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Gravity anomalies as trap sites in prospectivity modelling of the Eastern Gawler Copper-Gold Belt

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SUMMARY

A geoprocessing methodology has been developed to capture potential field anomalies from residual gravity and reduced to pole total magnetic intensity (RTP TMI) datasets. Anomalies captured using this process are converted to GIS polygons and attributed with descriptive statistics of the underlying grids. The polygons are subsequently included as criteria in a GIS analysis to target IOCG-style deposits beneath extensive cover in the Eastern Gawler Craton. The application of gravity anomaly polygons within this study was as potential trap sites, based on the assumption that a localised increase in density manifested as an anomalous gravity response may be associated with mineral accumulation. The characterisation of residual potential field anomalies for use in prospectivity modelling has resulted in the accurate identification of existing deposits of IOCG-style mineralisation and has suggested additional targets warranting further investigation.

Key words: Gravity, Residual, IOCG, Gawler

INTRODUCTION

The Woomera Prohibited Area - Eastern Gawler region is highly prospective for IOCG deposit styles (amongst other styles/commodities), ranging from hematite-rich breccias to magnetite rich skarn-style alteration and mineralisation (Figure 1). To aid exploration for such targets, a large, detailed gravity survey was conducted in the Eastern WPA between June and September 2013, with 34,541 new stations being recorded. The resolution of this survey was 1km x 1km in all areas excluding the Red Zone (Defence continual use) of the WPA, where stations were spaced at 2km x 2km.

The new gravity survey was the impetus for producing several new geophysical products for use in prospectivity modelling. Existing gravity surveys across the WPA were combined with the new gravity data to produce a new grid merge. To compliment the WPA-wide gravity grid, magnetic surveys were reprocessed and merged into a high-resolution grid spanning the WPA. The reprocessed datasets contain numerous surveys released through Sunset Clause since the last South Australian state grids (Magnetics - 2007, Gravity - 2011), improving detail and positional accuracy (Wise, 2014).

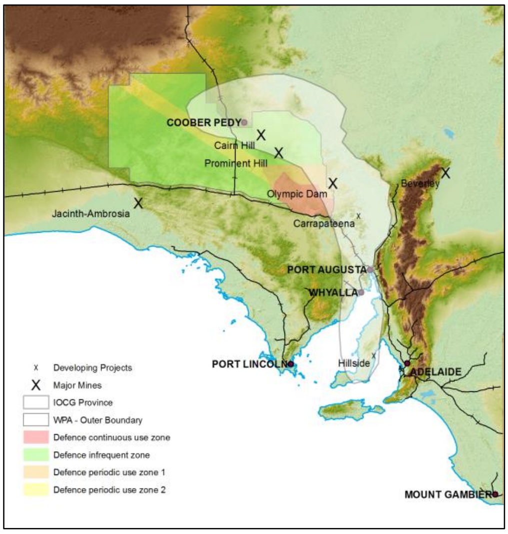

Figure 1: Location of the Eastern Gawler Copper-Gold Belt and WPA, central South Australia.

A method for extracting anomalous regions from the resultant gravity and magnetic grids was developed for use as inputs into mineral potential modelling. The outputs will be a set of polygons for each potential field dataset containing attributes populated with descriptive statistics for the regions underlying each polygon.

IOCG mineral potential modelling has been conducted based on methods and criteria outlined in Schofield et al (2013) and Huston and van der Wielen (2011). The aim of this mineral systems modelling is to define regions containing a spatial association between key characteristics of IOCG-type targets in the Eastern Gawler Copper-Gold Belt.

METHOD AND RESULTS

Mineral Systems Modelling and Rationale

Mineral systems modelling conducted in this study uses key mineral systems components, and proxies used to map these criteria. Mineral systems components adopted for this study are; Sources of Metals and Fluids, Heat Sources, Fluid Conduits, and Potential Trap Sites. Due to the paucity of outcropping prospective basement geology in the Eastern Gawler, many of the input data have been interpreted from airborne or ground geophysics.

Combining input data into an "IOCG Prospectivity" map has been undertaken using a spatial overlay method. Individual weightings assigned to criteria are visible in Figure 3.

Mineral Systems Modelling Inputs

Inputs used in the mineral systems modelling of this study are loosely based on a study of the IOCG potential of the Arunta Block (Schofield et al, 2013). A primary adaptation to the work performed by Schofield et al (2013) is the use of GIS-generated potential field anomalies instead of using regional inversions. Compared with regional coarse-scaled inversions, GIS-generated anomalies (as detailed below) have the capacity to better resolve potential trap sites for IOCG mineralisation.

The inputs used in modelling are detailed in Figure 3. Inputs are generally derived from the South Australian Solid Geology dataset (Cowley, 2006)), though additional interpretations of structures and probable intrusions have been undertaken.

