Potential field modelling of mafic and exhalative rocks in the Girilambone-Tritton mine area, western NSW

Rosemary Hegarty
Geological Survey of New South Wales
516 High Street, Maitland, NSW.
rosemary.hegarty@industry.nsw.gov.au

SUMMARY

Potential field geophysical data sets for the Coolabah 1:100 000 map sheet area (60 km east of Cobar) were interpreted to better understand poorly exposed bedrock as part of a regional mapping project by the Geological Survey of New South Wales. The map area includes historic and present-day copper mining of VHMS deposits in the Girilambone district and at Tritton mine. Information on the distribution and depth extent of mafic, ultramafic, and exhalative rocks is sought using regional aeromagnetic and gravity data.

Multi-scale edge analysis gradients and upward continuation filtering for both gravity and magnetic data provided preliminary ideas on the nature of anomaly sources in basement. Near-surface magnetic anomalies were reconciled with mapped lithologies and magnetic susceptibilities, and then magnetic sources defined using an iterative process of initial forward models, inversion of selected parameters, and resulting adjustment of the forward model. The results of magnetic and gravity modelling across the Coolabah map sheet (in the Tritton Mine area) were used to assist in the construction of geological cross-sections.

Correlations between near-surface magnetic sources and deeper gravity sources are good for ultramafic rocks and quartz–magnetite–hematite rocks in the southeast quadrant of the map area, but the two data sets are more difficult to reconcile elsewhere. The resulting modelling indicates complex steeply dipping stratigraphy (including narrow mafic and ultramafic rocks near to surface), and a high density basement unit (possibly a large mafic intrusion) below a depth of five kilometres.

Key words: magnetic modelling, gravity modelling, Girilambone Group

INTRODUCTION

Interpretation of potential field geophysical data can assist the challenge of geological mapping within areas of western NSW characterised by monotonous metasedimentary rocks and extensive regolith cover. The Geological Survey of New South Wales (GSNSW) carried out regional geological mapping in the Coolabah 1:100 000 map sheet area north of Nyngan (COOLABAH, Figure 1) during 2011 and 2012. Available magnetic, gravity and radioelement data were interpreted to derive any information relevant to the stratigraphy and structure of the area.

A low degree of petrophysical contrasts is typical within the dominant rock unit – the Girilambone Group turbidites of Ordovician age. Drill intercepts and sparse outcrops indicate minor local lithologic variations, including mafic schist (volcanic rocks), quartz–magnetite–hematite horizons (inferred exhalative rocks), ultramafic intrusions, serpentinite, and late intermediate to mafic dykes. Subtle near-surface anomalies present within basement in aeromagnetic data from the Cobar region are commonly masked by high frequency noise due to the presence of irregular surface deposits of maghemite. On COOLABAH these form dendritic palaeo-

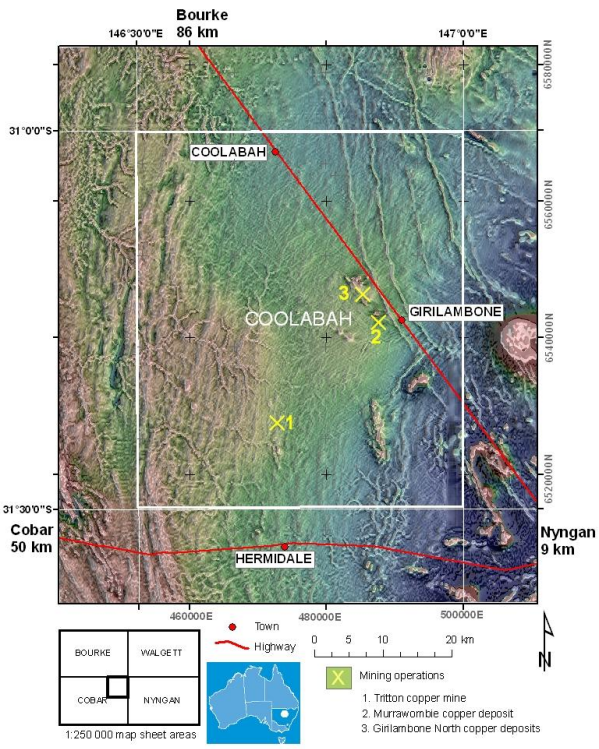

Figure 1. Location and mining operations in the Coolabah 1:100 000 map sheet area. Aeromagnetic image combines greyscale 1VD and inverted 2VD (50% transparency each), upon pseudocolour TMI RTP.

drainage patterns that feature prominently in aeromagnetic imagery, particularly in the west of the map sheet area.

