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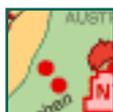
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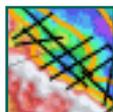
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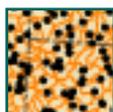
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# CEO comment



Neil Williams – CEO Geoscience Australia



This issue of *AusGeo News* features several articles relating to the recently completed geophysical and sampling surveys in offshore frontier basins along the southwest margin of Western Australia. These surveys are major outputs of Geoscience Australia's Offshore Energy Security Program. Data acquired will be used to assess the petroleum potential of these frontier areas and underpin future acreage release, and contribute to the management of marine habitats.

The sampling program covered a vast area from the Perth Canyon in the south to the Exmouth Plateau in the north. The report on the Wallaby Plateau leg of the marine reconnaissance survey provides details of the bathymetry of the area and the geological samples collected during the survey.

Details of the exploration areas being offered in the 2009 release of Offshore Acreage for petroleum exploration are also included in this issue. The North West Shelf features prominently in this year's release. Some areas being offered are close to existing production areas in the Bonaparte, Browse, and Carnarvon Basins. Other areas are frontier exploration areas along the Ceduna Sub-basin (Bight Basin) and in the Otway Basin. The first offshore acreage release for the geological storage of greenhouse gas took place earlier this year and details are included in this issue.

The update on the Onshore Energy Security Program reports on the current surveys including the seismic survey in South Australia, the airborne electromagnetic survey in the Northern Territory and the National Geochemical Survey of Australia. It also includes updates on the processing of data acquired during earlier surveys undertaken as part of the Program.

Much of our mineral wealth has historically been derived from deposits relating to the Phanerozoic rocks of eastern Australia. The article on the Phanerozoic Project outlines the approach taken in a geodynamic synthesis of eastern Australia to assist mineral explorers in selecting potential areas to prospect for accessible economic mineral reserves.

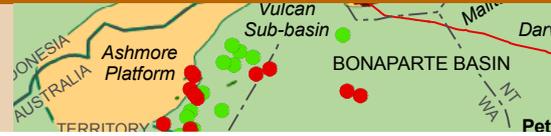
There is also a report on Geoscience Australia's contribution to the emergency response during the tragic Victorian bushfires earlier this year.

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

# New opportunities for offshore petroleum exploration

## 2009 acreage release includes deep water frontiers

Thomas Bernecker



The Australian Government formally releases new offshore exploration areas during the annual Australian Petroleum Production and Exploration Association (APPEA) conference. The 2009 release of offshore petroleum exploration areas was announced on 1 June in Darwin by the Hon Martin Ferguson AM MP, Minister for Resources and Energy.

This year, 31 areas plus two special areas in five offshore basins were released for work program bidding. Closing dates for bid

submissions are either six or twelve months after the release date, that is, 3 December 2009 or 29 April 2010 depending on the exploration status in these areas and on data availability. The 2009 Release Areas are

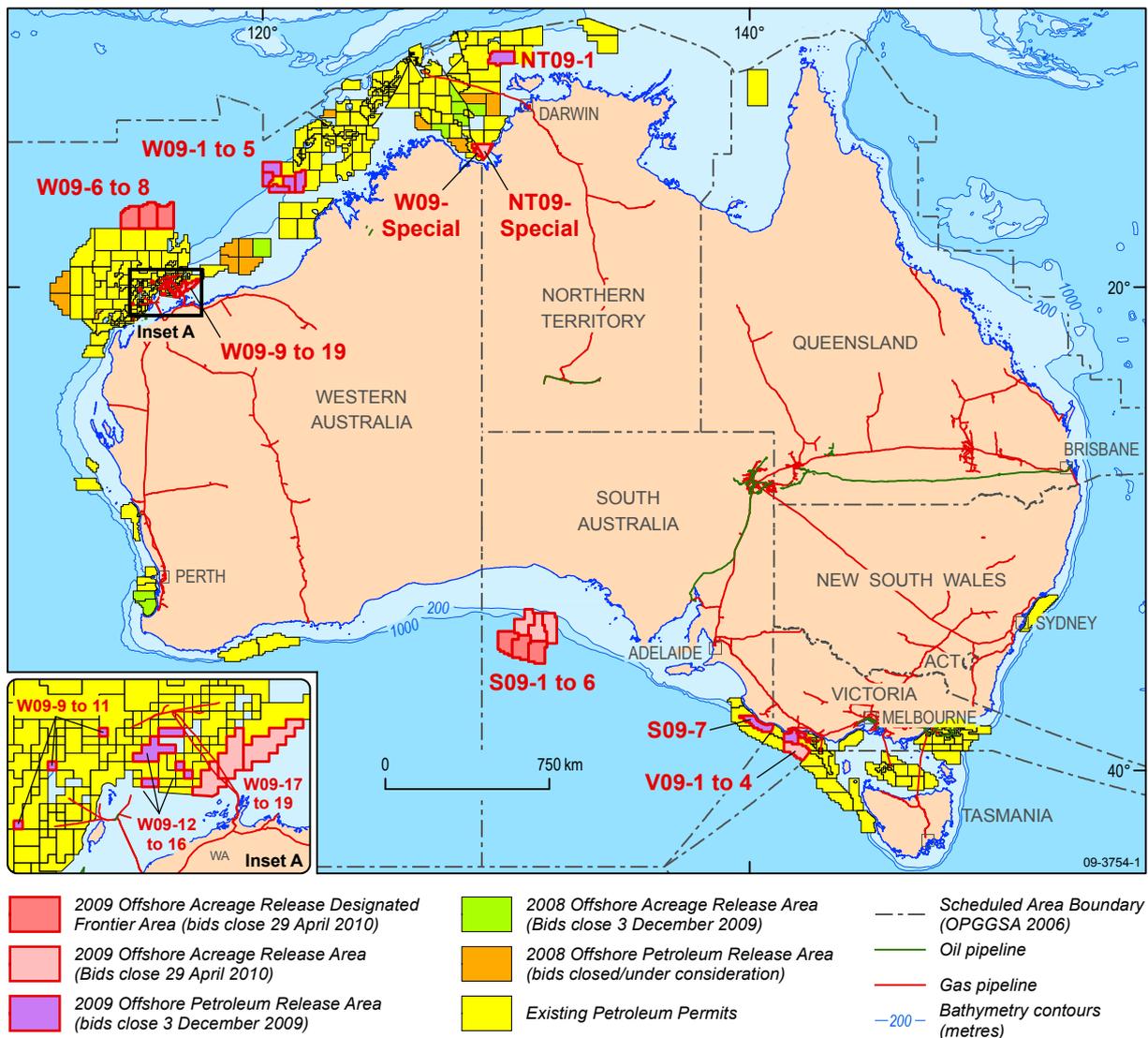


Figure 1. Location map of the 2009 Offshore Petroleum Acreage Release Areas.

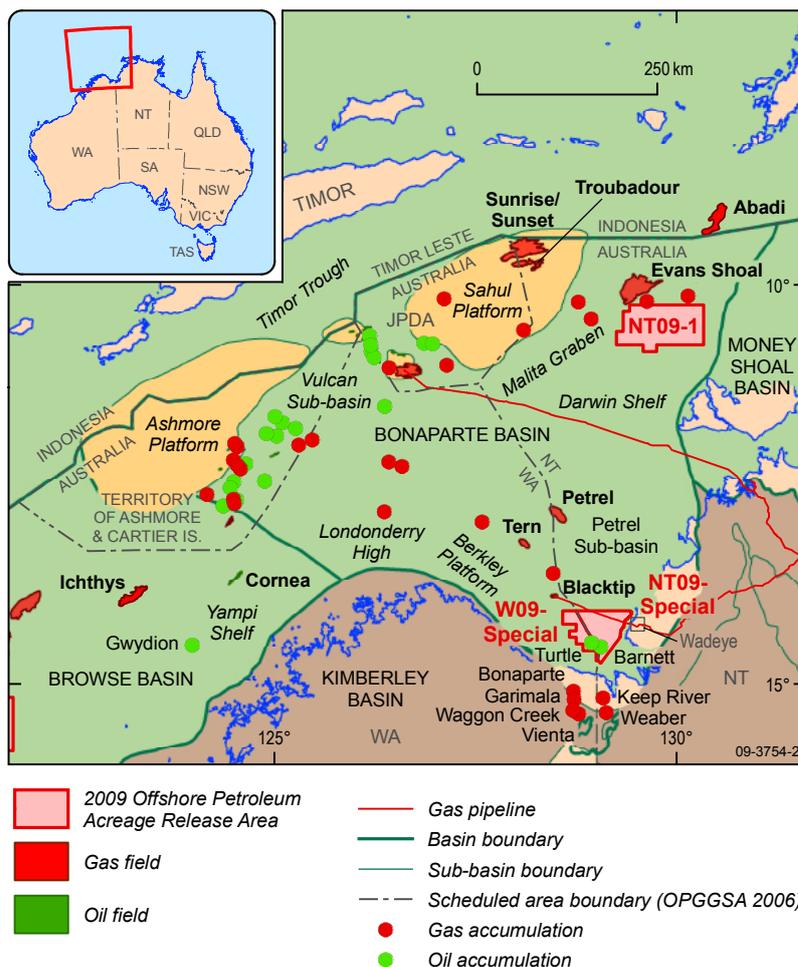
located in Commonwealth waters off the Northern Territory, Western Australia, South Australia and Victoria, and comprise intensively explored areas close to existing production, as well as new frontiers (figure 1). The North West Shelf features very prominently with release areas in the Bonaparte, Browse and Carnarvon basins. These are complemented by new areas along the southern margin, including frontier exploration areas in the Ceduna Sub-basin (Bight Basin) and the Otway Basin.

## Bonaparte Basin

The Bonaparte Basin lies on Australia's northwest continental margin and contains up to 15 000 metres of Phanerozoic marine and fluvial siliciclastics and marine carbonates. The basin is structurally subdivided into several Paleozoic and Mesozoic sub-basins and platform areas which host a number of proven petroleum systems for both oil and gas. This year, one Release Area is being offered within the Malita Graben.

Release Area NT09-1 is located on the northern margin of the Malita Graben, about 220 kilometres northwest of Darwin and 40 kilometres south of the Evans Shoal gas field (figure 2). It is close to the Darwin operations base and the Wickham Point LNG plant that is supplied by the Bayu–Undan gas pipeline. Water depths across the block range from 10 to 170 metres. The Malita Graben contains up to 10 000 metres of post-Paleozoic sediments as a result of high subsidence rates.

Release Area NT09-1 is highly prospective for gas as indicated by commercial accumulations immediately to the north and west of the block. It appears less likely that liquid hydrocarbons are present due to the dominant gas-prone source interval and the high geothermal gradients that have been recorded in the Malita Graben.



**Figure 2.** Structural elements map of the Bonaparte Basin showing location of the 2009 Release and Special Release Areas.

## Special Release, Petrel Sub-basin, Bonaparte Basin

The 2009 Special Offshore Acreage Release comprises two areas that are being offered to focus industry's attention on the former Turtle and Barnett Retention Leases which have oil accumulations. This Special Release complements the remainder of the 2009 release by making available areas with a full range of water

depths and prospectivity, from rank frontier to mature basins with known discoveries.

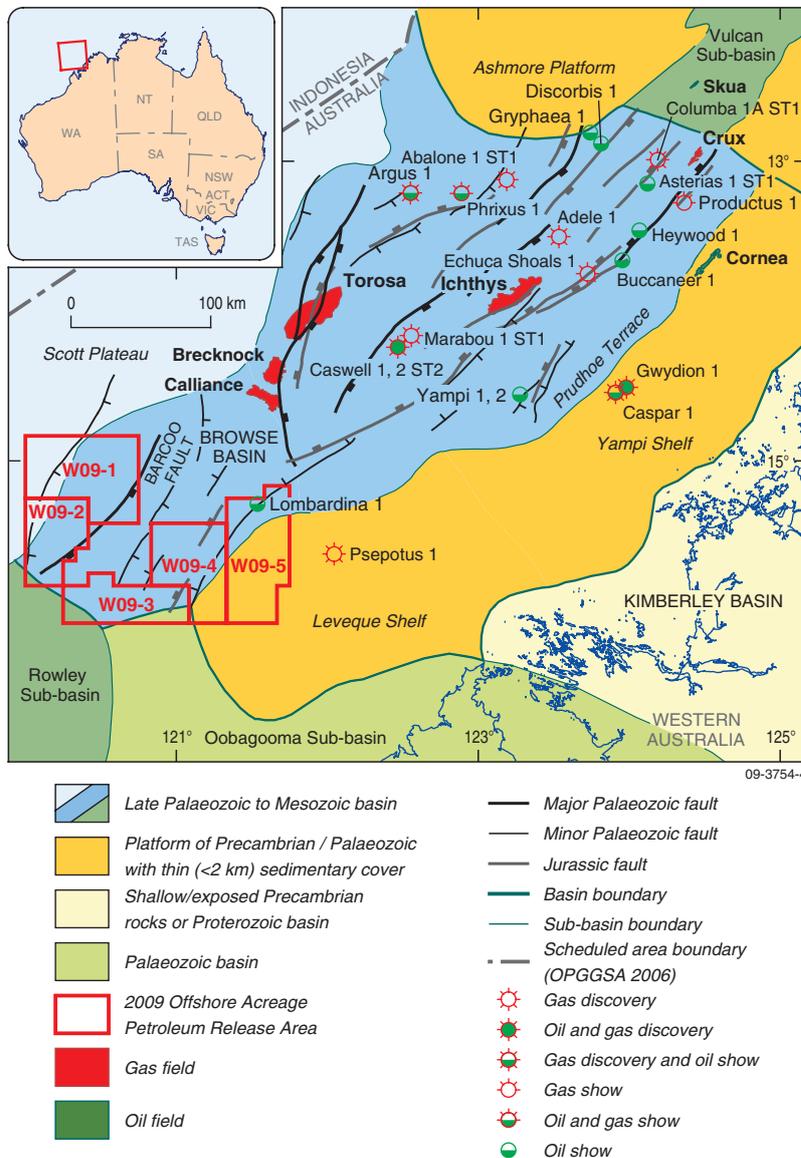
Release Areas NT09-Special and W09-Special are located in the Joseph Bonaparte Gulf, about 400 kilometres southwest of Darwin. The Release Areas are about 35 kilometres southeast of the Blacktip gas accumulation (figure 2). Following development drilling, gas will be piped to Darwin via the onshore gas plant near Wadeye and the Bonaparte trans-territory pipeline. This pipeline connects to the existing pipeline transporting gas from the Amadeus Basin to Darwin.

### Petrel Sub-Basin

The Petrel Sub-basin in the southern Bonaparte Basin is an asymmetric, northwest-trending Paleozoic rift that contains a succession of thick

Paleozoic and thinner Mesozoic sediments. The late Paleozoic–Mesozoic section exceeds 15 000 metres in thickness in the central and northern Petrel Sub-basin.

A variety of exploration plays exist in the southern Petrel Sub-basin, including structural and stratigraphic plays targeting both sandstone and carbonate reservoirs at numerous stratigraphic levels. The Middle-Late Triassic Fitzroy Movement is responsible for creating large-scale inversion anticlines (commonly associated with salt mobilisation), such as those drilled in the Petrel and Tern gas accumulations. Numerous potential structural and stratigraphic hydrocarbon traps were generated as the result of salt tectonics. Salt movement may have triggered petroleum migration pathways throughout the development of the Petrel Sub-basin.



**Figure 3.** Regional geological setting of the Browse Basin (after Struckmeyer et al, 1998), showing key discoveries.

### Browse Basin

The Browse Basin is a northeast-trending, Paleozoic to Cenozoic depocentre situated entirely offshore in the Timor Sea region of Australia's North West Shelf. The basin hosts vast commercial, but as yet undeveloped, reserves of gas and condensate, the majority of which are contained in six gas fields: Torosa, Brecknock, Brecknock South (Calliance), Ichthys, Crux and Argus. Five areas (W09-1 to

W09-5) are being released in the southern part of the basin. They overlie the Barcoo Sub-basin and adjacent portions of the Leveque Shelf and Scott Plateau (figure 3).

Given the under-explored status of the southern Browse Basin, potential plays remain untested. These include Carboniferous to Permian extensional half-graben, Late Triassic tilted fault blocks and associated anticlines, stratigraphic traps related to Early Cretaceous onlap and erosional truncation, as well as traps generated during Miocene fault re-activation. The main exploration risk is access to unproven oil-mature source rocks. The oil accumulations that have been discovered in the Browse Basin are sourced from the Early Cretaceous Echuca Shoals Formation in the Caswell Sub-basin, but this succession is immature to marginally mature in the Barcoo Sub-basin. Evidence of gas at Arquebus-1ST1 and Psepotus-1, however, suggests that source, maturity and relative migration/trap timing are not critical risks for gas prospectivity in the Barcoo Sub-basin and the adjacent Leveque Shelf.

