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Progress in deep seismic reflection transects across Australia

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The geotransect concept

In 2007, a working party of the National Committee for Earth Sciences, in association with AuScope, prepared a concept for a suite of geotransect corridors across the continent designed to implement the recommendation of the 2003 National Strategic Plan for the Earth Sciences: 'That the nation invest in a major geotransect study to gain fundamental information about the Australian plate, from its basic structure and evolution through to its mineral and petroleum systems and surficial processes'.

The transect plan illustrated in Figure 1 was used to guide AuScope investment in reflection and magnetotelluric work. The corridors build in part on the major efforts in reflection work with explosive sources, notably the 2000 km long Eromanga–Brisbane profiles of the Surat transect in Southern Queensland, which was acquired in stages from 1980 to 1986.

Australian seismic reflection database

The Australian continent has arguably the best coverage of all the continents for full-crustal deep seismic reflection data. To date, a total of more than 22 700 line-km of data have been acquired across most of Australia's major boundaries and provinces. Almost all of these data have been processed and delivered by the seismic and magnetotelluric team at Geoscience Australia.

In 1997 funding from the Australian Government to the ANSIR Major National Research Facility allowed the purchase of 4 heavy-duty vibrator sources for seismic reflection profiling together with modern recording equipment. Since the first survey in 1999 more than 12 700 km of reflection profiles across Australia have been carried out with coverage of the full crust (Figure 1).

The surveys have been supported by Geoscience Australia (GA), particularly through the Onshore Energy Security Program, the State and Territory Geological Surveys and the AuScope infrastructure program. Substantial investment from the Royalties for Regions funds in Western Australia and the Greenfields 2020 funding in Queensland have been a major contributors to the increase in coverage in these states.

Compared to the previous explosives sources, the vibrator sources allow a more rapid coverage and a large increase in the fold of reflection cover with consequent improvement in imaging quality. Current surveys use at least 75-fold cover, whereas with explosive sources it was often difficult to achieve even 10-fold. The result is an extensive pattern of large-scale reflection profiles that illuminate many of the geological features of the continent.

Demand for seismic has increased dramatically, with more than 1870 km of data collected or 'on the books' for 2014 alone. These raw and processed data provide an unprecedented view of the nature and structure of Australia's crust and upper mantle, which has led to new understanding on how and when the continent evolved and where minerals and energy resources are likely to have accumulated.

Recent surveys

With funding from the Geological Surveys of Western Australia and South Australia, AuScope and Geoscience Australia an 835 km-long profile across the Nullarbor Plain was completed at the turn of the year (2013–14). This survey forms the eastern half of the Eyre transect, which links an almost complete transect from west to east across the continent by linking the different surveys. The new profile extends from the Albany–Fraser Orogen across the Eucla Basin to the Gawler Craton and fills in the gap in a trans-continental transect including Eyre, Flinders and Surat transects (Figure 1).

In late May 2014 a 670 km-long reflection profile, funded by the Geological Survey of Queensland, was completed in northern Queensland. Known as the Cork Fault survey, these data partly complete the northern end of the Thomson transect (Figure 1). The survey also links to the previous surveys carried out in the Mt Isa region in 2006 and across to the Georgetown Inlier in 2007.

During June and July 2014, a 705 km-long survey, funded by the Geological Survey of Western Australia, was acquired along the coast road between Port Hedland and Broome, crossing the Canning Basin. This latest survey is parallel to the proposed Rudall transect (Figure 1).

Figure 1 represents the full extent of land seismic reflection profiles in Australia that provide coverage of the whole crust, together with the lines immediately offshore of Tasmania. This large body of information is held in the archives at Geoscience Australia in digital form and the images and data from each survey can be downloaded from their web site (see below).

