AusLAMP : Illuminating Australia's lithosphere

Stephan Thiel

MTNet Eminar, February 17 (18), 2021

AusLAMP
Illuminating Australia's deep earth

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Acknowledgements

PACE Copper

GEOLOGICAL SURVEY OF South Australia

Australian Government
Geoscience Australia

AusLAMP
Illuminating Australia's deep earth

THE UNIVERSITY of ADELAIDE

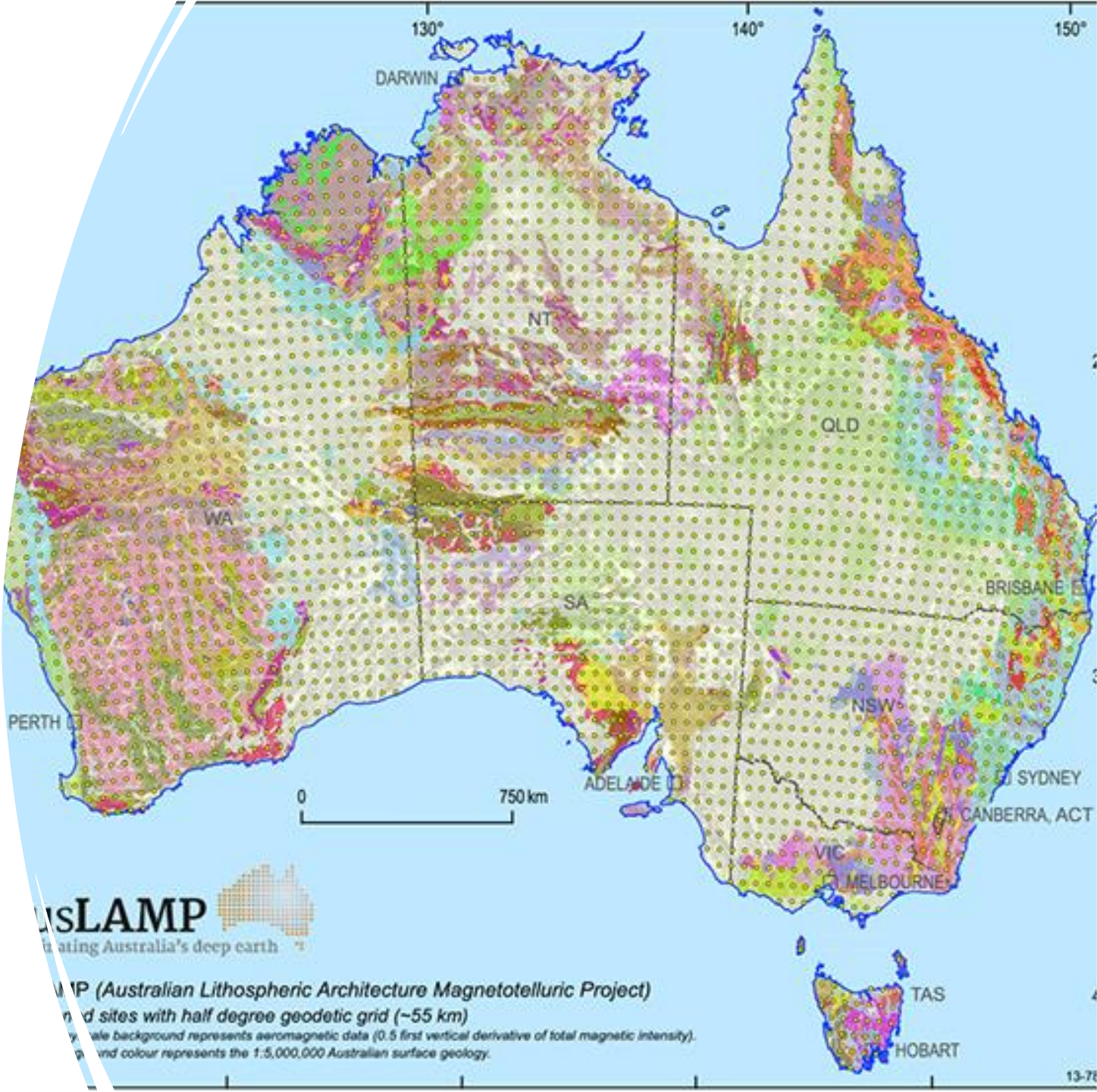
NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

