New oil province search begins off WA

The search for Australia's next oil province began earlier this year off the southern coast of Western Australia with a 32-day survey of the relatively unexplored Bremer and Denmark sub-basins.

The survey was part of the Australian Government's four-year, $61 million, Big New Oil Program aimed at identifying potential new oil provinces in frontier regions of offshore Australia.

Initial results suggest there are areas of sufficiently thick sediment for the generation of oil. Rocks sampled from various water depths are aged 160 to 65 million years. The older rocks are organically richer than the younger samples.

Basin formation

The Bight Basin and its sub-basins formed during the break-up of the Gondwana supercontinent (figure 1). About 160 million years ago Australia started to rift from Antarctica, and sediment poured off the land into the evolving rift depocentres of the Bremer and Denmark sub-basins.

The sea entered the rift from the west approximately 50 million years later. Steadily, the Southern Ocean widened to its present size.

Sandstone, siltstone, organic-rich mudstone and coal collected on the survey provide evidence that thousands of metres of sediment were deposited in fluvial systems, lakes and deltas.

These continental depositional systems eventually gave way to deeper marine environments in which fine-grained sediments were deposited. Later deformation created large, folded and faulted structures that could have trapped hydrocarbons.

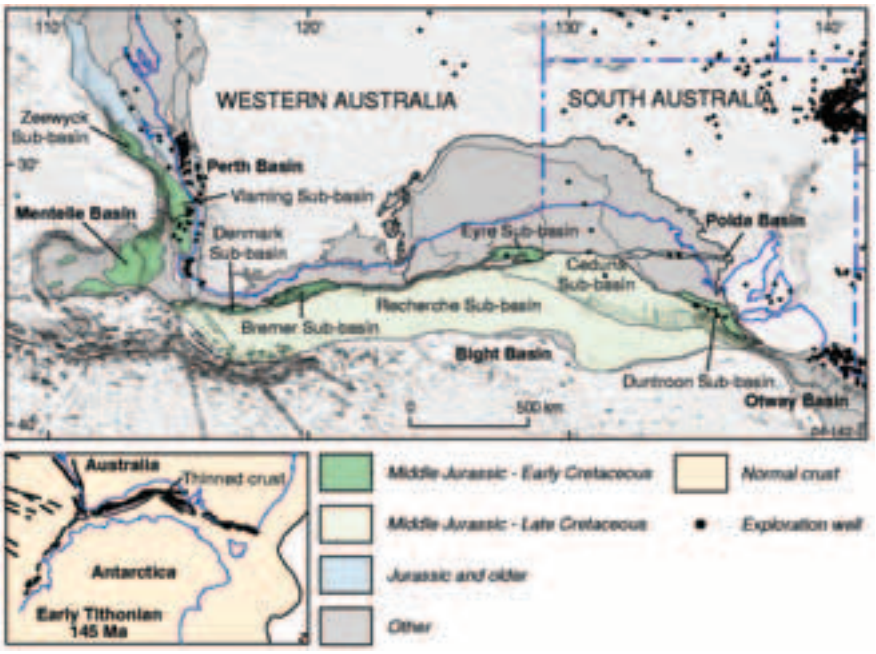


Figure 1. The map shows the locations and ages of geologic basins along south-western Australia. The basins formed during the early stages of continental break-up, approximately 160–140 million years ago (see the palaeogeographic setting of Australia and Antarctica at this time, in the insert map).

Survey operations

Geoscience Australia's Dr Neville Exon led the survey on board the *Southern Surveyor*, which departed Albany on February 8 and berthed in Hobart on March 10.

The first leg involved geophysical mapping of the seabed overlying the Bremer and Denmark sub-basins. In this region the seabed is incised by large submarine canyons that stretch from the outer continental shelf to the deep ocean sea-floor. Information about the canyons' shape and depth was collected to help identify suitable sampling sites on canyon walls for the survey's second leg.

Over 6200 kilometres of high-resolution swath bathymetry data were collected. The data were merged with existing information to yield a high-resolution bathymetric map for the region that shows for the first time, the vast extent of the canyons (figure 2). This information will be used by future oil explorers and the fishing industry, and for environmental management of the region.

More than a thousand kilometres of high-speed seismic data were also collected in deepwater parts of the basin.

The second leg began on February 24. More than 50 potential geological sampling sites, in water depths of 500 to over 3000 metres, were identified. Several tonnes of rocks and unconsolidated sediments were retrieved during the 24-hour operations. Representative samples were retained from each dredge haul, then described and catalogued on board for future use. A total of 45 dredge hauls were recovered (figure 2).

Early results

Nine samples of apparently organic-rich rocks were selected on board for analysis of their petroleum generation potential.

The geochemical results, when combined with later analyses of an additional 50 mudrocks, yielded 24 samples with total organic carbon (TOC) contents of over two per cent. This is generally the cut-off value for a good potential source rock. One coal-rich sample yielded a TOC content of 22.62 per cent. As well, the elevated hydrogen content of the organic matter in these rocks indicates moderate-to-excellent oil potential.

More geochemical work is under way to confirm the liquids potential of these sediments and to predict the oil composition that would be generated.

Fifty-nine samples were also analysed for organic maturity. All but one had a vitrinite reflectance (VR) within the range of 0.31 to 0.64 per cent, which means that the rocks are immature or just at the onset of petroleum generation.

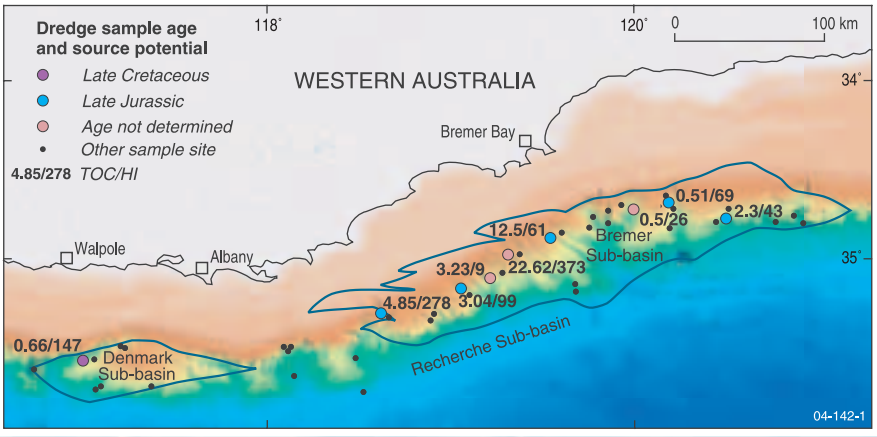
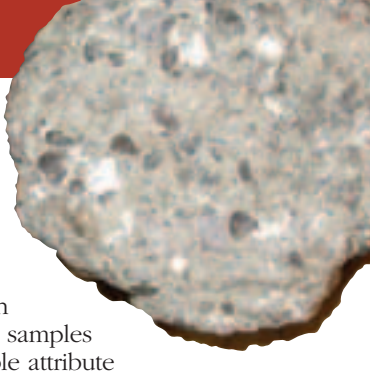
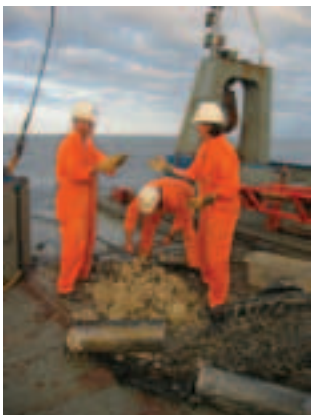


Figure 2. The Bremer and Denmark sub-basins are outlined in blue on the bathymetry map. Geoscience Australia's dredge sample sites are marked, the geological ages of the samples are colour-coded, and the geochemistry results are shown. The samples with TOC (total organic carbon) values over two per cent, and HI (hydrogen index) values over 200, have potential as petroleum source rocks.





