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CONTENTS

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In the June issue of *AusGeo News* I reported on the Government decision to establish the Australian Tsunami Warning System (ATWS) and how Geoscience Australia is playing an increasing role in the safeguarding of Australians. In line with strengthening Geoscience Australia's ability to monitor and advise on natural hazards in the Australian region, and the increasing recognition of the importance of spatial information, a new Division – Geospatial and Earth Monitoring Division (GEMD) has been created. GEMD is working to improve the safety of communities and the protection of Australia's critical infrastructure, through its comprehensive monitoring, research and mapping programs. The new Division brings together the spatial skills and expertise of the former National Mapping Division and hazard monitoring and risk assessment functions of the former Geohazards Division. The new structure, which is outlined in this issue, will improve the agency's capacity to respond flexibly to current and emerging government priorities. GEMD is headed by Dr Chris Pigram, who brings a wide range of scientific and management experience to the position.

This issue also includes an article outlining Geoscience Australia's contribution to protection of Australia's critical infrastructure (CI) that underpins the nation's social and economic well-being. The Government has identified the protection of critical infrastructure as a high priority and initiated a program involving government and industry to model the risks associated with and the consequences of CI failure. The project relies heavily on modelling and analysis of information in a spatial framework.

Gold is Australia's third most valuable mineral export, worth $5.5 billion in 2004, and this issue has two articles of relevance to gold exploration. One is a report on the new insights being gained into the potential for intrusion-related gold systems in parts of eastern Australia, particularly North Queensland. This study combines new knowledge on the relationship between granite geochemistry and gold potential with other parameters for the intrusion and country rocks to determine the potential for new gold deposits. There is also a report on the recently completed deep crustal seismic survey in the Tanami gold province in the Northern Territory.

A new assessment of the Dampier Sub-basin and Rankin Platform in the Carnarvon Basin suggest that 167 million barrels of oil, 0.4 trillion feet of gas, and 26 million barrels of condensate could be discovered in these areas in the next 10-15 years. This report is part of an ongoing assessment of Australia's petroleum resources by Geoscience Australia that draws on the best available geoscience information and a risk approach to model the nation's likely undiscovered petroleum resources.

Earth monitoring relies on consistent recording over extended periods of time to detect subtle but important changes. This year the Mawson observatory in Antarctica became the second Geoscience Australia observatory to have provided geomagnetic data over a 50-year time span. The geomagnetic data from Mawson contributes to the global and regional geomagnetic models used for navigation, exploration and research.

In closing I welcome your feedback on *AusGeo News* to ensure that it continues to meet your needs.

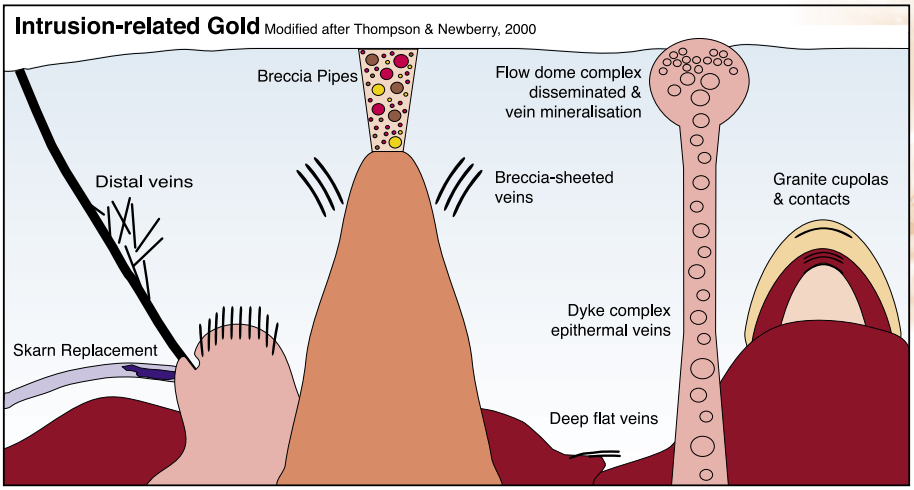
Comment

Neil Williams

NEIL WILLIAMS
CEO Geoscience Australia

PROSPECTS LOOK GOOD in north Queensland

New datasets available for gold prospectors in northern Queensland



▲ **Figure 1.** Generalised model for IRG systems. Modified from Thompson & Newberry (2000), to include breccia pipe (Kidston, Qld: Baker & Andrew 1981) and granite carapace (Timbarra, NSW: Mustard 2001) styles.

Table 1. Selected characteristics of intrusion-related gold deposits

Characteristics of IRG systems	Indicators of favourable areas undercovers
Porphyry Cu–Au generally absent	
Continental sedimentary assemblage, especially, carbonaceous or carbonate-bearing	Typically reduced to strongly reduced aeromagnetic signature
Often metaluminous, calc-alkaline, I-type granodiorite to granite, but range of compositions	Aeromagnetic and gravity signatures indicating granites
Typically high crustal levels at time of mineralisation	Indirect evidence such as presence of dyke swarms, particularly when associated with individual granites. Presence of texturally variable granites, including porphyries.
Fractionated granite compositions, with evidence for volatiles (e.g. miaroles, pegmatite, pebble dykes)	Zoned aeromagnetic signatures may indicate fractionation. F in groundwater. F, U, Th anomalies in geochemical data (e.g. stream sediment data). F and U mineral occurrences. Radiometric signatures elevated in K, Th and U (where outcrop exists)
Weakly oxidised to weakly reduced oxidation states	Aeromagnetic and gravity signatures for granites. Weakly oxidised granites readily apparent when intrusive into sedimentary sequences.
Bi, Mo, W, Sn, U, Au, Ag metallogenic signature	Mineral occurrence data—Bi, Mo in particular
May have lateral mineral zonation; W +/– Mo, Sn, Bi, Au > Au, As, Sb > Zn, Pb, Ag	Mineral occurrence data
May have vertical mineral zonation; Bi increases, As, Sb decrease with depth	

Source: Characteristics of IRG systems modified from Thompson et al (1999), Lang & Baker (2001) and Blevin (GA Report, in review).

David Champion

Geoscience Australia is releasing updated datasets of various metallogenic parameters for intrusive and country rock units in north Queensland to assist the exploration industry's search for intrusion-related mineralisation systems.

The work is part of the 'Felsic Igneous Rocks of Australia' project to compile and synthesise publicly available regional datasets of the Tasmanides of eastern Australia, and follows the release of datasets for Tasmania (a joint Geoscience Australia – Mineral Resources Tasmania product, see *Ausgeo News 74*).

Intrusion-related gold systems

Work in the past decade has identified a class of gold deposits associated with felsic intrusions—igneous rocks with high levels of quartz or feldspar. This has consolidated a variety of previously recognised intrusion-related mineralisation under the one mineral system, known as intrusion-related gold (IRG). See figure 1 and table 1, and also Thompson et al (1999).

Broad styles are included within IRG mineral systems. They range from those proximal to granites (e.g. greisen, disseminated gold, skarns) to more distal and controversial styles, such as breccias, and vein systems (figure 1) where the relationship with granites is equivocal. Although model development for IRGs has been largely based on North American deposits, well-studied Australian examples include Timbarra (Mustard 2001), Kidston (Baker & Andrew 1991) and Red Dome (see Blevin 2004).

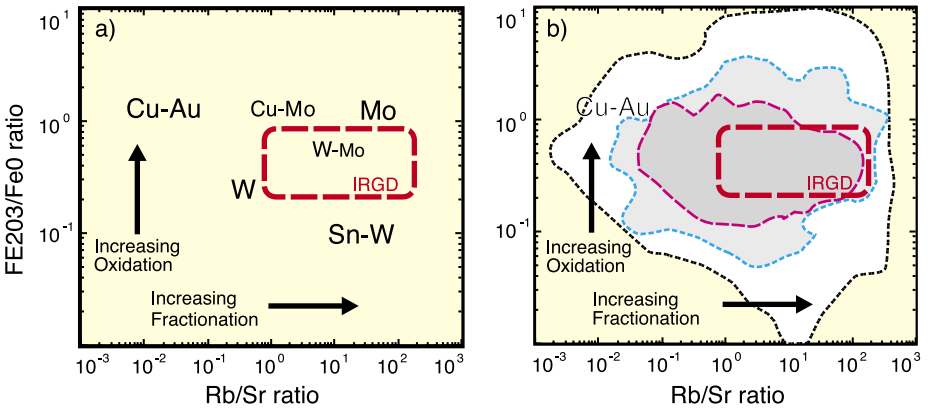


Figure 2. **(a)** Relationship between the oxidation state (calculated using total rock Fe_2O_3/FeO ratio) and the degree of evolution (calculated using total rock Rb/Sr ratio) of granites, and related metallogenic associations, as documented by Blevin et al (1996) and Blevin (2004). 9. **(b)** Oxidation-evolution plot contoured using available geochemical data for north Queensland granites. The bulk of the geochemical data falls within the dark grey contour (pink line), strongly overlapping with the suggested field (Blevin 2004) for IRG.

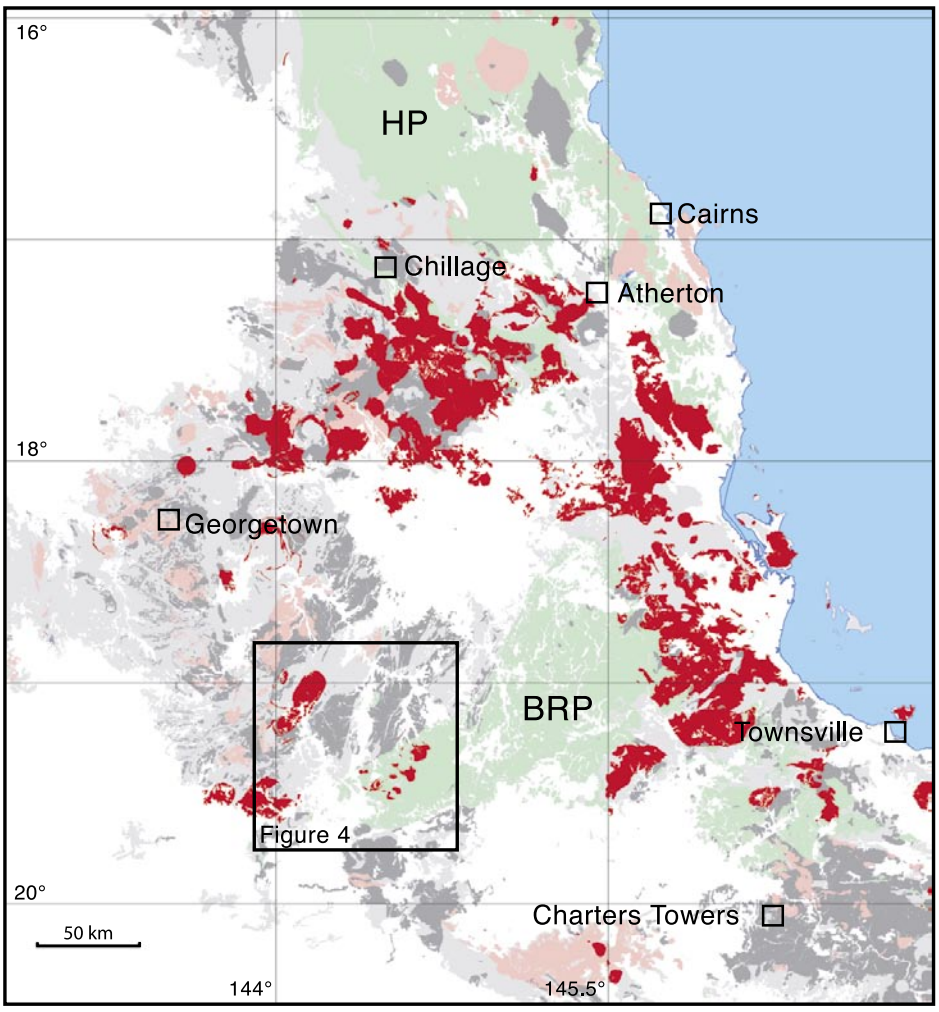


Figure 3. Distribution of North Queensland granites with favourable oxidation and fractionation characteristics for potential IRG mineralisation (i.e. those inside the IRG box in figure 2). Carboniferous to Permian I-type granites shown in red, other granites in pink; granites with non-favourable characteristics in dark grey; non-granites in light grey; Mesozoic and younger cover rocks in white. Major Palaeozoic basins, including the Hodgkinson Province (HP) and Broken River Province (BRP) shown in light green. Black box marks location of figure 4.

One of the central tenets of studies of granite-related mineralisation has been the recognised role of variations in granite properties such as oxidation state, as initially recognised by Burnham & Ohmoto (1980) and Ishihara (1981).

Blevin and co-workers (Blevin et al 1996, Blevin 2004), and more recently others (e.g. Thompson et al 1999), have documented the relationship between the degree of fractionation and the oxidation state of the associated intrusives and commodity-types in granite-related mineralisation systems. This simple but powerful relationship (figure 2) can be utilised predictively. Champion & Mackenzie (1994) demonstrated the very strong correlation between tin occurrences in north Queensland and reduced, strongly fractionated granites, regardless of age, granite type or other characteristics.

A similar approach can be utilised for IRGs, though their parameters are less certain. Most are clearly associated with evolved felsic intrusives. This is particularly true for Australian deposits, such as Timbarra (Mustard 2001), but probably less so for northern American deposits (e.g. Hart et al 2004).

Most controversy concerns the relative oxidation state of the intrusives. Early IRG models emphasised the mildly to moderately reduced nature of the granites, based on aeromagnetic signatures, whole rock Fe_2O_3/FeO ratios, magnetic susceptibility measurements, and the lack of modal primary magnetite (e.g. Thompson et al 1999).

This contrasts with reported data for Australian IRGs, which are commonly weakly to moderately oxidised, largely just above the Far North Queensland buffer (see Blevin 2004). The presence of titanite (if primary) in at least some of northern American granites associated with IRGs (e.g. Hart et al 2004) is also more consistent with a weakly oxidised (though magnetite-free) nature. Accordingly, we have followed the interpretation of Blevin (2004; see figure 2), an interpretation now also largely supported by Baker et al (2005).

