Yathong Trough deep 2D reflection seismic survey – identifying major structures for the southern Cobar Basin, NSW.

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SUMMARY

Two 2D deep seismic reflection survey lines totalling 229 km in length were completed in western NSW by the Geological Survey of New South Wales (GSNSW) under the New Frontiers initiative. Contract management for seismic acquisition and data processing were conducted by Geoscience Australia (GA), with funding for data processing contributed by Coal Innovation, NSW Industry. The survey aimed to detail the stratigraphy of thick Devonian sequences within the Yathong Trough in the eastern Darling Basin.

Survey line YT2 was extended eastwards across the southern Cobar Basin over rift-phase volcanic sequences of the Cobar Supergroup in the Mount Hope and Rast Troughs. The objective of acquiring 20 s two-way time data was to identify major structural elements, crustal architecture, and to improve understanding of this mineralised region. Preliminary interpretation of the deep 2D seismic data by GSNSW and GA has recognised reflector domains and discontinuities below the surface outcrops (in the east) and also within basement rocks beneath the basin sequences. These were considered in the context of regional aeromagnetic and gravity data, and previous deep seismic profile interpretations for the Cobar region. The key results are definition of crustal thickness and interpretation of prominent fault structures in the upper and middle crust. In particular, good correlation was found between near-surface fault zones (from geological mapping or interpreted from potential field data) and faulting related to a major west-dipping high-angle seismic discontinuity that penetrates to the middle levels of the lower crust.

This presentation describes the interpretation of major reflective horizons and structures, identifying upper, middle and lower crustal features. The profiles and interpretations will provide valuable input for regional geodynamic studies. Increased structural understanding may assist the search for additional gold and copper deposits in the southern Cobar Basin.

Key words: deep seismic reflection survey, Darling Basin, Yathong Trough, Cobar Basin, Mount Hope Trough, structural geology.

INTRODUCTION

The opportunity to acquire a deep seismic reflection survey in the southern portion of the Cobar Basin arose by extending a survey for petroleum investigations of the Yathong Trough stratigraphy within the Darling Basin during 2013. Acquisition of two seismic profiles was completed by Terrex Seismic (Tucker et al., 2014) as part of the GSNSW New Frontiers initiative to promote under-explored areas within NSW:

- Line YT01 is aligned approximately north–south, linking through the existing Rankins Springs deep seismic line 08GA-RS1. This line aimed to examine the stratigraphy of the longest axis of the Yathong Trough, where basin fill exceeds 5 km in thickness.
- Line YT02 lies approximately east–west, crossing the southern end of Line YT01. More than one half of the YT02 line length extends eastward of the Darling Basin, crossing several stratigraphic zones of the Cobar Basin on The Mount Allen and Kilparney 1:100 000 map sheet areas.

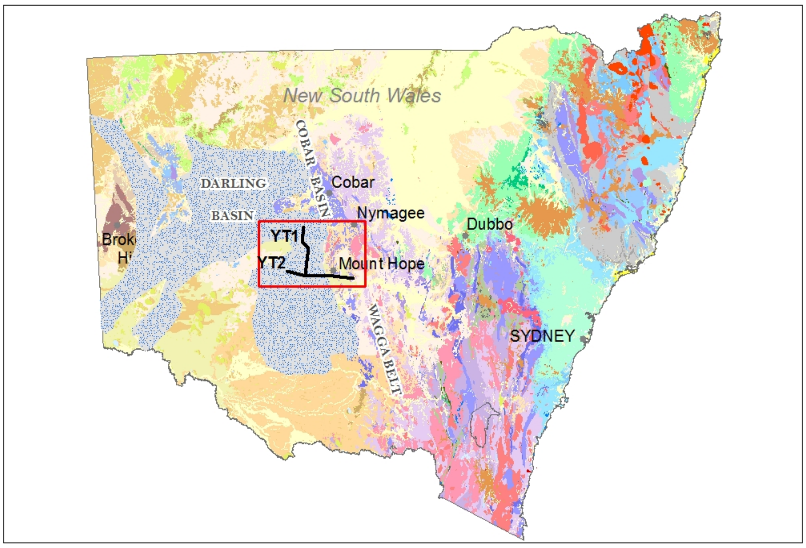

Figure 1: Location of the Yathong Trough deep seismic survey lines

Palaeozoic basement rocks of the Lachlan Orogen in central and western NSW have had a complex structural history with a series of deformational events evidenced by field mapping, drill holes, mine records and potential field geophysical data. The juxtaposition of metasedimentary rocks of Ordovician age against volcanic and sedimentary units of the Siluro-Devonian Cobar Supergroup commonly occurs along regional faults. These, together with deformational fabrics, create an overall north to north-northwest trend throughout the Cobar Basin (Figure 2).