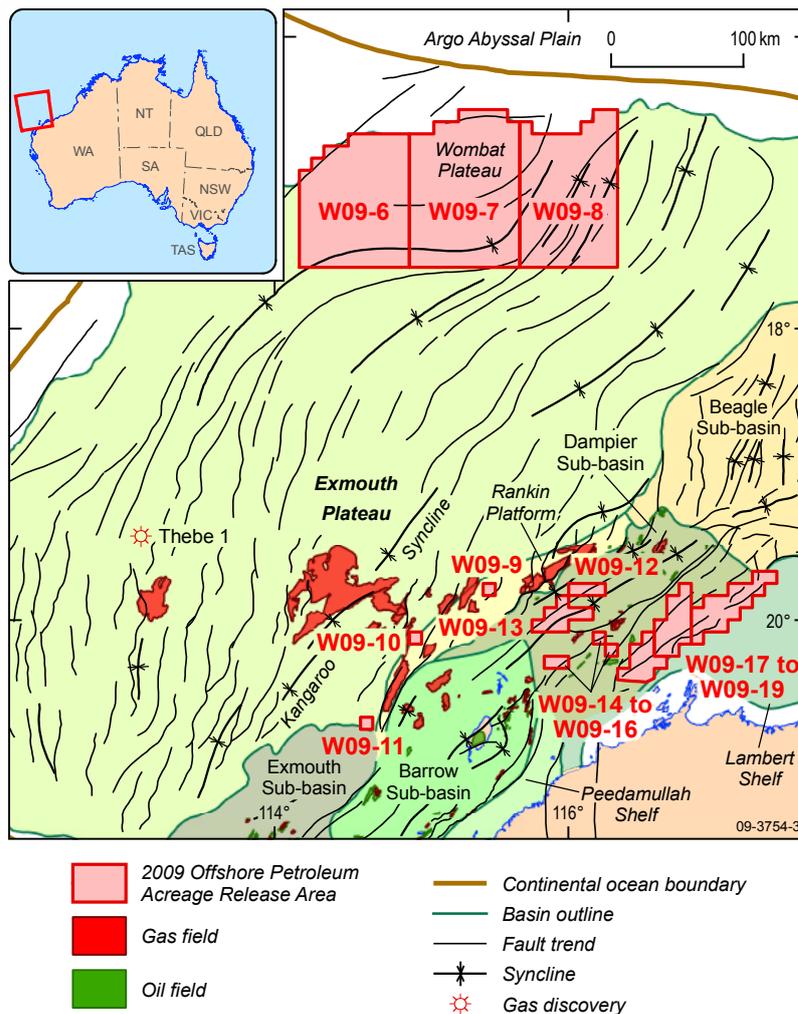
## Carnarvon Basin

The Carnarvon Basin is the southernmost province of the Late Paleozoic to Cenozoic Westralian Superbasin that underlies the northwestern continental margin of Australia from the Exmouth Plateau in the south to the Arafura Sea in the north. The northern offshore Carnarvon Basin contains about 15 000 metres of mainly Mesozoic sediments that host a world class gas and oil province and is Australia's premier hydrocarbon province. The 2009 Acreage Release Areas (figure 4) are located on the Northern Exmouth Plateau (three areas), on the Rankin Platform (three areas) and in the Dampier Sub-basin (eight areas).

## Northern Exmouth Plateau

The Exmouth Plateau is the deepwater frontier of the Carnarvon Basin, and is home to several giant gas accumulations (such as Jansz, Scarborough, Thebe). It is an area of active exploration with several recent significant gas discoveries including Martell-1, drilled earlier this year.

The three Release Areas (W09-6 to W09-8) are considered deep-water frontiers (figure 4) and were nominated for the status of Designated Frontier Area (DFA). Parts of Release Areas W09-6 and W09-7 are located within the



**Figure 4.** Structural elements of the Northern Carnarvon Basin showing the 2009 Release Areas (after Stagget et al, 2004).

newly defined outer limit of Australia's continental shelf, confirmed by the United Nations Commission on the Limits of the Continental Shelf (Geoscience Australia 2008). Water depths range from 2000 metres to over 4000 metres in the Montebello Canyon. Well control in this part of the basin is limited to four stratigraphic holes (ODP 759, 760, 761 and 764) drilled in 1988 on the Wombat Plateau which intersected Late Triassic carbonates of possible reef facies and underlying Norian coal measures.

The super-giant Io/Jansz gas field, the giant Scarborough gas field and the gas discovery in the Jupiter-1 well, along with the recent gas discoveries in the Chandon-1, Thebe-1,-2 and Martell-1 wells, demonstrate that the deepwater Exmouth Plateau is prospective for large gas discoveries. The extension of this gas potential to the northern margin of the Exmouth Plateau is yet to be demonstrated. However, several of the key elements, such as source and reservoir facies, that combine to produce successful petroleum systems further south probably also occur in the region of the three Release Areas.

These three deep water frontier areas offer opportunities for innovative exploration as well as access to DFA conditions. The key unknown aspect in this frontier is the presence of mature source rocks; but, if appropriate source rock intervals can be identified, all areas would be capable of hosting hydrocarbon accumulations.

## “The 2009 Release Areas ... comprise intensively explored areas close to existing production as well as new frontiers.”

### ***Rankin Platform***

The Rankin Platform is a structurally high area that flanks the western edge of the Dampier Sub-basin and the Exmouth Plateau (figure 4). It consists of tilted Triassic fault-blocks that contain the supergiant Goodwyn and North Rankin gas/condensate accumulations, as well as many other smaller fields. The Release Areas (W09-9 to W09-11) are three separate, individual graticular blocks located along the Rankin Platform. Although no wells have been drilled in any of these areas, they are considered highly prospective because of their close proximity to existing fields and successful exploration wells.

Proven exploration plays on the Rankin Platform include Triassic, Jurassic and Early Cretaceous targets. Two proven petroleum systems are recognised in the Release Areas. Areas W09-9 and W09-10 are

located within the heart of the Rankin Platform, where giant gas fields in Triassic and Early Jurassic sandstones are charged from deltaic Triassic to Middle Jurassic source rocks and sealed by Early Cretaceous shales. Release Area W09-11 is located at the southern end of the Rankin Platform and, in addition to the Triassic-dominated system, also has access to the Late Jurassic oil-prone system in the Barrow and Exmouth sub-basins. Early Cretaceous Barrow Group sandstones, as well as the Late Triassic Mungaroo Formation and the Early Jurassic Brigadier Formation, represent viable reservoirs.

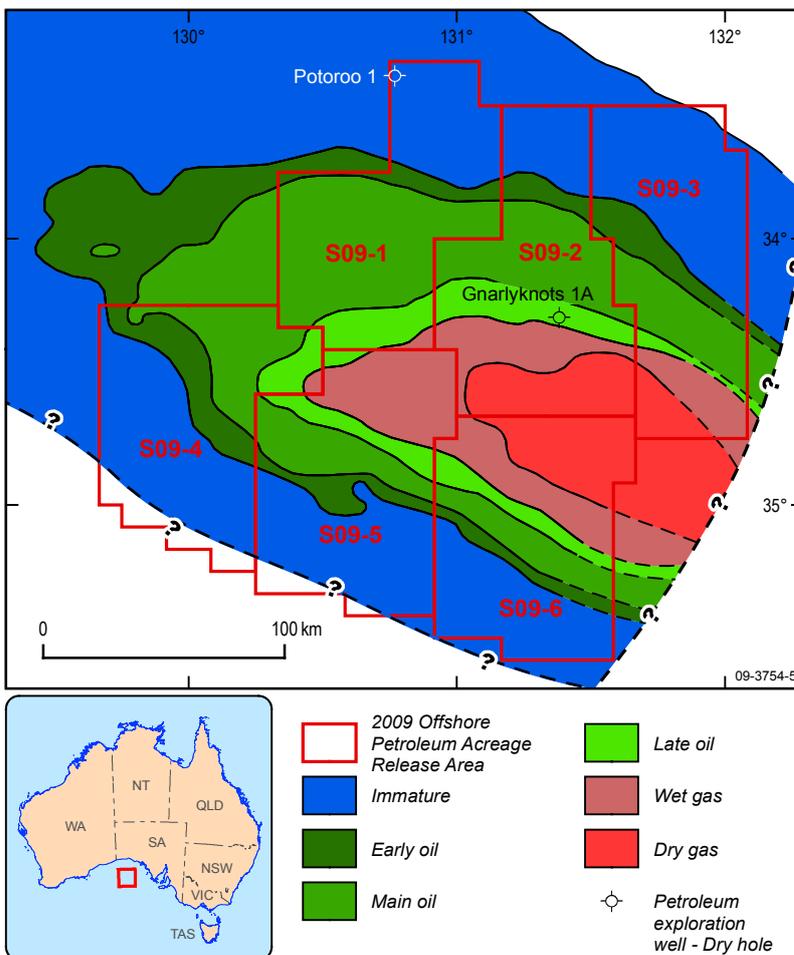
The proven traditional Triassic fault block play, which hosts most of the hydrocarbon reserves in the Carnarvon Basin, has the potential to extend onto the Rankin Platform. Gas charge in Triassic, Early Cretaceous and Paleocene reservoirs has a seismic expression which has been successfully used to guide exploration and development in the region surrounding the Release Areas. It appears that gas charge is pervasive throughout the region of the three Release Areas; in addition, there is some evidence of an oil charge. Exploration risks include trap geometries, reservoir facies distribution and relative location to migration pathways.

### Dampier Sub-Basin

The Dampier Sub-basin is an elongate northeast trending depocentre within the Northern Carnarvon Basin and contains over 10 000 metres of Paleozoic to Cenozoic sediments. The sub-basin is bound to the southeast by the Lambert Shelf and to the northwest by the Rankin Platform (figure 4) and hosts commercial oil and gas fields with hydrocarbon accumulations at multiple stratigraphic levels from the Triassic to the Cretaceous. The eight Release Areas are on structured flanks either side of the proven hydrocarbon kitchen to the west of the producing Wandoo and Stag oil fields.

Hydrocarbon plays in the central Dampier Sub-basin are related to Late Jurassic low-relief, oil-filled, drape structures that overlie gas-bearing horsts generated during Late Triassic to Early Jurassic rifting (such as Wanaea, Cossack, Mutineer, Egret). Seismic data suggests that this play may extend to Release Areas W09-12 and W09-13. The eastern flank of the Dampier Sub-basin contains a variety of play types along the Legendre Trend, with the principal types being Angel Formation sands sealed by Forestier Claystone, and Legendre

Formation overlain by Calypso Formation mudstones. Trap styles include Early Cretaceous low-side rollovers (Legendre) and faulted horsts (Talisman) and Middle Jurassic faulted anticlines (Reindeer gas field). These play types are relevant to Release Areas W09-14, W09-15 and W09-16. Fields on the Enderby Terrace are Early Cretaceous drape anticlines (Wandoo) and combination drape and onlap traps (Stag). Similar plays can be expected in Release Areas W09-17, W09-18 and W09-19, though in these basin margin locations, risks increase with longer migration pathways and thinning seal-units.



**Figure 5.** Present-day maturity map for Cenomanian-Turonian marine shale at the base of the Tiger Supersequence.

### Bight Basin

The Jurassic–Cretaceous Bight Basin is a large, mainly offshore basin situated along the western and central parts of the continental margin of southern Australia in water depths of less than 200 metres to over 4000 metres. The basin contains five main depocentres—the Ceduna, Duntroon, Eyre, Bremer and Recherche sub-basins.

### Ceduna Sub-Basin

The Ceduna Sub-basin is in the eastern part of the Bight Basin and contains up to 15 kilometres of Middle Jurassic to latest Cretaceous rocks. The Ceduna Sub-basin has been the focus of the most recent exploration effort which, for a number of reasons, has not met with success.

The six new Release Areas being offered in 2009 are located in the northern central part of the sub-basin (figure 1). The six blocks range in size from 6000 to 6400 square kilometres. The three inboard blocks (Release Areas S09-1 to 3) are in water depths of 130 to 1600 metres. The three outer blocks (Release Areas S09-4 to 6) are in water depths from 1200 to 4600 metres and are nominated for DFA status. Geoscience Australia has recently acquired new biostratigraphic and geochemical data for the Ceduna Sub-basin which have been interpreted and integrated with existing datasets to reassess the hydrocarbon prospectivity of this large offshore frontier (Totterdell et al 2008).

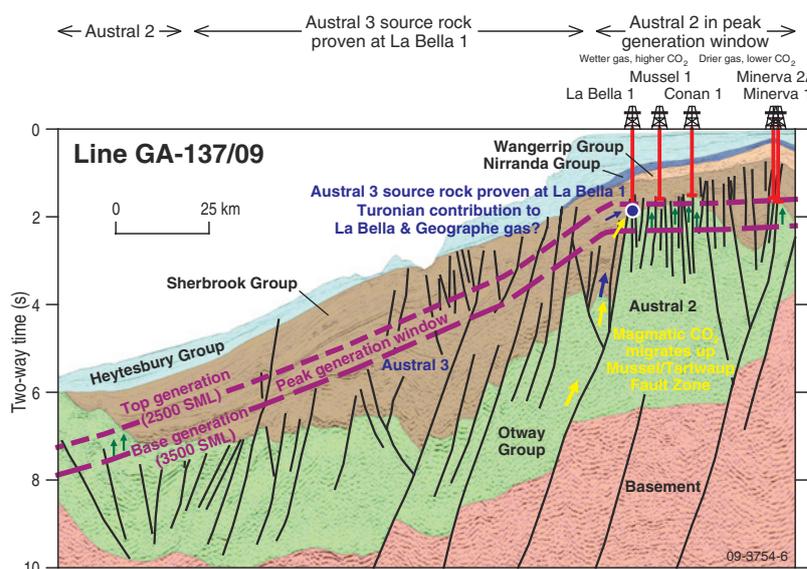
One of the key uncertainties identified prior to the most recent exploration phase was the possible lack of an effective source rock and thus adequate hydrocarbon charge. This uncertainty has been significantly reduced by the sampling and identification of a high quality marine source rock of Cenomanian to Turonian age as part of the southern offshore frontier study. The results of that work demonstrate the presence of a world-class hydrocarbon source rock of Turonian age which, according to petroleum systems modelling, is mature for oil and gas generation across much of the Ceduna Sub-basin (figure 5) and is capable of generating commercial quantities of liquid hydrocarbons.

Another concern is the presence of an effective seal, as evidenced by the high net to gross ratio encountered in the unsuccessful well Gnarlyknots-1A. However, seismic facies mapping suggests that pro-deltaic shales are likely to exist at various levels within

the Cenomanian–Turonian section. The majority of plays are structural and, as such, are dependent on cross fault seal. In the outboard basin this is probably less of a risk, because of the very likely presence of thick basinal shales in the Turonian-Santonian Tiger Supersequence, and outer shelf to slope fine-grained sediments within the lower part of the Santonian-Maastrichtian Hammerhead Supersequence.

## Otway Basin

The Otway Basin is a northwest-striking, passive margin rift basin that extends from southeastern South Australia to the northwestern coast of Tasmania. It belongs to a series of depocentres, including the Bight, Polda, Otway, Sorell, Bass and Gippsland basins, which were formed during Gondwana break-up and the Antarctic-Australian separation. The Otway Basin is filled with Late Jurassic to recent sediments and covers an area of 150 000 square kilometres, 80 per cent of which lies offshore. The basin hosts several producing gas fields, most of which are located in the eastern offshore region as well as onshore Victoria and South Australia. The 2009 Release Areas are located in the Western Otway Basin, offshore South Australia (S09-7) and in the Central Otway Basin, offshore Victoria



**Figure 6.** Hydrocarbon migration model for Austral 2 and Austral 3 petroleum systems (after O'Brien et al, 2009).



(V09-1 to V09-4). Of these five areas, four lie within shallow waters on the continental shelf, while area V09-4 is located in deep water over the continental slope (figure 1). All areas are proximal to existing infrastructure and growing energy markets.

Previous studies by Geoscience Australia (Edwards et al 1999) have identified three petroleum systems (Austral 1, 2 and 3) in the Otway Basin, of which Austral 1 is known to have produced hydrocarbons, including liquids, in the onshore part of the basin, while Austral 2 has produced most of the commercial gas accumulations. To date, the Austral 3 petroleum system is only recognised in a few onshore wells that have recorded gas shows in Late Cretaceous and Paleocene reservoir sandstones, but a source rock of that system has been identified in the offshore La Bella gas discovery (figure 6).

Although only a few exploration wells have been drilled in S09-7, the prospectivity of this area is largely similar to the three inboard blocks off Victoria (V09-1 to V09-3), where the Austral 2 petroleum system is accessible and known to be mature (figure 6). However, fault seal integrity and variable reservoir quality are the main uncertainties. In the deep-water area (V09-4), Early Cretaceous source rocks of the Austral 2 petroleum system are likely to be overmature. Therefore, source intervals within the Late Cretaceous section (Austral 3 petroleum system) are expected to occur within the maturity window and would have potential for hydrocarbon generation. Very little is known about the reservoir qualities of Late Cretaceous and Early Paleogene in the deep-water areas, and therefore require the testing of such exploration plays.

## Summary

In summary, the 2009 Offshore Acreage Release offers a wide variety of block sizes in shallow as well as deep water environments. Area selection has been undertaken in consultation with industry, the states and the Northern Territory. This year's Acreage Release caters for the whole gamut of exploration companies given that many areas are close to existing infrastructure while others are located in frontier offshore regions.

### For more information

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**To book into the 2009 Acreage Release Data Room**

**visit** [www.ga.gov.au/about-us/facilities/acreage-release-data-room.jsp](http://www.ga.gov.au/about-us/facilities/acreage-release-data-room.jsp)

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Edwards DS, Struckmeyer HIM, Bradshaw MT & Skinner JE. 1999. Geochemical characteristics of Australia's Southern Margin petroleum systems. *The APPEA Journal* 39: 297–321.

Geoscience Australia, 2008—[Web page] UN confirms Australia's extended marine jurisdiction, viewed 17 February 2008, <http://www.ga.gov.au/news/archive/2008/april/>

O'Brien GW, Boreham CJ, Thomas HJ and Tingate P. In press 2009. Understanding the critical success factors determining prospectivity, Otway Basin, Victoria. *The APPEA Journal*, 49.

Totterdell JM, Struckmeyer HIM, Boreham CJ, Mitchell CH, Monteil E and Bradshaw BE. 2008. Mid–Late Cretaceous organic-rich rocks from the eastern Bight Basin: implications for prospectivity. In: Blevin JE, Bradshaw BE and Uruski C (eds). *Eastern Australasian Basins Symposium III*, Petroleum Exploration Society of Australia, Special Publication, 137–158.

## Related websites/links

2009 offshore petroleum exploration areas (Department of Resources, Energy and Tourism)

[www.ret.gov.au/resources/upstream\\_petroleum/offshore\\_petroleum\\_exploration\\_in\\_australia/Pages/offshorePetroleumExplorationinAustralia.aspx](http://www.ret.gov.au/resources/upstream_petroleum/offshore_petroleum_exploration_in_australia/Pages/offshorePetroleumExplorationinAustralia.aspx)

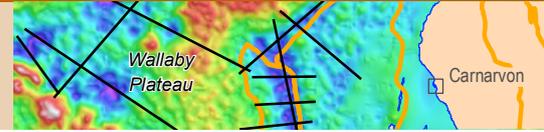
Data supporting the 2009 acreage release (Seismic data is available in GeoFrame™, Kingdom and Landmark™ formats)

[ausgeodata@ga.gov.au](mailto:ausgeodata@ga.gov.au)



# Southwest Margin surveys completed

*Surveys investigate basin structure, hydrocarbon potential and marine habitat*



*Clinton Foster, Bruce Goleby, Irina Borissova and Andrew Heap*

Two significant offshore data acquisition surveys along Western Australia's continental margin (*AusGeo News 92*) were recently completed by Geoscience Australia. They form part of the agency's ongoing collection of fundamental pre-competitive data and information to understand Australia's offshore frontier basins, and assist with planning and management of Australia's marine environments. These datasets will:

- support assessments of the petroleum potential of offshore frontier sedimentary basins located along Western Australia's continental margin
- underpin any subsequent petroleum acreage release in the area
- assist with planning and management of these marine environments.

