Tectonic framework of the southern Mount Isa Province

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SUMMARY

The North Australian Craton consists of a series of latest Archean to Paleoproterozoic cratonic blocks including several orogenic belts. The Mount Isa Province and the Tennant Creek-Davenport Terrane are two components of the North Australian Craton. These regions are interpreted to be adjacent west and south west of the Mount Isa Inlier. However, there is limited understanding of the tectonic architecture of this relationship. At best, conclusions drawn from studies of outcropping relationships can be extrapolated undercover.

This study uses recently collected magnetotelluric data, combined with deep crustal seismic, to directly investigate the relationship between the Mount Isa Province and the Tennant Creek–Davenport Terrane. The deep crustal seismic was collected along two orthogonal profiles capturing the relationship between the two regions, while the magnetotelluric (MT) data were collected in a regional grid over the junction between seismic lines, extending further west. The MT data underwent inversion before being jointly interpreted with the seismic data.

Magnetotelluric inversion shows a highly resistive mid to lower crust beneath the Kalkadoon-Leichhardt domain. In contrast, the mid to lower crust for the Ardmore May Downs (Tennant Creek-Davenport equivalent) display several discrete conductors. The Leichhardt River domain displays characteristics similar to both the Ardmore-May Downs and Kalkadoon-Leichhardt domains. The seismic data show a reversal in the dip of the primary structures which is consistent with a transition between two geologically distinct terranes. The variation in MT and seismic character within the project area suggests significantly different geology or tectonic histories between the Kalkadoon-Leichhardt and Ardmore-May Downs/Leichhardt River domains.

Key words: southern Mount Isa Province, tectonic architecture, magnetotelluric, seismic.

INTRODUCTION

The North Australian Craton consists of a series of latest Archean to Paleoproterozoic cratonic blocks including several orogenic belts. Basins which developed during the late Neoproterozoic to Phanerozoic conceal the relationships between older orogens and cratonic blocks (Cawood and Korsch, 2008). The Proterozoic rocks of the Mount Isa and Tennant Creek-Davenport terrane in the study area are overlain by sediments of the Georgina and Eromanga Basins (Figure 1).

The Mount Isa Province essentially comprises three stacked super basins – the Leichhardt, Calvert and Isa, deposited on top of an Archean to Early Proterozoic crystalline basement. The sequences were deposited and deformed between 1870 Ma and 1500 Ma. The project area (Figure 1) contains three domains, Ardmore-May Downs, Leichhardt River and Kalkadoon-Leichhardt. The Leichhardt River and Kalkadoon-Leichhardt domains are interpreted to be part of the Mount Isa terrane (Withnall et al., 2013), with the western margin of the Leichhardt River Domain corresponding to the western limit of the Mount Isa Province (Spampinato et al., 2015). The Ardmore-May Downs domain is interpreted to be equivalent to the Tennant Creek-Davenport Terrane of the Northern Territory (Gibson et al., 2016; Withnall et al., 2013).

MT inversion has been used to improve the understanding of crustal architecture in Australia (Robertson et al., 2016; Thiel et al., 2016) and across the world (Becken and Ritter, 2012). This study uses MT data together with deep crustal seismic to investigate the tectonic architecture of the Southern Mount Isa terrane and possible relationships with the Tennant Creek – Davenport Terrane of the Northern Territory.