As shown in Figure 3, individual proxies are combined (using spatial overlay), into a weighted overlay for each of the primary mineral systems components. For example; *mafic intrusion polygon + felsic intrusion polygon → Heat Sources.*

GIS Potential Field Anomalies

A methodology has been created to extract anomalous regions from gravity and magnetic grids for use as inputs into mineral potential modelling. Such regions are important mappable criteria as they represent locally anomalous density and magnetic susceptibility, and can signify mineral accumulations.

The methodology detailed below is applied to residual Reduced To Pole and Gravity grids, using an ArcGIS geoprocessing script;

1. Contours are generated at an interval defined by the analyst (as a script parameter). Optimally, a very small contour distance is used to produce the densest possible set of contours, within the limitations of the computer (memory) used for the processing. 0.1 mGal was used for gravity and 5 nT was used for TMI.
2. A perimeter distance threshold is set by the analyst (as a script parameter). The perimeter distance is used by the routine to select closed contours that are less than or equal to the distance threshold. Distances used were 30 km for gravity datasets and a combination of 60 km and 30Km for magnetic datasets (running the script once at 30 km and again at 60 km).
3. The contours selected during step 2 are converted to polygons and dissolved (generating a single feature from each set of contours representing a single anomaly), before being attributed with the contour value at the perimeter of each anomalous region.
4. Centroids of these polygons are then generated and the grid value underlying each centroid is transferred to the centroid as an attribute.
5. The centroid value is then transferred to its parent polygon using a spatial join. This completes two attributes for each anomaly polygon, a centroid value and a perimeter value.
6. Potential field anomalies are defined by selecting polygons whose centroid value exceeds the perimeter value. Polygons whose centroid value is lower than the perimeter value are discarded. Examples are shown in Figure 2.
7. The remaining anomaly polygons are intersected with the residual grid and "zonal statistics" are calculated as additional polygon attributes.

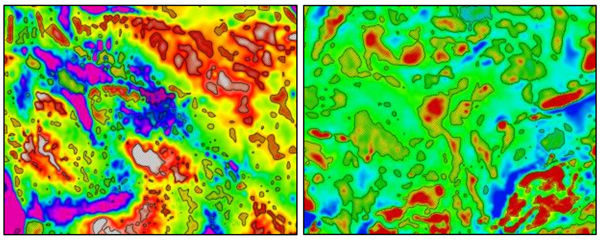

Figure 2: Anomalies defined by polygons whose centroid value exceeds the perimeter value; gravity (left) and TMI (right).

It is assumed that a density anomaly alone may represent mineral accumulation, though a magnetic anomaly coincident with a density anomaly is a more favourable target. Magnetic anomalies, defined by the above method, are therefore intersected with density anomalies, leaving polygons of coincident magnetic and gravity responses. Density anomalies and coincident anomalies are thus used as inputs to modelling, with coincident responses being assigned a higher weighting, (Figure 3).

Attributing zonal statistics to polygons representing anomalies enables filtering by area and/or magnitude, or using thresholds to target anomalies of a given range.

Combination of Mineral System Components

Once weighted overlays for each principal component are created, (Sources of Metals and Fluids, Heat Sources, Fluid Conduits, and Potential Trap Sites), principal component rasters are combined, again using a spatial overlay method. A ratio of 1:1:1:2 was used to signify the relative importance of a density response associated with a potential mineral accumulation. The relative IOCG prospectivity result is depicted in Figure 5.

CONCLUSIONS

GIS-based anomaly extraction (using the above method), successfully identifies both "stand-out" geophysical anomalies as well as more subtle features highlighted by residual techniques.

Combining extracted anomalies with geophysical interpretations and drillhole/outcrop geology, using the mineral systems modelling method detailed above, enables a ranking system of the classic density anomaly targeting system.

Successful identification of known mineral deposits and occurrences highlights the merits of this approach, whilst additional, un-tested, targets have been identified (Figure 4).

