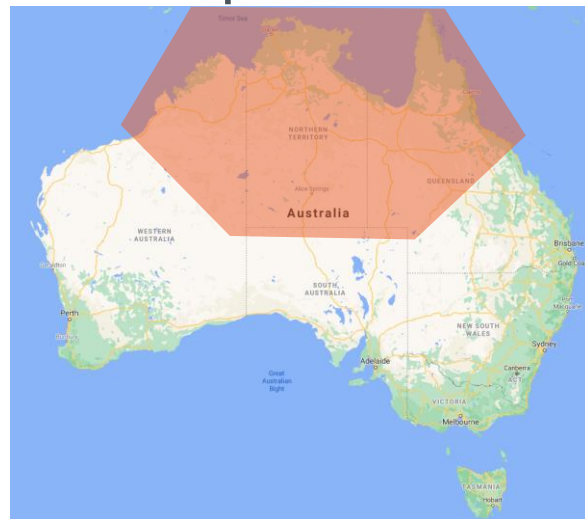


Mount Isa

Eastern part of the North Australia Craton

Exposed Proterozoic orogen

World class minerals province



modified after Korsch and Doublier, 2016; proto-NAC outline after Betts et al., 2016

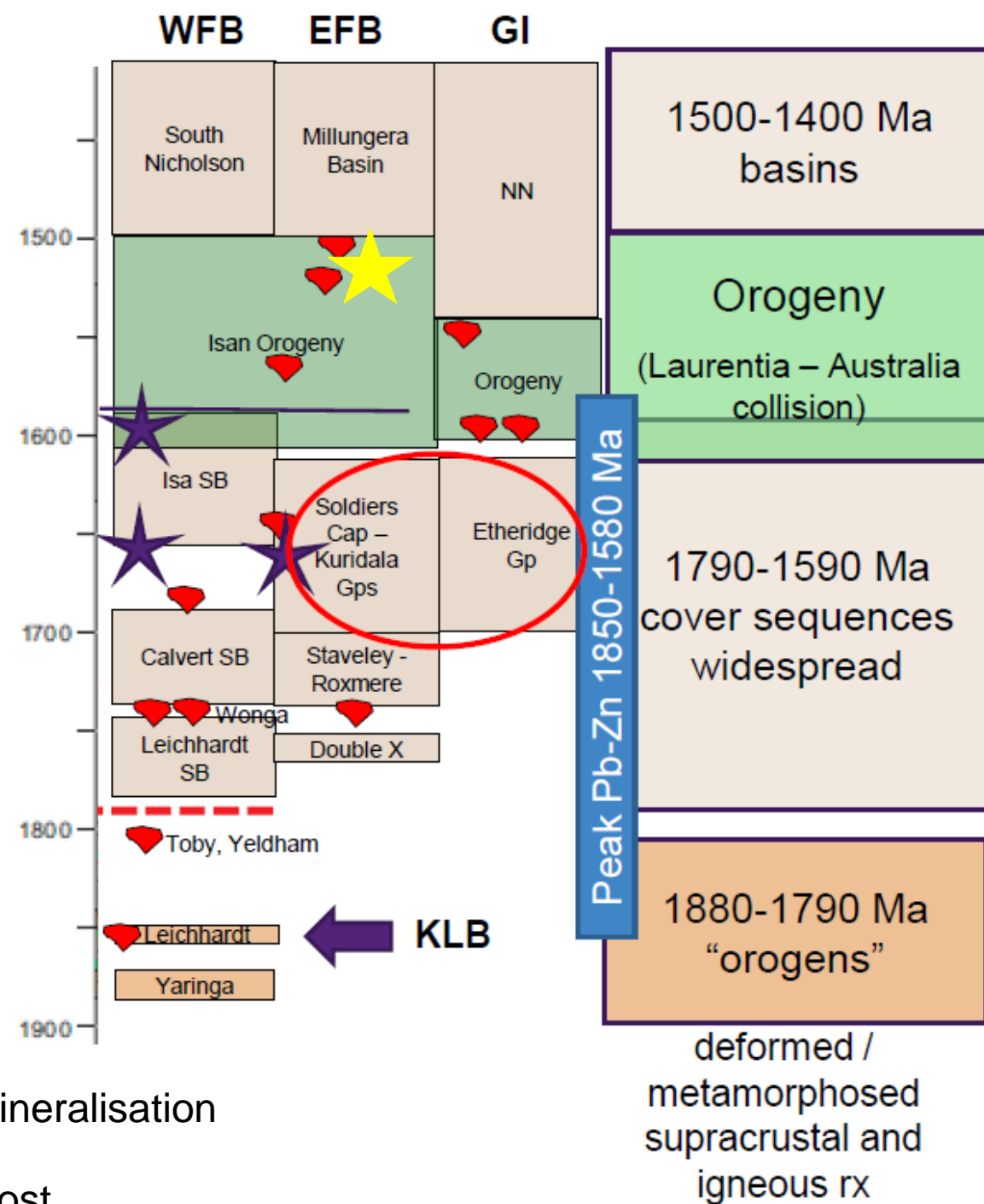
Simplified history

Pre 1850 basement

Deposition of three Superbasins between 1790Ma and 1590Ma

Isan orogeny 1600 – 1500Ma

Post-orogenic basins 1500Ma – 1400Ma



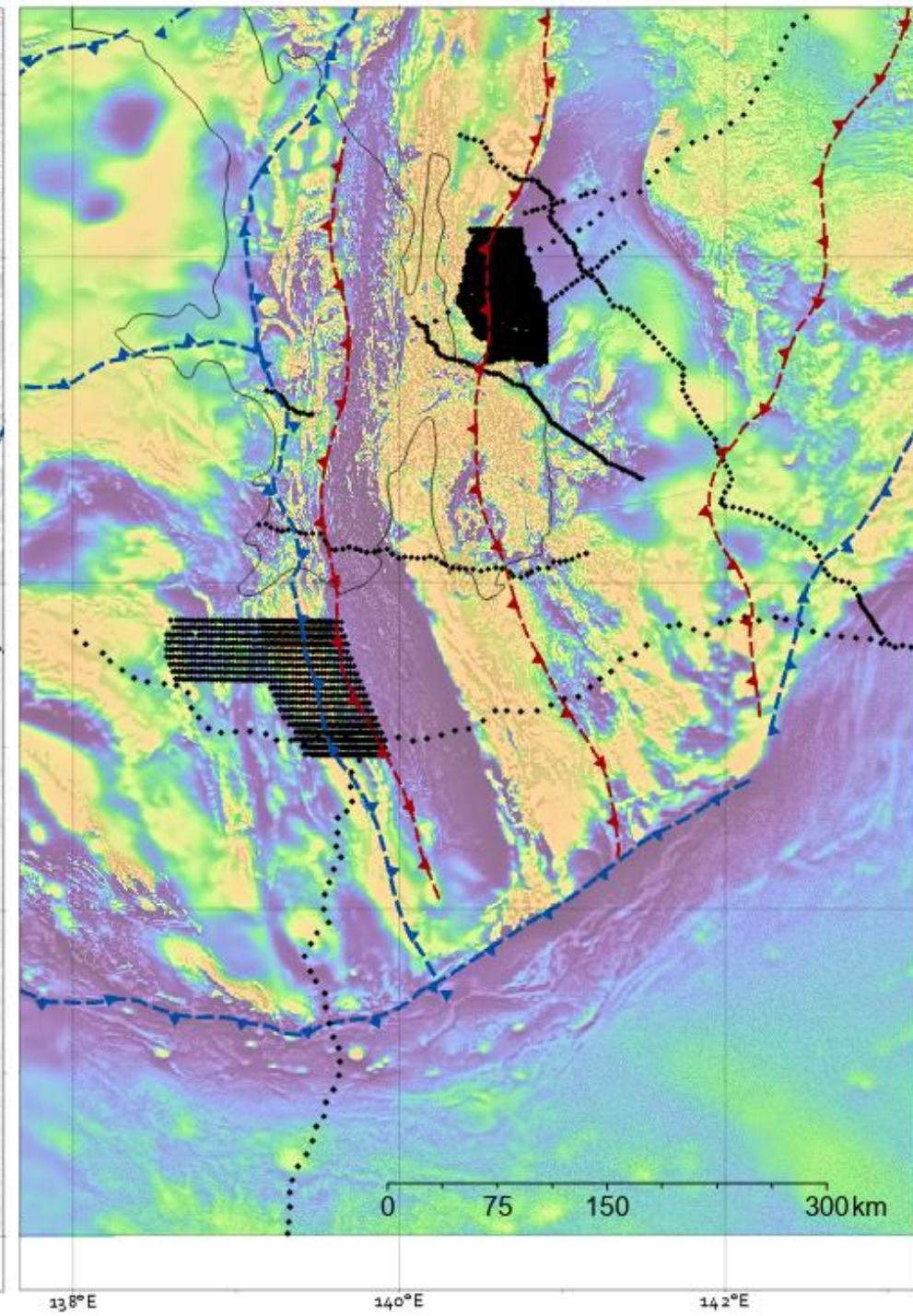
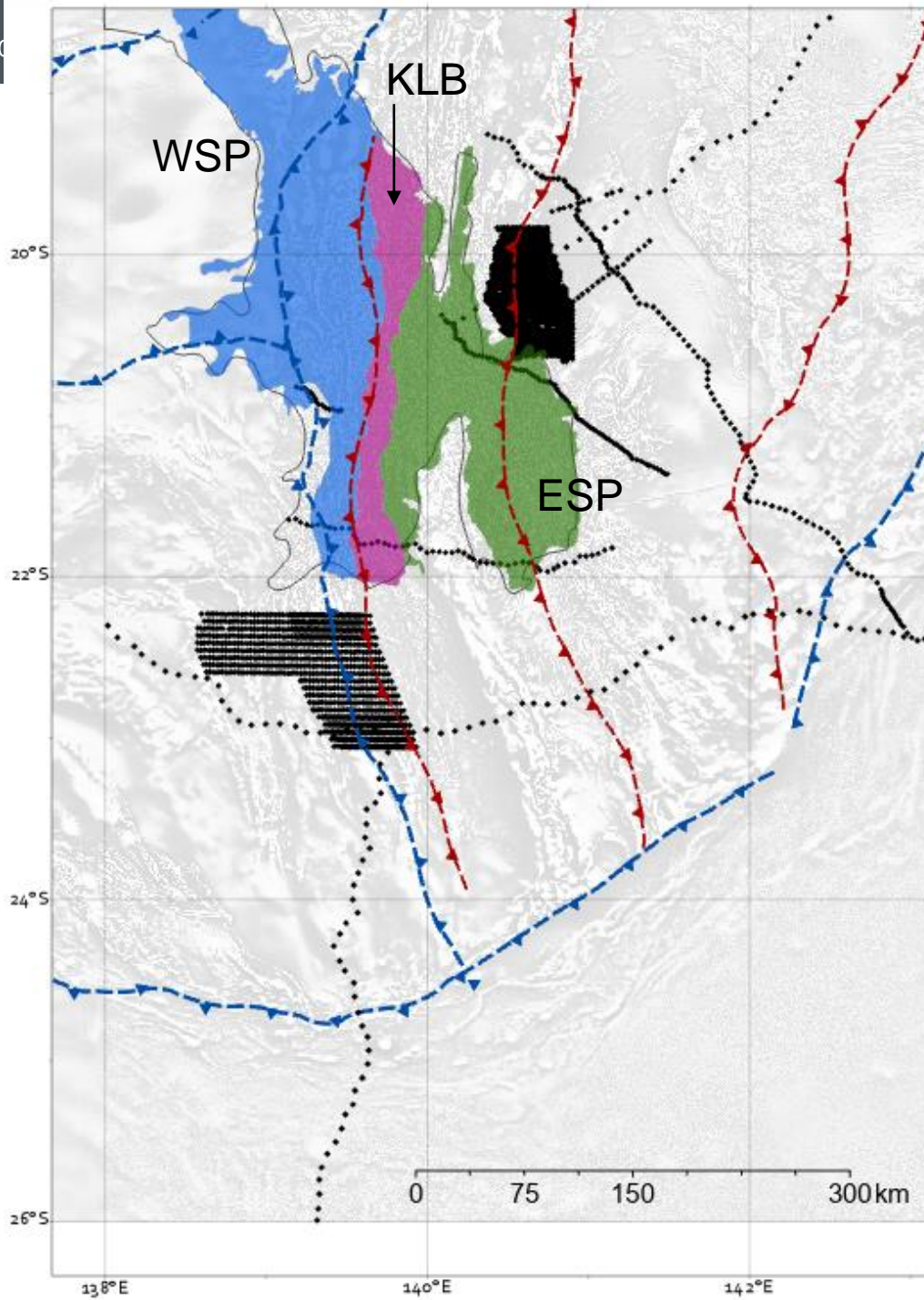
Simplified geology

Broadly three subdivisions:

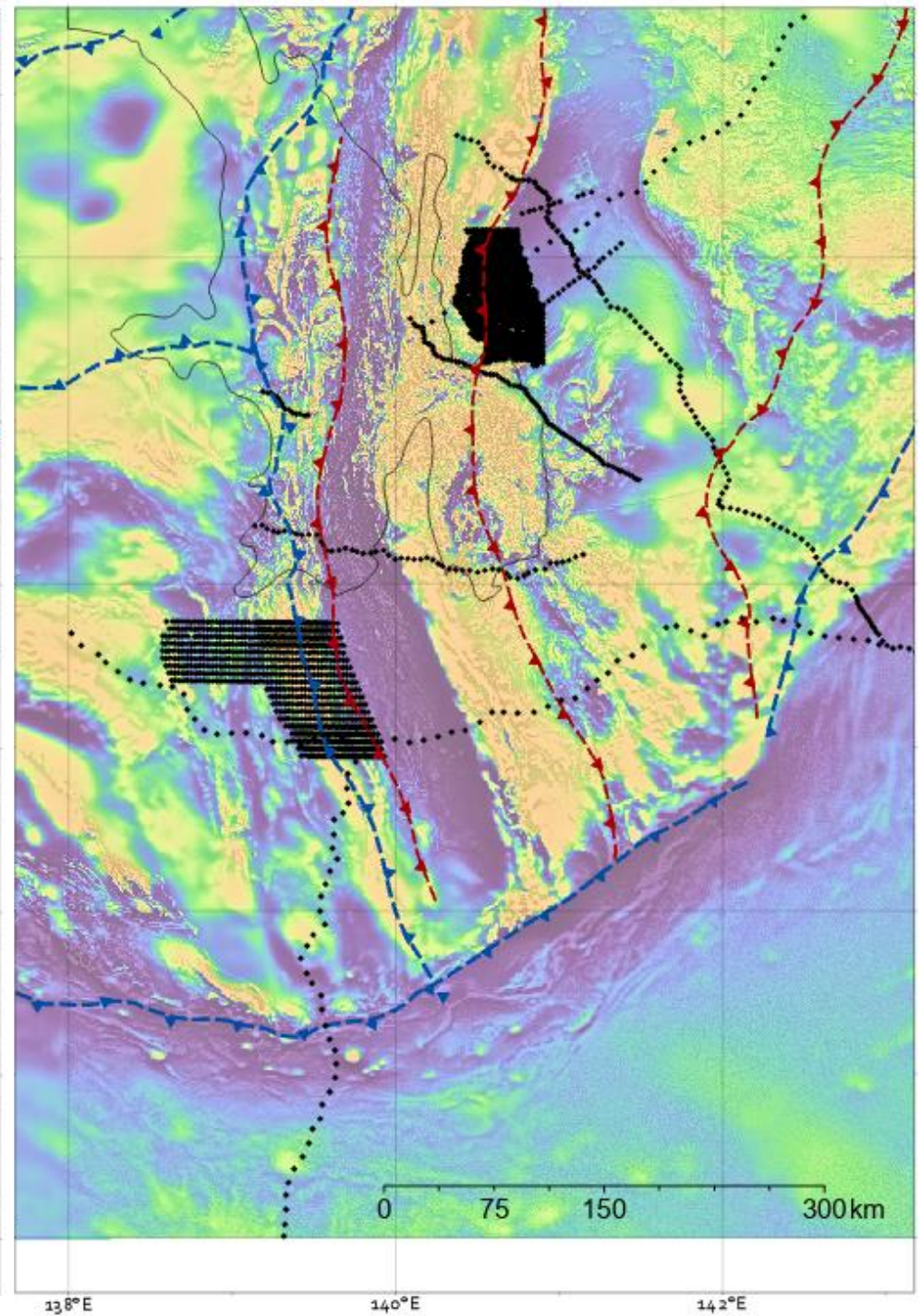
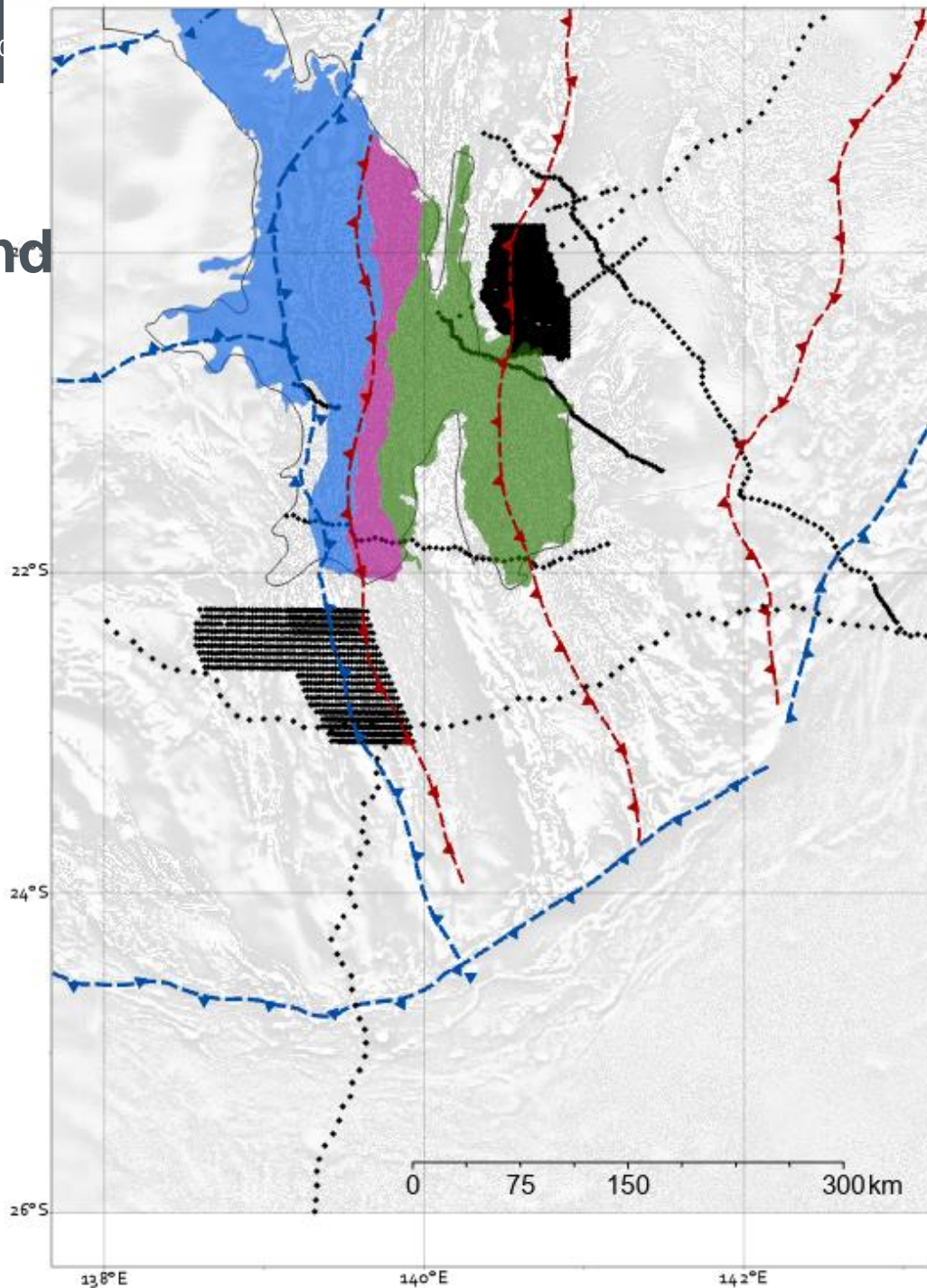
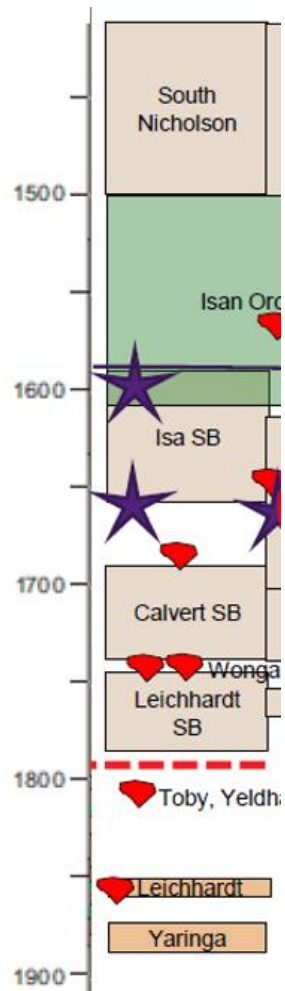
Western Subprovince

