

Contents

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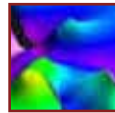
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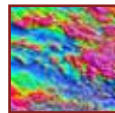
2



Integrated assessment of the Capel and Faust basins, offshore eastern Australia

4

New insights into the prospectivity of remote frontier basins



New magnetic datasets to identify energy, geothermal and mineral resources

10

New compilation of Magnetic Anomaly Map of Australia released



Winner's Bore—hard-won outback water

12

An important legacy of the Palaeovalley Groundwater Project

In brief

Aerial survey sets new benchmark 16

Gawler Craton and Curnamona Province seismic lines show potential 17

Towards a global earthquake model 18

Assessing the impact of seawater intrusion on groundwater 19

Product news

New geochronology results from South Australia 21

Gawler–Curnamona region mineral exploration maps now available 22

New geophysical datasets released 23

New maps cover the Red Centre 24

New maps of Australian territories 25

Events

27



CEO comment



Dr Chris Pigram – CEO Geoscience Australia



This issue of *AusGeo News* features several articles relating to Geoscience Australia's programs to provide pre-competitive information to significantly reduce risk in exploration and support development of Australia's onshore and offshore energy resources. There is also an article describing how a project investigating groundwater resources in Australia's arid areas has left a lasting legacy for two remote communities.

This issue reports on the new insights into the geological evolution and petroleum prospectivity of the Capel and Faust Basins. These deepwater basins, located 800 kilometres off the east coast of Australia, have previously seen little scientific or petroleum exploration effort. The assessment, carried out as part of Geoscience Australia's Offshore Energy Security Program, has significantly advanced current knowledge of the area and will guide future scientific and resource exploration in this vast frontier region.

The new fifth edition Magnetic Anomaly Map of Australia was released by Geoscience Australia on 1 July. Results from the Australia-wide airborne geophysical survey, a major output from Geoscience Australia's Onshore Energy Security Program, have been incorporated into the new map. As our article reports, the new edition includes an estimated 27 million line-kilometres of survey data which is eight million line kilometres more than the previous edition. Information from the new map and associated grid database provides insights into the distribution of magnetically susceptible minerals within the Earth's crust.

There is also a brief report on the most extensive airborne electromagnetic survey ever undertaken in Australia (the Frome survey) which will cover almost 10 per cent of South Australia's total area. Other reports covering products from the Gawler Craton and Curnamona Province in South Australia, include:

- Key results from seismic and magnetotelluric surveys which suggest that these regions have a high potential for uranium and other mineralisation
- New mineral maps using satellite imagery which can be easily integrated with other datasets, such as geology and regolith maps, in a GIS

- Geochronology results which will inform interpretation of the recently acquired seismic lines.

There is also a report on the installation of Winner's Bore on the Nyirripi to Kintore back-road in the southwest of the Northern Territory. These two Aboriginal communities are separated by a vast expanse of inhospitable desert and vehicle breakdowns along the road were particularly hazardous. A drilling program in the area by the Palaeovalley Groundwater Project, led by Geoscience Australia, found fresh groundwater. The installation of a hand pump at Winner's Bore is a lasting and durable legacy of the Project.

As usual we always appreciate your feedback and encourage you to use the online rating mechanism with each article.



Introducing the new CEO

The appointment of Dr Chris Pigram as CEO of Geoscience Australia was announced by Mr Drew Clarke, Secretary of the Department of Resources, Energy and Tourism, on 17 June 2010. Mr Clark said Dr Pigram's appointment was 'the culmination of a long and successful career in Geoscience Australia' and that it was 'especially pleasing to have a candidate of his experience and standing to take on the leadership role'.

Dr Pigram trained as a geologist and has over 30 years experience in a wide range of geological research and mapping. He has been a senior research manager since 1993 and has led Geoscience Australia's marine and petroleum geoscience and minerals geoscience programs. Prior to his appointment as CEO, he was Deputy CEO and Chief of the Geospatial and Earth Monitoring Division.

Dr Pigram has worked extensively in Australia as well as southeast Asia and the western Pacific. He has authored or co-authored over 90 publications covering tectonics, petroleum, basin analysis and marine geoscience. He is a graduate of the Australian Institute of Company Directors (2001) and participated in the APS Senior Leadership program - Leading Australia's Future in Asia in 2004.

After graduating with a BSc (Hons) in applied geology from the University of New South Wales in 1974 he joined the then Bureau of Mineral Resources, Geology and Geophysics (BMR), and was seconded to the Papua New Guinea Geological Survey. In 1978 he joined a BMR-led Australian aid project carrying out geological mapping in Indonesia. After returning to Australia in 1984 he joined the BMR's Marine Program and subsequently obtained a PhD in marine geoscience from the Australian National University. He became Chief of the Petroleum and Marine Division in 1993.

Dr Pigram was part of a working group that developed Australia's Marine Science and Technology Plan following the development of Australia's Oceans Policy in 1996. He also served on the National Committee for Earth Sciences that prepared a Strategic Plan for the Earth Sciences in Australia in 2003 under the auspices of the Australian Academy of Science. He is also a former member of the Australian Academy of Science's Solid Earth Sciences Committee.

He is a past Chairman of the Australian Committee for the Ocean Drilling Program (ODP) after serving as the PACRIM Consortium ODP Council Member from 1996 to 1998. He is the Australian Government representative on the Australian New Zealand Land Information Council.

Dr Pigram has been the Geoscience Australia Board Member for a number of Cooperative Research Centres. He has also been a member of university advisory committees at the Australian National University's Research School of Earth Sciences and the Centre for Ore Deposits Research at the University of Tasmania.



Geoscience Australia's new CEO Dr Chris Pigram following his appointment in June 2010



Chief of Minerals Division in the Australian Geological Survey Organisation (Geoscience Australia's predecessor) in 2000.



During fieldwork in Papua New Guinea in the 1970s, pointing out a soft sediment deformation in Cretaceous aged rocks in the Wahgi Valley.



Integrated assessment of the Capel and Faust basins, offshore eastern Australia

New insights into the prospectivity of remote frontier basins

Takehiko (Riko) Hashimoto, Nadege Rollet, Karen Higgins, Peter Petkovic, Ron Hackney and Geoff Fraser

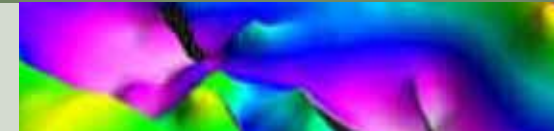
A recent assessment carried out by Geoscience Australia has provided new insights into the geological evolution and petroleum prospectivity of the Capel and Faust basins. These remote deepwater basins, located about 800 kilometres off the east coast of Australia in water depths of 1300 to 2500 metres (figure 1), have previously seen little scientific or petroleum exploration effort. This assessment was carried out under the Australian Government's Offshore Energy Security Program as part of Geoscience Australia's continuing efforts to identify a new offshore petroleum province and deliver pre-competitive geoscience information (*AusGeo News* 84).

“The analysis of geological relationships from the basement through the basin sediments to the seafloor was facilitated by 3D visualisation and geological modelling.”

Regional setting

The Capel and Faust basins are located within a large continental fragment that extends about 1600 kilometres from the southwest of New Caledonia to the Bellona Trough west of New Zealand (figure 1). Most of this fragment is located within the limits of the Australian Exclusive Economic Zone and Extended Continental Shelf as defined by the United Nations Convention on the Law of the Sea (UNCLOS).

Previous work in the region (including Willcox et al 2001; Staggs et al 2002; Willcox & Sayers 2002; van de Beuque et al 2003) was based mainly on a sparse coverage of 2D regional seismic data. This data included acquisitions by the Shell RV *Petrel* (1971) survey and the Australian Geological Survey Organisation (AGSO) surveys s177 (1996) and s206 (1998). The only well in the Capel and Faust basins is the Deep Sea Drilling Program (DSDP) drill-hole 208 (figure 1), which terminated at 594 metres below the seabed in Late Maastrichtian nannofossil chalk. There are no petroleum exploration wells in the area.



These early surveys indicated the existence of multiple large sedimentary depocentres in the region. Tectonic reconstructions (such as Norvick et al 2001, 2008; Willcox et al 2001) suggested that these basins were formed initially during the Early Cretaceous rifting of the former eastern Gondwana margin. This was followed by further rifting during the Late Cretaceous leading up to the opening of the Tasman Sea (Hayes and Ringis 1973; Gaina et al 1998). As such, the basins shared a common origin with other Cretaceous eastern Gondwanan basins, including some that are petroleum producers such as the Gippsland and Taranaki basins. However, the lack of seismic imaging and well control in the deeper sections of the basins precluded an assessment of the total sediment thickness. This is a key determinant of the region's petroleum prospectivity.

Data acquisition

To fill some of the data gaps, Geoscience Australia completed a series of marine surveys over the Capel and Faust basins during 2006 and 2007 (figure 1). The joint French–Australian

AUSFAIR survey in 2006 used the French Polar Institute (IPEV) vessel RV *Marion Dufresne*. The AUSFAIR survey collected shallow sediment cores to test for indications of gas hydrate deposits, and obtained rock samples to investigate the solid geology of the Capel, Faust, Fairway and New Caledonia basins (Colwell et al 2006). The survey did not yield conclusive evidence for gas hydrates. However it resulted in the recovery of volcanic and volcanoclastic rock samples that have provided invaluable information on the timing of deposition and geological setting.

