Preliminary results from the Thomson-Lachlan Deep Seismic Survey, northwest New South Wales

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Background

The Thomson Orogen is one of the five orogenic belts that form the Tasmanides of eastern Australia (Glen 2005). Although it occupies a vast area of western and central Queensland, very little is known about the orogen since it is covered by recent sediments as well as by the Mesozoic Eromanga Basin. Regional gravity and aeromagnetic data, suggest that the Thomson Orogen also extends south into NSW, occupying the far northwestern part of the state between Tibooburra and northeast of Bourke. This frontier of NSW geology is the focus of investigation by the Geological Survey of NSW because of its possible mineral potential coupled with the presence of mafic to intermediate igneous rocks reported from drill holes around the village of Louth.

The metallogenic implications of a major east-west gravity high, curvilinear aeromagnetic highs and igneous rocks in the southern part of the Thomson Orogen, and relationships with the Lachlan Orogen to the south, were the focus of the 2005 Thomson-Lachlan deep seismic reflection survey that forms a key part of the New South Wales Department of Primary Industries (NSWDPI) Exploration NSW Initiative. Other partners in the project are Geoscience Australia and the Predictive Mineral Discovery Cooperative Research Centre.

Objectives & Aims of Project:

The seismic project had both economic and scientific objectives.

The economic objectives were:

- To investigate the potential for a new metallogenic province north of the Thomson-Lachlan boundary, characterised by possible arc and ocean-crust related gold and base metal deposits.
- To investigate the potential for Mississippi Valley style silver and zinc deposits along the margins of the Mt Jack High, south of the boundary between the orogens.
- To collect key new data on the Nelyambo Trough, a key Devonian basin, with hydrocarbon potential, immediately south of the boundary.
- To investigate the potential for new Cobar-style deposits south of the boundary and examine the linkage between the between the Lachlan and Thomson orogens and evolution of the Cobar Basin and its rich base metal and gold deposits.

Tectonic aims of the survey were to:

- Investigate the nature and location of the east-west boundary between the Lachlan and Thomson orogens in north central New South Wales.
- Establish whether this boundary was part of a complex Delamerian or Benambran convergent margin.
- Establish the crustal geometry of this boundary, and interpret it in terms of north-south (repeated) ?oblique collisions through the Palaeozoic.
- Examine the possible link between evolution of the Tasmanides and intracratonic deformation of the Alice Springs Orogeny.
- Interpret the source of the second highest gravity anomaly, with associated magnetic highs.

Three traverses were sited to cross a ‘simple’ east-west section of the southern Thomson Orogen, where it is marked by a major east-west gravity high and linear magnetic highs that extend as far south as the southern edge of the Thomson Orogen defined from gravity data. These traverses crossed the boundary with the Lachlan Orogen and into the Devonian Nelyambo Trough and the Mt Jack High to the south.

Coupled with existing drill core data and proposed new drilling to basement, the seismic reflection survey was designed to reveal critical data on the crustal architecture across this major tectonic boundary. This in turn will allow us to model the geological history of the adjacent parts of the two orogens. Defining the tectonic framework will enable metallogenic models of this region to be placed on a more sound footing.

Background Geology

Palaeozoic geology in the vicinity of the seismic survey is mostly concealed beneath thin cover of alluvium or the southern part of the Mesozoic Eromanga Basin. The geology of the Thomson Orogen and the Thomson-Lachlan boundary itself are inferred from aeromagnetic and gravity data, supplemented by very sporadic outcrop (mainly to the east in a structurally complex area between Louth and Bourke) and drill holes.

State-wide aeromagnetic and gravity data indicate a major and abrupt change in tectonic grain from north-south in the south to curvilinear east-west in the north. This change is inferred to represent the boundary between the Thomson Orogen and the Lachlan Orogen. It lies just south of the second highest gravity anomaly in NSW with its coincident, curved aeromagnetic linears. The similarity of the gravity responses north of this boundary with those of accreted gold- and copper-rich Ordovician Macquarie Arc sampled by seismic reflection profiling in 1997 and 1999 (Glen *et al*. 2002) suggests that the boundary may be a convergent margin, marked by the possible development of island arc and ocean crustal igneous rocks. The southern edge of this anomalous curvilinear east-west zone coincides with the inferred Olepoloko Fault (Stevens 1991) and the Louth-Eumarra Shear Zone (Glen *et al*. 1996).

