Linking Western and South Australia – insights from magnetotelluric profiling

S. Thiel\textsuperscript{1,2}, M. Dentith\textsuperscript{3}, T. Wise\textsuperscript{1}, J. Duan\textsuperscript{4}, J. Spratt\textsuperscript{5}, C. Spaggiari\textsuperscript{6}, M. Pawley\textsuperscript{1}, R. Dutch\textsuperscript{1}, K. Gessner\textsuperscript{6}, H. Smithies\textsuperscript{6}, M. Doublier\textsuperscript{4}

\textsuperscript{1}Geological Survey of South Australia, Department of State Development
\textsuperscript{2}The University of Adelaide
\textsuperscript{3}The University of Western Australia
\textsuperscript{4}Geoscience Australia
\textsuperscript{5}Magnetotelluric Consulting, Quebec, Canada
\textsuperscript{6}Geological Survey of Western Australia

AESC Conference
www.statedevelopment.sa.gov.au
13GA-EG1 MT traverse – Gawler part

- 167 broadband (0.0025 – 2000 s) MT stations acquired along ~840 km profile along Trans-Australian railway
- Collected by Moombarriga Geoscience
- Mix of Phoenix and Metronix MT systems
- Based on overlap with seismic interpretation
- Consistent crustal strike across the Gawler Craton and Coompana/Madurah Province
13GA-EG1 MT traverse – Coompana/Madura – Albany Fraser part
Data of the entire 13GA-EG1 line

- Data quality very good, no vertical magnetic field information (train line noise)
- Minimum phase illustrates resistivity changes with depth
- $\Phi_{min} > 45$ resistivity decreases
- $\Phi_{min} < 45$ resistivity increases (e.g. sediment to basement)
TMI & phase tensors (1s period)

- Geoelectric strike N27°E
- Masked 3D data and phases below 0°
- Distortion removal prior to modelling (Becken and Burckhard, 2004, GJI)
TMI & phase tensors (100s period)

- Geoelectric strike N0°E
- Masked 3D data and phases below 0°
- Distortion removal prior to modeling (Becken and Burckhard, 2004, GJI)
13GA-EG1E line in context of AusLAMP MT array

- Long-period MT data (yellow; Thiel et al., 2010, 2013)
- AusLAMP long-period MT stations Sep-Dec 2015 (green; GSSA, GA, Uni of Adelaide); site spacing 50 km
- EG1 broadband MT profile; site spacing 5 km (blue)
13GA-EG1 MT traverse – Gawler part
TMI and resistivity model correlation – Gawler part

Phase skew

Karari SZ
Colona SZ
Cooarrie SZ

60 km
Gravity and resistivity comparison – deformation zones along margins of gravity defined blocks

- C2-R1 contact is eastern contact of the Karari deformation zone
- About 10 km wide
- C6 – Tallacootra formation (interbedding of quartzite with laminated carbonaceous and pyritic siltstone)
- Upper crustal half-graben structures
Comparison of 2D profile to seismic reflection
• Light coloured circles denote thicker sediments
• Dark ellipses denote shallower sediments and basement structure
Mid to lower crust

EG1 MT profile

WA SA
Coompana-Madura-Albany Fraser with TMI

- Mundrabilla SZ
- Urandangi & Moodini SS
- Toolgana SS
- Moodini SS
- Albany Fraser Orogen
- pervasive, fertile lower crust and upper mantle
- dry, depleted mantle

Distance (km)

Depth (m)

Total magnetic intensity

250 km
Comparison of 2D profile to LAB

pervasive, fertile lower crust and upper mantle

dry, depleted mantle
Conductive lower crust over resistive depleted mantle - Insights form tectonic history across Coompana-Madura

Moodini SS: UHT metamorphism, high KFe series, high Th
Nature of lower crust in the Coompana-Madura Province
Nature of lower crust in the Coompana-Madura Province

- Correlation between zones of low resistivity and low reflectivity zones
- Seismics suggests homogeneous crust void of deformational structures
- Low resistivity denote fertile crust (magnetite, fluorine, A-type granites)
- Similar in correlation to Olympic Dam (also A-type granites)
Pervasive lower crustal conductance – MASH zones?
Resistivity footprint of Proterozoic cratonisation

- Oldest age across Coompana-Madura ~1900 Ma, derived from oceanic lithosphere
- Lower crustal enrichment during the Maralinga event
- UHT metamorphism, high KFe, high Th
- Development of lower crustal MASH zone
- Process depletes the lithospheric mantle
- Has to cool enough to produce high mantle resistivity (also relatively fast seismic wavespeeds)
- Building a craton in the Proterozoic
Stitched resistivity profile

Moodini SS: high KFe series, high Thc
Department of State Development
Conclusion

- Different character between the Gawler and Coompana/Madura
- Subvertical conductivity zones in the Gawler separating resistive lithospheric blocks
- Pervasive lower crustal/upper mantle low resistivity zones across the Coompana/Madura (low resistivity – low reflectivity)
- Resistive and depleted mantle lithosphere beneath the Coompana-Madura
- Archaean character – yet isotopically Proterozoic and oceanic
- Proterozoic cratonisation?
Disclaimer

The information contained in this presentation has been compiled by the Department of State Development (DSD) and originates from a variety of sources. Although all reasonable care has been taken in the preparation and compilation of the information, it has been provided in good faith for general information only and does not purport to be professional advice. No warranty, express or implied, is given as to the completeness, correctness, accuracy, reliability or currency of the materials.

DSD and the Crown in the right of the State of South Australia does not accept responsibility for and will not be held liable to any recipient of the information for any loss or damage however caused (including negligence) which may be directly or indirectly suffered as a consequence of use of these materials. DSD reserves the right to update, amend or supplement the information from time to time at its discretion.
Dr Stephan Thiel
Department of State Development

Level 4, 11 Waymouth Street
Adelaide, South Australia 5000
GPO Box 320
Adelaide, South Australia 5001

T: +61 8 8204 1181
E: Stephan.thiel@sa.gov.au

www.statedevelopment.sa.gov.au