The Capel–Faust GA-302 survey in 2006–2007 acquired approximately 6000 kilometres of high-quality 2D seismic data along 23 lines with a typical spacing between 15 and 35 kilometres (*AusGeo News* 86). This survey filled a significant seismic data gap in an area where the occurrence of large sedimentary depocentres was indicated on regional satellite gravity imagery and the few existing seismic lines (Kroh et al 2007). Data were recorded to 12 seconds two-way time (TWT) which enabled, for the first time, the imaging of the entire thickness of the basin sediments. The survey also acquired shiptrack gravity, magnetic and sonobuoy refraction data.

In late 2007, the GA-2436 survey, using the New Zealand vessel RV *Tangaroa*, acquired approximately 24 000 square kilometres of multibeam bathymetry and 11 000 line kilometres of shipboard gravity and magnetic data with a line spacing of three to four kilometres over the central part of the Capel and Faust basins (*AusGeo News* 89). The survey improved geophysical data coverage over the largest basin depocentres imaged by the GA-302 seismic survey. Sediment and rock samples as well as video footage were also collected as part of a joint marine reconnaissance survey mapping seabed environments and habitats (Heap et al 2009).

Assessment methodology

The key datasets for the geological and petroleum prospectivity assessment included 2D seismic reflection, seismic refraction (sonobuoy), gravity, magnetic, multibeam bathymetry and rock sample data. Given the sparse data coverage of the Capel and Faust basins and the lack of geological constraints (to help a better understanding) an integrated workflow was developed to maximise information output from the available data sets.

The analysis of geological relationships from the basement through the basin sediments to the seafloor was facilitated by 3D visualisation and geological

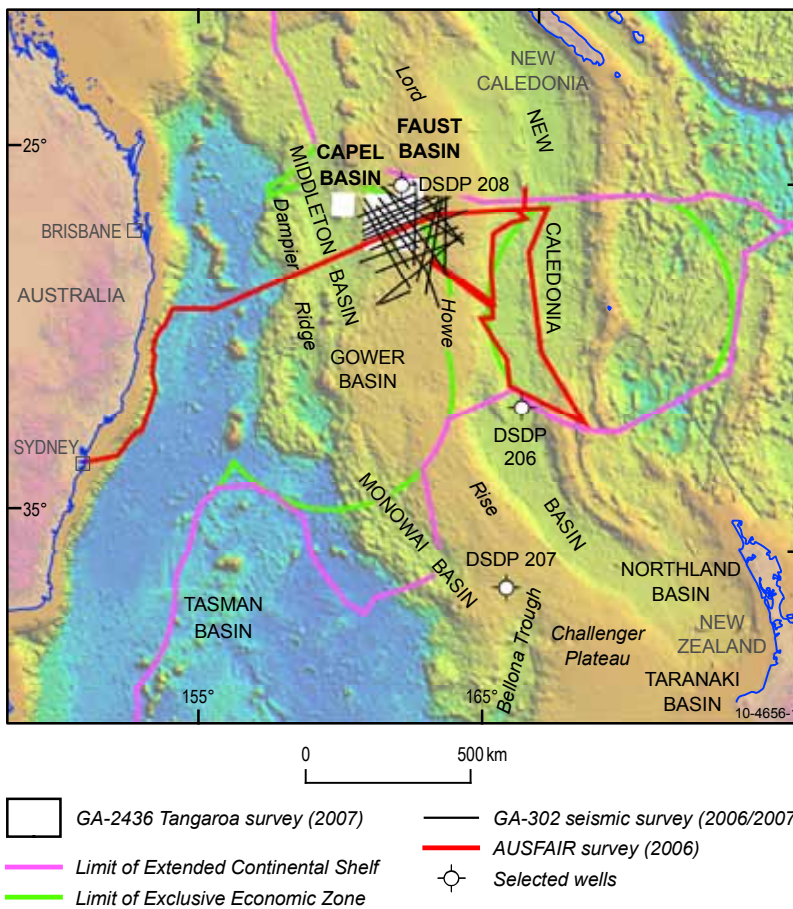


Figure 1. Location of the Capel and Faust basins, recent Geoscience Australia data acquisition surveys, DSDP drill holes and maritime boundaries.

modelling. In particular, the use of 3D analytical space assisted interpolation between the widely spaced seismic lines and in testing hypotheses regarding the complex basin architecture. Gravity data was found to be a reliable indicator of basement topography within the study area. Using this relationship, the sediment thickness distribution as interpreted from seismic data was tested by 3D gravity modelling. This provided a quality-control mechanism for the seismic interpretations.

In the absence of direct evidence, regional tectonic reconstructions and analogue basin studies were integrated with seismic interpretations. These were used to infer the composition and age of the basin sediments and the basement as well as the likely presence of petroleum system elements. Multibeam bathymetry and seismic data were integrated to map seafloor geology and fluid migration pathways. This provided an indication of seal integrity and the relationship between seafloor features and subsurface geological processes. Basin modelling, which was carried out in collaboration with GNS Science (Geoscience Australia's New Zealand equivalent), tested for the hydrocarbon generation and expulsion potential of the basins.

Basin structure and stratigraphy

The study has confirmed the existence of several large basin depocentres (or areas of thick sediments) within the Capel Basin and the western part of the Faust Basin, some of which measure up to 125 kilometres by 35 kilometres. The basin structure is complex, featuring a series of fault-bounded depocentres separated by basement highs (figure 2). The total thickness of sediment filling the depocentres increases westward, attaining a maximum of over six kilometres in the western part of the Capel Basin.

Seismic, gravity and magnetic data indicate a heterogeneous pre-rift basement underlying the Capel and Faust basins, including sedimentary, volcanic and intrusive rocks (figure 3). Regional tectonic reconstructions suggest that the sedimentary rocks may include the offshore extensions of the Mesozoic Clarence-Moreton and/or Maryborough basins of eastern Australia, both of which are known to contain potential petroleum source rocks.

The depocentres of the Capel and Faust basins evolved through two phases of rifting during the Early and the Late Cretaceous. Gravity, magnetic and fault modelling data suggest that a pre-existing NW-SE structural trend within the basement interacted with an E-W extensional vector to initially form NNE-SSW trending depocentres during the Early Cretaceous. This phase (Syn-rift 1) is likely to be part of a regional volcanic rifting event that affected much of the former eastern Gondwana margin during the Early Cretaceous. It resulted in widespread volcanoclastic deposition, such

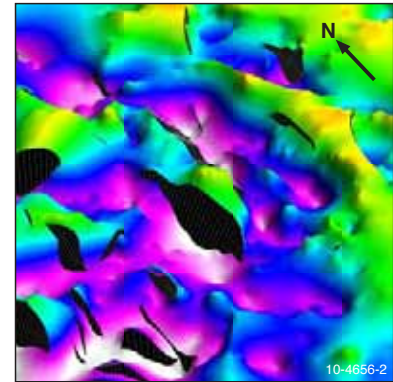


Figure 2. 3D geological model of the basement surface beneath the Capel and Faust basins, showing the compartmentalised, fault-bounded depocentres. The areas shown in violet to white colours indicate the depocentres while areas in yellow to green colours show the surrounding structural highs. The depocentres in the middle section are approximately 120 kilometres long.

as the Grahams Creek Formation in the Maryborough Basin (Hill 1994), Strzelecki Group in the Gippsland Basin and Eumeralla Supersequence in the Otway Basin (Norvick et al 2001, 2008; Krassay et al 2004). Seismic character and analogue basin studies suggest that widespread volcanics, volcanoclastic and fluvial sediments, localised coal and lacustrine sediments, were probably deposited in the Capel and Faust basins (figure 3). Syn-rift 1 deposition ended with regional uplift and erosion, probably correlating with a similar Cenomanian event in eastern Australia, attributable to a major reorganisation of the Australia-Pacific plate boundary (Veevers 2000; Norvick et al 2001, 2008; Willcox et al 2001; Schellart et al 2006; Rey & Müller 2010).

The second rifting event (Syn-rift 2) during the Late

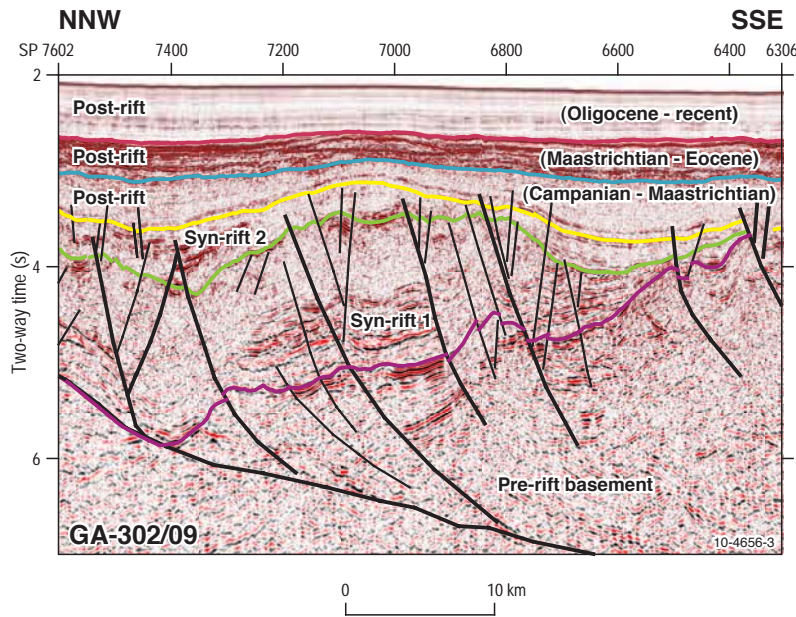


Figure 3. Seismic stratigraphy of the Capel and Faust basins.