Historical mining for copper and gold in this district has stimulated a long record of prospecting and mineral exploration projects. Underground mine development and extraction of copper ore currently take place at the Tritton mine in the Budgery area, and at the Murrawombie and Larsens/North East orebodies near Girilambone. There is also potential for nickel or platinum occurrences associated with ultramafic rocks, for metallic mineralisation synchronous with recently mapped exhalative rocks, and for structurally-controlled gold occurrences. Collins (2001) reviewed the use of geophysical techniques in the discovery of the Tritton copper deposit, and detailed the critical role of EM surveys. Close associations between mineralisation styles, alteration, structures and mafic/ultramafic rocks are reported for the district (e.g. mineralisation controls cited by Shields and Jones, 2010), and – as outcrop is limited in the area – gravity and magnetic data are critical to map these factors (Figure 2).

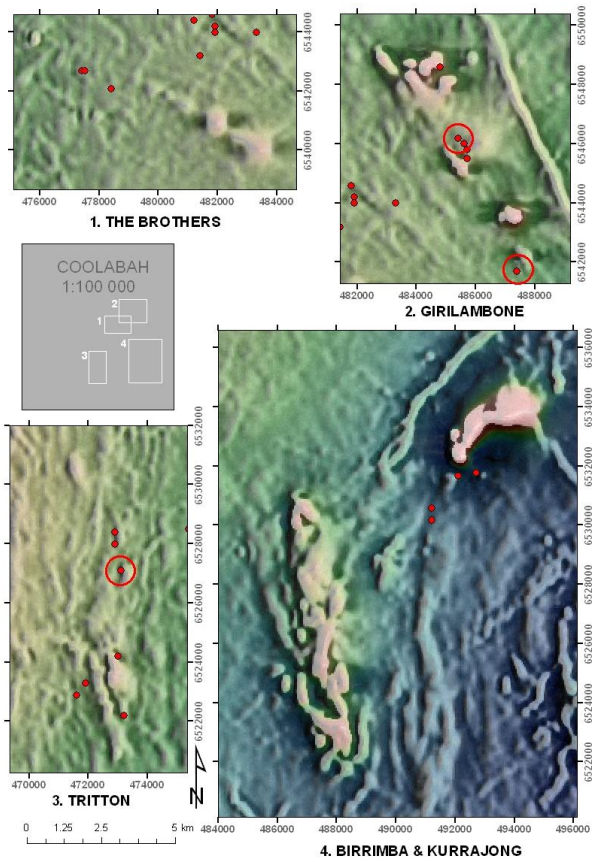

Figure 2. Main aeromagnetic anomalies associated with mafic, ultramafic and exhalative rocks and alteration in the Coolabah map sheet area. Mineral occurrences (red dots) and mining operations (red circles) are shown. The background image is greyscale 1VD as 50% transparency on pseudocolour TMI RTP.

The Cobar region pmd*CRC T11 project constructed a series of potential field models along east–west sections, including the current mapping area, and constructed a 3D model for the region (details in van der Wielen and Korsch, 2007).

An initial 2D interpretation of geophysical and satellite imagery for COOLABAH by the GSNSW geological mapping team) investigated the depth extent and nature of gravity and magnetic sources using multi-scale edge detection gradients and upward-continuation filtering. The modelling of the data sets aimed to generate geologically plausible sources and structures to assist the preparation of a geological cross-section for the map.