Eastern Subprovince

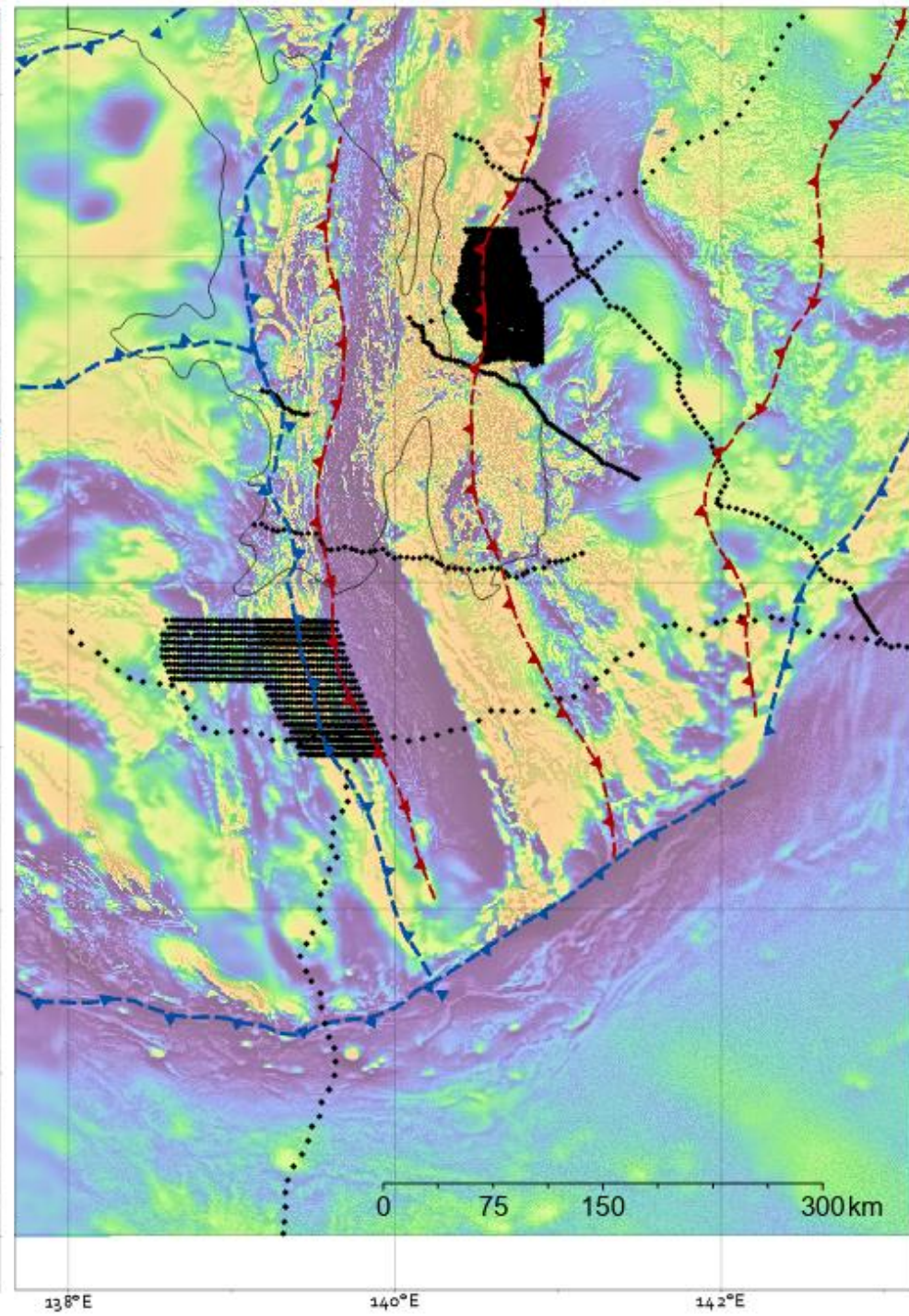
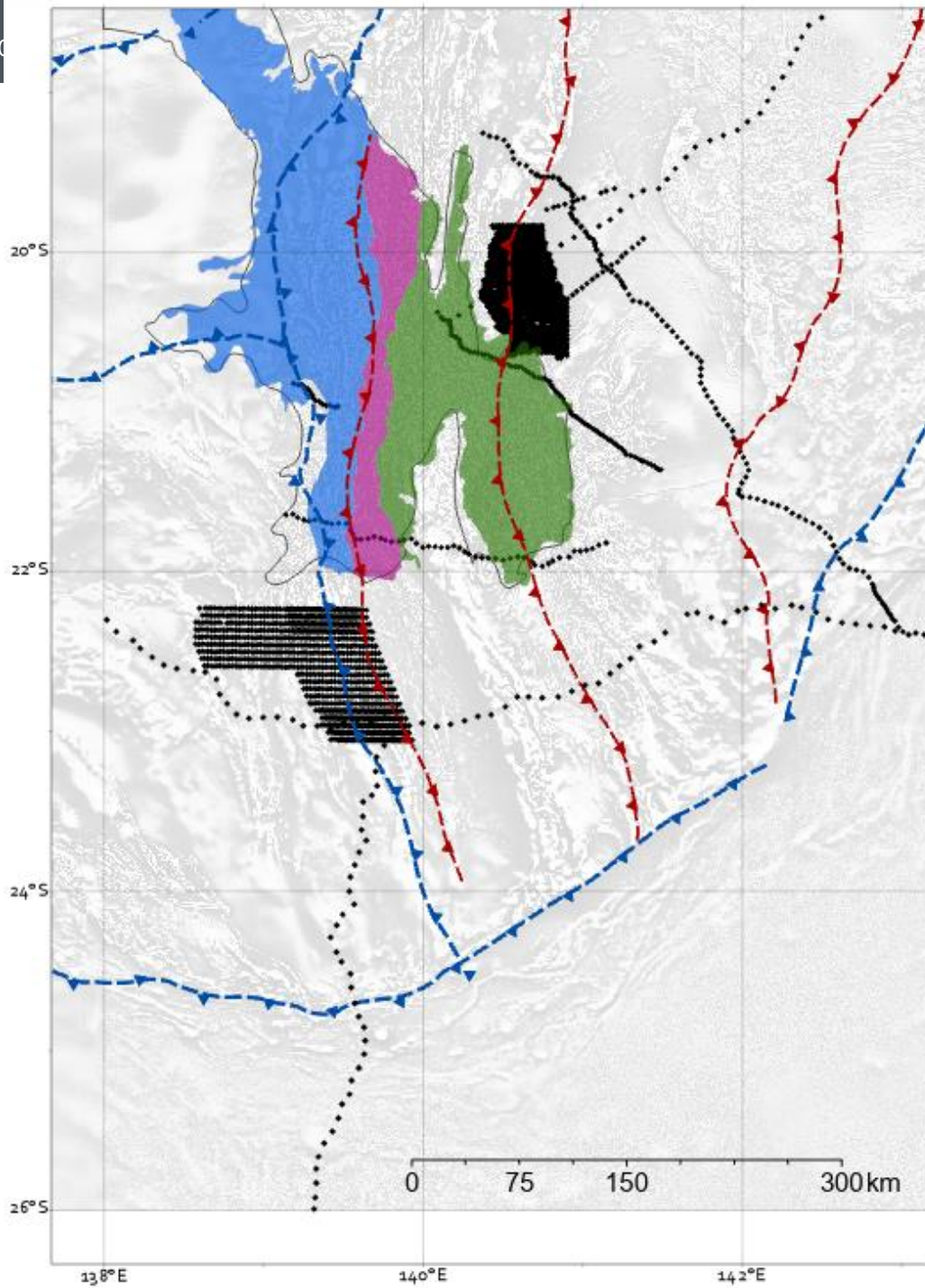
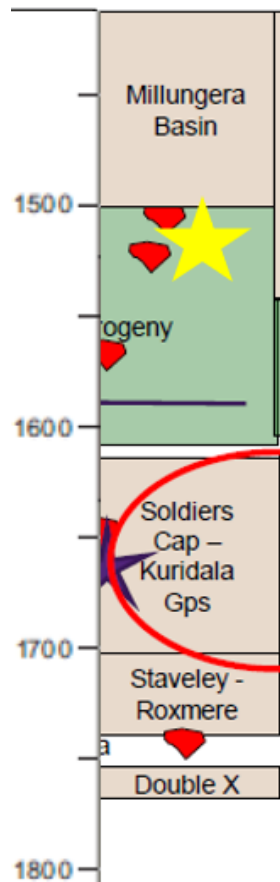
Kalkadoon Leichhardt Belt



Western Subprovince and KLB



Eastern Subprovince



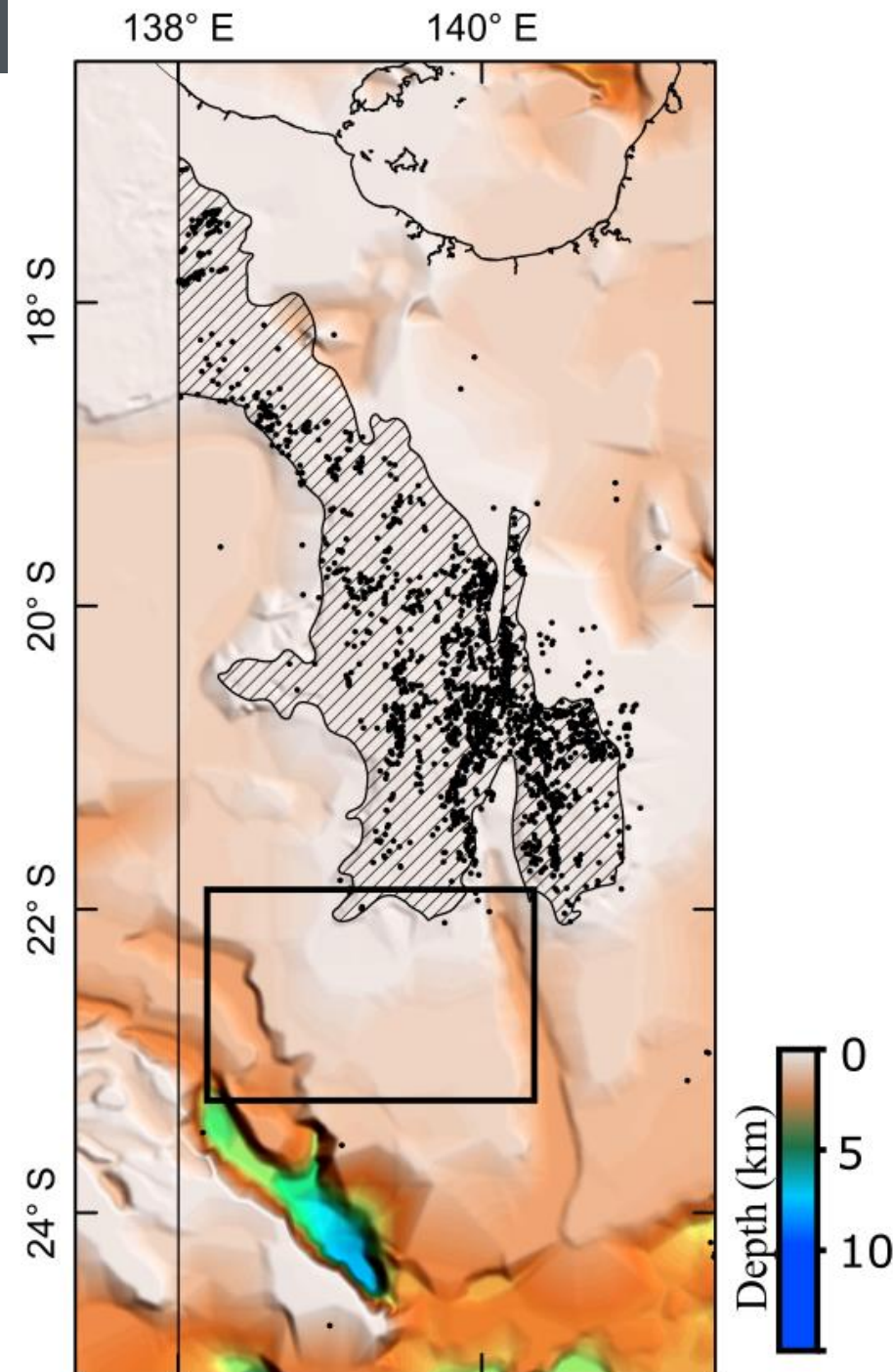
Challenges

Most known mineral occurrences on outcrop

Approx. 2/3rds of Province under cover

Expense of exploring undercover

Difficulty ground truthing interpretations



Challenges

Very conductive
cover

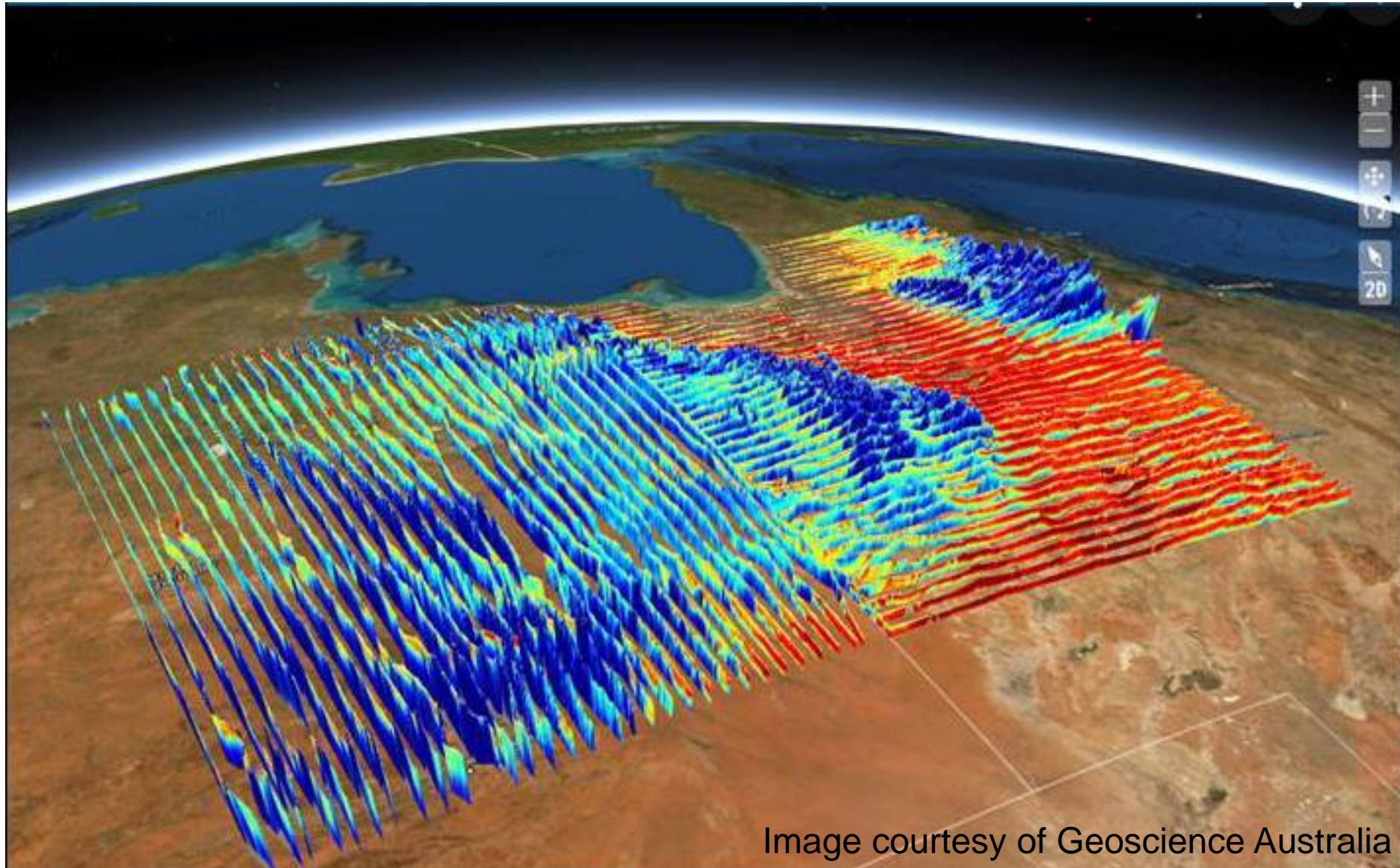


Image courtesy of Geoscience Australia

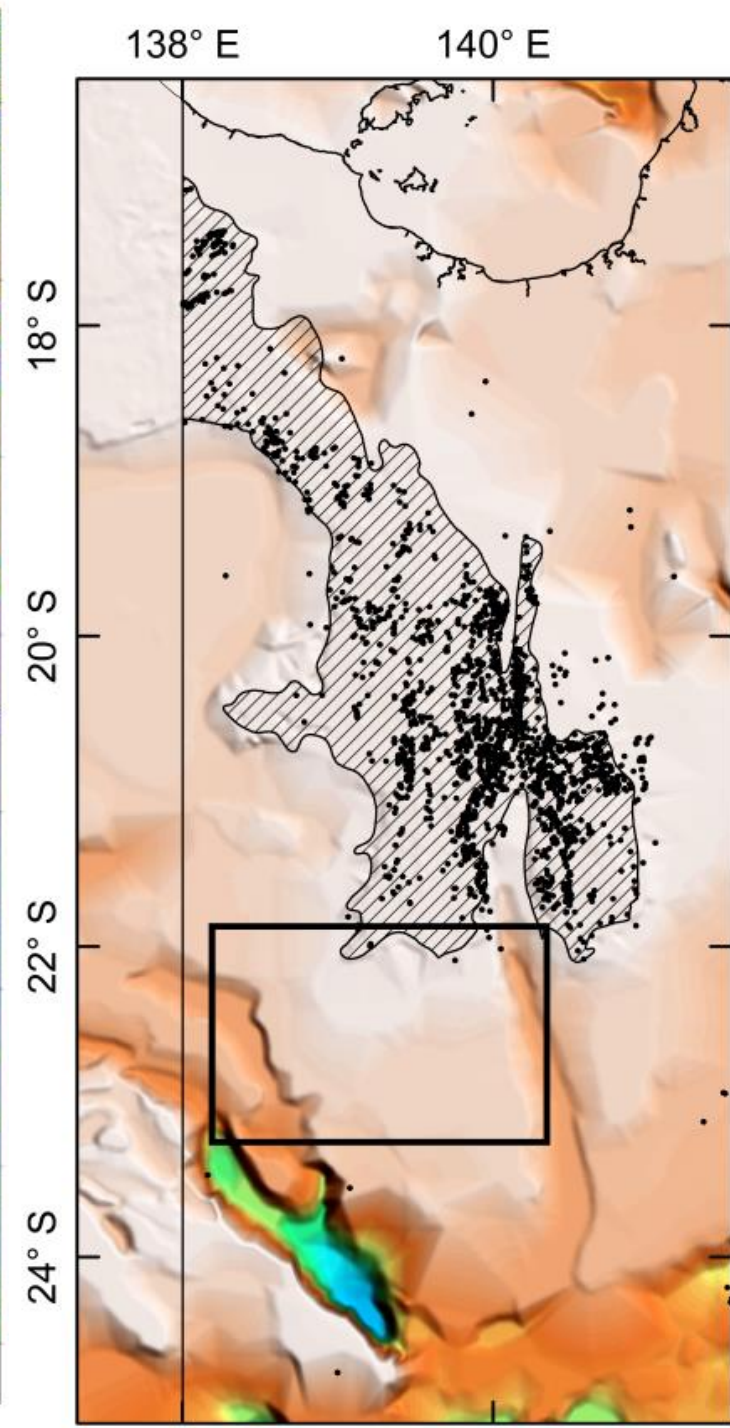
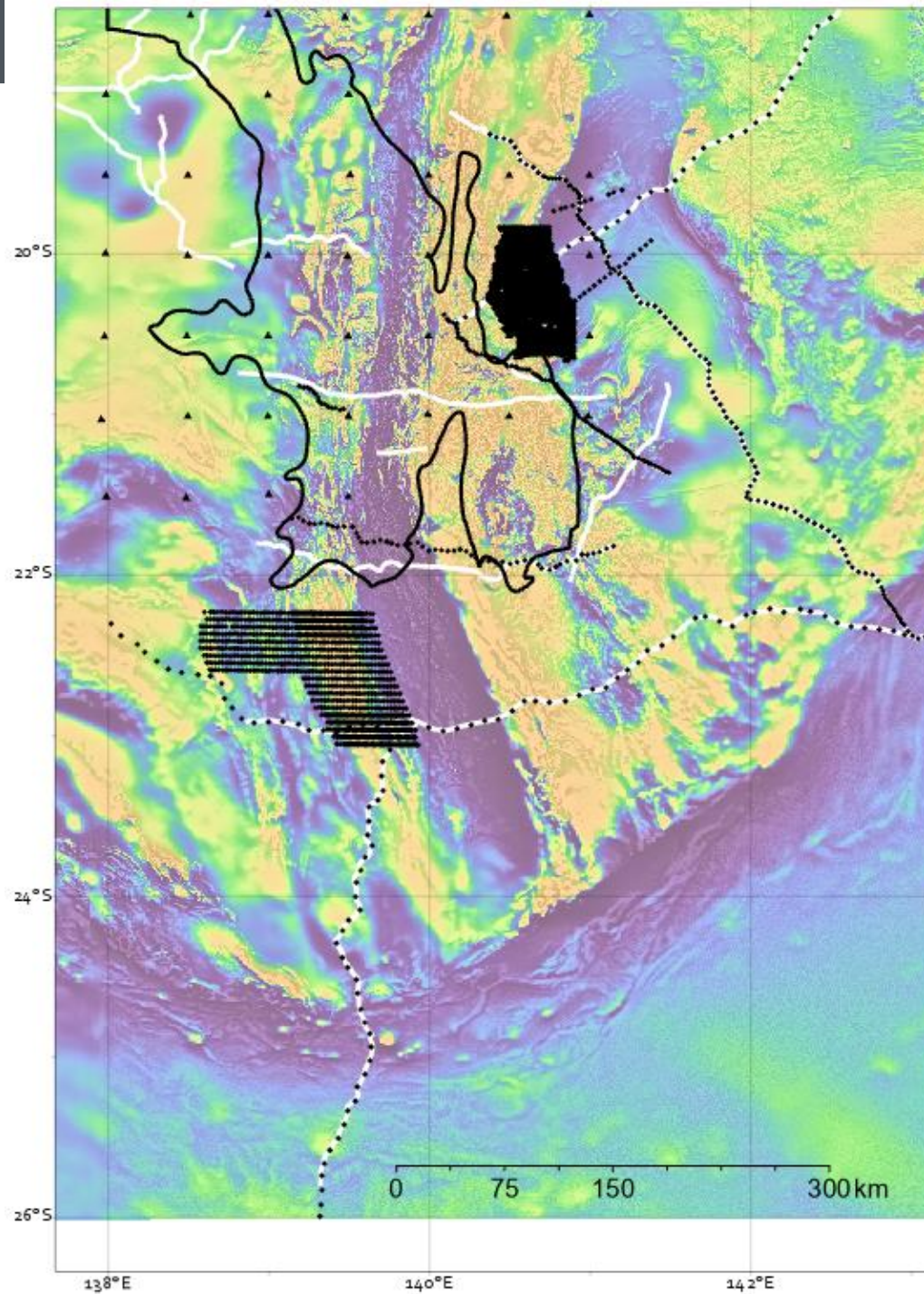