Cretaceous appears to be related to the opening of the Tasman Sea to the west (Hayes and Ringis 1973; Gaina et al 1998). In the Capel and Faust basins, rifting was focused in the westernmost areas, where the earlier formed NNE–SSW rifts were overprinted by NW–SE trending depocentres. Sediments deposited during this phase are likely to be predominantly fluvial, with deltaic, shoreline and shallow marine sediments in the uppermost part of the succession (figure 3). It is likely to correlate with the Emperor and Golden Beach subgroups of the Gippsland Basin (Bernecker & Partridge 2001; Bernecker et al 2001; Norvick et al 2001), and the Taniwha and Rakopi formations of the Taranaki Basin (King & Thrasher 1996; Norvick et al 2001, 2008; Uruski & Baillie 2004). Volcanism appears to have been common during the Syn-rift 2 phase. Ion microprobe (SHRIMP) dating of trachyte and latite samples recovered during the AUSFAIR survey (Colwell et al 2006; Purvis & Pontifex 2006) to the southeast of the Faust Basin yielded Late Cretaceous ages. Rhyolite from the DSDP 207 drilling site on the southern Lord Howe Rise was previously dated at around 94 million years (van der Lingen 1973).

Thermal subsidence of the region from the Late Cretaceous to the present resulted in marine deposition under progressively deepwater conditions. In the earlier part of this post-rift phase (figure 3), shallow to deep marine clastic sediments were deposited. Seismic data have revealed features that may be deltaic, shoreline and turbidite sand bodies. Since the Late Maastrichtian, deep marine conditions have dominated, resulting in the deposition of chalk, marl and calcareous ooze. The lateral continuity and thickness make these fine-grained sediments a potential regional seal for petroleum traps. Cenozoic

igneous activity, fluid migration and tectonism have extensively affected the post-rift sediments, as discussed below.

Seafloor and shallow sub-surface geology

The high-resolution multibeam bathymetry data acquired during the GA-2436 survey has revealed a variety of seafloor features over the Capel and Faust basins, including mega-pockmarks, slumps, polyforms, domes and volcanoes. Integrated analysis of bathymetry and seismic data has revealed that the occurrence of seafloor features is strongly controlled by the basin structure and subsurface processes originating within the basins. Many seafloor features are related to fluid flow from the subsurface. They are commonly underlain by older, buried fluid migration features such as mud volcanoes and polygonal faults and by deeper igneous intrusions. Other seafloor features are related to post-intrusion subsidence and fault reactivation associated with the collapse of magma chambers in the subsurface.

Volcanic build-ups and intrusions, evident at the seafloor and revealed in the subsurface on seismic data, indicate widespread post-rift igneous activity during the Maastrichtian–Paleocene/Eocene, the Late Oligocene–Miocene and the Pliocene. The close spatial association between igneous intrusions and fluid-migration features indicates that these Cenozoic igneous pulses

were the major driver of fluid migration. Consequently they drove the development of most seafloor and fluid migration features in the Capel and Faust basins. The occurrence of expulsion-related features at the present-day seafloor, several million years after the last major igneous pulse, suggests that fluid migration is an ongoing process that continues to affect basin evolution long after the cessation of igneous activity.

Petroleum prospectivity

The main type of potential petroleum source rocks expected in the Capel and Faust basins are coaly sediments that may be present in the pre-rift and the Early Cretaceous syn-rift successions. Lacustrine sediments may also be significant as potential source rocks. Multi-1D basin modelling, carried out in collaboration with GNS Science, has indicated that these rocks would be capable of generating and expelling oil and gas. These results have alleviated long-held concerns that sediment thicknesses in the depocentres were insufficient for active petroleum systems. Potential reservoir rocks may be found in fluvial sandstones within the syn-rift succession and the deltaic, shoreline and shallow marine sandstones in the upper syn-rift and lower post-rift successions. The upper post-rift deep marine sediments may act as a regional seal. Expected major trapping styles include fault-related plays, stratigraphic pinch-outs, unconformity plays, and drape and anticlinal structures. 3D geological modelling indicates the existence of several large potential anticlinal structures with likely four-way closure. Much of the petroleum generation and migration is expected to have occurred before most trapping structures and the potential regional seal were in place by the Oligocene. However, a significant amount of generation is also likely after this time. Cenozoic igneous activity, if sufficiently extensive, has been shown to potentially have a positive effect on late-stage petroleum generation. On the other hand, the widespread fluid migration triggered by the Cenozoic magmatism is a major risk for seal integrity of the upper post-rift sediments.

Implications

The recent assessment by Geoscience Australia has significantly advanced current knowledge of the Capel and Faust basins and regional tectonic evolution. The study has also indicated that, if source rocks are present, these remote offshore basins may contain petroleum systems that are capable of generating and accumulating oil and/or gas. These findings will guide future scientific and resource exploration in the vast frontier region to the east of continental Australia and assist in reducing exploration risk.

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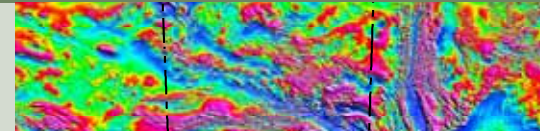
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New magnetic datasets to identify energy, geothermal and mineral resources

New compilation of Magnetic Anomaly Map of Australia released

Peter Milligan



Geoscience Australia has just released a new fifth edition full-colour Magnetic Anomaly Map of Australia at a scale of 1:5 million. It is estimated that 27 million line-kilometres of survey data were acquired to produce this new edition which is eight million line-kilometres more than were acquired for the previous edition released in 2004.

Information in the new magnetic anomaly map and associated grid database provides insights into the distribution of magnetically susceptible minerals within the Earth's crust. Such insights are of great value to energy and mineral exploration companies and for research into the solid earth and the environment. Magnetic minerals in small amounts are widespread in the crust, and become concentrated in zones which highlight the structure of the crust. This is particularly important for areas which have a significant thickness of surface cover (regolith and sedimentary basins) which can mask the underlying crystalline basement rocks. The magnetic signatures of the basement are measured through the cover and provide important information to help determine the nature and depth of the basement.

New independent airborne total-field magnetic data acquired in 2007 during the Australia-wide Airborne Geophysical Survey (AWAGS) have been used to increase the accuracy of intermediate wavelengths of the continental-scale merge of the grids. The very long flight lines of the AWAGS survey give an accurate coverage of the intermediate wavelengths (150 kilometres to 400 kilometres) of the Earth's crustal magnetic anomaly field. This provided an important control when merging nearly 800 separate airborne magnetic survey grids together to produce the new national dataset. The AWAGS survey was part of Geoscience Australia's Onshore Energy Security Program which is designed to reduce risk in exploration and support development of Australia's onshore energy resources.

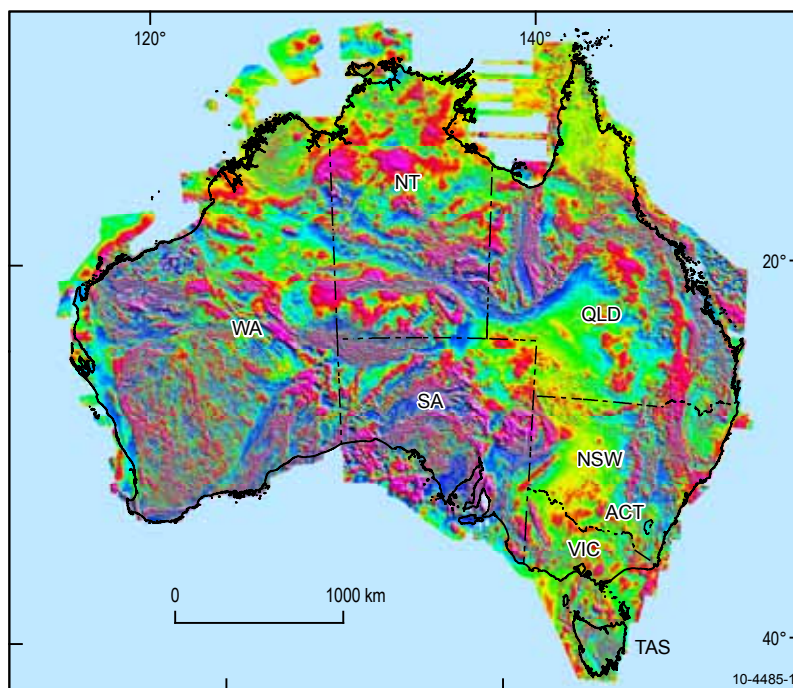


Figure 1. The main Total Magnetic Intensity colour image of Australia.

“This edition includes an additional 155 individual survey grids acquired since publication of the previous edition.”