METHOD AND RESULTS

Data sets and modelling process

The study is based on regional geophysical datasets that have been acquired and collated over recent decades by the GSNSW and Geoscience Australia: aeromagnetic and radiometric surveying coverage has merged the *Exploration NSW* Cobar–Nymagee Survey J-010 (60m flight height and 250m line spacing: 1998) with two earlier open-file company surveys (RGC Exploration and Nord/Straits). From those grids, suites of project and regional images were prepared by Lisa Nix (East Coast Geophysics) on behalf of GSNSW. Detailed mapping results and magnetic susceptibility readings from the field mapping party (Gilmore et al., in prep) provided lithologic control from outcrop and limited open-file drill holes.

Gradients in potential field data enhanced by multi-scale edge analysis highlight the positions and depths of major contrasts in magnetic susceptibility or density: these had been computed previously by GSNSW using Intrepid WormE™ software to a continuation height of 21 km. Upward-continuation FFT filtering of aeromagnetic data (heights to 3000 m) and Bouguer gravity data (heights to 10 000 m) was carried out using Encom PA™ software.

The modelling of both magnetic and gravity data was carried out to assist with preparation of a geological cross-section by providing an analysis of likely source characteristics (form, depth, width, dip, strike etc), and values for petophysical properties were drawn from field measurements where possible. Modelling used ModelVision™ software and followed an iterative forward-modelling procedure whereby the bodies (sources) were seeded initially using simplistic – generally tabular – forms to grossly match the most significant anomalies. Then several inversions were run, freeing particular parameters to experiment with those results, and finally the body parameters were selected to most closely match the forward model curve with the TMI or gravity field.

Upward continuation and multi-scale edge detection gradients

The preliminary review of the nature and depth extent of magnetic sources within basement showed a transition in the short-wavelength anomalies between a more complex western domain and an eastern domain (Figure 3). This transition occurs along a gradient where higher continuation edges migrate west, and this is more strongly enhanced in the Cobar pmd*CRC T11 project gradients (Murphy, 2007). Upward continuation of the more magnetic domain west of the Tritton area suggests it has limited depth extent, contracting west towards the north–south trending Muriel Fault at the western sheet boundary. In the southeast corner of COOLABAH, the multi-scale gradients indicate more deeply sourced anomalies; the Birrimba and Kurrajong anomalies showing higher continuation edges migrate east, while those of the West Lynne anomaly migrate west.

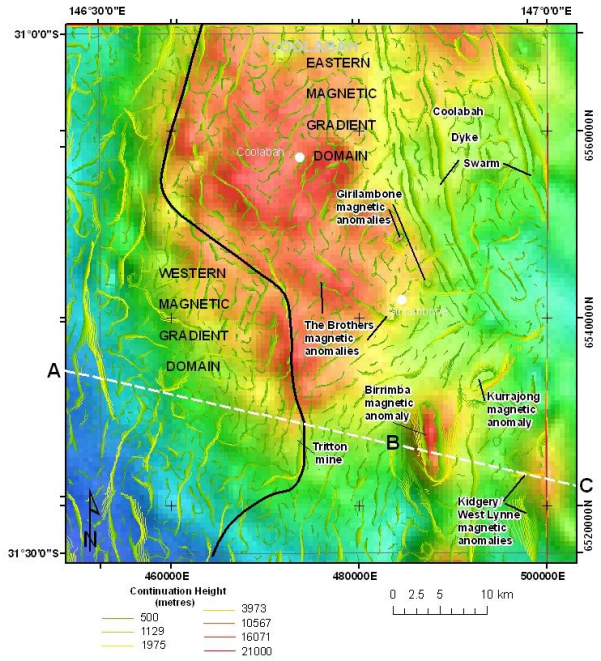

Figure 3. Composite image merging magnetic and gravity data: magnetic multi-scale edge gradients shown as continuation height contour lines (with important anomalies and domains highlighted), overlain on a pseudocolour isostatic Bouguer gravity image. Modelling profile shown as A–C (white dashed line).