Opportunities

Approx. 2/3rds of Province under cover

Very data rich

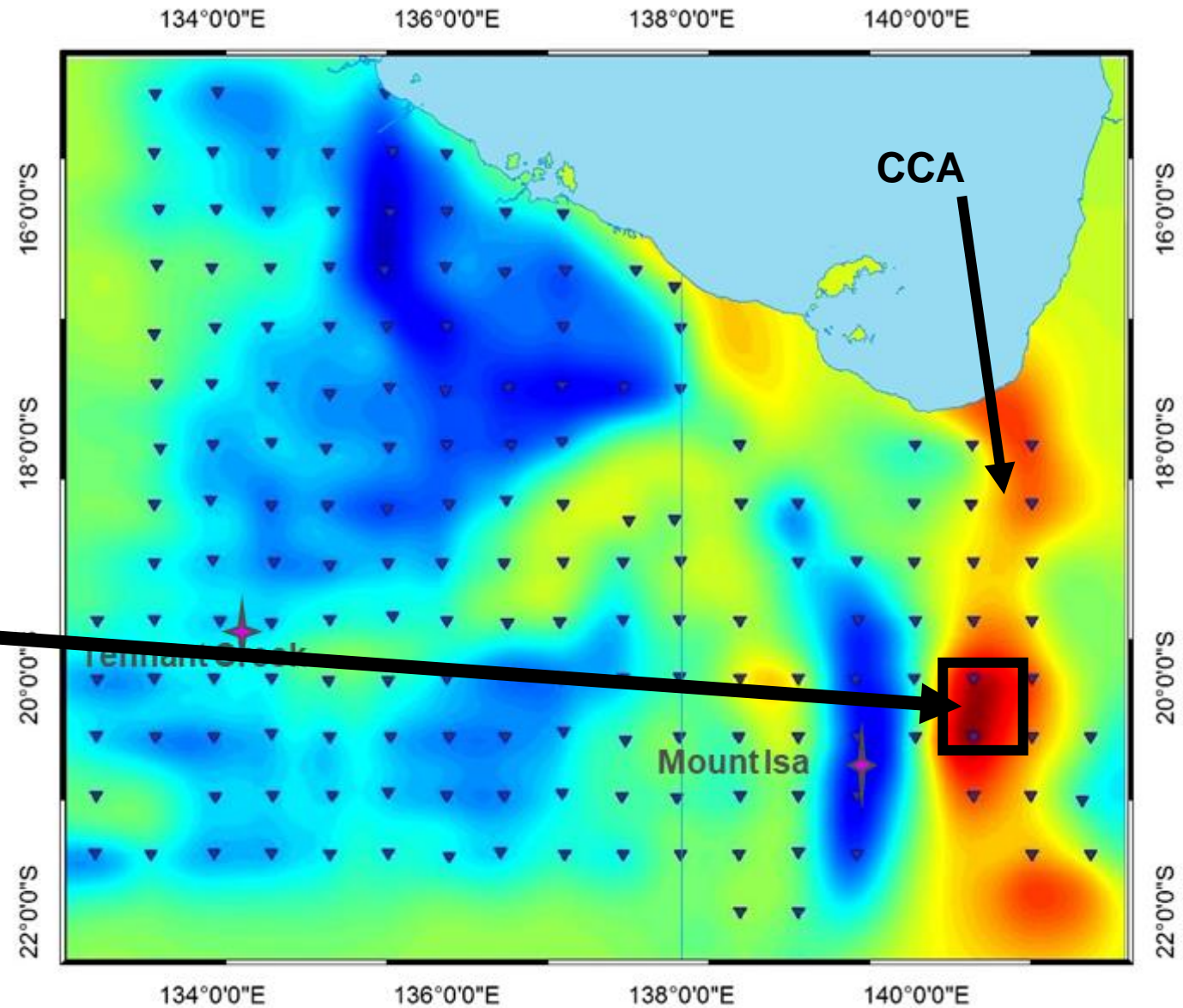
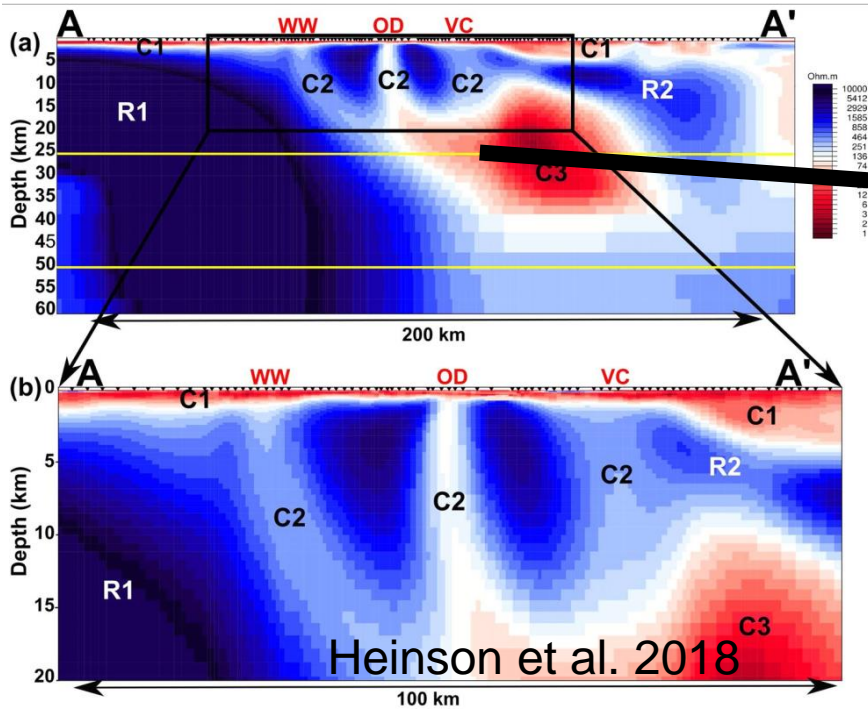
Active exploration community



Opportunities

Significant conductivity structure

Very similar context to the Olympic Dam example from SA



Regional conductivity structure at 33 km depth Duan (2020)

Recent(ish) MT projects

Acquisition

2014/2015 Isa Extension MT survey

- 1600 BBMT and AMT sites

2016 Cloncurry MT survey

- 470 BBMT sites

2020 Cloncurry Extension MT survey

- 530 BBMT sites

2021 CF23 Survey

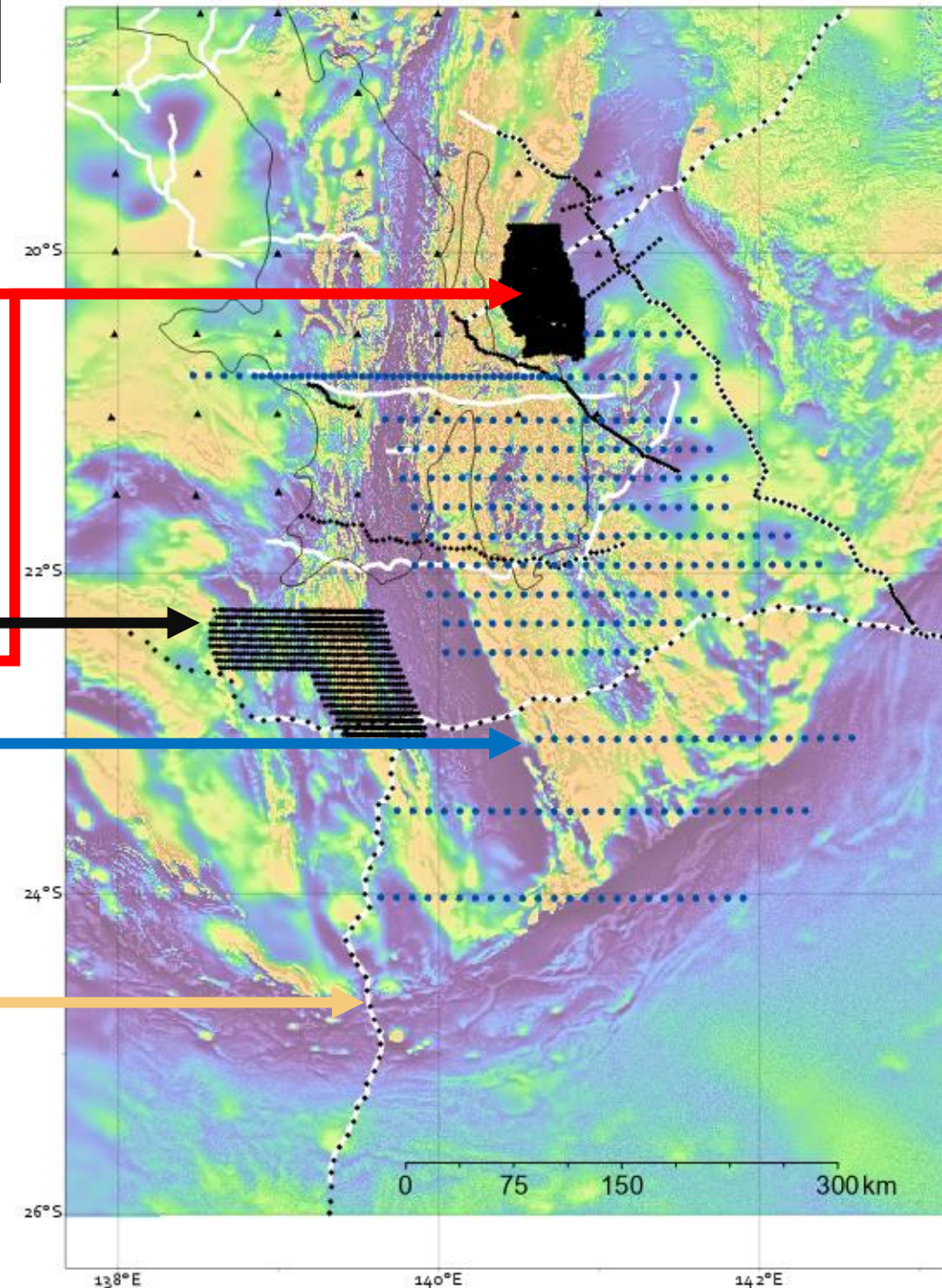
- 100 BBMT sites

Upcoming CCA MT survey

- 320 BBMT sites

Geoscience Australia Initiative

- Ongoing AusLAMP coverage



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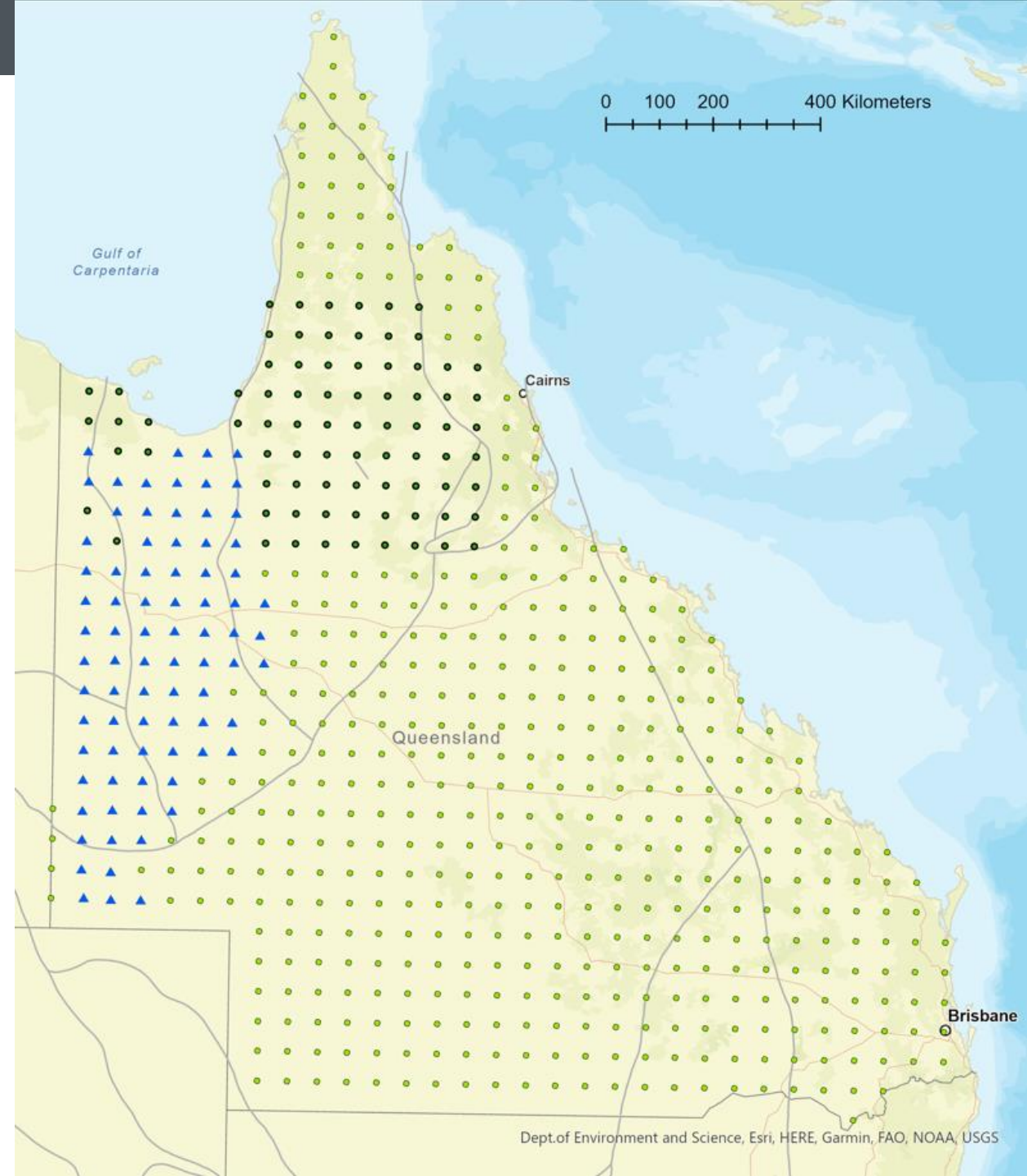
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Recent(ish) MT projects

Interpretation

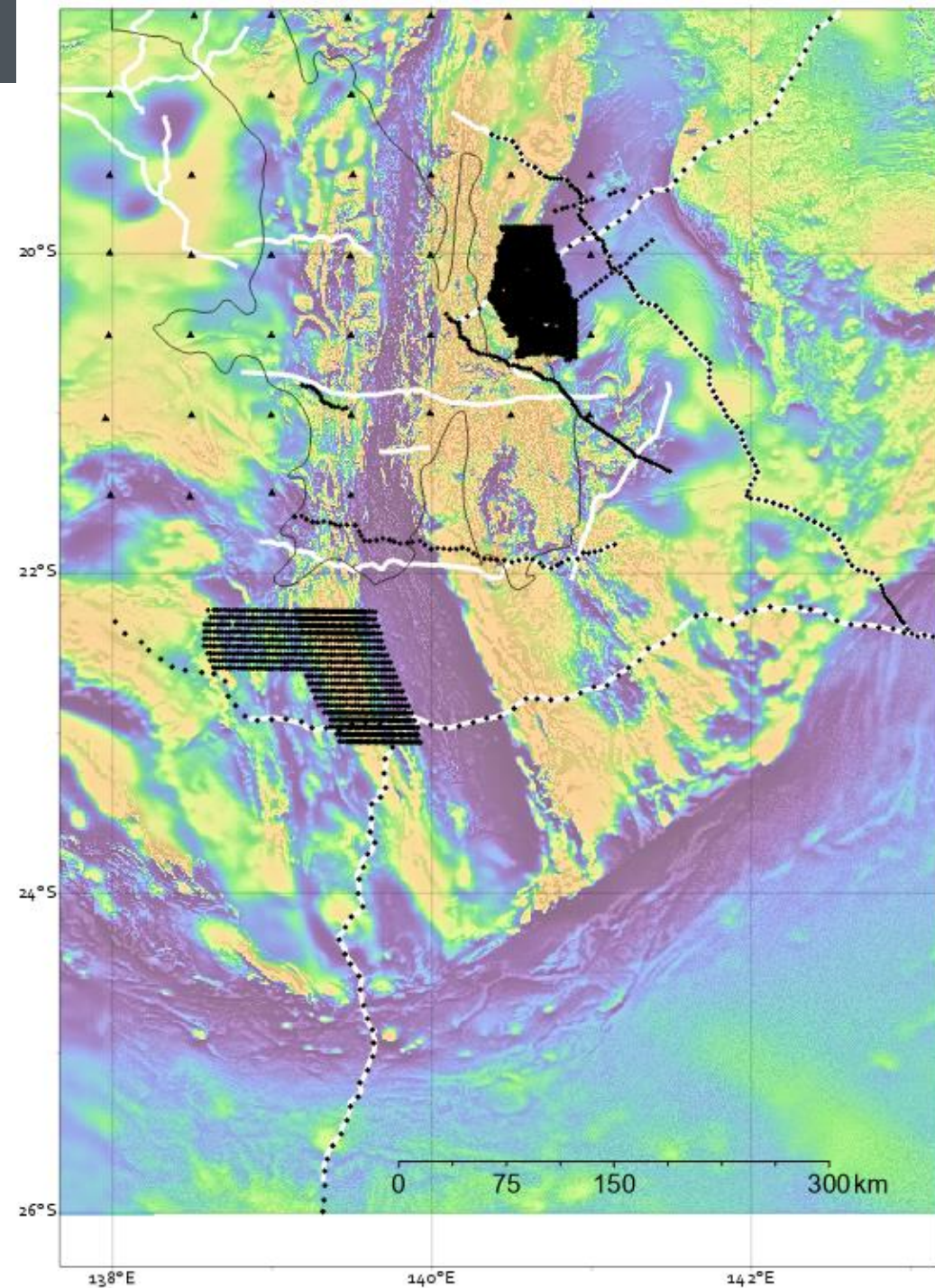
Deep crustal seismic interpretation project