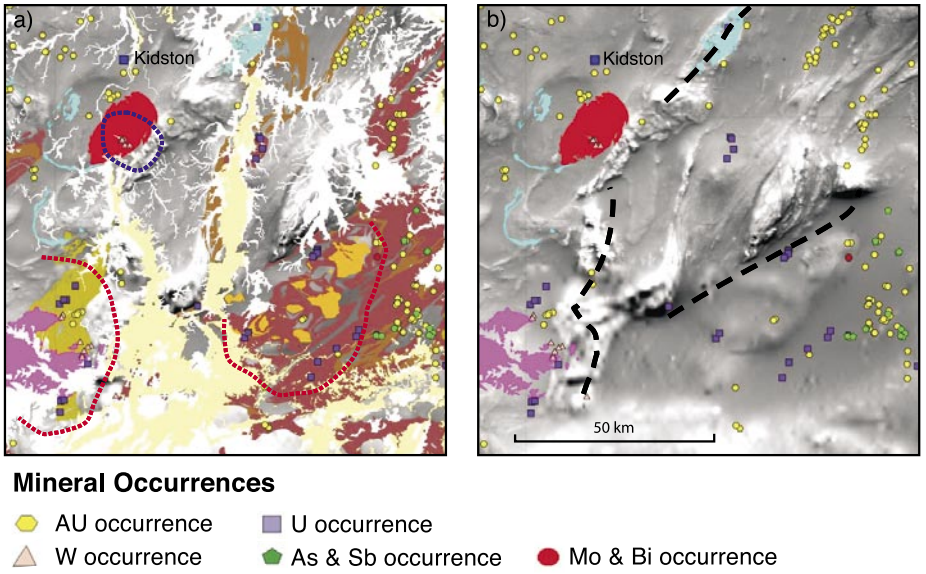


Figure 4. Geology of the Kidston region. **(a)** Mineral occurrence data and selected geology superimposed on regional aeromagnetic data. Broad metallogenic zoning centred around the fractionated, weakly oxidised granites (in red, blue, pink and ochre), is evident in the mineral occurrence data. Geology shown also includes high-level granites and porphyries (ochre), graphitic and carbonate-bearing sediments (browns), and cover rocks (Tertiary—yellow, Quaternary—white). **(b)** TMI aeromagentic image of the region showing the presence of major structures and a buried granite within the Broken River Province.

As part of the Felsic Igneous Rocks of Australia project, we have been compiling and synthesising various lithological, mineralogical, geochemical and metallogenic parameters for intrusive and country rock units of eastern Australia. One of the chief and first aims is compilation and interpretation of chemical-based metallogenic parameters for the granites, using characteristics identified by Blevin and other workers. The simplest first-pass approach has been to use the granite data in combination with the oxidation and degree-of-evolution parameters as defined by Blevin (2004; figure 2).

The north Queensland region (figure 3), has been the site of voluminous, episodic granite magmatism and associated volcanism, ranging in age from Mesoproterozoic (~1550 Ma), Silurian–Devonian (430–380 Ma), to Carboniferous–Permian (330–250 Ma). Magmatism of the most recent of these periods was the most voluminous and widespread, and is associated with a period of intense mineralisation, much of it probably granite-related (e.g. Bain & Draper 1997).

More than 650 intrusive units (Proterozoic to Permian) have been recognised in the region, with reliable geochemical data (in digital format) available for 375 units. Geochemical data from these units has been plotted (contoured) on the oxidation–fractionation diagram of Blevin (2004; figure 2), from which a number of points are illustrated.

First, it is evident that the granites collectively span a range of compositions, encompassing various metallogenic associations, consistent with what is known for this strongly mineralised region.

Second, it is evident that only a few of the granites have characteristics considered conducive for the granite-related copper–gold class of deposits (such as Cadia, New South Wales), potentially explaining the apparent dearth of significant deposits of such styles within the region. This is also consistent with the low potassium–rubidium ratios (< 400) of the north Queensland granites in the region, in contrast to the elevated values found with copper–gold associated granites elsewhere (Blevin 2004).

Third, and possibly most important, it is clear that a high percentage of the granites in north Queensland for which data exists have characteristics considered conducive for IRG-style mineralisation. Of approximately 300 granite units that fall within the IRG field of Blevin (2004), the majority (75%) are I-type and Carboniferous to Permian (figure 3), the age of most mineralisation in the region. Importantly, some 60% of these latter granites belong to just three granite supersuites: the well-endowed I-type Ootann, O'Briens Creek and Oweenee supersuites.

General models for the IRG system also highlight the importance of continental sedimentary assemblages as host rocks, especially those with carbonaceous- or carbonate-bearing units (table 1). When this is included as an additional selection parameter for north Queensland, only the western part of Hodgkinson Province and the eastern half of the Broken River Province (figure 3) emerge as prospective regions. Although these are sites of the major Palaeozoic basins in the region, it should be noted that one of the largest gold deposits in the region—Kidston—does not fall within these basins (figure 3).

Under cover/blind mineralisation

Two obvious features of Figure 3 are the amount of reasonable outcrop in the north Queensland region and, paradoxically, the extent of post-Permian cover for much of the region. Both offer additional exploration potential. It is evident that potential IRG-style mineralisation may be present beneath shallow cover along the north–south spine of the IRG-potential granites, in the northwest (west of Herberton, north of Georgetown) and in the southwest (south and southwest of Georgetown). Additional potential (buried) mineralisation, however, also exists in regions of good outcrop as blind deposits, related to buried granites. One potential example of this has been identified in the region just south of Kidston (figure 4).

As well as listing the general characteristics of IRG-style mineralisation, table 1 also documents how these characteristics may be recognised under cover or as blind deposits. Chief amongst these are geophysical characteristics, such as aeromagnetic and gravity data, recognised buried granites (especially those weakly oxidised or magnetically zoned, which may indicate fractionation), dyke swarms (which may also indicate buried granites and/or high crustal levels), and structural pathways.

Other important features include the presence of important pathfinder elements, especially bismuth and molybdenum, highlighting the importance of mineral occurrence databases. Other, more subtle, indicators could include recognised zoning in mineral occurrences (table 1), or possibly groundwater chemistry (such as presence of fluorine, uranium etc.), which may indicate strongly fractionated granites at depth.

Within the Kidston region (figure 4), favourable indicators include:

- presence of buried granites (as indicated by aeromagnetic data)
- abundant hypabyssal intrusions indicative of relatively shallow crustal levels
- presence of major faults
- bismuth and molybdenum occurrences
- presence of apparent broad mineral zoning from proximal uranium, molybdenum, tungsten, bismuth or tin to more distal gold or antimony
- presence of carbonate and graphitic horizons in the local country rocks
- proximity to known deposits of the IRG-style (Kidston).

Conclusions

The granite geochemistry of the north Queensland region shows many intrusives with characteristics considered conducive to IRG-style mineralisation. This is consistent with known occurrences of such deposits in the region but also reveals considerable potential for further discoveries.

Most of the favourable granites appear to belong to just three granite supersuites—the I-type Carboniferous to Permian Ootann, O'Briens Creek and Oweenee supersuites. Of these, the Ootann Supersuite is considered particularly favourable. Exploration should not only focus on regions under shallow cover but also on outcrop areas where buried granites (and potential for blind mineralisation) occur.

Acknowledgments

We thank Cathy Brown, Alan Whitaker, Daniel Connolly and Dale Percival for assistance with data compilation and digital geology; Phil Blevin and Lesley Wyborn for discussions on granite-related mineralisation; and Andy Barnicoat and Subhash Jaireth for reviewing the paper.

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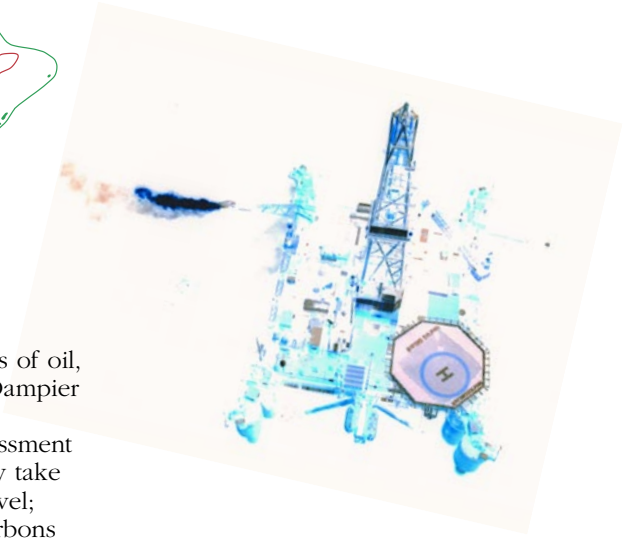
NEW RESOURCE ASSESSMENT FOR Dampier & Rankin



Geoscience Australia has updated medium-term forecasts for hydrocarbon discovery in the Carnarvon Basin.

Andrew Barrett

The next ten to fifteen years could see the discovery of 167 million barrels of oil, 0.4 trillion cubic feet of gas, and 26 million barrels of condensate in the Dampier Sub-basin and the adjoining Rankin Platform (table 1).

These predictions—generated by Geoscience Australia's resource assessment program AUSTPLAY—are the risked mean values from a distribution. They take into account the geological risk at both the play level and the prospect level; however, play-level risk is zero in these assessment areas, where hydrocarbons have already been discovered.

It is important to recognise that this is not an estimate of the ultimate potential for this region.

Table 1. Summary of Geoscience Australia's medium-term, medium drilling scenario assessment for the Dampier Sub-basin and Rankin Platform.

		Probability			
		90%	50%	10%	Mean
Oil	gigalitres	4	21	56	27
	million barrels	27	133	354	167
Gas	billion cubic metres	0.3	2.9	34.7	12.5
	trillion cubic feet	0.0	0.1	1.2	0.4
Condensate	gigalitres	0	1	12	4
	million barrels	0	5	77	26

Assessment units

AUSTPLAY considered two defined assessment units: a wet gas area on the Rankin Platform extending into the Dampier Sub-basin to include the Angel accumulation, and an oil area restricted to the Dampier Sub-basin (figure 1).

The gas area comprises the giant accumulations at North Rankin (including Perseus), Goodwyn and Angel. Of sixteen wells in the area defined as new field wildcats for the purpose of assessment, nine have discovered significant hydrocarbons and three are currently under production. Modelled drilling for the assessment expects to maintain this high success rate.

The southern limit of the assessment unit was defined by the Wilcox accumulation which contains relatively wet gas. All other accumulations to the west—including the recent Pluto and Wheatstone discoveries—contain very dry gas, suggesting a different hydrocarbon source.

The oil area includes current production at Cossack, Exeter, Lambert, Legendre, Mutineer, Stag, Wanaea and Wandoo, and also includes the depleted Talisman accumulation. Nineteen non-commercial discoveries have also been made in this area where a total of 76 wildcats have been drilled.

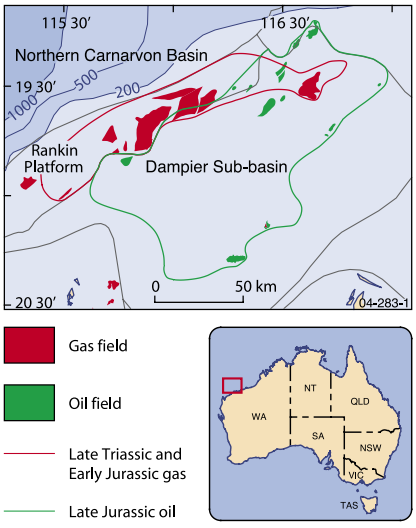


Figure 1. Assessment units for the Dampier Sub-basin/Rankin Platform.

Table 2. Summary of Geoscience Australia's medium-term, low and high drilling scenario assessments for the Dampier Sub-basin and Rankin Platform.

		P_{90}	P_{50}	P_{10}	Mean
Low drilling scenario – 0 wells gas assessment unit, 10 wells oil assessment unit					
Oil	gigalitres	0	5	28	10
	million barrels	0	33	176	64
Gas	billion cubic metres	0	0.3	3.3	1.2
	trillion cubic feet	0	0.0	0.1	0.0
Condensate	gigalitres	0	0	1	0
	million barrels	0	0	4	1
High drilling scenario – 6 wells gas assessment unit, 60 wells oil assessment unit					
Oil	gigalitres	11	37	84	43
	million barrels	71	231	526	272
Gas	billion cubic metres	0.8	5.7	45.3	17.6
	trillion cubic feet	0.0	0.2	1.6	0.6
Condensate	gigalitres	0	1	16	6
	million barrels	1	8	102	36

Forecast uncertainties

Forecasts of future wildcat drilling strongly influenced the assessment. Current permit drilling commitments were used as a starting point but these provide an outlook for only six years and drilling commitments in secondary work programs generally have a lower likelihood of occurring.

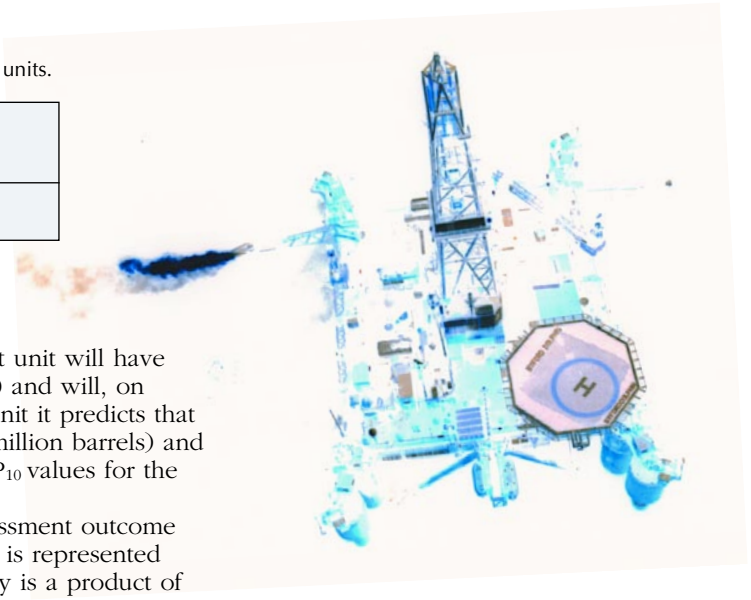
The assessment presented in Table 1 reflects the medium drilling scenario of 30 wildcats in the Dampier Sub-basin oil assessment unit—based on the historic drilling rate for the area of two wildcat wells per year—and only three in the gas assessment unit.