ACKNOWLEDGMENTS

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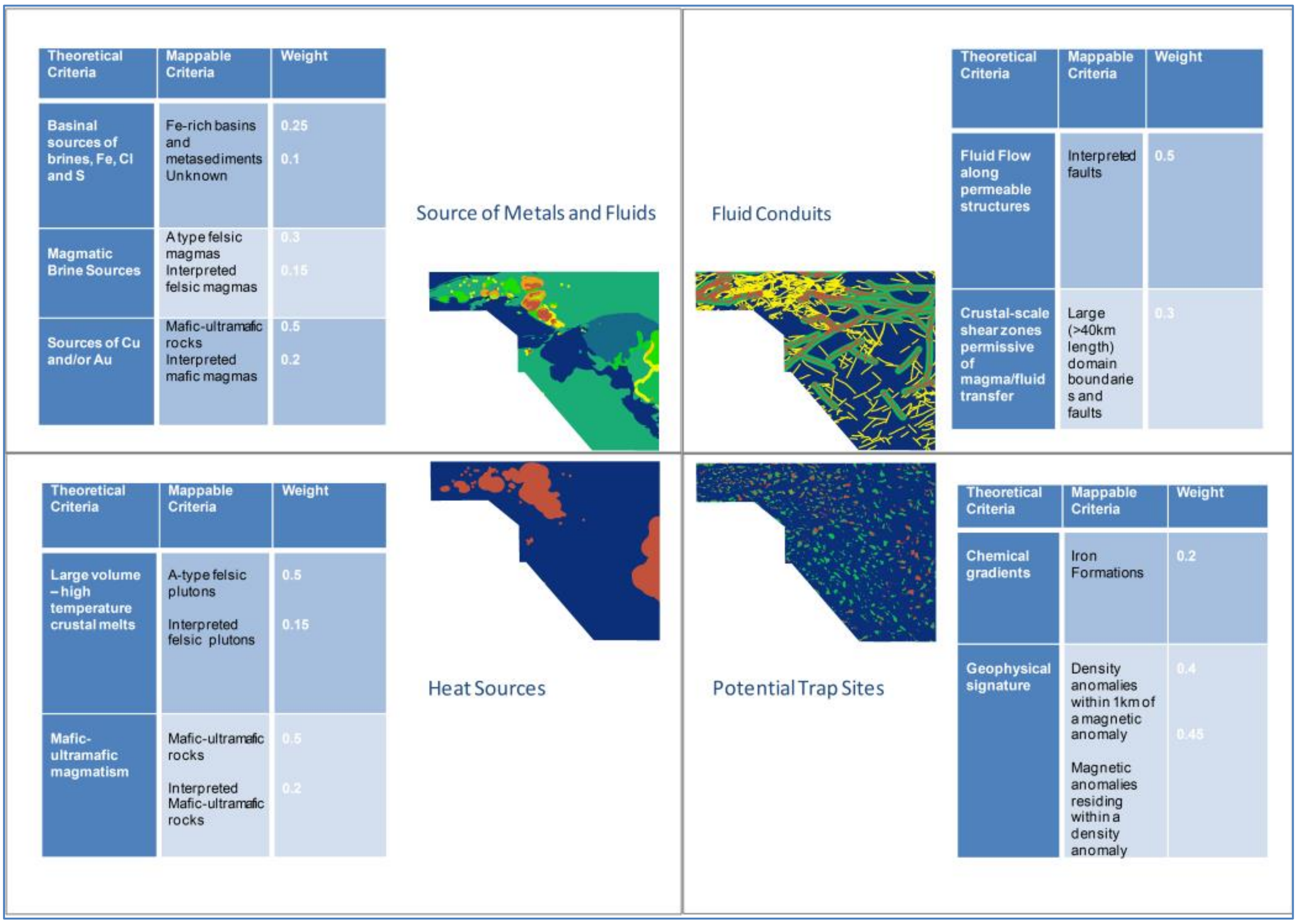


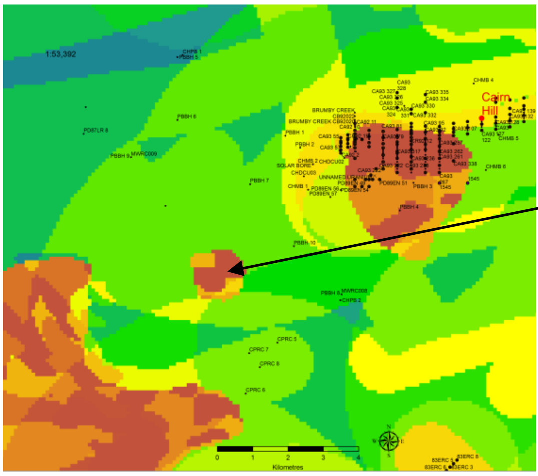
Theoretical Criteria	Mappable Criteria	Weight
Basinal sources of brines, Fe, Cl and S	Fe-rich basins and metasediments Unknown	0.25 0.1
Magmatic Brine Sources	A type felsic magmas Interpreted felsic magmas	0.3 0.15
Sources of Cu and/or Au	Mafic-ultramafic rocks Interpreted mafic magmas	0.5 0.2

Theoretical Criteria	Mappable Criteria	Weight
Fluid Flow along permeable structures	Interpreted faults	0.5
Crustal-scale shear zones permissive of magma/fluid transfer	Large (>40km length) domain boundaries and faults	0.3