For the composite grid used to produce this edition, 795 individual survey grids have been matched and merged, with the resolution of each grid optimal for the specifications of the original survey flight-line data. This edition includes an additional 155 individual survey grids acquired since publication of the previous edition. As well as the new composite digital grid of the total magnetic intensity (TMI) of Australia at a resolution of 80 metres (figure 1), a range of new digital derivative magnetic products at the same resolution will be released shortly. These will include variable reduction-to-the-pole of the TMI, the first vertical derivative of the TMI and various others.

Most of the new survey data have been acquired by the state and Northern Territory geological surveys.

The gridded datasets will be available free-of-charge in ERMMapper format from the Australian governments' Geophysical Archive Data Delivery System (GADDS). Because the new full-resolution grid datasets are up to 10 gigabytes in size an alternative is for Geoscience Australia to copy the data to a portable hard-drive disk supplied by the client. The Geoscience Australia contact is Murray Richardson (contact details below). Printed copies of the map are also available from the Geoscience Australia Sales Centre.

For more information

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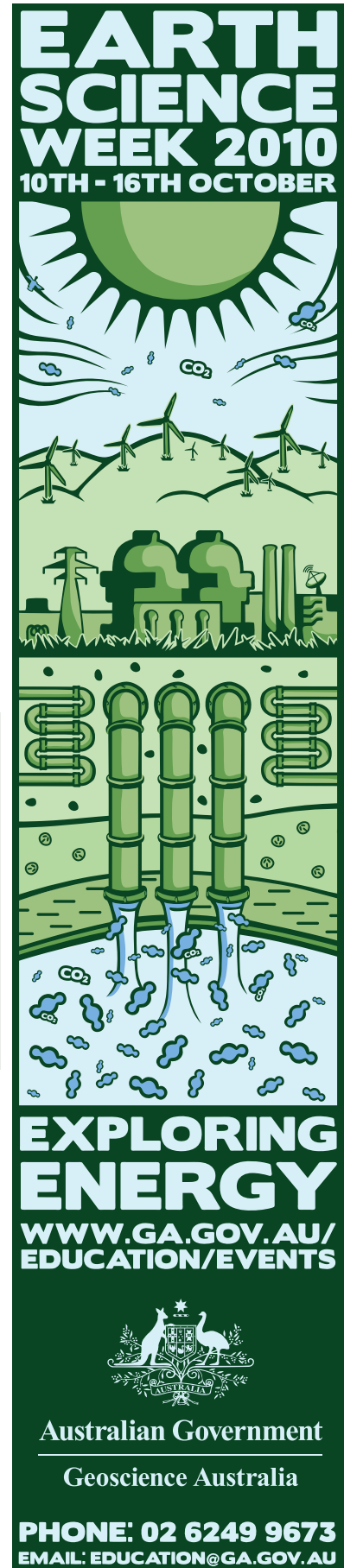
www.geoscience.gov.au/gadds

Onshore Energy Security Program website

www.ga.gov.au/minerals/research/oesp/

AusGeo News 92: New Radiometric Map of Australia

www.ga.gov.au/ausgeonews/ausgeonews200812/radiometrics.jsp



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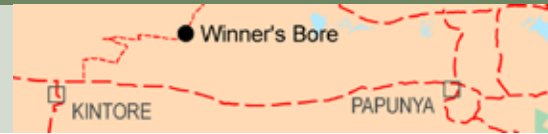
Australian Government
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Winner's Bore—hard-won outback water

An important legacy of the Palaeovalley Groundwater Project

John Wischusen and Steven Lewis



Nyirripi and Kintore are remote Aboriginal communities in the south-west of the Northern Territory, separated by a vast expanse of inhospitable desert. When Kintore community was established in 1981 the poor condition of the regional road network meant that a vehicle journey between the two communities involved considerable back-tracking and in excess of 450 kilometres of driving. In the late 1980s community members graded a more direct track to form the Kintore to Nyirripi back-road which is about 200 kilometres long (figure 1). However, the relatively small population of both communities and the remote arid location of this road meant vehicle breakdowns *en route* could be hazardous. This applied particularly during the summer months when temperatures commonly exceed

40°C and there were no permanent watering points readily accessible to travellers anywhere along the road.

The dangers posed by vehicle breakdowns on this remote road are widely recognised by the people of Kintore, Nyirripi and surrounding areas. In the summer of 1991 a famous Walpiri tracker and community police officer, Gavin Spencer, and three young children under 10 years of age (including two of his daughters) perished on this road after the vehicle in which they were travelling broke down. Mr Spencer attempted to save the lives of the children by burying their bodies under sand to conserve moisture. However by the time help finally arrived, Mr Spencer and three girls had perished. This tragedy took place very close to the present location of Winner's Bore.

In January 2008 a local couple from Kintore also broke down along the Kintore–Nyirripi back-road, near the then-dry Kalipima natural soak. They were carrying more than 30 litres of water in the vehicle and apparently tried to seal their leaking radiator with spinifex resin. The patch failed



Figure 1. Location of Winner's Bore, and the route of the Kintore to Nyirripi back-road. The areas marked in green define national parks.

and most of their available water was used up in the overheating radiator. When searchers arrived on the scene they found the man's body, and the woman died shortly after rescue. They had been broken down for only two days in the 40°C plus heat.

“The Project team agreed that an accessible watering point would be installed somewhere along the Kintore to Nyirripi back-road, should they succeed in finding fresh groundwater.”

These tragic events were paramount in the minds of senior staff from the Central Land Council (CLC) when negotiating with Geoscience Australia and the Northern Territory government, through the Department of Natural Resources, Environment, The Arts and Sport, about the commencement of the Palaeovalley Groundwater Project drilling program. The Project team agreed that an accessible watering point would be installed somewhere along the Kintore to Nyirripi back-road, should they succeed in finding fresh groundwater. They would also endeavour to equip the bore with a mechanical hand-pump for use in future emergencies. This bore would also serve the dual purpose of providing a groundwater monitoring point in this otherwise remote region.

The Palaeovalley Groundwater Project

The Palaeovalley Groundwater Project (Water for Australia's Arid Zone) aims to better understand the characteristics and behaviour of groundwater resources in Australia's arid areas. It is being led by Geoscience Australia in collaboration with geological and water resource agencies from South Australia, Western Australia and the Northern Territory. The consortium also includes several mining and exploration industry partners. The four-year project commenced in April 2008 with funding of \$4.935 million provided through the Raising National Water Standards program which is administered by the National Water Commission. The program supports the Australian Government's National Water Initiative through funding projects which improve Australia's national capacity to measure, monitor and manage our water resources.

Two of the Nyirripi investigation bores encountered fresh groundwater during drilling operations along the Kintore–Nyirripi

back-road. In particular, bore RN 18362 (the location of which was selected by Maria Woodgate from the Northern Territory government) was drilled to 79 metres and encountered low salinity groundwater containing total dissolved solid composition of 760 milligrams per litre which is potable quality water. Following completion of drilling, this bore was specially constructed and equipped with a flush cap windmill-like pump column. This would allow for later installation of a hand-pump mechanism so that groundwater could be readily extracted by a simple operation. An equipped bore would potentially save lives and hopefully prevent future tragedies.

The Project Team approached the Central Land Council about the possibility of using abandoned hand-pump mechanisms from nearby local communities to install and commission the watering point. During these discussions, Council anthropologist Hugh Bland suggested 'Winner's Bore' as the name for the Nyirripi to Kintore road bore. 'Winner' is the nickname of a local member of the community who is something of a celebrity around the Nyirripi region. He has walked back into town from several broken-down vehicles along this track, with the longest walk being some 70 kilometres.



Figure 2. CAT hand-pump of the type installed at Winner's Bore. The durability of these hand-pumps stems from their occasional use compared to the near continuous operation cycles of similar flush cap pumps used for windmill-operated systems (photo courtesy of Dr Bruce Walker).

The CAT hand-pump

In the early 1980s, when many Aboriginal outstations were being established in central Australia, money and resources were scarce. Consequently, expensive bore infrastructure such as windmills or submersible bore pumps were beyond the budget of many early settlements. To overcome this problem, Dr Bruce Walker turned his mind to designing a hand-pump mechanism whilst camping at an outstation near Mt Liebig. At the time Dr Walker was the head of the Centre for Appropriate Technology (CAT), a national indigenous science and technology organisation funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs. His design involved fitting a hand-operated mechanism to a windmill pump column so that a single operator could obtain groundwater by hand-pumping. This original bush design was subsequently fine-tuned and modified to become the well known CAT hand-pump range which was widely manufactured in the Alice Springs CAT workshop during the 1980s. Though once a common sight across many central Australian communities, the CAT hand-pumps are rarely seen on bores nowadays as most have been replaced by solar submersible bore pump systems.

The residents of Kintore have a particular affinity for mechanical bore hand-pumps, as the first reliable water supply scheme established at the community used CAT hand-pumps. Following the drilling of two successful bores in the fractured rock aquifers of the Kintore Ranges over 300 Pintubi Aboriginal people turned up to camp on these bores in 1981 and promptly announced that

they were going to stay there permanently. However, to sustain their 'return to country' the Pintubi needed reliable bore pumps and these came in the form of the then new CAT hand-pumps (figure 2).

The CAT hand-pumps proved to be durable and easy to operate. Similarly the steel CAT hand-pump frames are very hardy and commonly remain intact even after years of service, although many outstations in this region now use solar submersible pumps. Ironically, the actual pumping mechanism used for Winner's Bore was sourced from an abandoned CAT hand-pump left outside the Nyirripi community workshop for some considerable time.