AuScope
AN ORGANISATION FOR A NATIONAL EARTH SCIENCE INFRASTRUCTURE PROGRAM

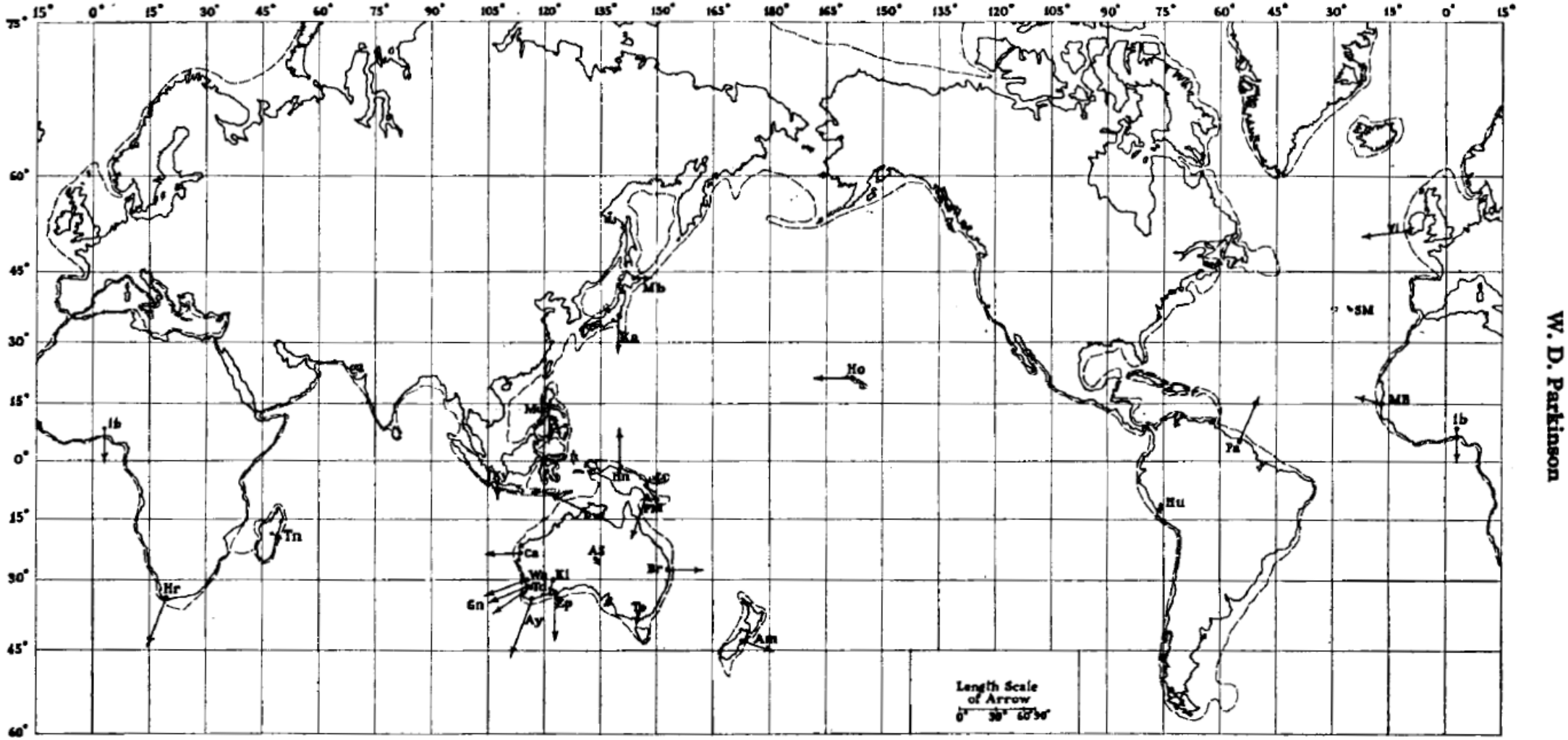
NCI

Australian Lithosphere Architecture Magnetotelluric Project

- History and background
- The AusLAMP Array
- Research highlights

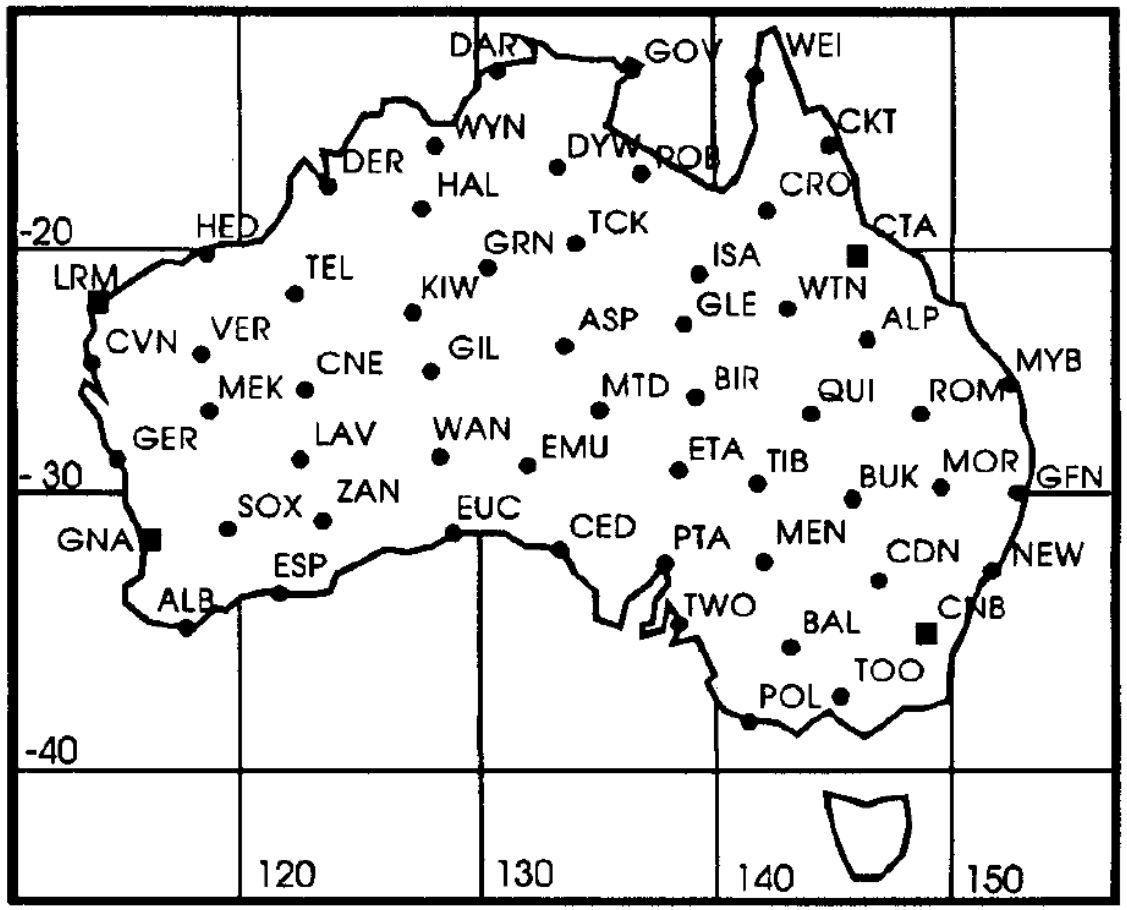


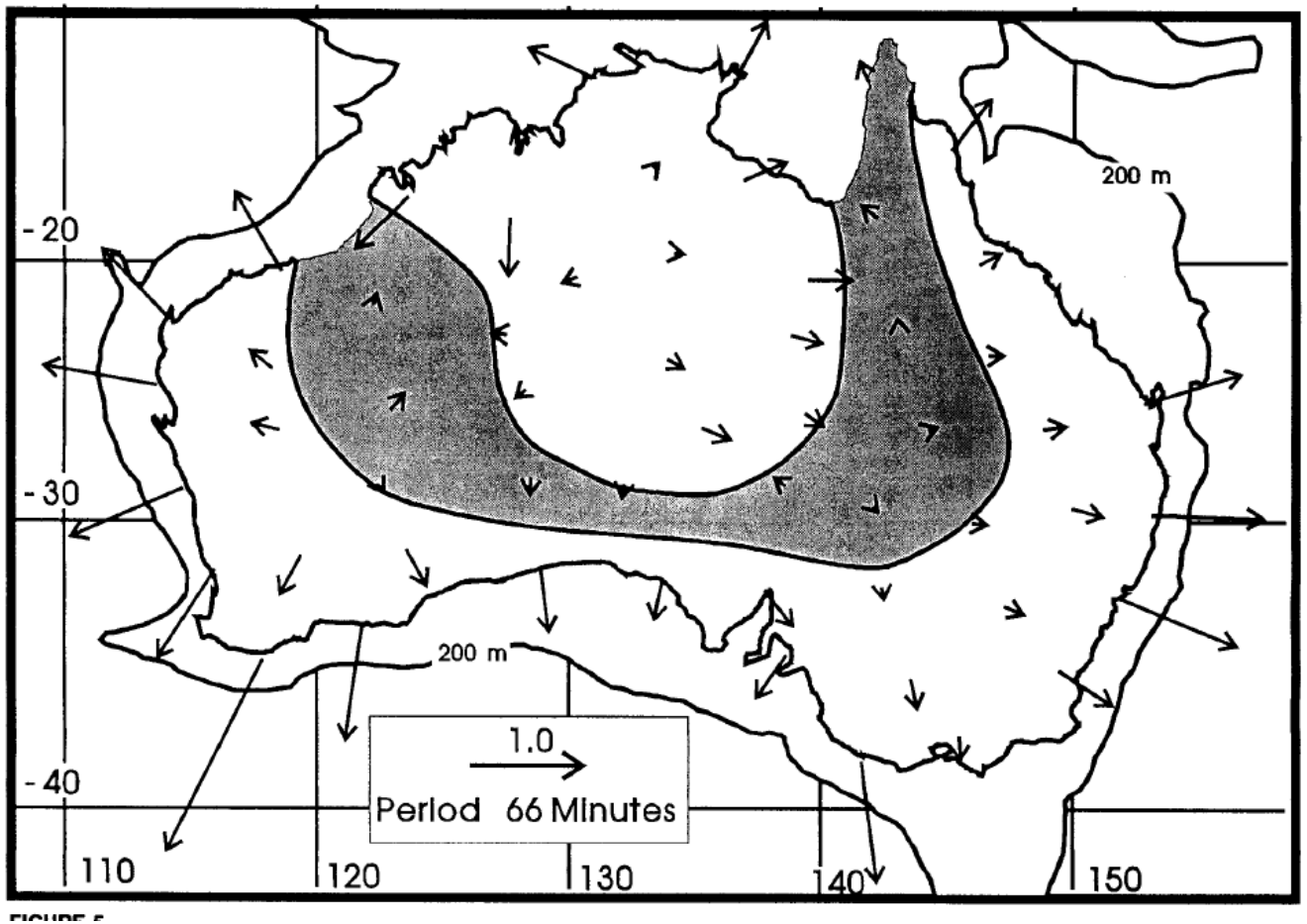
Geomagnetism – The very early Days



Parkinson 1962

Geomagnetism - The Early Days

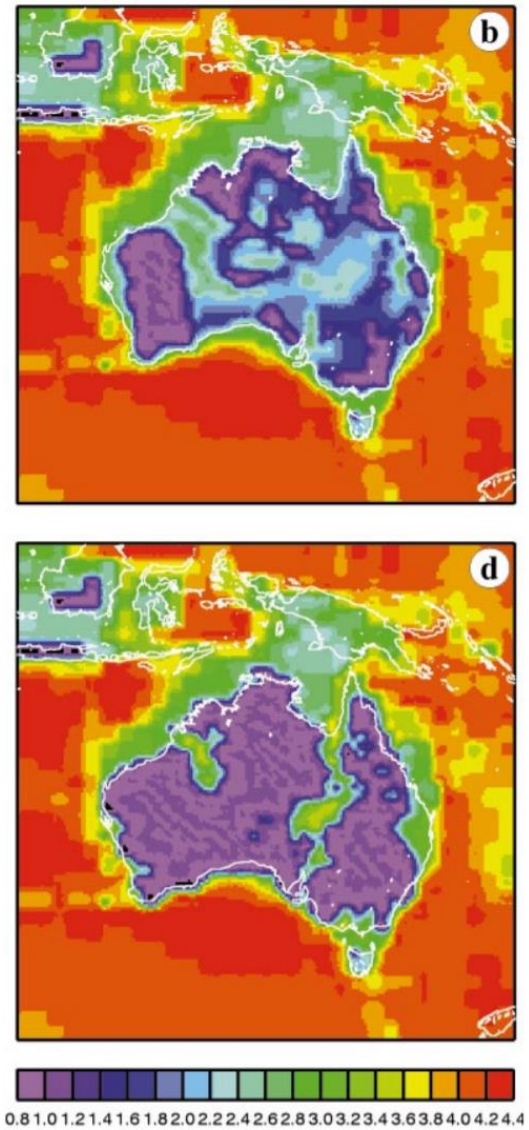




AWAGS, Chamalaun 1993

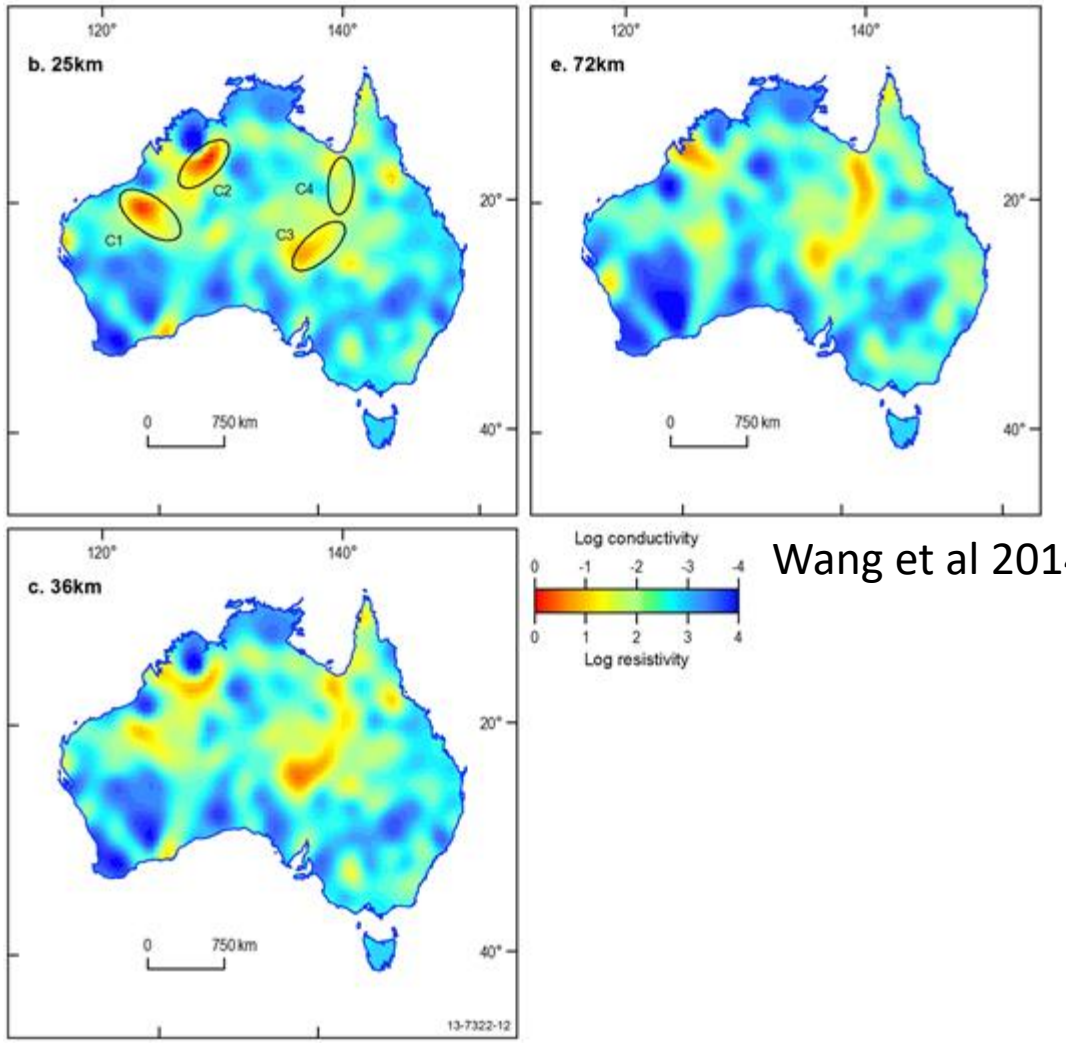
GDS - Now in colour

Thin sheet modelling



Wang and Lilley 1999

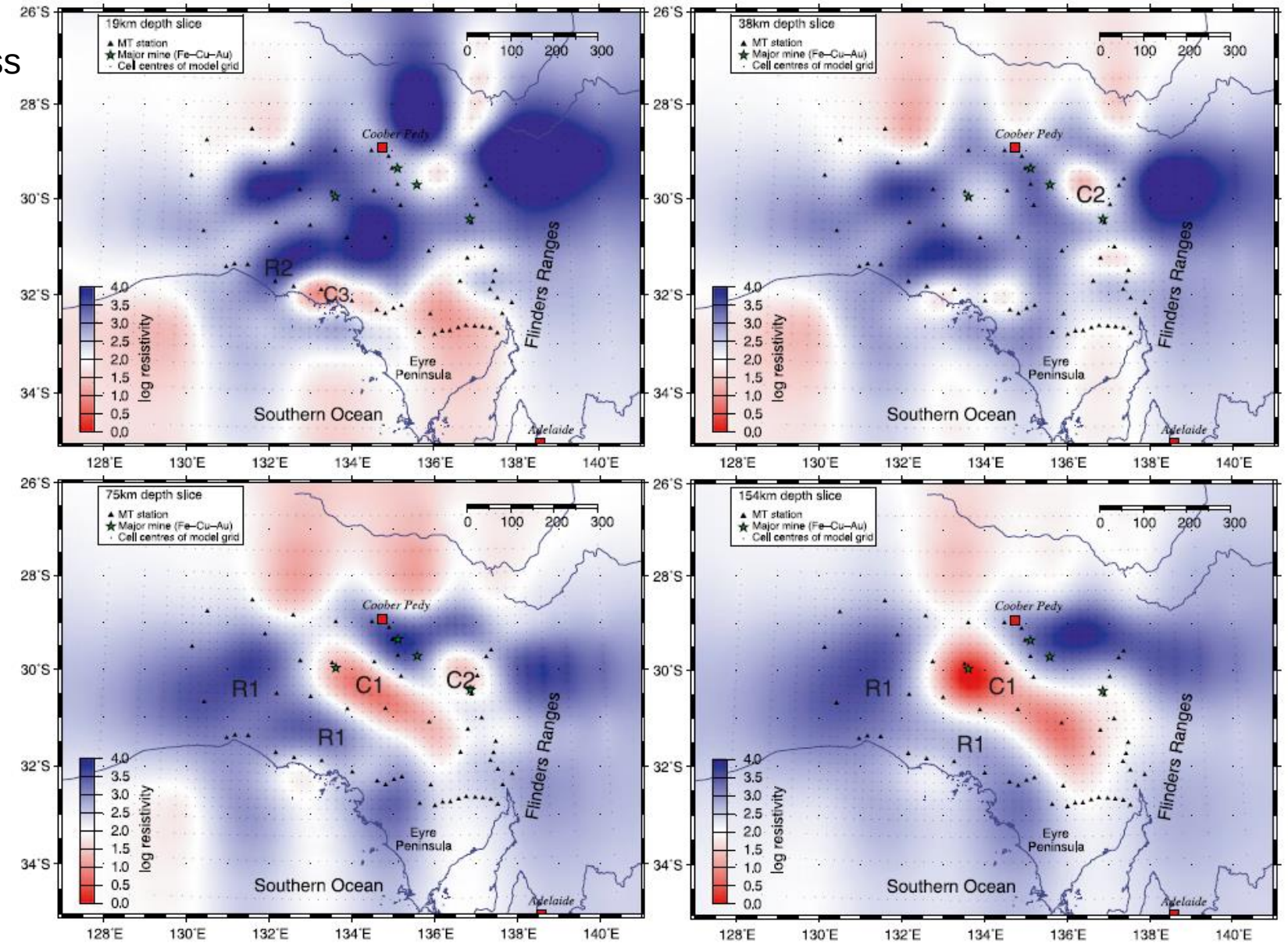
3D inversion of tipper data



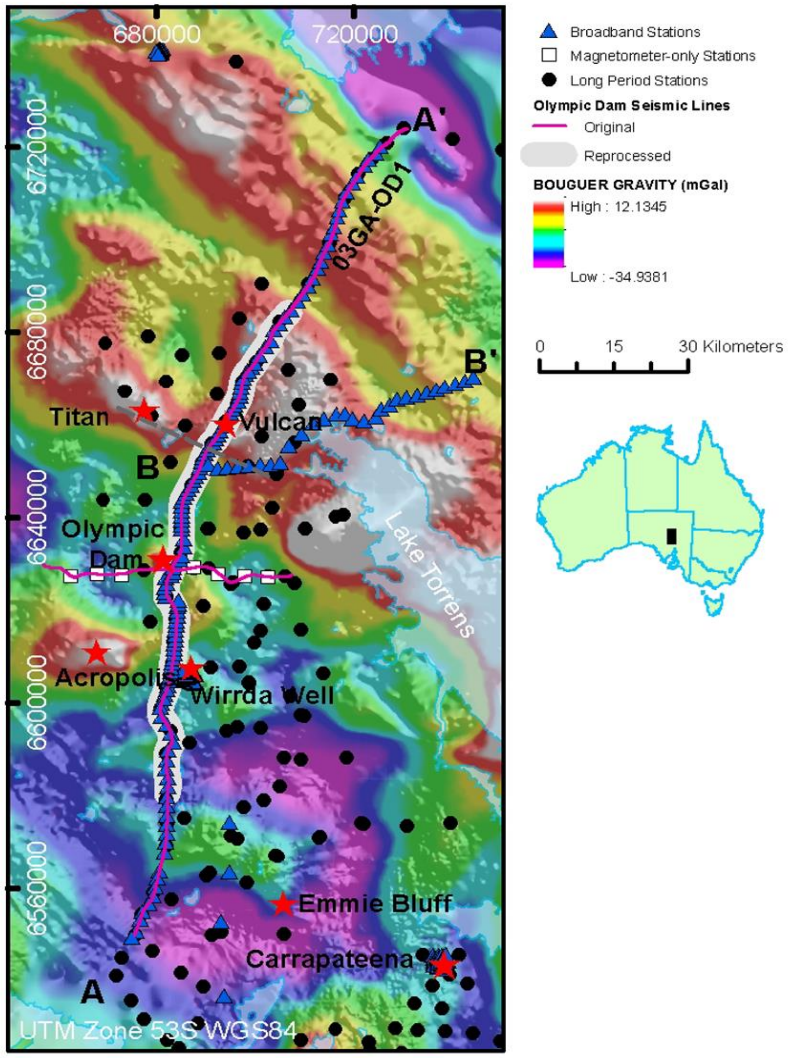
Wang et al 2014

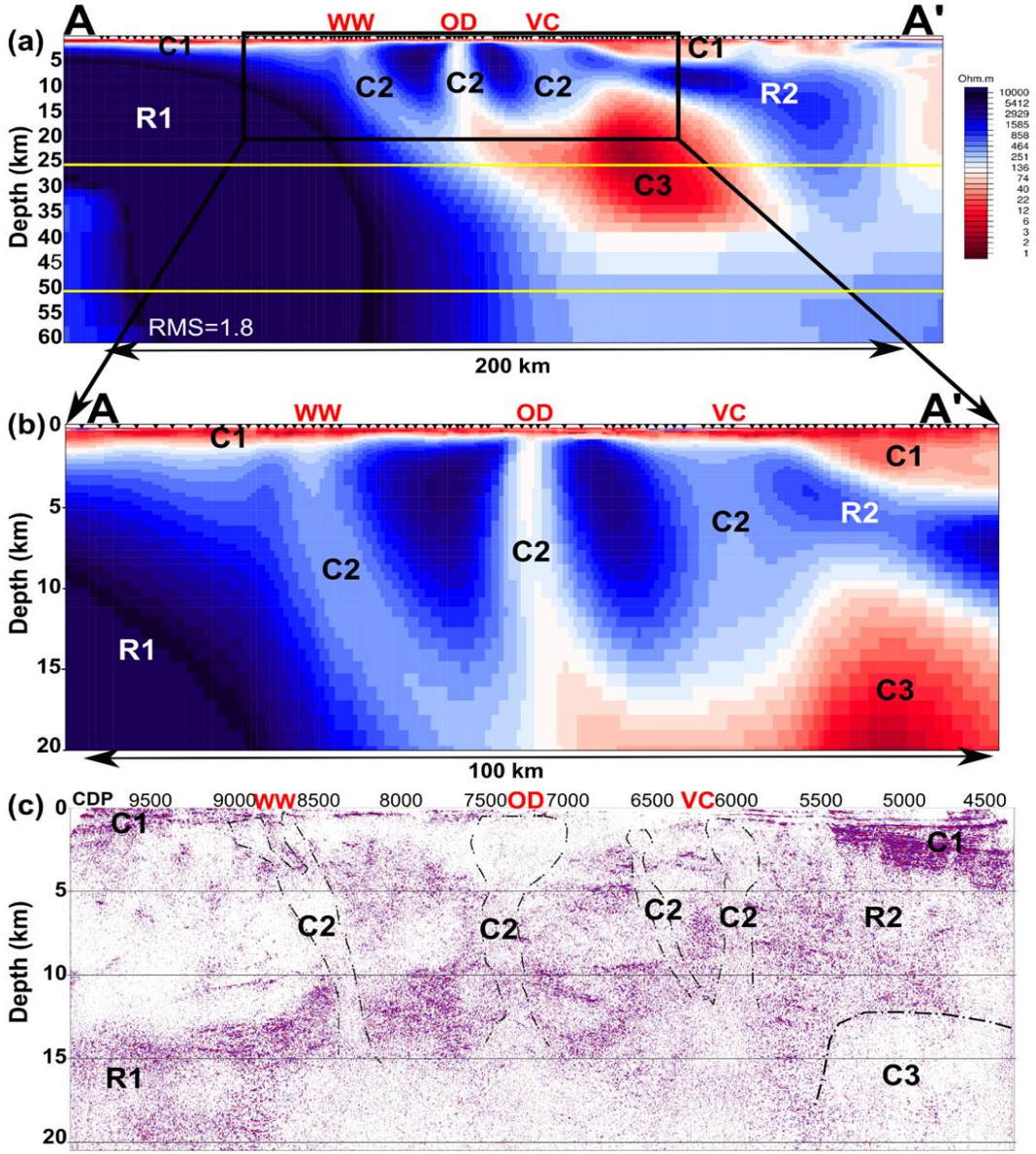
First 3D inversion of long-period MT in Australia

- Data acquired in 2006 and 2008 across the Gawler Craton
- First recognition of anomalous mantle resistivity as a result of metasomatic processes
- Only very loose correlation to major mineral deposits



Motivation – the first link of MT to major mineral systems

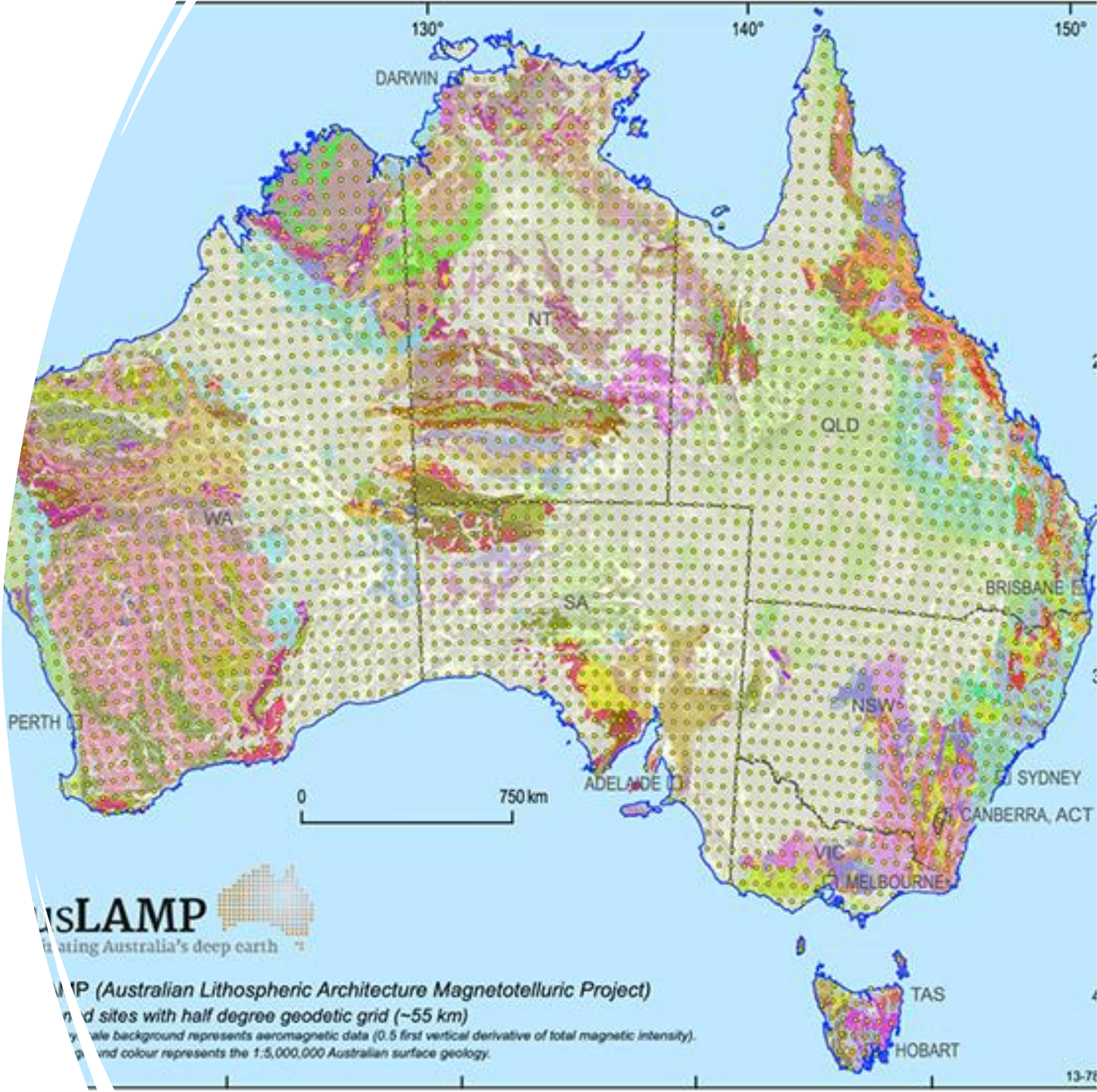




Olympic Dam, Heinson et al., 2018, 2006

Delivering AusLAMP

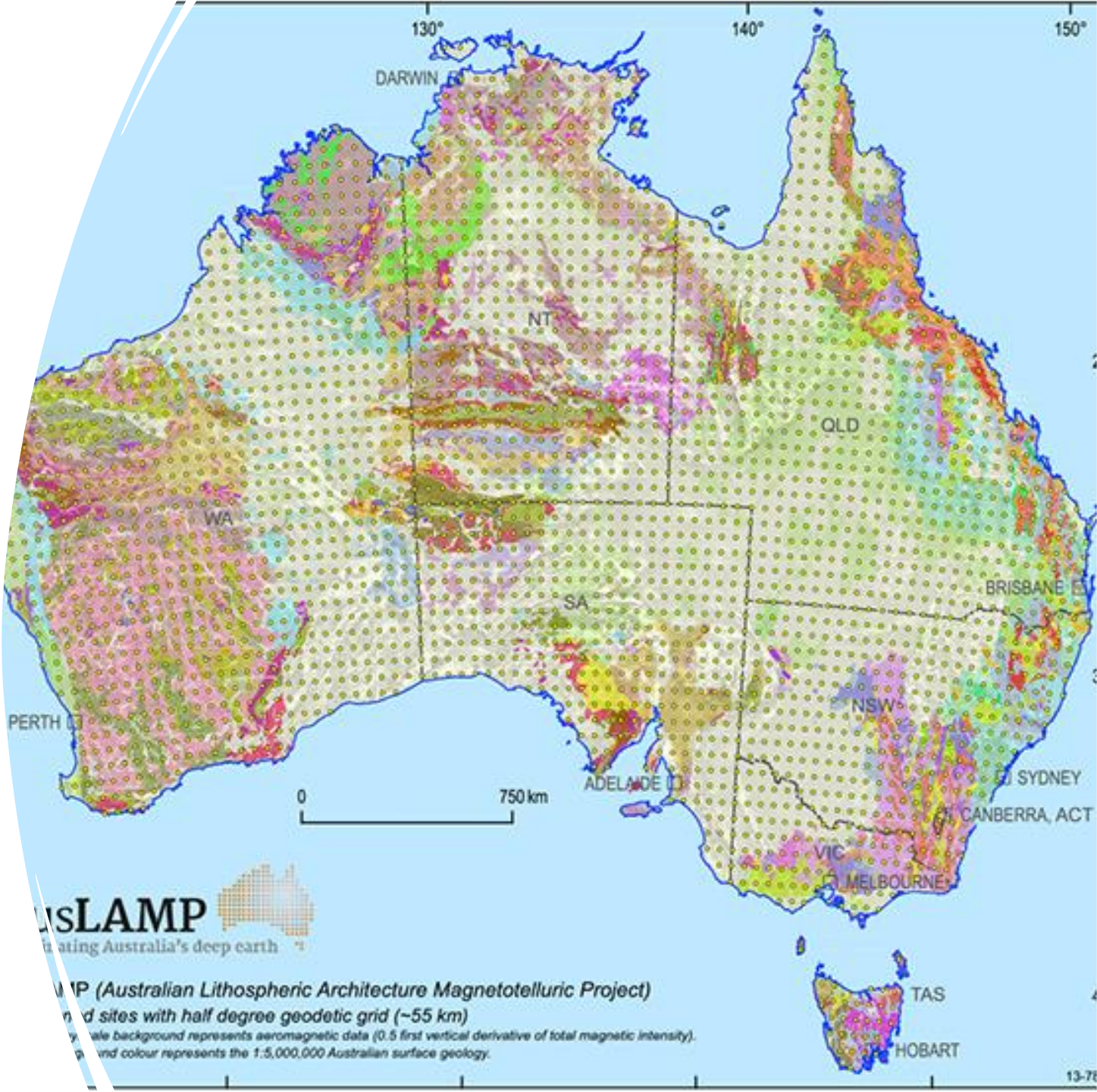
- Data acquisition funding from federal and state geological surveys, AuScope (to date around $6-7M)
- Instrument funding through AuScope and Geoscience Australia
- Some university funding (University of Adelaide and University of Tasmania)
- Computing time on NCI (National Computational Infrastructure)

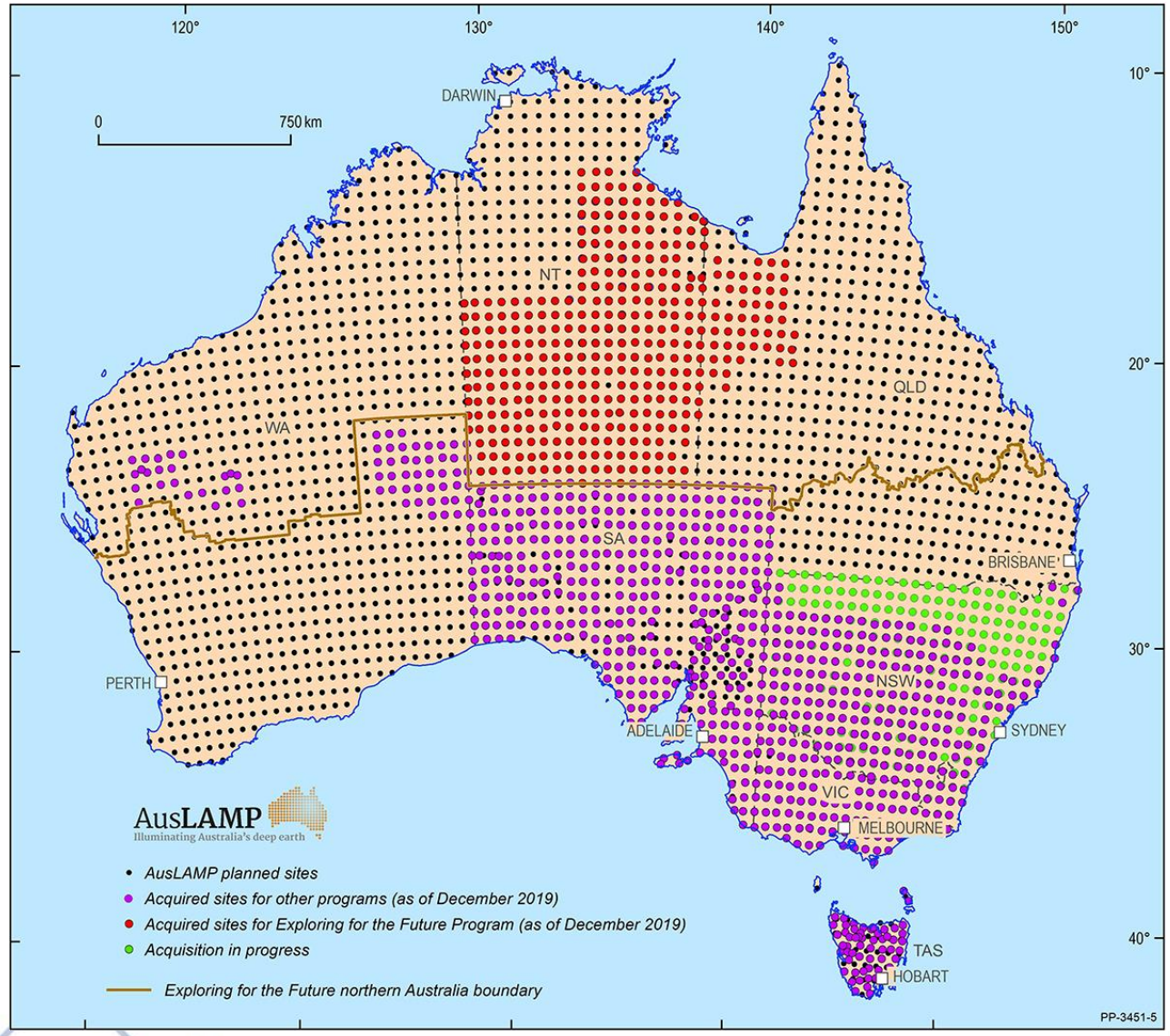


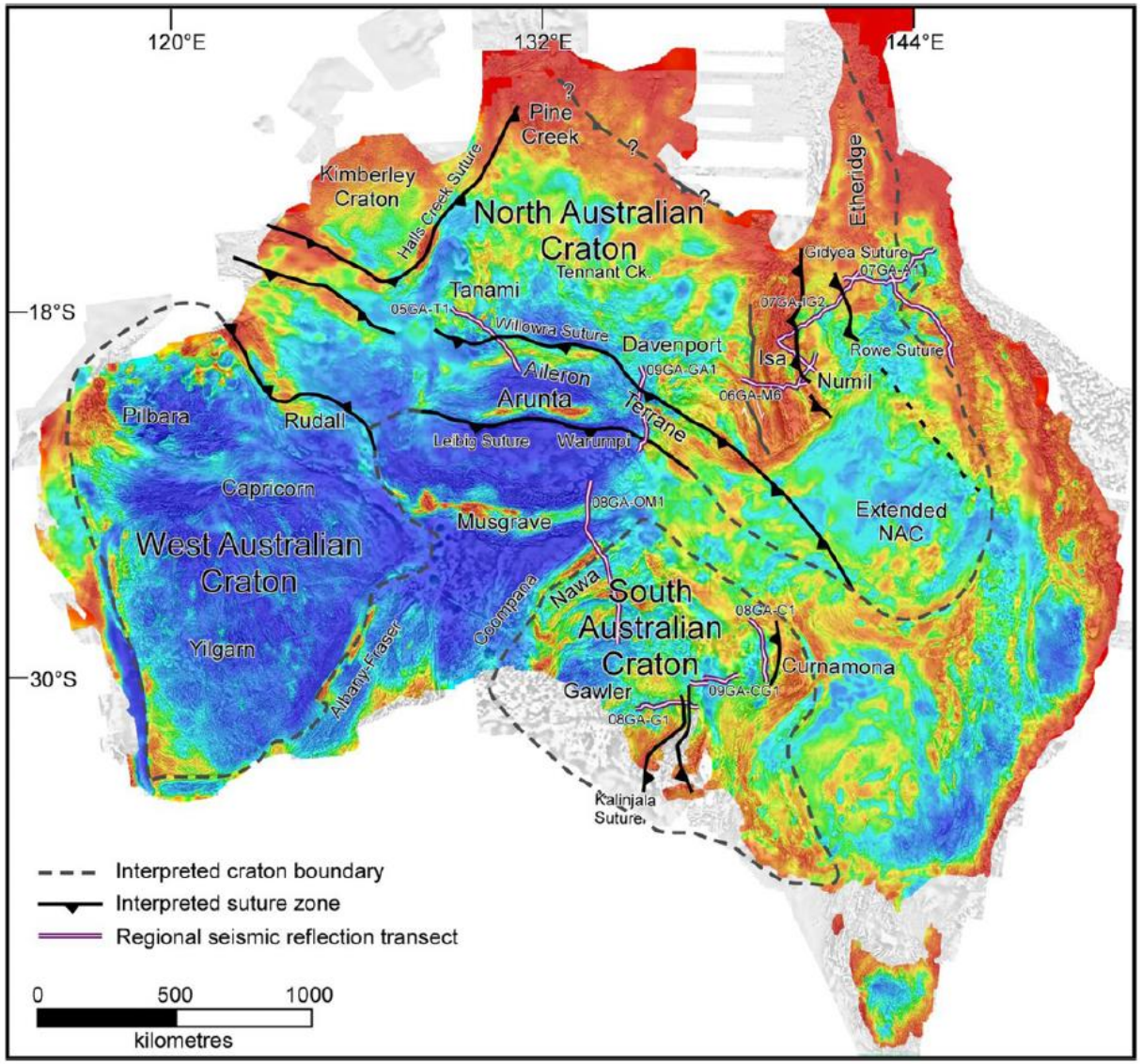
Goals of AusLAMP

Help to

- understand the geologic and tectonic history of the Australian continent
- helping to identify footprints of mineral and energy systems at a broad regional scale, not at a local property scale
- Provide a backbone EM data set to inform future and current high-resolution EM surveys, e.g. broadband MT, airborne EM
- analysing risks to Australia's electricity infrastructure