A new seismic atlas

In addition, a compilation of images of the reflection results and accompanying geological information has been prepared,

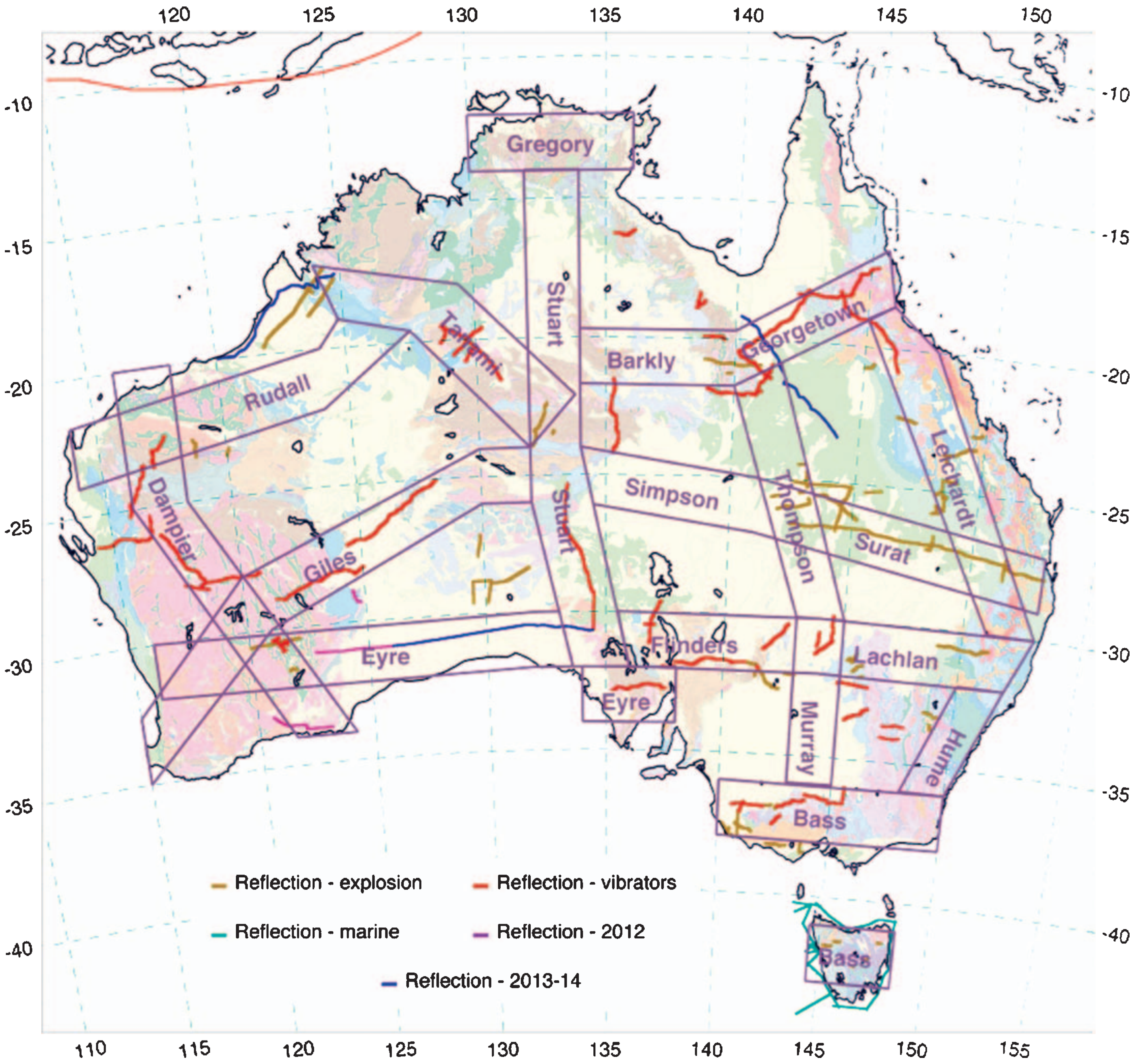

Figure 1. *Current configuration of full-crustal reflection profiles across Australia superimposed on the geological map (Source: Geoscience Australia). Transect corridors recommended by the 2007 working party are shown.*

with the aim of providing an overview of the full range of information on crustal structure and evolution contained in the reflection profiles. The publication *Deep Crustal Seismic Reflection Profiling: Australia 1978–2011* by Kennett *et al.* (2013) a co-publication by ANU Press and Geoscience Australia is available for free download as a PDF File (140 Mb). The book is also available for print on demand from ANU Press, in A4 landscape format.

