Interpretation of aeromagnetic and gravity data from western New South Wales – identifying basin and basement geology

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SUMMARY

High resolution aeromagnetic data and regional gravity data have been interpreted by the Geological Survey of New South Wales for the western half of the state. The region lies between the Curnamona Province and Koonenberry Belt in the far west, and the Lachlan Orogen in the central west, and it extends from the Queensland border to the Victorian border. Overlapping sedimentary basins – the Darling Basin, Eromanga Basin, and Murray Basin – cover virtually all the basement rocks throughout the region.

The primary objective is to identify lithological and structural variations within the basement layer, using them as the basis for creating an interpretive geophysical–geological map of the basement surface. Samples and information from drill holes (including water bores) provided limited geological control on the basement layer. Major results are improved classification of the numerous interpreted granite intrusions and recognition of major structures. Regions have been identified where basement occurs at depths viable for mineral exploration.

The detailed study has also defined subtle features in the aeromagnetic data that relate to basin structure and stratigraphy. These sequences include the Cobar Supergroup and the Darling Basin, and provide information which could be applicable to petroleum exploration, and groundwater and geosequestration investigations.

Key words: Darling Basin, aeromagnetic interpretation, gravity interpretation, western Lachlan Orogen, Thomson Orogen.

INTRODUCTION

The Geological Survey of New South Wales (GSNSW) aims to increase understanding of the geology in the Western Division of New South Wales, a broad region which is characterised by extremely flat, deeply weathered terrain. The surface geology is dominated by well developed regolith units and very limited exposures of sedimentary rocks (Figure 1). Basement rocks of Proterozoic to early Palaeozoic age crop out further west in the Curnamona Craton around Broken Hill, and the adjacent Koonenberry Belt. Palaeozoic metasedimentary rocks and intrusions dominate the geology of the Lachlan Orogen to the east of the study region. The identification of areas with only thin sedimentary cover can generate fresh exploration terrains with mineral prospectivity within New South Wales. A major uptake of exploration licences occurred for the poorly understood Thomson Orogen in the northwest of the state following the release of pre-competitive high resolution geophysical coverage of the Eromanga Basin in 2005.

Additional information on basement geology would assist in better understanding the inter-relations of tectonic zones adjacent to, and within, the Western Division of New South Wales. The contribution which geophysical datasets can provide in this region is vital, an example being interpretation by Hallett et al. (2005) which showed continuation of both the Stawell Zone and Bendigo Zone northward from Victoria, and defined the Hay–Booligal Zone within New South Wales.

The current study region has been the focus of several major basin studies of petroleum, geothermal and groundwater potential, with some using extensive appraisal of geophysical data (Pearson 2002, Hus et al. 2006). The sedimentary basins vary in age and distribution, the youngest being a relatively even thickness of Mesozoic sedimentary rocks of the Great Australian Basin, comprising the Eromanga Basin (in the north) and the Murray Basin (in the south). Sparse drilling has encountered small infrabasins of Permo-Triassic sedimentary rocks locally (such as the Oaklands Basin near Jerilderie) but their distribution is not well understood. The Darling Basin contains thick sedimentary sequences (up to 12 km thick) which have been tested by limited drilling and seismic surveying.

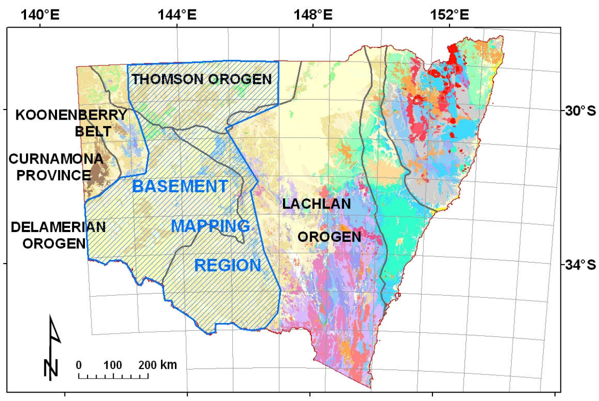

Figure 1. Location of the project region (blue hatching) in the Western Division of New South Wales and the distribution of major tectonic units relevant to the basement geology. The background map is the New South Wales Surface Geology (2nd edition) with Quaternary geological units shown in shades of beige.