Installation at Winner's Bore

The drill crew from the Northern Territory Government's Water Resources Branch completed the bore at RN 18362 so that it was ready and pre-equipped for installation of the CAT pump frame following drilling operations in September 2009. It was fortunate that Dr Bruce Walker, the original designer of the CAT hand-pump, was keen and available to assist the Project team with the installation of the pump mechanism. His timely and invaluable assistance ensured that the set-up of the hand-pump was completed without any problems in December



2009. This allowed Winner's Bore to become operational at the start of the extreme summer period, when it would potentially be most needed.

After installation and testing of the pump frame all that remained was to inform the local communities. Dr Bruce Walker, accompanied by Dr John Wischusen of Geoscience Australia, met with elders from the Kintore community to inform them that Winner's Bore on the Nyirripi to Kintore back-road was now operational. The shallow water table means that only one or two pumps are needed before water is delivered from the standpipe.

The only additional capital outlay for this hand-pump was the purchase of the pump column and associated fixtures for around \$3000. However the installation of a hand-pump at Winner's Bore is a lasting and durable legacy of the Palaeovalley Groundwater Project in this remote part of central Australia. While the discovery of fresh groundwater in this area is of potential long-term economic and social benefit to the local people (such as a water resource to support future horticulture projects) the tangible outcome of an operating hand-pump on the Kintore to Nyirripi back-road also provides an immediate community benefit. An additional benefit is that Winner's Bore can also be used to monitor any variation to the chemical composition of the groundwater that may occur over-time.

For more information

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Related websites/articles

AusGeo News 93: Understanding Australia's arid zone palaeovalley systems
www.ga.gov.au/ausgeonews/ausgeonews200903/inbrief.jsp#inbrief3

Palaeovalleys

Palaeovalleys are geologically ancient river valleys which no longer function as active surface water systems. Palaeovalleys in outback Australia were originally formed when climatic conditions were different than they are today. An example is the Eocene epoch (about 56 to 34 million years ago) when rainfall levels were significantly higher and much of the present-day outback was covered by rainforests. Although surface water no longer flows in most of the palaeovalleys, the sediment which has filled the river channels commonly forms good quality aquifers which are capable of storing significant quantities of groundwater. In many desert areas of Australia, the groundwater resources contained in palaeovalley aquifers may be the only reliable supply of potable water available to remote water users such as aboriginal communities and pastoral stations.

Aerial survey sets new benchmark

In recent years, Geoscience Australia has undertaken a number of significant aerial surveys, but the latest airborne electromagnetic (AEM) survey is eclipsing all others.

The Frome AEM survey, which commenced on 22 May 2010, will cover 95 450 square kilometres in South Australia's outback. This represents almost 10 per cent of South Australia's total area, or around half the area of Victoria, which makes it the most extensive single AEM survey ever undertaken in Australia (figure 1).

A fixed wing Shorts Sky Van aircraft will fly a total of 34 986 line kilometres at 2.5 and 5 kilometre line spacing over the Frome Embayment and northern Murray Basin to the east and north of the Flinders Ranges. The Frome region is considered to have a high potential for uranium mineralisation with major uranium deposits already identified in the survey area at Beverley, Honeymoon and Four Mile.

The Frome survey will demonstrate the effectiveness of AEM data in supporting exploration for energy resources through mapping subsurface geology, including prospective sedimentary horizons and faults. The survey datasets will also help to improve understanding of the groundwater resources in the area.

The survey has total funding of \$2.67 million and is a collaborative project involving Geoscience Australia, the South Australian Government through Primary Industries and Resources South Australia and a consortium of exploration industry representatives. It is a major component of Geoscience Australia's Onshore Energy Security Program which is designed to reduce risk in exploration and support development of Australia's onshore energy resources.

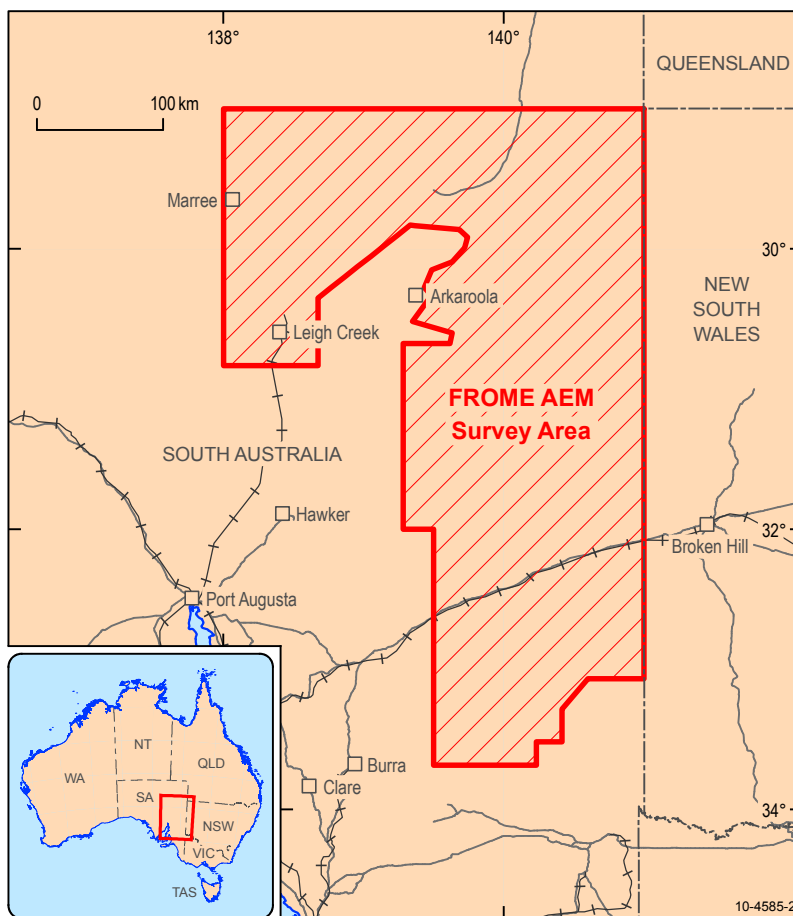


Figure 1. The survey area over the Frome Embayment and northern Murray Basin in South Australia.

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Gawler Craton and Curnamona Province seismic lines show potential

Between mid-2008 and early 2009, Geoscience Australia, in conjunction with Primary Industries and Resources South Australia (PIRSA), acquired around 720 kilometres of new deep seismic reflection data in the southern Gawler Craton and Curnamona Province, South Australia. The main aim of the seismic surveys was to image the crustal architecture of these areas, as well as the overlying Adelaide Rift System, to evaluate the uranium, geothermal and petroleum potential of the region. The project was part of Geoscience Australia's Onshore Energy Security Program which is designed to reduce risk in exploration and support development of Australia's onshore energy resources.

Seismic data were collected along a number of transects (figure 1):

- Curnamona Line, around 262 kilometres in length, which runs south to north across the Frome Embayment (08GA-C1)
- Curnamona-Gawler Link line, around 144 kilometres, which links the Gawler and Curnamona Provinces across the Flinders Ranges (09GA-CG1)

- Arrowie Basin line, around 60 kilometres, which crosses the Arrowie Basin to the north of Port Augusta (08GA-A1)
- Eyre Peninsula line, around 253 kilometres, across Eyre Peninsula from east of Streaky Bay to just south of Port Augusta (08GA-G1).

New magnetotelluric (MT) data, which measures variations in the electrical conductivity of earth materials, were also collected along some of the seismic lines. In 2009 Torrens