Geological interpretation of the sub-sea rocks, however, suggests there are areas in the basin where sufficient maturity for oil generation and expulsion could be achieved. Using stacking velocities from the 1974 Esso seismic survey, sediments up to eight kilometres thick are calculated in the deeper depocentres.

The remaining sample analysed for organic maturity (VR >4%) would have been exposed to very high temperatures far beyond those capable of sustaining oil and gas generation. Exposure to localised hot circulating basinal fluids is the likely cause of such extremely high maturities.

The initial nine samples are aged between 160 and 65 million years (Late Jurassic to Late Cretaceous age), based on palynology and nannofossils (figure 2). In general, the older samples are organically richer than the younger samples—a favourable attribute as the older samples are more likely to be deeply buried and hence more mature for potential hydrocarbon generation.

An additional 95 samples are currently being analysed for more details about the age and stratigraphy of rock units in the Bremer and Denmark sub-basins.

Further work

Dredge sample results will be integrated with interpretations of sub-surface seismic data to build a picture of how the Bremer and Denmark sub-basins formed during rifting, and to assess whether the geology of the sub-basins is conducive to oil accumulation.

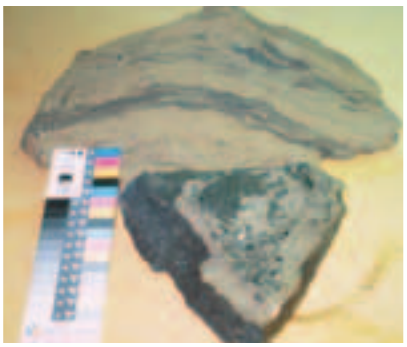
Geoscience Australia recently purchased licensing rights to more than 2000 kilometres of reprocessed seismic data that was acquired by Esso over 30 years ago across the sub-basins. These vintage data only provide glimpses into the sub-surface geology, so a survey to acquire a grid of high-quality seismic data covering the entire Bremer Sub-basin will occur in October and November this year (~1900 km in total).

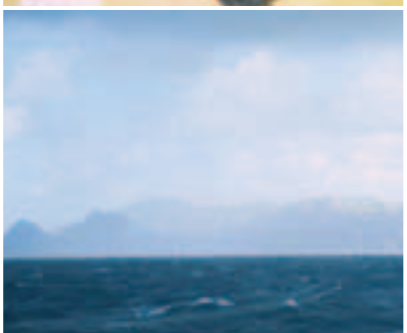
The new seismic data will be collected to petroleum industry standards, and should allow the depth and structure of key stratigraphic units to be mapped. Processed data will be available to explorers at the cost-of-transfer.

The data will offer insights into where potential hydrocarbon traps might occur in the Bremer Sub-basin. With geochemical and biostratigraphic data from dredge samples, the information should help determine whether the Bremer Sub-basin is a potential new oil province.

The planned Bremer Sub-basin seismic survey is part of a regional geophysical acquisition program that will include other frontier basins on the south-west margin, such as the Mentelle Basin about 500 kilometres west-north-west of the Bremer Sub-basin.

For more information about Geoscience Australia's South-west Frontiers Project phone Barry Bradshaw on +61 2 6249 9035 or e-mail barry.bradshaw@ga.gov.au





Shifting sands
the clue to vanishing seagrasses

Shifting sands and disappearing seagrass in the Torres Strait have been perplexing scientists from Geoscience Australia and the Queensland Department of Primary Industries and Fisheries for some time. To solve the riddle they collected high-resolution bathymetry and sediment samples, and filmed sand-wave movement, during a marine survey in Torres Strait from March 28 to April 18 this year.

The bathymetry showed that some underwater sand waves, up to three metres high, moved about seven metres in two weeks. The videos confirmed that tides, waves and wind-driven currents caused the dramatic movement.

Sand movement affects seagrass beds which are important habitats for dugong, green turtles and juvenile rock lobsters.

Survey program

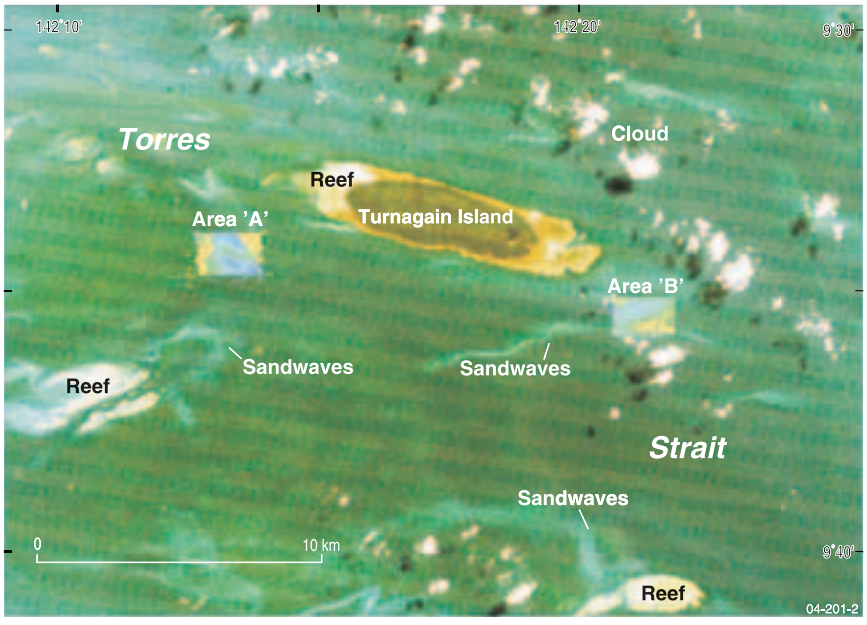
The survey was the first of two this year using James Cook University's research vessel *James Kirby*. The surveys are part of a larger program managed by the Reef Cooperative Research Centre (Torres Strait Program) in Townsville. The program includes field work to characterise seabed ecosystems, and modelling to show the physical and biological processes occurring in Torres Strait.

The two surveys focus on sand-wave movement and water-turbidity changes in Torres Strait. They aim to explain why seagrass periodically dies back and whether there are implications for Torres Strait Island communities that fish the migratory marine animals that depend on seagrasses.

The second survey will be conducted by Geoscience Australia at the end of the trade-wind season in October.

Two sites were chosen in central Torres Strait for the first survey (figure 1). The sites will be revisited in the second survey. In Area A, south-west of Turnagain Island, seagrasses and sand waves occur in close proximity. In Area B, south-east of Turnagain Island, sand waves occur but not seagrass.