http://www.ga.gov.au/about/projects/resources/auslamp

Betts et al 2015

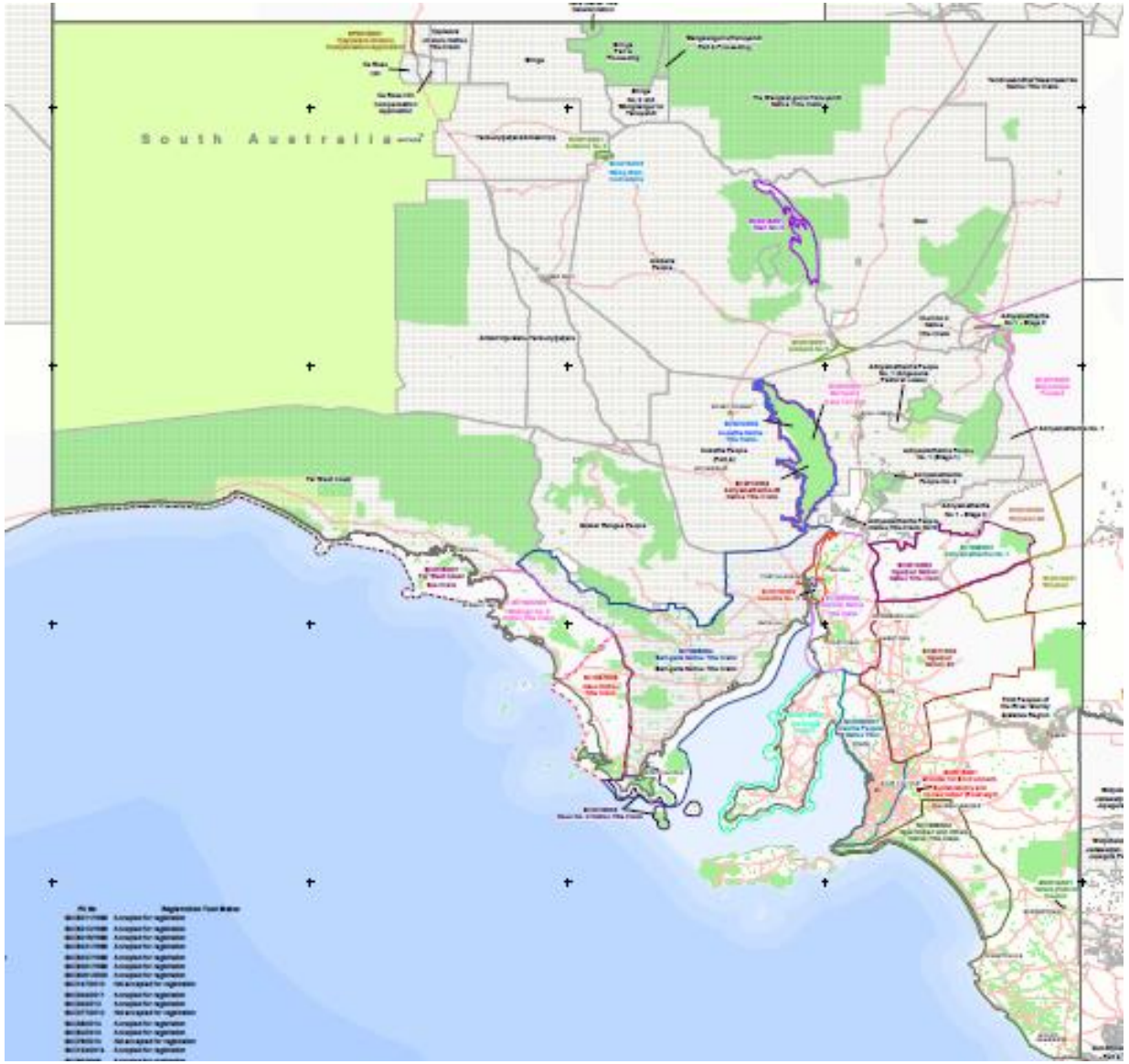
Instrumentation

- 10 Hz sampling in the field, reduced to 1Hz sampling for processing
- Low noise LEMI fluxgate instruments from AuScope National Instrument Pool (University of Adelaide, Goran Boren)
- Geoscience Australia Instruments pool
- 5 channel MT data

AusLAMP South Australian Community Engagement - Land Access

Land Tenure types encountered include:

- Pastoral Leases
- Freehold / Perpetual Lease Lands
- Aboriginal Freehold Lands / IPA's eg Maralinga-Tjarutja Lands, APY Lands
- Woomera Protected Area
- State Conservation Areas / National Parks / Wilderness Area
- Infrastructure Land



AusLAMP South Australian - Logistics

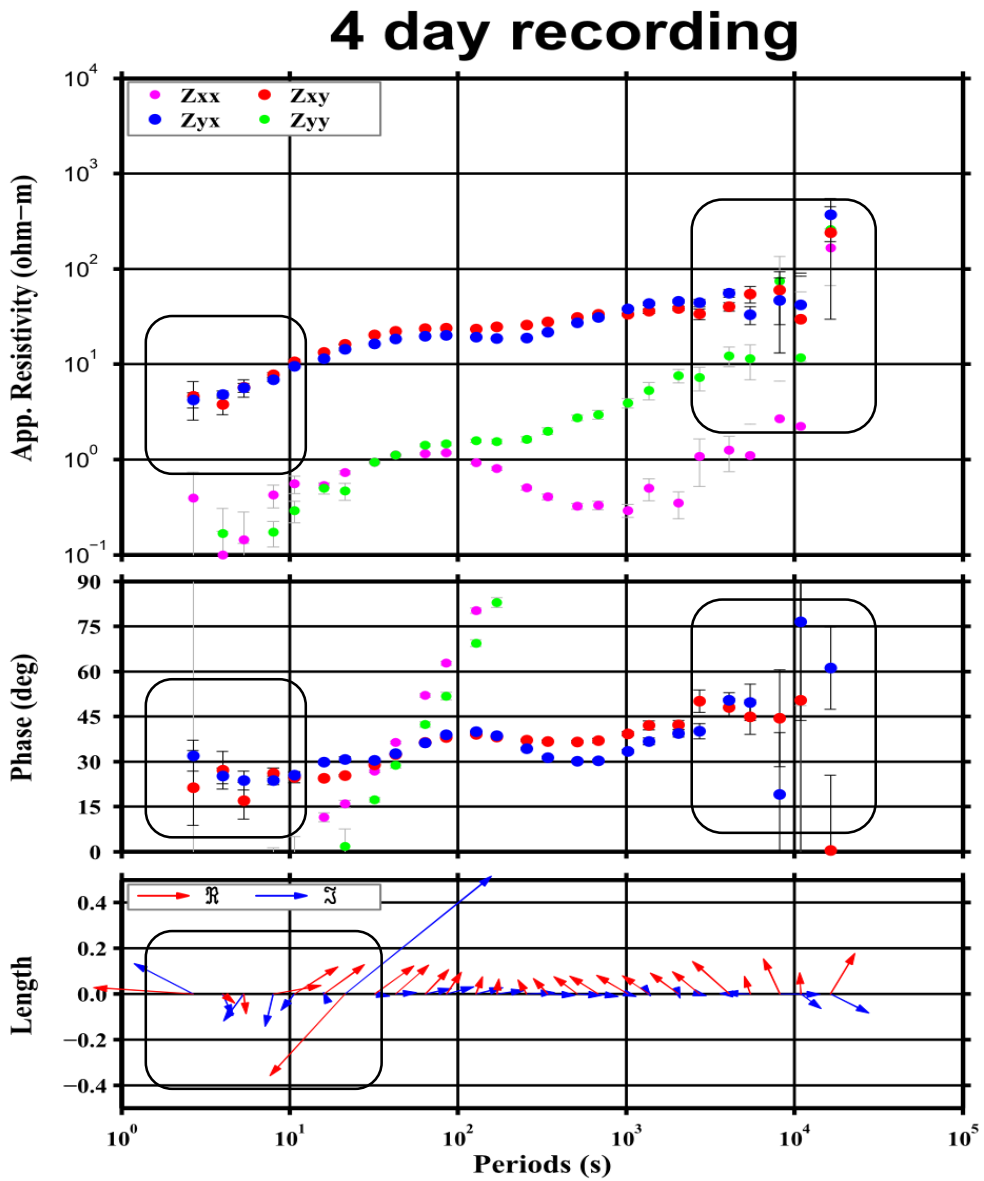
- Mainly used the ANSIR EDL MT Units housed at Adelaide University.
- Usually deployed 25 MT units per field trip, with around +/- 2 sites failing (best was 1 failure, worst was about 8 from animal damage).
- Depending on access, used a combination of vehicles and/or helicopter for deployment.
- Used a core group of three who managed SA AusLAMP and understood good deployment to maximise recording good data.
- Often camped out to reduce travel times.

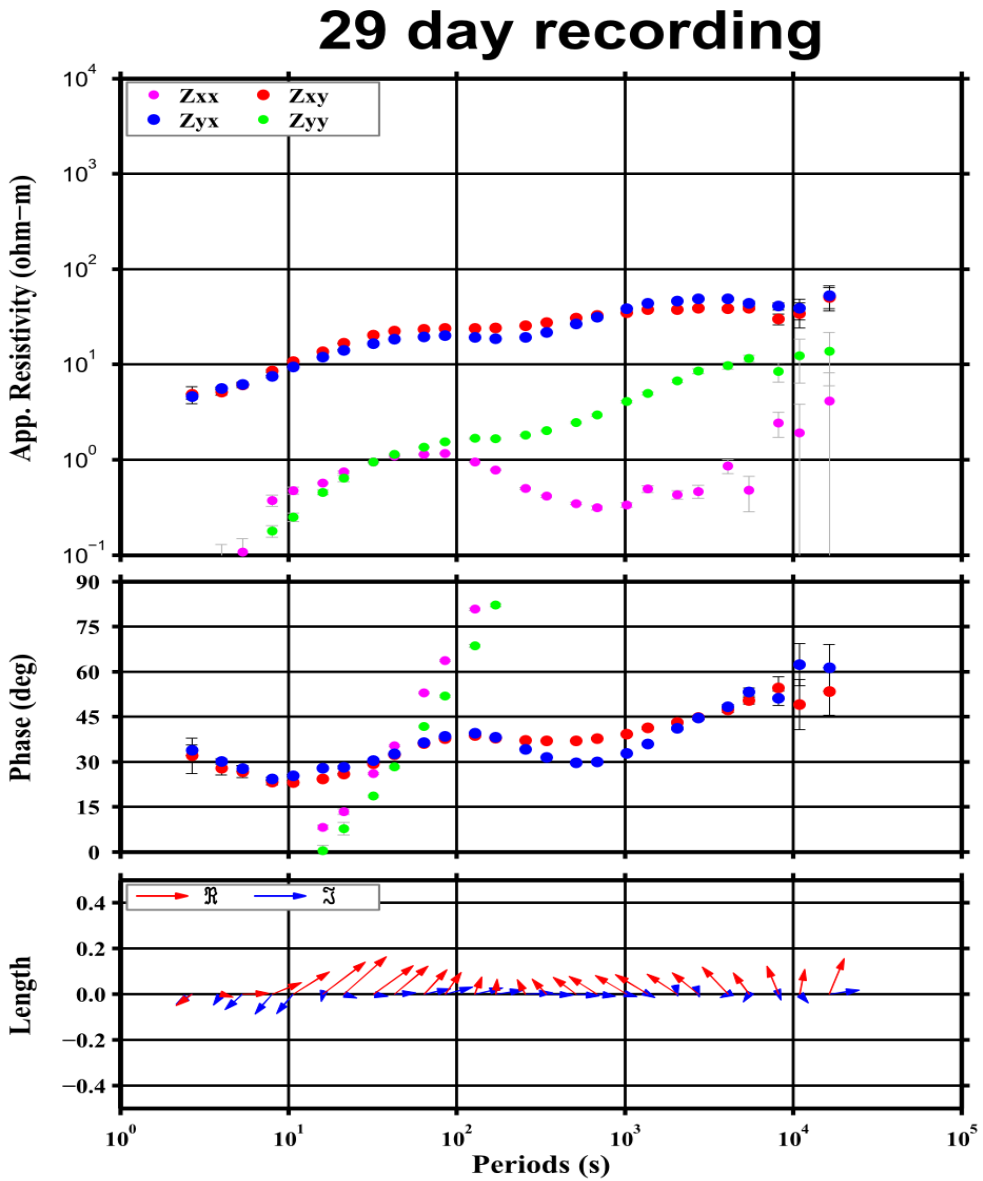
AusLAMP South Australian - Field Work

1. Communications
2. Language
3. Word-of-Mouth
4. Utilising networks
5. Build on existing deployments
6. University vs Government or Company Brand

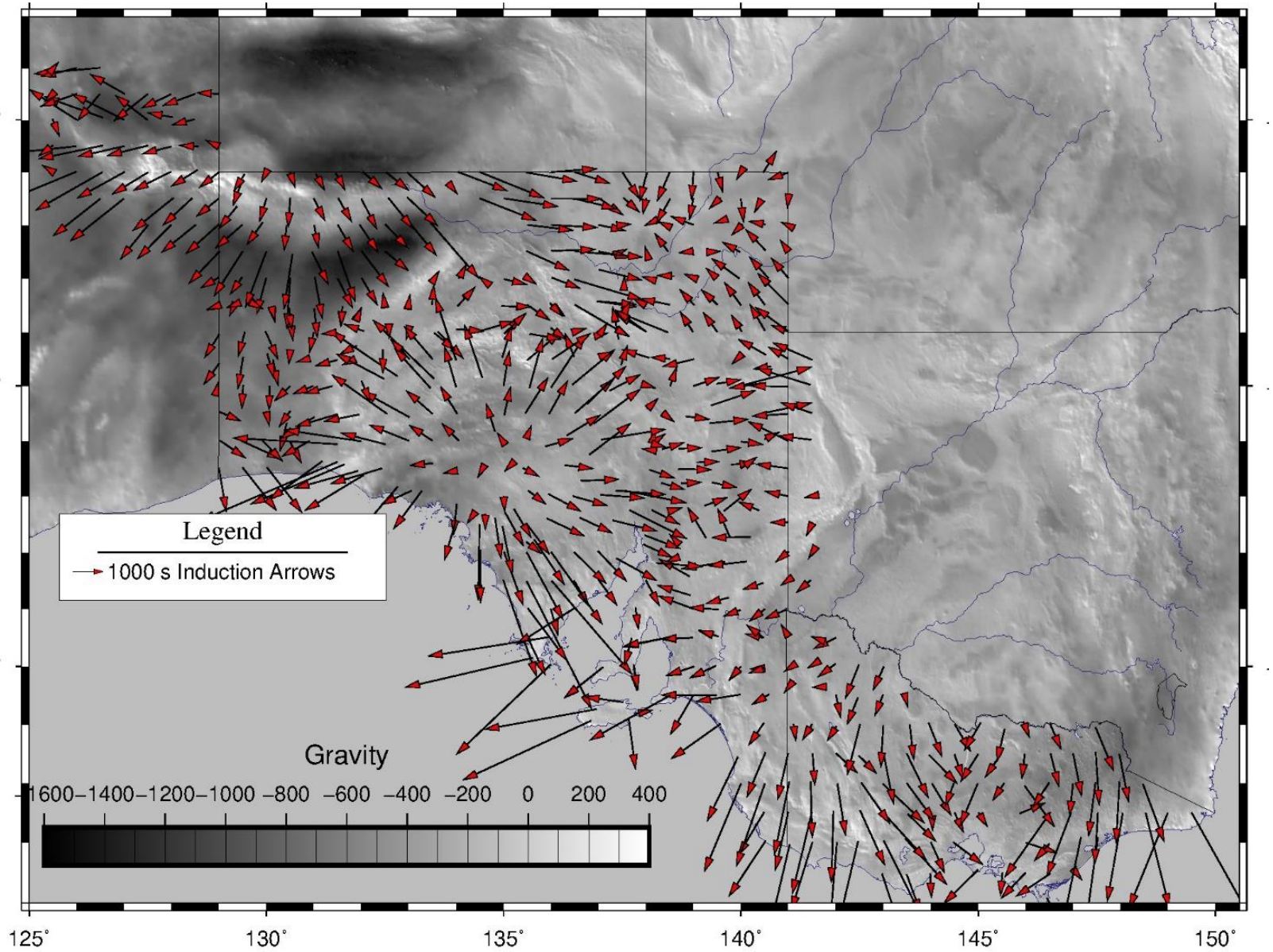
MT data collection

- Processing primarily using BIRRP and Lemi software
- Typical range of periods between 8-20,000 s
- Full impedance tensor and tipper data