For the gas area, the model is based on possible permit commitments. It is feasible that no new wildcats will be drilled in the gas assessment area over the next 15 years and that any drilling could be considered to be extension drilling to the large gas accumulations.

Assessment outcomes for low and high drilling scenarios are presented in Table 2.

Table 3. Forecast volumes for next discoveries in the gas and oil assessment units.

		Well number	P_{90}	Mean	P_{10}
Oil	gigalitres	1.5	1	7	17
	million barrels		7	44	110
Gas	billion cubic metres	4.0	17	39	73
	trillion cubic feet		0.6	1.5	2.6



Discoveries

AUSTPLAY predicts that the next discovery in the gas assessment unit will have a mean volume of 39 billion cubic metres (1.4 trillion cubic feet) and will, on average, be found with well number 1.5. In the oil assessment unit it predicts that the next discovery will have a mean volume of 7 gigalitres (44 million barrels) and will be found with well number 4.0. Table 3 shows the P_{90} and P_{10} values for the first discoveries.

The predicted first gas discovery appears to exceed the assessment outcome shown in Table 1. This emphasises that the assessment outcome is represented by a distribution, and that the predicted size of the first discovery is a product of many statistical realisations.

Other updates

Geoscience Australia is currently using AUSTPLAY to assess the Exmouth Sub-basin of the Carnarvon Basin, with results due to be released in late 2005. Geoscience Australia is also collaborating with the Victorian Department of Primary Industries in generating an updated assessment of the Gippsland Basin.

For more information phone Andrew Barrett on +61 2 6249 9502 (email andrew.barrett@ga.gov.au)

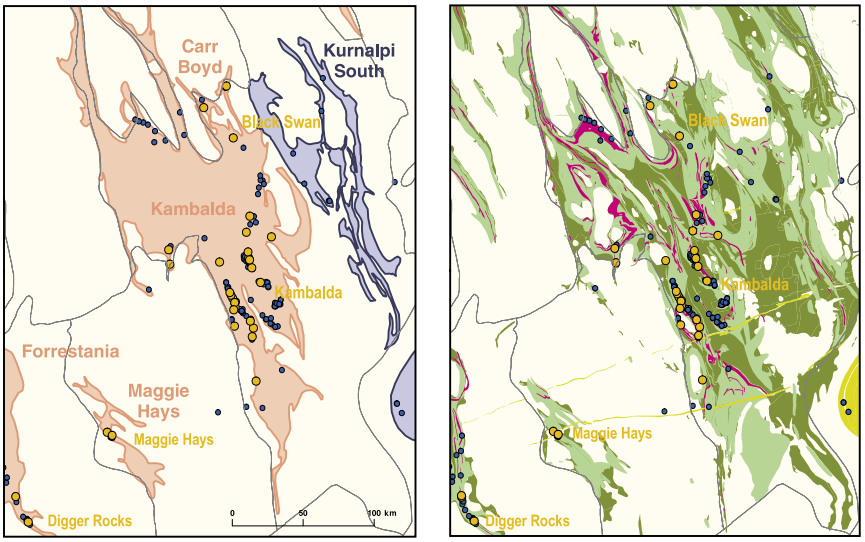
NICKEL SULPHIDE METALLOGENIC PROVINCES: *resources & potential*

Subhash Jaireth, Dean Hoatson, Lynton Jaques, Mike Huleatt, Mitch Ratajkoski

As strong demand for nickel stimulates exploration activity worldwide, Geoscience Australia has developed a web-based information and mapping system of metallogenic provinces to assist the discovery of new nickel sulphide resources to maintain Australia's position as the world's second biggest provider of this valuable mineral.

Geoscience Australia's Oracle-based Provinces and Events database provides information on regional geology, mineral occurrences and deposits, resources, and age of mineralisation of nickel sulphide deposits. The spatial extent of nickel provinces (currently metallogenic only) and their attributes can be viewed through Geoscience Australia's web-based mapping system, which provides links to other national databases of mineral deposits, geochronology and stratigraphy.

Three basic criteria define metallogenic provinces that contain known nickel sulphide mineral systems: style of mineral system, age and spatial contiguity. Additional prospective provinces are defined by the presence of nickel occurrences (with no recorded resources) and/or of mafic–ultramafic rocks interpreted to be favourable for nickel sulphide mineralisation (figure 1).



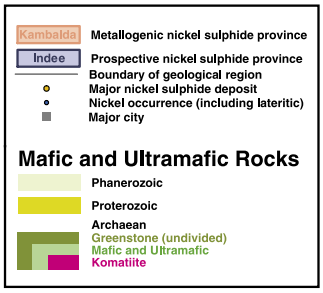


Figure 1. Metallogenic nickel sulphide provinces in the Kambalda region. The map on the left shows provinces from the nickel province map of Australia, metallogenic (in orange) and prospective (in blue). The map on the right shows the distribution of mafic and ultramafic rocks, known mineral deposits and occurrences that delineate the provinces.

Global metallogeny of nickel sulphide deposits/events shows that komatiite-related Ni–Cu deposits (such as Kambalda in Western Australia and the Abitibi and Thompson belts in Canada) are of Archaean and Proterozoic age, with relatively larger deposits formed ~2700 Ma (million years ago) and ~1900 Ma. Komatiites older than 3000 Ma are generally not mineralised.

Basal Ni–Cu sulphide deposits (such as Voisey's Bay in Canada) are not age-specific, although larger deposits of this type tend to be younger than ~2060 Ma. Stratabound deposits of platinum group elements, nickel and copper (PGE–Ni–Cu) associated with large Archaean–Proterozoic layered mafic–ultramafic complexes (such as the Great Dyke, Zimbabwe and Merensky Reef, South Africa) contain large resources of nickel (5 to 6 Mt Ni metal), but are of low grade (<0.2% Ni).

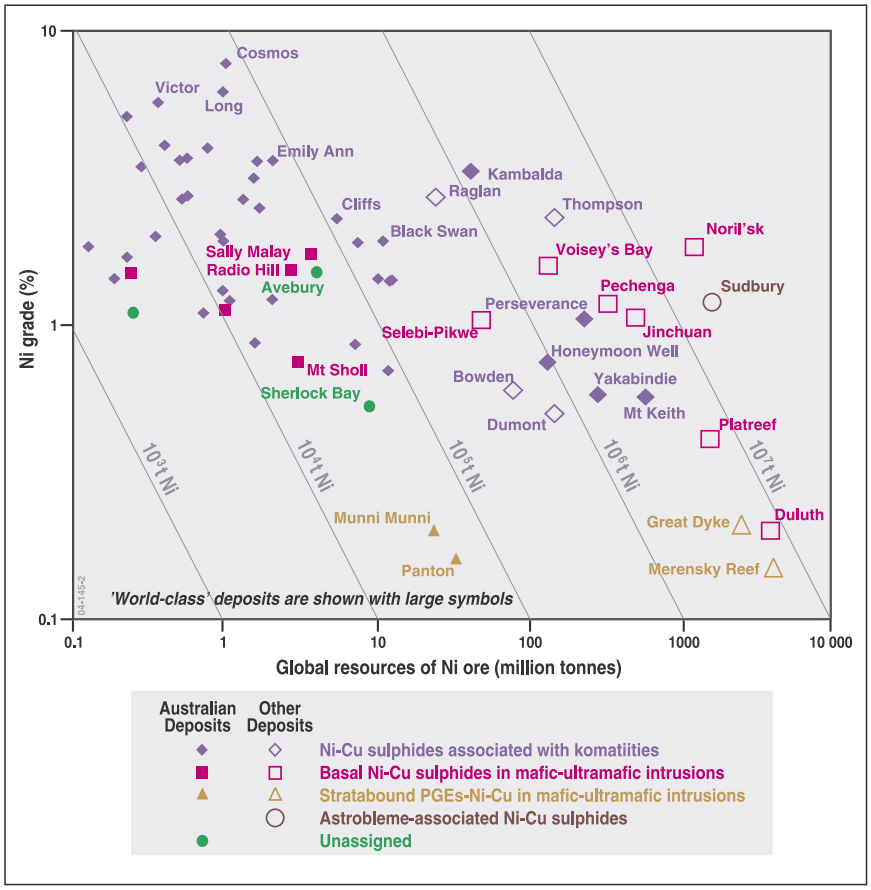


Figure 2. Logarithmic plot of nickel grade (wt%) versus global resources of nickel ore (production plus reserves and resources in million tonnes) for the major nickel sulphide deposits of the world. Australian deposits are shown with filled symbols and other deposits with open symbols. The grey diagonal lines show contained Ni metal in tonnes (source of data: OZMIN 2004, Naldrett 2002, Eckstrand 1995).

Australia is well represented by world-class nickel sulphide deposits (>1 Mt of Ni metal), and smaller, rich deposits (5–8% Ni) (figure 2). Australian deposits are associated with ultramafic and/or mafic igneous rocks and occur in three main geotectonic settings:

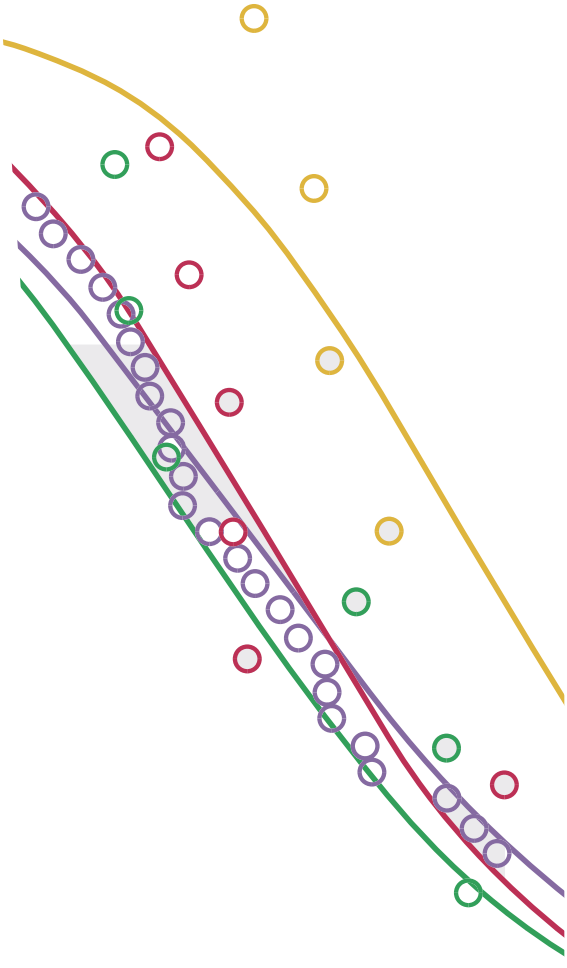
- Archaean komatiites in granite–greenstone terranes
- Precambrian tholeiitic mafic–ultramafic intrusions emplaced in former rift zones in Archaean cratons and Proterozoic orogens
- Remobilised-hydrothermal deposits of various ages and tectonic settings.

Australia's nickel–sulphide production and resources are dominantly associated with the komatiite-hosted deposits of the Yilgarn Craton formed ~2.71–2.70 Ga (billion years ago). The Mount Keith and Kambalda metallogenic provinces are the most endowed, containing ~9.5 and ~2.0 million tonnes of nickel (past production plus resources), and host the world-class deposits of Mount Keith and Kambalda. The older komatiitic sequences in the Pilbara Craton (~3.3–3.0 Ga) and the younger Lake Harris (~2.5 Ga) komatiite (Hoatson et al, 2005) in the central Gawler Craton appear to be less mineralised but have potential for further discoveries.

A comparison of global resources of nickel in deposits associated with komatiites (figure 3) shows generally similar cumulative frequency distribution curves for the Archaean Southern Cross, Eastern Goldfields and Canadian Abitibi provinces, reflecting their similar nickel endowment. This suggests that the Southern Cross Province (~2900 Ma) may host large undiscovered deposits of either the Kambalda or Mount Keith type and size.

The curve for the Palaeoproterozoic Thompson Belt shows a shift to the large-tonnage deposits. This belt has geological and geochemical features similar to those in the Eastern Goldfields and Abitibi provinces, except for the intense remobilisation of nickel sulphide mineralisation in the former. The rich Thompson mine is hosted by intensively deformed and metamorphosed sulphidic carbonaceous sediments, which suggests that intensive remobilisation could have led to the formation of a small number of high-grade nickel sulphide deposits.

Basal Ni–Cu–Co±PGE sulphide mineralisation is associated with tholeiitic mafic–ultramafic intrusions emplaced in former rift zones in Archaean cratons and Proterozoic orogens at ~2.93–2.89 Ga in the west Pilbara (e.g. Radio Hill, Mt Sholl), ~2.8–2.7 Ga in the Yilgarn Craton (Carr Boyd Rocks), ~1.86–1.84 Ga in the Halls Creek Orogen (Sally Malay, Corkwood), and ~1.08 Ga in the Musgrave Block (Nebo, Babel).



