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3D mapping for mineral exploration under cover: continental to regional scale examples in Australia

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Australia is well known for its mineral endowment and its long history of mining. Most of the ore bodies that make up this known endowment have been discovered in outcropping or near outcropping regions, which comprise around 20–30% of the Australian continent. The remaining regions that lie under the 70–80% cover represent an enormous potential opportunity for the discovery of new world-class deposits. Exploring beneath this vast area requires a methodology and suite of datasets that permit the mineral explorer to quickly and easily predict the location of favourable regions/camps that might host ore bodies. In these under cover and greenfield regions, the exploration process is one of successive area/volume reduction from the largest continental scale through province and district scales to the deposit scale.

There is an empirical association between giant mineral deposits and 'big' structures with broad alteration systems, which means mapping the large-scale features of the continent should vector to favourable regions under cover. At the giant Olympic Dam IOCG deposit, for example, first-order faults and alteration are mapped deep in the crust and upper mantle as anomalous density, seismic character, conductivity and susceptibility features that are evident on regional and national datasets. Indeed, this world-class deposit was discovered beneath barren cover rocks >300 m thick on the basis of a mineral system model and interpretation of continental-scale gravity/magnetic datasets.

Geoscience Australia aims to attract exploration investment by providing pre-competitive data to reduce risk for industry, including the provision of 3D maps and the underlying data across Australia. We are working towards an Australian Architecture Reference Model (AusARM), which seeks to integrate disparate datasets and 3D models, and make them accessible through Geoscience Australia's Earth*Sci* 3D viewer (https://github.com/GeoscienceAustralia/earthsci).

Current efforts in building AusARM are focused on compiling and updating major surfaces through, and petrophysical properties of, the Australian lithosphere with the aim not only to constrain the present lithospheric architecture but also its temporal evolution. The 3D surfaces include major basin boundaries, major crustal-scale faults derived from deep reflection seismic profiles and ever-growing potential field data, the maximum base of magnetisation, the Moho and the lithosphere-asthenosphere boundary. Volumetrically, the intention is to provide a national coverage of velocity, density and conductivity. In addition there is an ongoing programme of national chronostratigraphic solid geology, metamorphic and radioactive isotope mapping along with selected lithological compilations that place important constraints on the temporal evolution of the lithospheric architecture. Numerous higher resolution regional, camp and deposit scale 3D geological maps for many of Australia's fertile terranes have been integrated into the national 3D datasets.

Individually the above datasets are valuable, yet the integration of these datasets allows their limitations and uncertainty to be identified. Such integration is revealing of fundamental Earth processes and associated mineral system evolution such as: national predictions of magmatic Ni-Cu mineralisation, orogenic gold prospectivity within the Yilgarn Craton, metasomatised mantle distribution in Victoria with its potential association with gold, and the temporal lithospheric thickness variations beneath the Canning Basin. This 4D understanding across scale will aid the exploration decision-making process in under cover and greenfield regions in Australia and lead to new mineral and energy discovery.