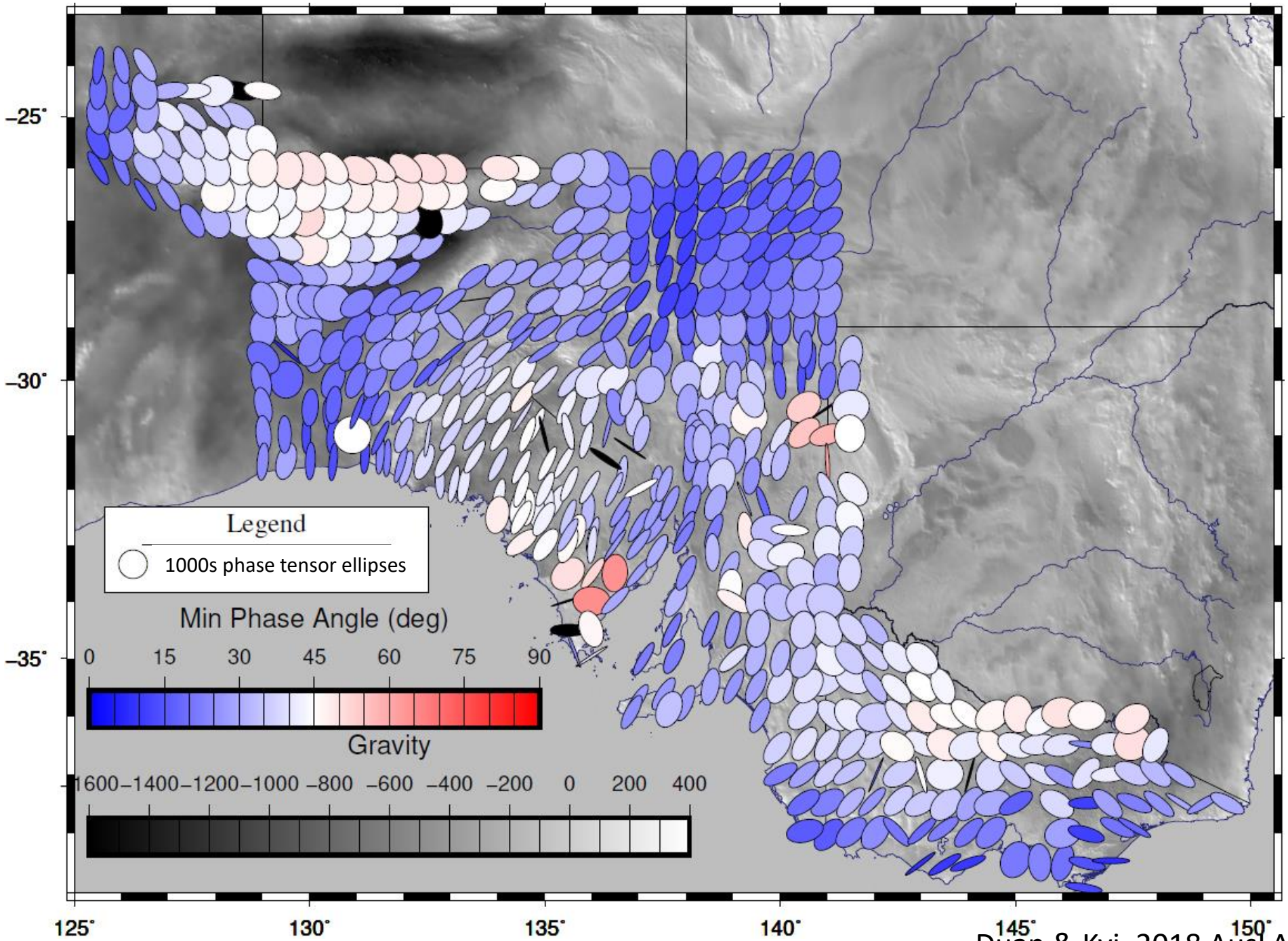




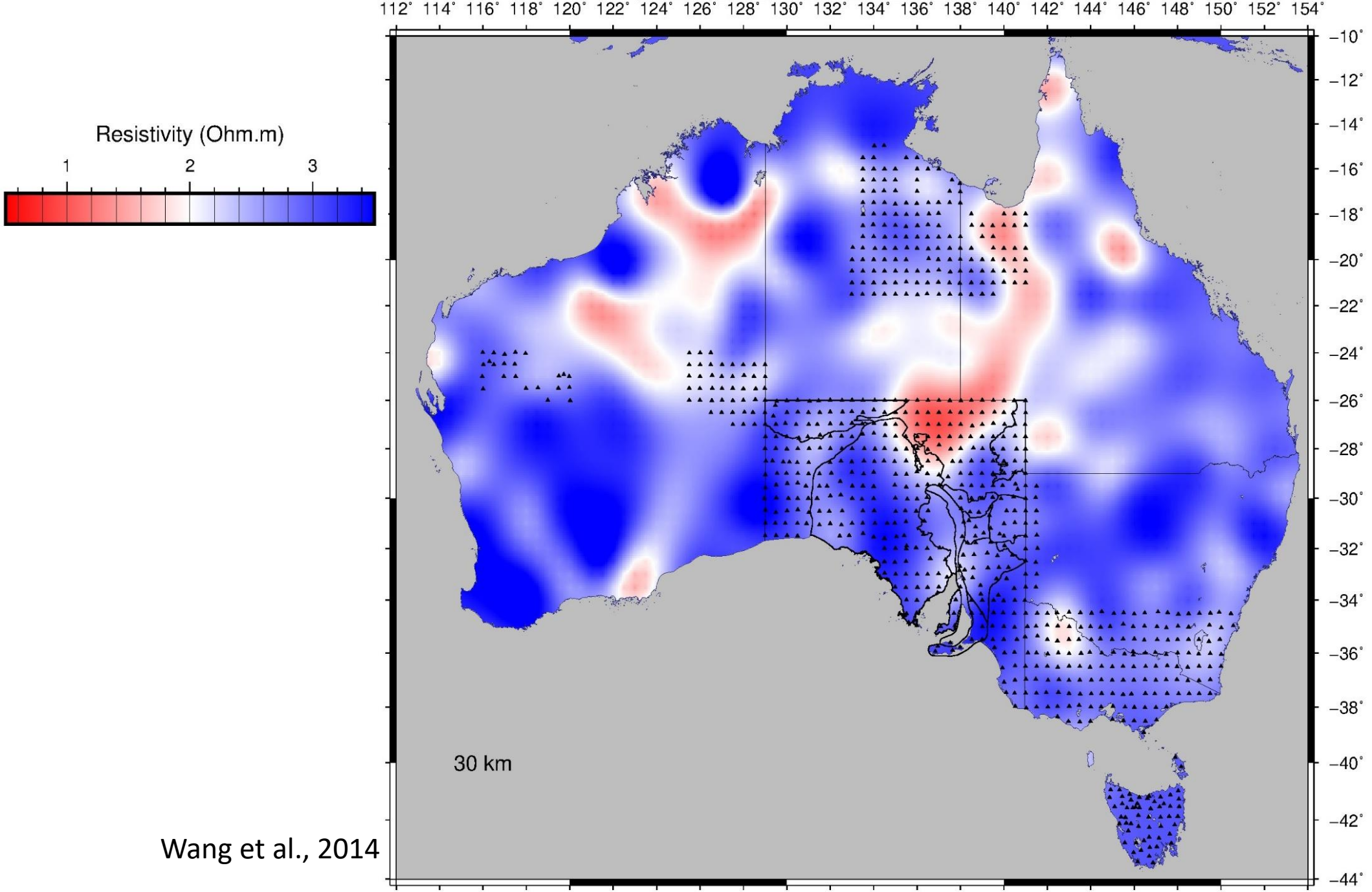
Induction Arrows



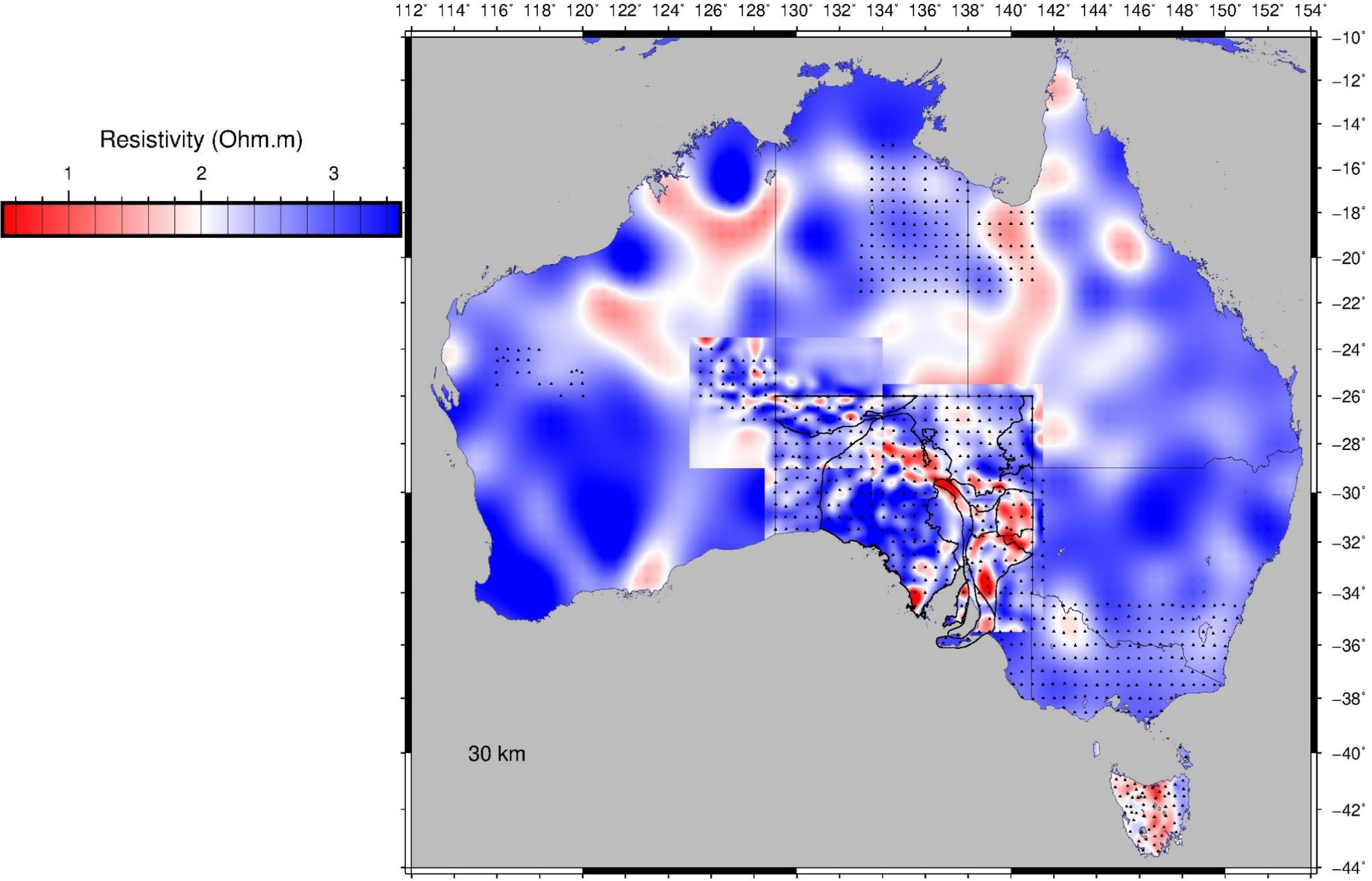
K Robertson pers comm.



Duan & Kyi, 2018 AusLAMP Victoria Data



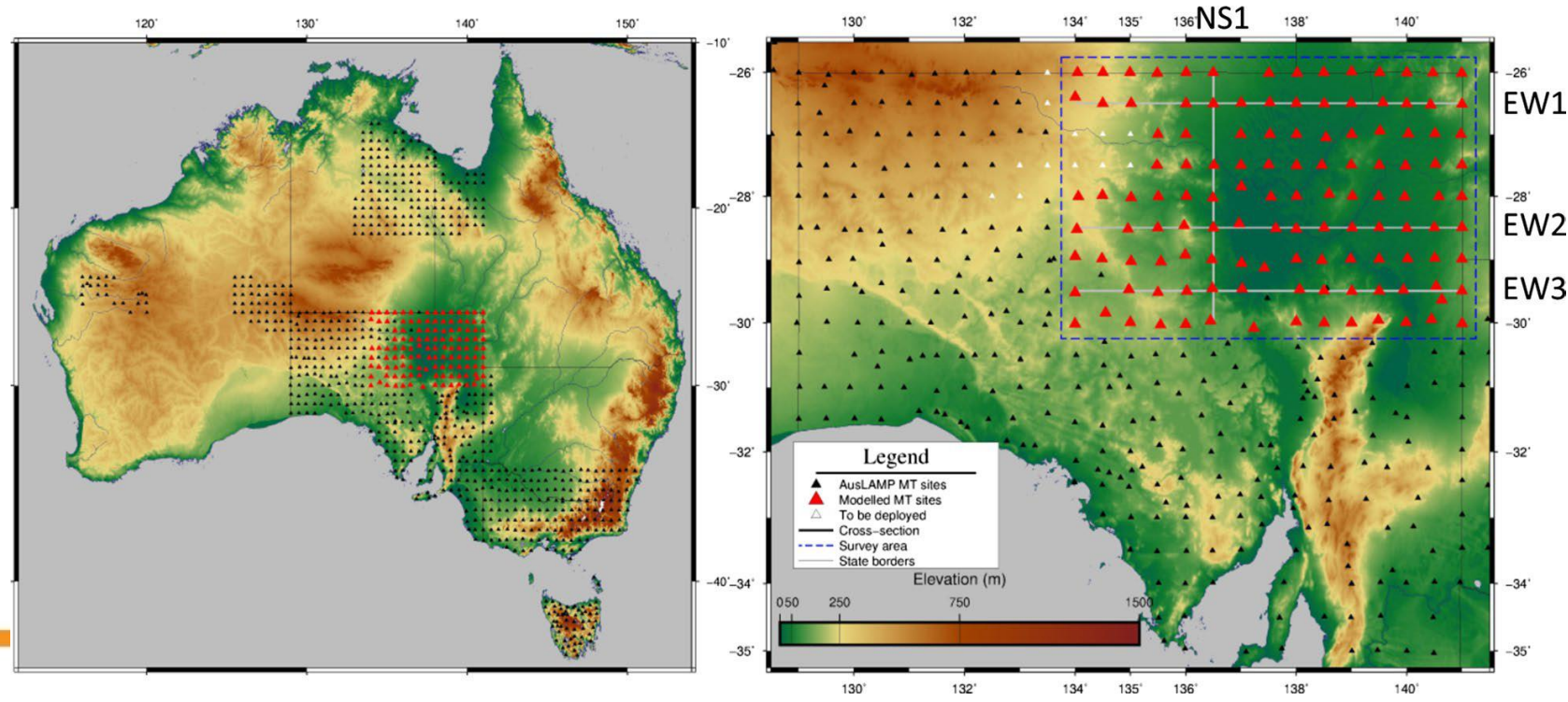
Wang et al., 2014



Tasmania Model kindly provided by Tom Ostersen, U Tas

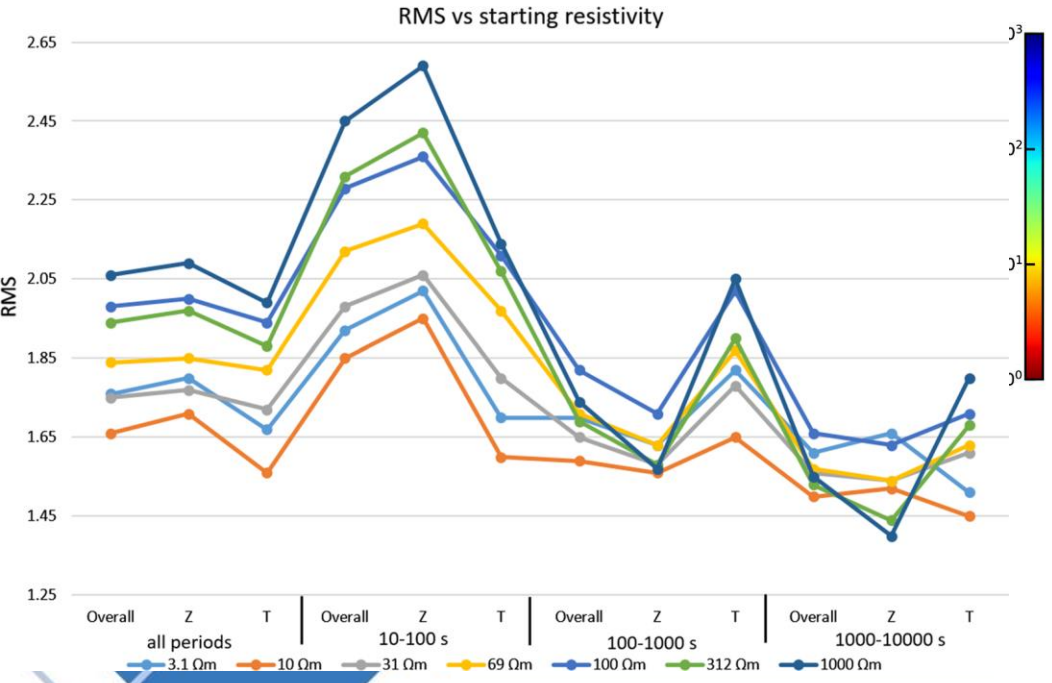
Modelling of AusLAMP data

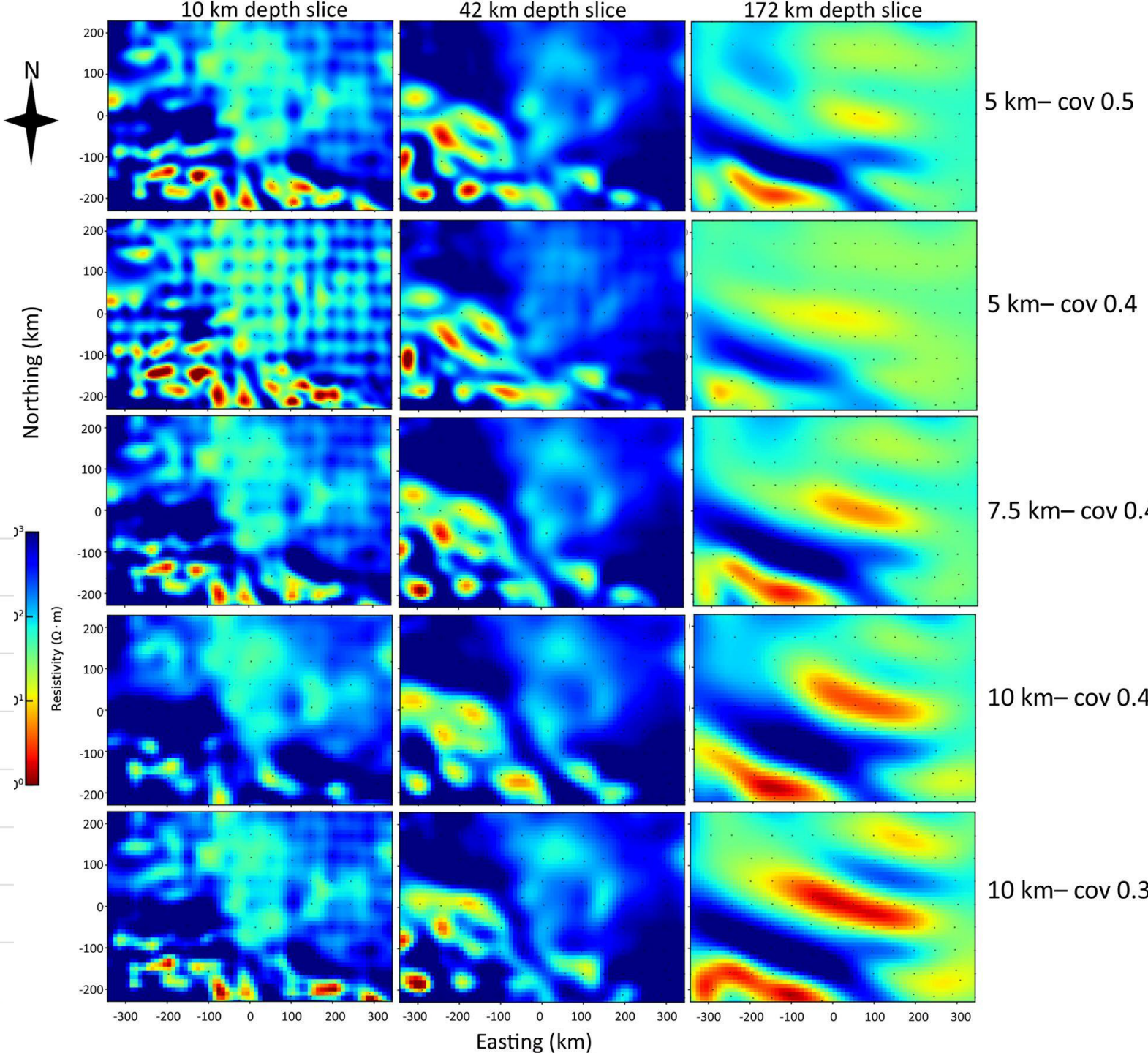
- Rigorous model parameter testing in Robertson et al., 2020, EPS
- Wide range of modelling parameters need testing, especially
  - model covariances in relation to cell sizes
  - Starting half spaces
  - A priori information



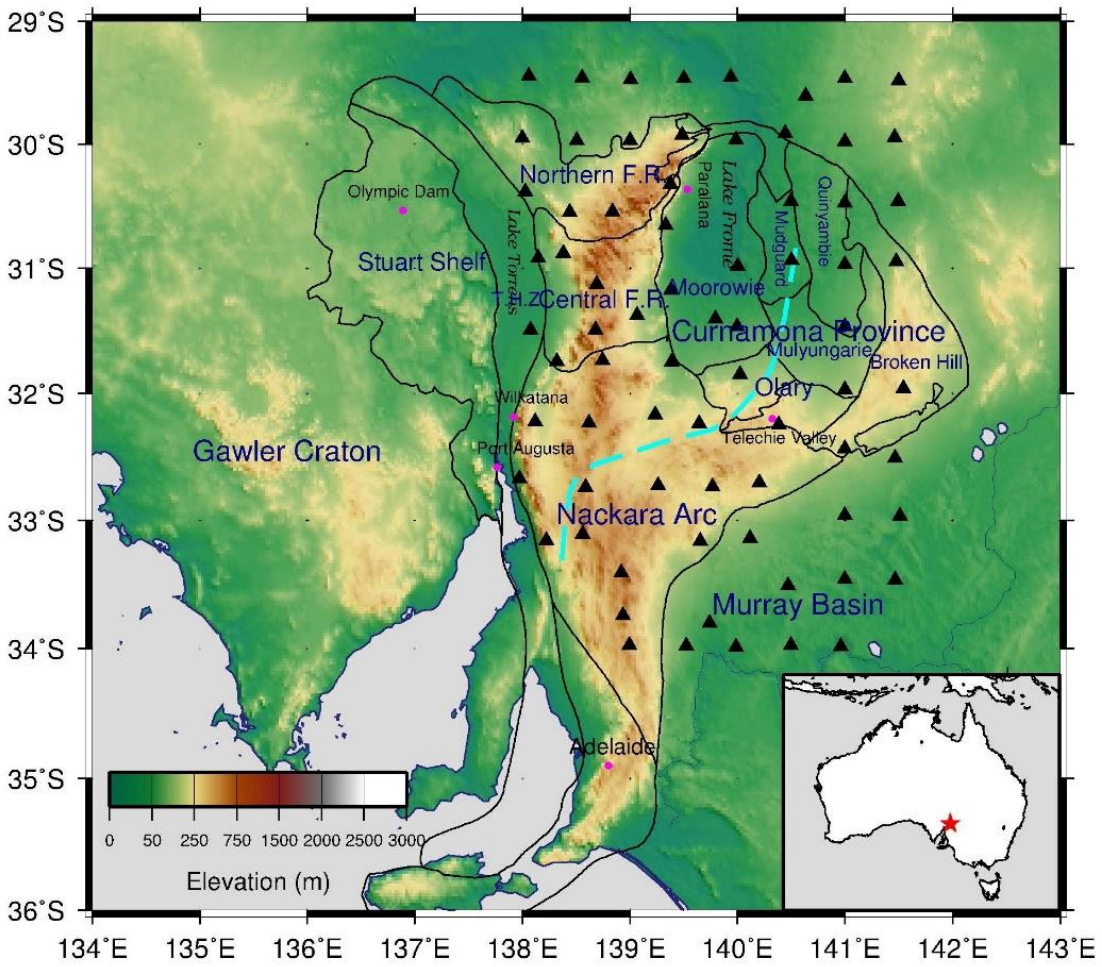
Modelling of AusLAMP data

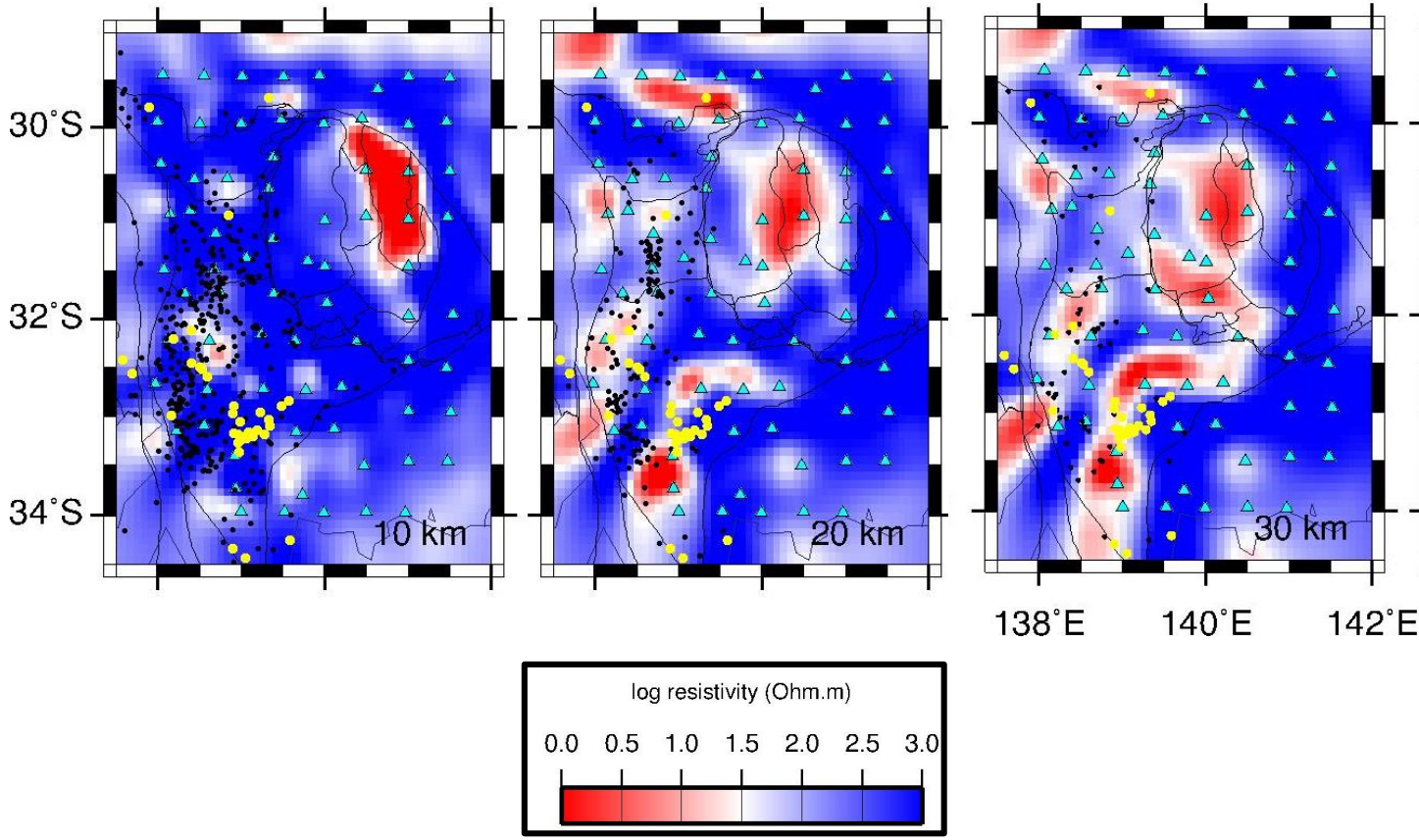
- Influence of model covariance on the inversion results