Theoretical Criteria	Mappable Criteria	Weight
Large volume – high temperature crustal melts	A-type felsic plutons Interpreted felsic plutons	0.5 0.15
Mafic-ultramafic magmatism	Mafic-ultramafic rocks Interpreted Mafic-ultramafic rocks	0.5 0.2

Theoretical Criteria	Mappable Criteria	Weight
Chemical gradients	Iron Formations	0.2
Geophysical signature	Density anomalies within 1km of a magnetic anomaly Magnetic anomalies residing within a density anomaly	0.4 0.45

Figure 3 (above): Input criteria according to Mineral Systems components, and assigned weights



"Untested" Target generated from modelling

Figure 4 (left): Untested and not drilled Target to the SW of Cairn Hill

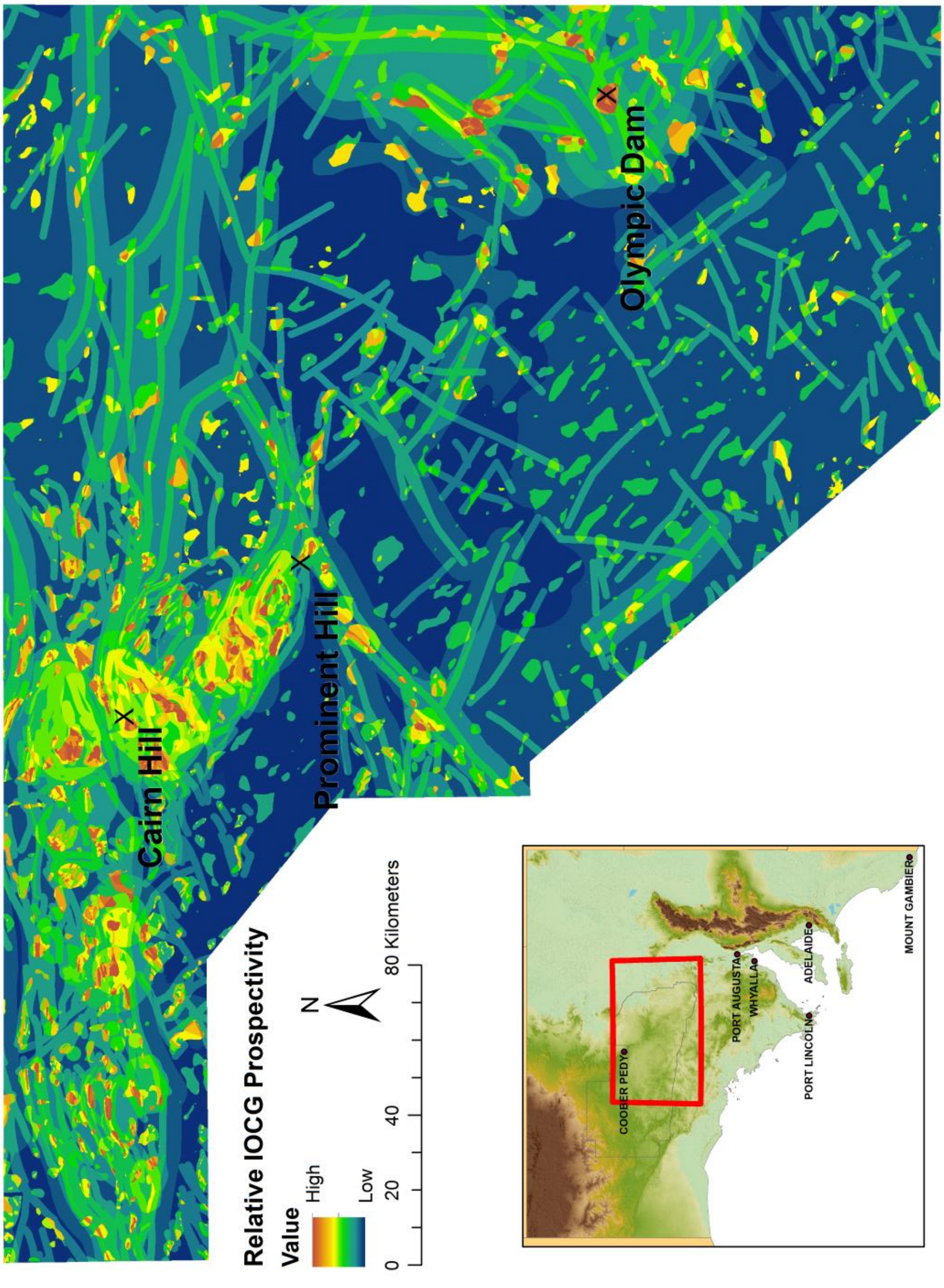


Figure 5: Relative Prospectivity of the Eastern Gawler – WPA region for IOCG deposits.