Lithospheric Electrical Resistivity Heterogeneity: A Vector to Mineralisation

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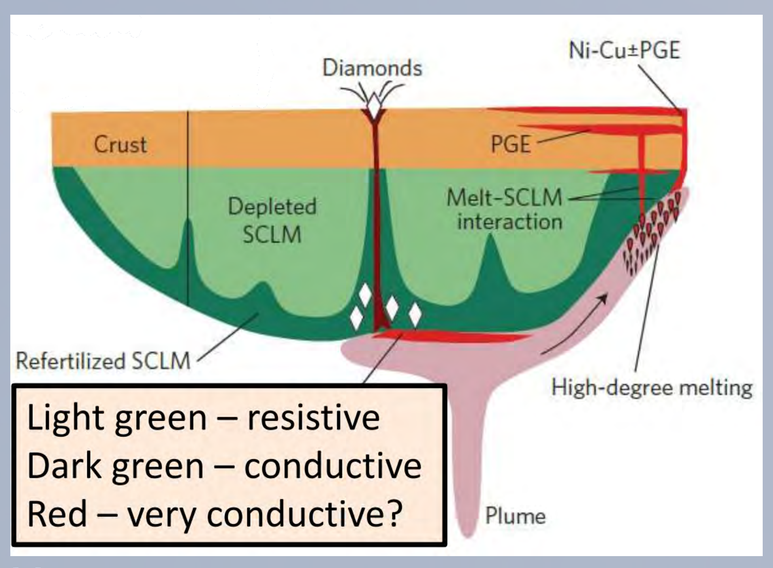
Summary

The resistivity structure of the Earth's upper crust is largely heterogeneous, particularly in intercratonic regions. Conductive incursions through the resistive crust, sourced from the mantle, are proposed as potential conduits for ore-forming elements. The steep resistivity gradient at the edge of these conductive incursions are host to significant mineralisation, leading to the proposition that a whole lithospheric view should be taken when exploring for mineralisation.

Background



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The Gawler Craton has long been known as a region of great importance in relation to mineralisation. The region is host to some of the world's most significant mineral deposits, such as the Olympic Dam and Prominent Hill deposits. However, the causal factors behind these rich mineral systems are largely unknown.
We propose an entire lithospheric view be taken when exploring for mineralisation. The sub continental lithosphere is rich in ore-forming elements that could be transported to the upper crust by intrusions mantle fluids. These intrusions favour areas of weakness such as the edge of ancient cratons, leading to a concentration in mineralisation along cratonic boundaries.
Through the use of magnetotellurics (MT), we can model these areas of weakness and potentially increased concentration of ore-forming elements transported from the mantle. We propose the use of both large and small scale MT surveys to map out regions of potential economic geology.

References

[1] W. L. Griffin, G. C. Begg, and S. Y. O'Reilly. Continental-root control on the genesis of magmatic ore deposits. *Nature Geoscience*, 6:905–910, Oct. 2013. ISSN 1752-0908.

[2] G. Heinson, N. Direen, and R. Gill. Magnetotelluric evidence for a deep-crustal mineralizing system beneath the Olympic Dam iron oxide copper-gold deposit, southern Australia. *Geology*, 34:573–576, 2006.