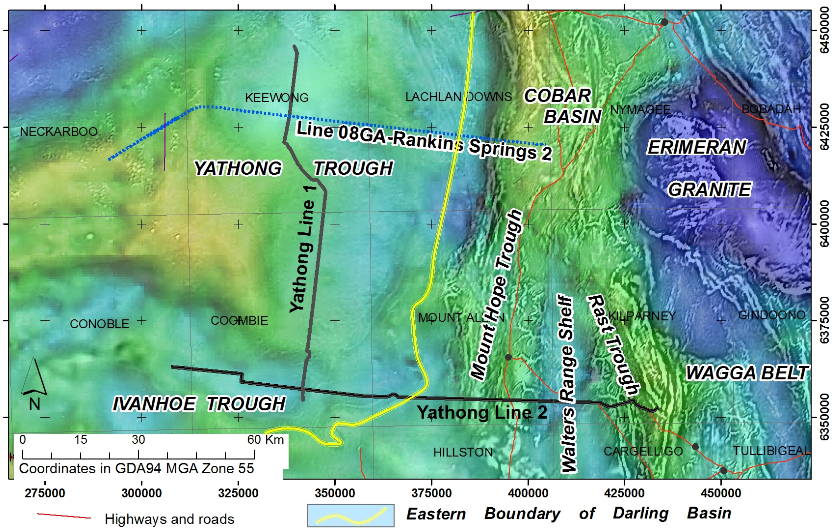

Figure 2: Locations of deep seismic lines relative to tectonic units, shown on a composite image of greyscale first vertical derivative total magnetic intensity (1vd TMI RTP) merged with pseudocolour isostatically-corrected Bouguer gravity

Previous structural interpretations of the Cobar Basin have concentrated in the areas immediately west, and southwest, of the Cobar mineral field. An explosive-source seismic survey of three regional lines was conducted in 1989 by a consortium of government agencies and mineral exploration companies. A tectonic model of basin formation was interpreted from profiles by Glen et al. (1994) and Drummond et al. (1992). This tested and developed two fundamental concepts for the Cobar Basin, that:

1. complex growth faulting sets were active during basin deposition, potentially controlling locations suitable to focus and preserve synsedimentary mineralisation, and
2. "thin-skinned" imbricate thrust sets above high-level detachments could have accommodated both extension phases and basin inversion.

The Rankins Springs 2D deep seismic survey was completed by GA in conjunction with GSNSW in 2008/200 to investigate the eastern margin of the Darling Basin at two locations – in the northeast (Yathong Trough) and the southeast (Cocoparra Group), Correlations between reflectors and the stratigraphy of Devonian Mulga Downs Group were interpreted by Carr et al. (2002) for the northern Line RS1, with a steeply west-dipping fault recognised bounding the eastern extent of the Yathong Trough. The pmdCRC final report for the T11 Cobar Project (van der Wieelen, 2007) includes serial east-west cross sections at 6,350,000 mN and 6,370,000 mN which straddle the position of recent seismic line YT02. Those two sections present a pattern where both east- and west-dipping upper crustal faults merge, soling into horizontal detachment zones at mid-crustal levels – Cobar Basin units being localised and preserved within those faulted blocks. This pattern is consistent with reactivated synsedimentary block faulting which Scheibner (1987) described from field relations in the Mount Allen map sheet area.

To interpret the newly acquired 20 s profiles, an in-house workshop was held by GSNSW. This resulted in a first-pass appraisal of fault systems in upper- to mid-crustal zones, as well as providing information on the nature of the Moho and the mantle.

METHOD AND RESULTS

Geoscientists from the three contributing GSNSW workgroups (including regional mapping, mineral systems, petroleum, geothermal and geosequestration staff) participated to create the preliminary linework from the deep seismic profiles using paper sections and 3D visualisation. The workshop included available geological maps and other seismic sections. Near-surface fault trends were also interpreted based on analysis of first-vertical derivative and tilt-filtered TMI images, isostatic gravity data, and multi-scale edge gravity gradients (generated using Intrepid WormE™ software). Preliminary 3D models had already been created for the Yathong Trough and Ivanhoe Trough (immediately to the south) for petroleum and geosequestration studies.