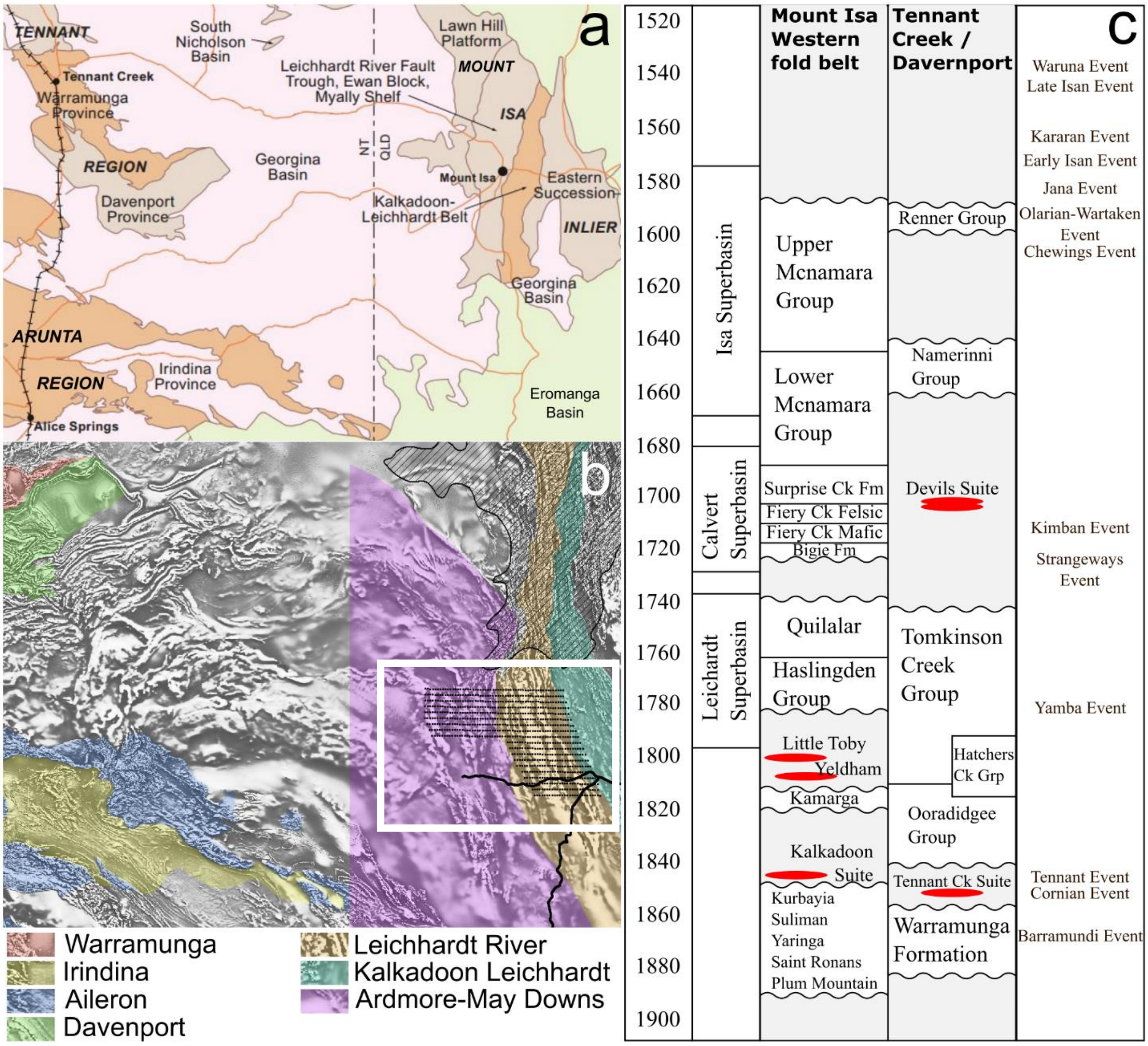

Figure 1: Geological and stratigraphic summary of the Mount Isa and Tennant Creek Regions. a) Major tectonic elements and cover basins (after Ahmad and Scrimgeour (2013)). b) Northern Territory tectonic elements and Mount Isa domains over 1VD magnetic data, project area marked in the white box, the location of MT array and deep crustal seismic in project area indicated in black. c) Summary of the main units and events for the Western Fold Belt of Mount Isa and the Tennant Creek-Davenport Terrane (after Withnall et al. (2013))

METHOD AND RESULTS

Two new datasets suitable for investigation of crustal scale features were collected by the Geological Survey of Queensland in the project area. An MT survey was acquired in 2014-15 with 809 broadband sites. Two deep crustal seismic lines were also collected in 2014. Together with pre-existing regional magnetic and gravity coverage, these datasets form the core of the project.

MT data was inverted using a three stage process, modified after Lindsey and Newman (2015). The coarse inversion involved two steps: the model was initialised using only the tipper data, then the full impedance data was incorporated into the inversion and run to minimum RMS. This tipper first approach preconditions the model to be as simple as possible, reducing the presence of poorly constrained features.

The output from the coarse inversion stage was used as the starting model for the fine inversion. The model mesh was refined to accommodate the increased data resolution. Shallow features unconstrained by the coarse inversion were removed from the model and replaced with the known basin resistivity distribution.