The interpretation procedure is based on the 'GeoMag' style of Isles and Rankin (2008), a technique of manually tracing and studying the characteristics of magnetic anomalies and rationalising the likely correlations with mapped geological information. This approach is particularly suited to extrapolating geology into areas covered by regolith or shallow sedimentary basins. While sedimentary basins are generally characterised by low magnetic intensity and gravity values, this study examined subtle trends from short-wavelength features to better understand near-surface basin architecture. It also considered long-wavelength features that are related to intra-basement sources.

METHOD AND RESULTS

Geophysical imagery and other relevant datasets were compiled and analysed using Esri ArcGIS software. Earlier geophysical interpretation linework for the Thomson Orogen (Hegarty, 2010) and for the Hay–Balranald area (Carlton, 2011) were incorporated. The capture of map data took place within the framework of the New South Wales Statewide Geodatabase GIS which allows modification should additional information become available.

The initial stage of interpretation was manual recognition of aeromagnetic trends from high-frequency filtered images; mainly a greyscale first vertical derivative image of TMI RTP. Anomalies are likely to relate to a range of shallow magnetic sources, including regolith, cultural and noise features, so only those trends interpreted as being due to bedrock geological sources are included. Viewing SPOT satellite imagery and topographic maps aided those decisions.

The second stage involved recognising pattern discontinuities among the anomaly trends, which were interpreted to relate to fault structures or lithological boundaries, and attributing that linework. Information related to longer wavelength anomalies in TMI and gravity data was interpreted in conjunction with seismic sections and drill logs to understand the basement layer. Unit polygons were created to represent interpreted basement geophysical–geological units.

Basin-related features

The interpretation identified many short-wavelength aeromagnetic features in 1VD TMI RTP imagery. Sources of cultural origin (such as towns, metal bores and gas pipelines) were ignored, and any features coincident with palaeodrainage or major watercourses were discounted. Narrow magnetic trends with consistent orientation are associated with strandlines within the Murray Basin. Many curvilinear aeromagnetic trends (typically traceable for 20 km to 100km) were mapped throughout the Darling Basin – in particular near the basin margins – and are considered to be related to bedrock geology. While there may be some degree of enhancement or reduction in anomaly amplitude due to flight drape over ridges or from regolith effects due to terrain, examination of data and imagery from the well exposed and mapped areas of the Darling Basin found these effects are not significant. Eroding ridges of coarse-grained sandstone have particularly low magnetic intensity but are readily traceable from SPOT imagery. The interbedded sedimentary rocks, which are poorly exposed on hill slopes and along valleys, show parallel linear trends of elevated magnetic intensity. Those rocks are probably finer-grained, more thinly bedded or less mature than the ridge sandstone, and are not well defined on SPOT imagery. Improved mapping resulted from combining the trends gathered from SPOT imagery and aeromagnetic data (Figure 2)