Thomson Orogen:

The southern part and southern boundary of the Thomson Orogen have curvilinear east-west trends that are convex to the south. Gravity data show a three-fold broad subdivision into a northern high, a central low and southern high that decreases in intensity towards the Thomson-Lachlan boundary. The central low reflects the presence of Late Devonian strata in the Paka Tank Trough in the east and probable granites farther west. The southern high coincides with mafic to intermediate igneous rocks between Louth and Bourke in the east, and these rocks are also inferred to underlie the gravity ridge to the west. The southern flank to this high is underlain by sedimentary rocks, some possibly turbiditic.

Available drill hole data show that the igneous rocks include volcaniclastic sediments, mafic to intermediate volcanics, gabbros and ultramafics. At least some of these rocks, at Louth and at Mt Dijou and Bald Hills (which we here suggest lie just north of the Thomson-Lachlan boundary), have oceanic island basalt (OIB) chemistry (K. Dadd Macquarie University written comm.). Uncertain age data suggests a possible Ordovician age near Louth. Recently, late Early Ordovician conodonts have been identified from inter-pillow material at Bald Hills (I. Percival unpublished palaeontology report 2006).

Granites and calcsilicates in thermal metamorphic aureoles occur in the eastern part of Thomson Orogen (eg at Doradilla, where granite and a porphyry dyke have been both dated as Triassic by Lance Black, pers. comm.).

Key high-grade metamorphic rocks occur in a couple of localities: kyanite-bearing in the east and sillimanite amphibolite facies in the west.

A key point is that Late Devonian sedimentary rocks occur in both orogens. This implies that the two orogens were most likely assembled before deposition of these rocks, and that the last deformation is post Late Devonian, probably Carboniferous in age.

Known mineral deposits include Doradilla southeast of Bourke and those around Mt Dijou south of Bourke.

Lachlan Orogen:

The Lachlan Orogen near the seismic line has a four-fold stratigraphic subdivision (Glen *et al*. 1996).

- The youngest rocks are mid to Late Devonian continental sandstone, shale and conglomerate of the Mulga Downs Group. The thickness may approach 4km. This unit crops out in the Nelyambo Trough and also on the Mt Jack High.
- Below the Mulga Downs Group are latest Silurian to Early Devonian rocks of the Cobar Supergroup. These were deposited in the Cobar Basin and on two flanking shelves, the Kopyje Shelf to the east and the Winduck Shelf to the west. These sediments probably thin over the Mt Jack High.
- Basement to the Cobar Supergroup consists of three units: Silurian granites, Ordovician turbidites of the Girilambone Group, and in one locality in the southeastern part of the Mt Jack High, hornfelsed Late Ordovician graptolitic shale probably part of the Bendoc Group. Turbidites of the Girilambone Group are associated with local mafic volcanics; serpentinites also lie along major faults.

Seismic Acquisition

The seismic data were acquired in August-September 2005 along 3 lines using vibrator trucks as the energy source. The lines mostly followed shire roads and station tracks. The seismic acquisition was carried out by ANSIR: the National Research Facility for Earth Sounding, who provided the seismic equipment and expertise during field acquisition. ANSIR’s facility manager, Terrex Seismic Pty. Ltd. conducted the field acquisition. ANSIR used an ARAM 24-bit 240 channel recording system in conjunction with three HEMI-60 (60,000 lb) peak force vibrators as the source.

An experimental program, designed to compare a number of source and recording parameters, was undertaken at the beginning of the survey. Experiments included monosweep and varisweep sweep configurations, different sweep frequencies, sweep length and source configuration. Several of the basic acquisition parameters, such as group interval, CDP fold, vibrator point interval and record length were selected from Geoscience Australia’s experience of the previously acquired data in hard rock environments.

Seismic line 05GA-TL01, 99.2 km long, is oriented northeast-southwest and follows the northern bank of the Darling River. This line is entirely within the Lachlan Orogen and, for the most part, traverses the Nelyambo Trough and the Mt Jack High.