Each reflection profile is presented at approximately true scale with up to 220 km of profile per page and overlap between pages. The sections were prepared to fit on an A3 page, but will stand further enlargement. Each reflection section is accompanied by a geological strip map, which shows the configuration of the line superimposed on 1 : 1 M-scale geology.

Figure 2 presents an example from the 2007 reflection profiling in northern Queensland, illustrating the major change in crustal structure at the edge of the Mt Isa Province with very different crustal reflectivity patterns. The latest 670 km-long profile in North Queensland crosses the 07GA-IG1 line illustrated in Figure 2 at approximately CDP 7000 and thus provides direct 3-D control on this complex structure that lies entirely under cover.

The compilation of deep crustal seismic results also includes a number of large-scale reflection transects, which are groups of 1000 km or longer that link across major geological provinces, and an extensive bibliography of reports and relevant publications. As new reflection surveys are released, we aim to produce a supplement with the new sections and updates of

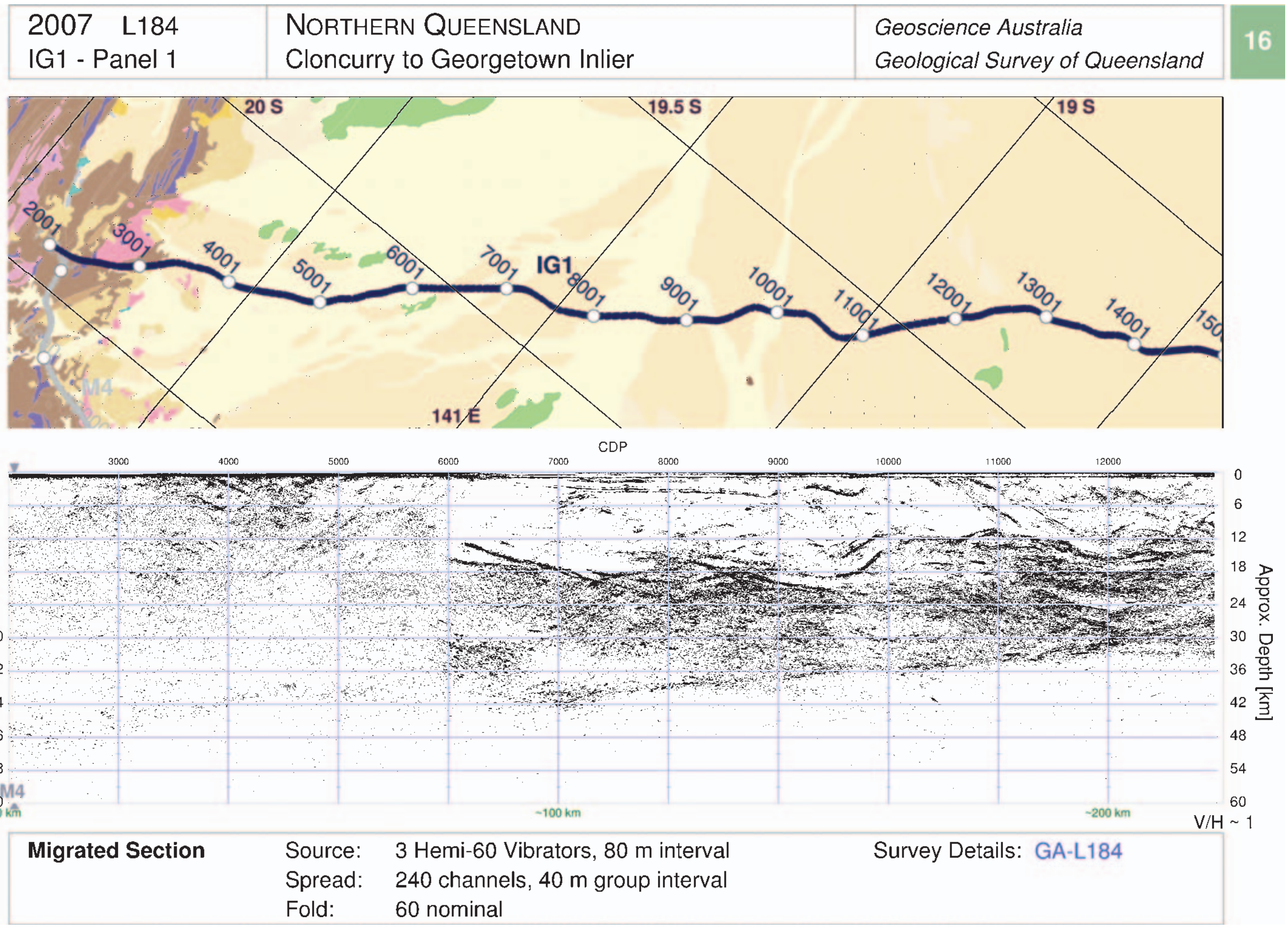

Figure 2. *Illustrative page from Kennett et al. (2013) for a section of 2007 reflection profiling in North Queensland, demonstrating the extension of the Mt Isa Province undercover and a dramatic change in crustal architecture at CDP 6000.*

older pages, where appropriate. These transects, including the latest results from 2012 surveys in the Albany-Fraser region of Western Australia, are available for free download at the Australian National University's Research School of Earth Sciences (RSES) seismology pages (see link below). The resolution is such that these long transect surveys can be plotted in large-scale formats.

Implications of the deep-crustal seismic transects for resource potential

The deep-crustal seismic reflection profiles provide one component of the information required to understand the structure and evolution of the continent and its minerals, energy and water resource potential. The seismic data need to be combined with a full suite of geophysical, geological, geochemical and geochronological results to secure maximum benefit. In regions of sparse to nonexistent basement outcrop, the reflection results allow a deep crustal image of underlying geology that otherwise would not be evident.

Having the seismic database has allowed systematic interpretation of the data, in particular the major terrane boundaries. Korsch and Doublier (2014) have produced a new map of the major boundaries, many of which are the first-order structures that control the focus of mineral systems, such as nickel and gold.