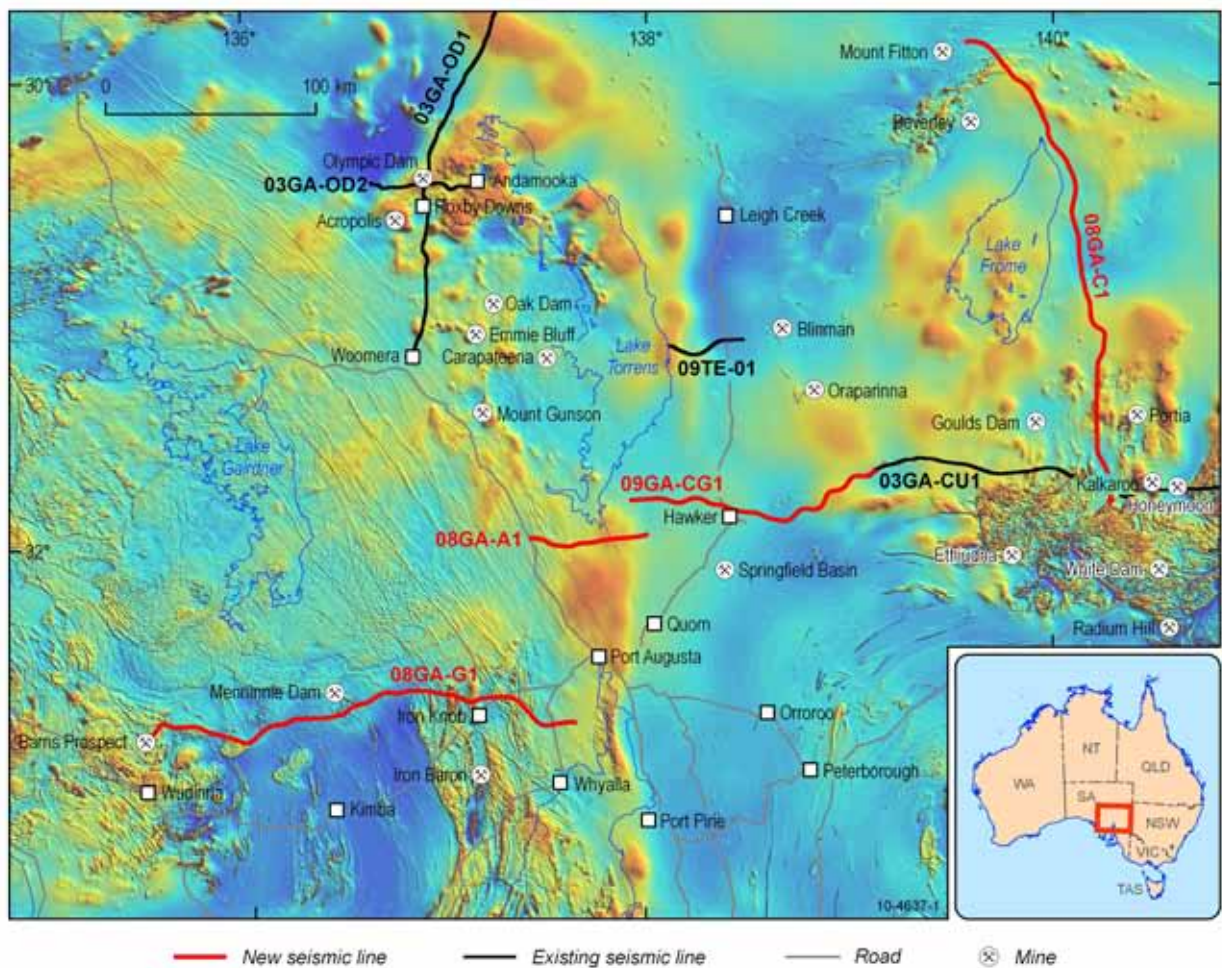


Figure 1. Location of new and existing seismic transects in the southern Gawler Craton and Curnamona Province, South Australia, on a total magnetic intensity image.

Energy acquired the 41 kilometres long Parachilna seismic line (09TE-01), which is about 90 kilometres to the north of the Arrowie Basin line, as part of their geothermal exploration program. This line was also integrated into this study. Collectively these lines, together with the Olympic Dam and Curnamona seismic reflection data collected in 2003 (03GA-OD1, 03GA-OD2 and 03GA-CU1), provide seismic transects which can be used to characterise the crustal architecture and inferred geodynamics of this region (figure 1). This architecture and geodynamic interpretation can then be integrated with other geological and geophysical data sets to evaluate energy and other mineral systems at a regional scale.

The seismic and magnetotelluric data and interpretations, together with other geological datasets and geophysical modelling, were presented at the South Australian Seismic and MT Workshop held in Adelaide on 6 May 2010. Some of the key results included the identification of deep faults and seismically nonreflective areas, along two of the new seismic lines, which are similar to those observed below the Olympic Dam deposit. This suggests that these regions also have a high potential for uranium and other mineralisation. The new data, which identify crustal boundaries and changes in seismic character across the region, also provide a guide for geothermal exploration when integrated with surface heat flow measurements.

The next seismic and MT Workshop, which will present the results from the GOMA transect (northern Gawler Craton, Officer Basin, Musgrave Province and southern Amadeus Basin) will be held in Adelaide on 25 November, 2010.

Towards a Global Earthquake Model

Over the last decade more than half a million people died as a result of earthquakes and tsunami. Most of these deaths occurred in the developing world, where risk is increasing because of rapid population growth and urbanisation. In many seismically active regions no hazard and risk models exist, and even where models are available, they are often poorly understood, highly subjective and inaccessible to the community at risk. Better risk awareness should reduce the toll from earthquakes by leading to better construction standards, improved emergency response, and greater access to risk transfer mechanisms such as insurance.

The Global Science Forum of the Organisation for Economic Co-operation and Development (OECD-GSF) has initiated and approved the Global Earthquake Model (GEM). GEM aims to establish a uniform, independent standard to calculate and communicate earthquake risk worldwide. With support from academia, governments, and industry, GEM will contribute to achieving profound, lasting reductions in earthquake risk worldwide.

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Related websites/articles

The processed seismic data from these transects can be downloaded at

www.ga.gov.au/minerals/research/national/seismic/index.jsp

South Australian Seismic and MT Workshop 2010: Extended Abstracts (Geoscience Australia Record 2010/10)

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=70149

Presentations from the South Australian Seismic and MT Workshop 2010 can be downloaded at

www.ga.gov.au/minerals/research/national/oegf/index.jsp



Figure 1. Signing of the collaborative agreement between Geoscience Australia and the Global Earthquake Model by GEM Secretary General, Rui Pinho, with John Schneider of Geoscience Australia in the background. The signing was held on 3 June 2010 in Washington, USA.

GEM is

- **dynamic**—users can input their own data into an updatable model.
- **global**—it will set uniform standards across the world and covers developed and developing areas.
- **open access**—a transparent tool available to everybody.
- **state-of-the-art**—with leading regional and global experts in all relevant disciplines sharing knowledge and working together on its development.
- **a public-private partnership**—combines the strengths and objectives of the public and private sector.
- **comprehensive**—it will consider earthquake hazard and risk, including direct and indirect estimates of socio-economic impact.
- **community-developed**—with a wide community involved in developing GEM's software and tools and collecting the data necessary to model earthquake hazard and risk.

Geoscience Australia has signed a collaborative agreement with GEM as a public partner which will facilitate and support collaboration until December 2013 (figure1). Over this period the agency will work closely with GEM's international network to enhance earthquake risk modelling capabilities throughout the world.

Assessing the impact of seawater intrusion on groundwater

Fresh groundwater stored in coastal aquifers constitutes an important resource for urban and rural residents as well as industrial and agricultural activities. Continuing population expansion along Australia's coastal fringe, combined with significant reduction in rainfall in many coastal catchments, has led to an increasing dependency on coastal groundwater resources. Although the situation varies across the country, there is evidence of over-use in several major Australian coastal aquifers.

One consequence of the over-use of coastal groundwater resources is the increased risk of salinisation of aquifers through the encroachment of seawater. Seawater (or saltwater) intrusion (SWI) is the influx of seawater into an area where freshwater normally predominates, and can occur undetected within sub-surface water resources. To date, there has not been a comprehensive SWI



In particular, Geoscience Australia will:

- engage with stakeholders in southeast Asia and the southwest Pacific to ensure that GEM addresses their needs, is understood and is supported
- represent the Australian Government by contributing to scientific and technical debate and participating in decision-making processes
- exchange scientific and technical information such as approaches to risk modelling.

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visit www.globalquakemodel.org

Geoscience Australia is currently undertaking a national-scale vulnerability assessment of coastal aquifers to seawater intrusion in collaboration with the National Centre for Groundwater Research and Training (NCGRT) as well as state and territory water agencies. Project funding has been provided through the Raising National Water Standards program which is administered by the National Water Commission. The project commenced in November 2009 and will run for two and a half years. The project will identify those coastal groundwater resources currently vulnerable to seawater intrusion and potentially at risk as a result of over-extraction, sea-level rise and/or recharge-discharge variations associated with climate change.

The first project stakeholder workshop, held in Canberra on 5 and 6 May 2010, was attended by eighteen representatives from the Australian Government, state and territory water agencies, NCGRT and CSIRO Water for a Healthy Country. The workshop provided a clear scientific direction for the project and stakeholders were generally supportive of the objectives and proposed approaches. They offered to provide relevant datasets and will continue to share knowledge and information.

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New geochronology results from South Australia

New geochronology results from the southern Gawler Craton and Curnamona Province in South Australia are included in a recently released report from Geoscience Australia (Geoscience Australia Record 2010/16). The 68 samples were acquired between 2008 and 2010 as part of Geoscience Australia's Onshore Energy Security Program (OESP). This program of geochronology was specifically targeted to provide time controls relevant to the interpretation of several deep seismic reflection profiles and consequently the geographic coverage of the samples is heavily biased towards these areas. The seismic data were also acquired by Geoscience Australia, in collaboration with Primary Industry and Resources South Australia (PIRSA), as part of the OESP. Information on the seismic transects is included in the *In brief* item on the Gawler Craton and Curnamona Province seismic lines in this issue of *AusGeo News*.

The geochronology results were obtained from Geoscience Australia's Sensitive High Resolution Ion Microprobe (SHRIMP). The SHRIMP measures uranium and lead isotopes from tiny portions of zircon crystals and the results are then used to calculate the age of the crystal based on the natural decay rate of uranium to lead (U-Pb). The samples are listed according to geological domains or regions, and the report includes a location map showing the location of samples for each domain. The results for each sample are presented in a standard format that includes a summary table, sample and zircon descriptions, U-Pb isotopic results, a geochronological interpretation and a data table.

The geochronological samples from the southern Gawler Craton come from a transect across the northern Eyre Peninsula in the vicinity of the seismic line 08GA-G1. Results from this region are presented in approximate geographic order, from east to west, and are subdivided according to regional tectonic domains. Samples from the Curnamona Province were concentrated in the outcropping Mount Painter and Mount Babbage Inliers and from selected drillholes along the seismic line 08GA-C1. The results are also presented in approximate geographical order, from north to south, and are subdivided according to regional domains.