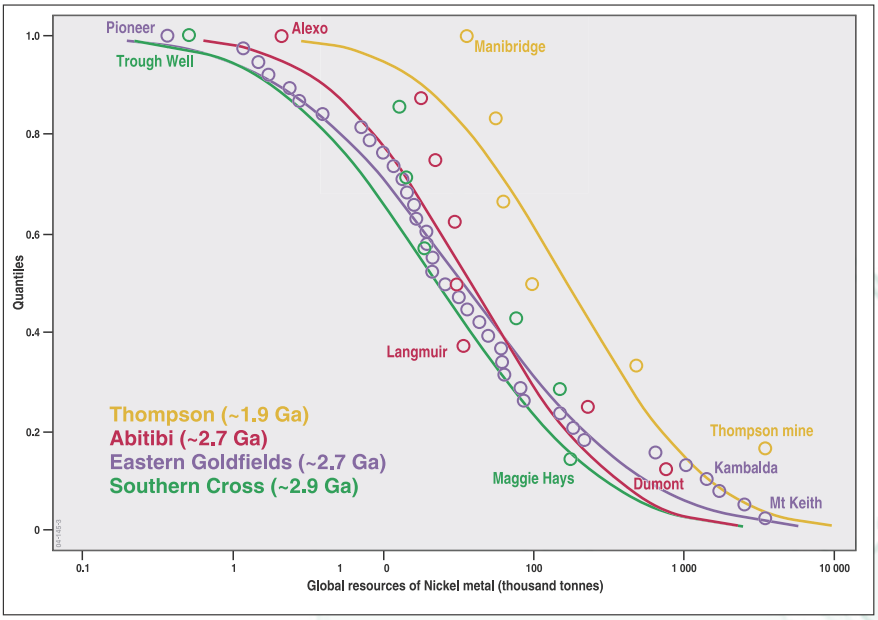


Figure 3. Cumulative frequency distribution of global resources of nickel metal (production plus reserves and resources) for the major nickel-bearing komatiite belts and provinces of the world (source of data: OZMIN 2004, Naldrett 2002, Eckstrand 1995).

In contrast to stratabound PGE deposits hosted by large layered mafic–ultramafic bodies (Munni Munni, Weld Range), basal Ni–Cu–Co sulphide deposits occur in small to medium size mafic bodies that may be layered or massive. Other styles of mineralisation of exploration interest include small, remobilised-hydrothermal nickel sulphide deposits in western Tasmania (Avebury) that are thought to be associated with Devonian granites that intrude Cambrian mafic–ultramafic sequences.

Analysis of the metallogenic provinces suggests considerable potential for further komatiite-hosted deposits in under-cover extensions of the mineralised komatiite sequences in the Yilgarn Craton. Similar potential exists for Ni–Cu–Co±PGE sulphide mineralisation associated with basal contacts and feeder conduit zones of sulphur-saturated tholeiitic mafic–ultramafic intrusions in the Musgrave, Halls Creek, Arunta and Gawler provinces, and unexposed areas of the Albany–Fraser Province region.

The recently discovered Collurabbie Ni–Cu–PGE prospect in the northeast Yilgarn Craton is an unusual, PGE-enriched nickel sulphide komatiite deposit that highlights the potential of poorly exposed Archaean greenstone sequences near the margins of the craton. There is also some potential for Noril'sk-type Ni–Cu–PGE deposits associated with major igneous provinces in western and northern Australia (such as Antrim Plateau Volcanics), although no deposits of this type are currently known (Wingate et al 2004).

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GOING FOR GOLD *beneath the Tanami*

A seismic acquisition project to identify big structures in the Tanami region will greatly assist mineral explorers.

Bruce Goleby

A principal objective of Geoscience Australia's North Australia Project is to assess the geology of the region and its known and potential mineral systems, particularly those associated with the gold deposits of the Tanami (see *AusGeo News 74*).

The Tanami National Geoscience Accord (NGA) Project—a collaborative initiative between Geoscience Australia, the Northern Territory Geological Survey and the Geological Survey of Western Australia—evolved from this work to more directly target controls on lode gold mineralisation.

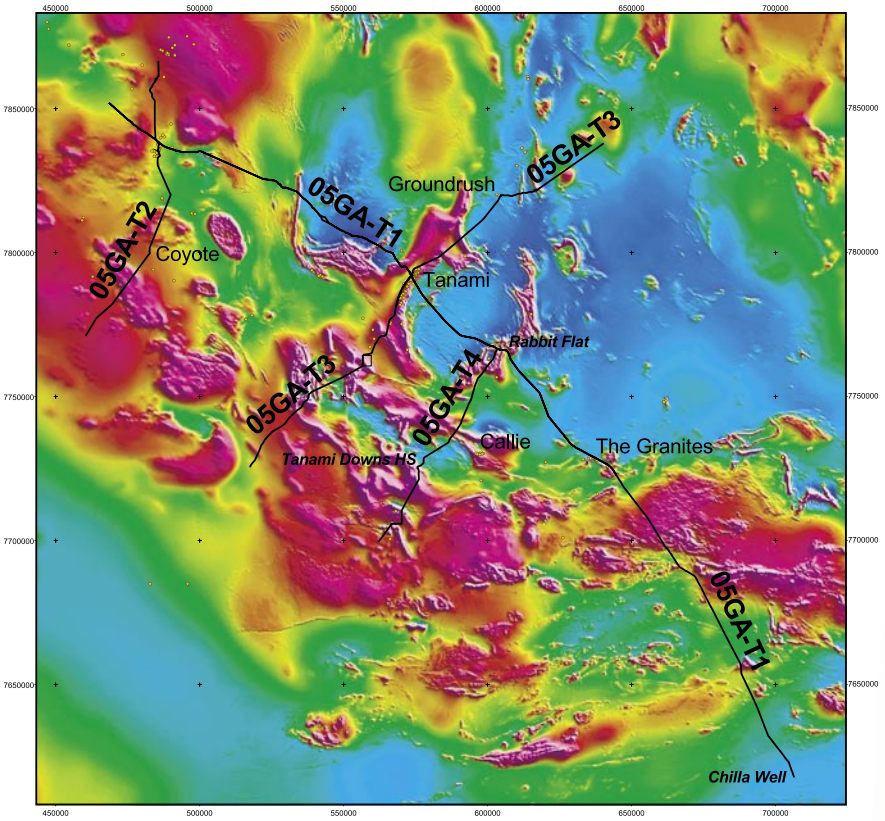

Figure 1. Location map of the Tanami region, northern Australia, showing the four Tanami traverses (05GA-T1 through to 05GA-T4). The dotted portion of 05GA-T1 indicates extra kilometres collected due to additional funding and excellent crew performance. A total of approximately 720 line kilometres were recorded. Locations of mineralisation are shown as circles.

Figure 2. ANSIR (through Terrex Seismic Pty Ltd) seismic acquisition in operation in the Tanami with three IVI 60 000 lb vibrators operating on traverse 05GA-T2 to send signals through whole of crust and back.

To answer questions arising from the newly constructed 3D model of the Tanami region (www.ga.gov.au/map/web3d/tanami/index.jsp), the collaborators agreed that collection of seismic data across the region was crucial. This data will greatly assist mineral explorers in discovering new mineral deposits.

The seismic reflection technique is considered the most suitable method to understand Tanami architecture at depth, including the key regional structures and fluid pathways that operated as part of the region's gold mineral system.

To facilitate this, the Tanami Seismic Collaborative Research Project—involving the Tanami NGA Project partners plus Newmont Exploration Pty Ltd and Tanami Gold NL—designed a program of seismic traverses to focus on the crustal architecture of the region and key structures connected with gold mineralisation.

Arrangements for the project began in April 2004, with the commencement of line preparation and surveying. Under the supervision of the Australian National Seismic Imaging Resource (ANSIR) through its facilities manager, Terrex Seismic Pty Ltd, seismic acquisition began in May 2005, working from west to east. The survey finished in early July, after completing all of traverse 05GA-T1.

The main objectives are to:

- image the geometry of the main faults
- determine a deformation sequence for these faults
- identify any through-going crustal structures
- determine stratigraphic thicknesses of the Tanami Group and granite body geometries
- determine relationships of the various stratigraphic packages to controlling structures
- investigate the relationship of mineralised domains to crustal scale structures
- identify Archaean basement and its relationship to the overlying Tanami Group stratigraphy
- investigate the character of the Tanami–Arunta boundary.

The Tanami seismic survey consists of four traverses totalling 724 kilometres (05GA-T1 through to 05GA-T4). Traverse 05GA-T1 is a northwest–southeast regional transect, while traverses 05GA-T2, 05GA-T3 and 05GA-T4 provide orthogonal 3D control on the geometry of the region's main fault systems (figure 1). The seismic traverses run close to the Coyote, Tanami, Groundrush and Callie mine sites and will provide information on the deeper structures in these areas.

The seismic data provides valuable 3D information about the Tanami crust, and will also help mineral explorers find new mineral deposits. In conjunction with the seismic acquisition, the Northern Territory Geological Survey is collecting 400-metre gravity data along each of the seismic traverses. Geoscience Australia is also collecting wide-angle velocity data along regional traverse 05GA-T1.

The seismic data was acquired using ANSIR's seismic reflection system, consisting of an ARAM24 (24-bit) seismic reflection recording system with 10 Hz geophones and three IVI 60 000 lb vibrators operating at all times (figure 2).

Processing began in June 2005, and is expected to be completed early in 2006. The five partners will begin interpretation in late 2005, and hope to have final interpreted sections by mid-2006.

The collaborators plan to hold a workshop on the seismic results soon after the data synthesis and final interpretations are completed. The results will be published as a Geoscience Australia Record in July–August 2006.

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PROTECTING **the nation**

Geoscience Australia's contribution to the National Critical Infrastructure Protection Strategy

Greg Scott

Protecting the critical infrastructure (CI) that underpins Australia's economic strength and social stability is a high priority for the Australian Government. The Trusted Information Sharing Network (TISN) for Critical Infrastructure Protection (CIP), established in April 2003, forms the basis of a strong business–government partnership approach to this important national objective.

To support the TISN and advance a range of high-priority CIP initiatives, the Australian Government's 2004–05 Budget allocated additional funding of $50.2 million over four years to Geoscience Australia and eight other Australian Government agencies. As the national agency for geospatial information, Geoscience Australia will contribute to three key areas—national coordination, infrastructure vulnerability identification, and interdependency modelling and analysis—by improving the government's capacity to analyse the consequences of CI failure within a geospatial modelling framework.

CI has been defined as physical facilities, supply chains, information technologies and communication networks whose destruction, degradation or unavailability for an extended period would significantly impact on the nation's social or economic wellbeing, or affect Australia's ability to conduct national defence and ensure national security. CI extends across many sectors of the economy, including banking and finance, transport, energy, communications, utilities, health and food supply.

Critical infrastructures are complex, highly connected and highly interdependent. This is particularly evident in sectors such as energy. The reliable continuity of supply of energy, and electricity in particular, is critical to many other sectors of the community. A significant loss of supply for an extended period would have substantial negative impacts, both on the economy and the social wellbeing of the population.

CI can be damaged, destroyed or disrupted by natural disasters, negligence, accidents, computer hacking, criminal activity and malicious damage, as well as by deliberate acts of terrorism. Accordingly, our CI must be protected against all threats and hazards presenting a risk to the continuity of service.

The main goal of the government's policy on CIP is to ensure that Australia's CI will be better protected and better able to continue to operate in the face of increasing threats and hazards. This will engender greater confidence in our CI in all sectors of the Australian economy and the community, and among foreign investors. The two programs Geoscience Australia will be working on are the CIP Modelling and Analysis Program and the Energy Group Supply Chain Mapping Project.

The CIPMA Program

The Attorney-General's Department is the lead coordinating agency for CIP, and is sponsor and manager of the CIP Modelling and Analysis (CIPMA) Program, one of the priority initiatives funded in the 2004–05 Budget. A CIPMA development team, consisting of representatives from that department, CSIRO and Geoscience Australia has been established to source necessary skills and expertise, and build the capability.

The overall aim of the CIPMA Program is to build and demonstrate the capability to answer the most important questions posed by key decision makers in government and industry about CI dependencies and interdependencies, and the flow-on consequences of a failure in one sector. The CIPMA Program will involve modelling, simulation and analysis of the primary dependencies and interdependencies and flow-on consequences for three priority sectors: banking and finance, communications, and energy. Building this capability will rely heavily on access to significant amounts of industry information and data, and will include geographic information system (GIS) functionality for data capture, management, modelling and visualisation.

The complexity and interconnectedness of CI poses challenges for the modelling and analysis of the systems in a spatial environment. While it may appear straightforward to apply GIS to site-specific physical CI, it is much more difficult to model and analyse the dynamics of CI systems. Crucial to the modelling process will be the capture and analysis of system dependencies via comprehensive geodatabase models that incorporate business processes and system functionality to determine the criticality or vulnerability of infrastructure systems.

Successful development of the capability will rely on strong support from key stakeholders, including the owners and operators of CI, and state and territory governments.

Specifically, the demonstration capability will provide significant input in four areas:

- **The consequences of a CI failure.** What are the consequences of attacks on or failures of infrastructure for national security, continuity of government, and economic and other impacts?
- **Single points of failure.** Are there key weaknesses in the nation's CI, where one or two attacks or failures could have a debilitating effect?
- **Risks.** What are the highest risk areas, considering consequences and likelihood?
- **Investment and mitigation strategies.** What investment strategies or policies can have the greatest impact in reducing overall risk?

Over the past 12 months, a strong foundation has been laid for the CIPMA Program, including an assessment of relevant initiatives in overseas jurisdictions, the development of a detailed CIPMA Implementation Plan, and collation of user requirements from government and participating industry sectors. Data capture and model development is now well underway.

The Energy Group and the Supply Chain Mapping Project

The TISN was created to establish a business–government partnership for sharing information on medium-to long-term aspects of CIP, particularly relating to the national interest, cross-sector interdependencies, regulatory impediments and research. The TISN comprises sectoral 'infrastructure assurance advisory groups' made up of industry and government representatives. The activities of the Energy Infrastructure Assurance Advisory Group (the Energy Group) are being undertaken in the context of the principles and responsibilities described in the National CI Protection Strategy.

In July 2004, the Energy and Environment Division of the Department of Industry, Tourism and Resources—which provides the secretariat to the Energy Group—commissioned Geoscience Australia to undertake a supply-chain mapping and vulnerability assessment project. The objective is to provide a comprehensive view of the energy supply chain to enable the Energy Group to assess vulnerabilities and interdependencies within the sector.

The supply-chain mapping project is focusing on the overall systems and networks that make up the national energy CI and associated interdependencies, and will:

- create a comprehensive picture of the Australian energy sector, including linkages between electricity, gas and liquid fuels.
- be an important tool both for energy industry owners and operators and for government, by providing a new level of understanding of the vulnerabilities and interdependencies associated with energy supply chains.
- assist in the development of appropriate measures and strategies for protecting energy infrastructure both at the organisational level and from a coordinated, national perspective.