Both surveys are part of Geoscience Australia's Offshore Energy Security Program which commenced in 2006 and extends to 2011. The Program has funding of \$75 million over this period to provide geoscience data and information to help stimulate exploration for petroleum resources in Australia's frontier offshore areas, and contribute to the increasingly vital quest to find a new oil province (*AusGeo News 90*).

The seismic survey involved the collection of approximately 7300 kilometres of commercial 2D seismic data. The marine reconnaissance survey involved swath mapping, gravity and magnetic data collection and seabed sampling. Further information on both surveys is provided below while reports on some early results from the marine reconnaissance survey are included in two other articles in this issue. The seismic survey data will need more than four months processing before it will be available for interpretation and distribution.

To support these surveys, Geoscience Australia completed an Ocean Bottom Magnetometer profile by acquiring ocean bottom magnetic readings, recording land magnetic readings from both permanent and temporary base stations and undertaking shipboard to land gravity reading ties. The Ocean Bottom Magnetometer profile coincided with one of the survey's long regional transects, which extended from north of Geraldton to the Wallaby Plateau. Some of this transect was located within Australia's recently confirmed extended continental shelf.

The shipboard gravity and magnetic data acquired along the marine reconnaissance and 2D seismic lines will be integrated into existing

potential field coverage, and used to provide an understanding of the structure and shape of these offshore frontier basins.

These datasets and their interpretation will assist in understanding the petroleum prospectivity of the region and, eventually, underpin Australia's future offshore petroleum acreage release. They will also increase our knowledge of seabed environments and marine habitats.

## 2D seismic reflection survey

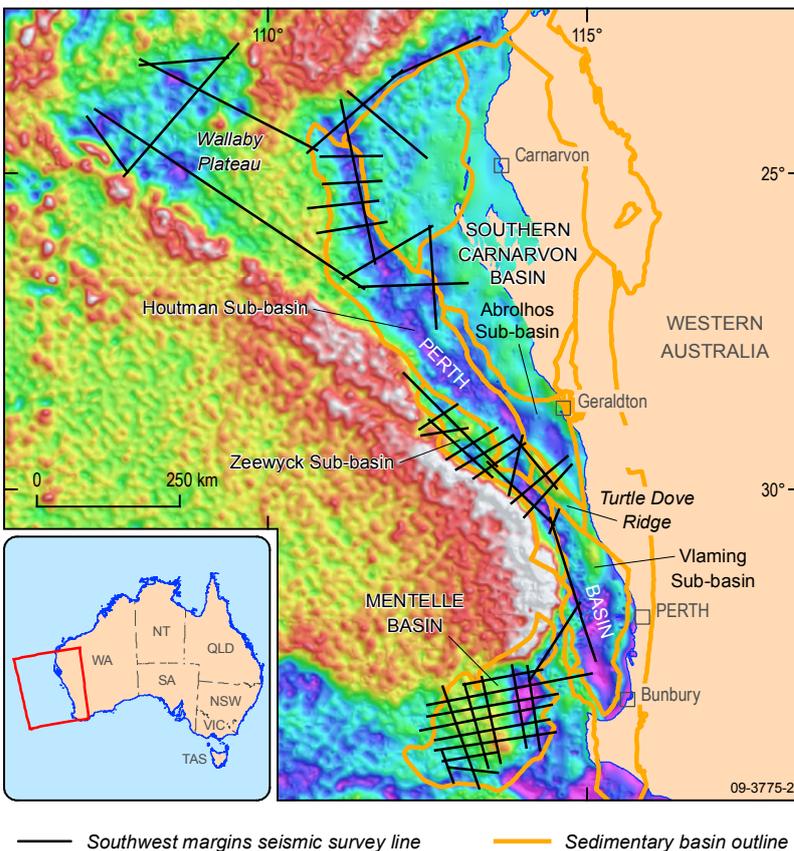
Geoscience Australia conducted the 2D seismic reflection, gravity, and magnetics survey between 26 November 2008 and 24 February 2009, using CGGVeritas's marine seismic vessel MV *Duke*.

This survey was Geoscience Australia's first regional seismic survey carried out in Australia's Exclusive Economic Zone (EEZ) and extended continental shelf in frontier areas off the Western Australian coast. It will provide critical information to support a better understanding of the regional geology, sediment thickness and hydrocarbon prospectivity of the area.

The seismic survey acquired approximately 7300 kilometres of industry-standard 2D reflection



**Figure 1.** The 8 kilometre solid streamer, tail buoy and stabilizer ‘birds’ being inspected prior to the start of the Southwest Margin 2D seismic survey.



**Figure 2.** Seismic lines acquired during the Southwest Margin 2D seismic survey by the MV *Duke*. The background image is Bouguer-corrected satellite gravity data.

“The seismic survey acquired approximately 7300 kilometres of industry-standard 2D reflection seismic data.”

seismic data using an 8 kilometre solid streamer (figure 1) of 12.5 metre groups (106-fold), 4290 cubic inch airgun array and the returned signal is recorded for 12 seconds. Ship-based gravity and magnetic data were also acquired along all seismic lines and transits while ocean-bottom and land-based magnetometers were deployed to better understand the magnetic field.

The 91-day seismic survey extended from Northwest Cape in the north to Cape Leeuwin in the south and acquired seismic data along 45 lines. These were over the deep-water underexplored areas of the Mentelle Basin, the Houtman/Zeewyck sub-basins of the Perth Basin and the southern Carnarvon Basin, as well as over the Wallaby Plateau which is further offshore (figure 2). The Wallaby Plateau was recently added to Australia’s extended continental shelf under the United Nations Convention on the Law of the Sea (see *AusGeo News* 93). Seismic data acquired will be used to understand the structure of the region and investigate the possible presence of areas of major sediment accumulation (or depocentres) capable of producing and preserving hydrocarbons.

The industry standard 2D seismic traverses were acquired both along dip (across the geological structures) and strike (along the main geological structural grain) lines. Wherever possible, these traverses tied into existing industry seismic grids,

regional seismic lines or surveys providing well ties. Interpretation of this new dataset will help scientists to better understand the regional stratigraphy of the surveyed areas.

The survey data is currently being processed and will be available from Geoscience Australia's repositories at the cost of transfer in the latter part of 2009. The newly acquired and existing geophysical data will assist Geoscience Australia's Southwest Margin project team to:

- map the extent and depth to basement of the main sedimentary depocentres
- determine the nature of the crust underlying these depocentres
- better define the structure and stratigraphy of the frontier basins along the western Australian margin
- better understand the tectonic evolution of the margin
- understand petroleum system elements, maturation and potential trapping mechanisms in these basins.

### Marine Reconnaissance Survey

The marine reconnaissance survey used the German research vessel RV *Sonne* and was conducted between 22 October 2008 and 15 January 2009. This survey focused on the underexplored areas of the

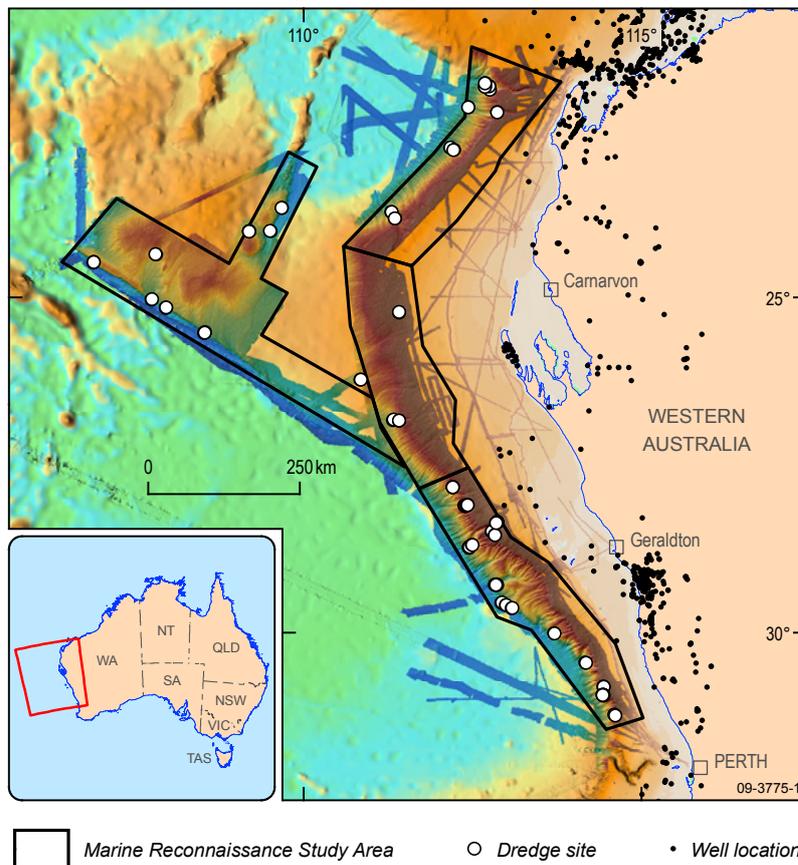
Zeewyck and Houtman Sub-basins (part of the Perth Basin), the southern Carnarvon Basin (figure 3) and on the Wallaby Plateau.

The objectives of the survey included:

- Determining the age, lithology and geochemical character of rocks from the main sediment depocentres and underlying basement.
- Determining the nature of the crust underlying depocentres by modelling calibrated geopotential data.
- Characterising the physical properties of the seabed associated with the basin areas.
- Characterising the abiotic and biotic relationships on a variety of ecologically significant geomorphic features (such as canyons, ridges, and plateaus).

Multibeam sonar was used to map more than 200 000 square kilometres of seabed – an area almost the size of Victoria – increasing the mapped area of Australia's EEZ by 12 per cent (table 1). More than 18 000 kilometres of magnetic, gravity and sub-bottom profiler (SBP) data were collected. In addition, samples were collected from 62 sites using a variety of equipment to gather information on the geology, geomorphology, sedimentology, ecology and oceanography of the region.

Analysis of the available seismic data from the frontier basins has shown that thick successions of sedimentary rocks



**Figure 3.** Swath bathymetry collected during the Southwest Margin marine reconnaissance survey onboard RV *Sonne* showing dredge sample locations.

are exposed in the steep walls of several large submarine canyons. These were targeted by the dredging program. Sedimentary rocks sampled at different stratigraphic levels in these canyons will provide crucial information on the basin stratigraphy. Moreover, sampling and imaging of the sedimentary successions in the Exmouth and Zeewyck sub-basins suggest that the outboard parts of these basins extend up to 60 kilometres seaward off the currently published basin boundaries. Analysis of samples from these areas will assist in developing an understanding of the basin history and assessing its potential petroleum prospectivity. These data will be used to underpin any future petroleum acreage release areas.

Over 40 new submarine canyons and previously unknown volcanic pinnacles were discovered during the survey. These discoveries revealed the spatial structure of the seabed environments to be far more complex than previously thought. Studies are currently underway to characterise the seabed environments for the purposes of defining Australia's little-known deep-sea biodiversity.

**“These discoveries revealed the spatial structure of the seabed environments to be far more complex than previously thought.”**

Work programs onboard the RV *Sonne* involved collaboration between Geoscience Australia and the Geological Survey of Western Australia (GSWA). Four geologists from the GSWA took part in the survey and provided expert knowledge about Western Australian geology. The survey also provided a unique opportunity for 18 university students from 10 countries (Australia, Belgium, Canada, China, France, Indonesia, Iran, Malaysia, Singapore and the United States) to complete crucial training in marine science and fieldwork as

part of the University of the Sea program. The students supported scientific staff in all onboard research activities.

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**Table 1.** Data and samples collected during the survey.

Data type	Total recovery
<b>Geophysical</b>	
Square kilometres of swath data	200 000
Kilometres of magnetic, gravity, and SBP data	18 000
<b>Physical</b>	
Rock dredges	53
Surface grabs (with black & white camera tows)	28
Camera tows (colour with stills)	17
Boxcores	8
Benthic sleds	4
Conductivity, turbidity and depth casts	8

### Related websites/articles

*AusGeo News 90:* Offshore energy program underway

[www.ga.gov.au/ausgeonews/ausgeonews200806/offshore.jsp](http://www.ga.gov.au/ausgeonews/ausgeonews200806/offshore.jsp)

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# The geology and deep marine terrains of Australia's western margin

## Preliminary results from major marine reconnaissance survey

*Danielle Payne, Daniel Mantle, Irina Borissova, Chris Nicholson and Diane Jorgensen*

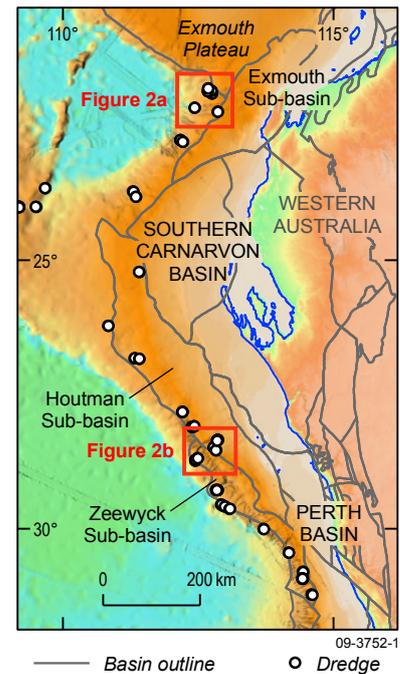
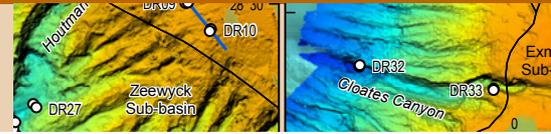
The recently completed marine reconnaissance survey of Australia's southwestern margin was the first survey to collect rock samples from this under-explored deepwater area. Significant outcomes of the survey included:

- the recovery of nearly 200 rock samples from deep to ultra-deepwater sedimentary basins.
- new evidence for the westward extension of the Exmouth and Zeewyck sub-basins
- mapping and sampling of several submarine volcanic features which provide the first evidence of recent volcanism on the western Australian margin

The sampling program conducted during the survey covered a vast area from the Perth Canyon in the south to the Exmouth Plateau in the north. Samples were obtained from deepwater areas (1000 to 5000 metres water depth) in the Perth and South Carnarvon basins. To date, hydrocarbon exploration in the area has focussed on shallow-water plays, leaving the deepwater parts of these basins under-explored and poorly understood.

**“The sampling program conducted during the survey covered a vast area from the Perth Canyon in the south to the Exmouth Plateau in the north.”**

Of particular interest were the Zeewyck and northern Houtman sub-basins of the Perth Basin (figure 1) which had been identified as potentially prospective frontier basins (Bradshaw et al 2003). Samples collected during this survey provided the first opportunity to get insights into the age and composition of sedimentary rocks in these basins. The dredge sampling used the technique developed during the Great Australian Bight Survey in 2007 to successfully target source rock intervals and provide invaluable geological data to support



**Figure 1.** Location of dredge sites in the Perth and southern Carnarvon Basins.

the hydrocarbon prospectivity assessment (Totterdell et al 2008).

Most of the dredge sites were located in submarine canyons and scarps where steep slopes offer the best opportunity for sampling the sedimentary strata. Grab samples were taken at the base of a steep slope and provided additional information on lithologies present in the sedimentary succession above. A total of 199 rock samples were collected from 53 dredges,

13 grabs, three benthic sleds and one box core. These samples include a suite of sedimentary and volcanic rocks. Their composition and organic content will be determined by geochemical analysis whilst microfossil analysis will help resolve the age and depositional environment of the sedimentary strata.

Considerable effort went into planning the dredge locations before and during the survey. Dredge sites were selected within deeply incised canyons that exposed rocks from the synrift succession, using seismic data and seafloor bathymetry images. The Houtman Canyon, which intersects both the Zeewyck and Houtman sub-basins, and the Cape Range Canyon, to the south of the Exmouth Plateau, are the two largest canyons within the survey area (figure 2) and provided some of the best sampling targets. Dredges were deployed in different parts of these canyons to provide samples from different stratigraphic levels in the basin succession. This article highlights preliminary results from these two locations. A full description of the sampling program and the rocks collected during this survey will be published later this year in a post-survey report.