The new results presented in this report inform the interpretation of the recently-acquired seismic lines, as well as providing much-improved age controls on surface rocks from regions for which relatively little age control has been available. The geographic coverage of the samples includes the Middleback Ranges, the site of Australia's oldest and longest operating iron-ore mines and recently discovered Mesoarchean rocks (see *AusGeo News* 92), lead-zinc and gold prospects on Eyre Peninsula, and the Mount Painter Inlier, regarded by many as the source of uranium for the nearby Beverley and Four Mile deposits.



For more information

email geoff.fraser@ga.gov.au

visit www.ga.gov.au/products

Related websites/articles

New SHRIMP U-Pb zircon ages from the Gawler Craton and Curnamona Province, South Australia, 2008-10 (Geoscience Australia Record 2010/16)

www.ga.gov.au/image_cache/GA17485.pdf

AusGeo News 99: Gawler Craton and Curnamona Province seismic lines show potential

www.ga.gov.au/ausgeonews/ausgeonews201009/capel.jsp

AusGeo News 92: Foundations of South Australia discovered

www.ga.gov.au/ausgeonews/ausgeonews200812/gawler.jsp

Gawler-Curnamona region mineral exploration maps now available

Geoscience Australia and CSIRO, in collaboration with Primary Industries and Resources SA, are releasing a suite of 14 new ASTER mosaiced mineral maps covering a significant part of the Gawler-Curnamona region in South Australia. These new products have numerous applications for mapping surface materials, understanding hydrothermal footprints and targeting surface sampling for mineral exploration. They can also be used to understand mineral dispersion pathways in the regolith. The maps were produced as part of Geoscience Australia's Onshore Energy Security Program which is designed to reduce risk in exploration and develop Australia's onshore energy resources.

Alteration chemistry associated with footprints of mineral systems, as well as surface and near-surface bedrock locations, and regolith characterisation and distribution can be determined by analysing spectral ground response, particularly in short-wave infra-red.

About 110 ASTER satellite scenes have been mosaiced and processed into georeferenced products that can be quickly and easily

integrated with other datasets, such as geology and regolith maps, or other geophysical datasets in a GIS. The products have been pre-processed and calibrated with available airborne HyMap (or hyperspectral mapping) data and provide basic mineral group information. This includes ferric oxide abundance and aluminium hydroxyl (AIOH) group distribution as well as mosaiced and levelled false colour and regolith ratio images. Key materials that can be identified include clays and magnesium/iron/aluminium oxyhydroxides, as well as information on mineral composition, abundance and physicochemistry. Multispectral ASTER data has much lower spatial and spectral resolution than HyMap, but the calibration and validation of the ASTER data using the higher resolution HyMap aims to greatly improve ASTER product accuracy.

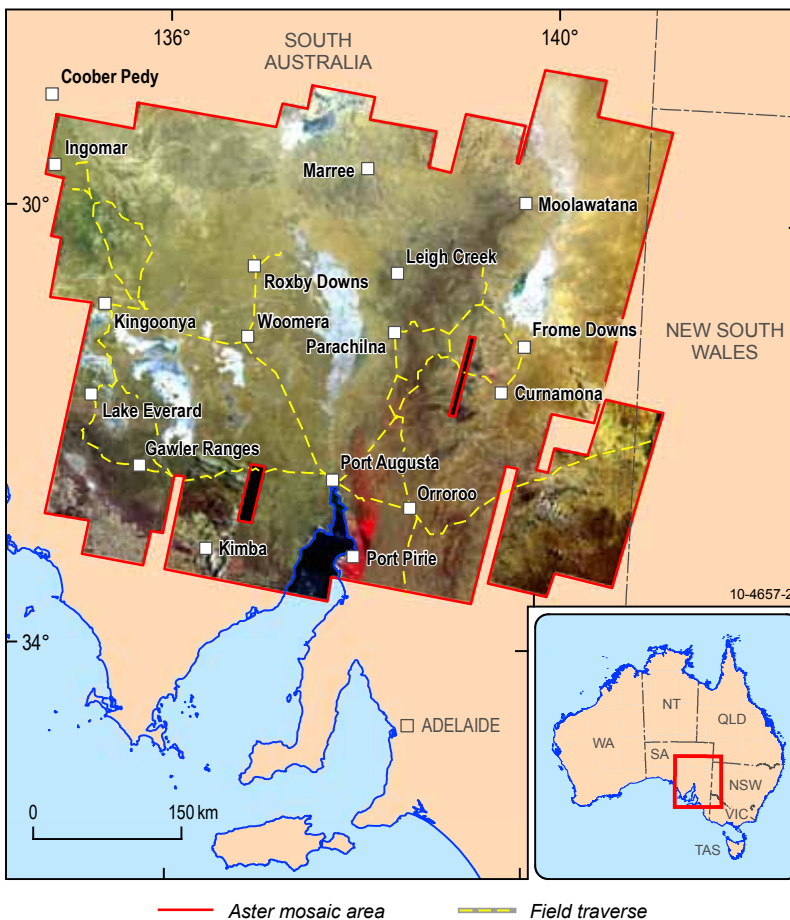


Figure 1. Levelled and calibrated VNR ASTER mosaic. Processing provides a significantly improved image of the study region (field traverse shown in yellow dashed lines).

The ASTER georeferenced products include:

- False colour
- Opaque group
- Ferric oxide content
- Iron hydroxyl group (Fe-OH)
- Green vegetation
- Aluminium hydroxyl group (AIOH)
- CSIRO regolith ratios
- Ferrous iron group

For further information

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Related articles/websites

Gawler-Curnamona region images with accompanying notes (free ftp download)

<ftp://ftp.arcc.csiro.au/NGMM/Gawler-Curnamona ASTER Project/>

- Magnesium hydroxyl group (MgOH)
- Ferrous iron abundance
- Advanced argillic group.

New geophysical datasets released

Gravity surveys

Datasets from two new gravity surveys covering the Southern Cross and Gascoyne North areas in Western Australia were released in May 2010. Each dataset provides basic geophysical data which can be interpreted to reveal the sub-surface geology of the survey area and will be a valuable tool in assessing their mineral potential.

Both gravity surveys were managed by Geoscience Australia on behalf of the Geological Survey of Western Australia. The point-located and gridded data for these surveys have been incorporated into the national geophysical databases and can be obtained free online using the GADDS download facility.

Radiometric Anomaly Grids of Australia updated

Updated digital gridded radiometric datasets that comprise the Radiometric Map of Australia were released on 1 July 2010. The new levelled composite K (potassium), U (uranium) and Th (thorium) grids cover Australia at 100 metres resolution and include data from geophysical surveys flown over Western Australia and Queensland in the last 12 months.

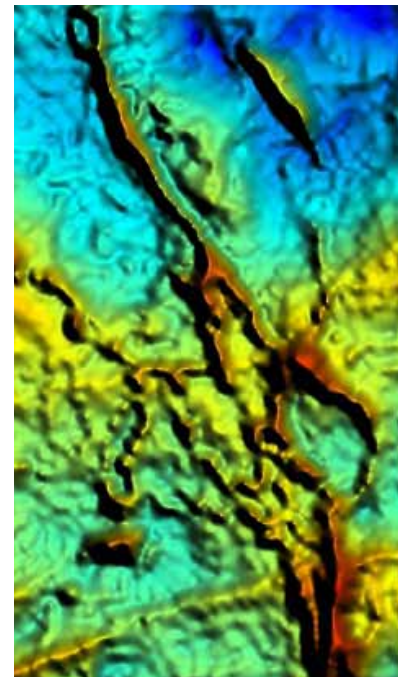
New Magnetic Anomaly Grid of Australia (5th Edition)

The gridded digital data that comprise the fifth edition Magnetic Anomaly Map of Australia were released by Geoscience Australia on 1 July 2010. The new magnetic anomaly grid includes an additional 115 survey grids acquired since the fourth edition was released in 2004.

The extracts from the gridded datasets can be downloaded free-of-charge in ERMMapper format from the Australian governments' Geophysical Archive Data Delivery System (GADDS).

Requests for data

The complete digital data for the Magnetic Anomaly and Radiometric Maps of Australia datasets cannot be requested through GADDS as the system has a download limit of one gigabyte for each download.



Clients requiring the complete Radiometric Map of Australia dataset (13 grids totalling 72Gb), or complete Magnetic Map of Australia (one grid approximately 8.5Gb in size) should supply digital media such as a portable external hard disk drive in NTFS format with at least 100Gb of free space. The Geoscience Australia contact is Murray Richardson (contact details below) who will arrange to load the data and for its immediate return.

Table 1. Details of the gravity surveys.