Final MT inversions show a broadly resistive crust with several discrete conductors. The conductive features strike N-S to NW-SE and occur only in the western part of the project area (Figure 2). In contrast, the seismic data show a reversal in fault polarity at the contact between the Leichhardt River and Kalkadoon-Leichhardt domains. A similar reversal of fault polarity is evident on the 06GA-M6 seismic line to the north of the project area (Hutton et al., 2009). The reversal has been interpreted to represent an accommodation zone between the Mount Isa sequences and an adjacent crustal block (either the Arunta or Tennant Regions) (Gibson et al., 2016).

Together the MT and seismic data provide evidence for differing geological histories for the Kalkadoon-Leichhardt domain and the other two domains in the project area.

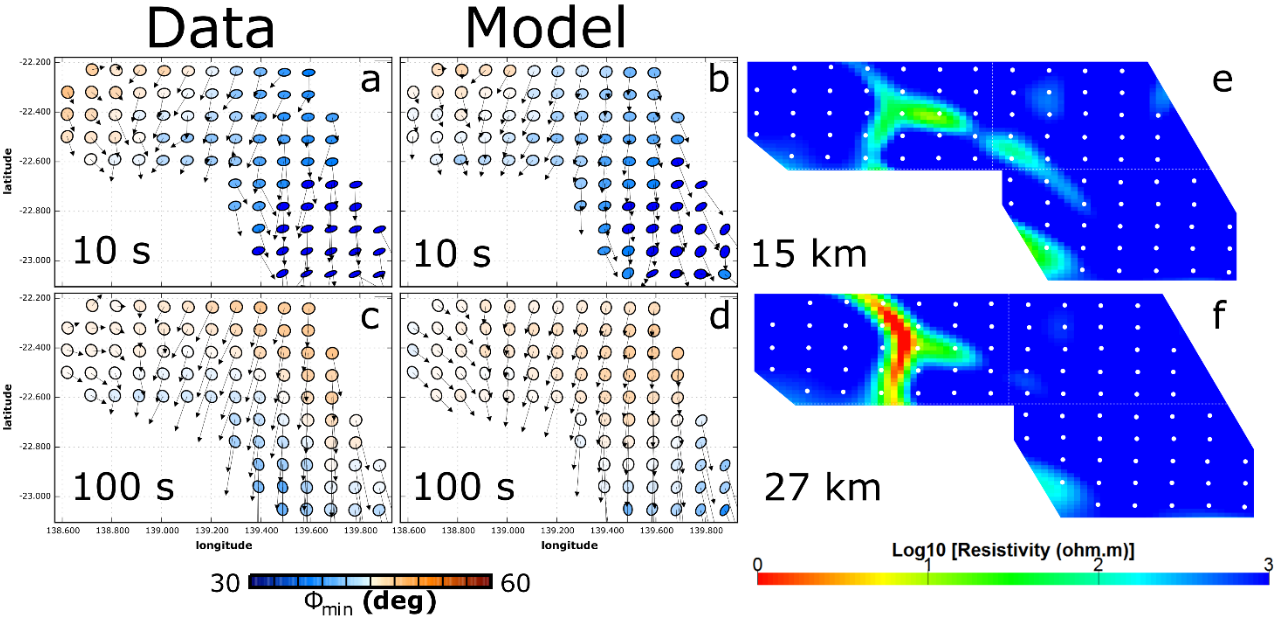

Figure 2: Inversion results and phase tenors plots of data and model response. a) Phase tensor and induction arrows for 10 s observed data (all induction arrow follow the Parkinson convention (Parkinson, 1959)). b) phase tensor and induction arrow plot from the calculated response at 10 s; c) phase tensor and induction arrows for 100 s observed data. d) phase tensor and induction arrow plot from the calculated response at 100 s. e) resistivity structure of inverted model at 15 km depth. f) resistivity structure of inverted model at 27 km depth

CONCLUSIONS

The new seismic and MT data in the project area allow the conclusions drawn from previous deep crustal seismic to be continued into the undercover part of the Mount Isa Province to the south of the outcropping Inlier. The data sets indicate a significant difference in conductivity and seismic character along the eastern margin of the Leichhardt River Domain in the study area. The observed features are consistent with two adjacent terranes which have experienced differing geological histories. The discussed results suggest the Leichhardt River Domain in the project area may be more closely associated with the Tennant Creek Terrane, than the Mount Isa Province. Additional work is needed to confirm this hypothesis.

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