A key consideration for gravity sources within basement is the broad area of high gravity in the central parts of COOLABAH which shows circular patterns (having diameters of 10 to 20 km) and has no obvious structural or stratigraphic explanation from surface geology. Its western margin shows as a major curved, semi-continuous multi-scale gravity edge gradient along the western sheet boundary (not illustrated in this abstract) which is one of a series of regional anastomosing, north-northwest trending gravity gradients interpreted as major faults (e.g. the Coonara Fault further west). Smaller high gravity features in the southeast quadrant of COOLABAH – typically oval to elongate and 5 to 8 km across – show varying degrees of correlation with high amplitude magnetic features. Of these, the Birrimba magnetic feature correlates closely with high gravity, the West Lynne feature correlates with a lesser degree, and the Kurrajong magnetic anomaly shows no gravity expression.

At increasing continuation heights (Figure 4), the high amplitude gravity anomalies in the map sheet area – features labelled C (Coolabah area) and B (Birrimba area) – form the western half of a major elliptical high gravity feature. At 2 km continuation height this major gravity high is interpreted to be disrupted by a series of northeast-trending linear trends and intruded by circular low gravity granites LPG (Little Plains Granite) and HP (Horton Park intrusion). The highest amplitude gravity anomaly is the Gerar anomaly (G) located 24 km east of COOLABAH. It is characterised by a corresponding anomaly of very high magnetic intensity, and previous exploration drilling intersected pyroxene biotite diorite (considered a possible layered intrusion) and altered pyroxenite/peridotite (drill hole G1: BHP Minerals Limited, 1985). Similar rock types at several kilometres depth on COOLABAH would be a likely source for the high gravity area.

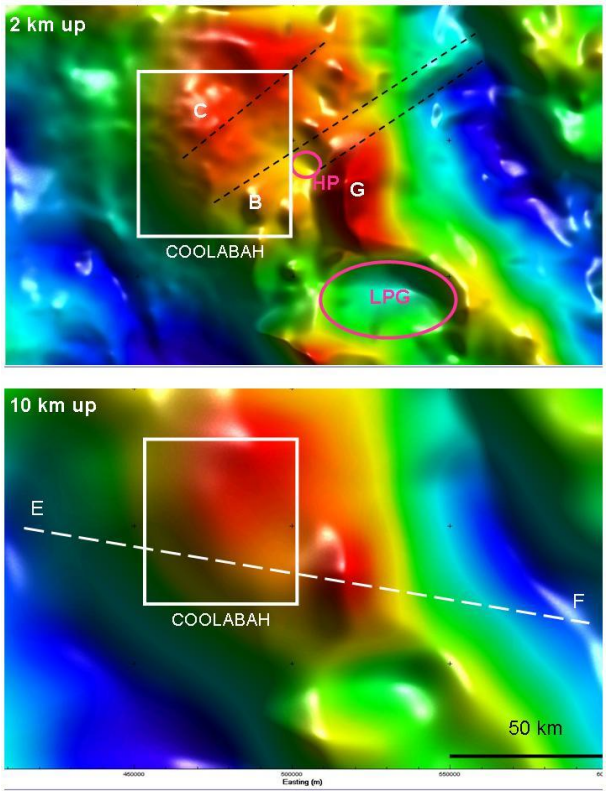

Figure 4. Images of upward-continuation filtered Bouguer gravity data for the region including the Coolabah map sheet area (white box), using continuation heights of 2 km and 10 km. Labelled anomalies are discussed in the text.

Gravity modelling

To investigate the relevant regional factors affecting COOLABAH, simplistic forward modelling was carried out for a profile extending approximately 200km from the western flank of Hume gravity low in the Cobar area, across high gravity areas on COOLABAH, to the eastern flank of Mt Foster/Mount Harris granite lows (Figure 5). A background density of 2.67 g/cm^3 represents the metasedimentary rocks of the Girilambone Group. Two east-dipping tabular bodies of ultramafics are modelled as the source of the highest gravity