Depth to basement projects

- Cloncurry in partnership with CSIRO
- Isa Extension

Inversion and modelling of MT

- CF23
- Cloncurry



Recent(ish) MT projects

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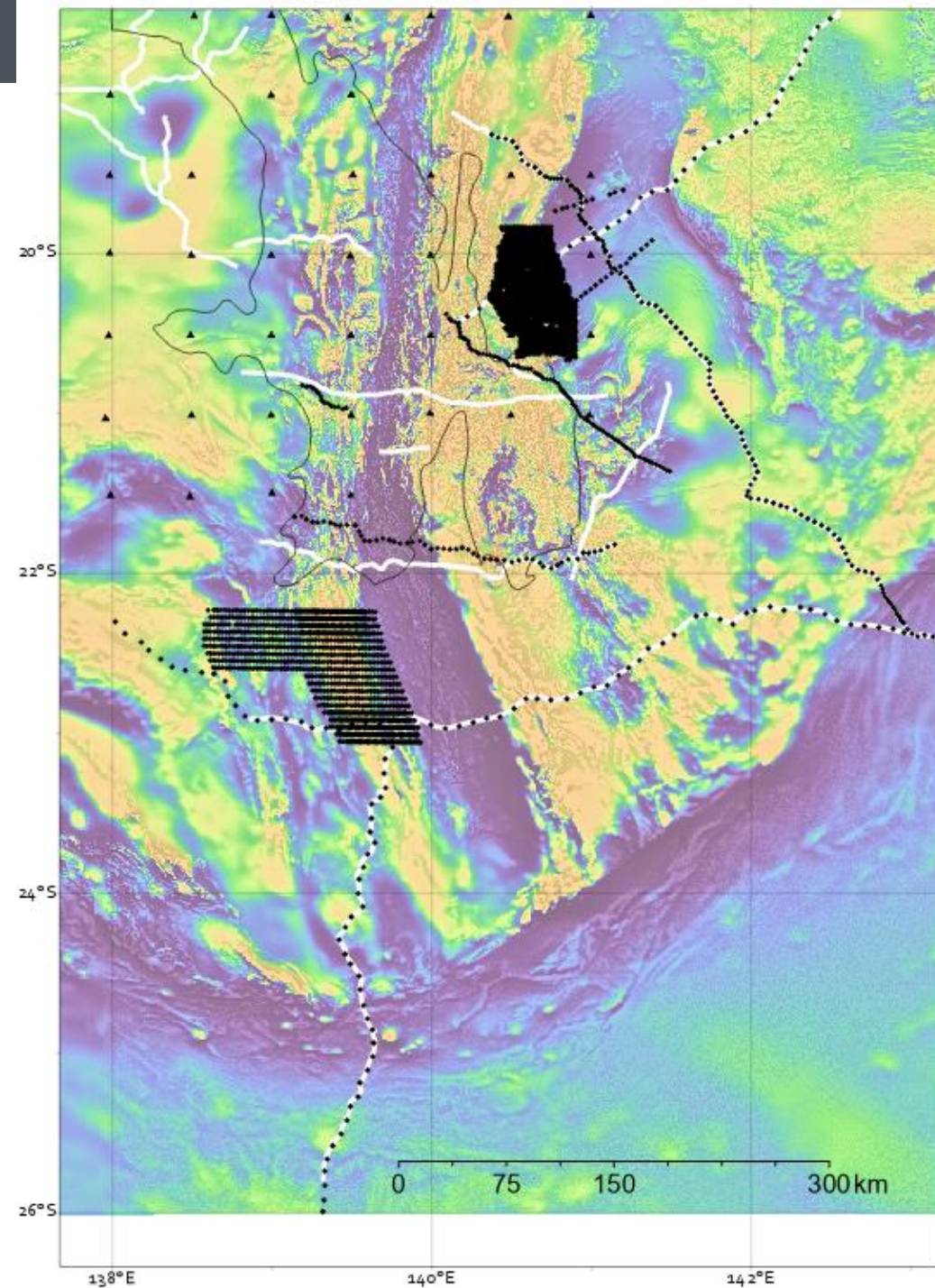
Deep crustal seismic interpretation project

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Inversion and modelling of MT

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Deep crustal seismic interpretation project



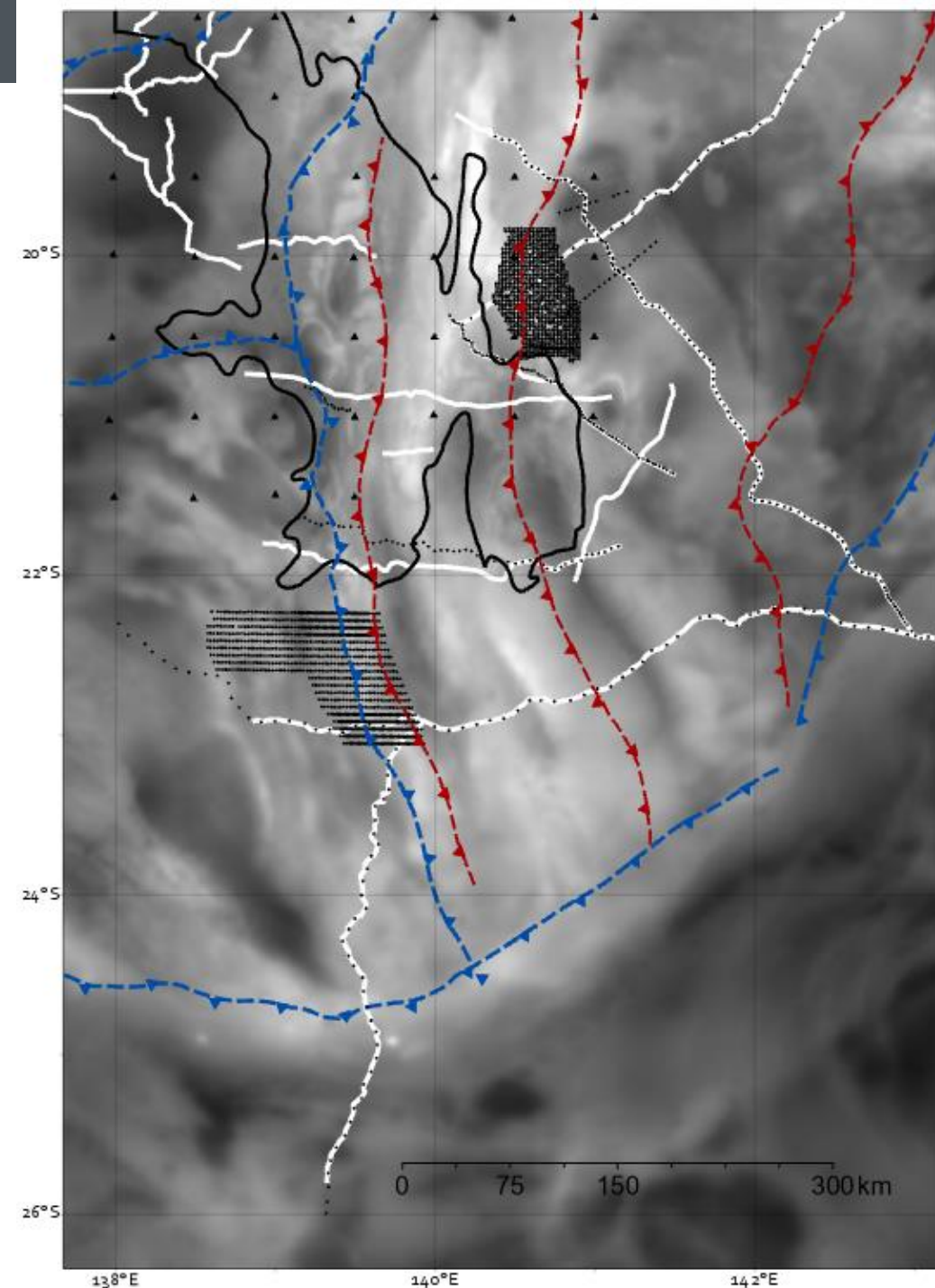
Deep crustal seismic interpretation project

Project aims

Use existing deep crustal seismic, gravity and MT data to understand large-scale structures in Mount Isa

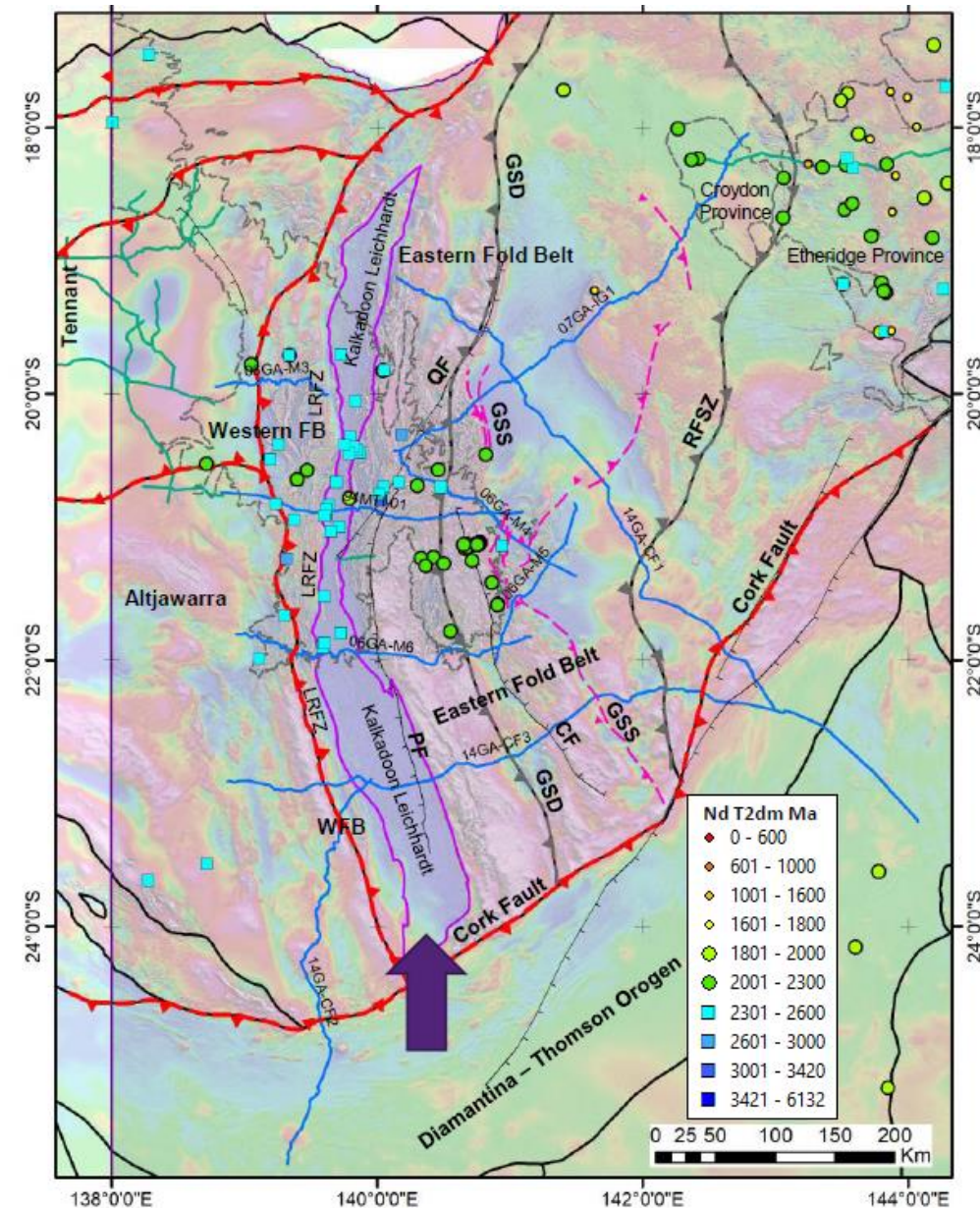
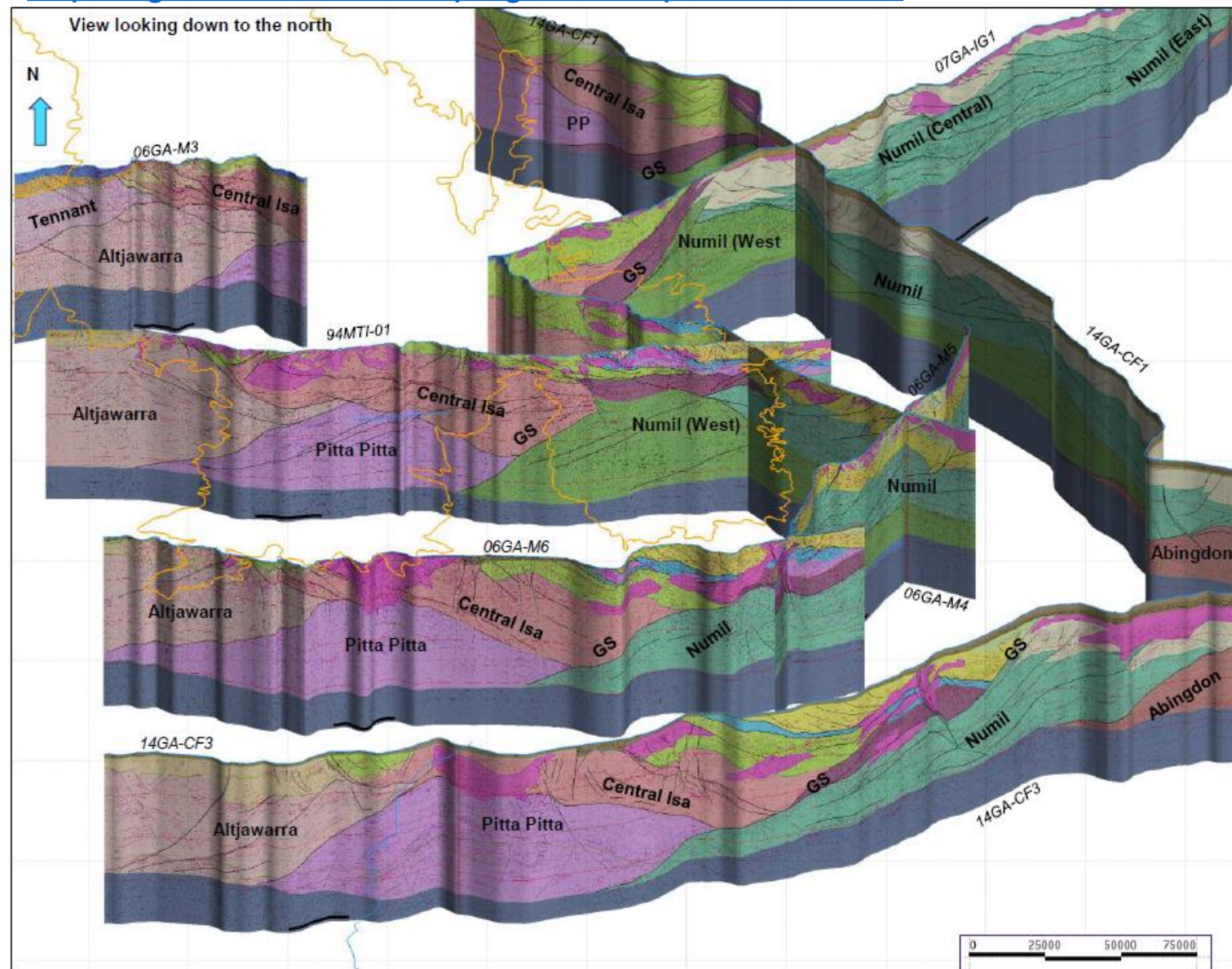
- Implications for tectonic evolution and mineral systems