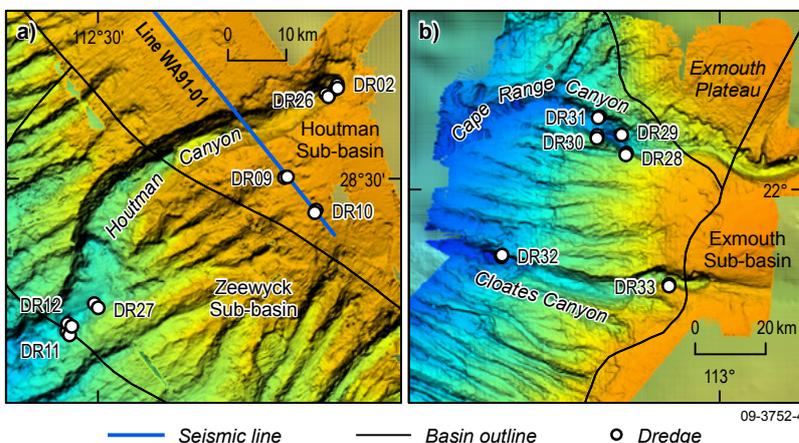
## Houtman Canyon: Zeewyck and Houtman Sub-basins

Both the Houtman and Zeewyck sub-basins are part of the 1300 kilometre long north-south trending Perth Basin (figure 1). The Houtman Sub-basin is a major Paleozoic–Mesozoic depocentre initially formed as a series of Permian to Early Triassic rift basins. In the Triassic these basins were overlain by sag deposits and in the Early Jurassic a new rifting phase led to the development of Jurassic depocentres (or areas of major sediment accumulation). The southern Houtman Sub-basin potentially hosts commercially viable Jurassic petroleum systems with gas and oil shows in the Early to Mid-Jurassic

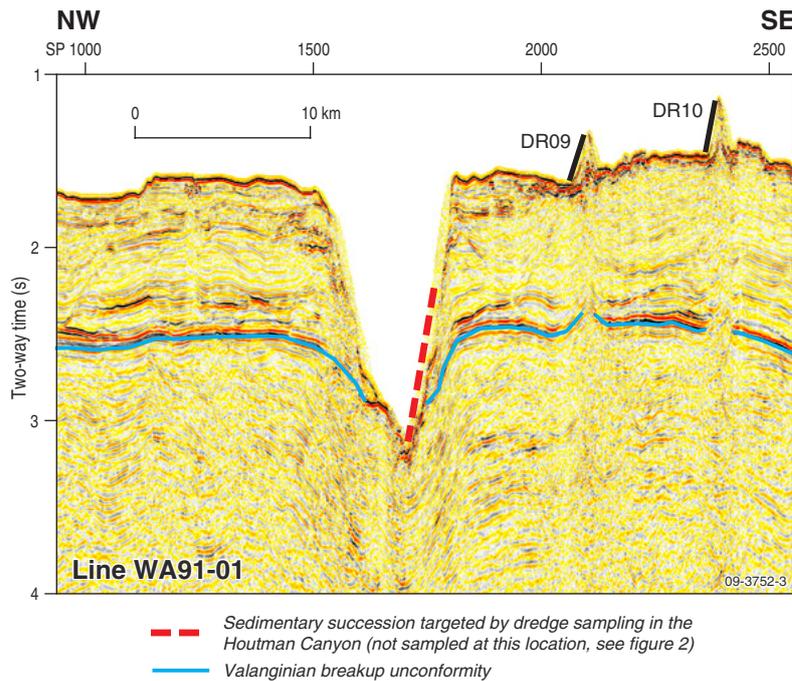
Cattamarra Coal Measures. The northern Houtman Sub-basin has only a sparse coverage by regional seismic lines and little is known about its hydrocarbon prospectivity.

The Zeewyck Sub-basin is a deep-water frontier basin with no record of previous exploration. Seismic data coverage is limited to 20 regional dip lines of varying vintage and quality. The sub-basin appears to consist of a series of depocentres containing Middle Jurassic–Lower Cretaceous synrift strata overlain by Lower Cretaceous–Cainozoic postrift strata (Bradshaw et al 2003). It has the potential to be a deepwater to ultra-deepwater petroleum province with hydrocarbons possibly generated from Jurassic and Early Cretaceous source intervals. New data collected during this survey will help to develop an understanding of the geology and exploration potential of the Zeewyck Sub-basin and data-poor areas of the Houtman Sub-basin.

The Houtman Canyon is located about 400 kilometres north of the Perth Canyon and extends from the upper continental slope (600 metres water depth) down to the abyssal plain (4900 metres depth). Part of the seismic line in figure 3 intersects the Houtman Canyon, showing that both synrift and postrift sections are exposed in the canyon walls. In the upper Houtman Canyon (Houtman



**Figure 2.** Location of dredge sites: a) the Houtman; b) the Cloates and Cape Range canyons.



**Figure 3.** Example of a seismic line (WA91-01) intersecting the upper part of the Houtman Canyon. Location of dredge paths on the volcanic cones are shown by the black lines while the targeted part of the basin succession at other locations in the canyon is shown by the red dashed line.

Sub-basin), 19 samples were obtained from three dredges in the interval from 2100 to 1700 metres water depth. Dark grey-green sandstones and claystones are the most common lithologies in this area, but siltstones, limestones and stratified siliciclastics were also recovered. Sedimentary structures recovered include planar, wavy, and ripple cross lamination. Additionally, coaly and mudstone intraclasts were observed in some of the samples.

In the lower Houtman Canyon (Zeewyck Sub-basin), 18 samples were collected from three dredges in the interval between 4100 and 3800 metres water depth. This 300 metre section yielded mostly yellow-brown and grey sandstones along with claystones, limestone, basalt, chert and mixed siliciclastics. The predominant sandstones were largely unstructured although planar and trough cross bedding, normal grading and laminae were recorded from interbedded clay- and sandstone samples.

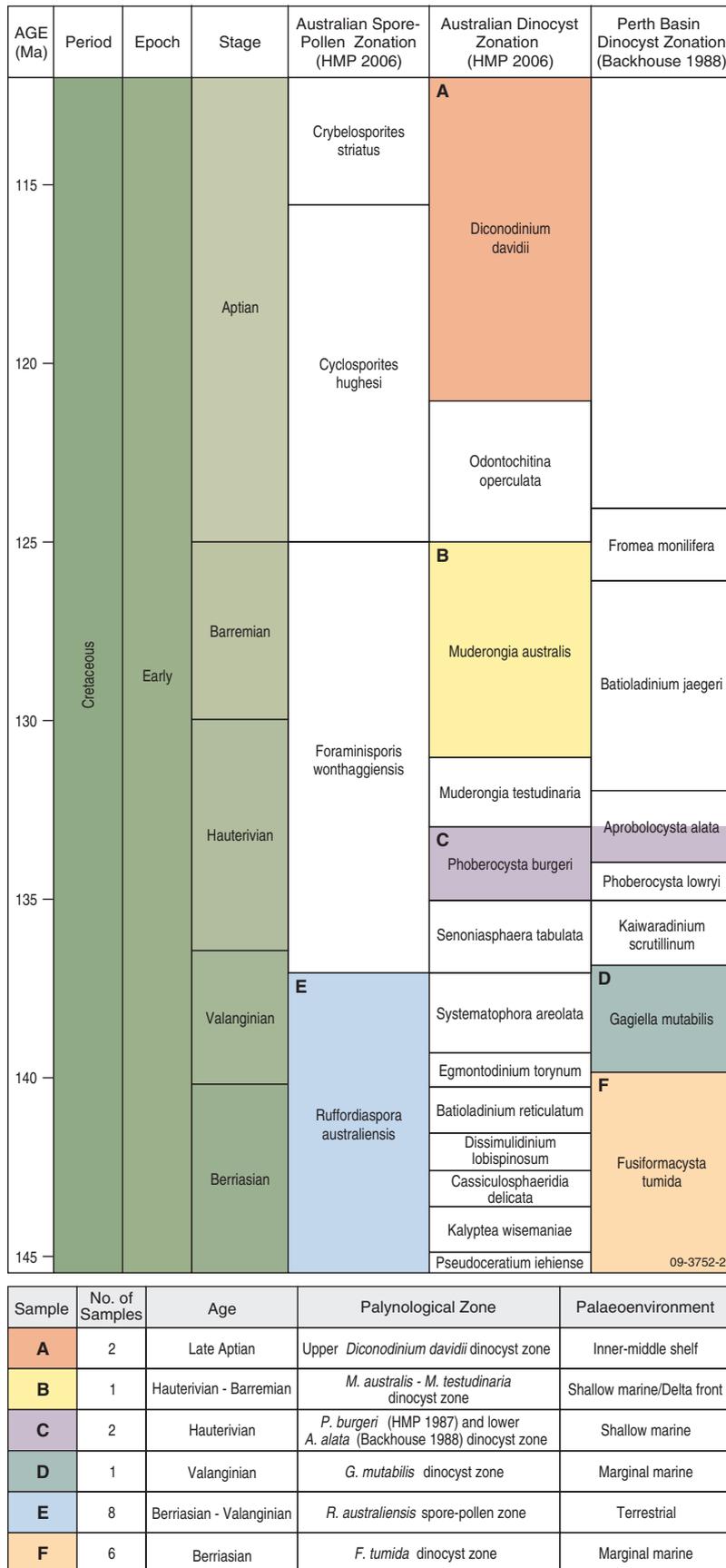
In the area surrounding the Houtman Canyon, seismic data shows several 200 to 300 metre high conical features exposed on the sea floor (figure 3). Preliminary interpretations identified two possible origins: either extrusive volcanic cones or mud diapirs (Gorter pers. comm.). Swath mapping confirmed the presence of these features and two of them near the upper Houtman Canyon were targeted for dredging (DR09 & DR10; figures 2 and 3). Three basalt samples were recovered: two vesicular basalts from the southern volcanic cone

and a volcanoclastic breccia with a carbonate matrix from the northern cone. This discovery of recent volcanism in the Houtman Sub-basin is very important for understanding the basin's tectonic and thermal history.

## Cape Range Canyon: Exmouth Sub-basin

The Exmouth Sub-basin is the southernmost part of the Exmouth-Barrow-Dampier intracratonic rift system of the Carnarvon Basin. It is a major Early to Middle Jurassic depocentre containing over 12 kilometres of predominantly marine and non-marine siliciclastics. The sub-basin is a proven petroleum province hosting a number of oil and gas fields. Upper Jurassic marine shales form the principal hydrocarbon source and the Lower Cretaceous Barrow Group sandstones are the primary reservoirs in this sub-basin. However, the southern part of the Exmouth Sub-basin remains under-explored.

Cape Range Canyon (figure 2) is one of the largest canyons on the western margin of Australia. It extends for over 120 kilometres from the westernmost Exmouth Sub-basin (1800 metres water depth) to the Gascoyne abyssal plain (4800 metres depth). Cloates Canyon is a slightly smaller canyon located about 40 kilometres south of the Cape Range Canyon and occurs in similar water depths. New swath



**Figure 4.** Initial palynological results for selected samples from the Houtman Canyon (Houtman and Zeewyck sub-basins) and Cape Range and Cloates canyons (Exmouth Sub-basin).

bathymetry has shown that both canyons incise deeply into the margin, and have steep walls suitable for dredging in their lower reaches. Samples were recovered from four dredges in the Cape Range Canyon and two dredges in the Cloates Canyon. Very similar lithologies were recorded in both canyons and may be representative of the sedimentary succession lying in the interval between 4300 and 3700 metres water depth. The recovered lithologies included stratified, olive-brown to grey sandstone, dark brown to black claystone, and minor cherts and felsic igneous rocks. Some sandstone samples contain plant material and fossils indicative of shallow water deposition.

This discovery of sedimentary successions within the lower Cape Range and Cloates canyons, combined with the newly-acquired swath bathymetry images, provides strong evidence of a westward continuation of the Exmouth Sub-basin into deeper waters than previously mapped. Consequently the boundaries of the sub-basin extend at least 50 kilometres westward to the base of the continental slope.

## Initial biostratigraphic results

Dredged rock samples with suitable fine-grained lithologies, likely to preserve microfossils, were selected to analyse for their foraminiferal, nannofossil, and palynological content. Most of these samples were productive and contain well preserved microfossil assemblages. Palynological analyses of 28 high priority samples has allowed initial inferences to be made on the age, depositional environment (palaeoenvironment), and thermal maturity of the rock strata. The ages and initial palaeoenvironmental results for 20 of the productive samples from the Exmouth, Houtman, and Zeewyck sub-basins are outlined in figure 4.

These samples were all of an Early Cretaceous age (145.5 – 99.6 million years or Ma) with most being restricted to the Berriasian-Valanginian stages (145.5-133.9 Ma) corresponding to the latest stage of synrift deposition. These older samples were mostly deposited in a terrestrial, probably fluvial, environment or in marginal (restricted) marine settings. Although samples classified as marginal marine are dominated by terrestrial plant spores and pollen, they also contain a sparse, low diversity assemblage of thin-walled, dinoflagellate cysts of probable restricted marine origin (such as *Fusiformacysta tumida*).

Samples collected from the deeply incised Houtman and Cape Range canyons (figure 2) are amongst the oldest samples analysed so far and are mostly assignable to the Berriasian portion of the *F. tumida* Dinocyst zone. The colour of the palynomorphs (thermal alteration index or TAI) acts as a rough proxy for the thermal maturity of the samples. The TAI values from these samples indicate that most are thermally mature and are within or approaching the 'oil window'. Many of the Berriasian-Valanginian samples also contain copious amounts of reworked Late Permian and Early Triassic palynomorphs which, in some samples account for over half of the entire assemblage.

Younger, more open marine samples of Hauterivian to late Aptian age were collected from the Cloates Canyon (Exmouth Sub-basin) and the upper parts of unnamed canyons in the Houtman Sub-basin. These samples are dominated by marine dinoflagellate cysts with some bisaccate pollen and only sparse terrestrial plant spores which are denser and rarely transported offshore in great abundance. These samples fall within the postrift stages (following the breakup between Australia and Greater India) of the northern Perth and southern

Carnarvon basin successions. The TAI values for these samples indicate they are all thermally immature for hydrocarbon generation.

## Summary

Preliminary analyses on the palynology of these rock samples suggest that both synrift and postrift successions have been sampled in these basins. When the results from more detailed analyses become available, they will provide invaluable information on the stratigraphy and petroleum prospectivity of these frontier basins.

### For more information

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### References

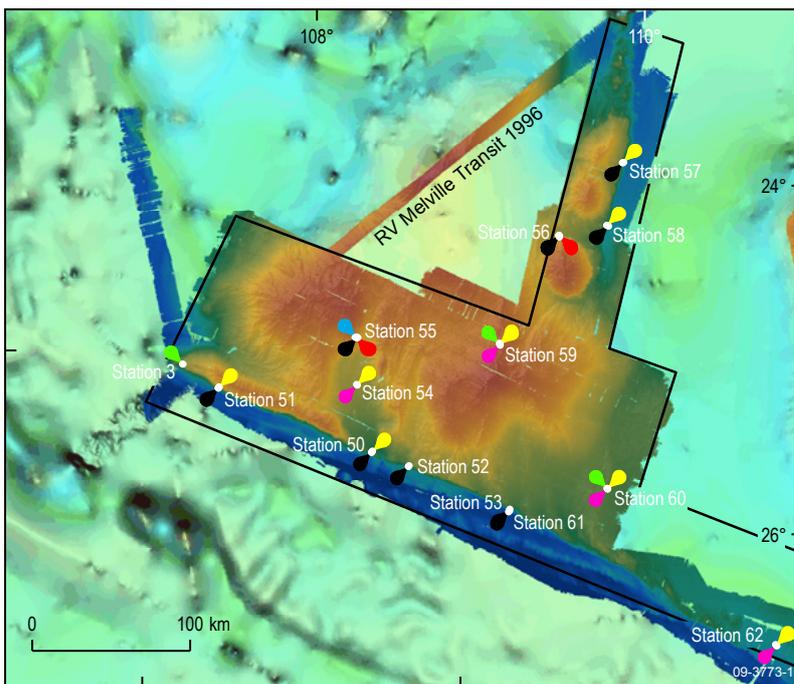
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- Totterdell JM, Struckmeyer HIM, Boreham CJ, Mitchell CH, Monteil E & Bradshaw BE. 2008. Mid-Late Cretaceous organic-rich rocks from the eastern Bight Basin: implications for prospectivity. In: Blevin JE, Bradshaw BE & Uruski C (eds), Eastern Australasian Basins Symposium III, Petroleum Exploration Society of Australia, Special Publication, 137-158.

# Revealing the Wallaby Plateau

*Recent survey delivers geophysical, geological and biophysical data*

*Gabriel Nelson, Michael Hughes, Rachel Przeslawski, Scott Nichol, Bridgette Lewis, and Kane Rawsthorn*

The Wallaby (Cuvier) Plateau was the focus of the third leg of the recent Geoscience Australia Southwest Margin marine reconnaissance survey. The plateau is a large bathymetric high, lying in water depths from 2000 to 4000 metres approximately 500 kilometres west of Carnarvon, Western Australia. Satellite-derived gravity data and initial seismic interpretations indicate a portion of the plateau comprises continental crust with sedimentary depocentres. This submarine plateau has been recently added to Australia's extended continental shelf under the United Nations Convention on the Law of the Sea (*AusGeo News 93*), and is one of the frontier areas being focussed on by Geoscience Australia's Offshore Energy Security Program.



- Camera-grab
- Benthic trawl
- Box core
- CTD
- Camera
- Dredge

**Figure 1.** New swath bathymetry acquired during the Southwest Margin marine reconnaissance survey on the Wallaby Plateau overlain on satellite-derived bathymetric image. The station locations and type of sampling done at them during the survey are also shown.

Approximately 65 000 square kilometres of the Wallaby Plateau were surveyed over 29 days (figure 1). Key datasets collected during this time include multibeam swath bathymetry and about 8000 line kilometres of high resolution gravity, magnetic and Acoustic Doppler Current Profiler measurements. Additional data were collected with 11 rock dredges, three sediment grabs, four box cores, one benthic (sea floor) trawl, eight camera tows as well as 10 temperature, conductivity (salinity) and depth profiles through the water column. These complementary datasets will continue to contribute to a better geologic, sedimentologic, oceanographic and biologic understanding of this frontier region of Australia's continental shelf.

## New geology from swath bathymetry

Detailed bathymetry acquired over the Wallaby Plateau area showed new seafloor features interpreted as volcanic in origin, as well as structurally-controlled valleys, scarps and ridges. Five interpreted volcanic features have been identified on the plateau; four from the new bathymetric

data and one from a pre-existing multibeam swath track. Three large volcanic complexes with amorphous perimeters and relatively flat tops were identified in the southwest, southeast and north. Two smaller, steeper and more cone-shaped volcanic features were identified in the northeast. A steep sided, 5.5 to 23 kilometre-wide valley extending to the north from the southwest edge of the Wallaby Plateau has also been identified.

