New magnetotelluric data across the Delamerian and Lachlan orogens

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SUMMARY

Broadband magnetotelluric (MT) data were acquired along two ~E-W trending profiles across the Delamerian Orogen in South Australia and the Lachlan orogen in Victoria. The MT profile follows a geotransect of reflection seismic and gravity data across the Proterozoic-Phanerozoic transition to illuminate the crust and constrain the tectonic evolution and mineral potential of the region.

Key words: magnetotellurics, Delamerian orogen, electrical resistivity, modelling, geotransect

INTRODUCTION

The Cambrian-Ordovician Delamerian Orogen is a key region in the geological evolution of the Australian continent, as it marks the transition along the eastern margin of Proterozoic Australia from a passive to an active continental margin. This region also has potential for a range of mineral systems including porphyry Cu±Mo±W, sediment-hosted Cu of various origins, epithermal Au-Ag, orogenic Au, volcanic-hosted massive sulphide Cu-Pb-Zn-Au, skarn (Cu,Mo,W,Pb,Zn,Fe,Sn) and magmatic Cr-PGE.

The Geological Survey of Victoria (GSV) and Geological Survey of South Australia (GSSA) are acquiring magnetotelluric (MT) data across the Delamerian Orogen in northwest Victoria and southeast South Australia.

Broadband MT data is collected at a nominal 3-4 km site spacing along a 750 km-long profile from the Spencer Gulf in South Australia to Pinnaroo on the Victorian-South Australian border, and across the Murray Basin from Murray Bridge to Swan Hill in Victoria.

The GSV-GSSA MT survey augments a wider program of regional pre-competitive geoscience acquisition planned for the region in collaboration with Geoscience Australia and MinEx CRC. Acquisition includes deep crustal reflection seismic, ground gravity and airborne electromagnetic surveys under the national Exploring For The Future program and GSSA-led Minex CRC drilling in South Australia as part of the National Drilling Initiative. The drilling campaign is located at the western margin of the southern MT profile.

Previous MT transects across the Delamerian – Lachlan transition ~200 km further south revealed a distinctly more conductive lower crust beneath the Lachlan Orogen, compared to the Delamerian Orogen further west (Robertson et al., 2017). Furthermore, upper crustal narrow conductivity pathways extend toward the surface location of major faults, including the Yarramyljup, Moyston, and Avoca fault.

The new models will further refine publicly available AusLAMP and broadband MT models of the region (e.g. Delamerian AusLAMP survey through the GSSA SARIG portal). The new data and models will provide electrical constraints to improve understanding of the regional geology and structural architecture of the Delamerian Lachlan Orogen transition as well as the mineral potential of the region.

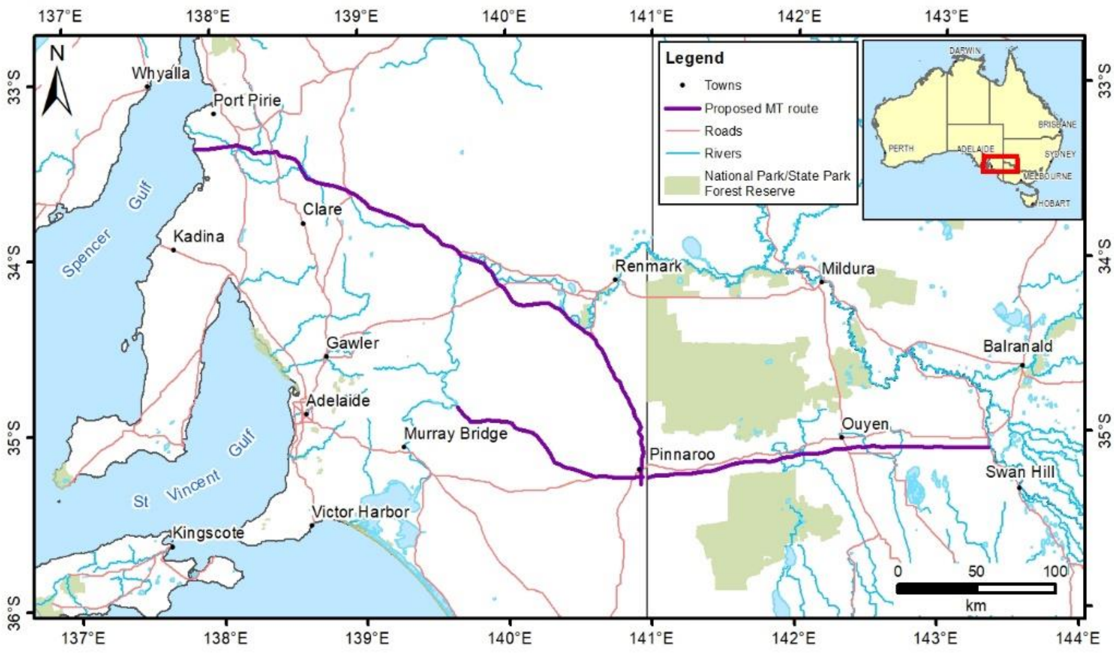

Figure 1: Location map showing the MT survey route. Broadband MT stations were placed ~3-4 km apart to illuminate the crust beneath the transects.