Fault traces mapped and inferred by Scheibner (1987: Mount Allen area) and Trigg (1987: Kilparney area) bound the major stratigraphic packages along Line YT02 (summarised in Figure 3). In addition to the meridional fault zones, sets of northeast trending faults occur at a spacing of 1 to 8 km. Mapped, inferred and potential faults identified, from west to east, are:

1. Mount Hope Lineament
2. Possible southern extension of Thule Fault southward beneath cover
3. Possible southern extension of Boolahbone Fault and intrusions

4. Great Central Fault – Sugarloaf fault
5. Scotts Craig Fault
6. Un-named fault between Waters Range Shelf and Rast Trough
7. Extension of Woorara Fault (postulated Rookery Fault extension)

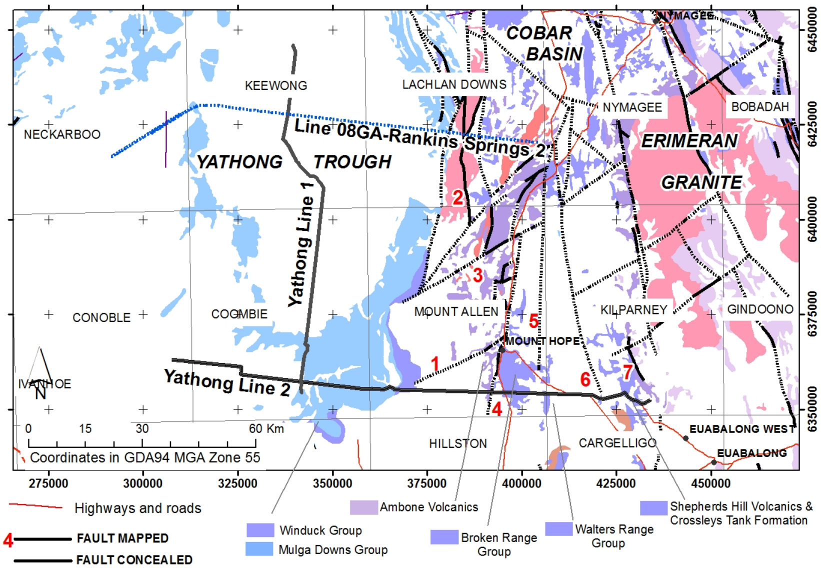

Figure 3: Locations of stratigraphic packages and regional fault patterns relevant to the deep seismic profiles

The overall layout of basin units and deeper reflections is shown in Figure 4. During interpretation it was possible to match some surface traces to identify major fault zones within the reflections, in particular the Scotts Craig Fault and the Boothragandra Fault (from the south). There are some challenges presented with interpretation of 2D profiles in this circumstance, where conjugate sets intersect the YT02 at low angles, but a dominant west-dipping penetrative fault is confidently correlated with the meridional Scotts Craig Fault. The fault blocks east of this trace appear on seismic images as thrust splays related to the main structure (potentially late movement or reactivation), where the steep fault may represent a late phase of reactivation within a lower angle overall structure (i.e. the Scotts Craig Fault surface trace being a steepened, late, high-strain zone). West of the main fault discontinuity on seismic images there are a series of antithetic reflective zones interpreted as faults – these blocks may represent sites of early growth faulting, with clear evidence of post-basin deposition, reverse movement during compressive events.

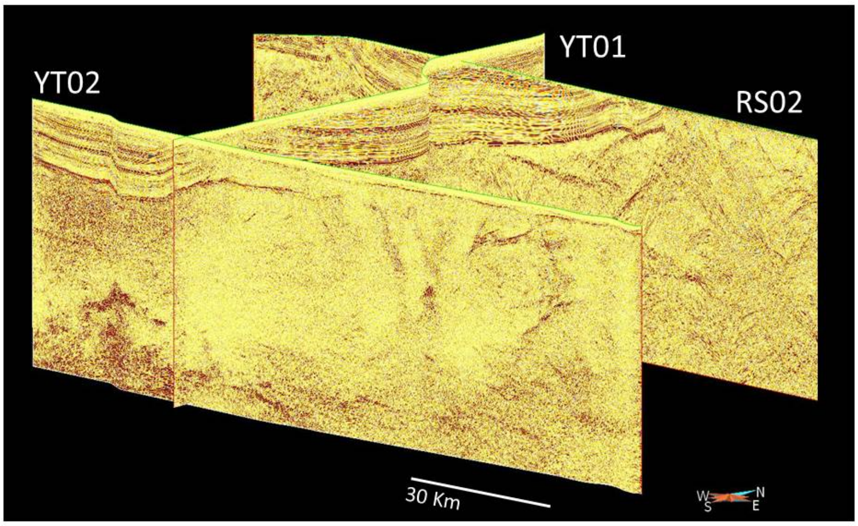

Figure 4: 3D perspective view of newly acquired 20 s Yathong Trough deep seismic lines YT01 and YT02, showing the existing Rankins Springs profile acquired in 2008/2009