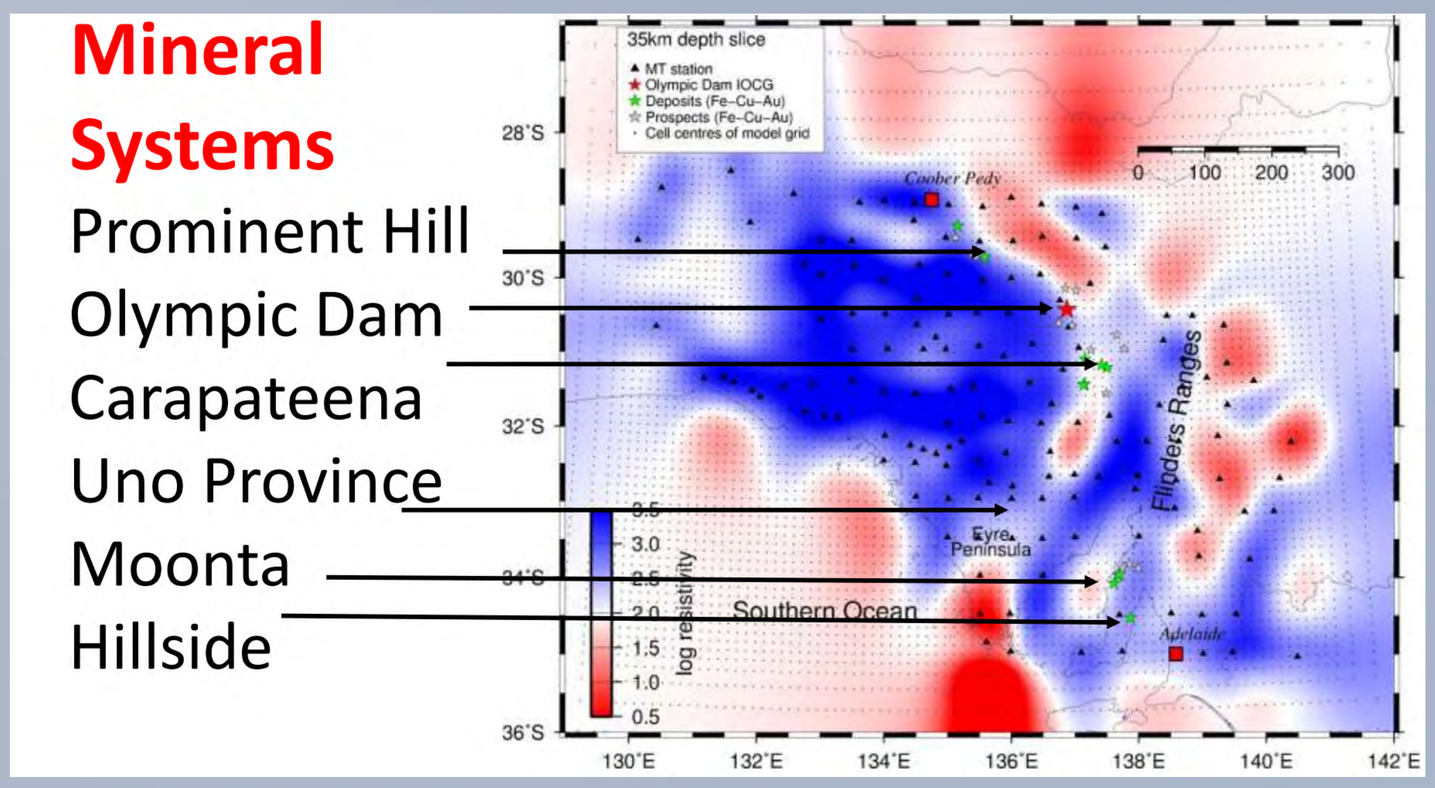
[3] A. Kelbert, N. Meqbel, G. D. Egbert, and K. Tandon. Modem: A modular system for inversion of electromagnetic geophysical data. *Computers and Geosciences*, 66: 40–53, 2014.

Acknowledgements

I would like to acknowledge BHP Billiton for allowing access to the Olympic Dam Special Mining Lease. Kate Robertson, Sebastian Schnaidt, Nigel Rees and Jake Macfarlane for their help in conducting the two-dimensional survey. Geoscience Australia and the South Australian Geological Survey for allowing the use of AusLamp data. Goran Boren for the meticulous maintenance of the MT instruments, the South Australia Department of State Development for their support throughout the project, and ASEG for providing the funding needed to conduct the two-dimensional survey.