First AusLAMP deployment – Proterozoic-Phanerozoic Transition

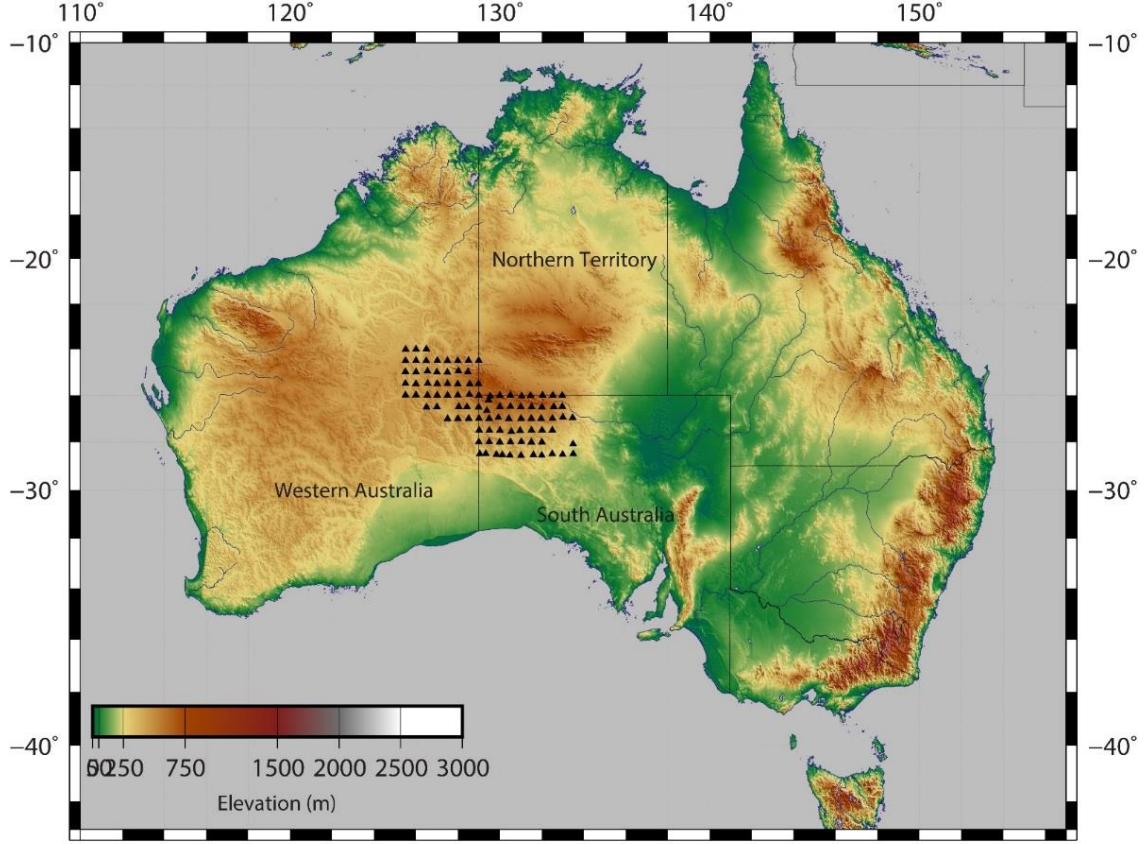




Robertson et al., 2016

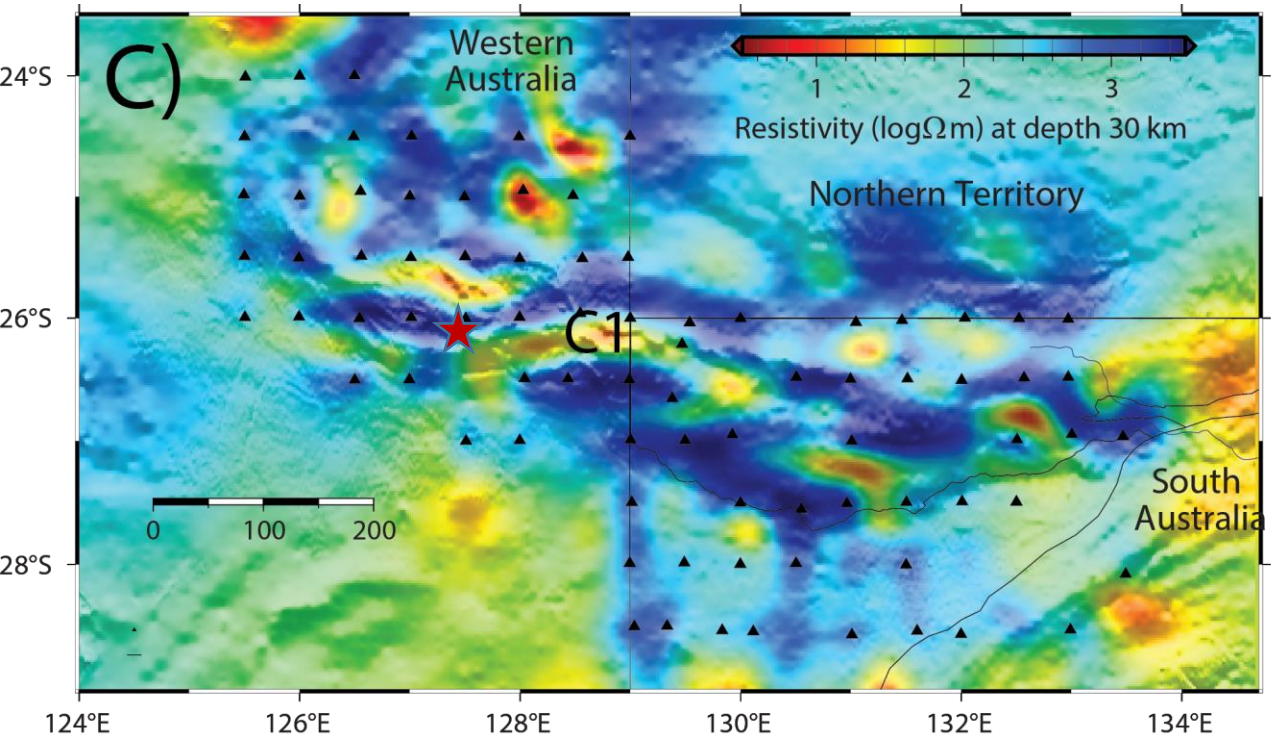
Musgrave Province

- Area of intraplate deformation
- At the triple junction between Western Australian Craton, Northern Australian Craton, South Australian Craton
- mineralization associated with ~1070 Ma Warakurna Large Igneous Province Giles Complex, e.g. Ni potential of Nebo Babel deposit

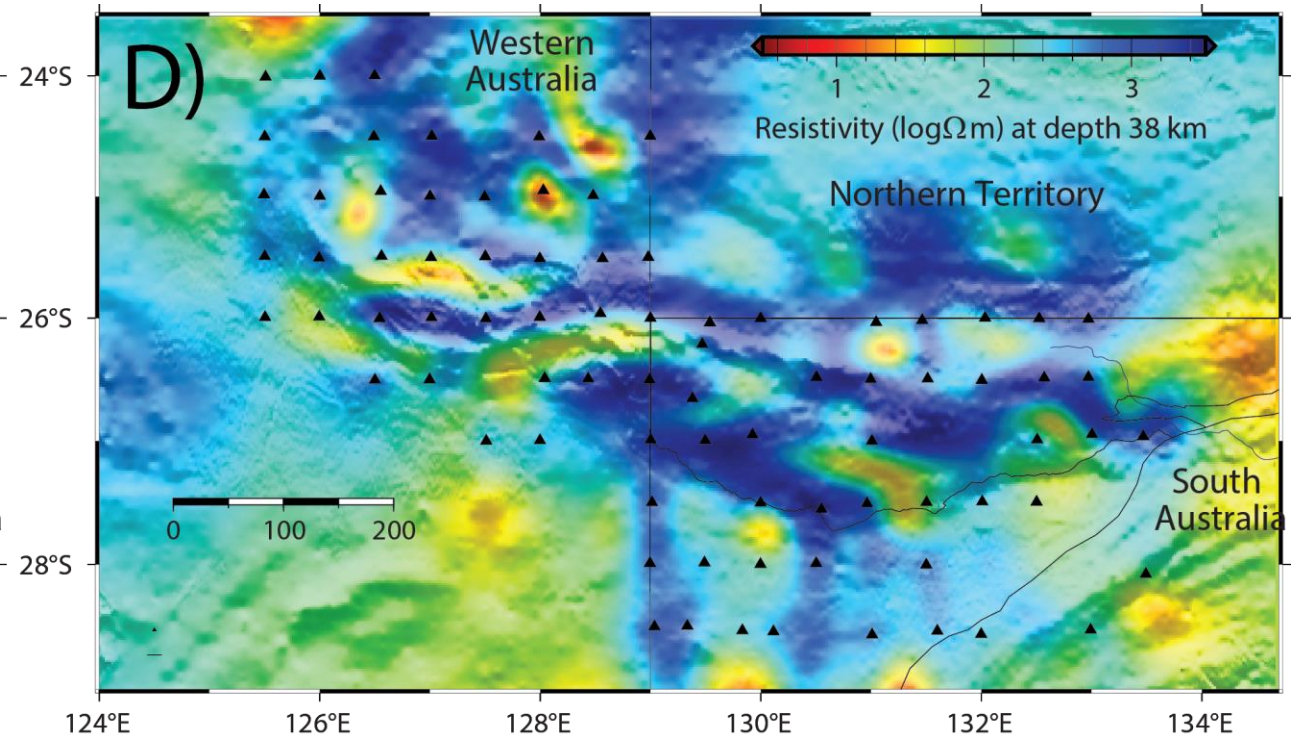


Mid-lower crust model slices – development of E-W trend

30 km



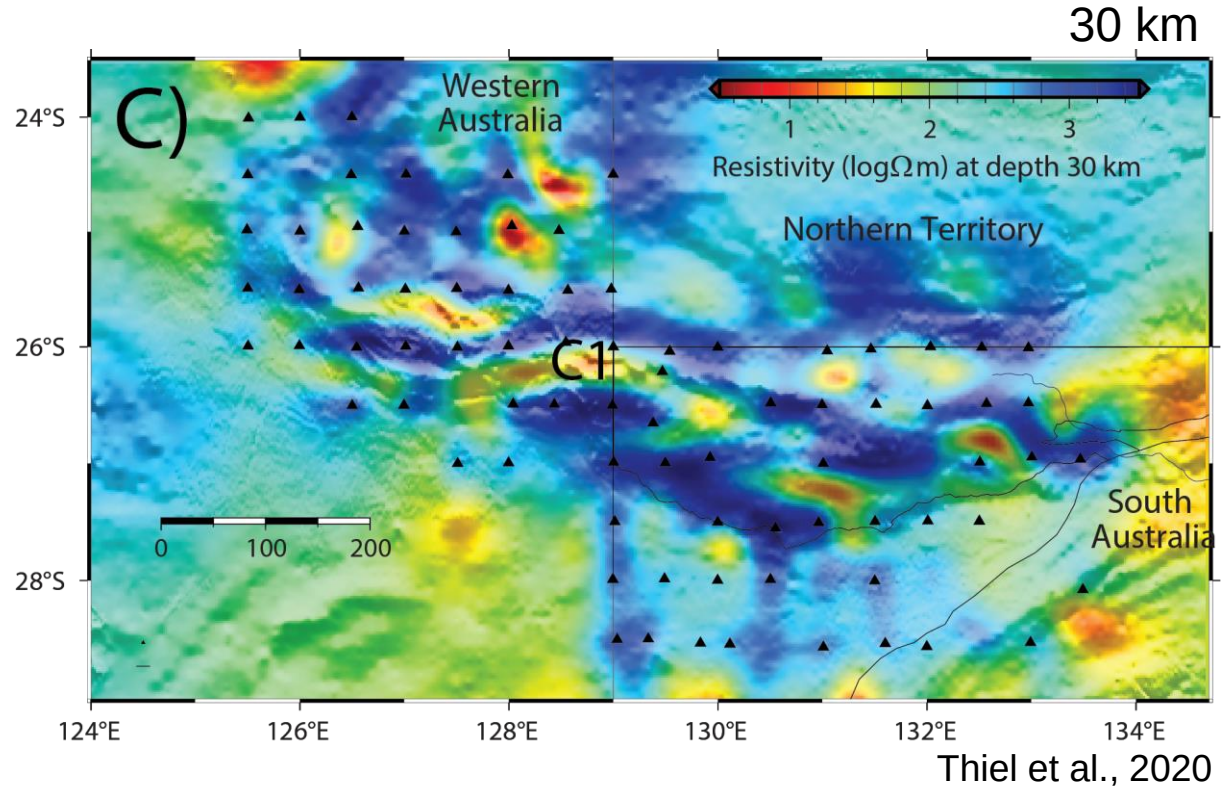
38 km



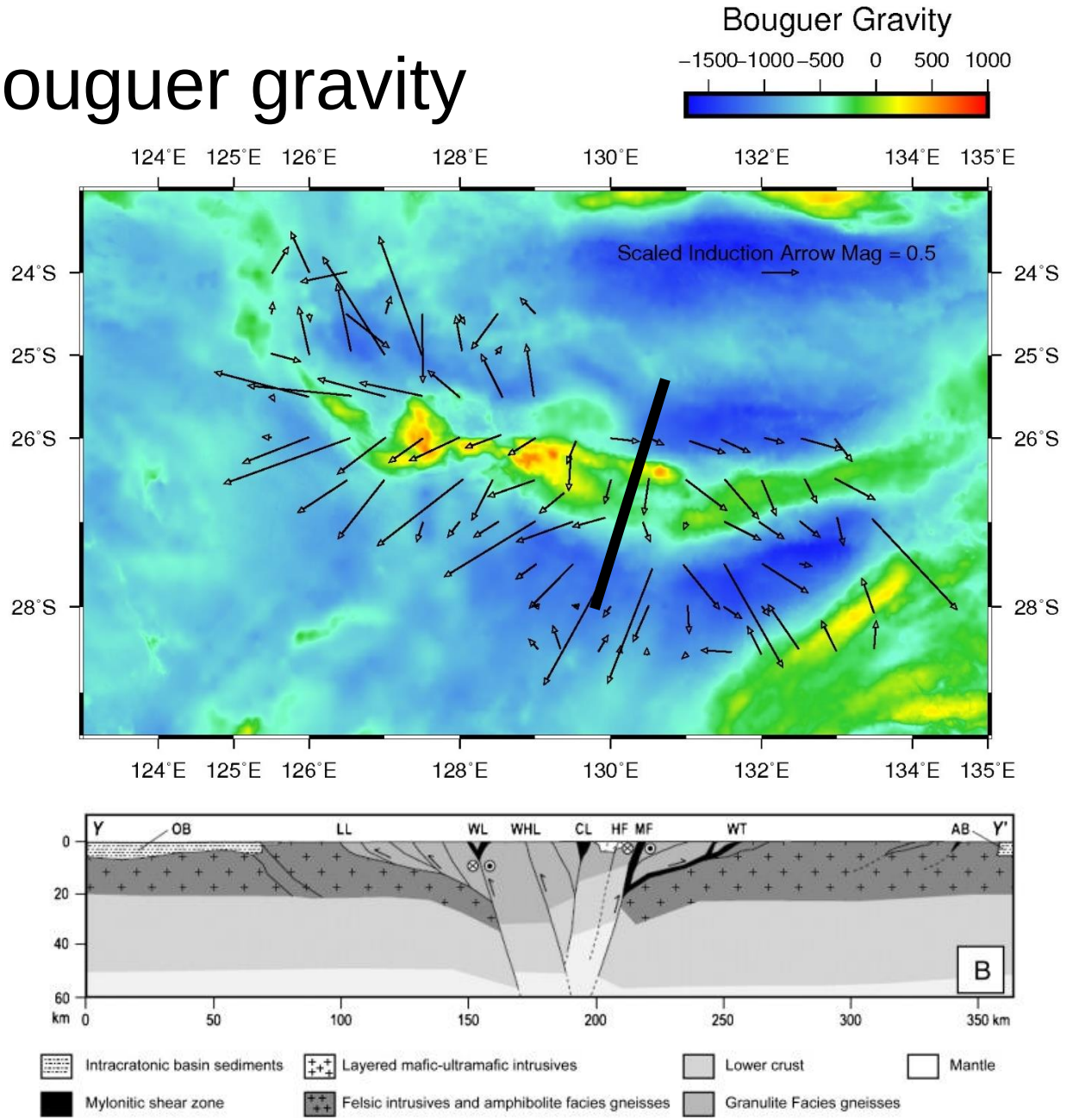
★ Nebo Babel Ni-Cu sulfide deposit

Thiel et al., 2020

Comparison of resistivity with Bouguer gravity

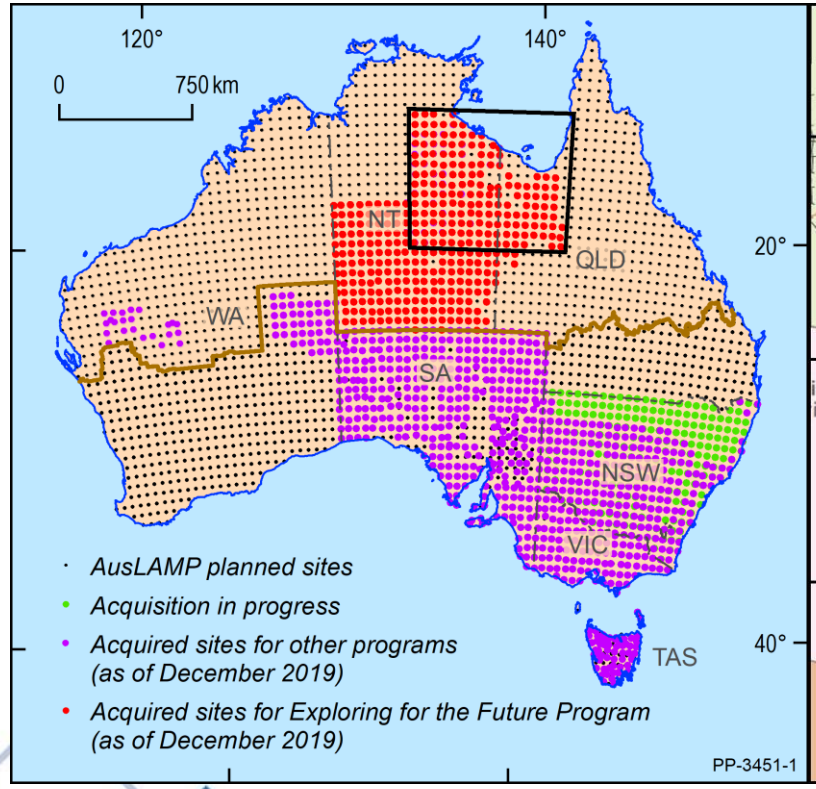


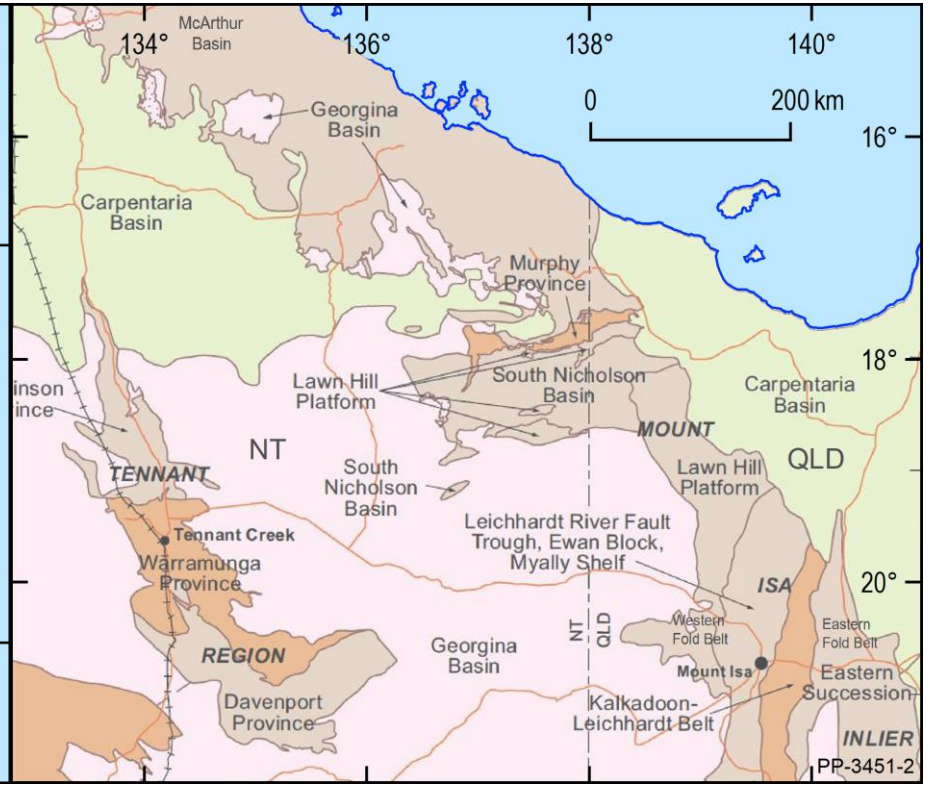
Thiel et al., 2020

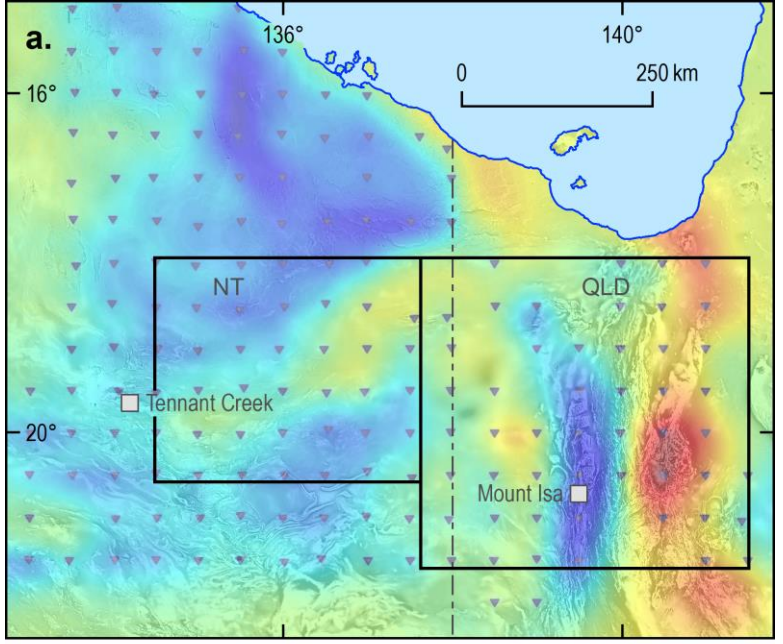


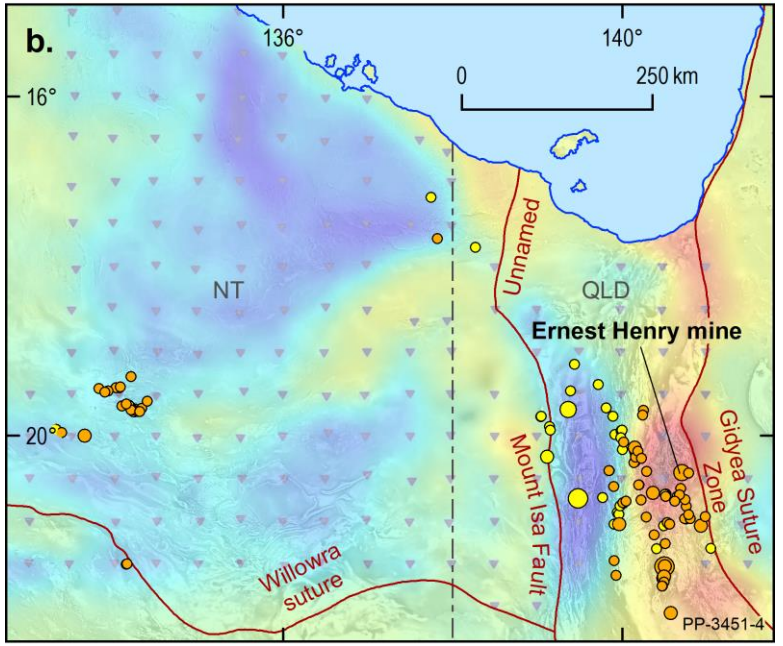
Mid-lower crust model slices. East west trend.
Follows the gravity signature, Moho offset?