Both sites are about 1 x 1.5 kilometres in size. They are representative of the major sedimentary environments in Torres Strait that could be used to examine how sand-wave movement affects the survival, burial, and possible death of seagrasses.



▲ **Figure 1.** Turnagain Island, the nearby study sites for the seagrass survey, and sand waves are marked on a Landsat TM image of Torres Strait.

Shifting sands

Multibeam sonar data were collected in both areas during the first week to produce a detailed picture of the seabed (figures 2a & b). The data are some of the highest quality ever collected in Torres Strait. The sand waves in Area B are up to three metres high and spaced up to 200 metres apart.

Repeat multibeam surveys of both sites were undertaken to determine whether the sand waves had moved. Area B sand waves were very mobile; some had moved up to seven metres from their original positions in two weeks (figure 3, page 34). The wind had also changed direction from northerly to south-east. Consequently most of the sand waves had reversed their direction. Their orientations are probably affected by wind-driven currents, which vary from the summer monsoon to winter trade-wind seasons.

It is thought that certain climatic conditions may be causing widespread movement of Torres Strait sand waves and be responsible for the observed die-back of seagrasses.

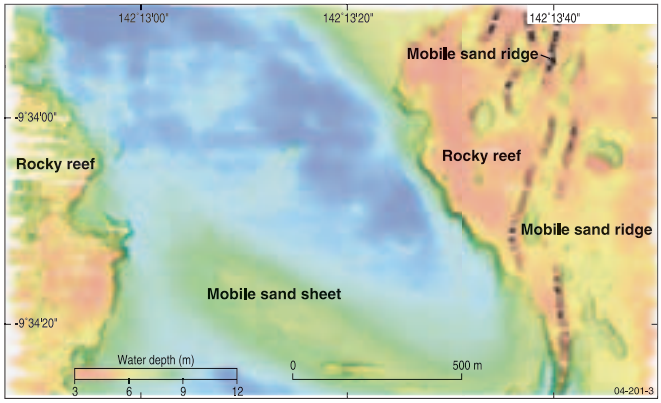
In the next survey, multibeam data will be used to calculate the magnitude of sand-wave movement at the end of the trade-wind season. This approach builds on established theories for sediment transport over sand waves in shallow tropical marine environments.

Camera action

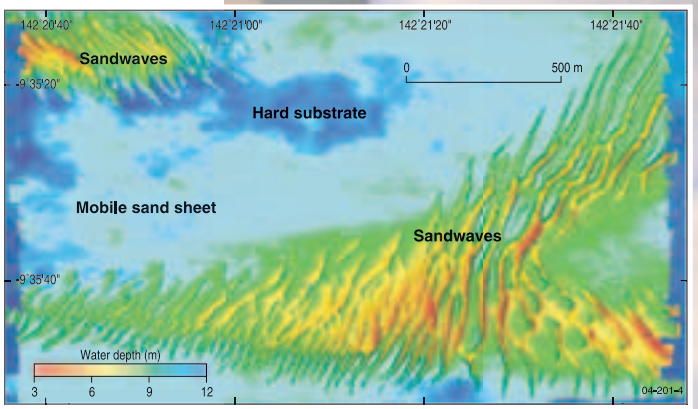
Sixty-nine camera stations in the two study sites provided broadcast-quality digital video footage of the seabed. The footage allowed scientists to observe the movement of sand along the seabed, and to characterise the benthic habitats, including the amount of seagrass cover, and the distribution and abundance of biota. The seabed habitats included: mobile sands, hard-grounds, rocky and algal reefs, sponge gardens, seagrass meadows, cemented ridges, talus slopes, and sink holes.

The nature of the seabed habitats changed dramatically over distances of less than a few metres. The seabed was highly mobile near sand waves and less mobile in the vicinity of seagrasses and on reef tops. The biota was relatively more abundant over the shallow (reefal) regions in Area A. Interesting relationships between habitats and biota were recorded, including one example of fish using sponges and rocky reefs for shelter and protection from the vigorous ocean currents and moving sand grains.

(a)



(b)



▲ **Figure 2.** High-resolution bathymetry provides a detailed picture of the seabed in study area A (2a) and study area B (2b). The multibeam sonar data that produced these images are some of the highest quality ever collected in Torres Strait.

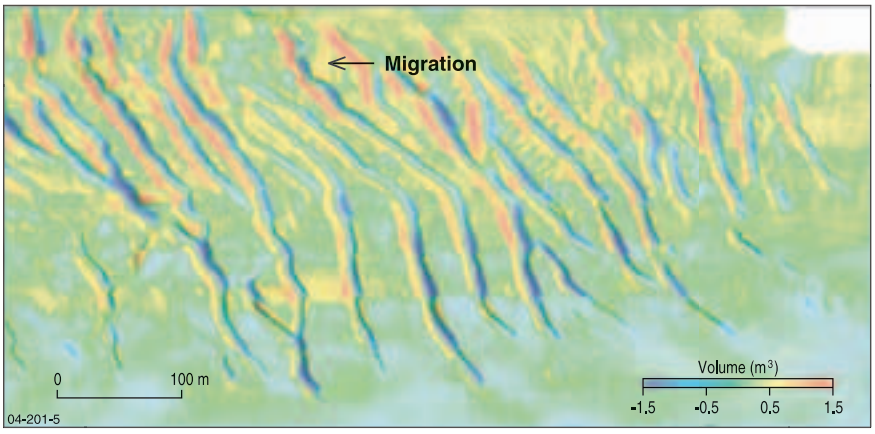


Figure 3. The westward migration of sand-wave crests is evident in the bathymetric image.

Sampling program

Camera station observations were supplemented with 71 seabed sediment samples. The samples recovered were calcareous gravelly sand comprising the fossil remains of foraminifers, molluscs, *Halimeda*, and hard corals. The average sand concentration was 64 per cent and average carbonate concentration was 86 per cent. Mud concentrations were less than 10 per cent and comprised mainly carbonate material, indicating that there was little build up of land-derived sediment in the study areas.

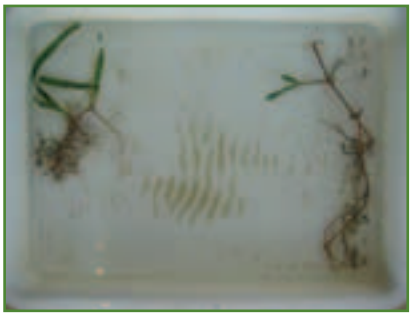
Six cores up to 1.5 metres long were taken from a variety of seabed habitats in Area A to collect a relatively undisturbed sample of the seabed, and to investigate sedimentation over a longer period. Geophysical properties of the sediment in the cores will be used with the multibeam data to calculate the total amount of sediment that moves in the sand waves. The fossil shells will be used to assess the biodiversity of the preserved organisms through time.

The seabed was also videoed at two 24-hour stations to observe near-bed currents and sediment movement. Sediment moved throughout the tidal cycle, but the amount transported was not uniformly distributed through time. 'Pulses' of sediment movement were associated with groups of waves.

Three hundred water samples were also filtered for suspended sediment concentrations. The peaks in concentrations were approximately 12 hours apart indicating that tides influence sediment concentrations.