The mapping project will also be an important input into the CIPMA Program.

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MAWSON GEOMAGNETIC OBSERVATORY TURNS 50

This year marks 50 years of continuous operation of the geomagnetic observatory at Mawson in Antarctica.

Andrew Lewis

In August 2005, the Mawson observatory became the second Geoscience Australia magnetic observatory to have provided more than a 50-year time-series of data. The observatories at Macquarie Island, which began operations in 1952, and Mawson continue to produce high-quality data, with further upgrades planned for Mawson to meet changing demands for geomagnetic data.

The 50 years of data generated from the Mawson observatory is one of the longest continuous time-series of geomagnetic data available from the Antarctic continent. Such long datasets are particularly valuable in the study of geomagnetic secular variation—the slow change of Earth's magnetic field arising from its liquid core (figure 4).

Mawson geomagnetic data is used in the development of global and regional field models, such as the International Geomagnetic Reference Field model, the World Magnetic Model, and the Antarctic Reference Model, all of which have applications in navigation, exploration and research. The data is also used to support satellite magnetic field missions, and helps us better understand the nature and origin of Earth's magnetic field and of ionospheric and magnetospheric processes in the polar region.

The pioneers

Geoscience Australia's predecessor, the Bureau of Mineral Resources, Geology and Geophysics (BMR), established the Mawson Geomagnetic Observatory as part of the Australian National Antarctic Research Expeditions.

Jim Brooks, the geophysicist who spent 1953 operating a geomagnetic observatory established on Heard Island in the sub-Antarctic the previous year, joined the pioneering voyage of *Kista Dan* that led to the selection and establishment of Mawson Base. In mid-February 1954, he made absolute observations of intensity and direction in the area allocated for the eventual magnetic observatory.

Two original plywood observatory huts—known as the 'absolute' and 'variometer' huts—were removed from Heard Island in October 1954 and installed at Mawson the following February.

The Heard Island absolute observing piers were left in place for future use, and a new wooden absolute observing pier was installed at Mawson. The original magnetic absolute hut and pier (figures 1,2 and 3) are still a vital part of the Mawson observatory, where they are used for weekly absolute calibration observations. The original variometer hut, which remained in place when a new hut was installed in 1985, was accidentally destroyed in a quarry blasting accident in 1994.

Hugh Oldham, the first in a long line of Australian Government geophysicists to spend the winter at Mawson, established the observatory. He made his first observations on 4 May 1955, and the observatory started producing hourly mean values of the vector geomagnetic field in August 1955. Geomagnetic hourly mean values are still one of the data products of the observatory today, while the variometer equipment also records changes in the geomagnetic field with a time resolution of one second and a field resolution of 0.025 nT (nanoteslas).

At least four Mawson veterans still work in Geoscience Australia today. Observers typically spent one year at the observatory to run the equipment and prepare data. Many observers did multiple 'tours of duty' at Mawson, or a year at Mawson followed by a year at the Macquarie Island Observatory.

Figure 1. The Mawson absolute hut soon after installation (photo by Hugh Oldham, 1955).

Figure 2. The absolute hut (foreground) and the variometer hut installed in 1985 (photo by Peter Crosthwaite, 2003).

Figure 3. Inside the absolute hut—an Askania declinometer is mounted on the primary absolute pier.

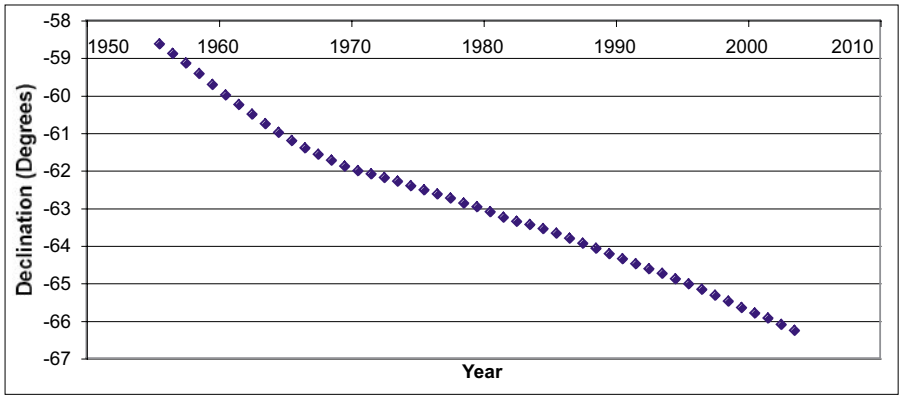

Figure 4. Annual mean declination for Mawson Geomagnetic Observatory, 1955–2004. Magnetic north at Mawson is to the west of true north, hence the negative values of declination shown in the plot.

The technologies

The first variometer equipment to monitor changes in the magnetic field at Mawson was a La Cour photographic system. The La Cour variometer consisted of several suspended magnets that were free to rotate in response to the changing magnetic field. Mirrors attached to the magnets reflected carefully directed light beams onto a rotating drum carrying photographic paper. Much of the work of the early Mawson geophysicists involved attending to the variometer equipment, developing the photographic paper and hand-scaling the magnetic traces.

The La Cour system operated from 1955 to 1985, when it was replaced with a photo-electronic system. Data was recorded on chart paper and also digitised for recording on cassette tape. A further upgrade in 1989 integrated a personal computer into the system. In 1993, the photo-electronic variometer was replaced with a modern electronic three-axis ring-core fluxgate magnetometer, which continues to run as the primary instrument today.

Full-time geomagnetic observers operated the Mawson Observatory until 1997, when data telemetry and electronic communications technologies were installed to provide daily downloads of data to Geoscience Australia's Canberra headquarters.

In 1998, the observing duties were converted to a part-time position shared with the Bureau of Meteorology. Onsite observing duties are currently performed by the Australian Antarctic Division's communications technical officers. In 2005, the duties of the geomagnetic observer are being carried out by Mathew Leayr, who undertook intensive training in observatory procedures at Geoscience Australia before he left for Mawson in January this year.

The excellent communications infrastructure that has been available at Australian Antarctic stations for some time allows all the data processing, analysis and dissemination to be done from Geoscience Australia's headquarters in Canberra.

Future plans for the Mawson observatory include installation of a new primary magnetic variometer system and an upgrade from daily data downloads to real-time data (both planned for early 2006). This upgrade should allow Mawson to be accepted in the near future as a member of the INTERMAGNET global network of high-quality geomagnetic observatories.

The most recent data from Mawson, and from Geoscience Australia's eight other magnetic observatories (figure 5) is available on-line from the geomagnetism pages of the Geoscience Australia website (www.ga.gov.au) or on request.

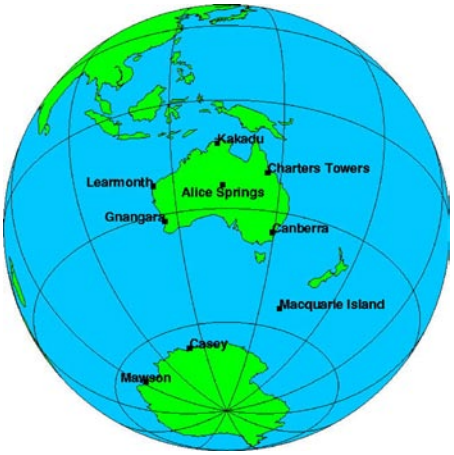

Figure 5. Geoscience Australia's network of geomagnetic observatories.

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Enhanced GEOSPATIAL AND EARTH MONITORING *capabilities*

Geoscience Australia's new Geospatial and Earth Monitoring Division (GEMD) is working to improve the safety of communities and the protection of Australia's critical infrastructure, through its comprehensive monitoring, research and mapping programs.

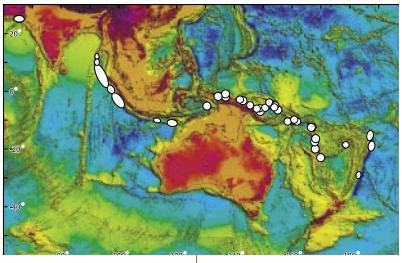
The merger of Geoscience Australia's Geohazards and National Mapping Divisions enhances the agency's geospatial information and knowledge management, and earth observations capabilities. Combining the strengths of the two former divisions will improve the agency's capacity to respond flexibly to current and emerging government priorities.

In developing its risk assessment, mitigation and Earth monitoring capacity, GEMD will provide a single point of focus for negotiating with jurisdictions and industry on technical and implementation aspects of spatial sciences in government. It will also facilitate the use of geodesy, satellite remote sensing and other earth observation and monitoring tools in new areas of rapid and slow-onset hazards, and climate change impact.

The new division supports five key agency functions under the leadership of Dr Chris Pigram, former Chief of Geoscience Australia's Minerals Division.

Earth Monitoring Group

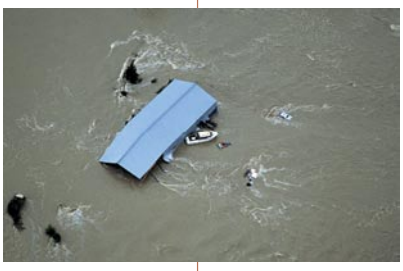
The Earth Monitoring Group is tasked with developing and implementing the Australian Government's 24/7 Tsunami Warning System. It will also continue to deliver earthquake, nuclear event, geomagnetic event and geodesy monitoring and advice services.



Group Leader: Dr Barry Drummond (email: barry.drummond@ga.gov.au)

Risk Research Group

The Risk Research Group is continuing its natural and human-caused hazard research to enhance Australia's risk mitigation capabilities through policy and decision-maker support. The group is working with other agencies to develop and collect information on natural disasters, and develop risk models for forecasting the impact of future hazard events.



Group Leader: Dr John Schneider (email: john.schneider@ga.gov.au)

National Mapping and Information Group

The National Mapping and Information Group provides maps and fundamental spatial data sets to emergency managers, defence, other government departments and the public. It also coordinates the agency's national mapping activities and standards, through the Intergovernmental Committee for Surveying and Mapping (ICSM).

Group Leader: Mr Ian O'Donnell (email: ian.odonnell@ga.gov.au)

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GEMD

AUSGEO news
ISSUE 79 September 2005

GEMD

Enhanced GEOSPATIAL AND EARTH MONITORING *capabilities* *(continued)*

Spatial Information Access and Remote Sensing Group

The multifunctional Spatial Information Access and Remote Sensing Group supports both internal and external clients by providing spatial data, remote sensing, GIS, and visualisation services, and facilitating data integration and interoperability. The group also operates Australia's public good remote sensing satellite data reception facilities, and provides access to and delivery of geographic, spatial and remote sensing data.

Group Leader: Dr Adam Lewis (email: adam.lewis@ga.gov.au)

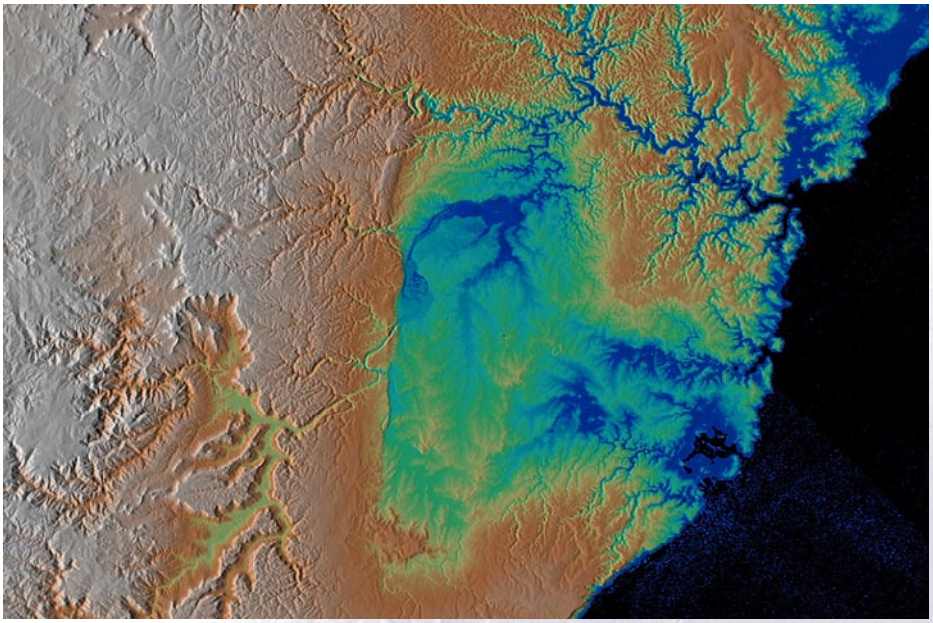
Spatial Information Industry Advice and Facilitation Branch

The newly formed Spatial Information Industry Advice and Facilitation Branch will provide advice and information to government. The branch aims to facilitate improved decision-making through better use of spatial information industry capability. It will focus on providing the government with advice on the form and capacity of the spatial information industry and its strategic issues. It will also work to improve access to industry capabilities and Australian Government support programs.

General Manager: Mr Peter Holland (email: peter.holland@ga.gov.au)

Geologic sources of seismic hazard *in* Sydney Basin

The Sydney Basin is home to a significant proportion of the Australian population, and the 1989 M5.6 Newcastle earthquake demonstrated that the basin is vulnerable to impact from a relatively modest earthquake. In spite of this, few investigations have been conducted to identify and characterise potential sources of seismic hazard. A recent major study on the southern part of the basin found that "The available data are less complete than ideal for the purposes of probabilistic seismic hazard analysis". Essentially, the extreme infrequency of large earthquake events in intraplate regions, such as Australia, means that the short historic record of seismicity forms a poor basis on which to make informed hazard assessments. Consequently, large earthquakes might be expected to occur in unanticipated places. In these circumstances, the record of pre-historic seismicity captured in the landscape provides an important tool to capture the recurrence intervals of large and damaging earthquakes.