Seismic interpretation, gravity modelling, geochronology



Report available

<https://geoscience.data.qld.gov.au/report/cr124986>



Conductivity structure

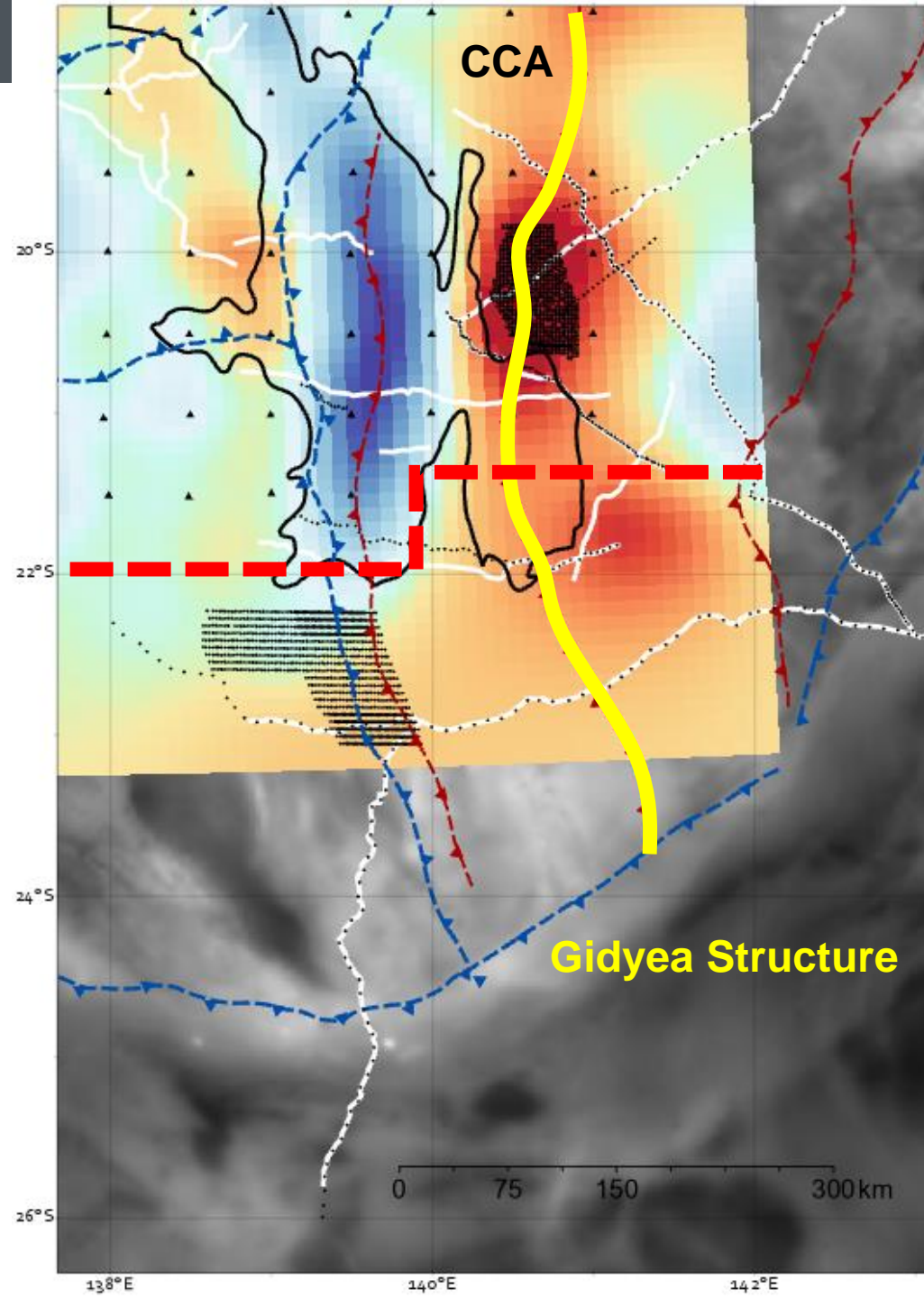
Duan et al 2020

AusLAMP model

33 km depth slice

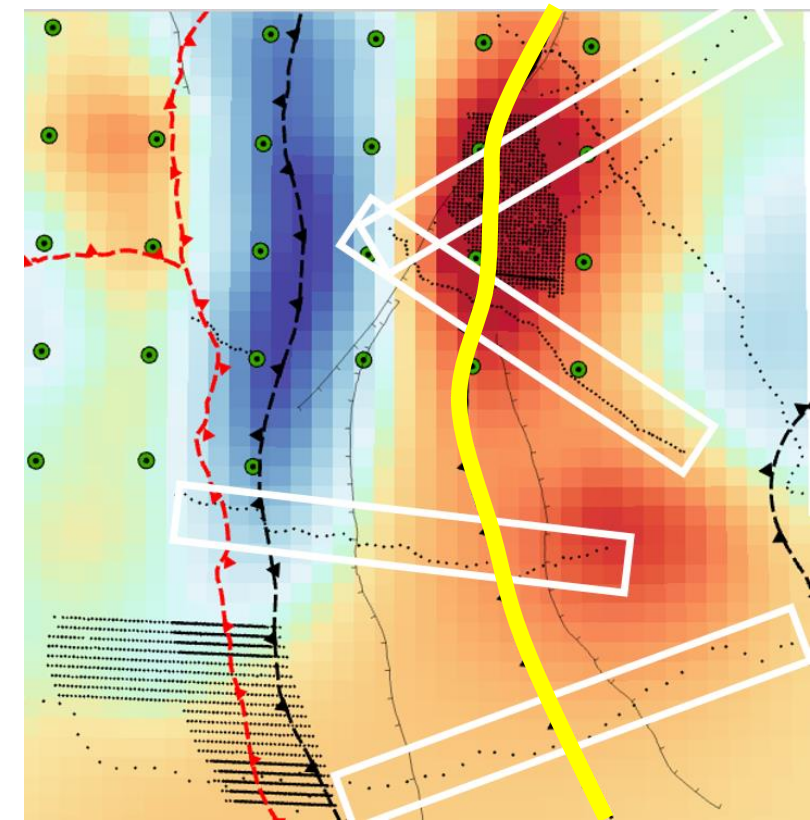
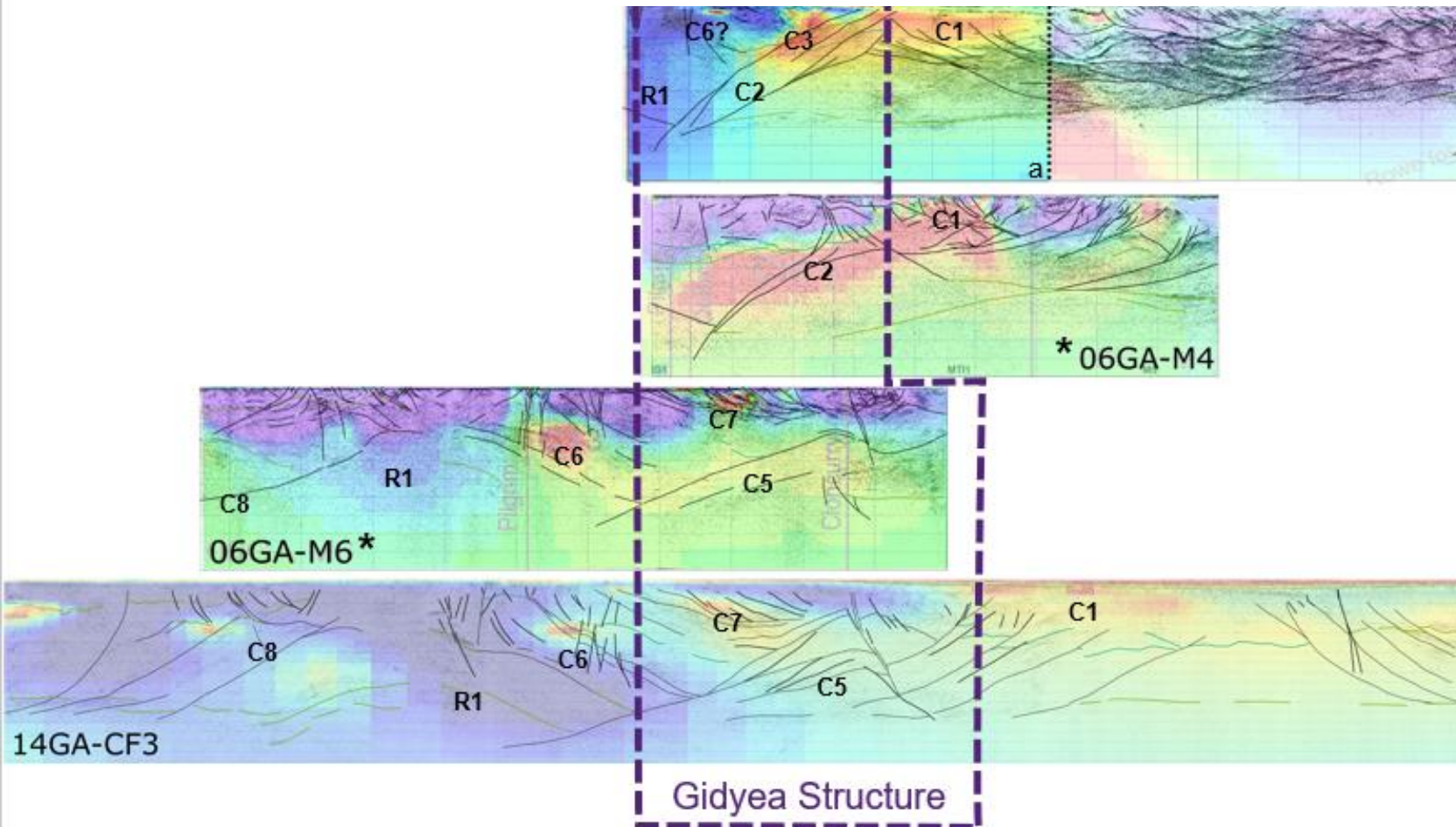
3 major features

- CCA
- Central Isa resistive block
- Western conductor

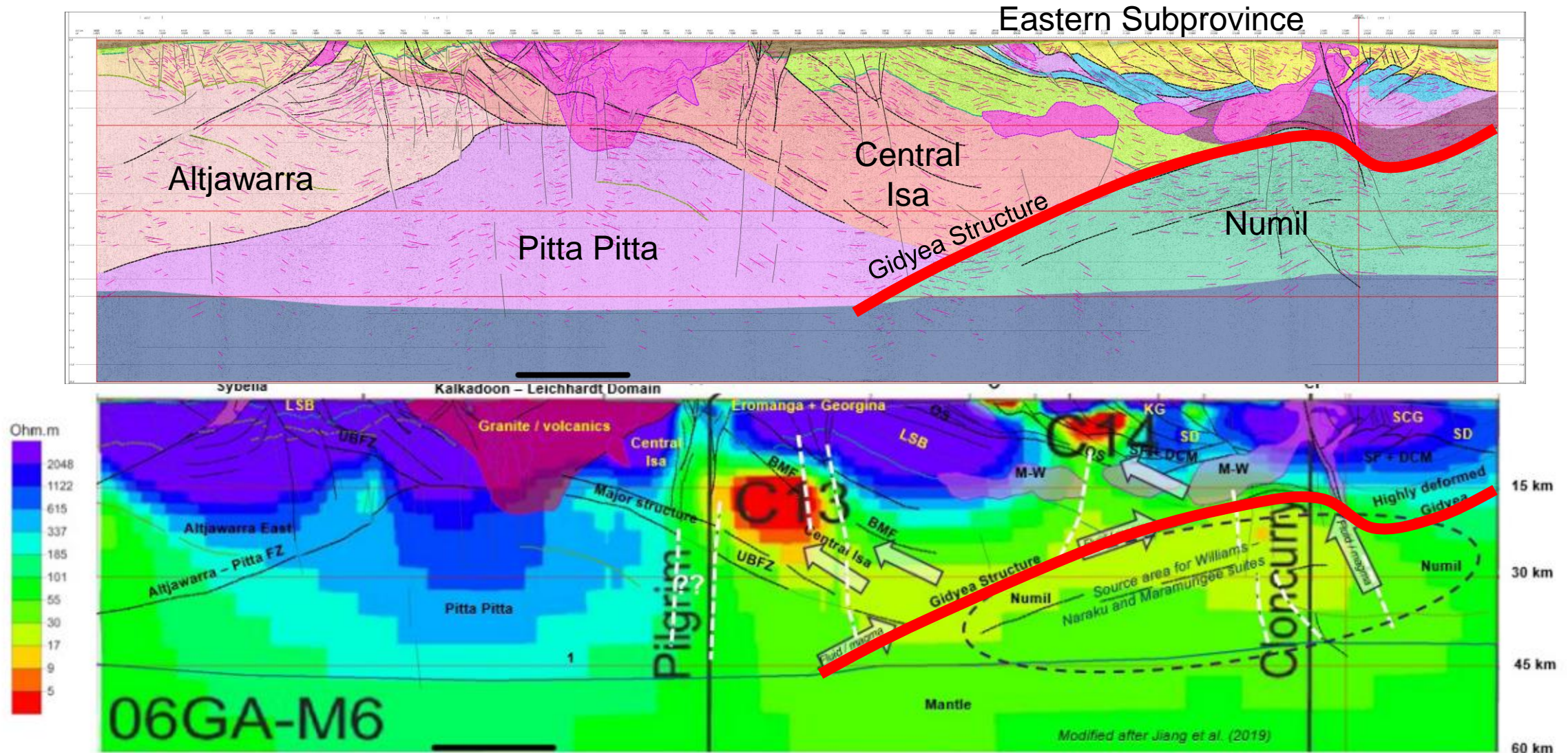


Seismic and MT comparison

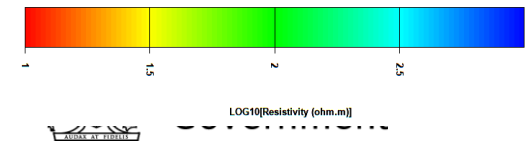
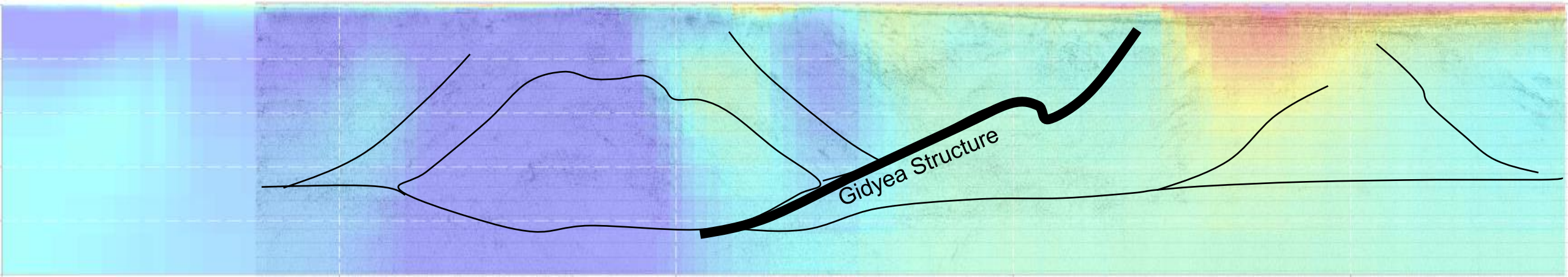
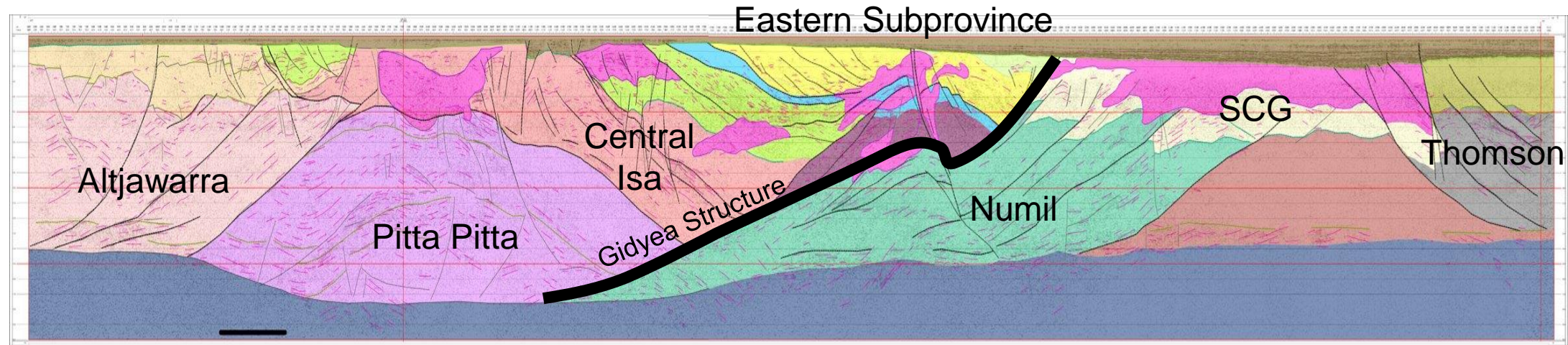
* MT models from Jiang et al. 2018



Implications for fluid movement



Implications for fluid movement

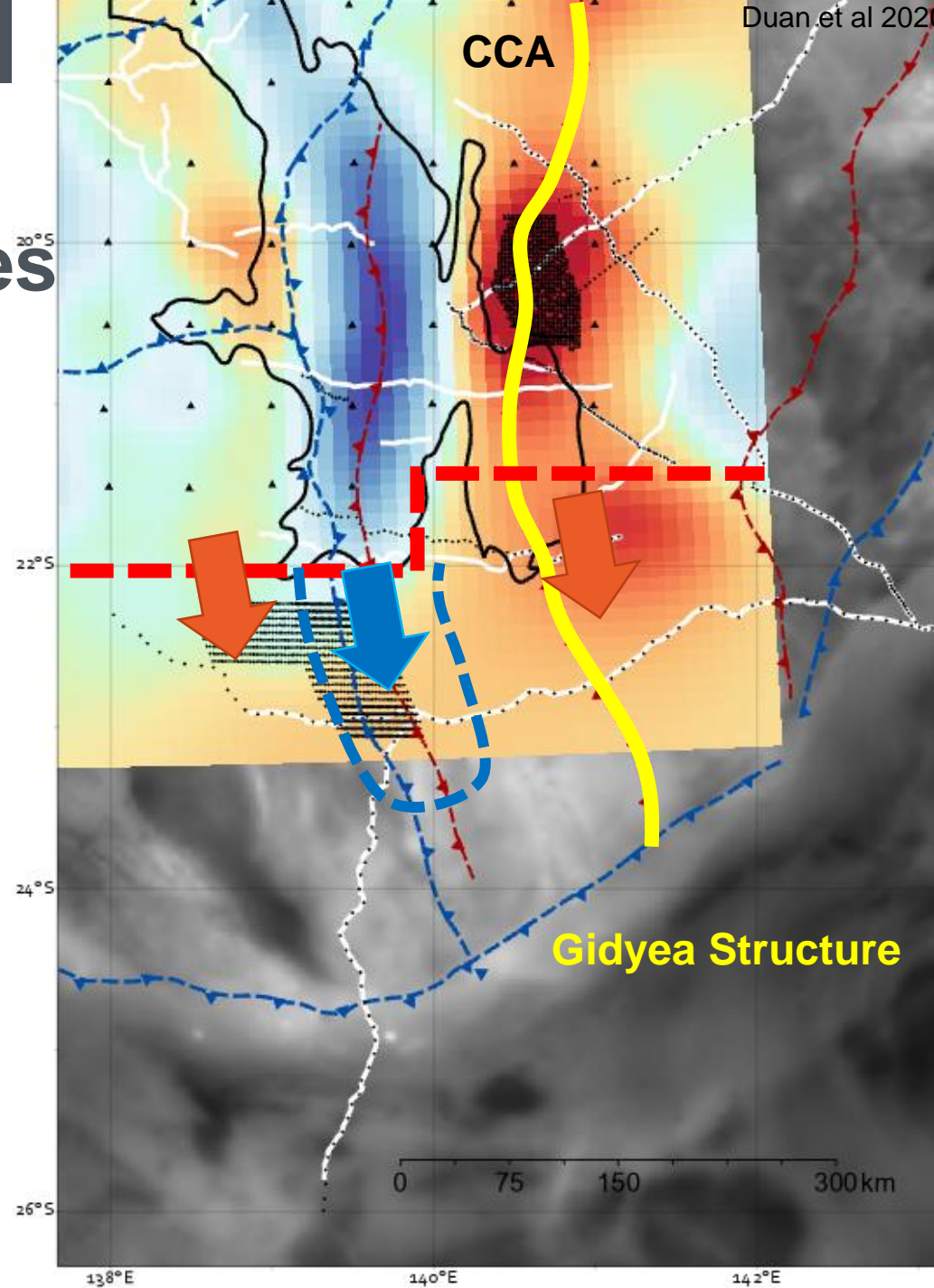


Continuation of resistivity structures

Resistive block continues south

Western conductor continues south

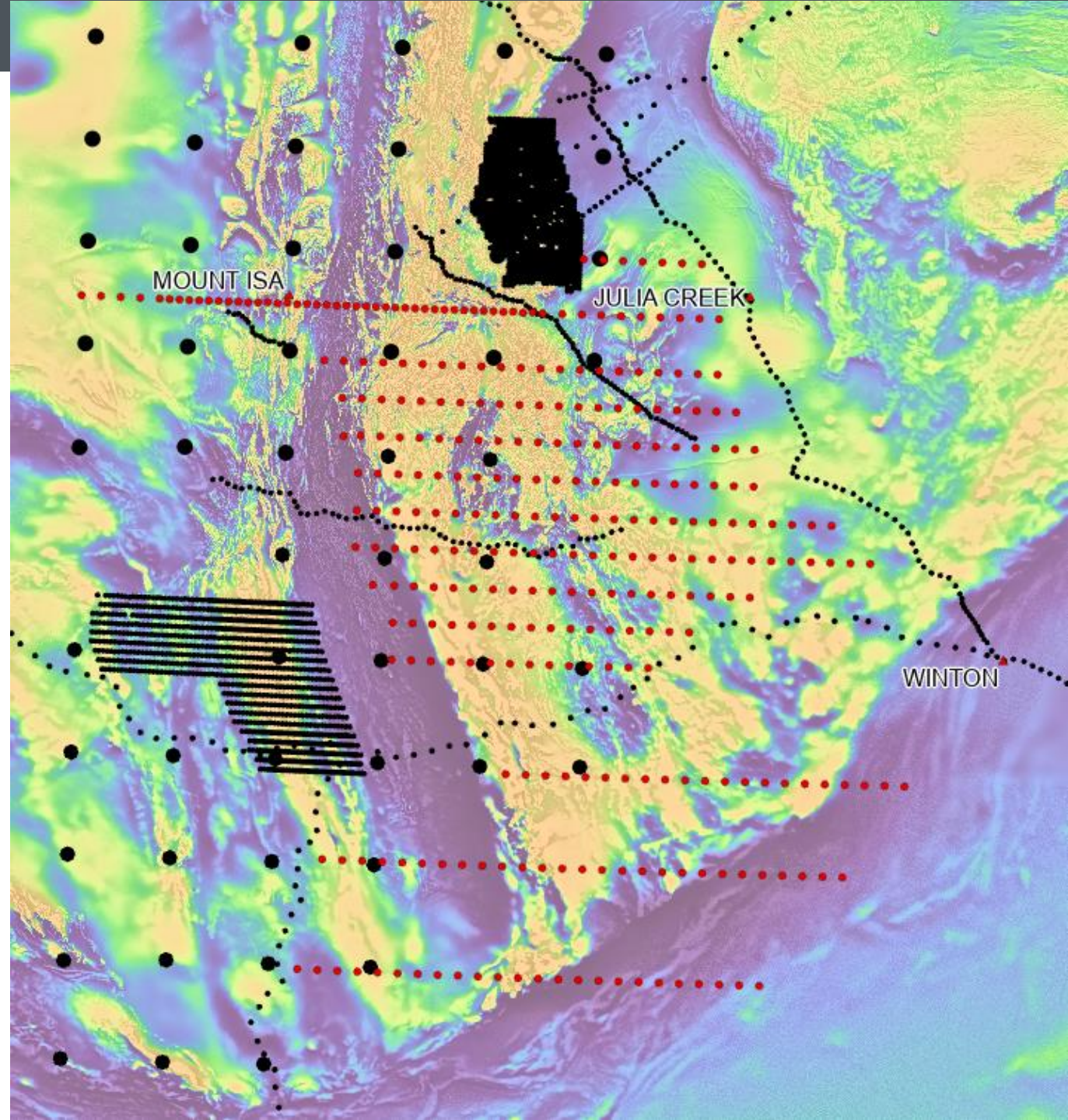
CCA a bit more uncertain but seems related to Gidyea Structure



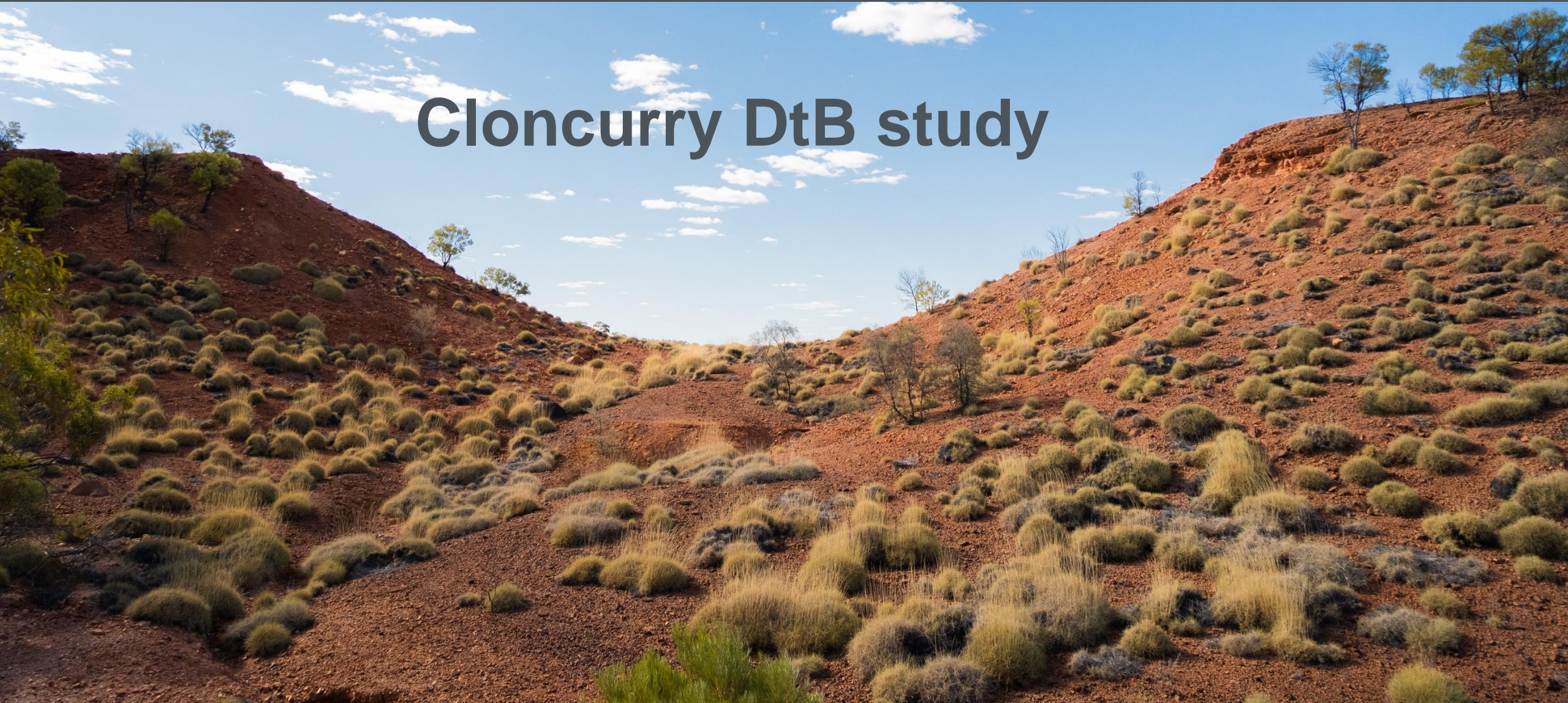
CCA MT survey

Building a framework of sites in the Eastern Subprovince to better understand the CCA