Survey	Date	1:250 000 map sheets	Station spacing/ orientation	Line km	Contractor
Southern Cross (WA)	January–March 2010	Jackson (part), Southern Cross, Hyden.	2500 m east–west	6343	Atlas Geophysics Pty Ltd
Gascoyne North (WA)	March–May 2010	Edmund, Turee Creek (part), Kennedy Range (part), Mount Phillips (part), Mount Egerton (part).	2500 m east–west	7292	Atlas Geophysics Pty Ltd

For more information

Radiometric Map

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Magnetic Anomaly Map

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Geophysical datasets

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Geoscience Australia Sales Centre

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e-mail sales@ga.gov.au

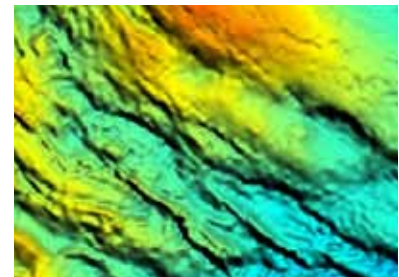
Related websites

Geophysical Archive Data Delivery System (GADDS)

www.geoscience.gov.au/gadds

Geological Survey of Western Australia

www.dmp.wa.gov.au



New maps cover the Red Centre

Uluru-Kata Tjuta National Park and the Watarrka National Park are the subject of two new 1:100 000 scale topographic maps recently released by Geoscience Australia. These maps will provide an important reference for visitors seeking to explore and appreciate the scenic beauty and history of Australia's vast and spectacular Red Centre, in the Northern Territory, which is an outstanding example of an ancient landscape sculptured by nature.

The Uluru-Kata Tjuta National Park map features the awe-inspiring rock formations of Uluru and Kata Tjuta. This World Heritage-listed landscape is approximately 440 kilometres southwest of Alice Springs.

The Watarrka National Park, located 330 kilometres southwest of Alice Springs, is where the vast red sandhill country of the western desert abruptly meets the ancient ranges of central Australia. It is an internationally significant conservation area and provides refuge



for more than 600 species of native plants and animals. The Park's attractions include Kings Canyon, Kathleen Springs and the Giles Track.

Each of the maps feature a topographic map useful for tourists, bushwalkers, four wheel driving and sight seeing. The reverse side of each map depicts the same area using a satellite image overlaid with major roads, camping areas, fuel services, water supplies, telephone access and medical facilities. The Uluru Kata Tjuta map includes insets featuring aerial photographs of Yulara, Uluru and Kata Tjuta at 1: 30 000 scale. The maps are valuable for emergency managers involved in search and rescue operations or dealing with bushfires and other natural disasters in these remote regions.

The maps are part of a pilot project made possible by increased Australian Government investment in the tourism industry through the National Landscapes initiative. The program identifies and promotes distinctive and inspirational destinations to domestic and international visitors.

The maps are the result of collaboration between Geoscience Australia, the Australian Government Department of Resources, Energy and Tourism, the Department of the Environment, Water, Heritage and the Arts and Northern Territory Government agencies

including the Departments of Planning and Infrastructure and Natural Resources, Environment, The Arts and Sport. The maps are available from the Geoscience Australia Sales Centre and map retailers.

For more information or to order a copy visit

Uluru Kata Tjuta National Park 1:100 000 scale topographic map
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69344

Watarrka National Park 1:100 000 scale topographic map
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=70462

New maps of Australian territories

Geoscience Australia has recently released new topographic maps of three of Australia's offshore territories: Norfolk Island, the Cocos (Keeling) Islands and Christmas Island. Each territory includes a National Park which highlights their unique geography and many natural wonders.

The maps, which are at 1:25 000 scale (Norfolk Island and Cocos (Keeling) Islands) and 1:30 000 scale (Christmas Island), feature detailed contour or height information, infrastructure, vegetation and reserves, and rivers and streams. Each map also includes a location map relative to the continent of Australia as well as a climate graph showing temperature and rainfall.

Norfolk Island is located off Australia's east coast in the South Pacific Ocean, approximately 1700 kilometres northeast of Sydney. The island is approximately eight kilometres long and five kilometres wide and has an area of 3455 hectares. Its unique geography includes 32 kilometres of mostly inaccessible cliffs which slope down to the sea only at Sydney and Emily bays. The Norfolk Island National Park, which covers about 10 per cent of the land area, contains remnants of the forests which originally covered the island including stands of subtropical rainforest.



The **Cocos (Keeling) Islands** are located in the Indian Ocean approximately 2950 kilometres northwest of Perth and 3700 kilometres west of Darwin. There are 27 coral islands in the group with a total land



area of approximately 14 square kilometres. The northern atoll of North Keeling Island and the marine area extending one and a half kilometres around the island form the Pulu Keeling National Park. The Park features an intact coral atoll, supports an internationally significant seabird rookery, and is home to land crabs and turtles as well as a range of flora.

Christmas Island is located in the Indian Ocean approximately 2650 kilometres northwest of Perth and 900 kilometres northeast of the Cocos (Keeling) Islands. The island covers an area of 135 square kilometres of which 63 per cent is Christmas Island National Park. The Park also includes a marine area extending 50 metres seaward from the low water mark. The island's coastline is an almost continuous sea cliff up to 20 metres high. In a few places the cliff gives way to shallow bays with small sand and coral shingle beaches with the largest bay being Flying Fish Cove, the island's only port.

During the compilation information was contributed by the Australian Government Attorney-General's Department and Parks Australia within the Department of the Environment, Water, Heritage and the Arts.

For more information or to order a copy visit

Norfolk Island 1:25 000 scale topographic map

https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=70147

Cocos (Keeling) Islands 1:25 000 scale topographic map

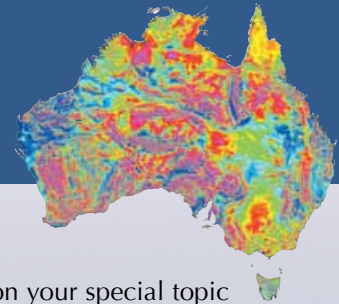
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=70146

Christmas Island 1:30 000 scale map

https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=70145

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Alice Springs Convention Centre Alice Springs, NT Contact: 15ARSPC Conference Secretariat 18 Hawthorne Parade, Haberfield, NSW 2045	P +61 414 971 349 e email info@arspc.com www.15.arspc.com
spatial@gov Conference 2010	5 to 7 October
Australian Spatial Community and CeBIT National Convention Centre, Canberra, ACT Contact: Australian Spatial Community and Hannover Fairs Australia	P +61 2 9280 3400 e info@osdm.gov.au www.cebit.com.au/2010/conferences/spatial-at-gov
Mining 2010 Resources Convention	27 to 29 October
Hilton Hotel Brisbane, Qld Contact: Vertical Events PO Box 1153, Subiaco WA 6904	P +61 8 9388 2222 f +61 8 9381 9222 e info@verticalevents.com.au www.verticalevents.com.au
GROUNDWATER 2010 –the challenges of sustainable management	31 October to 4 November
International Association of Hydrogeologists & Geological Society of Australia National Convention Centre, Canberra, ACT Contact: Conference Solutions, PO Box 238, Deakin West ACT 2600	P +61 2 6285 3000 f +61 2 6285 3001 e groundwater@con-sol.com www.groundwater2010.com
China Mining Congress	16 to 18 November
Ministry of Land and Resources, China Tianjin Meijiang International Convention & Exhibition Centre, Tianjin, China Contact: China Mining Congress & Expo Organising Committee	P +86 10 6446 6855 f +86 10 5885 7006 e info@china-mining.org www.china-mining.org/en
Australian Geothermal Energy Conference	17 to 19 November
Australian Geothermal Energy Association & Australian Geothermal Energy Group Adelaide Convention Centre, Adelaide, SA Contact: Rob Bulfield, Sapro Conference Management	P +61 8 8274 6060 e agec10@sapmea.asn.au www.ausgeothermal.com
Gawler–Officer–Musgrave–Amadeus Seismic and Magnetotelluric Workshop	25 November
Geoscience Australia, Primary Industries and Resources South Australia, AuScope, and Northern Territory Geological Survey Adelaide Convention Centre, Adelaide, SA Contact: Dr Russell Korsch, Geoscience Australia, GPO Box 378, Canberra ACT 2601	P +61 2 6249 9495 f +61 2 6249 9971 e russell.korsch@ga.gov.au

NAPE Expo 2011	16 to 18 February
George R Brown Convention Center, Houston, Texas, USA Contact: NAPE, PO Box 224531, Dallas, Texas 75222 USA	f +1 972 993 9191 e info@napeexpo.com www.napeexpo.com/about-winter-nape.html
PDAC 2011 International Convention & Trade Show	6 to 9 March
Prospectors and Developers Association of Canada Metro Toronto Convention Centre, Toronto, Canada Contact: PDAC, 135 King Street East, Toronto, Ontario M5C 1G6	P +1 416 362 1969 f +1 416 362 0101 e convention@pdac.ca www.pdac.ca/pdac/conv/index.html
MSIA Conference 2011	28 and 29 March
Mapping Sciences Institute Australia University House, Australian National University, Canberra, ACT Contact: Mapping Sciences Institute, GPO Box 1696, Darwin NT 0801	P +61 2 9280 3400 e info@osdm.gov.au
2011 APPEA Conference and Exhibition	10 to 13 April
Australian Petroleum Production and Exploration Association Perth Convention & Exhibition Centre, Perth, WA Contact: Moira Lawler, APPEA Limited, GPO Box 2201, Canberra ACT 2601	P +61 2 6267 0906 f +61 2 6247 0548 e mlawler@appea.com.au www.appea2011.com.au

For more information on Geoscience Australia's involvement in the above events
phone Suzy Domitrovic on +61 2 6249 9571 **email** suzy.domitrovic@ga.gov.au

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