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Magnetotelluric imaging of a Palaeozoic Andean margin subduction zone in western Victoria

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SUMMARY

A 450 km long transect of broadband (200 Hz – 2000 s) magnetotelluric (MT) sites spaced between 1 and 5 km apart, has been collected across the Palaeozoic Delamerian-Lachlan Orogens in western Victoria. The bandwidth of responses yields resistivity constraints between a few tens of metres in near-surface cover to sub-Moho depths. The passive nature of the source-field means that the MT responses have been collectively assembled in several tranches over ten years, with the last section across the transition between the Orogens collected in June 2014. The MT coverage now completely coincides with a deep crustal reflection seismic transect to generate complementary insight of the crustal structure. We report on preliminary modelling and interpretation.

Key words: Magnetotellurics, Lachlan, Delamerian, Orogen

INTRODUCTION

The Cambrian Delamerian Orogen is the oldest part of the Phanerozoic Tasmanides, which now form the continental crust of eastern Australia. The Tasmanides were oceanic terranes and micro-continental blocks accreted from the palaeo-Pacific back onto the Australian continental margin when subduction and convergence replaced an earlier phase of rifting and continental break-up (Cayley et al., 2011).

The transitional boundary between the Delamerian to Lachlan orogens is the Stawell Zone that strikes northerly through western Victoria (Miller *et al.*, 2005). The latest geological model for the Delamerian model – based largely on the presence of magmatic rocks with subduction zone geochemistry (Foden *et al.*, 2005) suggests this region was the site of a westward, continent-dipping (Andean-type) subduction zone during Cambrian convergence within the Tasmanides.

Andean-type subduction zones can generate large copper porphyry systems. Thus the recently proposed Andean tectonic setting for western Victoria has given a new round of impetus to re-evaluating some poorly explored copper porphyry prospects known in western Victoria. These prospects were found in the 1980s and 1990s but lack of economic grade and no plate tectonic context meant that only a small number of moderately shallow exploration drill holes were attempted. Deeper drilling by Stavely Minerals in the last year has provided good encouragement that some of these prospects might in fact be economic.

REFLECTION SEISMICS

Interpretation of the 2006 deep crustal seismic transect by Cayley *et al.* (2011) suggested that the mid to lower crust consisted of crystalline basement (seismically-transparent regions) interspersed with regions of thickened mafic crust (seismically reflective regions). The geometry of this crustal arrangement is consistent with an attenuated rift margin containing continental ribbons, amidst oceanic crust, being deformed and thickened up to full crustal thickness. The faulted belts of andesite exposed at surface in the Stavely Zone region can be traced down into what appears to be a larger arc edifice upon a continental ribbon in the subsurface.

MAGNETOTELLURICS

Magnetotelluric responses collected in 2010-2012 over the westerly Delamerian portion of the seismic transect by Robertson *et al.* (2014) imaged several highly conductive anomalies in the mid-crust region below the Stavely Zone. These anomalies coincide with thickened regions of ultramafic-mafic rocks and were interpreted as regions where the ultramafics had been serpentinised to create conductive magnetite. Potential pathways for the fluids causing the serpentinite alteration can be traced down through the lower crust and into the mantle as weaker conductive pathways. These pathways would match fluxed melts ascending upwards through the mantle wedge above the paleo-subduction zone.

MT response over the easterly Lachlan portion of the seismic transect did not find significant conductive anomalies within the crust (Dennis *et al.*, 2011a, Dennis *et al.* 2011b). Small, thin conductors in the mid-crust coincided with the top of ancient seafloor basalts and the anomalies were interpreted as being cause by graphitic black shales known from this level.

In June 2014, 44 new broadband MT sites were collected over the Delamerian to Lachlan transition, to connect the two previous MT surveys, as shown in Figure 1. Site spacing was generally 3 km, with a reduced spacing of 1.5 km at the western end of the line. Recording times were two to three days, with a sampling rate of 1000 Hz. The higher density sites locations were closest to the Orogens' transition. Figure 2 shows data quality from the eastern most site of the profile DLT01.

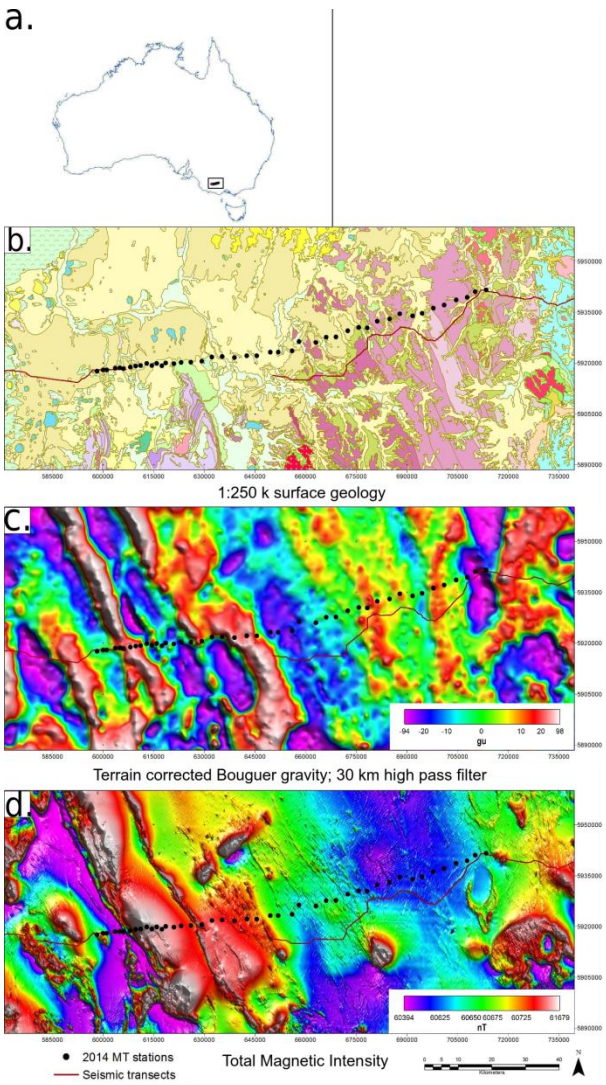

Figure 1. (a) 2014 MT sites in western Victoria. Figures (b-d) show the MT sites as black dots and previous seismic transects as solid lines overlaid on (b) geology, (c) terrain corrected Bouguer gravity and (d) total magnetic intensity.

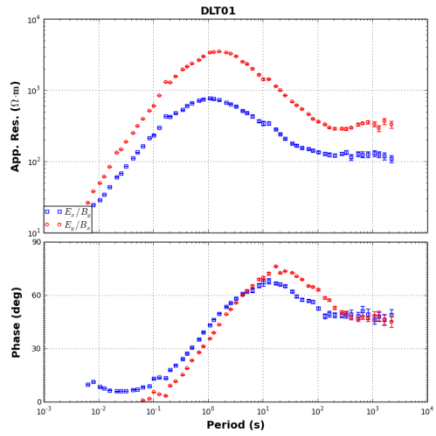

Figure 2. Typical data quality from site DLT01.

CONCLUSIONS

The 2014 MT line is the first transect to directly cross over the boundary between the Lachlan and Delamerian Orogens. Stitching the MT lines together to create a single, continuous line of data will yield the best possible resistivity model of the transition zone.

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