Geoscience Australia's oceanographic mooring, the Benthic Research Underwater Conductivity Experiment (BRUCE), was deployed at the start and recovered at the end of the survey to provide data about the physical processes and environmental conditions in Torres Strait. The mooring contained a current meter to measure wave and tide currents one metre above the seabed, a particle sizer to measure sediment suspension above the bed, and other instruments to measure salinity, temperature and depth. Additional oceanographic data were collected by CSIRO moorings that were located with BRUCE.

For more information phone Andrew Heap on +61 2 6249 9790 or e-mail andrew.heap@ga.gov.au



COMPLEX GEOLOGY OF REMOTE KENN PLATEAU

slowly unfolding

Geoscience Australia has long had a role in exploring marginal plateaus to determine their geological make-up and resource potential and, more recently, their sea-floor environments for regional marine planning.

In May, the remote Kenn Plateau off the Queensland coast was the focus of one of these studies when Geoscience Australia and Sydney University spent 24 days at sea on the *Southern Surveyor* exploring the plateau's geology.

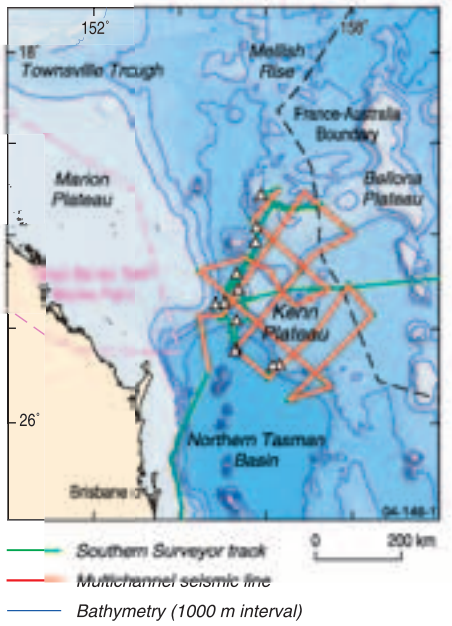
The voyage was led by Geoscience Australia's Dr Neville Exon with Dr Yves Lafoy from the New Caledonian Mines Department aboard, as part of Australia's ongoing cooperation with France and New Caledonia in marine geoscience.

Continental fragment

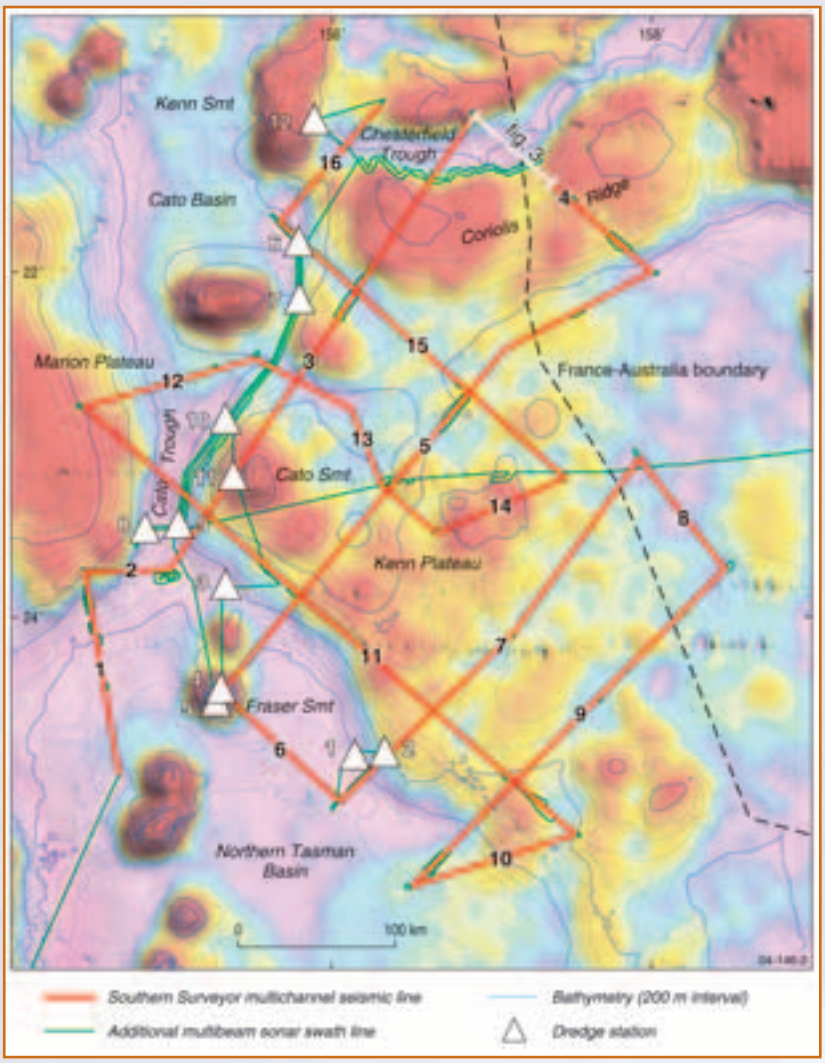
The Kenn Plateau comprises continental fragments that moved north-east from Australia because of plate changes and sea-floor spreading from about 65 to 50 million years ago. It once fitted against what is now the Queensland coast north of Brisbane and south of today's Marion Plateau (figure 1).

The plateau's north-west margin separated from the Marion Plateau by strike-slip faulting, forming the Cato Trough. The south-west margin rifted from the area west of today's Fraser Island, forming the oceanic crust of the northern Tasman Basin. The eastern margin is marked by a limestone-capped volcanic chain extending southward from Bellona Plateau to Lord Howe Island.

The Kenn Plateau's total area is about 140 000 square kilometres of which about 90 000 square kilometres is under Australian jurisdiction (an area much larger than Tasmania). The eastern part of the plateau is French–New Caledonian territory.



▲ **Figure 1.** The Kenn Plateau comprises continental fragments that once fitted against the coast north of Brisbane and south of today's Marion Plateau. The *Southern Surveyor* track and seismic survey lines (SS5/2004 lines) from the May expedition are shown.



▲ **Figure 2.** The complexity of Kenn Plateau is evident in this map of the Earth's gravity field recorded from satellites and ship surveys, overlain by the best available bathymetric contours. Details of the May survey on Kenn Plateau are included. The crustal structures on Kenn Plateau are apparent as is the north–south chain of Tasmantid hot-spot volcanoes.

Acquisition program

Geophysical surveys of the area conducted by the BMR Continental Margins Program in the early 1970s did not include rock sampling to date and determine the nature of the sedimentary strata and basement rocks. The May survey (figures 1 & 2) acquired 12 dredge hauls of rocks, 3090 kilometres of multichannel seismic profiles, ~2000 kilometres of magnetic profiles, and ~7600 kilometres of multibeam sonar data (~25 000 km^2 of seabed mapping).

More rocks will be dredged on the *Southern Surveyor* transit to the nearby Mellish Rise early next year. Once the Mellish Rise survey is complete, all major plateaus off Australia will have been geologically evaluated to at least reconnaissance level.