Acquisition forthcoming



Cloncurry DtB study



Cloncurry DtB study

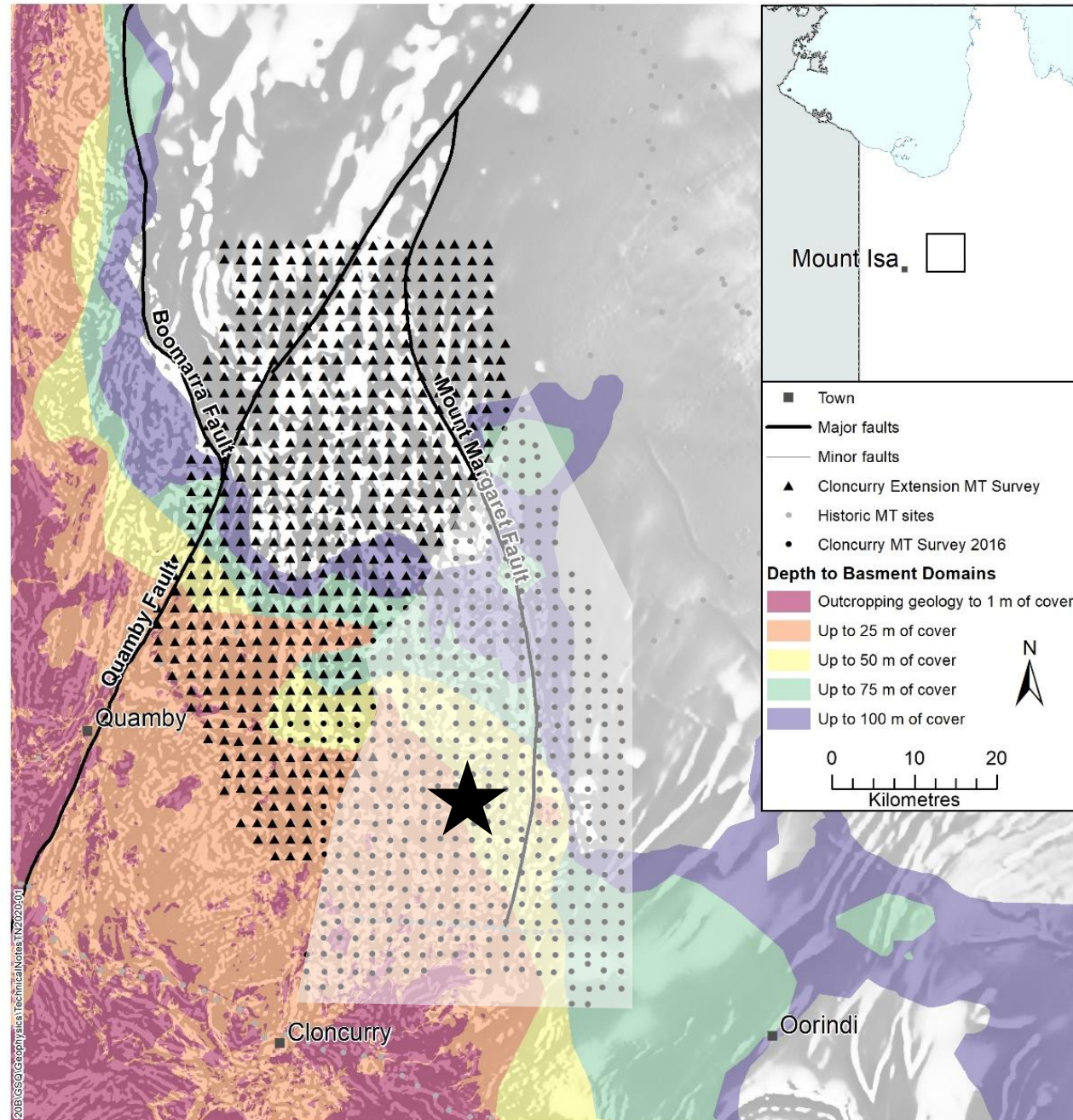
Eastern Subprovince of Mount Isa

Less than 400 m cover

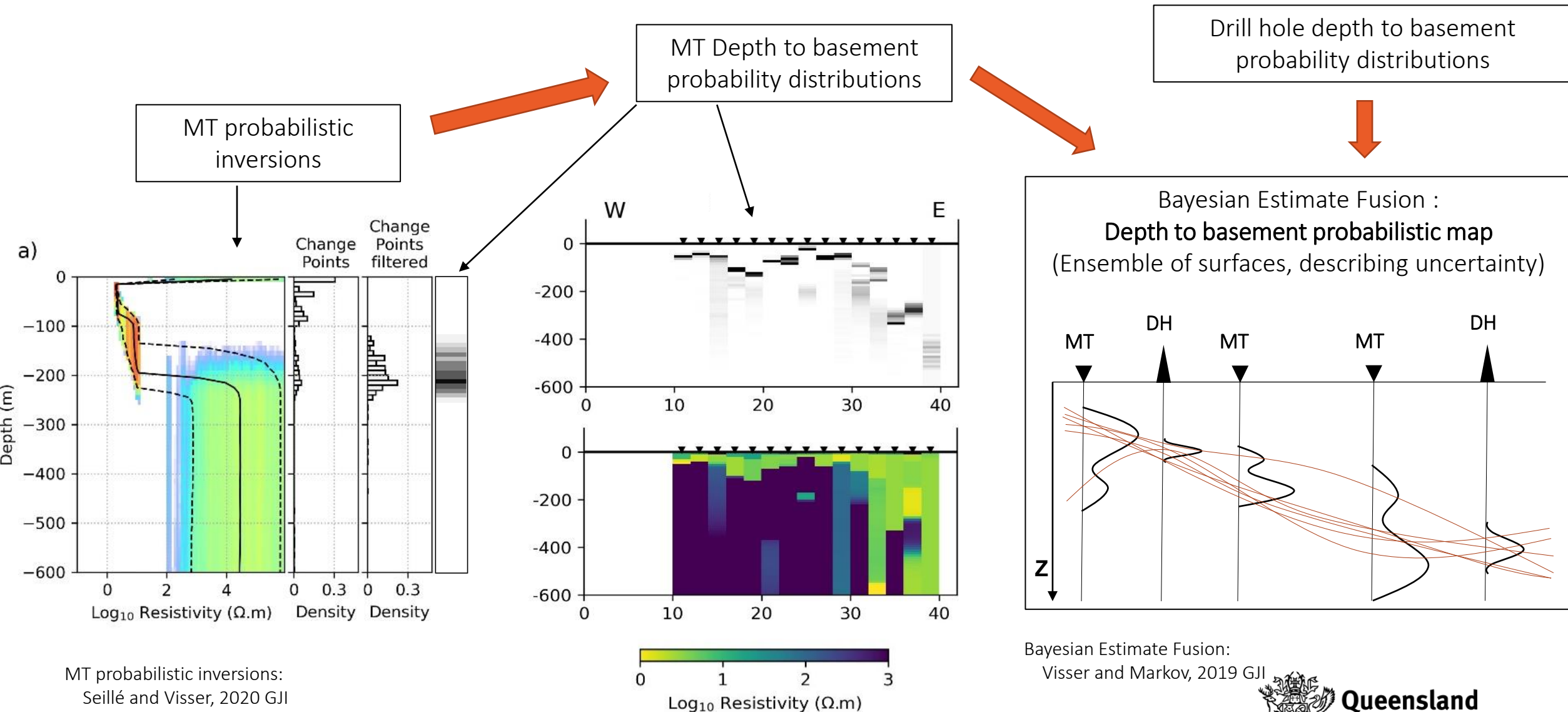
Pre-1650 Ma terrane boundary

Prospective for IOCGs

★ Ernest Henry IOCG



Probabilistic depth to basement mapping using MT



MT probabilistic inversions:
Seillé and Visser, 2020 GJI
Seillé, Visser, Markov and Simpson, 2021 JGR

Bayesian Estimate Fusion:
Visser and Markov, 2019 GJI



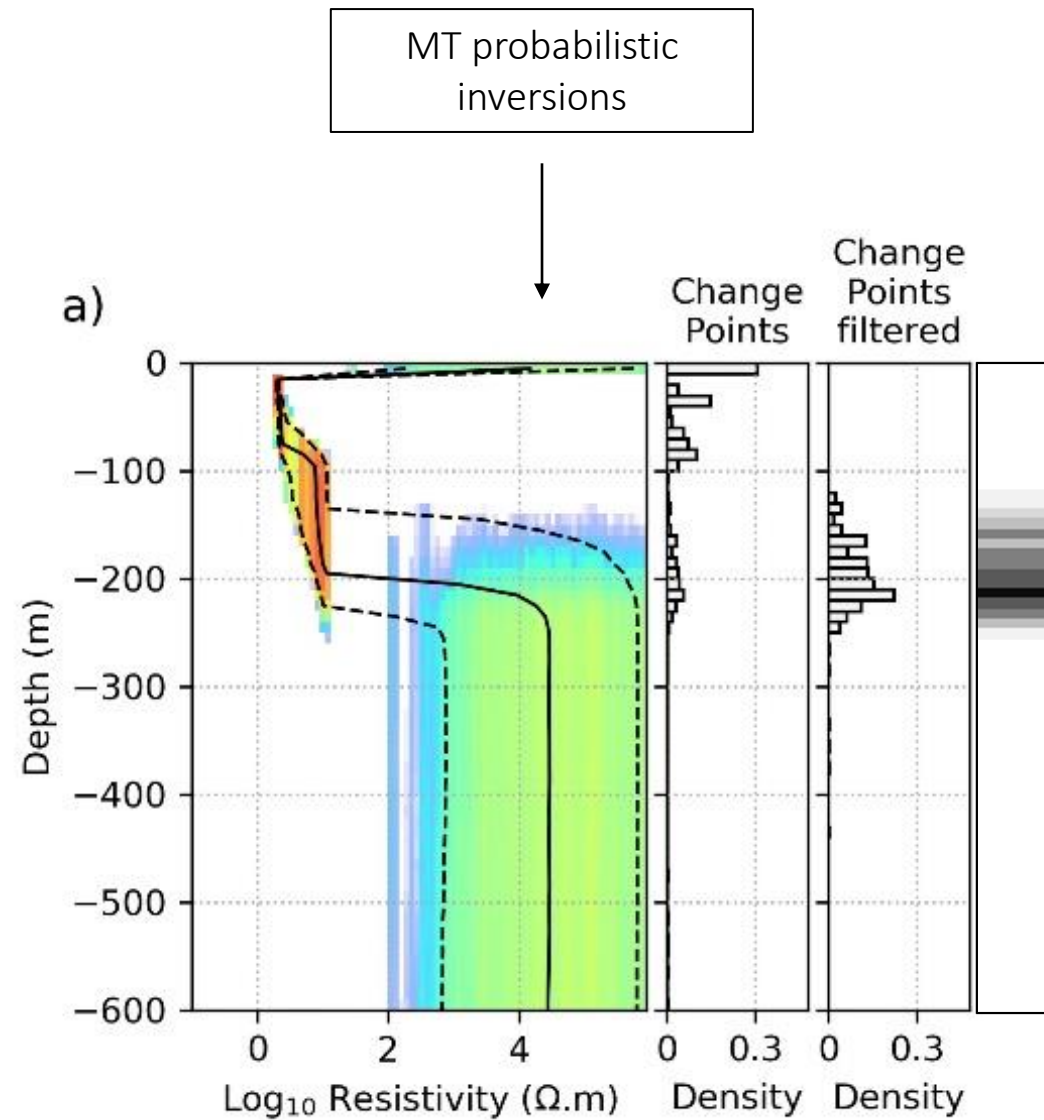
Queensland
Government

Courtesy of Hoel Seille

Step 1

Probabilistic 1D inversion
of all sites

Flexible error weighting to
accommodate non-1D
data



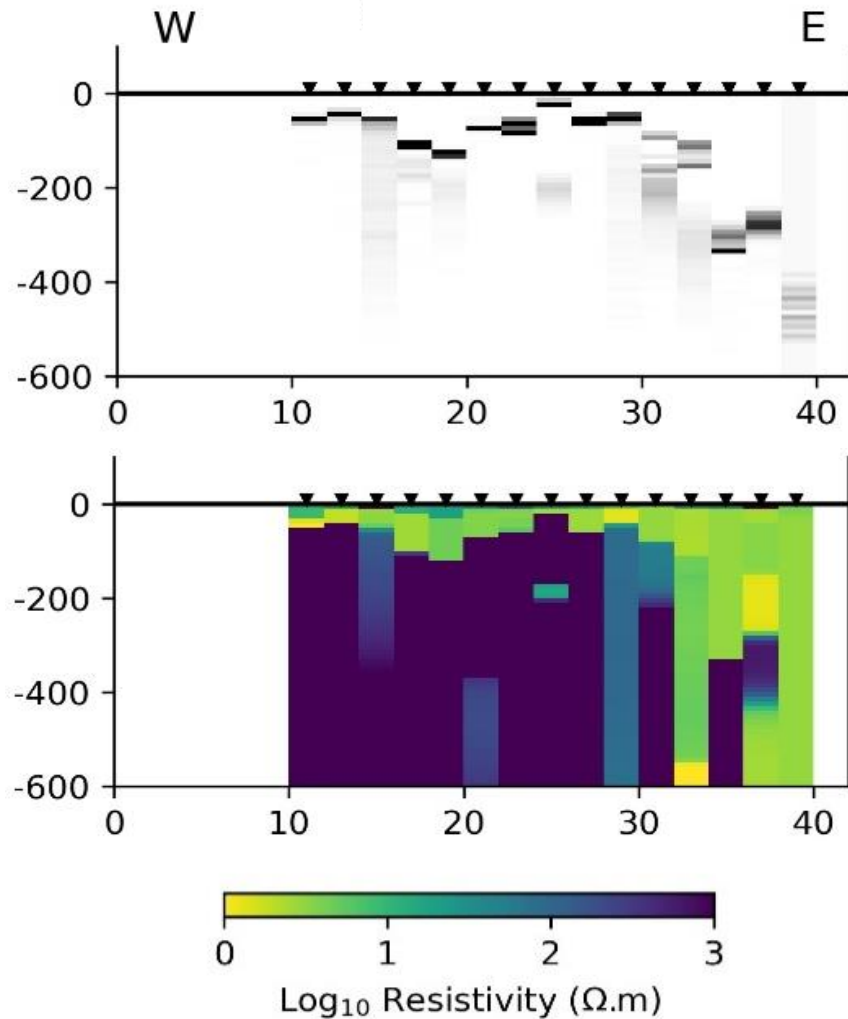
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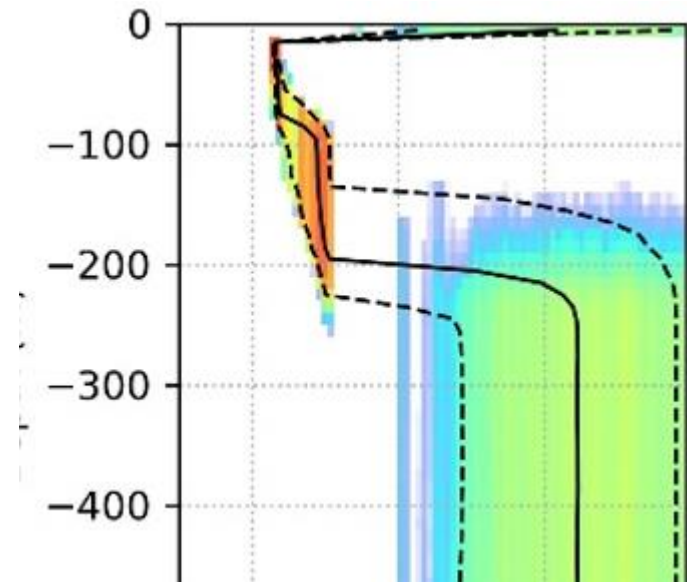


Step 2



Combine estimates of individual inversions into dataset

Some local knowledge needed for this step



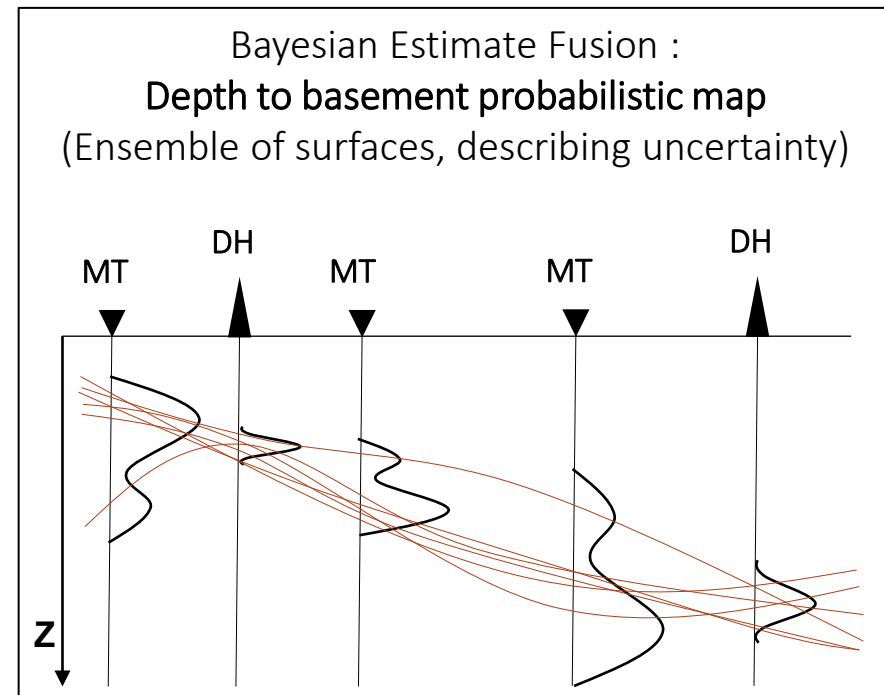
Step 3

Bayesian estimate of depth to basement using all input data

Can incorporate fault offsets

MT Depth to basement probability distributions

Drill hole depth to basement probability distributions

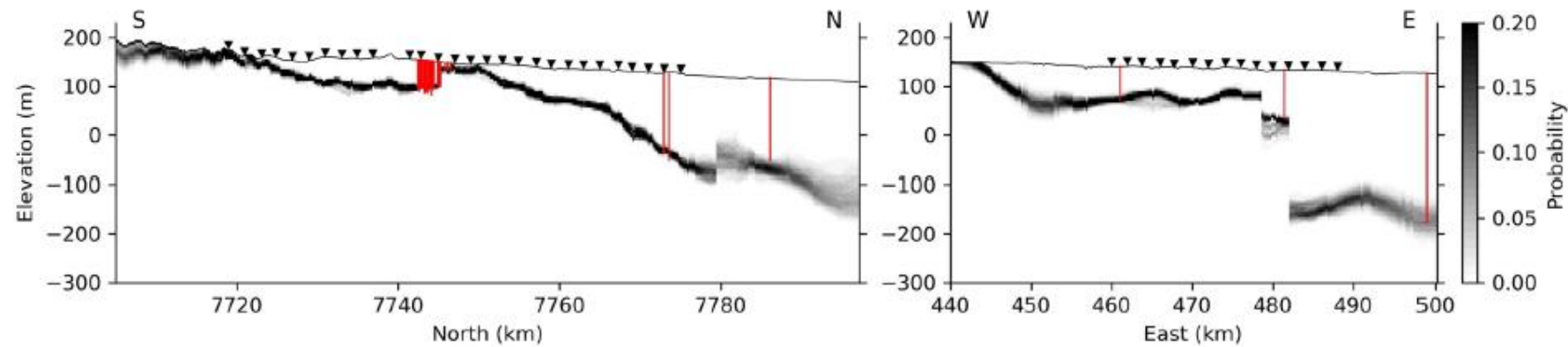


Bayesian Estimate Fusion:
Visser and Markov, 2019 GJI

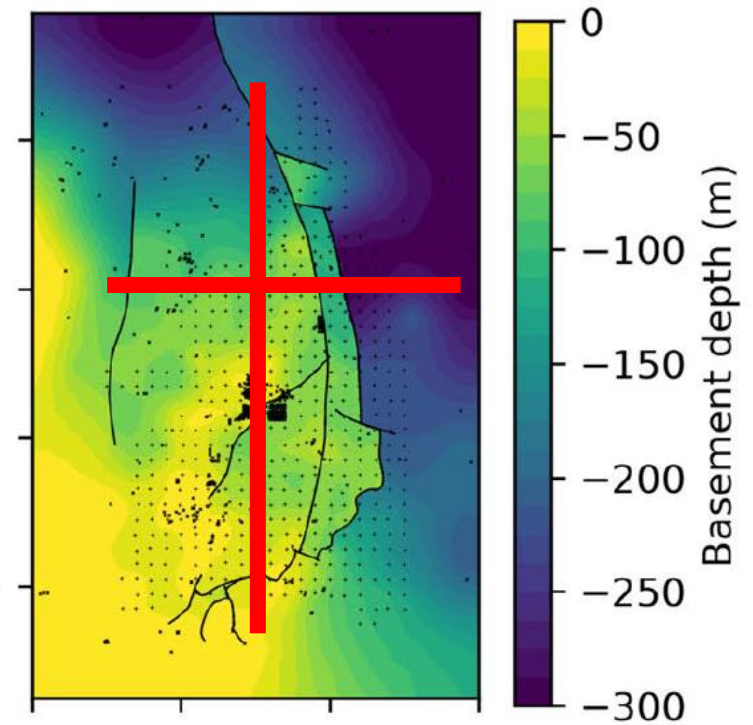
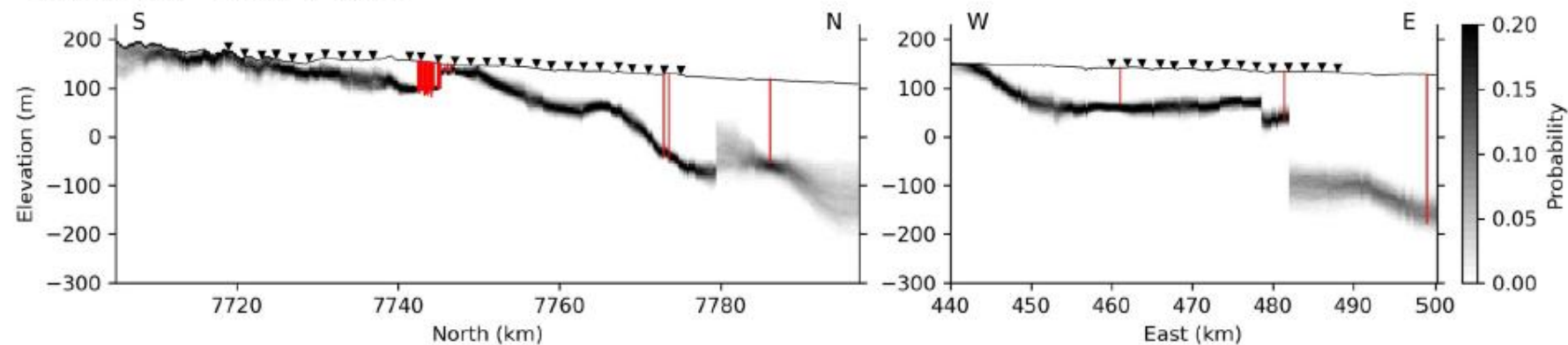
Results