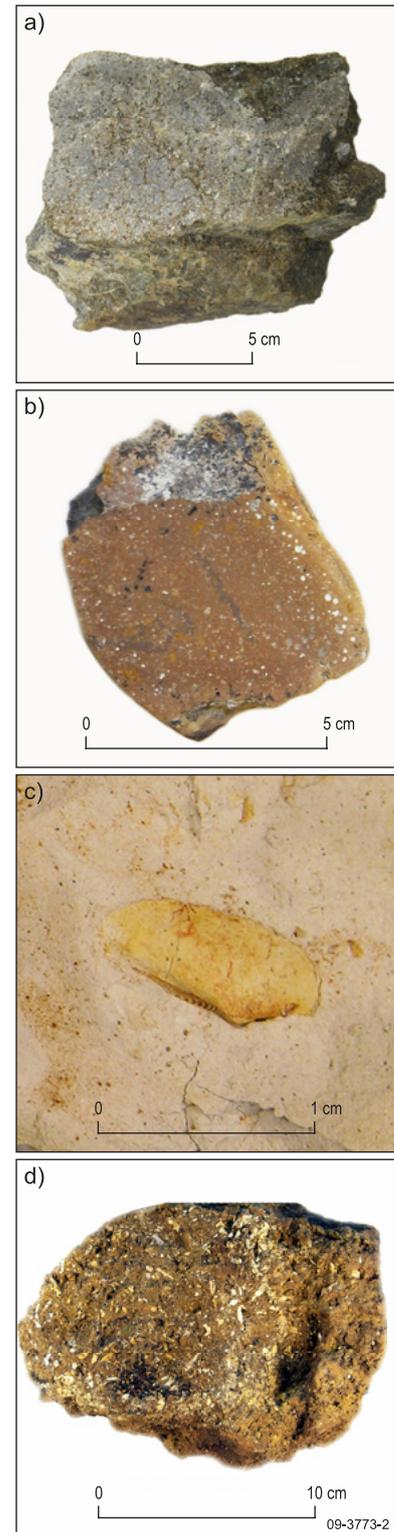
The edge of the plateau is defined by a scarp that extends about 360 kilometres and up to two kilometres high. Several offset ridges, 50 to 800 metres tall and 125 to 200 kilometres long, are at acute angles to the southwestern edge of the Wallaby Plateau. These ridges are the morphological expression of the Wallaby-Zenith Fracture Zone. Northeast of the plateau more than 30 closely spaced possible volcanic hills (270 to 400 metres tall) are visible in the new swath bathymetry data. These appear to be an extension of the Sonne Ridge on the Cuvier Abyssal Plain.

Regionally, the main phase of volcanism is related to the break up of Australia and Greater India about 130 million years ago. Many of the volcanic features on the plateau are likely to correspond to regional volcanism during break-up, and the variable morphology may indicate multiple episodes of volcanic activity. Other volcanic features, including those located on the abyssal plain, are probably a result of volcanism during seafloor spreading after break-up. The southern margin of the plateau may have developed with a transtensional component, shown by the series of *en echelon* offset ridges within the Wallaby-Zenith Fracture Zone. The steep sided submarine valley in the central area of the plateau is the surface expression of extensional faults observed in 2D seismic lines. Relatively recent movement of these faults is suggested by the distinct nature of the valley sides despite extensive modern sedimentation.

## Geological sampling

Geological samples were collected at nine stations (or locations) from 11 dredges, one grab sample, and one benthic trawl. There are 10 samples of sedimentary rocks, 14 volcanic samples, and seven samples with a high degree of alteration and secondary mineral development. Most volcanic samples are vesicular with a fine grained groundmass and likely to be basaltic in composition. Three volcanic samples from different parts of the plateau appear more siliceous, potentially indicating variations in magma composition in the area (figures 2a, 2b). Of the 10 sedimentary samples two contain abundant bivalve fossils and other macrofossil fragments (figure 2c, 2d). These fossil rich samples are predominantly made up of terrigenously derived grains.

Rock samples collected on the Wallaby Plateau are mostly igneous, reflecting a predominantly volcanic origin of the bathymetric features.



**Figure 2.** Geological samples recovered from the Wallaby Plateau: a) possibly evolved (more siliceous) volcanic sample; b) possibly evolved volcanics with very fine crystals and no evident olivine; c) disarticulated bivalve with evident dentition; d) very fine grained sandstone with bivalve fragments, echinoderm spines, bryozoan fragments, and other carbonate bioclasts.

The potential variability in the silica content of igneous samples suggests variable evolution of the magmatic system(s) spatially and/or temporally. Of particular importance is the recovery of several terrigenous clastic rocks. They are the first physical evidence confirming the previously inferred sedimentary depocentres on the Wallaby Plateau. The various terrigenous clastics were likely deposited during a time when a portion of the plateau was near or above sea-level.

## Sedimentology

Seafloor sediments collected from 12 stations at 2050 to 4650 metres water depth represent scarps, valleys and volcanic features (figure 1). Most sediment samples were collected from pipe buckets attached to the rock dredge. Samples were also collected using a grab at three stations and a box core at three other stations, with the latter providing undisturbed sediment samples.

Visual observations of samples indicate seafloor sediments on the Wallaby Plateau comprise unlithified sandy mud that forms an extensive deposit of cohesive, poorly sorted ooze. In all samples, the sand fraction is calcareous and dominated by foram tests (or shells). Some samples also included small amounts of gravel, derived from rock outcrops that were observed by camera in the vicinity of the sample site.

The uniformity of surface sediment type across the Wallaby Plateau is consistent with a gradual accumulation of pelagic material from the water column, dominated by calcareous foram tests. Where outcrops of volcanic rock occur, the ooze is mixed with gravel clasts but these deposits appear to be of limited extent. Based on the available samples, there does not appear to be any variation in sediment type as a function of water depth or between the different geomorphic environments of the Plateau.

## Oceanography

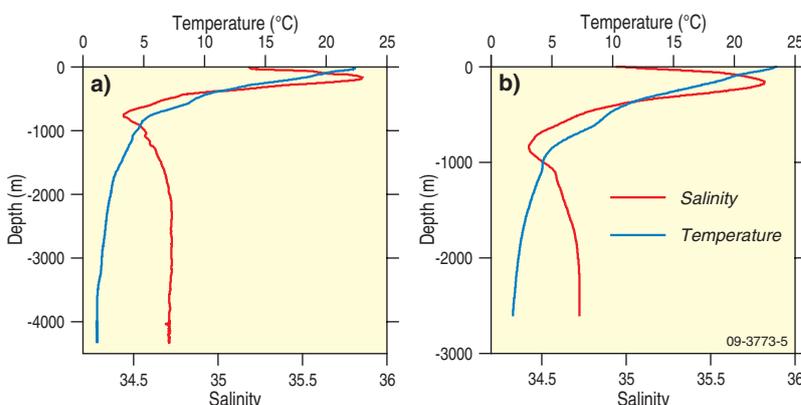
Water properties over the Wallaby Plateau were sampled at ten stations (figure 1). The general pattern observed was a three layer water-column. Within the surface layer, which is about 40 to 50

metres deep, the salinity and temperature did not vary significantly because of mixing by surface waves and currents. Below this were seasonal and permanent thermocline layers that extended down to a depth of 850 metres (figure 3). Through this depth range both the temperature and salinity decreased markedly. Below the permanent thermocline water temperatures decreased slowly with depth. Bottom water temperatures were only 1 to 2° C, considerably cooler than a typical domestic refrigerator which is about 4° C.

Ocean current data collected using an Acoustic Doppler Current Profiler provided current speed and direction at intervals of 24 metres through the first 800 metres of the water column. Thus the measurements extended to the base of the permanent thermocline. Surface currents observed over the Wallaby Plateau at the time of the survey were typically 0.25 metres per second (or  $m s^{-1}$ ) and reached up to 0.4  $m s^{-1}$ . The pattern of flow was consistent with a clockwise-rotating eddy (figure 4). It is not known whether such an eddy is usually centred on the plateau, if so, then vertical currents within the clockwise-rotating eddy are expected to be directed towards the sea surface. This would limit the connectivity between the surface and deep water masses.

## Biology

In order to characterise the biodiversity on the sea floor of the Wallaby Plateau, nine video transects were undertaken on

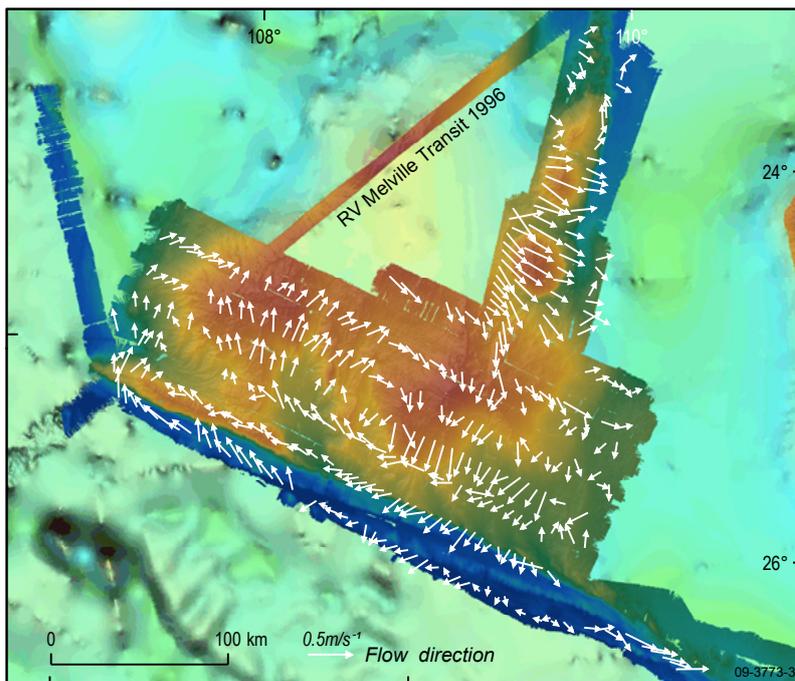


**Figure 3.** Depth-profiles of water temperature and salinity at Stations 50 and 59 (see Figure 1 for station locations).

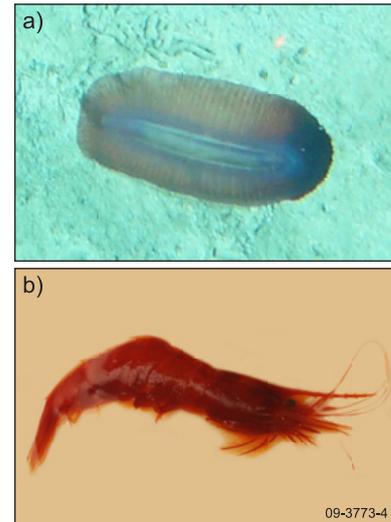
the plateau and slope. In addition, three grabs and three box cores were deployed to investigate deep sea animal communities that live beneath the sea floor (infauna) out of video view. In addition, surface zooplankton was sampled to compare pelagic (in the water column) and benthic (on the sea floor) biodiversity in the region.

Observations revealed very few animals on the Wallaby Plateau compared to other locations sampled during the Southwest Margin reconnaissance survey. In the deep sea, hard substrates are often colonised by scattered suspension feeders such as sponges, gorgonians, and crinoids, however videos showed almost no such organisms on the rocky habitats. Soft sediment habitats are usually dotted with distinct tracks, burrows, and mounds from deposit-feeding infauna: but again, there was little evidence of biological activity, with few fresh tracks seen. The only animals that occurred regularly were deposit-feeding sea cucumbers and scavenging prawns (figure 5). The box core and grab samples corroborated the video, with only a few marine worms and crustaceans collected.

The comparative barrenness of the Wallaby Plateau may be the result of an abrupt decrease in oxygen availability on the sea floor. However, the only dissolved oxygen profile collected during the survey showed that the oxygen gradient in the water column was normal for deep sea habitats and did not explain the apparent lack of animals. An alternative explanation is that the ocean currents above the Wallaby Plateau drive the biological patterns observed, such that food and larvae bypass the area and never make it to the sea floor to nourish, establish, and perpetuate populations. Indeed, the Wallaby Plateau had less zooplankton than the nearby Houtman Sub-basin, suggesting that the amount of nutrients and propagules reaching the Wallaby Plateau sea floor is less than for other benthic habitats in the region.



**Figure 4.** A sample of the surface ocean currents measured over the Wallaby Plateau showing evidence of a clockwise-rotating eddy.



**Figure 5.** Sea cucumbers (top panel, video screenshot photograph from ~3950 metres) and prawns (bottom panel, collected from ~3820 metres) found regularly on the sea floor of the Wallaby Plateau.

## Conclusions

The successful marine reconnaissance survey of the Wallaby Plateau resulted in several new datasets that have already revealed new geologic, sedimentologic, oceanographic and biologic discoveries. Further work is in progress to refine this understanding and place it in a regional context. This research includes detailed analysis of the bathymetry and geophysical datasets as well as the geological samples. Future analysis will provide an understanding of volcanic and depositional evolution, as well as the geomorphic and biologic state of the Wallaby Plateau.

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# Uncovering Phanerozoic mineral wealth

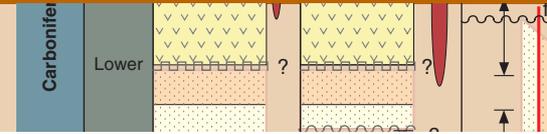
## *Geodynamic synthesis points to mineral deposit potential*

*David Champion, Natalie Kositcin and David Huston*

A Geoscience Australia project synthesising geology, geochronology, geodynamic analysis and tectonic modelling will give mineral explorers clearer information on where to prospect across eastern Australia for large accessible economic mineral reserves.

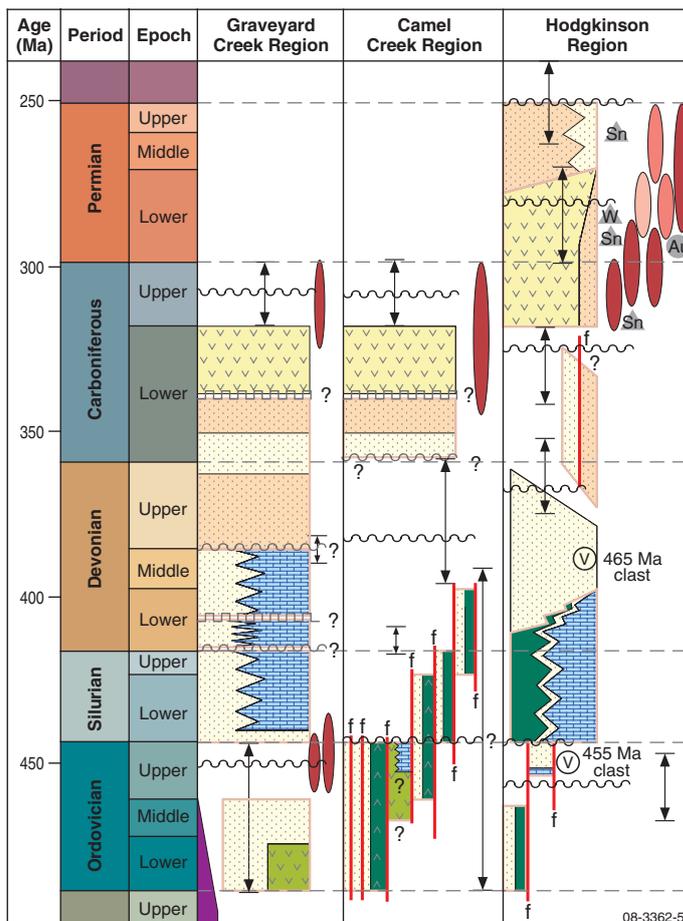
Mineral wealth has been derived from both current and historic mineral deposits related to the Phanerozoic rocks of eastern Australia. These comprise a wide range of commodity types including:

- gold (the Bendigo, Stawell, Hill End, Charters Towers, Beaconsfield, Kidston, Mount Leyshon, Cracow, Pajingo, and Gympie mines)



- copper-gold (the Cadia, North Parkes, Mount Morgan, and Cobar mines)
- base metals (the Rosebery, Hellyer, Lyell, Henty, Thalanga, Balcooma, Woodlawn, Endeavour, and Mount Chalmers mines)
- nickel (the Avebury mine)
- tin-tungsten (the Renison, King Island, Mount Bischoff, Ardlethan, Herberton, and Collingwood mines).

However, there are significant challenges for explorers in eastern Australia today. These range from developing innovative new approaches or exploration models for the well exposed 'brownfield' regions, such as the eastern Lachlan, and north Queensland, to the challenges of working under cover, for example, in the western Lachlan Orogen and the Thomson Orogen.



**Figure 1.** Time-space plot for the north Queensland region. Time-space plots have been compiled for the Lachlan, Thomson, New England and North Queensland orogens, as well as overlying Paleozoic and Mesozoic basins, for eastern Australia.

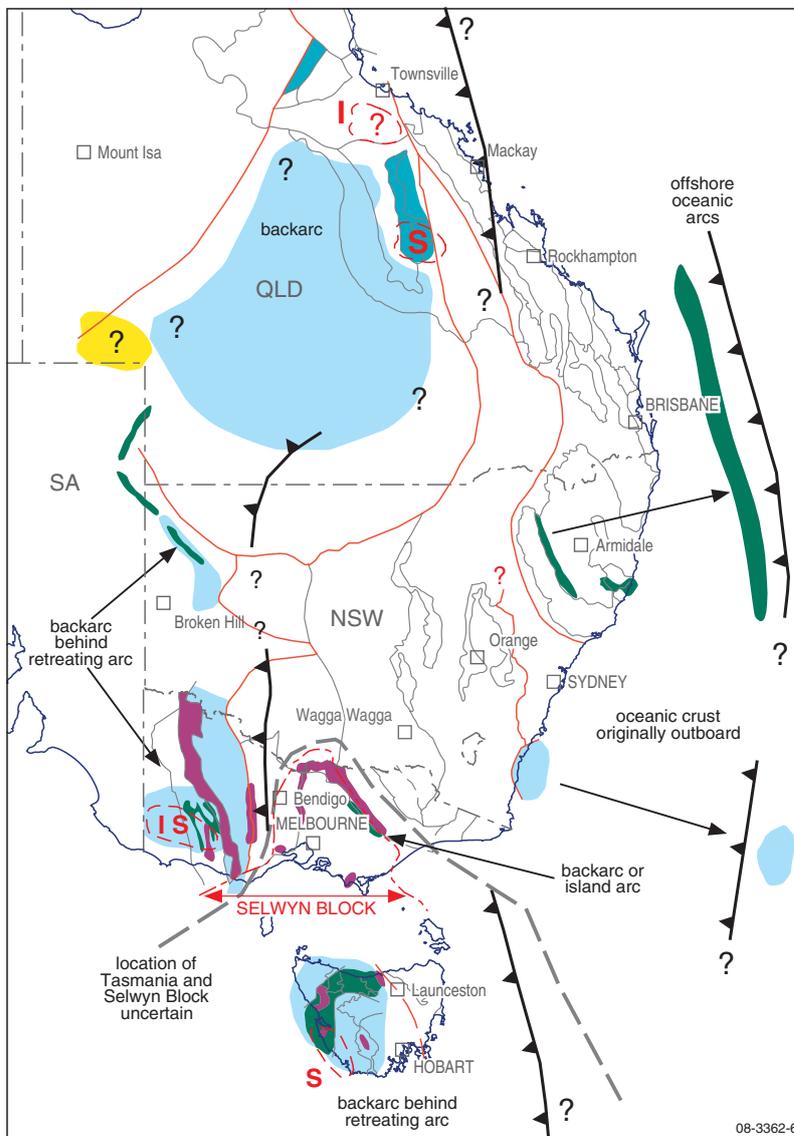
## Geodynamic synthesis

Over the past year, Geoscience Australia's Phanerozoic Synthesis Project has worked to tackle these challenges through undertaking a geodynamic synthesis of the Phanerozoic of Eastern Australia.