The overall bland (low reflection) nature of the upper crust appears to be a typical feature within the region, where metasedimentary rocks of various ages, before and after the Benambran cycle, share similar composition and metamorphic grade. The interpretation recognises a series of low- to moderate-dipping patterns of reflection breaks within the upper, middle and lower crust along Line YT01. These potential faults consistently dip southwards beneath the southern half of the Yathong Trough in the central area of Line

YT01. It is difficult to relate this to other seismic lines, due to the distance, so the true orientations are unknown. An interesting raft of highly reflective material is evident below this complex area, isolated within the mantle below 33 km depth.

Elsewhere on the lines, the nature of the lower crust is reasonably consistent. It includes marked displacement of reflectors into the mantle where the Scotts Craig Fault extends west at great depth. There are also poorly understood irregular reflections in the mid to lower crust beneath the southern Yathong Trough. The Moho depth is estimated as being from 30 to 33 km along both of the seismic lines.

The potential of structures as pathways to focus the metal-bearing fluids into suitable stratigraphic and structural sites has been reviewed for the Cobar Basin by David (2003). A wide variety of deposit styles were recognised with structural controls, in particular with imbricate thrust zones and anticlinal hinge zones, and basin-wide tear faults that offer dilational sites. Synsedimentary mineralisation may have spatial associations with faults active during sedimentation.

CONCLUSIONS

(1) Deep seismic profiling reveals details of structural complexity both below the Devonian sequences of the Yathong Trough and the adjoining units of the Cobar Basin.
(2) Profile YT02 displays a major west dipping fault corridor which penetrates the upper, middle and lower crust. Antithetic faulting on the west side (and splays on the east side) are likely to have been active in the rift phase of the Cobar Basin, as well as accommodating basin closure.
(3) Interpretation of Line YT01 identified a consistent, but internally complex, zone of south-dipping faults below the Yathong Trough
(4) Interpretation aimed to be cautious and restrained, considering limitations due to processing artefacts, out of plane effects, bland zones, and the inherent over-emphasis of low angle and flat contrast features in the seismic method.

As mineralisation styles are associated with structures at different times in the evolution of the Cobar Basin, the interpretation of this deep crustal seismic data will contribute to prospectivity evaluations in future.

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REFERENCES

Carr, L.K., Korsch, R.J., Jones, L.E.A., and Holzschuh, J., 2002, The role of deep seismic reflection data in understanding the architecture and petroleum potential of Australia's onshore sedimentary basins, Geoscience Australia poster GA18093.

David, V., 2003, Cobar Superbasin System Metallogenesis, paper presented at Sydney Mineral Exploration Discussion Group, http://www.smedg.org.au/Daviab.pdf, 1-13

Drummond, B. J., Glen, R.A., Goleby, B.R., Wake-Dyster, K. D., and Palmer, D., 1992, Deep seismic of the Cobar Basin-II a ramp basin controlled by a deep detachment. Geologocal Society of Australia, Abstracts 32, 44.

Glen, R.A., Drummond, B.J., Goleby, B.R., Palmer, D., and Wake-Dyster, K.D., 1994, Structure of the Cobar Basin, New South Wales, based on seismic reflection profiling, Australian Journal of Earth Sciences, 41:4, 341-352.

Scheibner, E., 1987. Geology of the Mount Allen 1:100,000 Sheet 8032. New South Wales, Maitland.

Trigg, S., 1987, Geology of the Kilparney 1:100,000 Sheet 8132. New South Wales Geological Survey, Maitland.

Tucker, J., Manicaros, R., and Coleshill, L., 2014, Terrex Seismic Field Operations Report for Yathong Trough 2D, report prepared for NSW Trade & Investment.

van der Wieelen, S., and Korsch, R. (editors) 2007, 3D Architecture and predictive Mineral System Analysis of the Central Lachlan subprovince and Cobar Basin, New South Wales, Final Report for the *pmd**CRC T11 project.