Final depth to basement with uncertainty

c) MT + faults + DH ($n_{DH} = 540$)



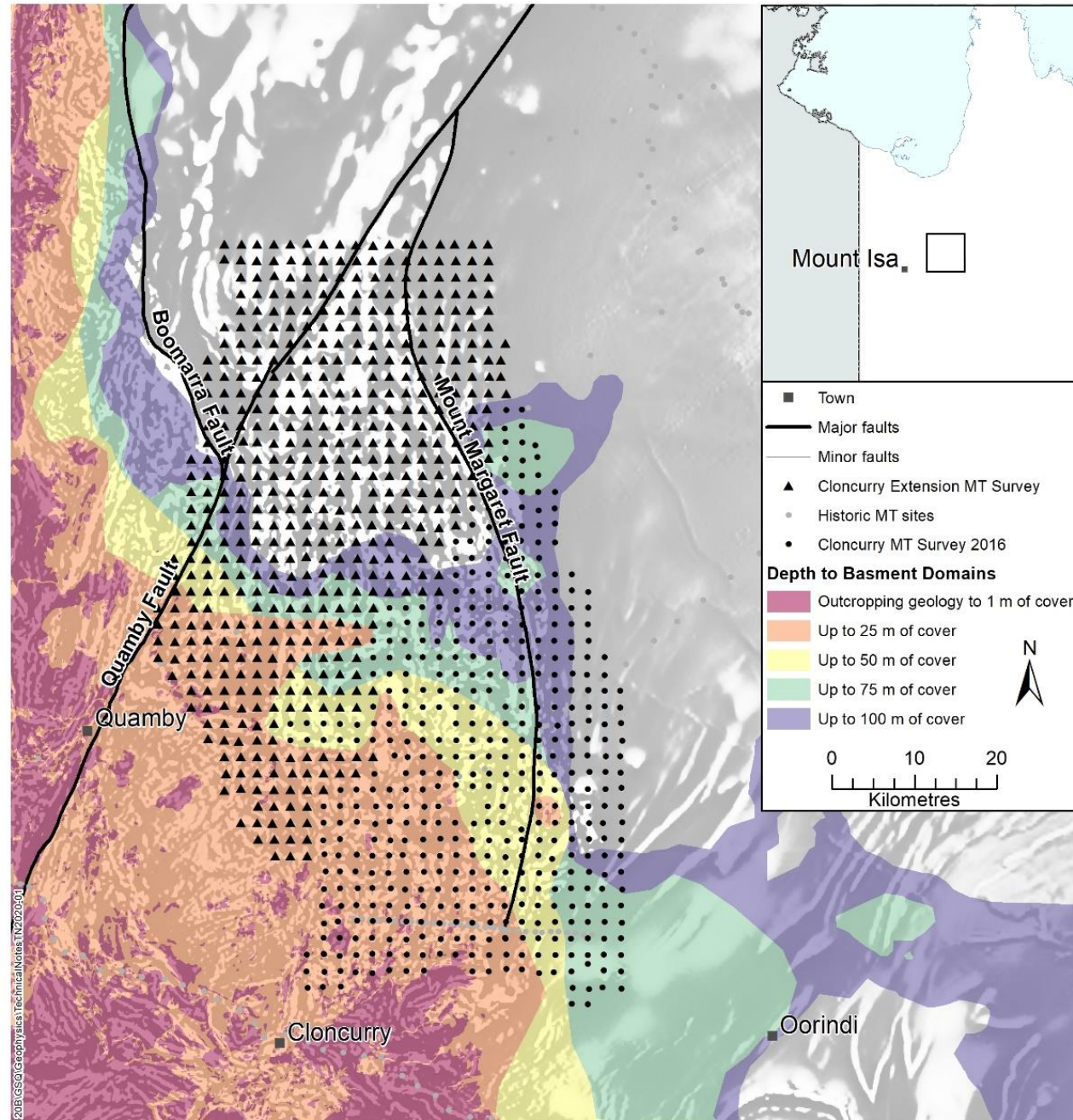
d) DH ($n_{DH} = 540$) + faults



Expanded program

To start in 2022

Will expand method to all sites in Cloncurry Extension dataset



Cloncurry Inversion Project



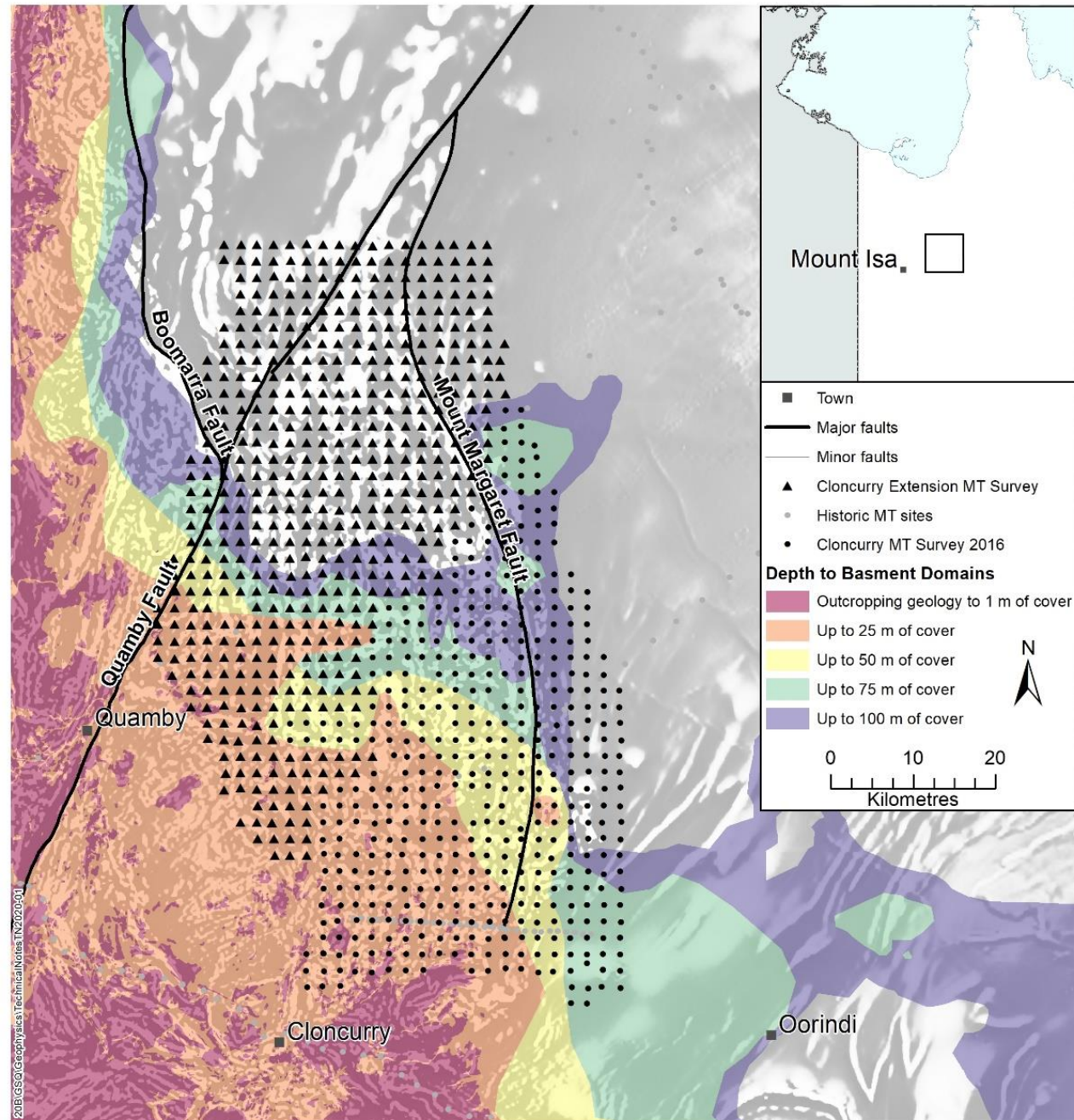
The dataset

Two phase survey

- All sites on 2 km x 2 km grid
- Wide band data
 - 10^{-4} to 10^3 s

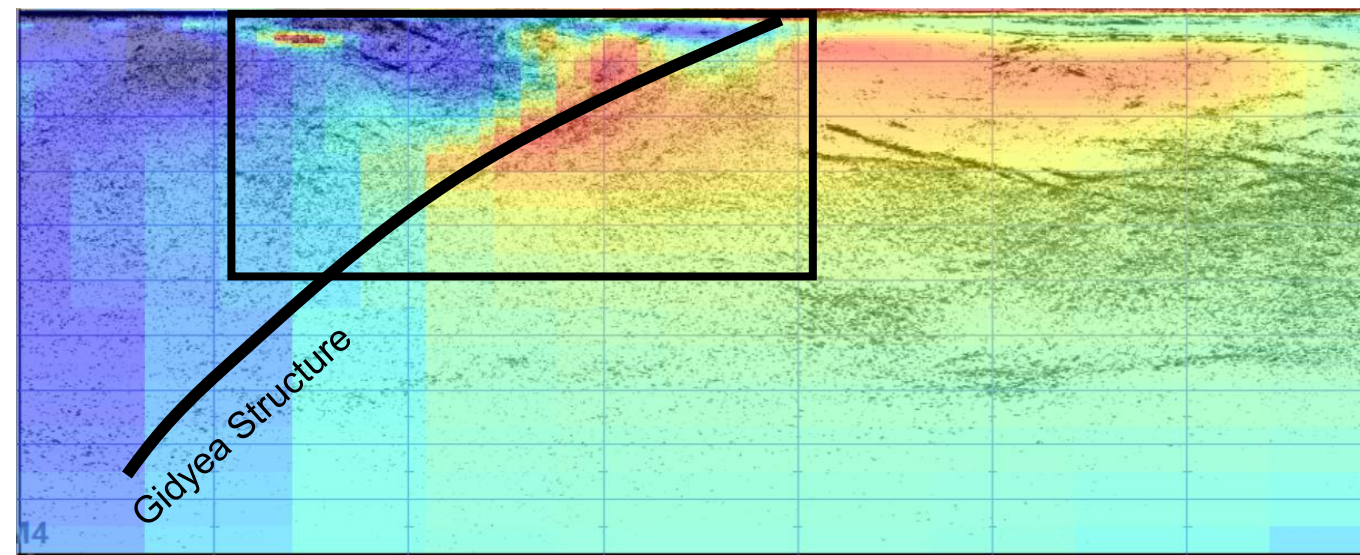
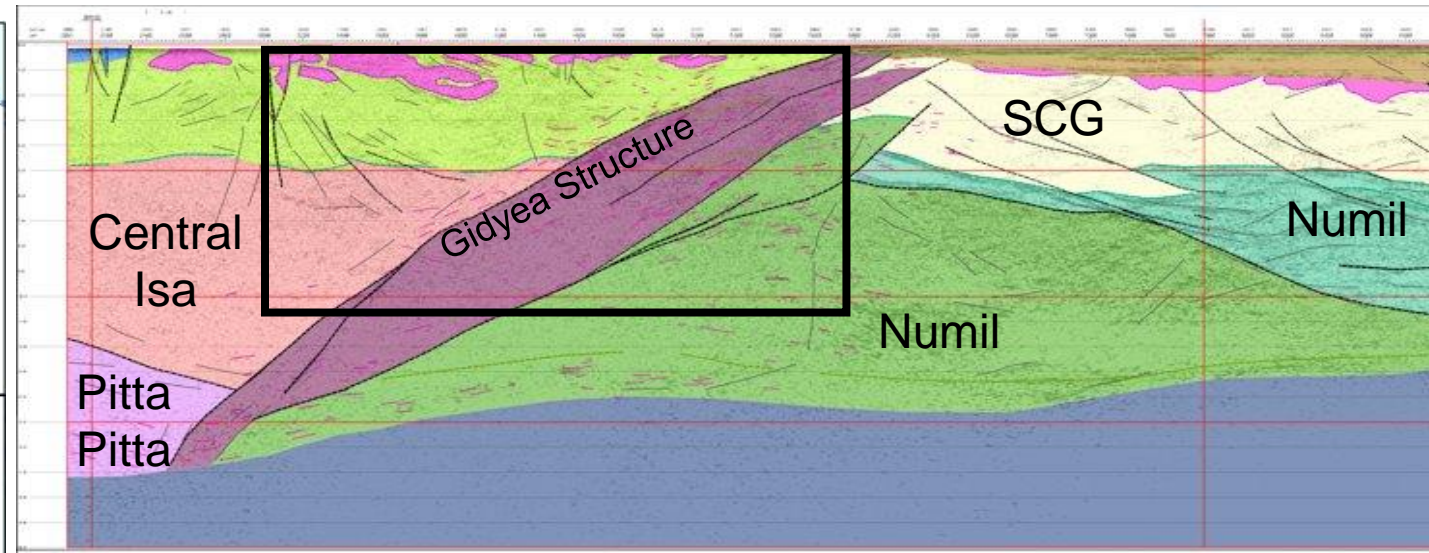
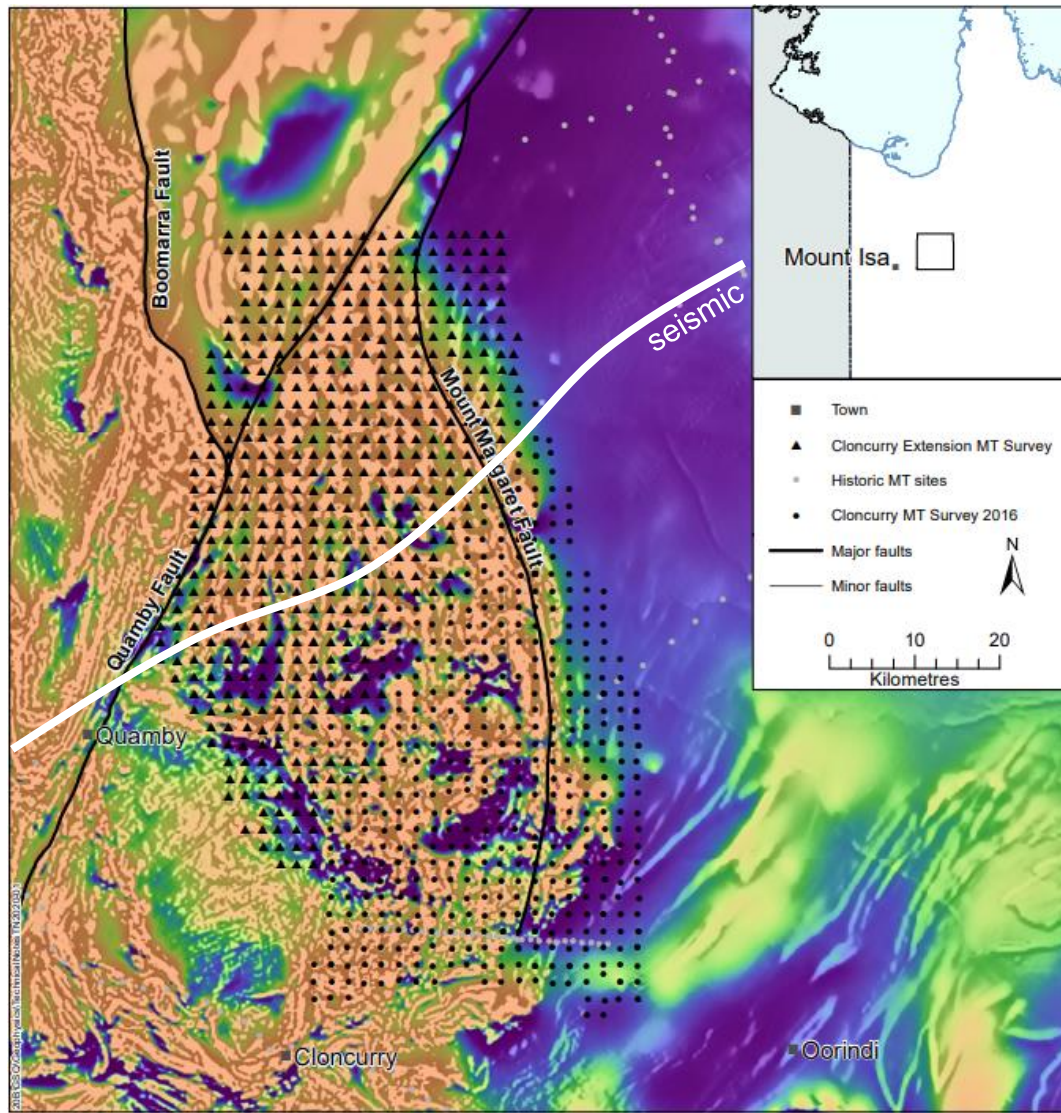
2016 – 470 sites collected