Complex area

The Kenn Plateau is a complex area (figure 2). The seismic data show that the highs are either basement blocks or volcanic edifices, and the lows are thick sedimentary basins. Most lows are oriented east–west or north-east.

The strata in the sedimentary basins (figure 3) appear to be in three packages: Cretaceous (140–65 Ma), Paleocene–Eocene (65–34 Ma), and Oligocene and younger (33–0 Ma). Several phases of tectonism are apparent. Some may be residual from pre-break-up times (>65 million years ago), but at least one is younger and may be related to compression that occurred about 43 million years ago when the global plate tectonic system changed its configuration.

Volcanic edifices, such as Kenn and Cato seamounts, are part of the Tasmantid seamount chain that extends southward to east of Tasmania. They probably formed 30–35 million years ago.

Dredge information

Several types of rocks were dredged. Probably the oldest is ironstone-cemented sandstone breccia from dredge 2, on the southern margin. Eroded volcanic seamounts with flat tops that are hundreds of metres deep are found along the western margin. A hyaloclastite breccia, consisting of basalt and glass fragments embedded in an altered matrix, was recovered from Fraser Seamount in dredge 5. If the glass fragments can be dated, this will be the most northerly and oldest date from the Tasmantid seamount chain.

Hundreds of metres of limestone (sampled in dredges 4, 11 and 12) have formed on the eroded volcanoes. Based on earlier work on the Marion Plateau, cool-water carbonate platforms first formed in the region about 25 million years ago (Miocene). The reef-forming organisms eventually could not keep up with the subsidence of the extinct volcanoes in the Kenn Plateau region. Limestone ages are believed to be Early Miocene.

The deepwater parts of the plateau are draped in 500–600 metres of seismically transparent material, which generally comprises pelagic calcareous ooze and chalk containing Miocene and younger nannofossils. Two chalk samples appear to be older (probably 47 and 37 million years old).

Earlier drilling programs in the region suggest that the oldest chalks are about 70 million years old. They do not contain the silica-cemented skeletal remains of microscopic sea creatures evident in the 65–33 million-year-old chalks. Chalks that form the youngest strata (33 million years and later) are non-siliceous like the oldest ones.

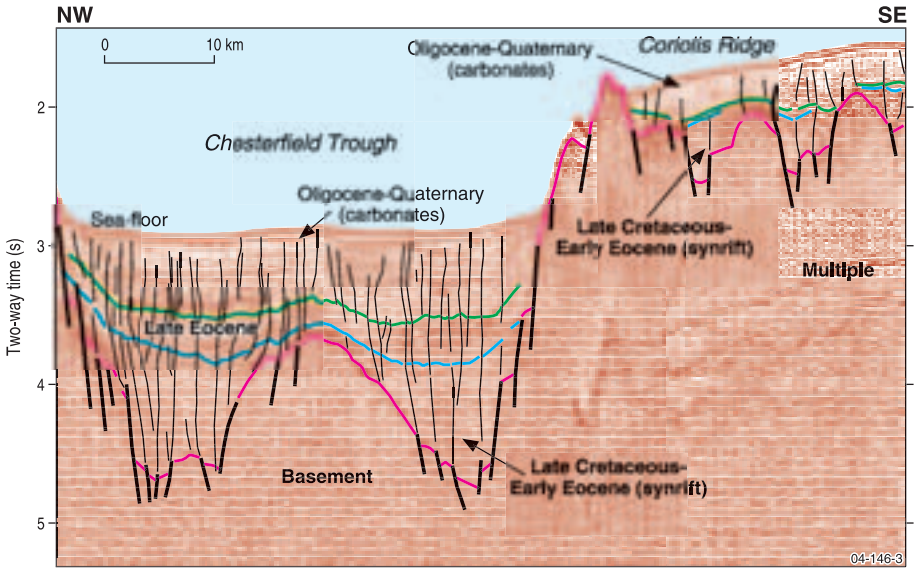


Figure 3. Interpreted seismic profile across the Chesterfield Trough (see figure 2) on the northern Kenn Plateau showing a thick (~2.5 km) fill of deformed sediments deposited over the past 97 million years. About 49–41 million years ago, compression produced widespread and locally intense folding of synrift depocentres, causing uplift and erosion of basement blocks such as Coriolis Ridge. Small-scale faulting in younger sections is attributed to intra-plate stress resulting from convergence at the Australia–Pacific plate boundary to the north and east.

Further analysis

The seismic interpretation, petrological examination, and nannofossil and foraminiferal evaluation of the chalks and limestones that are under way should provide an excellent picture of the sedimentary history of the region.

In February, the *Southern Surveyor* will again be used to dredge basement outcrops and core the central and southern plateau. Once the recovered samples are evaluated, Geoscience Australia should be able to compile a broad picture of the plateau's geological history, determine what happened in this part of the ocean in the past 50 million years, and understand the modern seabed. The information will contribute substantially to what is known about this complex part of the South-west Pacific.

For more information phone Neville Exon on +61 2 6249 9347 or e-mail neville.exon@ga.gov.au

GRANITES may be the key to unlocking YILGARN HISTORY

The tectonic history of the gold-rich eastern Yilgarn Craton in Western Australia is controversial. Many believe the region evolved as a simple progression of four deformation events, and assume that the main rock types—greenstones and granites—have undergone the same event history.

These beliefs are based on field mapping studies that focused on the mineral-rich greenstones.

The many open-cut mining pits in the greenstones show that the rock structure is complex. The complexity could be due to the way gold-bearing fluids were localised, and this may be unrelated to the regional arrangements, making the locations of deposits structurally unique. But this interpretation cannot be tested until someone digs a comparable pit along an un-mineralised structure.

A study of only greenstones is limited because the greenstones do not necessarily record the complete deformation history.

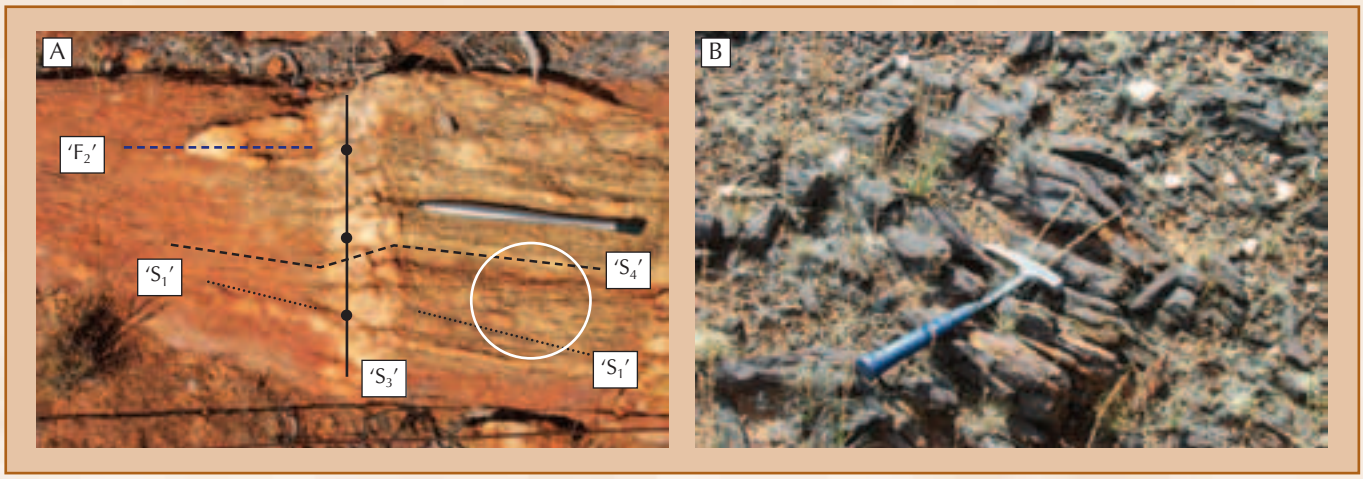
For example, in figure 1, the granite outcrop and adjacent meta-basalt (greenstone) responded differently to one regional contractional phase of deformation (D_2). A number of events preserved in the granites are not visibly preserved in the greenstone. This observation suggests that there has been significant reactivation or reworking of the greenstone, and that the obvious cleavage (S_2) is the likely product of several superimposed events. The reworking has apparently simplified the deformation history of the greenstone.