The project's aims were to:

- better understand the tectonic and geodynamic setting of existing mineral deposits within eastern Australia
- provide a predictive capability, within the synthesised geodynamic framework, not just for extending potential regions of known mineralisation but also for potential new styles of mineralisation and commodities.

The project used the 'Five Questions' methodology adopted by the Predictive Mineral Discovery Cooperative Research Centre (pmd\*CR : Barnicoat 2008). It clearly targeted the first of the 'Five Questions', namely, constraining and understanding the regional and local geodynamic environment as the first step in delineating mineral systems.



**Figure 2a.** Interpreted tectonic environment of eastern Australia for the Early to Middle Cambrian Delamerian cycle (ca. 520 to 490 Ma). Interpretation based on synthesis of published geological data and tectonic models.

To achieve this, Geoscience Australia's research team synthesised geological data on a regional, largely orogenic basis, focussing on the eastern states of Australia particularly the belt of Paleozoic and early Mesozoic rocks that run from Tasmania to north Queensland. The synthesis involved the compilation of available published and unpublished state geological survey data, as well as data from general scientific literature. In addition, discussions were held with relevant state geological survey scientists and other key researchers of eastern Australian geology. All data was captured in Geoscience Australia's PROVINCE and EVENTS databases and used to produce time-space-event plots for each region of eastern Australia. This was undertaken to summarise regional geology to allow comparison between regions, and to identify geological events and geodynamic cycles within and between regions. An example of a time-space-event plot is shown in figure 1.

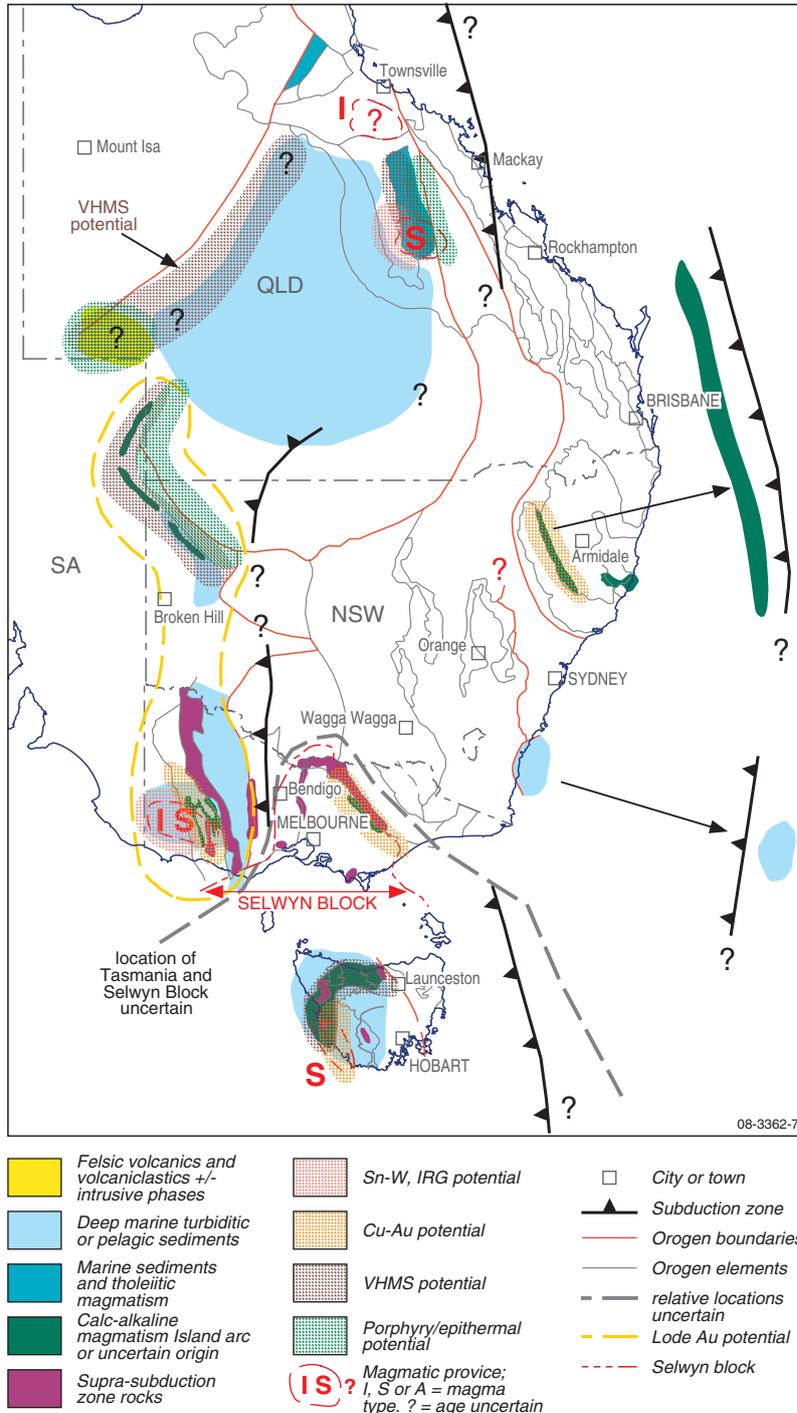
One important outcome of the project was the realisation that there are broadly contemporaneous orogenic events recorded in all of the orogens of eastern Australia. These have been previously recognised (such as the 'stages' described by Scheibner and Basden (1998) and Korsch and Harrington (1981) in New South Wales and the New England

Orogen, respectively) or used (for example, Glen (2005)) to define tectonic cycles for all the Tasmanides. The research team followed the latter approach, documenting the geological syntheses and tectonic interpretations for each region and for all of eastern Australia on the basis of the Delamerian, Benambran, Tabberabberan, Kanimblan and Hunter-Bowen Tectonic Cycles. The models are presented as

a series of diagrams showing major geological features and the inferred geodynamic setting for each cycle (see figure 2a).

## Known and potential mineralisation

The new geodynamic synthesis provides the geodynamic framework to both constrain known mineralisation and provide a predictive capability for potential mineralisation. To better understand the geodynamic setting (and spatial relationships) of existing and historic mineralisation within eastern Australia, a review of significant Phanerozoic mineral deposits was compiled. This was used to help delineate possible extensions of such mineralised belts based on the geodynamic interpretation. The research team also used this geodynamic synthesis to predict areas for potential new deposits (see figure 2b). Base metal deposits, for example, often occur in developing sedimentary basins, while porphyry-related deposits are often in magmatic arc settings. These conclusions are presented as a series of diagrams using coloured overlays to depict predicted mineral commodities, based on associations between mineral systems and geodynamic processes for each orogenic cycle (see figure 2b). Prediction of mineral prospectivity at the eastern Australian scale will provide a first-order guide to area selection for mineral exploration.



**Figure 2b.** Simplified mineral potential map of eastern Australia for the Delamerian cycle based on the interpreted geodynamic regime (figure 2a), the distribution of known mineral deposits, and the relationship between geodynamic setting and mineral deposits.

## Implications for explorers

The geology and tectonic development of the Tasmanides of eastern Australia has been the focus of numerous studies (Murray 1986, Coney 1992, Gray and Foster, 2004, Scheibner and Basden, 1998, VandenBerg and others 2000, Li and Powell 2001, and Glen 2005). Results of this research are two-fold. Firstly, there is a general consensus that since Rodinian-break-up in the Late Neoproterozoic, eastern Australia has been a convergent margin alternating between extensional and convergent orogenic cycles, and accretionary growth, continuing through to the Mesozoic. Secondly, there has been the recognition that the current make-up of Paleozoic to early Mesozoic eastern Australian provinces represents a potential amalgamation of terranes that may originally have been some distance apart.

Additional uncertainty revolves around actual tectonic reconstructions, such as the actual positions and number of subduction zones/magmatic arcs, best exemplified in debate over the Ordovician and Silurian of the Lachlan Orogen (for example, Gray and Foster 1997). This has a number of important implications for mineral exploration. Obviously there is significant potential for (continental and island) arc and back-arc related mineralisation in eastern Australia. However, the present-day locations of such zones can be complex, may be poorly understood, may be non-continuous (such as remnants of the Macquarie and Calliope island arcs), and perhaps be in areas not previously considered. A good example of the latter is the poorly exposed and understood Thomson Orogen (north-western New South Wales and western Queensland). Recent seismic and geological data along the southern margin of the Orogen suggest that it may once have been an east-west oriented accretionary convergent margin (for example, Glen and others 2007), significantly increasing its potential for arc and back-arc related mineralisation.

These results will shortly be released as a Geoscience Australia Record which will report on the following outputs:

- Geological summaries and time-space-event plots (Part 1)
- Interpreted geological and geodynamic synthesis for eastern Australia (Part 2)
- Interpreted mineral potential, along with a compilation of known mineral deposits (Part 3).

### For more information

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### Related websites

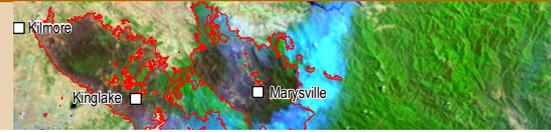
Predictive Mineral Discovery (pmd\*CRC)

[www.pmdcrc.com.au/RESprograms.html](http://www.pmdcrc.com.au/RESprograms.html)

# Fighting fire with satellite datasets

## Satellite imagery aids emergency relief

David Hudson and Norman Mueller



On the weekend of 7 February 2009 a series of large bushfires across Victoria resulted in Australia's most serious bushfire event which claimed 173 lives.

During the emergency, Geoscience Australia provided satellite-derived information to support the emergency response and recovery efforts. This support was through the Sentinel system (an online 'hotspot' detection system) and provision of satellite imagery and maps showing areas affected by bushfires.

“Within an hour of the satellite overpass the hotspots appear on the internet site.”

### Sentinel (online hotspot detection system)

The Sentinel online hotspot detection system was initially developed during the bushfires in New South Wales and the Australian Capital Territory in early 2002. Operation of the Sentinel system passed

from CSIRO to Geoscience Australia in 2005. Sentinel's contribution to fire regime mapping was highlighted in the Council of Australian Governments' (COAG) National Inquiry on Bushfire Management, Prevention and Mitigation (COAG 2004, Recommendation 5.2).

Sentinel uses United States satellites with thermal infra-red sensors to detect hotspots which indicate bushfires. The satellites pass over Australia each morning and afternoon, observing the land surface and beaming that information to Geoscience Australia's ground station at Alice Springs. The information is analysed automatically by a computer to detect hotspots. Within an hour of the satellite overpass the hotspots appear on the internet site.

Record numbers of people accessed the Sentinel website during Victoria's catastrophic fires in February. Over 5.2 million hits were recorded on Sunday 8 February, and Geoscience Australia staff struggled to keep the system running. Figure 1 shows the levels of use experienced during

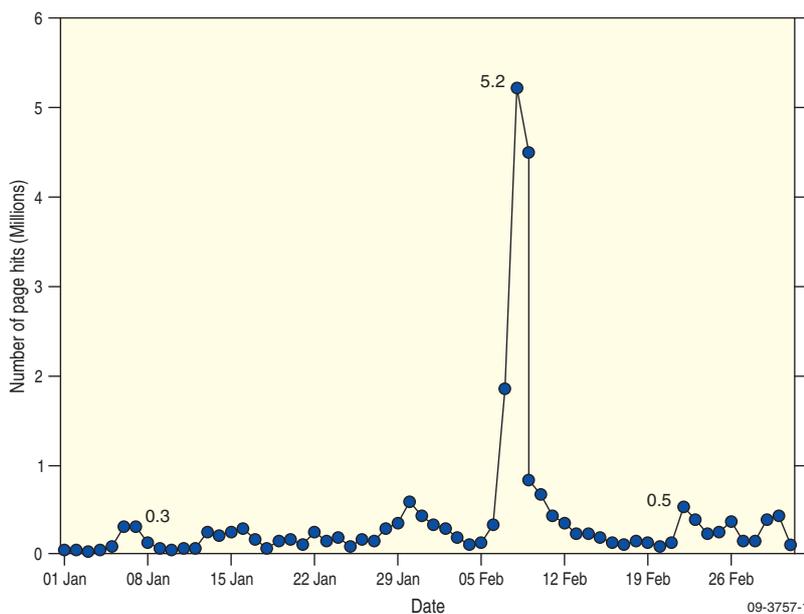


Figure 1. Levels of usage of the Sentinel website during January and February 2009.

this period. The website's usage levels returned to normal by Wednesday 11 February, and full web mapping functionality was restored to the public later that week.

**Table 1.** Detailed breakdown of each of the acquired datasets and their source.

Satellite, Sensor	Type	Scenes acquired	Resolution (m)	Acquired by
ALOS, AVNIR-2	Optical	18	10	GA
ALOS, PALSAR	RADAR	16	10-30	Sentinel Asia
Terra, MODIS	Optical/thermal	24	250	GA
Aqua, MODIS	Optical/thermal	21	250	GA
Landsat 5, TM	Optical	11	30	GA
Landsat 7, ETM	Optical	10	30	GA
KOMPSAT-2, MS	Optical	3	4	KARI*
<b>Total</b>		<b>103</b>		

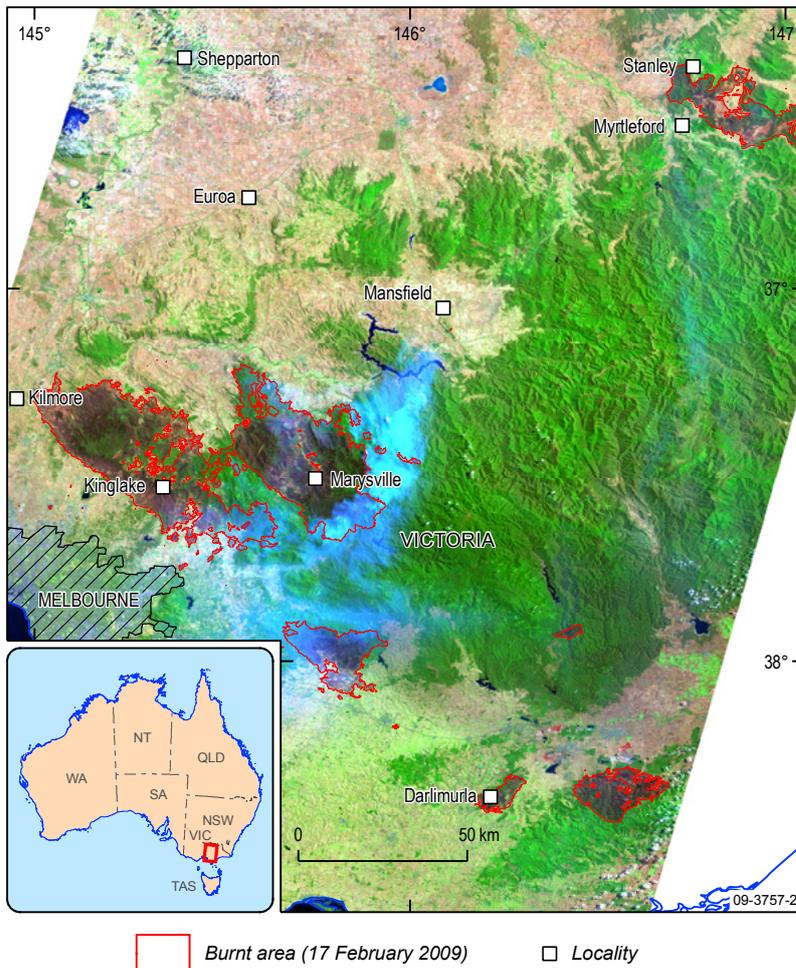
\*KARI: Korea Aerospace Research Institute

## Satellite imagery and maps showing areas affected by bushfires

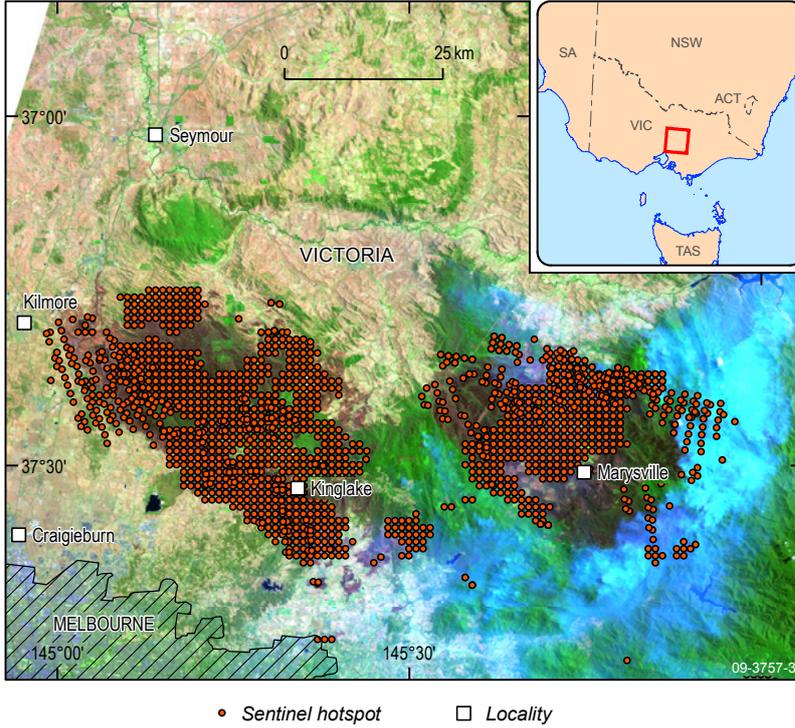
Between 7 February and 26 February, Geoscience Australia acquired 103 satellite scenes over the fire affected areas. Satellites operated by the United States, Korea and Japan all provided data (see table 1). China also provided satellite information products during the fires. Geoscience Australia's remote sensing scientists were able to analyse these images to produce some of the first maps showing the actual areas burnt. These maps and images were distributed to emergency managers, researchers and the media.