▲ **Figure 1.** SRTM 3-second Digital Elevation Model over the Sydney Basin. The Lapstone Structural Complex is the northerly trending linear feature in the middle of the image. Sydney CBD is in the centre-right.

To address this issue, Geoscience Australia held a workshop entitled "Geologic sources of seismic hazard in the Sydney Basin" in April. The workshop was attended by 30 expert representatives from government, academia and industry. They heard a number of talks covering aspects of geology, geomorphology, seismicity and hazard. It was found that in the recent geologic past there is robust geomorphic evidence in stream profiles, ponded drainage and along several faults scarps, that large earthquakes have occurred on faults comprising the Lapstone Structural Complex (LSC). A clustering of epicentres recorded in the last several decades beneath and to the west of the LSC show that these structures may still be active and pose an unquantified hazard to greater Sydney. The possibility of future neotectonics research was examined in order to support future seismic hazard studies in the Sydney area.

A proceedings and discussion volume will be published as a Geoscience Australia Record in November 2005.

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Major coral reef discovery
IN GULF OF CARPENTARIA

Scientists from Geoscience Australia recently announced the discovery of a previously unidentified major coral reef province in the southern part of the Gulf of Carpentaria.

This discovery makes the Gulf of Carpentaria an important coral reef region of Australia encompassing as many as 50 small coral patch reefs, one to ten kilometres in diameter, plus an elongate platform coral reef that is around 100 kilometres in length extending westwards from Mornington Island. The thickness and wide distribution of the reefs point to a long history of reef growth extending possibly over the past 100 000 years or more.

The first hint of the reefs' existence came two years ago during a survey in the Gulf conducted by Geoscience Australia (see *AusGeo News 72*). Three patch reefs which varied from one to ten kilometres across were discovered northeast of Mornington Island.

Information on the distribution of coral reefs in the Gulf will assist the Department of Environment and Heritage in developing the Northern Regional Marine Plan as well as establishing a series of marine protected areas in northern Australia to represent the diverse range of habitats in that region.

Geoscience Australia led the survey which was run in conjunction with the Department of Environment and Heritage and CSIRO Marine and Atmospheric Research. It was the second leg of an 80 day marine science voyage conducted in northern Australian marine waters on board the Australian Government's National Facility ocean research vessel, the *Southern Surveyor*.

The survey used a sophisticated sonar seabed mapping system and an under-water corer to investigate the reefs (see *AusGeo News 72*). This research forms a critical part of Geoscience Australia's Seabed Mapping and Characterisation Project.

For more information phone Peter Harris on +61 2 6249 9611 (email peter.harris@ga.gov.au)

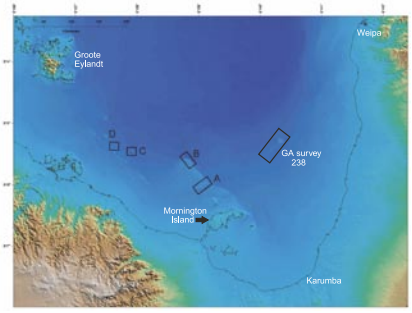


Figure 1. The newly-discovered coral reefs, extending westwards from Mornington Island, are shown as areas A, B, C and D. The patch reefs discovered two years earlier on GA survey 238 are about 100 kilometres north-east of Mornington Island.

New agreement *furthers Antarctic research*

French-Australian cooperation in marine and Antarctic geoscience is being further strengthened by the signing of a new MOU between Geoscience Australia and the Institut Polaire Français Paul-Emile Victor (IPEV) during a visit by the Institute's Director Dr Gérard Jugie. Cooperation between IPEV and Geoscience Australia goes back many years through joint surveys on the IPEV research vessel *Marion Dufresne II*. The *Marion Dufresne II* is used for resupply of French sub-Antarctic islands but is also equipped with full ocean-depth multibeam sonar and a unique "jumbo" piston corer capable of recovering sea floor sediment cores up to 60 metres long. The multibeam sonar provides detailed maps of the sea floor in water depths beyond the reach of similar systems on Australian survey vessels and the cores provide extended records of environmental change.

The *Marion Dufresne II* has conducted surveys with Australian participation in the Murray Canyons area in the Great Australian Bight, the Diamantina Fracture Zone off Western Australia and the Wilkes Land-Terra Adélie area of Antarctica.

The Antarctic survey used seismic data collected by Geoscience Australia in 2001 and 2002 to select suitable coring sites.

During his visit, Dr Jugie met with staff in Geoscience Australia's Petroleum and Marine Division to discuss possible projects using the *Marion Dufresne II* in the south-west Pacific region and the continental slope off New South Wales. Discussions also covered French and Australian geoscience projects in the Antarctic and how collaborative projects could be based around Geoscience Australia's extensive Antarctic seismic data sets. Possible projects to mark the next International Polar Year in 2007-08 is another area of joint interest.

For more information phone Peter Harris on +61 2 6249 9611 (email peter.harris@ga.gov.au)

Remote Sensing *update*

National Remote Sensing Technical Reference Group

The National Remote Sensing Technical Reference Group (NRSTRG) provides advice to Geoscience Australia on strategic positioning and technical decisions relating to the provision of 'public good' satellite imagery.

The Group, which was established by Geoscience Australia's remote sensing unit, ACRES, held its second meeting in April 2005. Two items of particular interest that were discussed during this meeting included an update on ACRES activities in relation to the Advanced Land Observing Satellite (ALOS) mission and the draft LANDSAT Contingency Plan.

ALOS Data Node

ACRES has been appointed as the Oceania Data Node for acquisition and distribution of ALOS data.

ACRES has been preparing for ALOS for two years, and is on schedule to complete all the mission tests required of Data Nodes prior to the launch. In total there are five Data Nodes covering the globe: Japan, Thailand (sub node), Europe, Oceania, and North America.

As the Oceania Node, ACRES's responsibilities will include data acquisition, archiving, cataloguing, and distribution, as well as coordinating acquisition requests for the region and managing the 'announcement of opportunities'.

The ALOS satellite will have three sensors onboard. The Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM), which comprises three sets of optical systems to measure precise land elevation, the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) and the Phased Array type L-band Synthetic Aperture Radar (PALSAR).

LANDSAT Contingency Plan

The draft LANDSAT Contingency Plan identified the China Brazil Earth Resources Satellite 2 (CBERS-2), the Indian Remote Sensing Satellite (IRS-P6), SPOT and ASTER as suitable alternative data sources for LANDSAT data. The plan recognises that there is no one-to-one match or single replacement for LANDSAT data to cover all application needs in Australia. A combination of data sources would therefore be needed to satisfy all user needs.

ACRES is currently gathering further information about the CBERS-2 mission and data access. CBERS-2 is a joint venture mission, between the Chinese and Brazilian governments and was launched in October 2003. There are three sensors onboard CBERS-2: a High Resolution CCD Camera (HRCC), an Infrared Multi-spectral Scanner (IRMSS), and a Wide-Field Imager (WFI). Spatial resolution ranges from 20 to 260 metres with spectral range similar to that of LANDSAT. Access to IRS-P6 imagery will also be explored as part of the LANDSAT Contingency Plan. ASTER and SPOT data are already available via ACRES and Raytheon respectively.

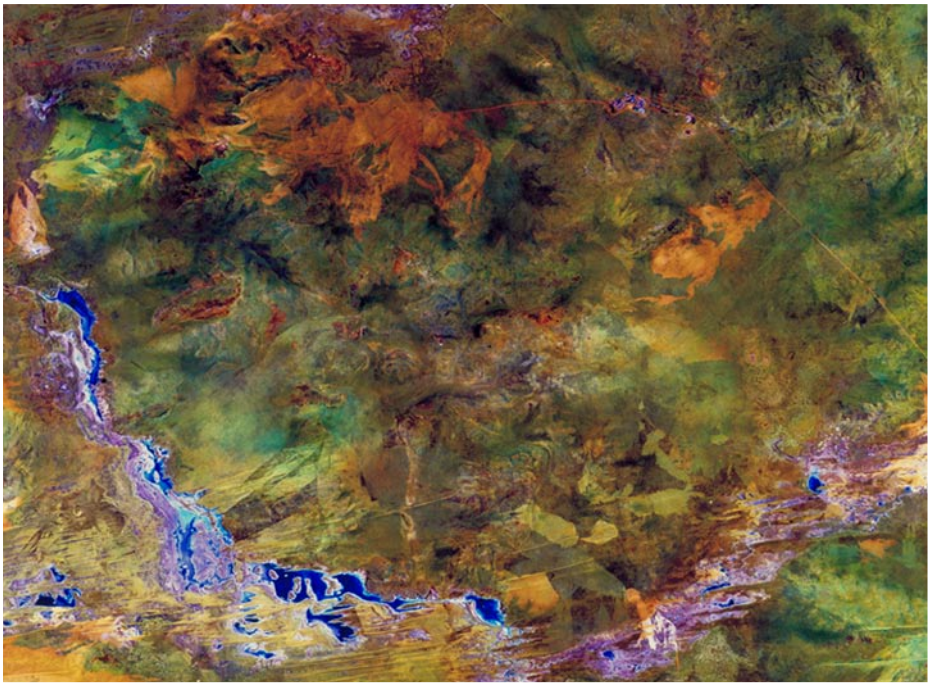


Figure 1: LANDSAT 5 image of The Granites area, Northern Territory.

Other remote sensing news

Following the signing of a data distribution agreement with the Japanese Earth Remote Sensing Data Analysis Centre (ERSDAC), ACRES is distributing ASTER products and placing future data acquisition requests through ERSDAC's General Programming Request (GPR) program. For more information about ACRES ASTER products and services see: www.ga.gov.au/acres/prod_ser/aster.jsp

According to user feedback composite LANDSAT 7 Scan Line Corrector (SLC)–off products, released by ACRES in April 2005 (www.ga.gov.au/acres/referenc/slcoff_composite.jsp), have been considered suitable for map revision and production. However, suitability for other applications still needs further investigation. Therefore individuals or organisations using these products for other applications (and finding them useful) are requested to contact ACRES (acres@ga.gov.au).

For more information phone Dr Adam Lewis on +61 2 6249 9353 (email adam.lewis@ga.gov.au)

AUSGEO news
ISSUE 79 September 2005

New 1:1 million Geology of Eastern Australia available

Seamless outcrop geology data is now available for all of the eastern states of Australia, from Tasmania to Cape York, at 1:1 million scale. The data provides an invaluable baseline dataset for large-scale regional and national evaluation of resource potential, environmental issues, and land use.

The digital data is available either in state sections on CD or can be downloaded free from the Geoscience Australia website (www.ga.gov.au/products/). The data includes:

- a first edition dataset for the whole of Queensland
- a first edition dataset for New South Wales
- updated second edition datasets for Tasmania and Victoria.

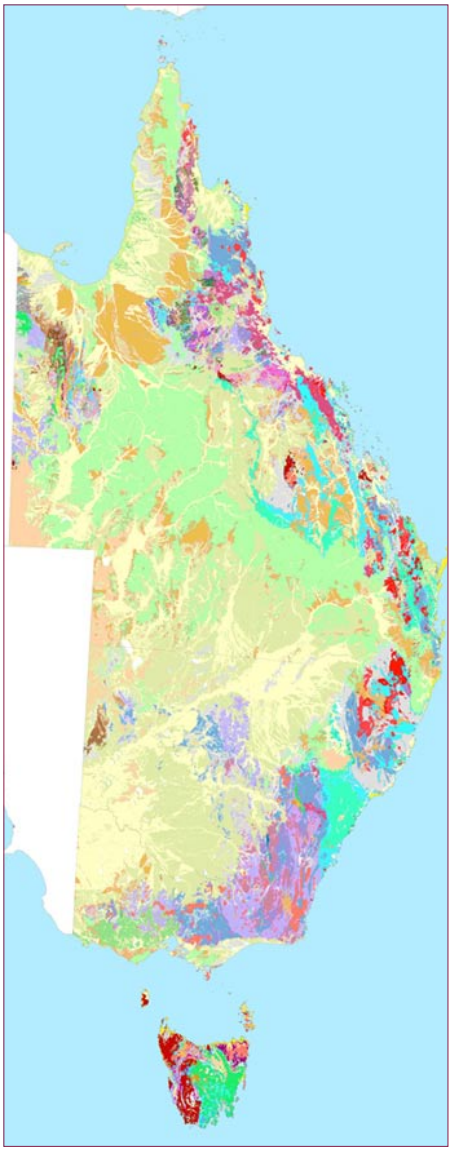
The Queensland dataset replaces previously released data sets of 'South Queensland' and 'Northwest Queensland, western Cape York and Torres Strait'. The new dataset includes first time coverage of the Townsville–Georgetown–Coen region at this scale, and also a significant upgrade of the geology of the New England Fold Belt, between Warwick and MacKay, in the southeast of the state. The new digital data were largely compiled from regional 1:500 000 and 1:1 million scale maps but also include significant re-compilations from the Geological Survey of Queensland's 1:100 000 series, notably through the New England Fold Belt and in the Townsville–Georgetown area.

The New South Wales 1:1 000 000 scale dataset is the most detailed seamless geology data available for the state. The dataset was compiled primarily from the NSW Department of Mineral Resources statewide 1:250 000 and 1:100 000 database, as well as several broader scale regional datasets in the Broken Hill and Murray Basin areas. The work involved edgematching over 40 individual maps and applying a consistent stratigraphic and regolith classification scheme across the state and into Queensland and Victoria.

The second edition Tasmanian and Victorian datasets have been updated to include geological unit names and descriptive information for nearly 300 granite plutons which were grouped together in first edition data releases.

The digital data are intended for use at 1:1 million scale and have a spatial accuracy of between 200 metres and one kilometre depending on the quality of the original source data. Geological unit (polygon) attributes include stratigraphic name (linked to the Australian Stratigraphic Units Database), map symbol, unit description, maximum and minimum age, and summary lithology information. Faults and stratigraphic boundaries are also coded in the data. The datasets come with comprehensive metadata attached.