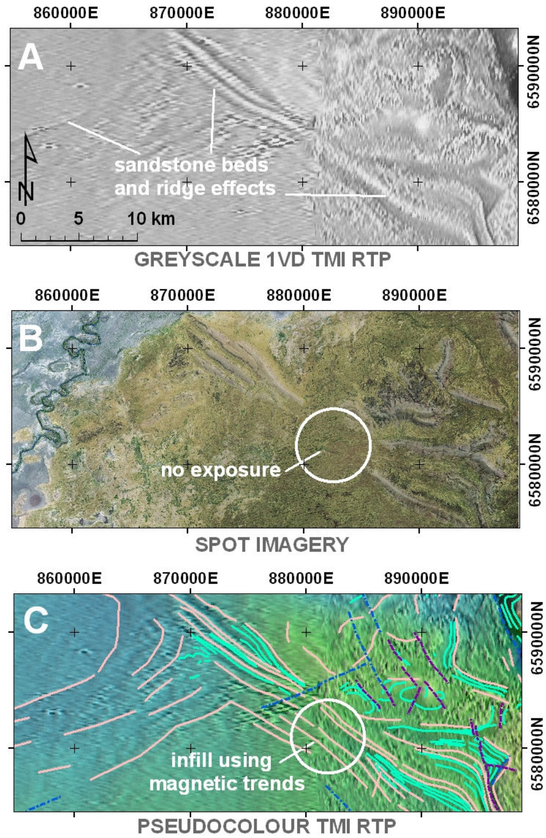

Figure 2. Short-wavelength linear features in aeromagnetic data (A) relate to bedding within the Late Devonian sedimentary rocks along the northeastern margin of the Nelyambo Trough. Outcrops of sandstones form discontinuous ridges in SPOT imagery (B). Combining bedding trends and structural discontinuities obtained from SPOT imagery (in green and purple) and aeromagnetic data (in pink and blue) enables more comprehensive interpretation (C).

Basement-related features

Previous geophysical studies within the Darling Basin by Gunn (2003, 2008) concluded that gravity lows occur over basement granites and synclinal sediment troughs, noting that these features are often coincident. Hus et al. (2006) suggested that granite provided a stable basement and thus any overlying sequences underwent only gentle folding in response to Palaeozoic deformation. In contrast, rocks close to and adjoining the intrusions suffered greater deformation and became the sites of increased thrust faulting and major anticlines.

Along some margins of the Darling Basin it is possible to extrapolate the basement lithologies from adjacent mapping. An example of this is the faulted eastern margin of the Yathong Trough, southwest of Cobar, where the gravity low due to the S-type Thule Granite can be traced westward beneath the overthrust basin sedimentary rocks (Figure 3). A small window to basement exposes granite along a narrow, strongly faulted antiformal zone, but the penetration provided by gravity data allows basement to be interpreted under adjacent sedimentary cover of the Darling Basin.

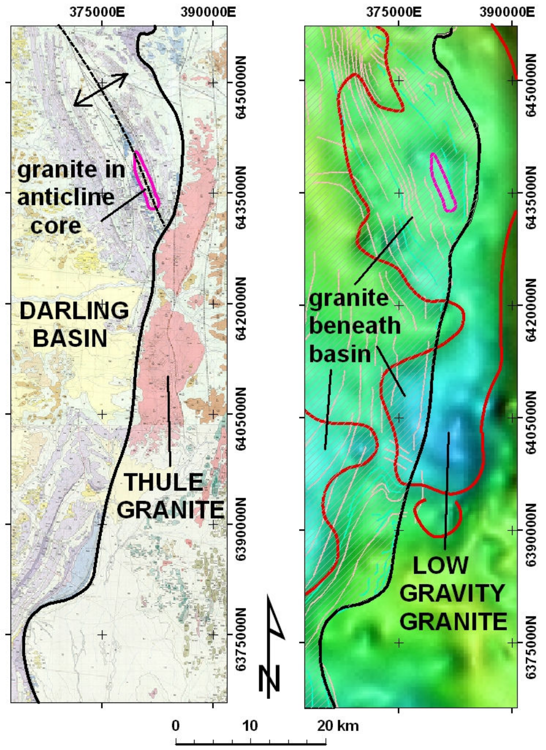

Figure 3. Gravity data assists basement mapping beneath the Yathong Trough in the Darling Basin. The Devonian sedimentary units of the trough are thrust eastward over Silurian Granite (map on left). Small basement inliers expose granite in structural settings within the basin. The potential extent of granite beneath the Yathong Trough is outlined in red on the isostatic Bouguer gravity image (right), showing the location of the fault-controlled eastern edge of the Devonian basin (black line).