Granite study

Granitic rocks comprise more than 60 per cent of the surface rocks in the eastern Yilgarn (figure 2). Their history is critical to understanding the craton's evolution.

The many advantages in using the eastern Yilgarn granites to establish a time-space-event history for the region include:

1. a widespread geochronological and geochemical database;
2. a ductile mineralogy of quartz and feldspar that readily accommodates deformation;
3. multiple magmatic phases of sills and dykes that provide excellent markers for defining the subtleties of many of the events (figure 1);
4. locally excellent exposure so that structures can be traced many tens of metres across a site to determine multiple relationships;
5. exposure at various structural levels in the upper crust.

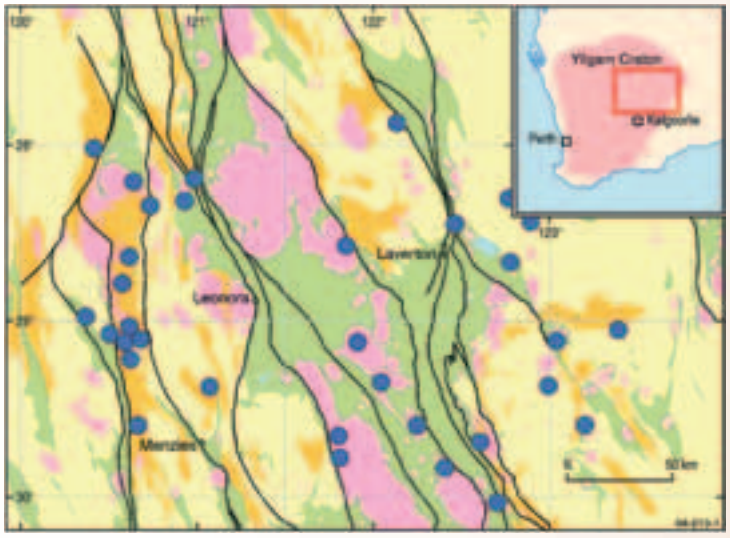


▲ **Figure 1.** Photographs A and B, taken at a site near Mars Bore, demonstrate the difference between the data-rich granite (A) and the data-poor greenstone (B). North is to the left on each photograph. The greenstone shows a single, well-developed north–south striking cleavage (S_2) and associated gentle north-plunging lineation typical of an east–west compressive event (D_2). The granite shows at least four events where shortening could have been east–west. Both the encircled part of the granite (A) and the greenstone outcrop (B) lack suitable markers for revealing the complete deformation history.

Through the Norseman Wiluna Synthesis Project, Geoscience Australia and the Geological Survey of Western Australia have been analysing the structure of granites recorded by a transect of the central eastern Yilgarn Craton. The transect coincides with a deep seismic reflection profile (01AGSNY1) carried out in 2001 and a revised solid geology map (Leonora–Neale transect 1:500 000 scale solid geology map).

The study's inferences about the structural evolution are based on linking granites at the surface to structures that underlie the greenstones which are imaged in the felsic crust. The structural history of more than 30 granite sites was documented (figure 2). Structural patterns (event history) were recorded at each site, and were constrained by the existing geochronology database. Each site was correlated with adjacent sites to construct an event history through time for four geological domains of the central eastern Yilgarn Craton (Southern Cross, Kalgoorlie, Gindalbie/Kurnalpi/ Laverton, and Merolia).

Events in the various domains were also correlated to provide a new, regional time-space deformation framework for the central eastern Yilgarn granites (figure 3).



▲ **Figure 2.** The geology map of the central eastern Yilgarn Craton shows the 30+ granite sites of this study.

Regional	Southern Cross	Kalgoorlie	Greenstones	Kurnalpi Gindalbie Laverton	Merolia
14					
13					?
12			D4		
11					
10		2647–4	D3		~2638
9			?		
8			D3	2664–5	
7					
6		2652–5	D2b	2662–5	
5			D2E	2667–4	2664–2
4			D2a		
3			D1		2663–7
2		~2675	De		~2675
1		~2800		~2710	~2770

▲ **Figure 3.** A synthesis of the granite deformation history provides a new correlation chart for the Eastern Goldfields terranes.

Study results

Overprinting relationships (events) were successfully matched across large areas.

There was widespread major melting (a metamorphic event) and gneiss development at about 2675 million years. A consistent north–south contraction (?) later folded this gneissic fabric.

East–west shortening was followed by north-west to south-east shortening, probably from uplift and extension during the second deformation phase. After this phase there was a significant switch to north–south to north-west—south-east contraction. It occurred just before a change in granite types at around 2650–2640 million years. This stress switch and change in granite types began at the same time as the late orogenic gold event in the eastern Yilgarn Craton.

New product

It can be difficult to assess what assumptions and decisions were made by a geologist in correlating observations to form a regional framework.

Geoscience Australia has produced a new CD-ROM (GA record 2004/10) about the deformation history of the eastern Yilgarn Craton granites that can be navigated at the data level or at various interpretation levels (domain and province histories). More than 450 photographs of structural relationships are linked to data tables of each site. The site observations and accompanying photographs are separated from the ever increasing levels of interpretation to allow alternative interpretations.

At the lowest level of interpretation, the structural events at each site are reported in chronological order. Estimates of palaeostress are presented for each event or deformation phase. The palaeostress estimates, geochronological ages and sequence of preceding and succeeding events are then used to correlate the various events at a site with other sites. The result is an interpreted deformation history for each domain.

The highest level of interpretation is a correlation of four domains into a new deformation history for the central eastern Yilgarn Craton.

This new framework offers industry and researchers in the eastern Yilgarn a new way to consider the complex local (commonly mine) deformation history—in terms of broader regional events.

For more information phone Richard Blewett on +61 2 6249 9713 or e-mail richard.blewett@ga.gov.au

GEOSCIENCE AUSTRALIA'S ANNUAL

Minerals Exploration Seminar

PERTH
Monday, November 29
2004

Interested in mineral-rich provinces, gold and nickel, exploration under cover… DON'T MISS THIS EVENT!

Find out about the latest research results, the new Paterson and Proterozoic Synthesis projects, and some new products for minerals exploration.