2020 – 530 sites collected



Context for survey

Structures from Connors et al. 2021

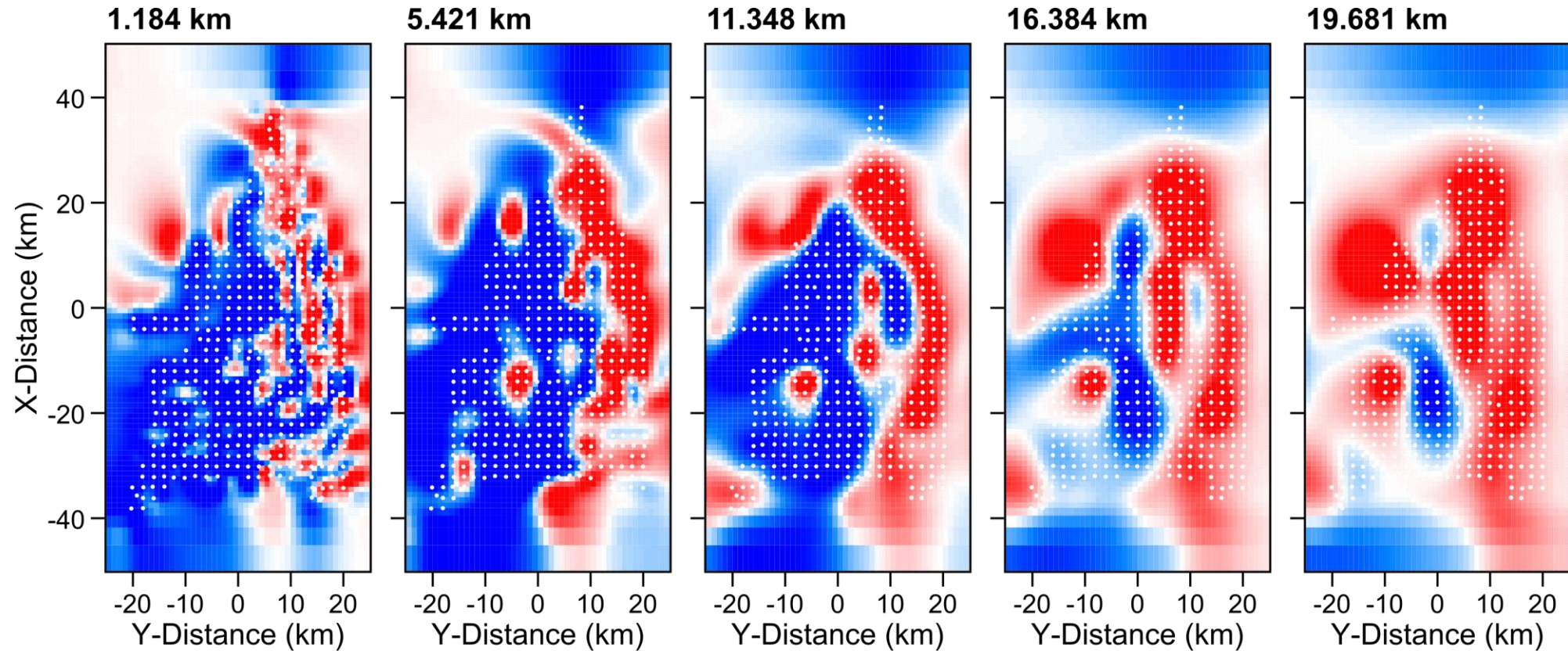


2016 results

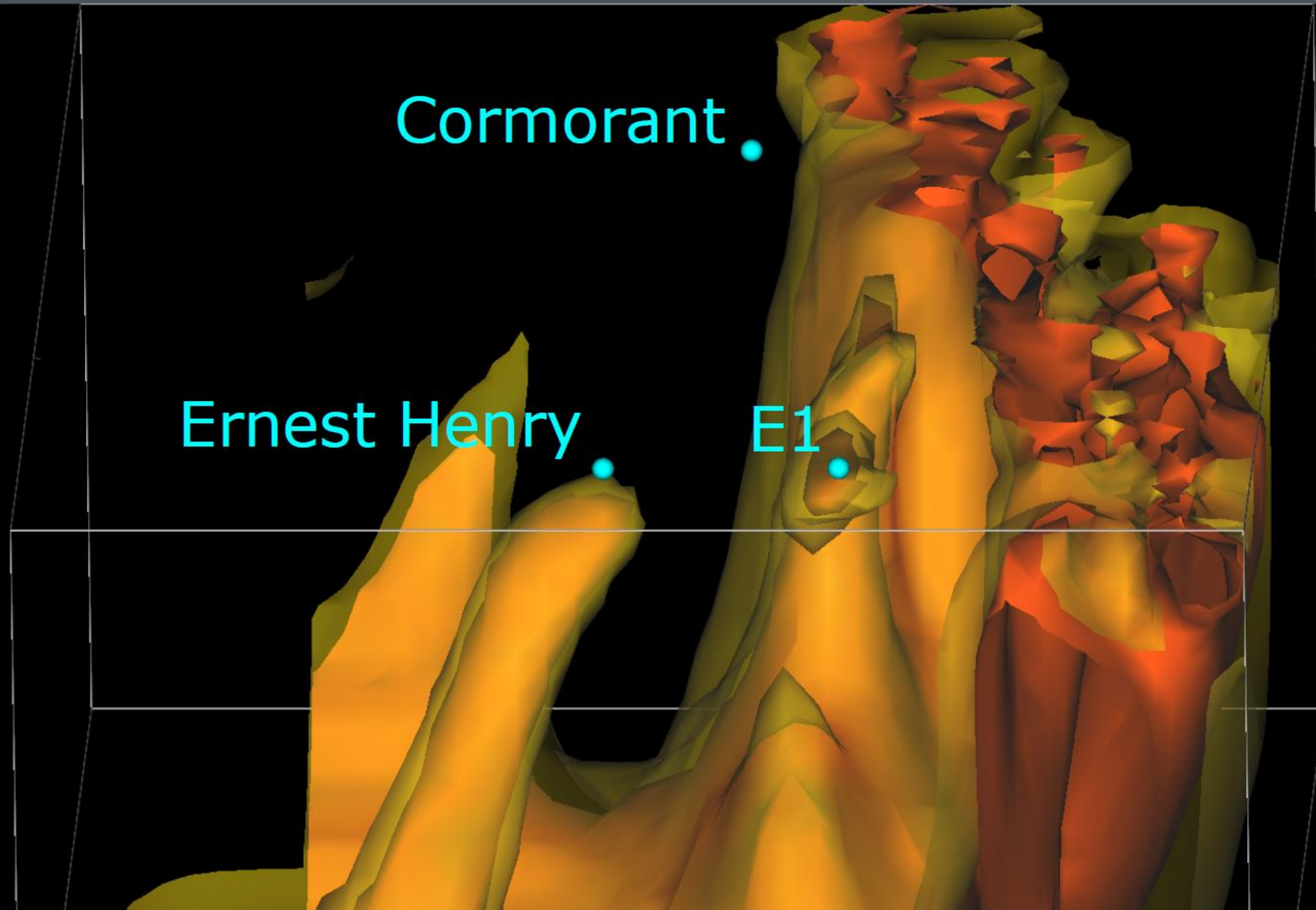
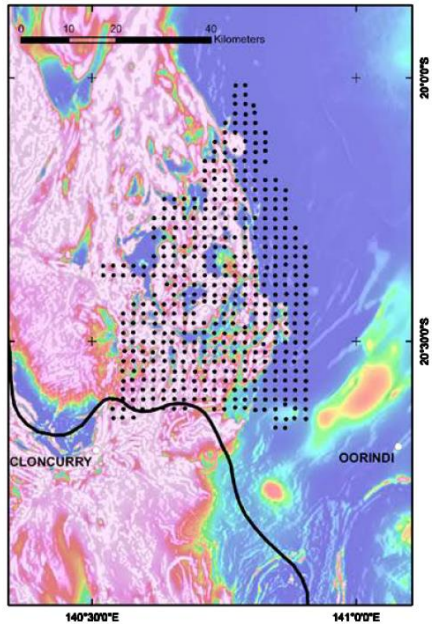
Modelling from Wang et al. 2018

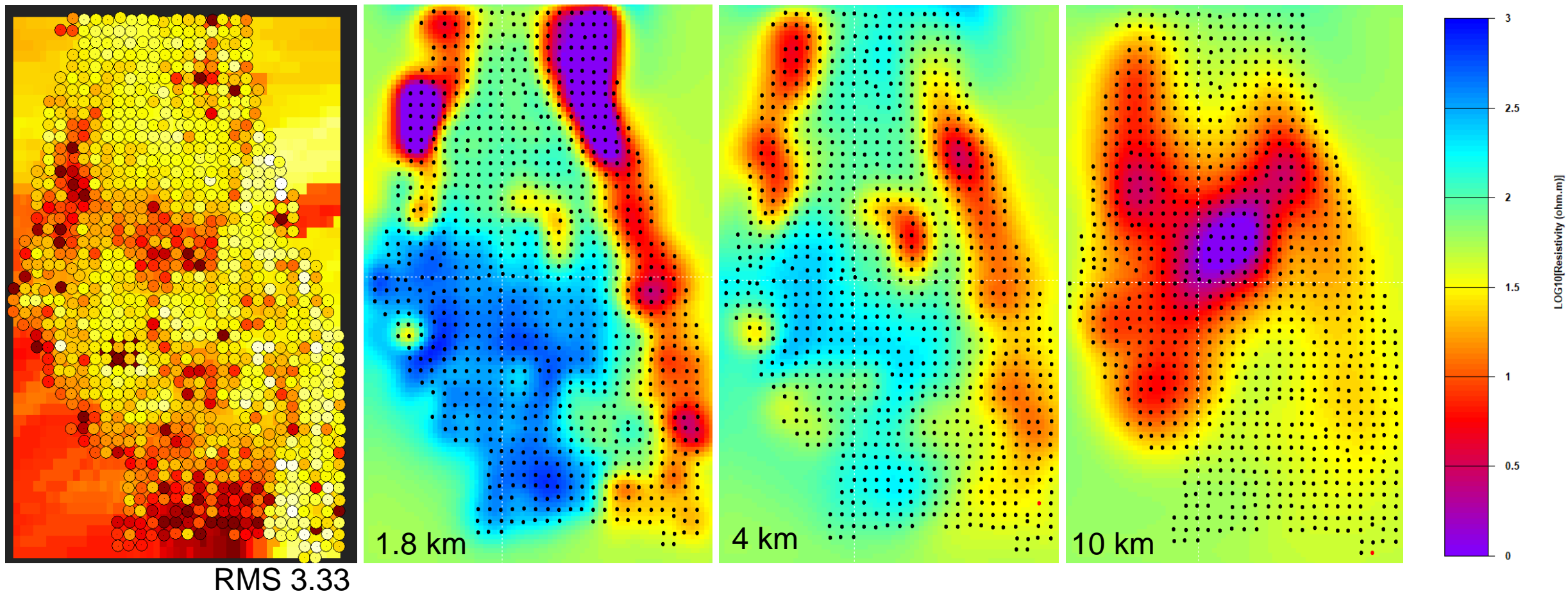
Eastern conductor

Pipe-like structures associated with Ernest Henry Mine



2016 results



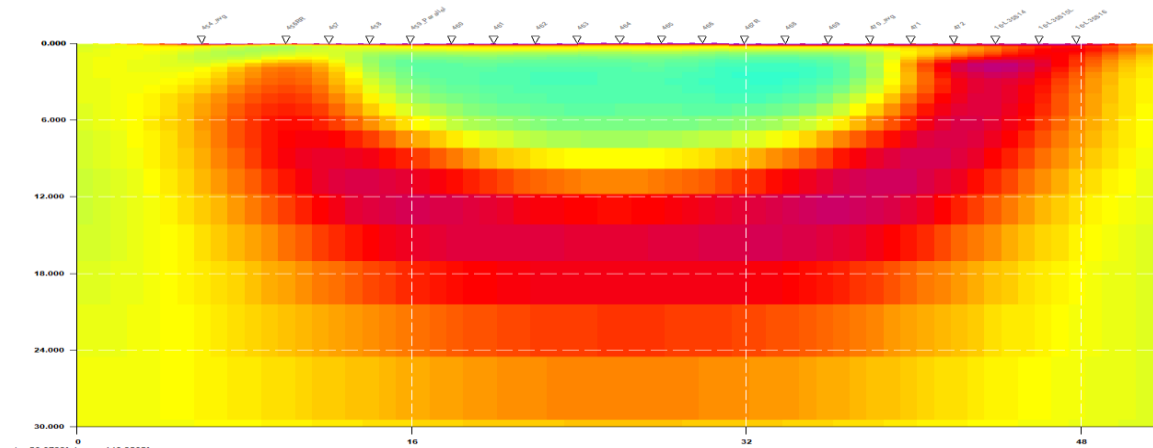


Still some systematic misfits – spatial variability and more at longer periods

Features shown in map slice consistent with data analysis structures

Tipper and Impedance joint inversion

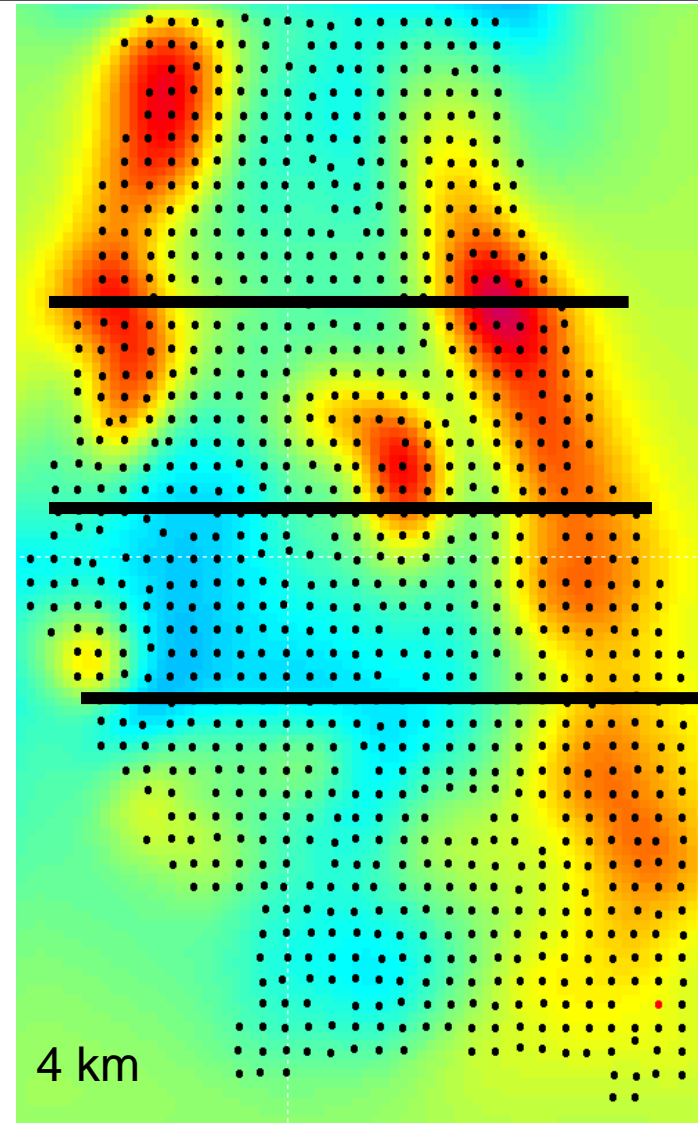
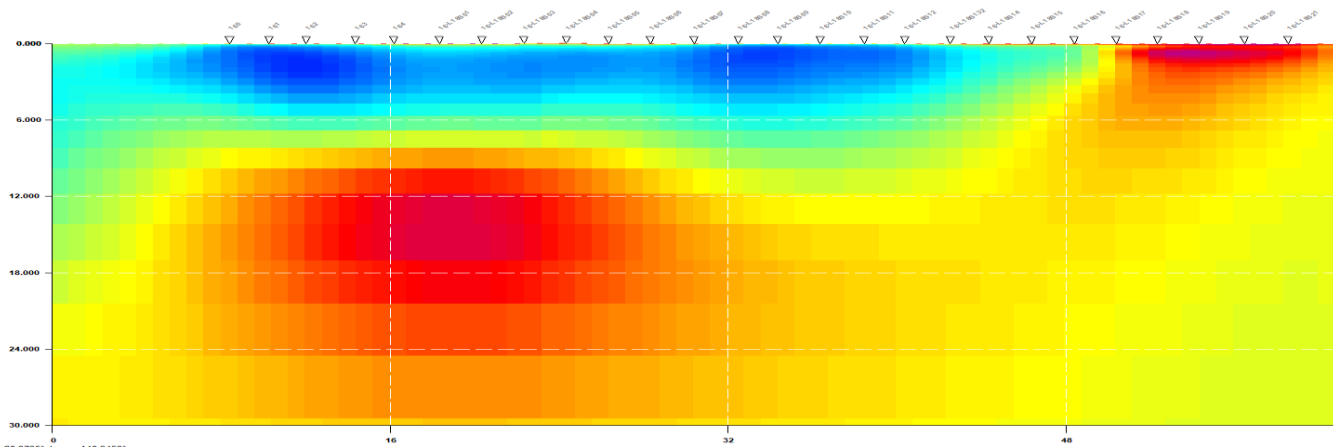
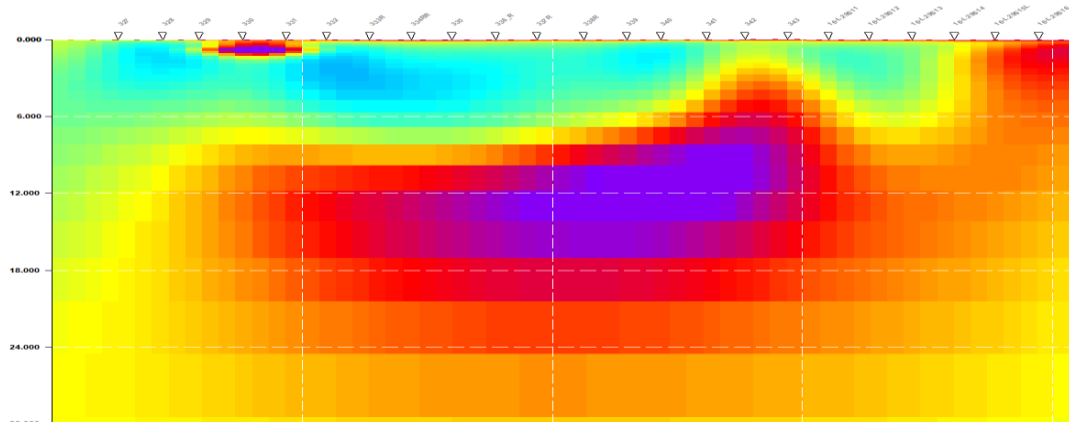
Inverted data range 1000 Hz – 0.001 Hz



Vertical section
depth 30 km

VE ≠ 1

Work ongoing



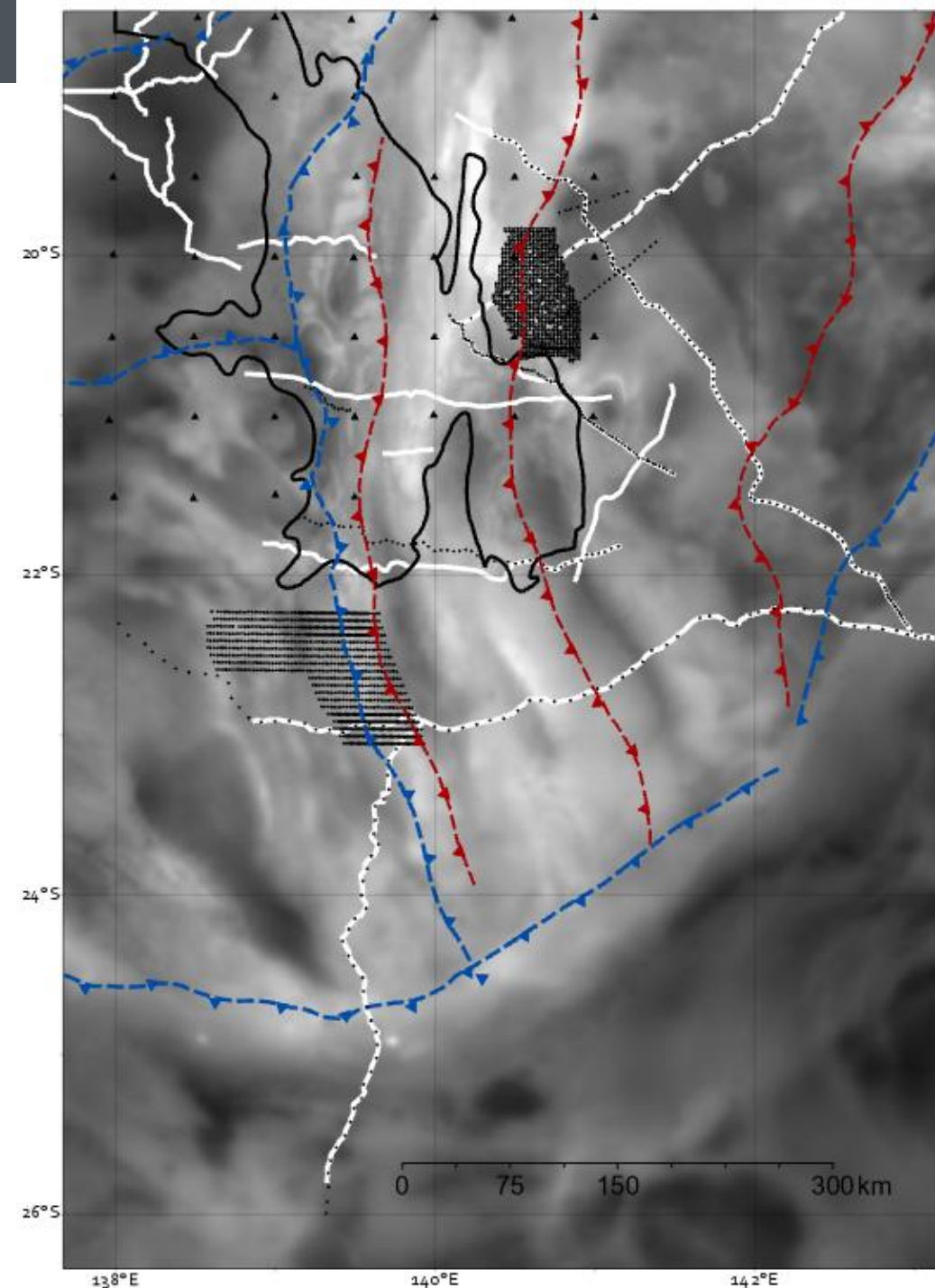
TL;DR

MT has been used at a variety of scales in Mount Isa

- Large-scale crustal structures
- Depth to basement studies
- Upper crustal modelling
- Lithospheric modelling
- Company exploration

Particularly useful for

- Areas with deep or very conductive cover
- Studies interested in structures at a range of scales



Questions?

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