GA's Exploring for the Future program

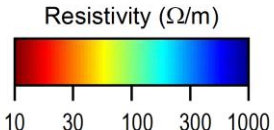






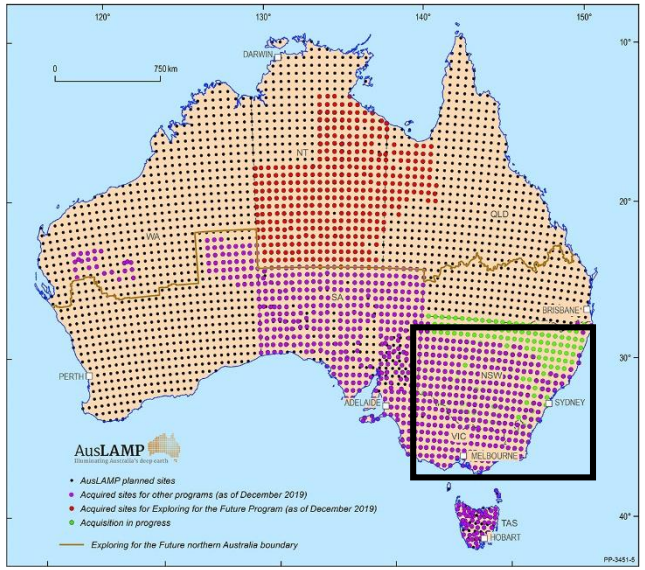


Duan et al., 2020, EFTF extended abstracts

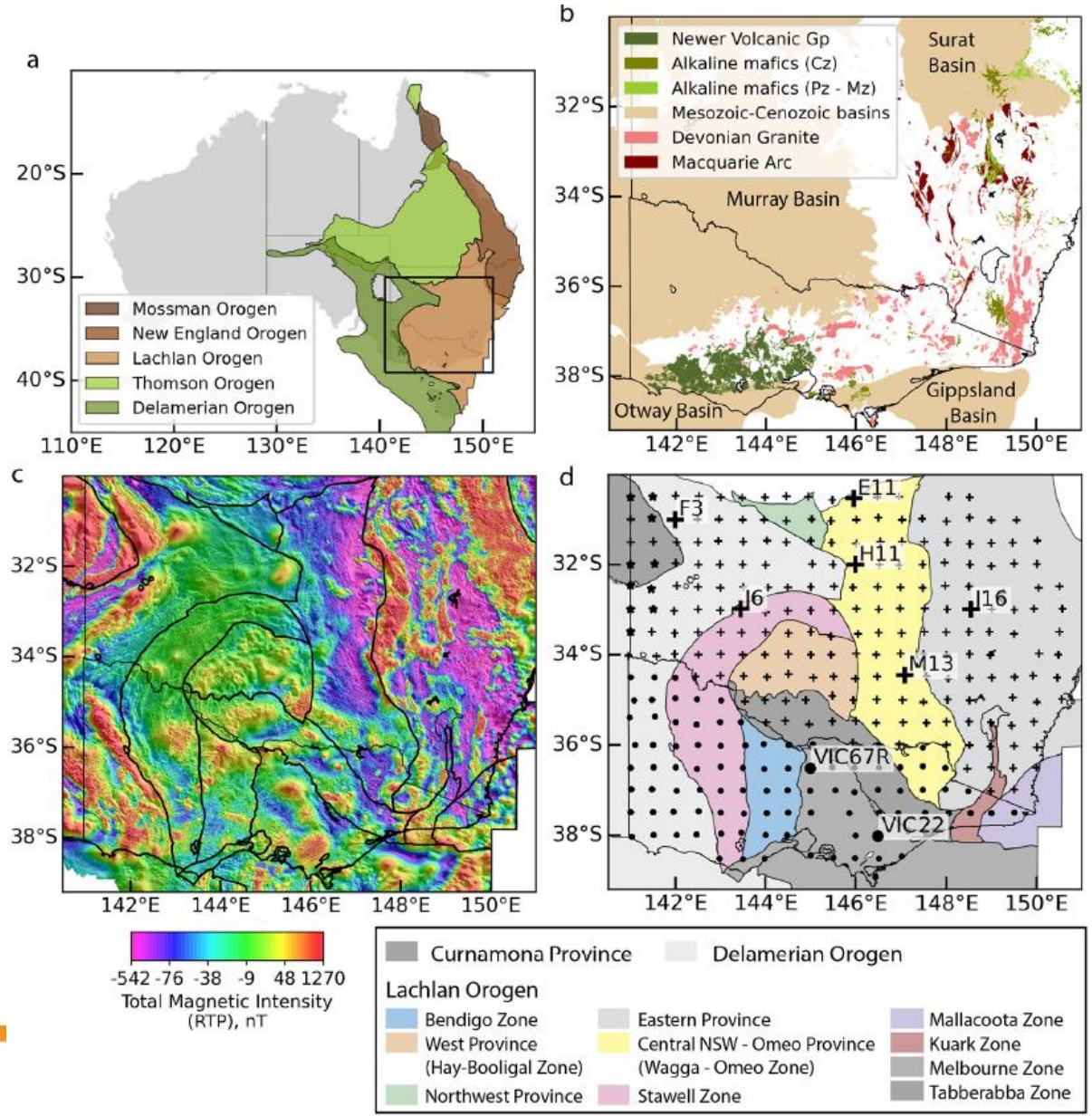


Phanerozoic tectonics in SE Australia

- Model of the Tasmanides in SE Australia
- Crustal architecture a result of an Orocline model during the Silurian (Moresi et al., 2014)
- Oroclinal rotation along the eastern Gondwana margin around the Proterozoic Selwyn Block (microcontinent) (Cayley, 2015)

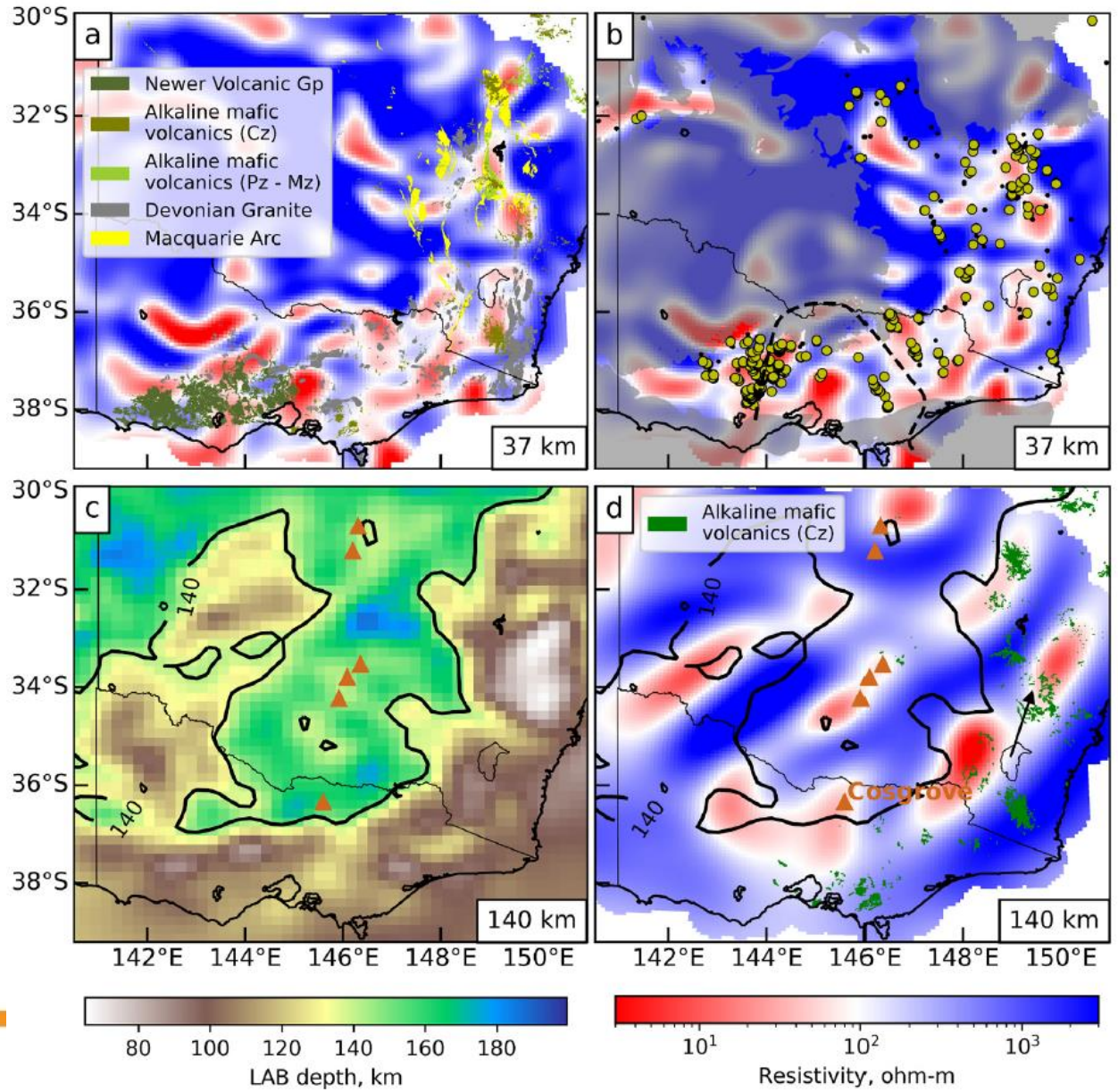


Kirkby et al., 2020



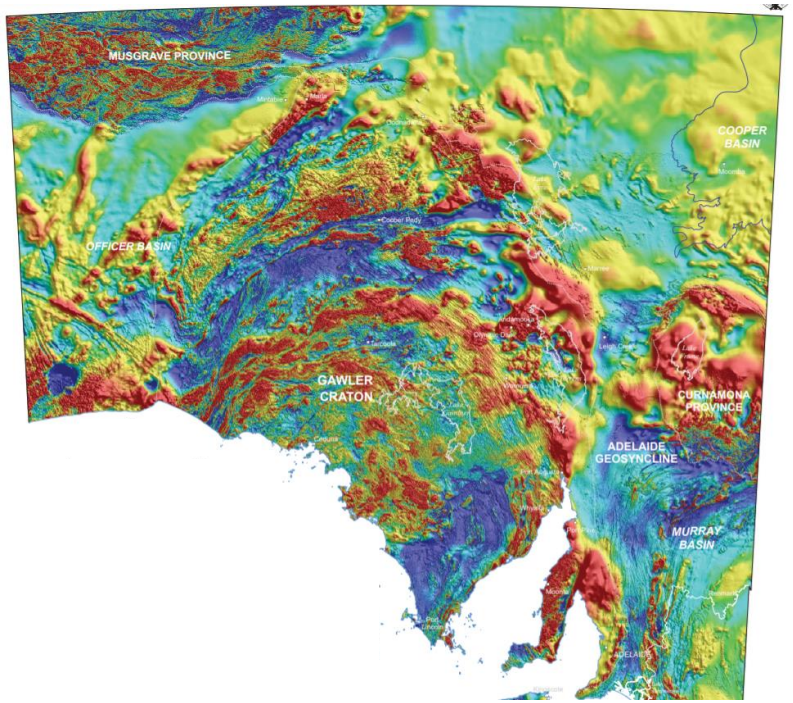
Phanerozoic tectonics in SE Australia

- Lower crustal conductors align with potential field data and seismic anisotropy (not shown)
- Correlation with Ordovician arc magmatism and alkaline mafic volcanism
- Generally good correlation of lower crustal conductors with gold deposits
- NE trending mantle conductors associated with Cenozoic volcanism along the Cosgrove hotspot track (Davies et al., 2015)

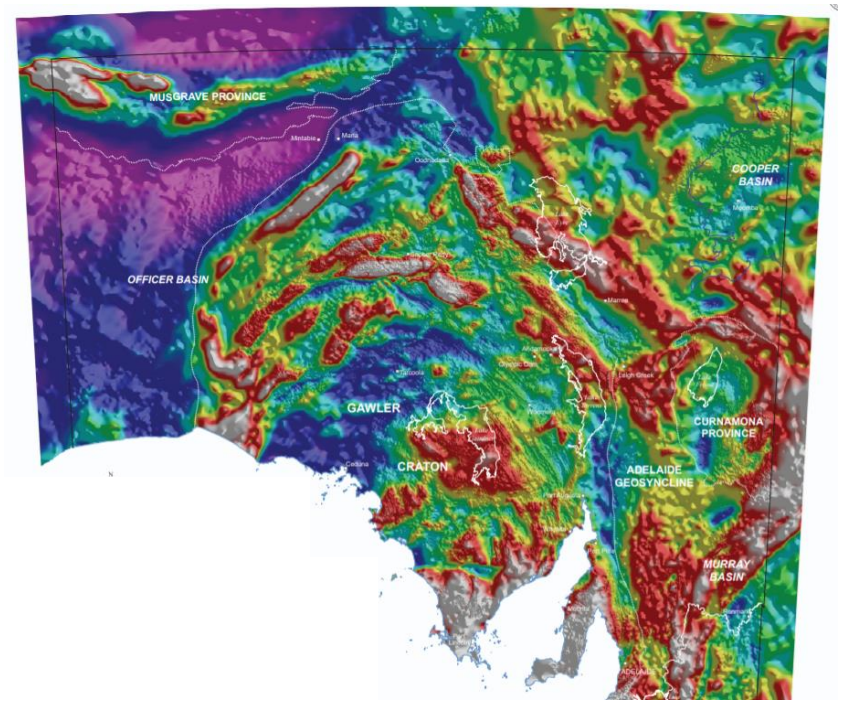


Kirkby et al., 2020

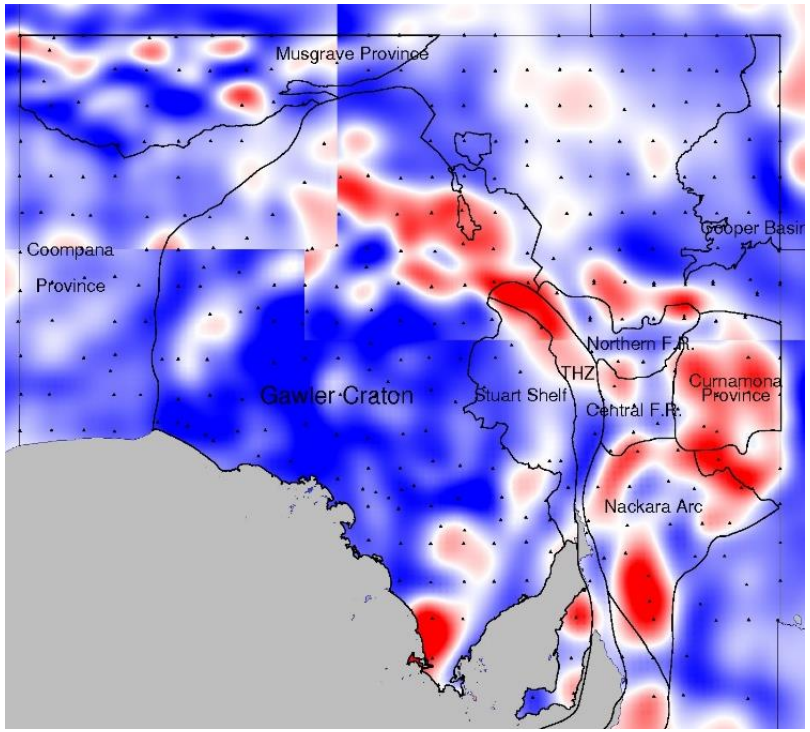
The mineral potential of the Gawler Craton



Total Magnetic Intensity

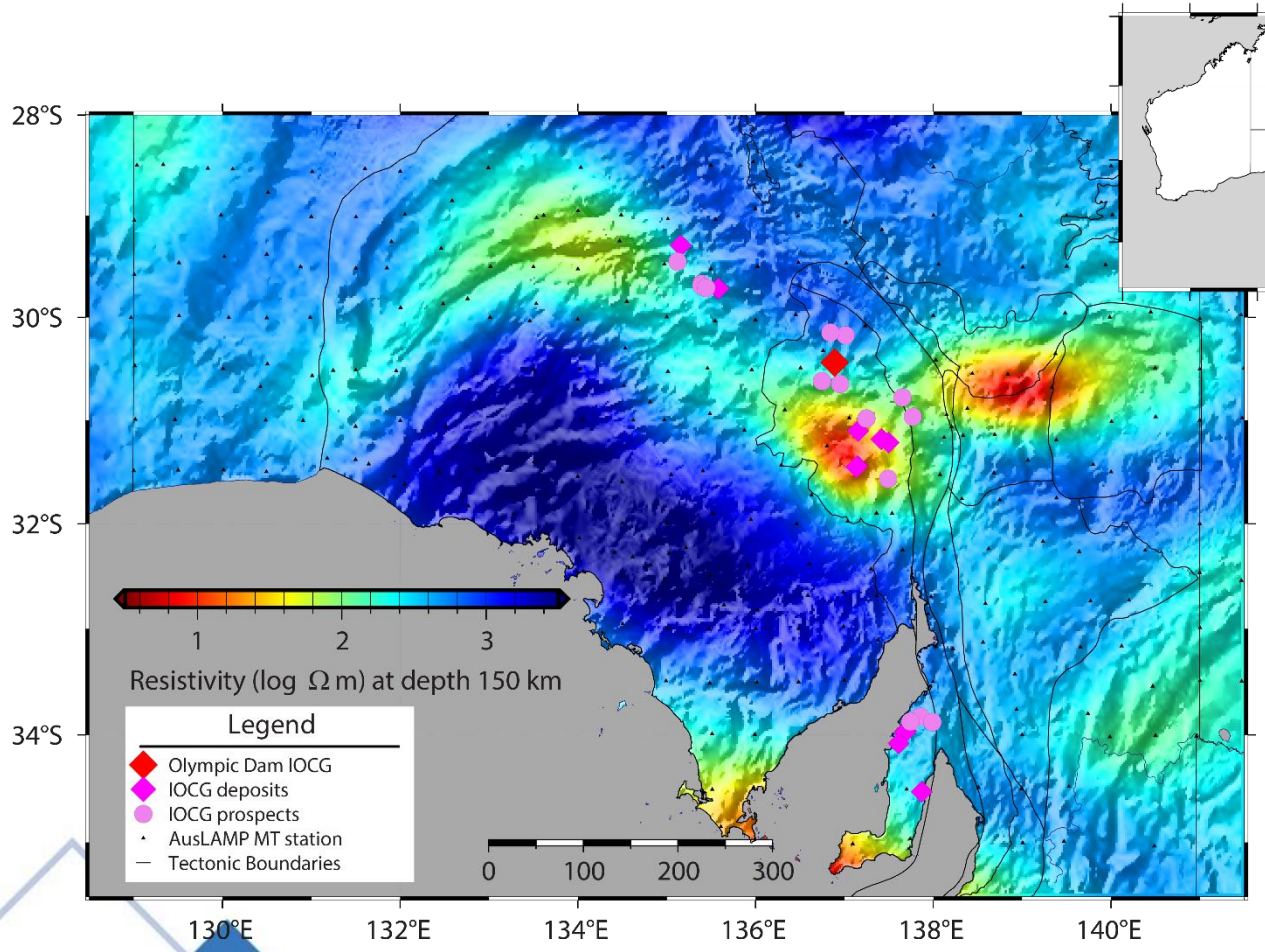


Bouguer Gravity

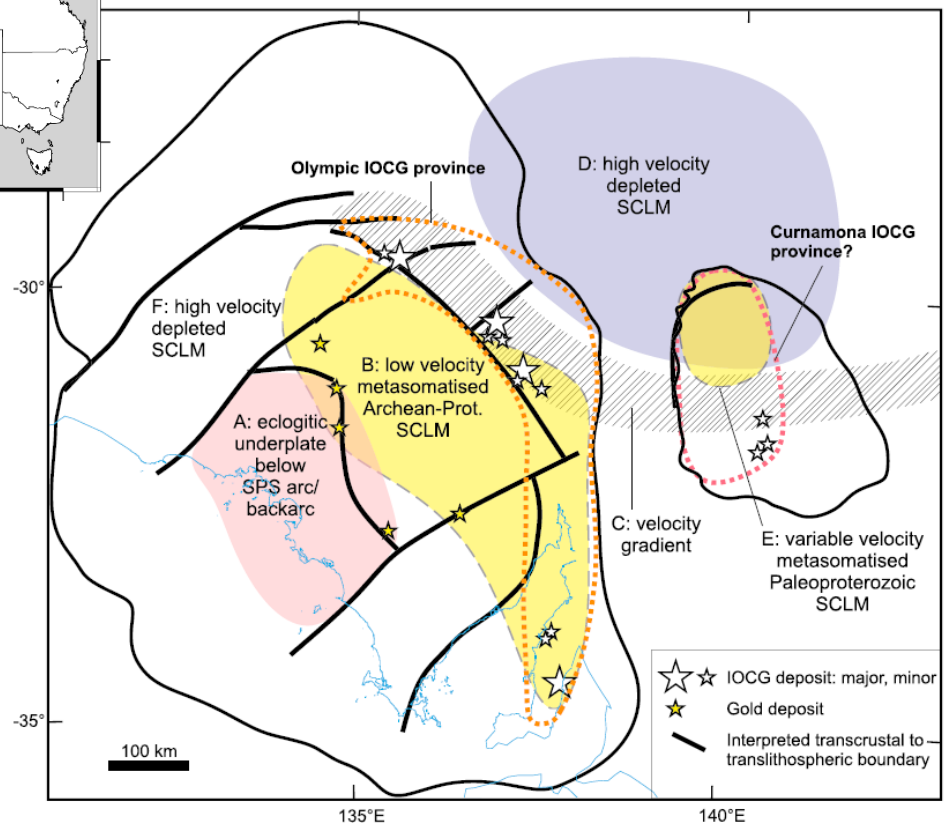


Electrical Resistivity (30 km)

Imprints of metasomatised lithosphere in the Gawler Craton



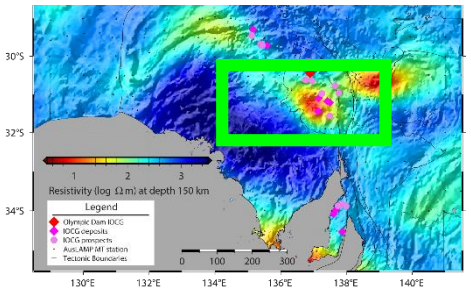
Thiel et al., in prep

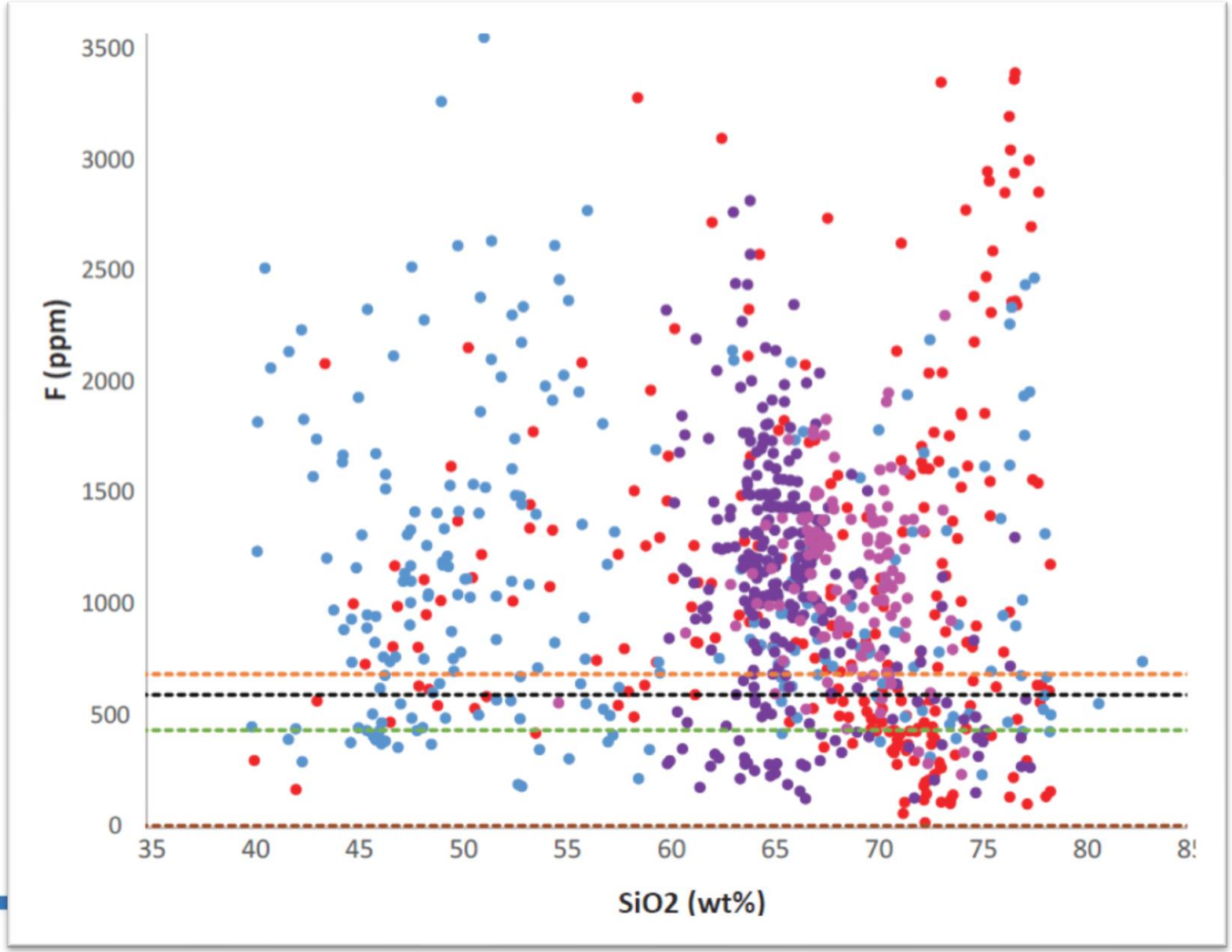


Skirrow et al., 2018

Anomalous abundance of hydrated minerals - fluorine

- Hiltaba Suite
- lower GRV
- undifferentiated GRV
- upper GRV
- average continental crust
- average felsic volcanics
- average granite
- DM