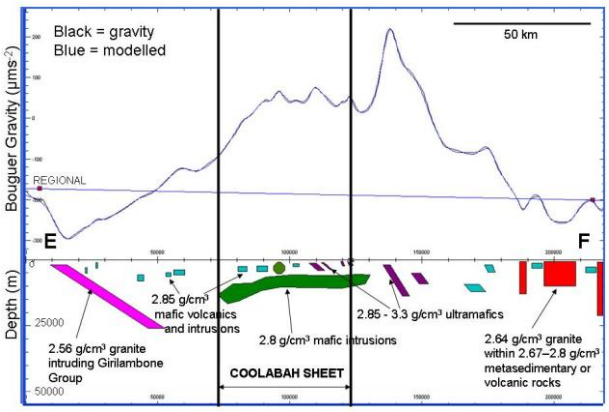

Figure 5. Modelled Bouguer gravity data for the Coolabah map sheet within the regional context.

values (the western body is the source of the Gerar anomaly). Sources modelled to depths from approximately 1 to 5 km on

COOLABAH include: several mafic rock units (2.8 g/cm^3), a discrete spherical source (intrusion), and some narrow tabular ultramafic bodies (2.85–3.3 g/cm^3). A slab-like layer (2.8 g/cm^3) has been used to contribute density below a depth of 5 to 6 km, and is modelled deepening towards (and truncating at) the western boundary of COOLABAH. Overall this model is in agreement with earlier modelling by the Cobar region pmd*CRC T11 project (van der Wielen and Korsch, 2007), but includes additional shallow sources.

Magnetic modelling

On the eastern end of the COOLABAH profile (Figure 6) TMI anomalies due to ultramafic bodies have amplitude exceeding 1800 nT, dwarfing the quartz–magnetite–hematite horizons which produce anomalies of 50 to 100 nT amplitude at most. Ultramafic rocks in this area have magnetic susceptibilities between 250 and 20000 x 10^{-5}, with strongly serpentinised rocks showing slightly reduced values (1500 x 10^{-5}). A complex pattern of tight folding is inferred for the Birrimba area, and a larger more open structure (syform–antiform pair) interpreted for the West Lynne serpentinite.

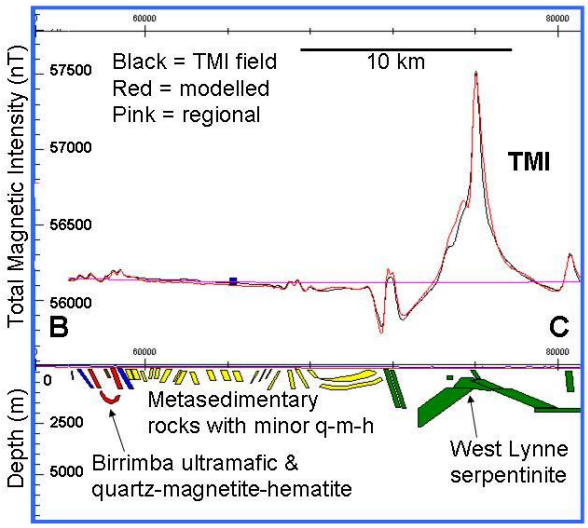

Figure 6. Modelled magnetic data for the southwest of COOLABAH (location B–C in Figure 3).

CONCLUSIONS

This interpretation and modelling of geophysical data for the Coolabah 1:100 000 map sheet area has reconciled surface geological information with magnetic and gravity sources, and investigated the continuation of those sources with increasing depth. The two data sets show reasonable correlation in the Birrimba and West Lynne areas where interpreted bodies of mafic, ultramafic and quartz–magnetite–hematite rocks revealed by magnetic data extend to depths of around 2 km. The broad gravity high on the map sheet, however, does not have a close correlation with magnetic sources, and the modelling of regional gravity data suggests that pyroxenite/serpentinite intrusions (similar to the Gerar anomaly) could be present below 5 km depth.

Recent mapping advances are highlighting the stratigraphic component to controls on copper mineralisation. This interpretation provides information on the distribution of mafic, ultramafic and quartz–magnetite–hematite bodies, but it also raises questions. For example, why do the mafic rocks around the Girilambone–Tritton mine area occur on the margins of the deeper gravity highs, and are those margins structurally controlled?

The process of investigation has assisted with the mapping for the compilation of a solid geology map and cross-section in the regional mapping project, and has also provided deeper information which will be of use when tectonic concepts and regional geochemical trends are considered in future.

ACKNOWLEDGMENTS

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