MAGNETOTELLURIC DATA AND RESULTS

A total of 222 broadband MT sites were collected along two main profiles (Figure 1) from the Spencer Gulf in South Australia to Pinnaroo on the Victorian-South Australian border, and across the Murray Basin from Murray Bridge to Swan Hill in Victoria. Each MT station recorded five components (B_x, B_y, B_z, E_x, E_y,) using Phoenix MTU-5C recorders at a minimum of 40 hours for most sites which were converted to periods between $10^{-4} - 5 \times 10^{3}$s.

While data collection is still on-going at the north-western end of the survey at the time of writing, the southern profile is complete. A total of 118 sites are spaced every 3-4 km. Data were cleaned of outliers and rotated to strike for subsequent 2D modelling. The data is mostly 1D for periods less than 0.1 – 1 s reflecting the shallow sedimentary cover across the area based on phase tensor analysis (Caldwell et al., 2004). Deeper structures show mostly 2D characteristics given phase tensor skew values < 3°. Preliminary two-dimensional inverse models of the southern line indicate a conductive lower crust beneath the Grampian-Stavely Zone and the Lachlan orogen further to the east (Figure 2). The upper to mid crust (<25 km) is comparatively more conductive in the Lachlan orogen, manifested by a larger number of upper crustal conductivity pathways extending to the surface. Upper crustal conductors exist across the Delamerian Orogen, however there are fewer in between zones of high resistivity compared to the eastern part of the profile in the Lachlan orogen.

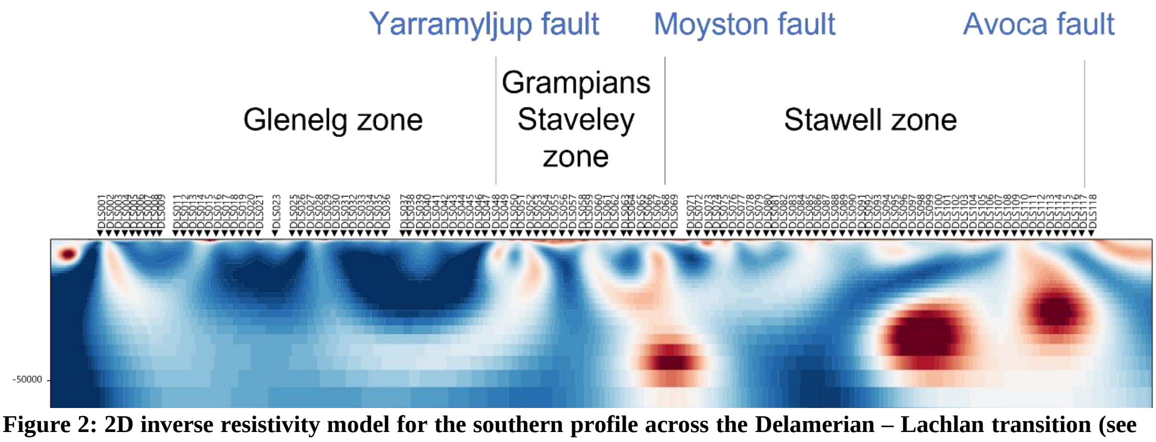

Figure 2: 2D inverse resistivity model for the southern profile across the Delamerian – Lachlan transition (see Figure 1). The model shown extends to ~60 km depth and highlights conductive lower crust (red colour) beneath the Lachlan orogen of the Stawell Zone and multiple upper crustal conductors in the Grampians Stavely zone.

DISCUSSION

Comparison of the preliminary resistivity model of the southern profile to known geology shows a good correlation of upper crustal conductors to major faults, such as the Yarramyljup, Moyston, and Avoca fault (Figure 2). Similar observations have been made for a magnetotelluric transect about 200 km to the south (Robertson et al., 2017). It is also evident that the upper crustal conductors are predominantly observed beneath areas of high gradients in the Bouguer gravity. This suggests that major lithological blocks guide deformation and fluid ascent along its margins. As an example, the highly resistive upper to middle crust beneath the Glenelg zone appears to be a rigid, possibly Precambrian crust, which is intersected by narrow steeply dipping upper crustal conductors. Early drilling results of the MinexCRC NDI campaign run by the Geological Survey of South Australia show alteration zones correlated with the location of the upper crustal conductivity pathways, and further corroborate the genesis of the conductors as signatures of fluid ascent.

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REFERENCES

Caldwell, T.G., Bibby, H.M. and Brown, C., 2004. The magnetotelluric phase tensor. Geophysical Journal International, 158: 457-469.

Robertson, K.E., Heinson, G.S., Taylor, D.H. and Thiel, S., 2017. The lithospheric transition between the Delamerian and Lachlan orogens in western Victoria: new insights from 3D magnetotelluric imaging. Australian Journal of Earth Sciences: 1-15.