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Magnetotelluric experiments in central and southern Australia and their implications for tectonic evolution

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Abstract

This project comprises four magnetotelluric (MT) transects in central and southern Australia which were carried out with the aim of improving the understanding of the tectonic evolution of the region. The basement geology of central and southern Australia records a long and complex evolution. Prevailing theories suggest that during the Proterozoic, the Australian continent assembled through the collision of separate continental pieces including the North Australia Craton, South Australia Craton, Warumpi Province and Musgrave Block. The suture zones between these separate basement blocks are proposed to lie within central and southern Australia. However, thick sedimentary cover obscures the proposed suture zones so the theories are hard to substantiate through geological or geochemical data. Central Australia also records significant Palaeozoic intracratonic reworking, including the Alice Springs Orogen. Despite relatively good outcrop, significant aspects of the Alice Springs Orogeny, such as its crustal-scale structure and the source and extent of syn-orogenic fluid flow, are unknown. Long-period MT is able to image lithospheric-scale resistivity contrasts within the Earth which are often related to the lithological or tectonic history of the survey region. MT has previously only been carried out to a limited degree in Australia, and never to address the geologically motivated questions of Proterozoic accretion in central and southern Australia and the extent and nature of the Alice Springs Orogen. This study therefore involved carrying out four MT surveys in central and southern Australia, totalling 900 line kilometers, with the aim of using the results to improve the understanding of the Proterozoic evolution of Australia and of the Alice Springs Orogen.

Equipment consisted of five-component MT instruments with fluxgate magnetometers recording long-period data. Data were generally recorded for two to three days to give resolution to crustal or upper mantle depths. Data were processed using the code Robust Remote Reference Magnetotellurics (RRRMT) and modelled using the Non-Linear Conjugate Gradients code in the WinGLink package. Three MT surveys were carried out to investigate Proterozoic accretion. Two of these surveys were linked and together extended from the Palaeoproterozoic North Australia Craton, over the proposed exotic Palaeoproterozoic Warumpi Province, over the Neoproterozoic to Palaeozoic Amadeus Basin and to the Mesoproterozoic Musgrave Block. Modelling results show two lithospheric-scale domains, one corresponding to outcropping North Australia Craton and the other corresponding to outcropping Warumpi Province and Musgrave Block. The boundary between the two domains dips south to at least 150 km depth. These results suggest that the lithosphere of the Warumpi Province and the Musgrave Block is contiguous and support the proposition that the Warumpi Province is exotic to the North Australia Craton. The southerly dip of the interface suggests that the North Australia Craton and Warumpi Province juxtaposed through south-dipping subduction, in contrast to prevailing models which propose that a north-dipping subduction zone existed on the southern margin of the North Australia Craton at this time. The third survey was carried out from the Archaean to Palaeoproterozoic Gawler Craton to the Mesoproterozoic Musgrave Block. Results suggest that magnetically interpreted faults beneath cover in the Gawler Craton may be significant crustal-scale features and also suggest that the juxtaposition of the Gawler Craton and Musgrave Block may have occurred along structures with a south-dipping geometry. Since the northern Gawler Craton is entirely covered by sediment, the delineation of contrasting crustal-scale resistivity domains from the MT data can provide a valuable constraint to future drillhole and geophysical investigations. The structure of the Alice Springs Orogen was investigated with one MT survey which crossed the extent of basement-involved deformation. While the results did not provide significant new information regarding the crustal-scale structure of the orogen, a 20 km deep region of higher resistivity has been imaged which is interpreted to represent the extent of fluid-rock interaction. A model is presented whereby oxidising fluids reach mid-lower crustal depths during pre-Alice Springs Orogen rifting and later syn-deformational compression, destroying graphite in the Palaeoproterozoic basement and increasing its resistivity.

The results from this study have provided significant new insights into the tectonic evolution of central and southern Australia. Further MT surveys are planned and proposed throughout Australia to continue to develop an understanding of the geological history and structure of the continent.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by any other person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Katherine M. Selway

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"Nothing shocks me. I'm a scientist"

Indiana Jones

Publications and Conference abstracts

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** Change of name from Broxholme to Selway in early 2005*