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3D model of the major crustal boundaries of Australia: implications for metallogenesis

Doublier, M.D., Korsch, R.J., Brennan, T., Champion, D.C., Czarnota, K., Huston, D.L., Nicoll, M.G.

Geoscience Australia, GPO Box 378, Canberra ACT 2601 Australia; Michael.Doublier@ga.gov.au.

For over 35 years, deep seismic reflection profiles have been acquired across Australia [1] to better understand the crustal architecture and geodynamic evolution of key geological provinces, basins and resources. Major crustal-scale breaks have been interpreted in many of the profiles, and are often inferred to represent relict sutures between different crustal blocks. The widespread coverage of seismic profiles has allowed construction of the 'Major Crustal Boundaries of Australia' dataset by using geological (e.g. outcrop mapping, drillhole, geochronology, isotope) and geophysical (e.g. gravity, aeromagnetic, magnetotelluric) data to map the plan form distribution of crustal boundaries away from the seismic profiles [2].

Here we present the first continental-scale 3D model of the 'Major Crustal Boundaries of Australia'. This model is constructed from the 2D linework in map view [2], with the third (depth) dimension constrained using the geometry of the boundaries interpreted in deep seismic reflection profiles, and then interpolated away from the profiles. The implementation of the third dimension (depth) has led to improvement of the 2D linework by identifying areas of inconsistency, e.g. with regards to cross-cutting relationships in the third dimension. Both the 2D and 3D datasets allow for a better understanding of the evolution and amalgamation of the Australian continent through time, from the Mesoarchean to the Cenozoic. They also provide a powerful reference frame for integrated studies focused on crustal and lithospheric architecture utilising datasets such as isotopic maps (e.g. Sm-Nd [3]) and seismic velocity models (e.g. P- and S-wave velocity [4]). This is illustrated by the example of the Archean Yilgarn Craton, where various geophysical, geochemical, geological and geochronological datasets have matured over the last decade to the point that craton-scale investigations are now possible. Integration of these data sets with the 3D crustal boundaries shows that the latter provide additional important constraints for models of the crustal development of the Yilgarn Craton, and also for explaining the localisation of mineralisation.

In recent years, the distributions of a range of different types of mineral deposits have been interpreted to be spatially and genetically associated with crustal boundaries [5]. For example, Goleby et al. [6] showed that orogenic gold deposits are associated with major crust-penetrating structures identified in seismic profiles, Groves et al. [7] proposed that iron-oxide copper-gold deposits are genetically associated with, and localised within a few hundred kilometres of, major crustal boundaries, and Begg et al. [8] suggested a similar relationship between some orthomagmatic Ni-Cu deposits and cratonic margins. These relationships are thought to be due to the presence of major architectural breaks that allow access of mineralising fluids and/or melts into the middle and upper crust, or to pre-mineralisation fertilisation of the mantle, for example by subduction, along cratonic margins. These proposed relationships are examined in both time and 3D space with respect to Australia's largest ore deposits utilising Geoscience Australia's EarthSci 3D visualisation tool.

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