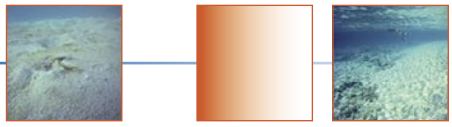
The new data are designed primarily as a digital tool for GIS applications. It is not planned to issue a printed map—a paper map of Australia at 1:1 million scale would be almost four metres tall—and a legend for the several thousand stratigraphic units would be enormous! A 1:5 million hardcopy map was released in 1999 and is still available through the Geoscience Australia Sales Centre. The data for the new releases are available in ESRI coverage and shapefile and Mapinfo formats, and this is the first Geoscience Australia dataset based on the new National Geological Data Model for GIS data (www.geoscience.gov.au/geoportal/standards.html).



For more information phone Alan Whitaker on +61 2 6249 9702 (email alan.whitaker@ga.gov.au). To order copies of the CDs phone Freecall 1800 800 173 (in Australia) or +61 2 6249 9966 (email mapsales@ga.gov.au)

Product News

Dive into MARS



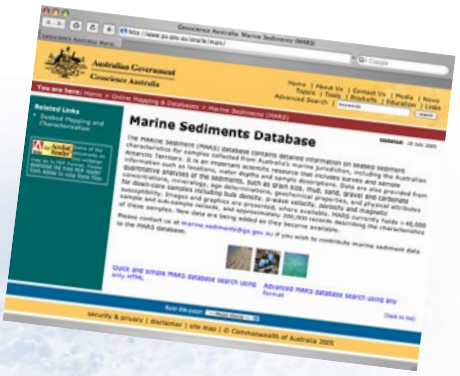
The new national MARine Sediments (MARS) database provides detailed information on seafloor sediment characteristics for the entire Australian continental margin.

Developed by Geoscience Australia in collaboration with the National Oceans Office of the Department of the Environment and Heritage, the MARS database is now freely available to the public via the Geoscience Australia website.

The MARS web page enables users to map samples spatially and zoom in on areas of interest. It can also produce graphical results of grain size analyses, and will soon display underwater movies and photographs of the sea floor. Users can also access data from other Geoscience Australia databases, including organic geochemistry and estuary data.

The texture and composition of more than 45 000 sediment samples and subsamples collected within the Australian continental margin are described in the MARS database. In addition to this quantitative information, other analyses available include radiocarbon ages, elemental analyses, biogenic silica, mineralogy and water depths.

Most of the data comes from Geoscience Australia's surveys, with some input from external sources. Continually updated with new quality-controlled data, MARS is fast becoming a powerful research tool. Already Australia's most comprehensive marine sediment database, it is expected to become a fundamental geoscience dataset for the marine geoscience community.



For more information phone Alison Hancock on +61 2 6249 9551 (email alison.hancock@ga.gov.au)

Related information
www.ga.gov.au/oracle/mars

IMPROVED Landsat composite products

Geoscience Australia's remote sensing unit (ACRES) has released new products that resolve problems caused by the malfunction of Landsat 7's Scan Line Corrector (SLC).

The SLC compensated for forward motion of the satellite before a malfunction caused it to be turned off in May 2003. As a result, subsequent images from Landsat 7 contain alternate scan lines of missing data at the edges of scenes.

To restore the value of Landsat 7 data, ACRES released SLC-Off products and SLC On/Off composite products in 2004. The SLC On/Off composite replaced the missing data with data from one SLC-On scene taken before May 2003. However, this approach was limited by potential variation of ground features during the time interval.

The new SLC-Off composite products are a significant step forward in providing more useful Landsat 7 data:

- Customers can now combine SLC-Off scenes acquired in subsequent passes in the same season, reducing ambiguity in interpretation due to temporal changes.
- Customers can now select up to five SLC-Off scenes of an area of interest to maximise the chance of filling data gaps, which vary from acquisition to acquisition.
- One additional SLC-On scene can be included to eliminate all gaps in the final product.

The new SLC-Off composite products are only available as ortho-corrected products and in Fast L7A format. When ordering a Landsat 7 ETM+ SLC-Off composite product, customers should nominate a primary SLC-Off scene to be used as the base image.

For optimal results, images chosen to generate a gap-filled product should be from the same season and contain minimal transient data such as clouds, snow cover or fires. Customers should also avoid selecting fill scenes with quality problems such as high bit error rate and drop-outs. These are identified in the ACRES digital catalogue.

For more information
www.ga.gov.au/acres/referenc/slcoff.jsp

Figure 1. Combining SLC-Off and SLC-On scenes. The edge portion of a primary SLC-Off scene (left), an SLC-On scene with equivalent seasonality (middle), and the composite product generated from these two scenes.

Figure 2. Combining two SLC-Off scenes. The edge portion of a primary SLC-Off scene acquired on 2 March 2004 (left), an SLC-Off fill scene acquired on 18 March 2004 (middle), and the composite product generated from these two scenes.

AUSGEO news
ISSUE 79 September 2005

Re-processed seismic data a BIG improvement

Geoscience Australia has recently released reprocessed data from the 1975 Bureau of Mineral Resources (BMR) Galilee Basin Seismic Survey, following the analogue to digital transcription of the original magnetic field tapes.

The survey, which collected 338 km of seismic reflection data in the western part of the Galilee Basin in central Queensland (figure 1), was carried out by Geoscience Australia's predecessor the BMR in 1975 (Harrison 1976). The data provided basic information on the extent and thickness of the western part of the basin, defined the southern margin of the Lovelle Depression, and mapped major faulting within the basin.

The data were recorded on frequency modulated (FM) magnetic tapes using an SIE PMR20 data recorder. Geoscience Australia contracted Echo Surveys Pty Ltd to transcribe the 734 field tapes from this survey to shot records in SEG-Y format. Technical details of the transcription process undertaken are available on request.

The majority of the data was acquired as single-fold. However, some three-fold and six-fold traverses were also recorded (table 1). The geophone group interval used was 45 metres and the shot point interval was 540 metres.

An example of the improvement to data quality achieved from the transcription and reprocessing is shown in figure 2. There is considerable improvement in the section above one second two-way time (TWT).

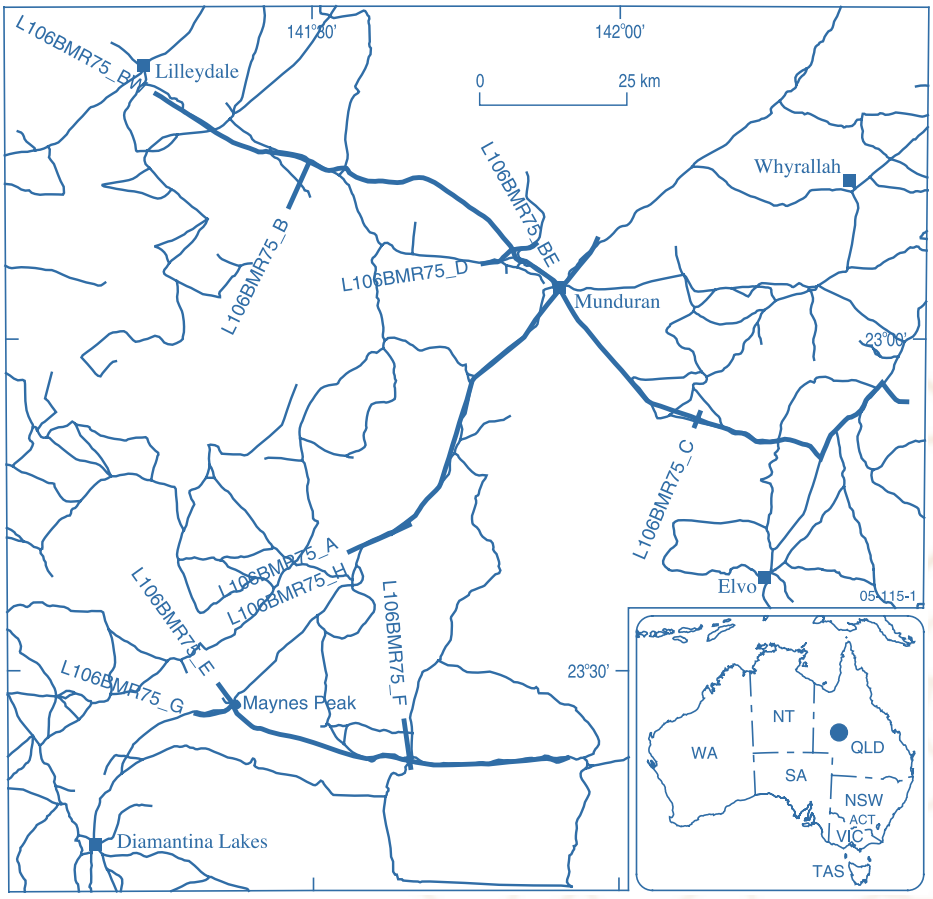
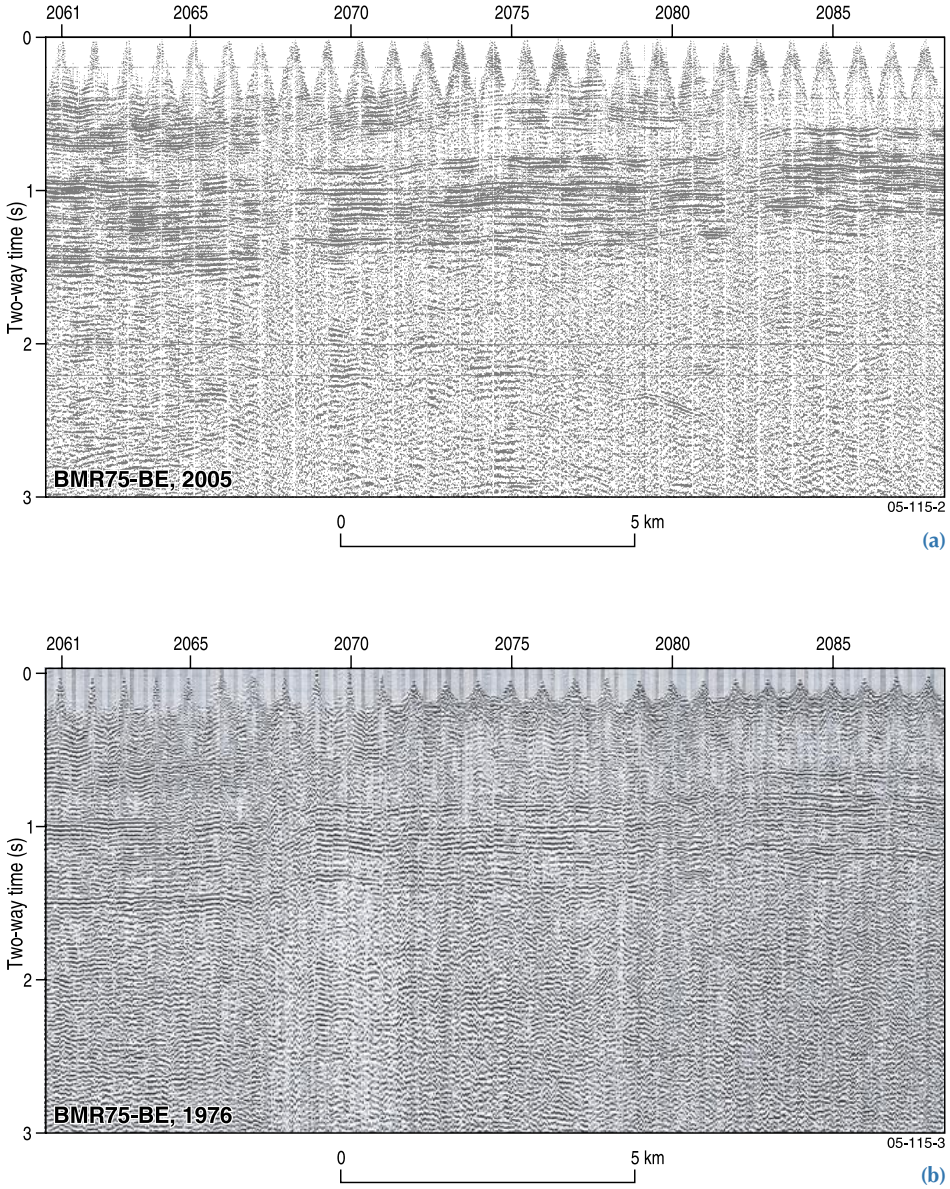


Figure 1. Location map of the 1975 Galilee Basin seismic survey.



▲ **Figure 2.** (a) 2005 reprocessed section of part line BMR75-BE, (b) 1976 vintage processing of part line BMR75-BE.

The processing steps used to produce figure 2 were:

1. Line geometry defined, all shots/ receivers re-numbered
2. SEG-Y tape input
3. Resample to two millisecond sample rate
4. Static time correction for field time break
5. QC control and trace edits
6. Statics computation and application
7. Common Mid-point (CMP) sort
8. Velocity analysis
9. Residual statics computation and application
10. Spectral equalisation
11. Bandpass filter
12. Normal Moveout (NMO) correction
13. First break mute
14. CMP stack
15. Signal enhancement
16. Add traces for CMP display.

The re-processed data are available from Geoscience Australia in shot ordered or stacked SEG-Y format. Surveying, observers, shot firers, drilling and operations reports as well as scanned images are also available.

References

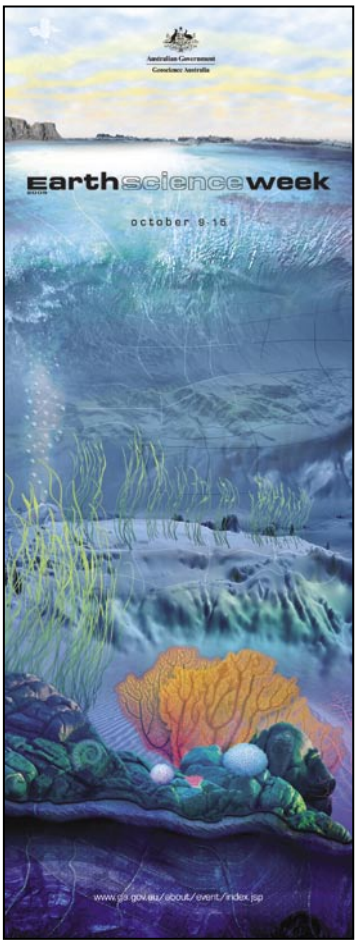
Harrison PL & Bauer JA. 1976. Galilee Basin seismic survey, Queensland, 1975, Operational Report. Bureau of Mineral Resources, Record 1976/27.