Topics in this year's program include:

- Regional geology and prospectivity of the Yilgarn, Gawler and Tanami
- Australian mineral systems, resources and potential, especially for gold and nickel
- Gravity mapping and 3D geology for exploration under cover
- Demonstrations of on-line access to data, information and tools.

Program and registration
Phone +61 2 6249 9087 Fax +61 2 6249 9983
E-mail mike.huleatt@ga.gov.au Visit www.ga.gov.au/news/index.jsp#minsem

OFFSHORE PETROLEUM ACREAGE *vigorously promoted*

Since the 2004 Offshore Petroleum Exploration Areas were released in April, Geoscience Australia and the Commonwealth Department of Industry, Tourism and Resources (DITR) have been busily promoting the areas through industry visits and conference displays and presentations.

The first major opportunity was the annual American Association of Petroleum Geologists (AAPG) convention in late April in Dallas, Texas. More that 5500 people attend AAPG, the largest annual petroleum exploration convention in the world. It gives Australian companies and government agencies the chance to engage the global petroleum exploration sector.

Geoscience Australia coordinated the Australian Government's technical promotion in the International Pavilion. The Commonwealth and every state except Queensland were represented, with specialists available to answer the numerous questions.

A major display feature was Geoscience Australia's 3D fly-through of the release areas overlain on a grid of topography and bathymetry, which was projected on a large plasma screen. Live demonstrations of on-line databases, particularly the Geological Provinces database, proved popular, as was a promotional video highlighting Geoscience Australia's 'Big New Oil' program to find a new offshore petroleum province.

Industry visits

While at AAPG, the Australian Government team visited a number of companies based in North America, giving technical briefings on petroleum exploration opportunities in Australia. There was strong interest in the 'Big New Oil' program and optimism and support for this initiative.

In late May, some Geoscience Australia and DITR staff visited Japan, Korea, China and Taiwan to promote petroleum exploration opportunities. Again, there was strong interest in the 2004 Acreage Release and the new petroleum program, with companies supporting the 'Big New Oil' initiative and keen to gain access to data as they become available.

Eastern Australian Basins II

Geoscience Australia petroleum staff attended the 2nd Eastern Australian Basins Symposium (EABS II) in Adelaide in mid-September. They presented a number of papers on studies in the Southern Margin basins. Preliminary results from the first stages of data acquisition were available at the Geoscience Australia booth.

For more information about petroleum exploration opportunities in Australia phone Jenny Maher on +61 2 6249 9896 or e-mail jenny.maher@ga.gov.au

EVENTS calendar

12th ARSPA Conference
Australasian Remote Sensing & Photogrammetry Association
18 to 22 October
Esplanade Hotel, Fremantle
Contact: ACTS Conferencing, GPO Box 2200, Canberra ACT 2601
phone +61 2 6257 3299
fax +61 2 6257 3256
e-mail 12arspc@ausconvservices.com.au
www.rss.dola.wa.gov.au/12arspc

Mining 2004
27 to 29 October
Carlton Crest Hotel, Brisbane
Contact: Mining 2004, PO Box 1153, Subiaco WA 6904
phone +61 8 9388 2222
fax +61 8 9381 9222
e-mail abbie@verticalevents.com.au
www.mining2004.com.au

North American Prospects Exhibition
American Association of Professional Landmen
26 & 27 January 2005
Houston, Texas
Contact: AAPL, 4100 Fossil Creek Boulevard, Fort Worth, Texas 76137 USA
phone +1 817 847 7700
fax +1 817 847 7704
e-mail nape@landman.org
www.napeonline.com

PDAC International Convention & Trade Show
Prospectors & Developers Association of Canada
6 to 9 March 2005
Metro Toronto Convention Centre, Toronto
Contact: Prospectors & Developers Association of Canada, 34 King Street East Suite 900, Toronto, Ontario M5C 2X8
phone +1 416 362 1969
fax +1 416 362 0101
e-mail info@pdac.ca
www.pdac.ca

APPEA Conference & Exhibition
Australian Petroleum Production & Exploration Association
10 to 13 April 2005
Convention & Exhibition Centre, Perth
Contact: Julie Hood, APPEA, GPO Box 2201, Canberra ACT 2601
phone +61 2 6267 0907
fax +61 2 6247 0548
e-mail jhood@appea.com.au
www.appea.com.au

AUSTRALIA 2012

Opportunity knocks with International Geological Congress *win*

Australia and the Oceania region have won their bid to host the prestigious International Geological Congress (IGC) in August 2012.

The event will be held at the Brisbane Convention and Exhibition Centre and will be called 'Australia 2012'. It should attract at least 5000 delegates from about 100 countries.

The IGC has only been held in the Oceania region on one previous occasion in its 124-year history. The Sydney IGC in 1976 heightened interest in the geosciences, and was followed by several years of increased mineral exploration expenditure.

Another opportunity knocks with Australia 2012, allowing Oceania to showcase the region's geoscience strengths, innovations and natural wonders.

Oceania's fascinating geology was a drawcard, which delegates will see during field trips. Other factors that were viewed favourably by voting delegates include Australia's leadership in a range of geoscience research, the strong and committed organising committee, support from the Prime Ministers of Australia and New Zealand, and Brisbane's world-class venue, great August weather, and proximity to the Great Barrier Reef and other geo-tourist features.

The theme of Australia 2012 is 'Unearthing our Past and Future'. It sets the scene for congress activities that demonstrate the crucial role that geoscience plays in the quest for sustainable development. In Australia's case, it is a chance to show how geoscience directly contributes to the future of its agriculture and resource-based industries.

Australia 2012 will include a GeoExpo, an education outreach program, and a support program to encourage young delegates to attend.

The Australian Geoscience Council will be the formal organising body responsible for Australia 2012. The President and Secretary-General of the Preparatory Committee are Geoscience Australia's Dr Neil Williams and Dr Ian Lambert.

Regional involvement will be through the New Zealand Institute of Geological and Nuclear Sciences and the South Pacific Applied Geoscience Commission. Malaysia, Indonesia and the Philippines are planning field trips in their environs. Regional participation will be maximised by integrating meetings of the major regional geoscientific societies into Australia 2012.

Australia 2012 will provide a window that opens up wonderful new international research alliances, and encourages the careers of young geoscientists. It will present important opportunities for business and industry-based investment. The challenge is to make the most of the opportunities between now and 2012 to ensure some great geoscientific achievements and to build on sponsorship and support.

The bid for Australia 2012 was supported financially by the Australian Government through a grant from the Innovation Access Program, a Backing Australia's Ability initiative, and by the Queensland Government.

For more information phone Ian Lambert on +61 2 6249 9556 or e-mail ian.lambert@ga.gov.au

Earthquake data NOW ON-LINE

Those searching for information about Australia's earthquakes now have a quick and easy way to access it—on-line.

The 'Quakes' database contains information about Australia's earthquakes and seismicity dating from 1841 to the present day. The earthquake magnitudes vary, with the largest estimated as 7.2 in Meeberrie, Western Australia.