Thick smoke and cloud were common during the fires making it very difficult to gather complete satellite images. Although the fires began on 7 February, the first completely cloud-free image was not acquired until ten days later on 17 February by the Landsat-5 satellite. An image of the area of interest, which was cloud free, was highly processed to highlight burnt areas and show fire fronts (figure 2a).

As is common during an emergency, many requests for data of the affected area were received. Geoscience Australia worked with Emergency Management Australia's Incident Management Facility to distribute this data. Satellite imagery, burn extent information and Sentinel hotspot data were requested by power and water utilities, communications



**Figure 2a.** Cloud-free image highlighting burnt areas (in red) and showing smoke rising from the Kinglake and Marysville fires.



**Figure 2b.** Hotspot data from the Sentinel system (red square dots) overlaid on a satellite image of the Kinglake and Marysville fires.

companies, insurance providers, state and federal Government agencies involved in disaster mitigation and relief, as well as Australian and overseas research organisations.

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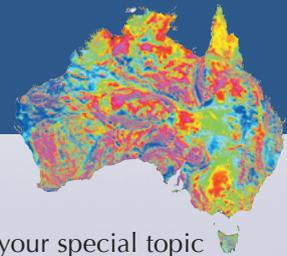
**Related articles/websites**

Sentinel online hotspot detection system  
[sentinel.ga.gov.au/acres/sentinel/index.shtml](http://sentinel.ga.gov.au/acres/sentinel/index.shtml)

Council of Australian Governments' (COAG) National Inquiry on Bushfire Management, Prevention and Mitigation  
[www.coagbushfireenquiry.gov.au/findings.htm](http://www.coagbushfireenquiry.gov.au/findings.htm)

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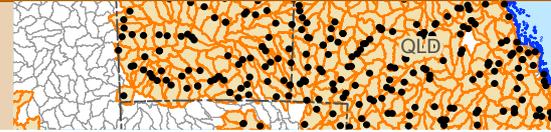


Australian Government  
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in  
collaboration  
with



# Onshore Energy Security Program update



Ned Stolz

Geoscience Australia's Onshore Energy Security Program (OESP) commenced in late 2006. The Program is applying the latest geoscientific imaging and mapping technology to boost investment in exploration for onshore energy resources such as petroleum, uranium, thorium and geothermal energy. There have been significant data acquisition programs in several regions during the last few months as well as the release of processed data and interpretations from earlier programs.

Regular updates on the OESP are available through the program's website, which contains summaries of current and planned surveys, and recent presentations. The program's five year plan, which is

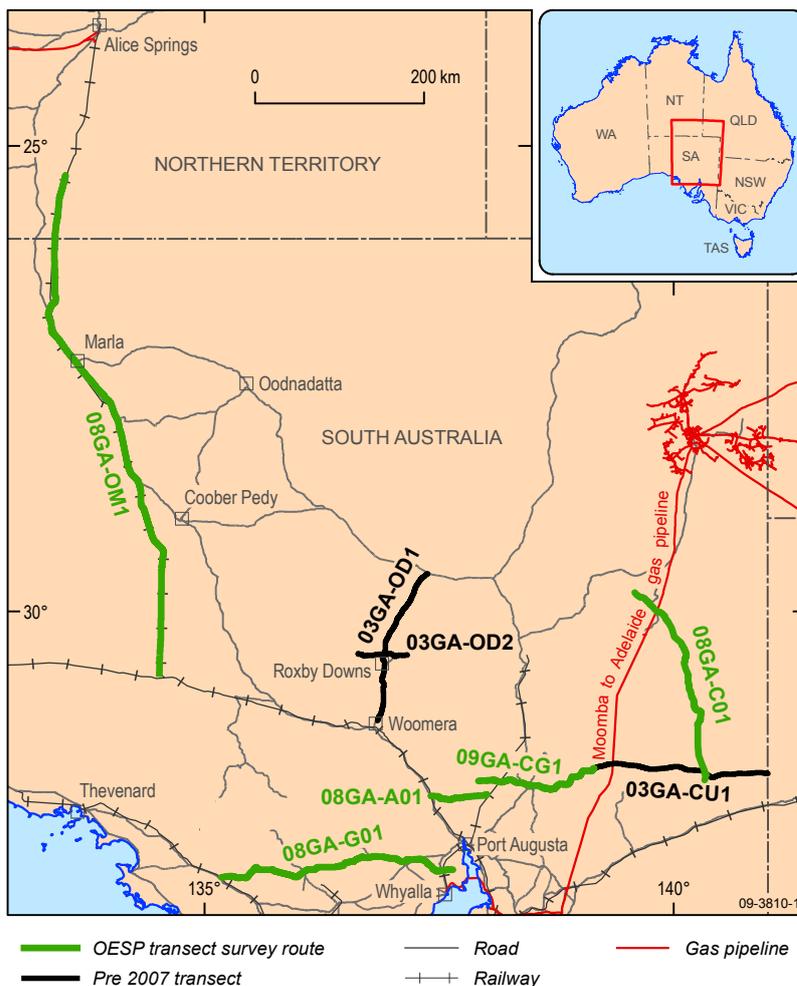
included on the site, provides further information on objectives, outputs and planned activities for each project. All new data releases for the OESP will be announced through Geoscience Australia's monthly *Minerals Alert*.

## Onshore Seismic Program

### Gawler-Officer-Musgrave-Amadeus (GOMA) Seismic Survey

Acquisition of deep reflection seismic and magneto-telluric (MT) data was completed along the Gawler-Officer-Musgrave-Amadeus (GOMA) line in December 2008. This line follows the Alice Springs to Adelaide railway line for 634 kilometres (figure 1) and crosses the northern margin of the Gawler Craton, the eastern ends of the Officer Basin and the Musgrave Block, and the southern margin of the Amadeus Basin.

The survey will provide new insights into the crustal architecture of the two Neoproterozoic sedimentary basins in Central Australia and their tectonic relationship to older (Mesoproterozoic) basement terrains. Of particular interest is the identification of structural elements in the basinal sections which may host hydrocarbons that were generated prior to the Alice Springs Orogeny.



**Figure 1.** Deep reflection seismic traverses in northern South Australia. The green lines are traverses acquired between May 2008 and February 2009, while black lines are traverses acquired prior to 2007.

This survey was jointly funded by Geoscience Australia through the OESP, Primary Industries and Resources South Australia and AuScope. AuScope is an initiative established under the National Collaborative Research Infrastructure Strategy to characterise the structure and evolution of the Australian continent. Processing of the data from the GOMA Seismic Survey as well as data from the Gawler-Curnamona Seismic Survey, acquired in mid-2008, will be continuing through 2009.

### **Curnamona – Gawler Link Seismic Survey**

In conjunction with Primary Industries and Resources South Australia, Geoscience Australia acquired 145 kilometres of deep reflection seismic data across the Flinders Ranges during January 2009 (figure 1). The main objectives of the traverse were to:

- Examine the relationship between the Gawler Craton and the Curnamona Province.
- Identify areas with potential for uranium-rich iron oxide copper-gold deposits (IOCGU) and sedimentary basin-related uranium deposits.
- Designate potential sites for hot rock geothermal energy.

When combined with the Gawler and Arrowie Seismic Lines (collected in mid 2008) and the Curnamona Seismic Line (2003), the acquisition of the Curnamona-Gawler Link line provides continuous west-to-east deep reflection seismic coverage from the western Eyre Peninsula to Broken Hill. The linked traverses span the Gawler Craton, Adelaide Geosyncline, and Curnamona Provinces which all host major mineral and energy resources. The seismic traverses acquired by Geoscience Australia will provide a comprehensive dataset for interpreting the geodynamic framework and geological evolution of northern South Australia.

### **Mt Isa – Georgetown Seismic Survey**

The Mt Isa – Georgetown Survey was the first major seismic project completed under the OESP, and comprises three lines for a total of 1175 line-kilometres (See *AusGeo News* 88). The project aimed to define a geodynamic framework for the uranium and geothermal energy potential of the Mount Isa, Georgetown, and Charters Towers provinces of northern Queensland. An additional 200 kilometre long seismic line (07GA-A1) was undertaken by AuScope and was designed to image the Tasman Line between the Proterozoic and Paleozoic rocks of eastern Australia. Deep seismic reflection and magneto-telluric data were acquired during 2007.

Processing and interpretation has been continuing through 2008 and early 2009. Seismic data for line 07GA-IG1 (432 kilometres) linking the Mt Isa and Georgetown blocks was released in December 2008 and to date, three significant features have been interpreted:

- A new sedimentary basin, now named the Millungera Basin, lying beneath the younger Carpentaria Basin.
- A major west-dipping shear zone which defines the eastern boundary of the Mt Isa Block.

- An interpreted fossil subduction zone penetrating the Moho and separating the Georgetown and Mt Isa Provinces.

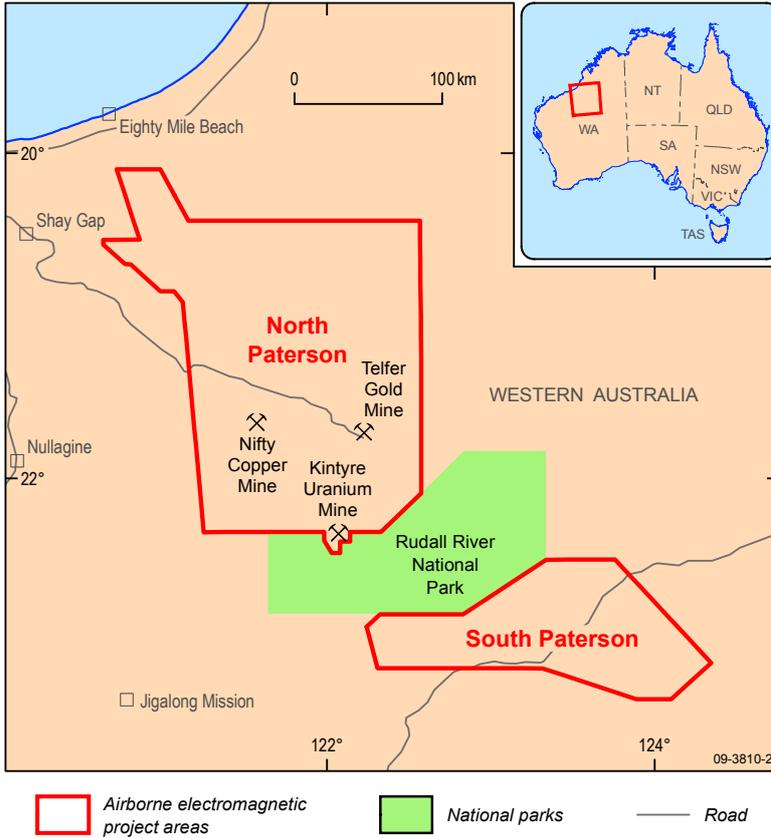
Data and interpretations from lines 07GA-IG2 (243 kilometres) and 07GA-GC1 (492 kilometres) will be released at the North Queensland Exploration and Mining Conference (NQEM) in Townsville in June 2009. Scientists from Geoscience Australia will be leading an interpretation workshop for industry geologists interested in finding out more about the seismic and magneto-telluric results during the conference.

## **Airborne Electromagnetic (AEM) Projects**

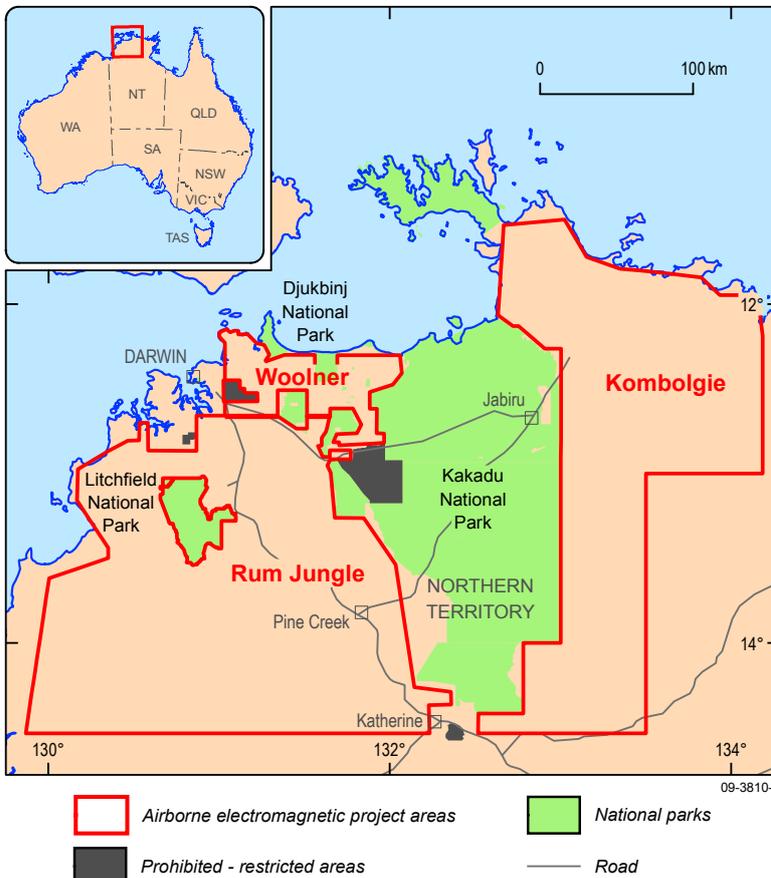
### **Paterson Project**

Airborne electromagnetic (AEM) surveys are being conducted over selected regions around Australia considered to be prospective for uranium. The Paterson AEM survey in north-west Western Australia was the first such dataset to be acquired under the OESP. The survey data comprises 29 200 line-kilometres covering 49 000 square kilometres flown on lines spaced 1 kilometre, 2 kilometres and 6 kilometres apart in a region which includes the Kintyre uranium deposit, the Nifty copper mine and the Telfer gold mine (figure 2).

The Paterson AEM Survey includes 5000 line-kilometres of infill flight lines funded by mining and exploration companies. The data funded by industry will remain confidential for a period of



**Figure 2.** Survey boundaries for the Paterson AEM Project.



**Figure 3.** Survey boundaries for the Pine Creek AEM Project.

12 months. Contractor-supplied data from the Paterson AEM survey has been released to the mining and exploration industry through Geoscience Australia's website and Sales Centre.

During 2009, Geoscience Australia's scientists will undertake further processing and inversion of the AEM. Results will then be combined with outcrop and drilling geology to interpret geological features with possible implications for the uranium prospectivity of the Paterson Province.

### **Pine Creek Project**

The second airborne electromagnetic (AEM) project to be conducted under the OESP is being flown in the Pine Creek province of the Northern Territory. This is the largest AEM survey ever undertaken in the Northern Territory and will cover more than 71 000 square kilometres of the top-end (figure 3). The project was subdivided into three separate survey areas: Kombolgie, Woolner, and Rum Jungle. Line spacings vary between 2 kilometres and 5 kilometres. Data acquisition in the Kombolgie and Woolner areas was completed in late 2008 and flying is anticipated to finish at Rum Jungle by late May 2009.

AEM results to date have improved the understanding of the mineral and groundwater potential in the region by mapping the conductivities of different geological, hydrogeological and regolith units. Inversions of the data will contribute to interpretations of the uranium prospectivity of the

Pine Creek Orogen by imaging key geological features including:

- the depth to the unconformity between rocks of the older Pine Creek Orogen and the younger Kombolgie Sandstone
- the depth and extent of the Woolner Granite and Koolpinyah Dolomite
- the thickness of regolith cover
- major faults and shear zones.

Infill flying is being funded over various locations within the survey area by ten exploration companies, and the National Water Commission provided funding for the Woolner Survey. Data from the Pine Creek AEM Project is expected to be released in late 2009.

### National Geochemical Survey of Australia

The National Geochemical Survey of Australia was initiated to complement the results of the Australia-wide airborne geophysical survey (AWAGS) and improve the existing knowledge of concentrations and distributions of energy-related elements, such as uranium and thorium at the national scale. It will also provide complete uniform geochemical coverage across Australia.

Sampling of surface and subsurface transported regolith at the outlets of large catchments for the project is now well underway in all states and in the Northern Territory. Of about 1500 sites selected to cover all of Australia, 78 percent had been received at Geoscience Australia by 31 December 2008 (figure 4). The field work component of the

survey has been extended to 30 September 2009, in an attempt to maximise the number of target sites that can be sampled.

Sample preparation (drying, sieving, milling, etc.) is well advanced with 50 per cent of the samples ready for analysis by January 2009. Analysis of 25 percent of the samples had been completed by 31 March 2009. The planned outputs of the NGSa project include a multi-element surface geochemistry data set, a web-delivered geochemical atlas, and reports on energy and minerals exploration implications by 2012.