AusLamp

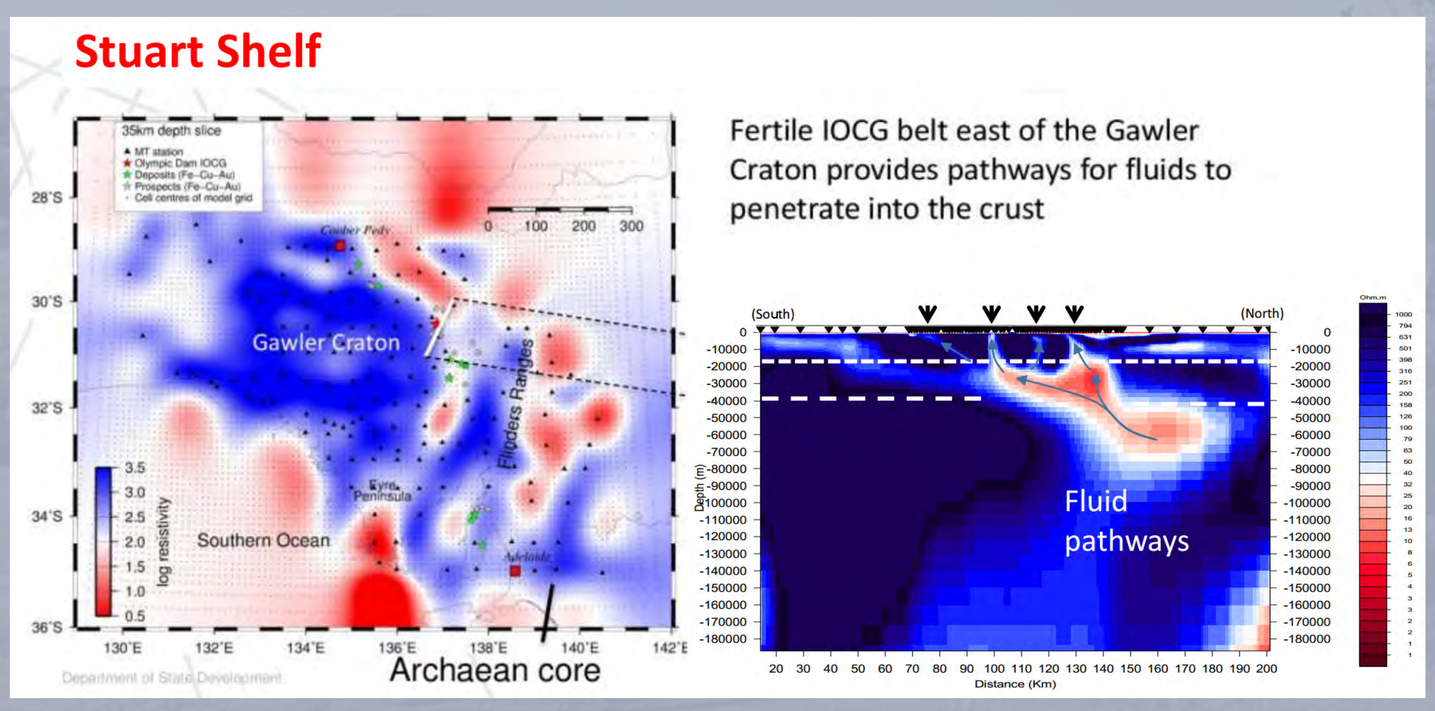
The AusLamp project is a nation wide magnetotelluric (MT) survey, with sites spaced every 55km or 0.5° across Australia. Each site is recorded for three weeks and provides information about the Australia lithosphere over a depth range of 20 - 200 km. Over 3000 individual sites will be recorded over the life of the AusLamp project, which is in excess of 12 years from start to finish. Currently data has been collected across Victoria and a significant amount of South Australia, with data from western South Australia currently being recorded.



Depth slices of the South Australian sites have revealed significant results around the Gawler Craton. The craton itself is mainly resistive (1000 Ω m), however, strong conductive features can be seen wrapping the eastern margin. This conductive band correlates well with rich mineral deposits, such as Olympic Dam, Prominent Hill and Carapateena. Each of these sit in the steep resistivity gradient observed at the boundary between the resistive Gawler Craton and the conductive band. It was originally thought that the same conductive band attributed to Olympic Dam was also home of the Moonta and Hillside deposits, but there seems to be a separate conductive feature attributed to them.

Olympic Domain

A transect of broadband MT data was collected along a 200 km section intersecting the eastern edge of the Gawler Craton and encompassing the Olympic Dam deposit. The transect consists of 120 MT sites, with sites initially evenly spaced at 5 km intervals [2], the central 80 km have higher site density at 1 km intervals for increased resolution.



Two-dimensional modelling of the transect is shown on the right of the AusLamp depth slice. The AusLamp depth slice is taken at 35 km depth and has a strong correlation with the 2D MT model, revealing the extent of the conductive boundary of the Gawler Craton from the upper mantle through to the brittle-ductile boundary. In the top 10 km of the crust, conductive fingers can be seen linking the conductor to the surface. The fingers are well correlated to the known mineral deposits along the transect; Wirrda Well, Olympic Dam and Vulcan, with one finger unaccounted for. This suggests mantle fluid pathways linking the mineralised areas with the lower crust and Moho. These pathways could have contributed to the environment required for mineralisation to concentrate in the regions near the surface.

Conclusion

The large scale AusLamp MT survey across the Gawler Craton has lead to the identification of conductive zones along its eastern margin, with strong correlations to known mineral deposits. The higher density two-dimensional transect recoded over the Stuart Shelf revealed a strong correlation with the large scale survey and has resulted in significantly increased model resolution. The enhanced resolution has allowed the exploration of possible fossil fluid pathways linking the deep crust to the known mineralisation zones in the region. In the future, further high resolution broadband MT surveys could lead to the identification of more potential mineral exploration targets.

Outlook

Further modelling of the AusLamp data is being undertaken using the MODEM 3D algorithm [3] as new data is recorded, to provided information about the northern and western margins of the Gawler Craton. Further high density 2D surveys are planned for the eastern margin of the Gawler Craton, intersecting with the steep conductivity gradient in the hope of finding further correlations with known mineralisation and potential location of new mineral deposits.