Aeromagnetic data contributed basement information in the Thomson Orogen (in the north of study area) and the Delamerian Orogen (in the southwest). Short-wavelength magnetic features in the Pooncarie, Manara and Anabranch 1:250 000 map sheet areas have indicated a broad region where basement could be expected within 300m of the surface. Sparse drilling encountered bedrock at depths of less than 200m. The main lithologies recognised in this southwestern region are phyllite and metasedimentary rocks of unknown age, feldspar porphyry, and Devonian granite.

Careful interpretation of geophysical data incorporated SPOT imagery and existing mapping, forming a structural framework for the Western Division. Comparisons between the subtle trends in aeromagnetic data – which can often relate to major drainage patterns or regolith features – and SPOT imagery revealed fault patterns which appear meaningful (in the absence of more information). The results have been checked against surface positions for faulting shown in seismic surveys, but further three-dimensional analysis would be valuable. Important regional structures have been resolved, including a set of northeast-trending en echelon fractures extending over 200 km from the Manara 1:250 000 map sheet area to the Cobar area (including the Danyo Fault and Norwood Fault). These fracture patterns identified from aeromagnetic data are located along a major contrast in gravity data on the Neckarboo High.

CONCLUSIONS

Like previous workers, this study has found that gravity highs reflect major antiforms and rises in basement, and that gravity lows result from granitic basement, deep basins, and major synclines. The increased amount of detail from this interpretation – including subtle features identified from high resolution aeromagnetic data – has improved the understanding of basement and basins in the Western Division of New South Wales. The information gained is applicable to petroleum exploration, investigation for groundwater, and the search for potential geosequestration sites. While there is a degree of subjectivity for the trends and discontinuities in the geophysical data, care has been taken to incorporate information from mapping, drill logs, seismic sections and satellite imagery.

The interpretation has resulted in basement maps of areas within the Western Division which have been little explored; in particular the Thomson Orogen. The geophysical–geological units and structures provide a framework for basement in the region, and the mapping will be incorporated into the New South Wales Statewide Geodatabase GIS. The interpretation has also highlighted large areas where basement may lie at drillable depths in the southwest of the state, thus enhancing its mineral prospectivity.

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REFERENCES

Carlton, A.A., 2011, Geophysical–geological interpretation notes for the Hay 1:250 000 map sheet area (SI/55–9). Geological Survey of New South Wales Report GS2011/0800.

Gunn, P., 2004, Interpretation of gravity and magnetic data over the Darling Basin, PEL 8, PEL 422, PEL 424. New South Wales. Geological Survey of New South Wales Report GS2008/0477.

Gunn, P., 2008, Interpretation of gravity and magnetic data over Red Sky Energy Ltd Permits, Darling Basin, New South Wales. Geological Survey of New South Wales Report GS2008/0477.

Hallett, M., Vassallo, J., Glen, R., & Webster S., 2005, Murray–Riverina region: an interpretation of bedrock Palaeozoic geology based on geophysical data. Quarterly Notes of the Geological Survey of New South Wales 118.

Hegarty, R.A., 2010, Preliminary geophysical–geological interpretation map of the Thomson Orogen in Thomson Orogen: release of preliminary and provisional information, June 2010 (Digital Dataset). Geological Survey of New South Wales, Maitland.

Hus, R., Pryer, L., & Petrovich, S., 2006, Murray–Darling–Eromanga Infill SEEBASE and Structural GIS Project. Report to NSW Department of Primary Industries by FrOG Tech Pty Ltd.

Isles, D., & Rankin, L., 2008, Geological interpretation and structural analysis of aeromagnetic data. Short course presented to the Geological Survey of New South Wales, Orange.

Pearson, P., 2002, Darling Basin SEEBASE ™ Project: SRK Consulting Project MR710. Geological Survey of New South Wales, NSW Department of Primary Industries. Report GS2006/146.