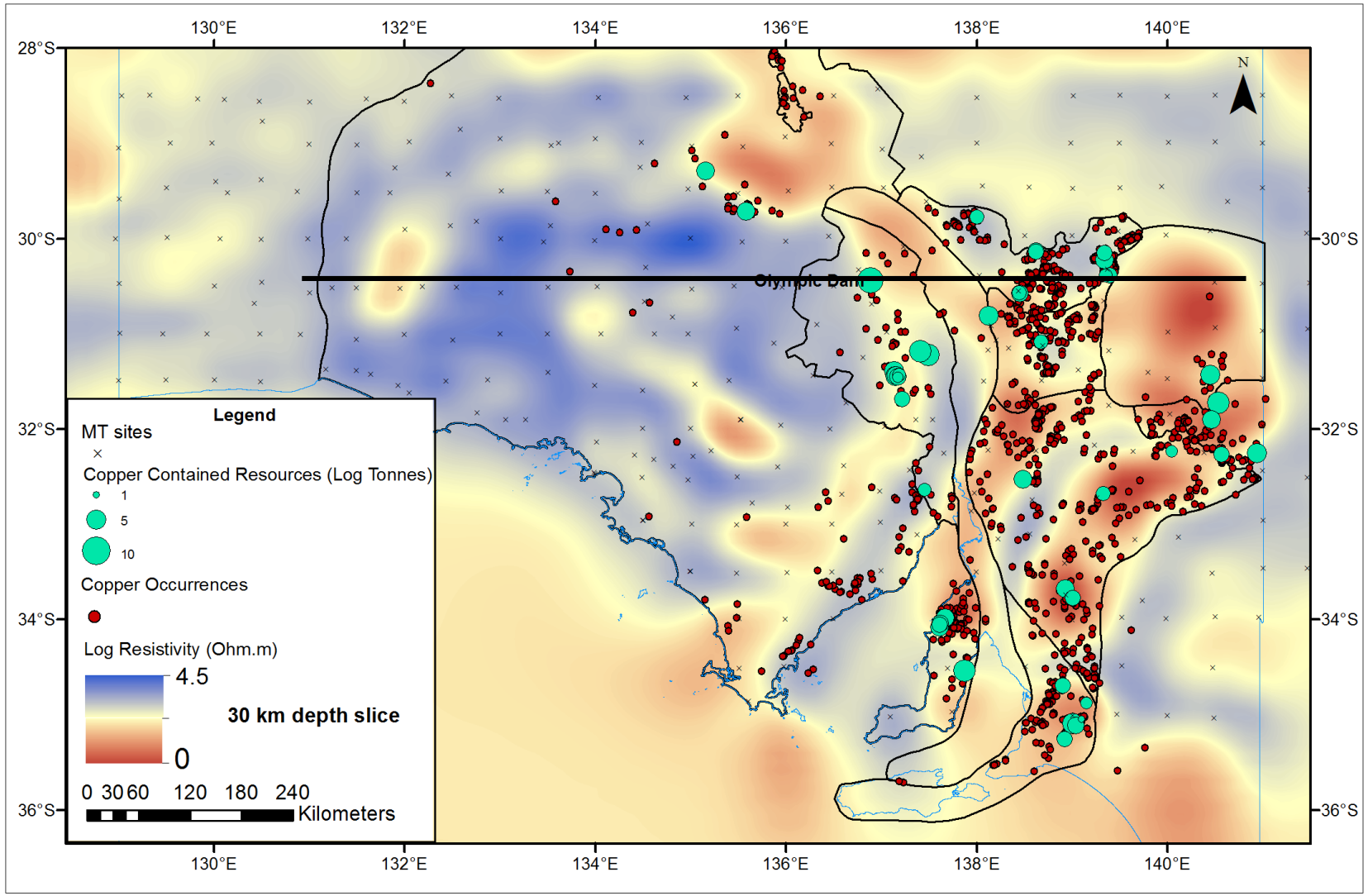




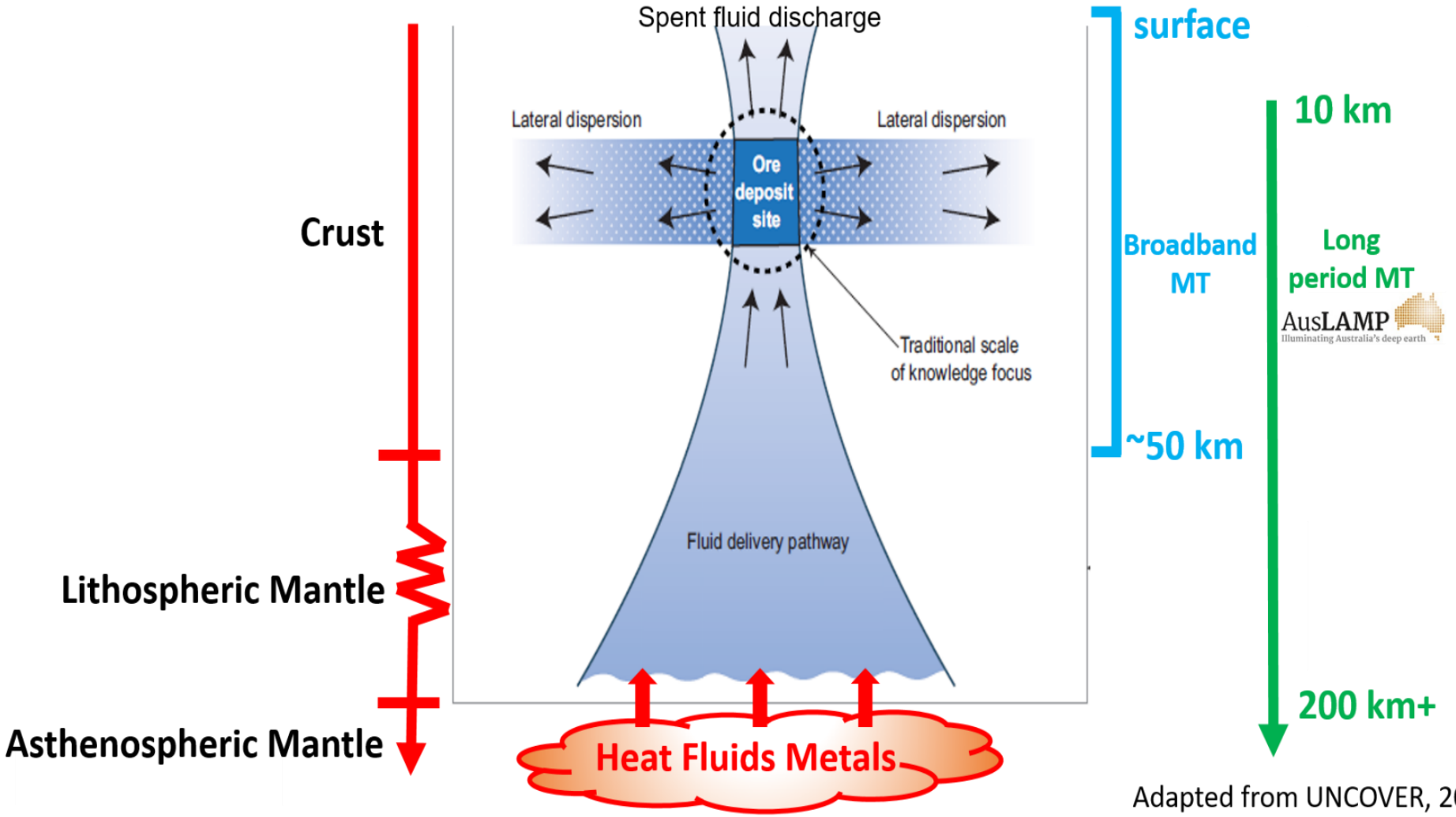
Data source for plot:
GSSA data; Pankhurst 2006; Budd 2006; Creaser 1989; Salters & Stracke 2004

Cratonic root control on mineral deposits – South Australia

Copper occurrences and resources occur on high conductivity regions or on the boundaries between low resistivity and high resistivity



Mineral system concept



Adapted from UNCOVER, 2012

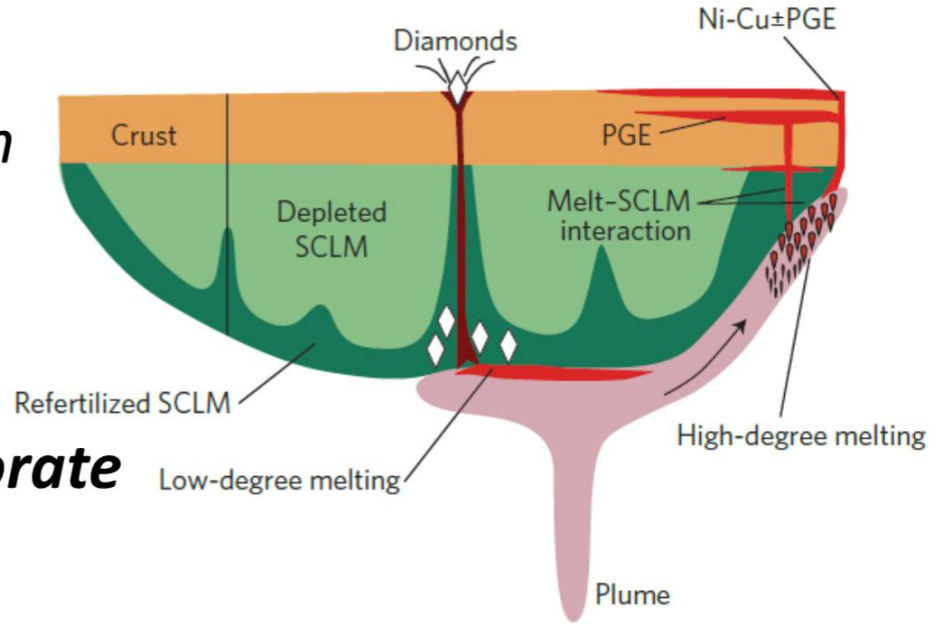
Cratonic root control on mineral deposits – South Australia

nature geoscience
FOCUS | PERSPECTIVE
PUBLISHED ONLINE: 13 OCTOBER 2013 | DOI: 10.1038/NGEO1954

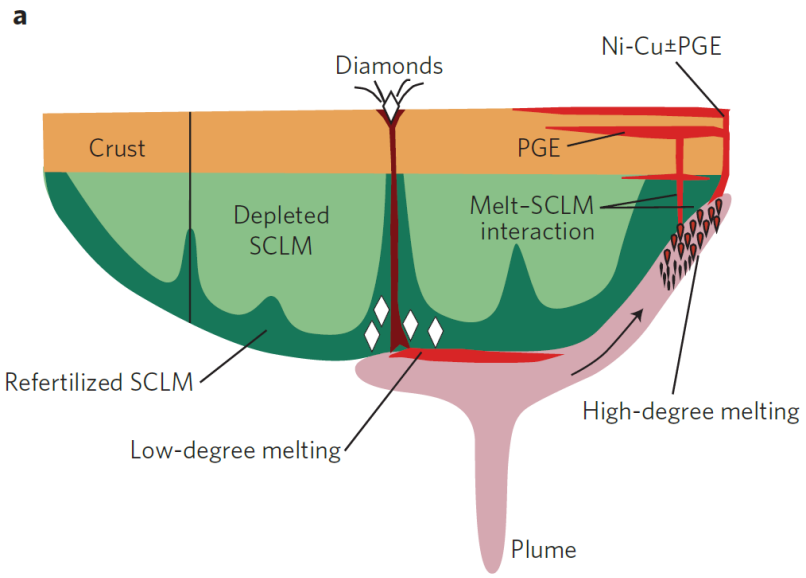
Continental-root control on the genesis of magmatic ore deposits

W. L. Griffin[1]*, G. C. Begg[1,2] and Suzanne Y. O'Reilly[1]

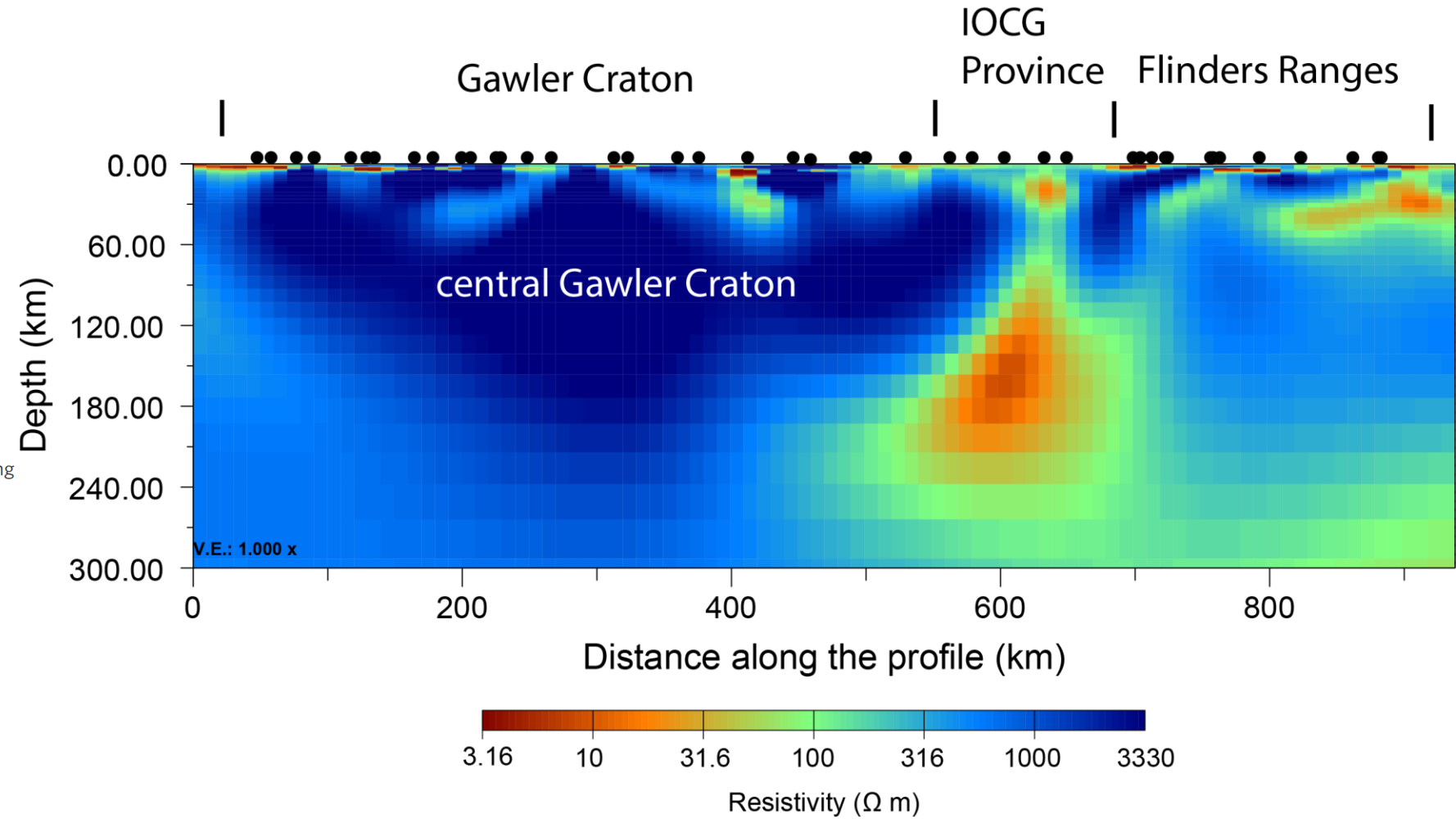
"..we argue that the sub-continental lithospheric mantle may actually contain ore-forming elements that could be entrained by ascending magmas....We therefore suggest that models for ore genesis and exploration ***need to incorporate the entire lithosphere*** *to be effective"*