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##### National Geochemical Survey of Australia

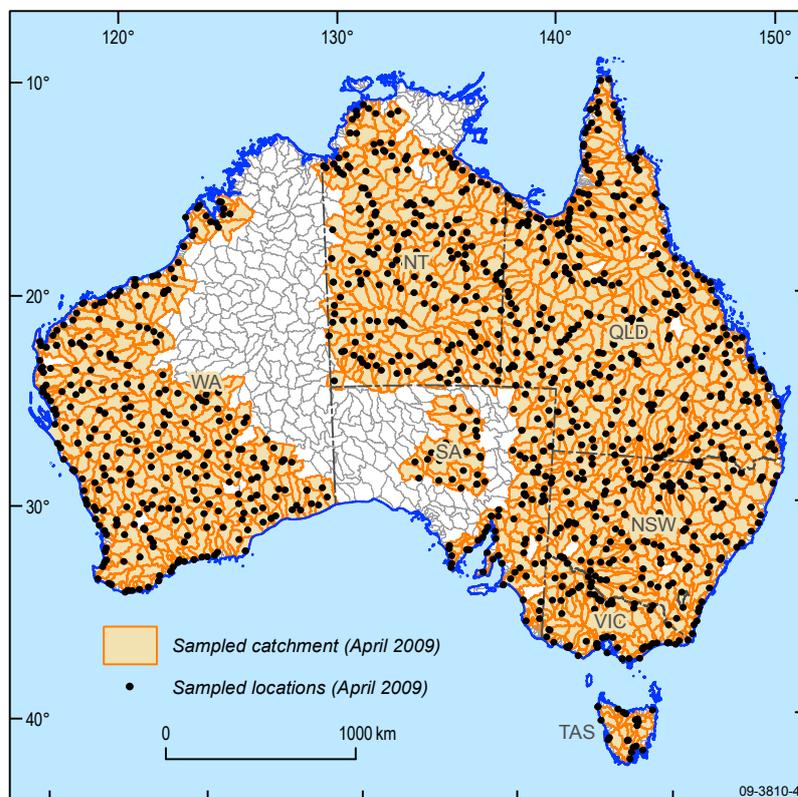
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**Figure 4.** Sampling of surface and subsurface transported regolith for the National Geochemical Survey of Australia to 31 December 2008.

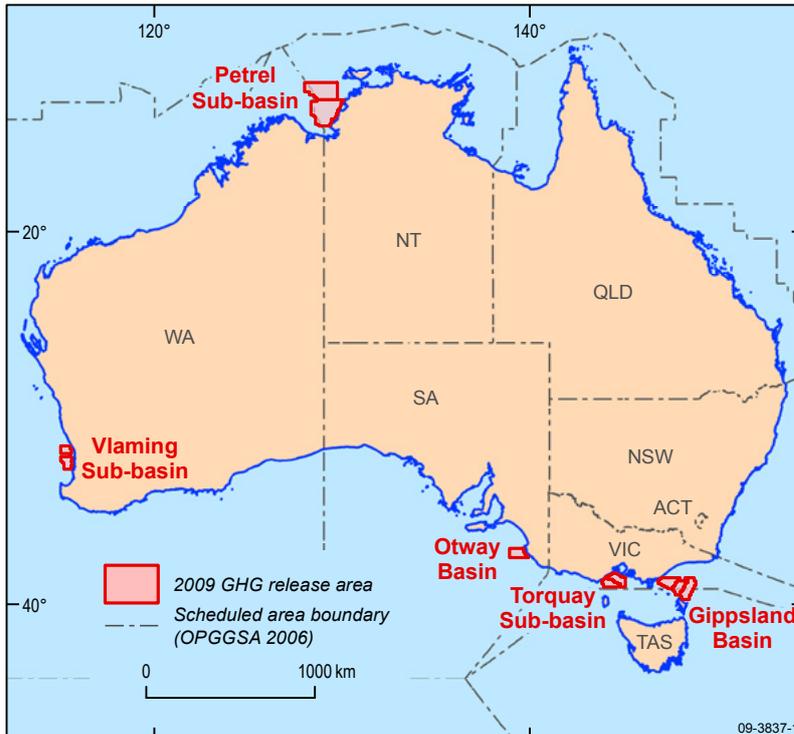
## Greenhouse gas offshore acreage release

The Minister for Resources and Energy, the Hon Martin Ferguson AM MP, announced the release of the world's first commercial offshore areas designated specifically for the assessment of their greenhouse gas storage potential on 27 March 2009.

'The first ever release of exploration areas for greenhouse gas storage sites forms an important part of the Government's commitment to reducing Australia's carbon emissions while maintaining economic growth. Advancing storage technology and capacity is vital to the future



**Figure 1.** The Minister for Resources and Energy, Martin Ferguson AM MP, with Dr Clinton Foster, Chief of Geoscience Australia's Petroleum and Marine Division and Dr Neil Williams, CEO of Geoscience Australia, following the announcement of the world's first commercial release of offshore areas for the assessment of their greenhouse gas storage potential.



**Figure 2.** The exploration areas released for assessment of their greenhouse gas storage potential on 27 March 2009.

of Australia's coal industry and to coal's future as part of the world's transition to cleaner energy pathways,' the Minister said.

Ten offshore areas have been released to allow industry to undertake further assessment of potentially viable greenhouse gas storage formations. The initial release areas are located across five offshore basins off Victoria, South Australia, Western Australia and the Northern Territory. The areas being released have been identified as having the best potential in terms of geological suitability and current industry needs. Technical preparation of the data underpinning the release was undertaken by Geoscience Australia, in conjunction with the relevant state-based geological organisations, in particular Geoscience Victoria.

Geoscience Australia's technical expertise will be made available to potential applicants through the Department of Resources and Energy's website and meetings with interested parties. The Minister encouraged potential applicants to work closely with Geoscience Australia to gain a full appreciation of the potential of these areas and their storage opportunities in the future.

Regulations and guidelines to support the new legislation are under development and will be finalised in the third quarter of 2009. The acreage release bidding will remain open until two months after the completion of the regulations.

### For more information

visit [www.ret.gov.au](http://www.ret.gov.au)

## Encouraging prospects for uranium in Northern Territory

The oldest exposed rock yet discovered in the Northern Territory was identified by geochronologists at Geoscience Australia working in partnership with the Northern Territory Geological Survey. The rock, from west Arnhem Land, was identified as being 2671 million years old.

The sample, which is from the Neoproterozoic era of geological time from 2800 to 2500 million years ago, was one of several collected during geological mapping of western Arnhem Land by the Northern Territory Geological Survey. Overall the five rock samples collected dated from 2513 million to 2671 million years old. They were dated with the aid of Geoscience Australia's new Sensitive High Resolution Ion Microprobe, or SHRIMP, as part of a geochronology collaboration between the two organisations.

When announcing the results, Dr Andrew Barnicoat of Geoscience Australia's Onshore Energy and Minerals Division, said that the discovery of the Neoproterozoic rocks is of great significance for uranium explorers in the area. He pointed out that uranium deposits in this



region are commonly associated with rocks of this age, including the Ranger and Jabiluka deposits and numerous other smaller occurrences. Explorers would be encouraged that these recently identified rocks are similar to Neoproterozoic rocks in the Darwin-Rum Jungle region about 250 kilometres to the west, a region also renowned for uranium mineralisation.

The Australian designed and built SHRIMP instrument measures uranium and lead isotopes from tiny portions of zircon crystals extracted from rock samples. The natural decay rate of uranium to lead is used to calculate the age of the crystal.

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## New satellite imagery now available

New products from the Indian Remote Sensing Satellite Resourcesat-1 are now available, following extensive work to implement processing and distribution mechanisms for satellite imagery acquired since February 2008.

These new products are a direct result of Geoscience Australia's contingency plan for the possible failure of the ageing Landsat-5 satellite. Since 2008, power problems with Landsat-5 have significantly reduced its capability to acquire data over Australia during the winter months. Resourcesat-1 imagery was identified as the best option for filling this gap. A comparison of the Resourcesat-1 and Landsat spectral bands was included in an article in *AusGeo News 91*. This article also highlighted the main differences between these two data sources.

**Table 1.** Interim product specifications for Resourcesat-1 products from the Linear Imaging Self Scanner (LISS-III) and the Advanced Wide Field Sensor (AWiFS).

Sensor	LISS-III	AWiFS	
Scene Size	140 x 140 km	740 x 740 km, 4 quadrants	
Nominal pixel size	23.5 metres	56 metres at nadir, 70 metres at field edge	
Processing Level	Level 2 Radiometric and Geometric Correction - Path based	Level 1 Radiometric Correction	Level 2 Radiometric and Geometric Correction - Map oriented
Projection	UTM	Unprojected data	Lambert Conformal Conic (LCC)
Datum	WGS84	No Datum	WGS84
Resampling	NN	Not Applicable	KD16
Format	Fast Format	LGSOVG	GeoTIFF

Geoscience Australia provides imagery acquired from both the Linear Imaging Self Scanner (LISS-III) and the Advanced Wide Field Sensor (AWiFS) on board the Resourcesat-1 satellite. In a break with previous distribution practice, Geoscience Australia is processing all Resourcesat-1 data into a standard range of products ready for immediate use.

It is planned to have ortho-corrected Resourcesat-1 products available by mid-2009 with an interim product (see table 1) available in the meantime.

The satellite imagery is being distributed under either a non-commercial licence or a commercial licence depending on proposed usage. Geoscience Australia will distribute data for non-commercial purposes directly to some key clients.



Resourcesat-1 products will be available through selected distributors around Australia. At the time of writing, these distributors are:

- Geoimage Pty Ltd
- Terranean Mapping Technologies
- Resource Imaging Australia
- Department for Environment and Heritage, South Australia
- Landgate.

An up-to-date listing of current distributors is available on Geoscience Australia's satellite imagery and earth observation website.

### For more information

phone Jim Mollison on  
+61 2 6249 9221  
email jim.mollison@ga.gov.au

### Related websites/articles

AusGeo News 91: New satellite imagery for Australia  
[www.ga.gov.au/ausgeonews/ausgeonews200809/inbrief.jsp#inbrief1](http://www.ga.gov.au/ausgeonews/ausgeonews200809/inbrief.jsp#inbrief1)

Listing of current distributors of Resourcesat-1 data  
[www.ga.gov.au/remote-sensing/get-satellite-imagery-data/ordering/distributors/index.jsp](http://www.ga.gov.au/remote-sensing/get-satellite-imagery-data/ordering/distributors/index.jsp)

## New Gazetteer of Australia released

The Gazetteer of Australia 2008 is the authoritative source of Australian place names and their location for both natural features, such as mountains and rivers, and built features such as homesteads and bridges. This latest version includes more than 323 000 official and unofficial place names, plus 33 061 variant names and their co-ordinates in GDA 94 (Geocentric Datum of Australia 1994) which covers Australia and its offshore regions.

The 2008 version includes the addition of new place names, the removal of invalid records and the revision of place names preserved for use in community geographic domain names (for internet sites). To check the spelling of a town's name or a geographical feature, visit Geoscience Australia's Place Name Search facility on its website.

The Gazetteer is revised biennially by Geoscience Australia under the auspices of the Intergovernmental Committee for Surveying and Mapping (ICSM). Data is provided by state, territory and Commonwealth Government authorities responsible for administering place names. The Gazetteer of Australia 2008 is available on CD ROM from Geoscience Australia's Sales Centre.



### For more information

visit [www.ga.gov.au/products](http://www.ga.gov.au/products)  
email [mapsales@ga.gov.au](mailto:mapsales@ga.gov.au)  
to order a copy

### Related websites

Geoscience Australia's Place Name Search facility  
[www.ga.gov.au/map/names/](http://www.ga.gov.au/map/names/)

## New geophysical datasets released

Datasets from five new geophysical surveys, which will be a valuable tool in assessing the mineral potential of their respective survey areas and will help stimulate mineral exploration, have been released since March 2009.

These include data from the offshore area off northeast Tasmania, the Esperance and Balladonia areas of Western Australia and the Cooper Basin North in Queensland. The radiometric and elevation point-located data from the Australia-Wide Airborne Geophysical Survey (AWAGS) were released in April 2009.

The airborne magnetic and radiometric data covering areas of Tasmania, Western Australia and Queensland were acquired in surveys managed by Geoscience Australia on behalf of Mineral Resources Tasmania, the Geological Survey of Western Australia and the Geological Survey of Queensland respectively.

The AWAGS data acquisition was managed by Geoscience Australia and funded under Geoscience Australia's Onshore Energy Security Program. The magnetic point-located data for this survey are scheduled for release by March 2010.

Each survey provides basic geophysical data which can be interpreted to reveal the sub-surface geology of the respective survey areas. The data have been incorporated into the national geophysical databases. The point-located and gridded data for the surveys can be obtained free online using the Geophysical Archive Data Delivery System (GADDS) download facility.

### For more information

phone Murray Richardson on  
+61 2 6249 9229  
email [murray.richardson@ga.gov.au](mailto:murray.richardson@ga.gov.au)

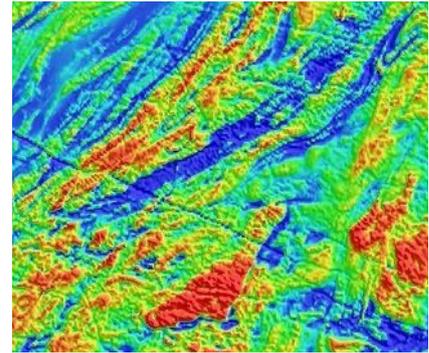
**Related websites**

Geological Survey of Queensland  
[www.dme.qld.gov.au/mines/about\\_us.cfm](http://www.dme.qld.gov.au/mines/about_us.cfm)

Geological Survey of Western Australia  
[www.dmp.wa.gov.au](http://www.dmp.wa.gov.au)

Mineral Resources Tasmania  
[www.mrt.tas.gov.au](http://www.mrt.tas.gov.au)

Geoscience Australia – Onshore Energy Security Program  
[www.ga.gov.au/minerals/research/oesp/index.jsp](http://www.ga.gov.au/minerals/research/oesp/index.jsp)



**Table 1.** Details of the airborne magnetic, radiometric and elevation surveys.

Survey	Date	1:250 000 map sheets	Line spacing/ terrain clearance/ orientation	Line km	Contractor
Offshore NE Tasmania (Tas)	Dec 2008 – Jan 2009	Not Applicable	800 m 90 m east - west	29 262	Fugro Airborne Surveys Pty Ltd
Esperance (WA)	Sep – Dec 2008	Esperance (pt), Malcolm (pt), Mondrain Island (pt), Cape Arid (pt).	400 m 60 m east – west	82 674	Thomson Aviation Pty Ltd
Balladonia (WA)	Dec 2008 – Jan 2009	Widgiemooltha (pt), Zanthus (pt), Norseman (pt), Balladonia (pt).	400 m 60 m east – west	44 511	UTS Geophysics Pty Ltd
Cooper Basin North (Qld)	Sep 2008 – Feb 2009	Maneroo (pt), Longreach (pt), Connemara (pt), Jundah (pt), Blackall (pt), Canterbury (pt), Windorah (pt).	400 m 60 m east - west	168 444	GPX Surveys Pty Ltd
AWAGS	Mar – Dec 2007	Not Applicable	75 km 80m north – south	156 763	UTS Geophysics Pty Ltd



<b>Marine Connectivity AMSA 2009</b>	<b>5 to 9 July</b>
Australian Marine Sciences Association Adelaide Convention Centre Contact: AMSA-SA	p +61 8 8207 5305 f +61 8 8207 5481 e <a href="mailto:amsa2009@amsa.asn.au">amsa2009@amsa.asn.au</a> <a href="http://www.amsaconference.com.au">www.amsaconference.com.au</a>
<b>7th International Conference on Geomorphology</b>	<b>6 to 11 July</b>
Australian and New Zealand Geomorphology Group (Inc.) Melbourne Exhibition and Convention Centre Contact: Tour Hosts Conference & Exhibition Organisers GPO Box 128, Sydney, NSW 2001	p +61 2 9265 0700 f +61 2 9267 5443 e <a href="mailto:geomorphology2009@tourhosts.com.au">geomorphology2009@tourhosts.com.au</a> <a href="http://www.geomorphology2009.com">www.geomorphology2009.com</a>
<b>Diggers and Dealers Mining Forum 2009</b>	<b>3 to 5 August</b>
Goldfields Arts Centre, Kalgoorlie Contact: Diggers and Dealers Mining Forum PO Box 979, West Perth, WA 6872	p +61 8 9481 6440 f +61 8 9481 6446 e <a href="mailto:suzanne@diggersndealers.com.au">suzanne@diggersndealers.com.au</a> <a href="http://www.diggersndealers.com.au">www.diggersndealers.com.au</a>
<b>NSW Mineral Exploration &amp; Investment 2009</b>	<b>13 &amp; 14 August</b>
NSW Department of Primary Industries Four Seasons Hotel, Sydney Contact: Rosemary Ryan	p +61 2 9810 7322 e <a href="mailto:meetings@tmm.com.au">meetings@tmm.com.au</a> <a href="http://www.dpi.nsw.gov.au/aboutus/news/events/minerals/">www.dpi.nsw.gov.au/aboutus/news/events/minerals/</a>
<b>Spatial Sciences Conference 2009</b>	<b>28 September to 2 October</b>
Spatial Sciences Institute Adelaide Convention Centre Contact: ICMS Pty Ltd, 84 Queensbridge Street Southbank, Victoria 3006	p +61 3 9682 0244 f +61 3 9682 0288 e <a href="mailto:ssc2009@icms.com.au">ssc2009@icms.com.au</a> <a href="http://www.ssc2009.com">www.ssc2009.com</a>
<b>Geothermal 2009: Making Renewable Energy Hot</b>	<b>4 to 7 October</b>
Geothermal Resources Council 2009 Annual Meeting Peppermill Resort Spa Casino Reno, Nevada USA Contact: GRC, PO Box 1350, Davis, CA 95617	p +1 530 758 2839 f +1 530 758 2839 <a href="http://www.geothermal.org/">www.geothermal.org/</a>
<b>China Mining Congress</b>	<b>20 to 22 October</b>
Ministry of Land and Resources, China Tianjin Binhai International Convention & Exhibition Centre, Beijing Contact: Julie Zhu (Registration Service)	p +86 10 6592 9809 e <a href="mailto:info@mining-expo.com">info@mining-expo.com</a> <a href="http://www.china-mining.com/">www.china-mining.com/</a>
<b>Mining 2009 Resources Convention</b>	<b>28 to 30 October</b>
Hilton Brisbane Contact: Vertical Events PO Box 1153, Subiaco WA 6904	p +61 8 9388 2222 f +61 8 9381 9222 e <a href="mailto:info@verticalevents.com.au">info@verticalevents.com.au</a> <a href="http://www.verticalevents.com.au/mining2009/">www.verticalevents.com.au/mining2009/</a>