Seismic line 05GA-TL02, 115.5 km long, is oriented north-south and ties in with the northeast end of line TL1. It investigated the Thomson-Lachlan boundary. The line extends to the north to examine the magnetic and gravity high and the southwestern extension of the Paka Tank Trough.

Seismic line 05GA-TL03, 73.2 km long, is oriented north-south, and was planned to investigate the Thomson-Lachlan boundary and cross a narrow part of the Nelyambo Trough, to terminate on the Mt Jack High in the Lachlan Orogen. Drought-breaking rain resulted in the shortening of traverse 05GA-TL3 by approximately 8 km in the north.

A total of 288 km of 2D seismic data were thus collected.

Preliminary Geological Interpretation

05GA-TL01

- Mid to Late Devonian sedimentary rocks in the Nelyambo Trough thicken to the southwest, to a thickness of at least 6-7 km. This sedimentary package is cut by northeast dipping thrusts.
- The Mt Jack High is located further south than predicted from gravity data alone, and represent a complex thrust zone that cuts the mid-Late Devonian rocks.
- There is a highly reflective lower crust.
- The Moho is relatively flat at ~32 km.

05GA-TL02

- The Thomson-Lachlan boundary dips north and cuts through the entire crust.
- The Moho lies at a depth of ~32 km under the Lachlan Orogen, but is deeper (~48 km) under the Thomson Orogen. This raises the question as to whether the Moho has been downwarped or faulted.
- The seismic character of the crust is very different under the two orogens.
- There is up to 5 km of mid to Late Devonian sedimentary rocks in the Nelyambo Trough.

05GA-TL03

- The Thomson-Lachlan boundary is a major planar fault dipping to north and cutting deep into the crust.
- The Nelyambo Trough contains at least 5 km of mid to Late Devonian sedimentary rocks.
- A probable Early Devonian half graben lies beneath the mid to Late Devonian sedimentary rocks.
- The Mt Jack High is defined by northwest-directed thrusting over the Nelyambo Trough, which occupies a triangle zone between inwardly dipping thrusts.

Preliminary Tectonic and Economic Implications

1. The boundary between the Thomson and Lachlan orogens is a north-dipping fault zone/shear zone that cuts down through the crust. Latest movement was in the Carboniferous, part of the Kanimblan Orogeny, and related also to north-south shortening of the Alice Springs Orogeny.
2. North-south interactions between the Thomson and Lachlan orogens during the Palaeozoic were probably responsible for the north-south components of shortening and extension recorded in the Lachlan Orogen (Glen 2005).
3. Mid to Late Devonian strata in the Nelyambo Trough seem to be underlain by ?Early Devonian strata preserved in rift graben. These graben thin onto the Mt Jack High.
4. The Lachlan Orogen has a very reflective lower crust, which is not seen in the seismic lines in the Lachlan Orogen to the east (Glen *et al*. 2002), but is seen in the Eromanga-Brisbane seismic transect in southern Queensland (Finlayson *et al*. 1990). This raises the question as to whether the Girilambone Group is actually part of the Thomson Orogen.
5. The greater thickness of reflective lower crust (?mafic granulites) in the Thomson Orogen raises questions as to whether it was doubled up on the north-dipping bounding thrust? If so, this must have been in response to a collision to the north (in Southern Queensland).
6. At present, we are uncertain how much of the east-west gravity high in the Thomson Orogen is due to this thickened crust and how much to volcanics in the upper crust.
7. The OIB volcanics in the Thomson Orogen probably formed as seamounts on oceanic crust.
8. While the ultimate tectonic setting of the southern Thomson Orogen is still unclear, it may have constituted an east-west convergent margin towards which seamounts of different ages were being carried as a result of seafloor spreading.
9. Identifying this margin, any possible arc and the suture itself remain priority issues.

10. Economic targets include more Girilambone-style deposits associated with mafic to intermediate volcanic rocks in the southern Thomson Orogen, MVT type deposits on the flanks of the Mt Jack High and enhanced hydrocarbon prospects in anticlinal and other structures in the Nelyambo Trough.
11. The significance of the Doradilla style of deposits requires reinvestigation within the crustal architecture and tectonic framework derived from the deep seismic reflection data.

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