The deep-crustal seismic reflection lines have changed the way people think about a region's geology and prospectivity. For example, the deep-crustal seismic reflection data along the Bass transect in western Victoria (Figure 1) changed the interpretation of the tectonic setting to be one suggestive for Cambrian Andean-style copper mineral systems (Cayely, 2011). As a result, Geoscience Australia and the Geological Survey of Victoria are testing this metallogenic model with a new drilling programme in the Stavely Zone. Several companies are also actively exploring this region for gold, copper and other base metals.

The future

Although Australia has made remarkable strides in studying the transect corridors, many segments have yet to be addressed. Notable gaps include southwest Giles, Simpson, northern Stuart, Barkly, Gregory, Hume and Leichardt transects. There are plans for the infill of the eastern Bass transect and further surveys are planned around the northern end of the Thomson transect (Figure 1). As funds become available the priority will be to continue to complete the geotransect vision of the National Committee for Earth Sciences.

References and other web links

Australian National University Research School of Earth Sciences seismology http://rses.anu.edu.au/seismology/AuSREM/Reflection_Atlas/ (link to the long seismic transects)

Cayley, R., 2011. Exotic crustal block accretion to the eastern Gondwanaland margin in the late Cambrian, Tasmania, the Selwyn Block, and implications for the Cambrian-Silurian evolution of the Ross, Delamarian and Lachlan orogens. *Gondwana Research* **19**, 628–649.

http://portal.auscope.org/portal/gmap.html (a portal for many geoscience data layers)

http://www.ga.gov.au/news-events/newsletters/minerals-alert/minerals-alert/minerals-alert-june-2014#b (for instructions on how to find the seismic data)

Kennett B.L.N., Saygin, E., Fomin T. & Blewett R.S., 2013. Deep Crustal Seismic Reflection Profiling Australia 1978–2011. ANU Press–Geoscience Australia. http://press.anu.edu.au/titles/deep-crustal-seismic-reflection-profiling/

Korsch, R.J. & Doublier, M.P., 2014. Major crustal boundaries of Australia. 1st edn. Scale 1 : 2 500 000. Geoscience Australia, Canberra.

***Richard Blewett** joined Geoscience Australia in 1990 as a structural geologist and has worked in many of Australia's Proterozoic and Archaean terranes. He has been involved in the interpretation of nine deep seismic transect programmes in Queensland, South Australia, Northern Territory and Western Australia. He is presently the Group Leader of Mineral Systems in the Resources Division at Geoscience Australia.*

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