Cratonic root control on mineral deposits – South Australia

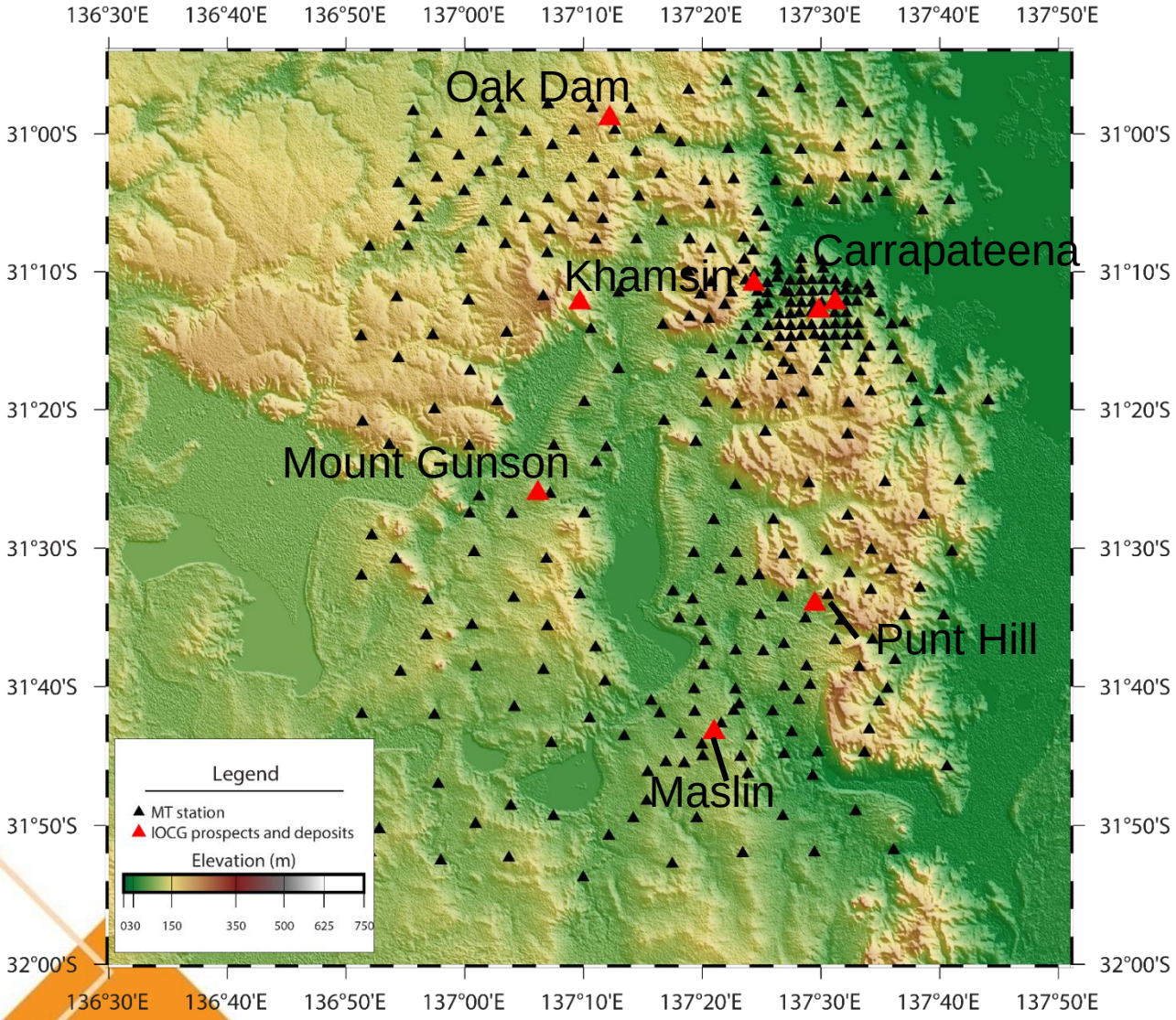


Griffin et al., 2013



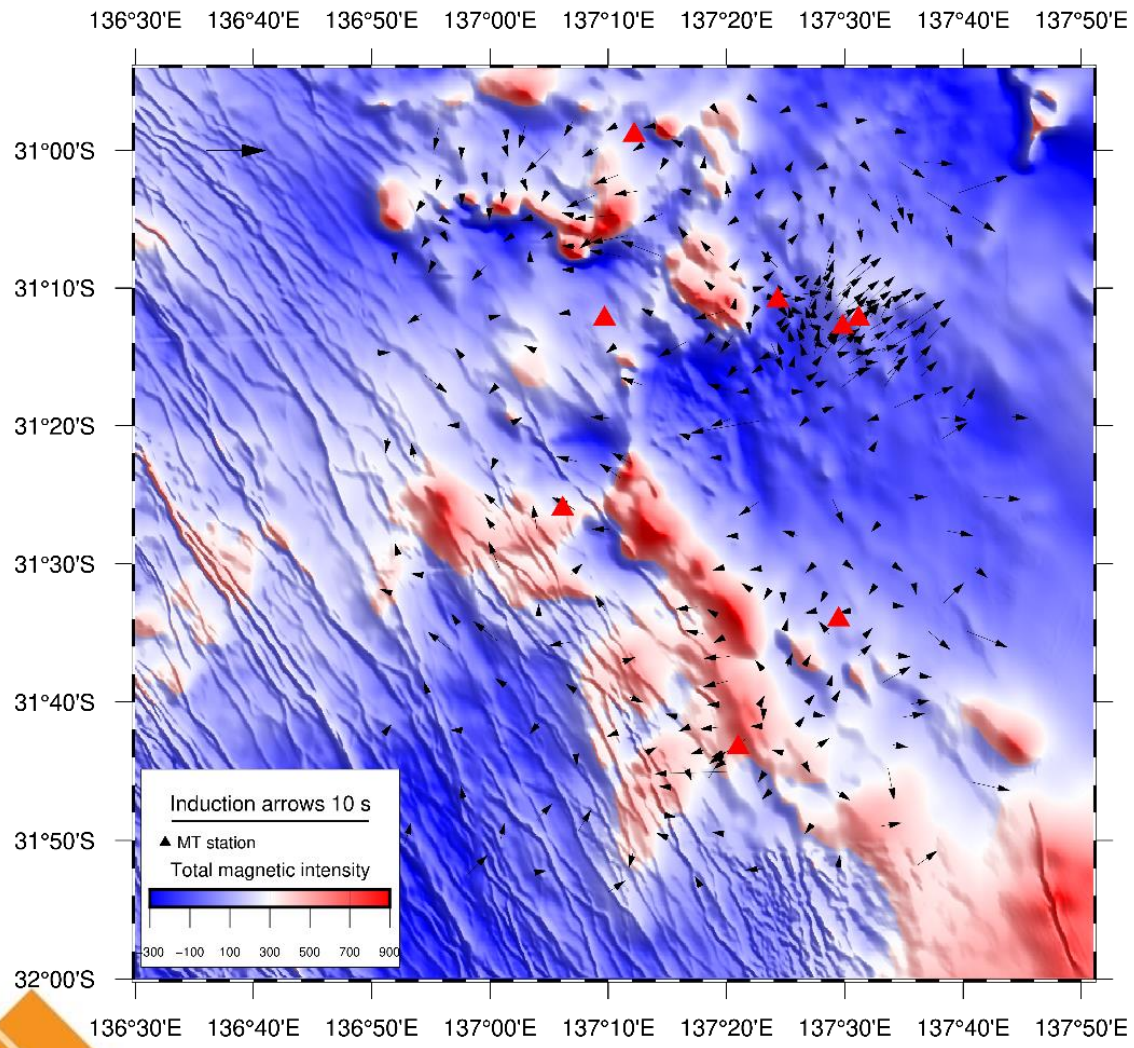
Thiel et al., in prep

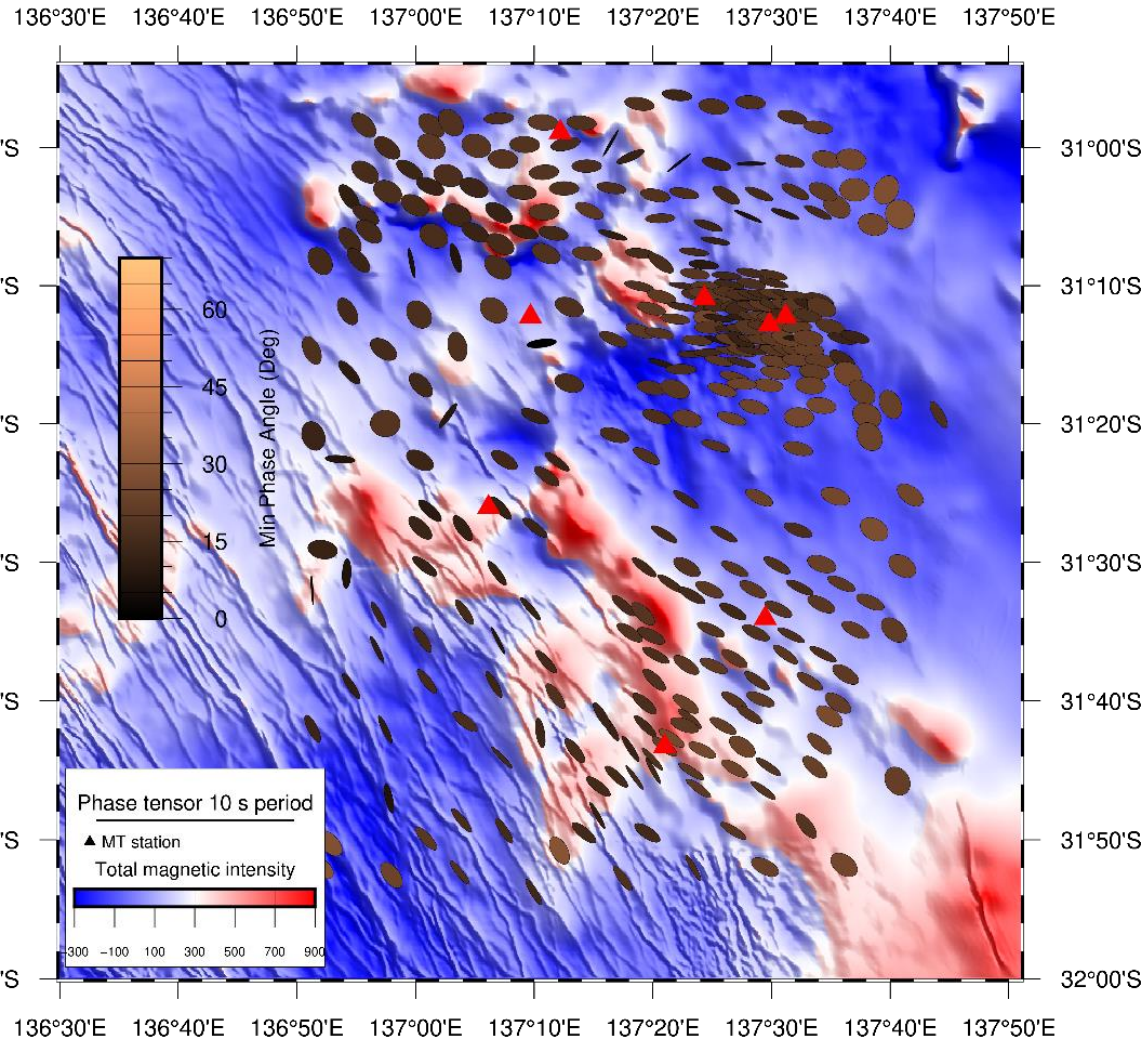
Olympic Domain in-fill survey



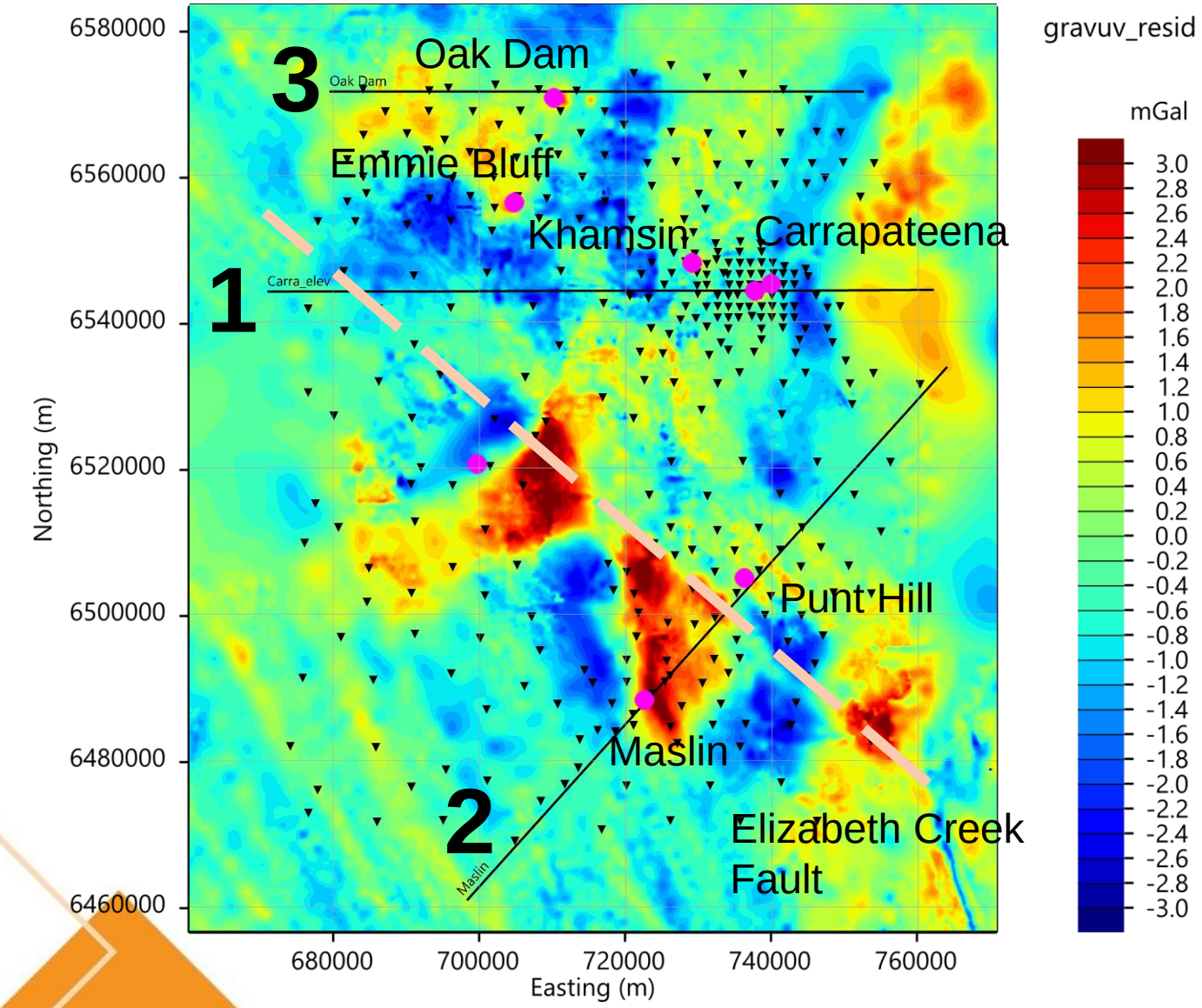
- Funded by PaceCopper, South Australia government initiative funding
- Tender process with Geoscience Australia
- Total of 334 BBMT and AMT stations (10^{-4} s - ~2000 s)
- Collected by Zonge in mid 2018, reprocessing by CGG in Q2 2019
- Variable site spacing between 1.5 km and 5 km
- Grid dependent on road access, geographical features (dry lake beds)
- Co-located airborne EM survey for cover characterisation

Olympic Domain in-fill survey



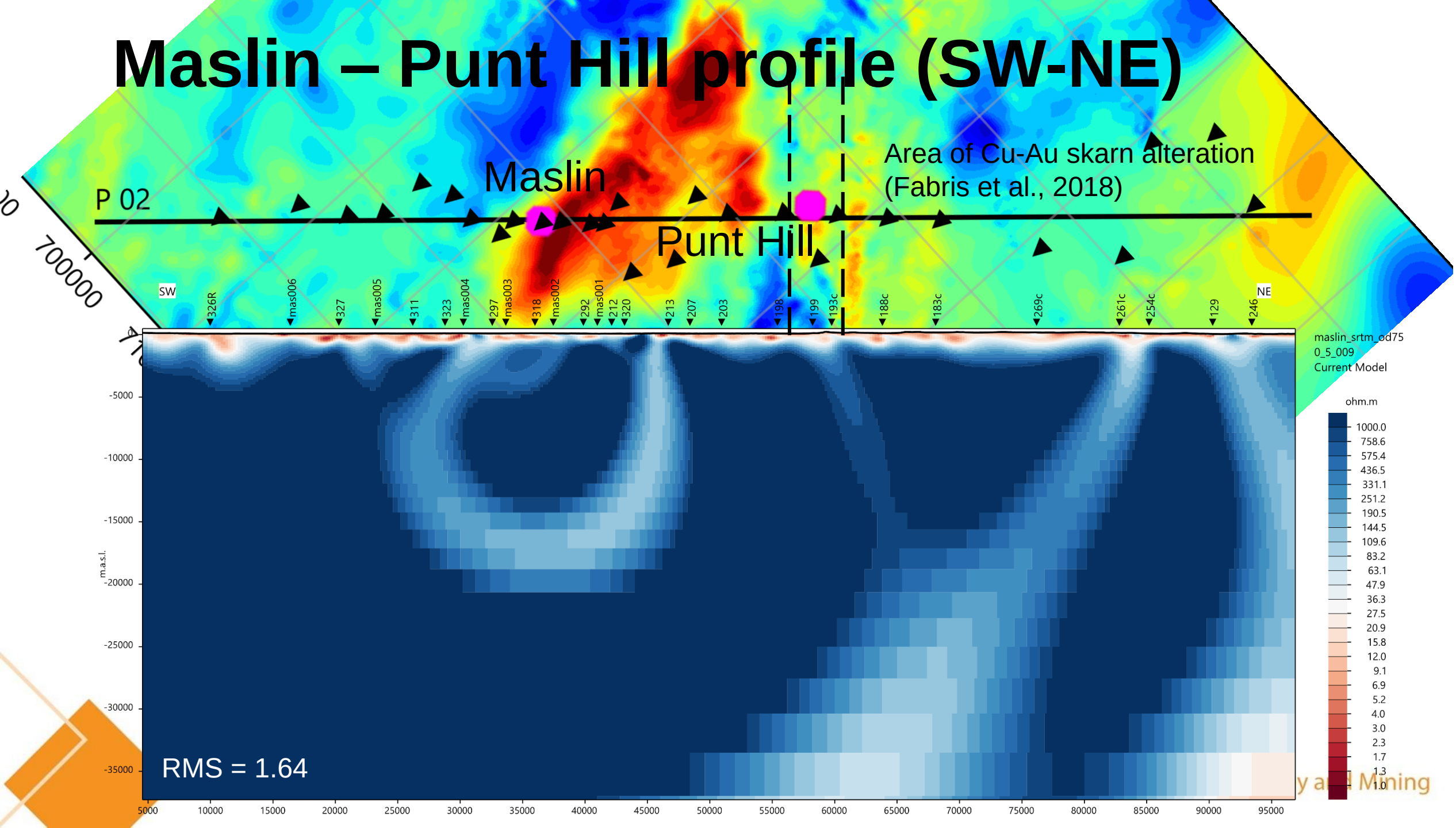


Detailed 2D profiles

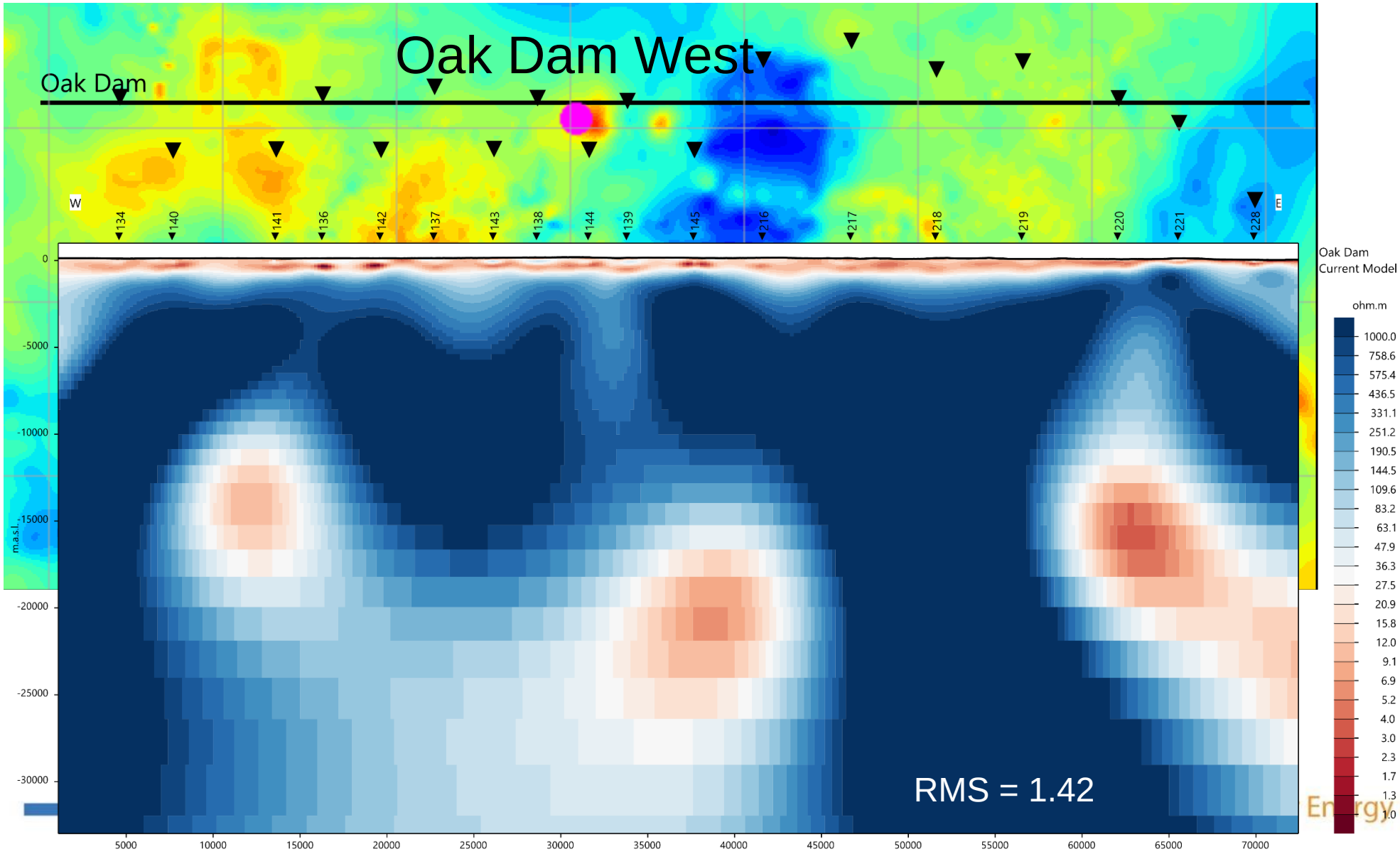


- Profile selection based on deposits and dimensionality/strike of data
- 200 m horizontal cell spacing
- Vertical cells 5 m increasing with depth including topography
- Periods from 0.0001 s to 2000 s
- TE (50% and 7% error, ρ_a and ϕ), TM (6% and 3% error, ρ_a and ϕ), and Hz data (0.01 error floor)
- inverted using Non-linear conjugate gradient approach (Rodi and Mackie, 2001; Geotools)

Maslin – Punt Hill profile (SW-NE)

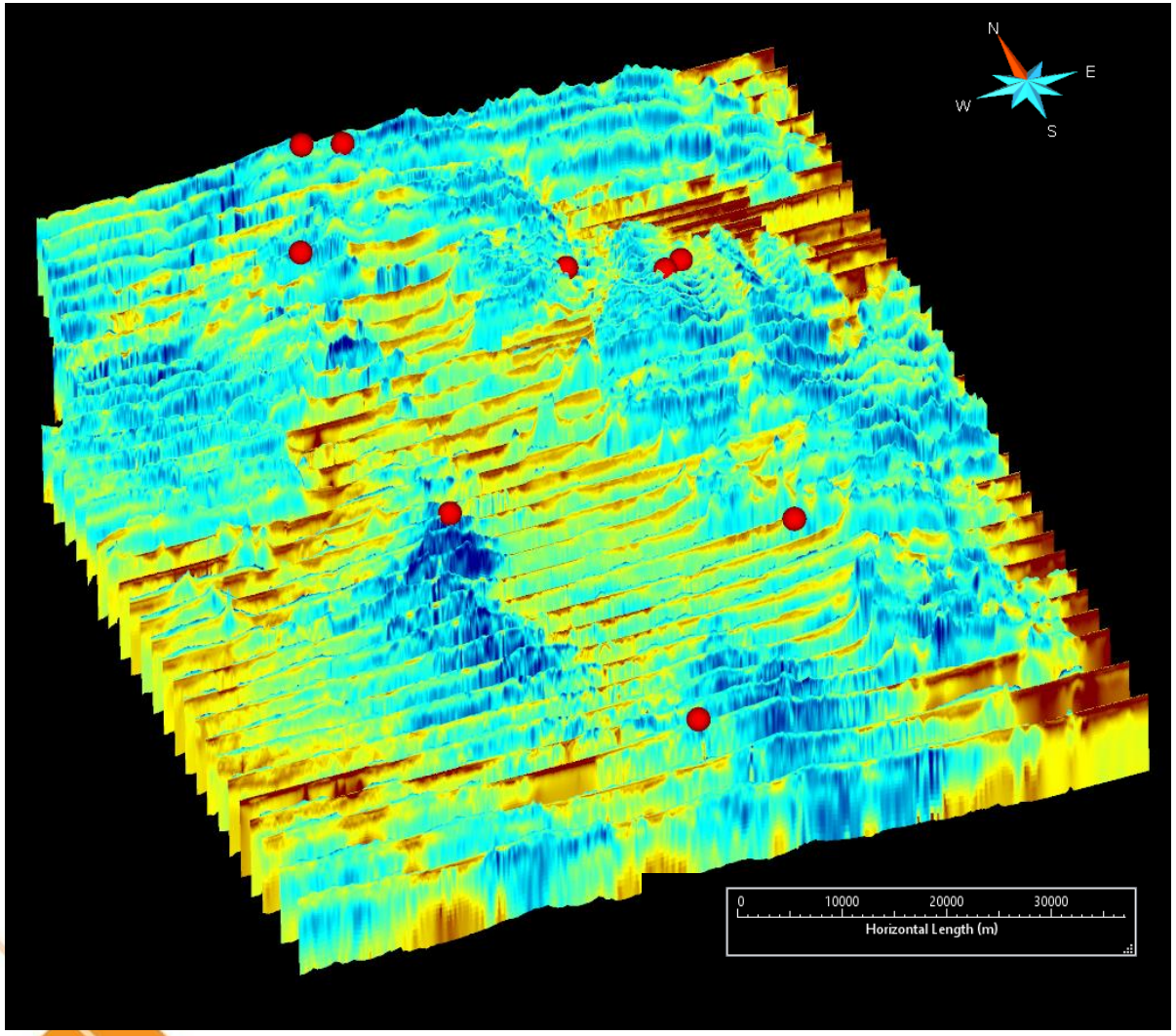


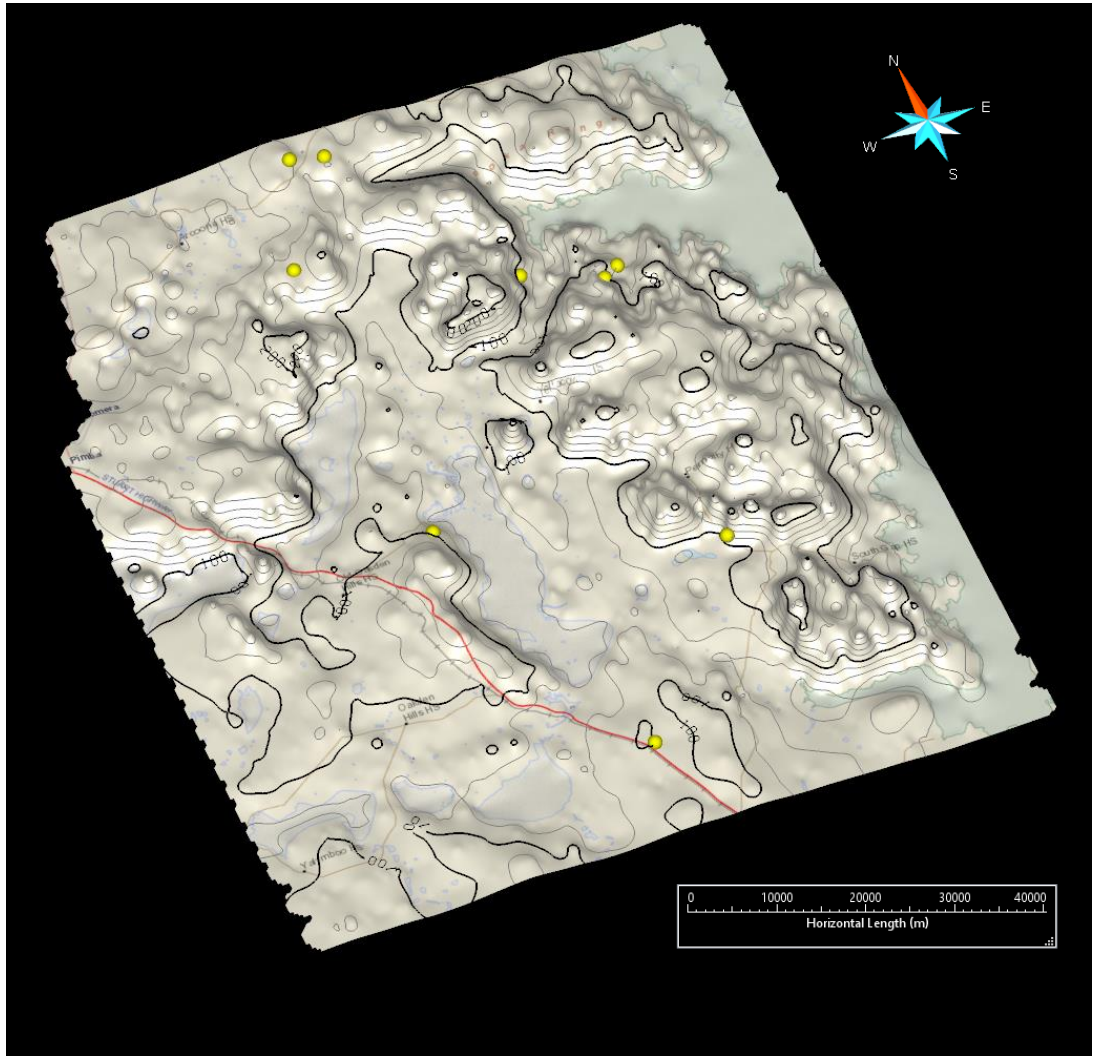
Oak Dam profile (E-W)



Energy and Mining

Airborne EM draped on topography





Vertical exaggeration 20x

Conclusions

- AusLAMP is a publically available long-period MT data set through web portals of state and federal geological surveys
- The AusLAMP arrays advance our understanding of mineral systems of the Australian continent, the geodynamic framework of past and present tectonism, and space weather hazard
- Through AusLAMP, the EM community has steadily grown over the last ten years with growing expertise within geological surveys working in conjunction with academia
- Led to exponential increase in the uptake of MT in industry, academia and government with particular focus on mineral exploration in a wider geological context

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- University of Western Australia: Mike Dentith, Perla Pina Varas
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- Numerous staff at state and federal geological surveys who put their faith into MT
- We thank traditional owners and landholders for granting access to their land. We also acknowledge the field team and technical team that made data acquisition possible.
- Model files were generated and viewed using MTpy software (Kirkby et al, 2019) and 3D grid software from Naser Meqbel. Some figures were drawn using the Generic Mapping Tools (Wessel and Smith, 1998).