For more information phone Tim Barton on +61 2 6249 9625 (email tim.barton@ga.gov.au) or David Johnstone on +61 2 6249 9446 (email david.johnstone@ga.gov.au)

Table 1. 1975 Galilee Basin Seismic Survey (L106) line summary.

Original Line Name	Shot Point Range	New Line Name	Reprocessed cdp range	Length (km)	Nominal Fold
A	877-100	BMR75-A	2012-4988	67.0	1
A	974-982	BMR75-A	2000-2119	5.4	6
B	2001-2142	BMR75-BE	5828-9236	76.7	1
B	1842-1999	BMR75-BW	2012-5804	85.3	1
C	1-5	BMR75-C	2012-2132	2.7	1
D	2996-3008	BMR75-D	2012-2324	7.0	1
E	3994-4110	BMR75-E	2012-4796	62.7	1
F	5001-5010	BMR75-F	2025-2156	5.9	6
G	5988-5999	BMR75-G	2012-2300	6.5	1
H	6984-6996	BMR75-H	2000-2167	7.5	6
I	85-99	BMR75-I	2012-2372	8.1	1

Celebrate EARTH SCIENCE



International Earth Science Week is an ideal opportunity for those involved in earth sciences to share the significance of their work with the community. This year it will be celebrated between October 9 to 15. The theme is "Geoscientists Explore our Earth" and encourages people to learn more about what geoscientists do and how their work contributes to society's wellbeing.

Geoscience Australia has coordinated Earth Science Week events in Australia since 1999 and is continuing to encourage participation. This includes production and distribution of an Earth Science Week poster to relevant scientific and cultural communities. The agency also maintains the national Earth Science Week website at www.ga.gov.au/education/events which details activities in each state and territory as well as information and suggested activities to celebrate the week. Organisations wishing to share their activities with the rest of Australia are invited to submit details of their events to be included on this site.

This year's Earth Science Week poster is a dramatic submarine composite that represents several areas of current geoscience research. A wave on the cusp of breaking is an uncomfortable reminder of the threat of tsunamis, with gossamer-thin threads trailing from the wave to a satellite highlighting the important role of satellites in a tsunami early warning system. The grid superimposed on the ocean floor alludes to the importance of seabed mapping and characterisation. Strands of seagrass atop sand waves and a coral reef emerges from mysterious emerald green depths which include a sedimentary cross section. They represent the use of high-resolution bathymetry in important recent marine research in Torres Strait and the southern Gulf of Carpentaria.

For more information phone Jeanette Holland on +61 2 6249 9731 (email jeanette.holland@ga.gov.au)

Events Calendar 2005

Australia's Frontier Basins Workshop
13 & 14 October
Geoscience Australia, Canberra
Contact: Jenny Maher, Geoscience Australia, GPO Box 378, Canberra ACT 2601
phone +61 2 6249 9111
fax +61 2 6249 9980
email: jenny.maher@ga.gov.au

Mining 2005
26 to 28 October
Carlton Crest Hotel, Brisbane
Contact: Mining 2005, PO Box 1153, Subiaco WA 6904
phone +61 8 9388 2222
fax +61 8 9381 9222
email: abbie@verticalevents.com.au
www.mining2005.com.au

NewGenGold 2005
28 & 29 November
Burswood Convention Centre, Perth
Contact: Juliet Kirk, PO Box 1589, West Perth WA 6872
phone +61 8 9321 0355
fax +61 8 9321 0426
www.newgengold.com/index.php

NAPE Expo 2006 –North American Prospects Exhibition
American Association of Professional Landmen
2 & 3 February
Houston, Texas, USA
Contact: AAPL, 4100 Fossil Creek Boulevard, Fort Worth, Texas 76137 USA
phone +1 817 847 7700
email: nape@landman.org
www.napeonline.com

PDAC International Convention & Trade Show
Prospectors and Developers Association of Canada
5 to 8 March
Metro Toronto Convention Centre, Toronto, Canada
Contact: PDAC, 34 King Street East, Suite 900, Toronto, Ontario M5C 2X8
phone +1 416 362 1969
fax +1 416 362 0101
email info@pdac.ca
www.pdac.ca

AAPG Annual Meeting
American Association of Petroleum Geologists Annual Meeting and Exhibition
9 to 12 April
Houston, Texas
Contact: AAPG Convention Department, PO Box 979, Tulsa Oklahoma 74101-0979 USA
phone +1 918 560 2617
fax +1 918 560 2694
email: convene@aapg.org
www.aapg.org

APPEA Conference and Exhibition
Australian Petroleum Production and Exploration Association
7 to 10 May
Gold Coast Convention and Exhibition Centre
Contact: Vicki O'Gorman, APPEA Limited, GPO Box 2201, Canberra ACT 2601
phone +61 2 6247 0960
fax: +61 2 6247 0548
email: vogorman@appea.com.au
www.appea.com.au

AUSGEO news
ISSUE 79 September 2005

STRONG INTEREST *in Australia's offshore petroleum opportunities*

The encouraging uptake of new exploration acreage shows that Australian petroleum exploration is on the increase. Bids were lodged for 22 of 31 areas released for exploration in 2004, with 16 areas now allocated and negotiations continuing with bidders for the remaining six.

Of 29 offshore areas released in 2005, bidding closes for 15 in October 2005 and for the remaining 14 in April 2006. More information on these release areas is available from the Geoscience Australia website: www.ga.gov.au/oceans/projects/OG_SpecS_AcreageR.jsp

Showcasing our petroleum resources in Asia

During May, a delegation from Geoscience Australia and the Department of Industry, Tourism and Resources (DITR) promoted the 2005 offshore petroleum exploration opportunities during visits to exploration companies in Japan, Korea and China. The delegation was well received, with much of the discussion focused on LNG and the Australian Government's new tax initiatives to encourage exploration.

Australia on display in Canada and the US

In May, Geoscience Australia again coordinated the Australian governments' technical display of petroleum exploration opportunities at the annual American Association of Petroleum Geologists (AAPG) Convention in Calgary, Canada—the largest annual petroleum exploration conference in the world.

This year's convention attracted more than 7500 delegates, the largest attendance in almost 20 years. The overall optimistic mood of the convention was driven by the belief that higher oil prices are renewing interest in exploration.

The Australian team consisted of officers from DITR and state and territory government agencies from Western Australia, South Australia, Victoria and the Northern Territory. The delegation answered many pertinent questions, which indicated a genuine interest in the opportunities offered by Australia. Strong interest was shown in Geoscience Australia's 'Big New Oil' program, especially the results of the South Western Margins Project in the Bremer Sub-basin.

The consistent message was that explorers appreciate the Australian Government's initiatives to encourage exploration, especially the open data policy, and they are keen to see more data come on-line.

Delegates from Geoscience Australia and DITR also visited five Calgary-based companies before travelling to Houston, Texas, for meetings with several American petroleum exploration companies. These meetings included detailed technical presentations on Australian exploration opportunities, including the 2005 release areas.

Upcoming activities

DITR and government agencies from Western Australia and South Australia are joining with Geoscience Australia in a delegation to the AAPG International Convention in Paris in September. It has been some years since Australian exploration has been promoted at this event and we believe our presence will attract a good level of interest.

Further promotion of petroleum exploration opportunities will occur at:

- the annual Good Oil Conference in Perth in September
- the North American Prospects Expo in Houston in January 2006.

▲ **Figure 1.** Geoscience Australia staff at the AAPG Convention in Calgary, May 2005.

Australian Frontier Basins Workshop

Geoscience Australia is hosting a two-day workshop in Canberra on 13 and 14 October to present results and discuss petroleum exploration opportunities in Australia's frontier basins. New data acquired through the 'Big New Oil' program will be made available at this workshop, including interpretation results of the new seismic data acquired from the South West margin and results from the hydrocarbon seeps studies. Details of the workshop are included in this issue.

For more information phone Jenny Maher on +61 2 6249 9111 (email jenny.maher@ga.gov.au)

Consortium for Ocean Geosciences (COGS) CONFERENCE 2005

Figure 1. Attendees of COGS 2005, Orpheus Island.

Figure 2a. Orpheus Island Research Station.

Figure 2b. Mangroves adjacent to the Orpheus Island Research Station.

Figure 3. COGS field survey.

This biannual event was held at Orpheus Island Research Station at the end of June 2005. This year's conference was hosted by the School of Earth Sciences, James Cook University led by Graham Shields. The meeting covered a range of topics from coastal processes, catchment to reef dynamics, Quaternary palaeoenvironmental records, palaeoceanography, and marine biogeochemistry.

The conference was attended by 30 marine geoscientists and students from around Australia, with a large contingent of Queenslanders who gave excellent talks on the Queensland coast and Great Barrier Reef. Several talks highlighted the use of new geophysical techniques, such as swath mapping, and improved geochemical analyses. The student prize was awarded to Michael O'Leary from James Cook University for his review of the problems he has encountered dating Marine Isotope Stage 5E coral terraces from Western Australia to determine a sea level record for the Last Interglacial.

The Orpheus Island Research Station is situated on the mangrove lined west coast of the island, the former site of an oyster lease (Fig. 2a and b). The station is the only development on the island other than a small holiday resort. The research station has recently been renovated with good accommodation facilities and a newly built lecture theatre. Orpheus Island is part of the Palm Island group, which is a granitic continental nearshore island northwest of Townsville and just south of Hinchinbrook Island. Orpheus Island has an unusually wide variety of habitats. It is surrounded by well-developed fringing reefs. The shoreline includes stands of mangrove forest, sandy beaches backed by strand vegetation, sand, cobble and boulder beaches, and steep rock faces. The island is dominated by eucalypt forest, with patches of other forest types and grassland. This provided an ideal back drop for the talks and discussions of the conference, and plenty of sites of interest to visit on the excursions around the island, including visits to stranded fossil coral reefs and aboriginal fish traps.

For more information phone Helen Bostock on 6249 9436 (email helen.bostock@ga.gov.au)

Surveying Sydney

Sydney has won a bid to host the World Congress of the International Federation of Surveyors in 2010. The FIG General Assembly held in Cairo in April chose Sydney after fierce bidding for the Congress which is expected to attract over 2500 delegates.

The success of the bid was attributed to the attractiveness of Sydney as a venue, the inclusion of Australia's Asia Pacific neighbours as integral partners and to the solidarity within the Australian spatial professions. The Sydney bid enjoys the national support of the government, professional and business sectors of the spatial information industry in Australia and attracted the support of 30 other member countries, particularly those in the Asia Pacific region.

For more information phone Peter Holland on +61 2 6249 9736 (email Peter.Holland@ga.gov.au)

ANSIR NATIONAL RESEARCH FACILITY FOR EARTH SOUNDING

ANSIR CONTINUES: 2005 ONWARDS

Good news for Earth Science researchers working in the third (depth) dimension.

The contractual arrangements for ANSIR, Australia's Major National Research Facility (MNRF) in Seismic Imaging, specified under the agreement with the Commonwealth through DEST (Department of Education, Science and Training) expired on 18 June 2005.

The good news is that ANSIR is set to continue into the future with an expanded role as ANSIR – National Research Facility for Earth Sounding.

The success of the facility over its seven year life encouraged both the ANSIR Board and the ANSIR owners, The Australian National University and Geoscience Australia, to agree to continue the facility. There was a strong endorsement of the need for maintaining a capability for seismic imaging across the full range of scales currently supported by ANSIR. In addition, the ANSIR Board recommended to the owners that there was a need to broaden the scope of the contribution made by ANSIR to encompass other techniques in earth sounding that could make use of common data recorders, in particular magnetotelluric methods.

ANSIR will therefore continue its assistance for the strengthening of research and education in the Earth Sciences in Australia, and to provide a national focus and leadership through its work in Earth Sounding, which helps to foster collaboration between individual scientists, institutions and across industry sectors.

ANSIR's owners have agreed to continue under their existing agreement a further two years in the first instance, with an annual review. Management will be through a Steering Committee that will meet twice a year to oversee the development of the facility with advice available from an Access Committee to inform the selection of proposals for the Work Plan. Day to day ANSIR operations will continue to be handled through the ANSIR Executive.

ANSIR will continue to use its current Facility Manager, Terrex Seismic Pty Ltd, to provide reflection services and the Research School of Earth Sciences at ANU will continue to provide portable (short period and broadband) services. Both ANSIR and Terrex Seismic are pleased to continue the facilities management relationship developed during the MNRF years which has delivered regional seismic surveys in an efficient and economical manner. Continuing efforts will be made through appropriate national funding mechanisms to continue to improve ANSIR's capabilities. ANSIR will be striving to secure a component for basic facility support and for operational funds to ensure that maximum effort is provided for elucidating deep Earth structure in the context of the Commonwealth Government's National Research Priorities.

ANSIR provides equipment and training for seismic imaging experiments. The staff of the facility can provide help to researchers with the design and implementation of experiments and facilitate data processing and interpretation. The Director, Professor Brian Kennett and Deputy Director, Dr. Bruce Goleby, maintain active research programs at ANU and Geoscience Australia and are thereby able to provide their experience to prospective applicants for use of the facility.

ANSIR has established a pool of equipment capable of imaging the Earth's interior at a variety of scales using different styles of seismic techniques. ANSIR's equipment is portable and can be moved to any part of the Australian continent. Components of the equipment have been used overseas in international collaborative experiments. The ANSIR equipment can record energy from many types of sources, including earthquakes, explosions and truck-mounted vibrators; it can operate in a wide range of environments, including the remote hot and dusty conditions of the Australian outback, the humid tropics of the north and the freezing conditions of Antarctica.

The resources of ANSIR are available to all researchers. The scientific merit of the proposed research is the main criterion used to determine priority for access, but researchers have to be able to cover the operating costs for their projects.

For further information on ANSIR please visit www.rses.anu.edu.au/seismology/ANSIR/ansir.html or contact Bruce Goleby +61 2 6249 9404 or (email bruce.goleby@ga.gov.au)