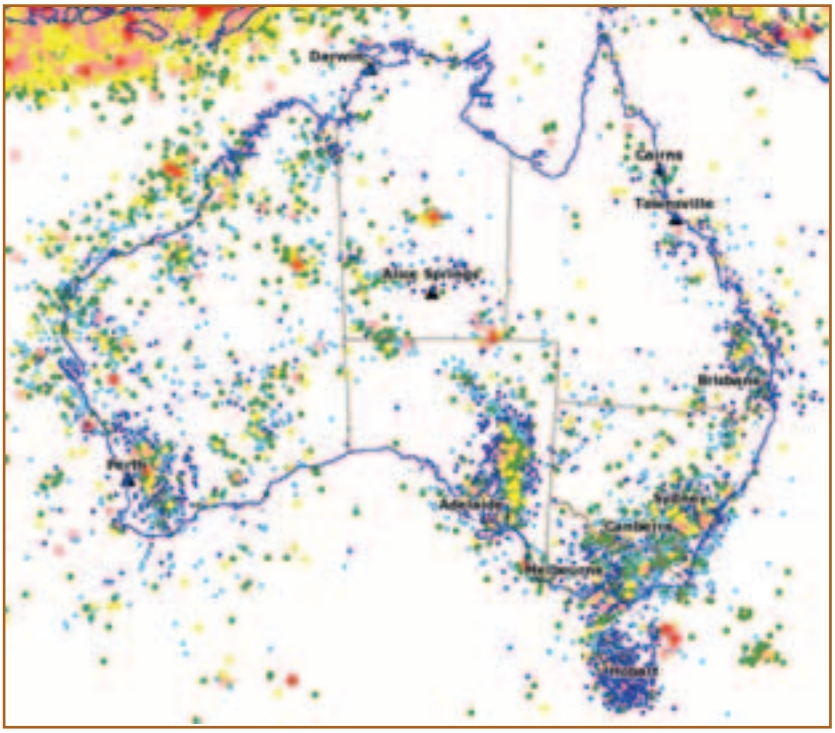
The database also contains information about overseas earthquakes greater than magnitude six. The earliest overseas earthquake listed occurred in Jordan in 2150 BC.

The database is continuously updated, as real-time seismograph data are analysed and earthquake locations are determined. It can be searched through a map or text-based interface.

The information can be tailored to the user's specific needs and downloaded to the user's computer. The earthquakes can be plotted on a map with a number of optional backgrounds, and details of earthquakes can be queried individually or as groups within specified areas. A zoom-in feature allows the user to focus on and plot out an area of interest on the maps.

Easy access to information about Australia's earthquakes will assist researchers and the general public in Australia and overseas.

For more information visit www.ga.gov.au/oracle/quake/quake_online.jsp



▲ **Figure 1.** The Australian earthquakes recorded for the period 1841–2004 that are listed in Geoscience Australia's 'Quakes' database. The colours represent different magnitudes: red 9.9–6.5, pink 6.5–5.5, yellow 5.5–4.5, green 4.5–3.5, light blue 3.5–2.5, and dark blue 2.5–0.0.

New SHORE SAFETY *brochure*

This handy colour brochure, illustrated with lots of photographs and diagrams, warns of the dangers of sand cave-ins and rock-falls on the beach. It uses simple, easy-to-understand English to explain why they happen.

Prepared as a public information tool, the brochure is an ideal handout at community meetings, and to teachers and senior primary and secondary school students.

On average, about two people are killed and two injured each year in sand cave-ins and natural and human-induced rock falls on the Australian coast. Most of these deaths and injuries are avoidable if people understand how their actions place them in danger.

The shore safety brochure provides hints about having fun at the beach while minimising the risks. It also explains why sand easily caves-in, and cliffs shed rocks, and how sea caves, arches and stacks form.

The brochure was produced by Geoscience Australia and Emergency Management Australia as a double-sided A3 sheet folded to A5 for ease of postage or for slipping into a pocket.

To obtain copies phone Matt Hayne on +61 2 6249 9536 or e-mail landslides@ga.gov.au. For more information on landslides visit the Australian Landslide Database via www.ga.gov.au

New edition

LEONORA 1:250 000 EXPLANATORY NOTES

The recently released second edition Explanatory Notes for the Leonora 1:250 000 Sheet describes rock types, structure, metamorphism, and major mineral deposits in an area approximately 250 kilometres north of Kalgoorlie in Western Australia's Eastern Goldfields.

Outcrop mapping by Geoscience Australia during the National Geoscience Mapping Accord is the basis of this comprehensive report.

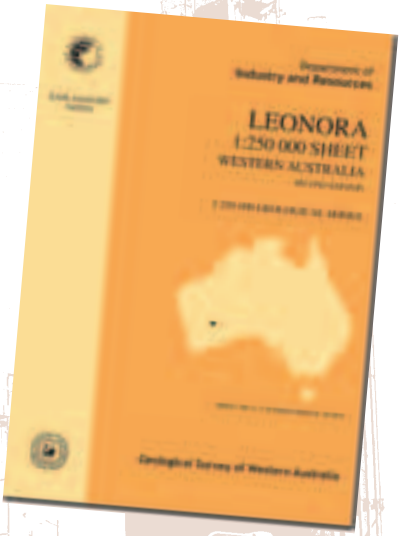
The Leonora 1:250K sheet area covers parts of seven greenstone belts: Agnew, Yandal, Mount Clifford, Malcolm, Murrin, Mount Ida, and Maynard Hills. Most greenstones were deposited in the time range 2700–2665 million years as mafic to ultramafic volcanic rocks with subordinate intrusive equivalents, felsic volcanic rocks, and fine-grained to conglomeratic sedimentary rocks. Large areas of granite and granitic gneiss separate the greenstone belts. At Leonora the granite dates at about 2760 million years, and the greenstone it intrudes is an older basement unit.

The Explanatory Notes include two text figures showing solid geology and metamorphic facies.

The Leonora sheet area has some 550 known mineral deposits, most of them gold, including the world-class Sons of Gwalia (160 t), Emu (127 t), and Tarmoola (110 t) gold deposits. Other commodities include nickel, base-metals, and uranium. Most large gold deposits discovered to date lie in greenstone, but there are significant deposits (e.g. Tarmoola) in granitic rocks.

The Explanatory Notes are published by the Geological Survey of Western Australia in digital format (PDF) and are available on-line. The maps were released during 1996–2000 as separate 1:100 000 sheets, and in 2001 as the second edition of the 1:250 000 sheet.

Laser-printed copies of the Explanatory Notes can be ordered from the Information Centre, Western Australia Department of Industry and Resources by phoning +61 8 9222 3459, or faxing +61 8 9222 3444, for the cost of printing and binding.



Paper copies of the Leonora 1:250 000 second edition map cost $9.90 each, including GST, postage and handling. Digital data cost $99 and includes GST. Both are available from the Geoscience Australia Sales Centre by telephoning +61 2 6249 9966 or e-mailing sales@ga.gov.au.

For more information about the Leonora sheet, phone Richard Blewett on +61 2 6249 9713 or e-mail richard.blewett@ga.gov.au

PRICE REDUCTION for geological products

Geoscience Australia is standardising the cost of most geological maps and publications following a review of product pricing. The price of many products will be reduced, some substantially, as a result.

Printed maps in stock	$9.90
Print-on-demand maps	$22.00
Records, reports, journals and bulletins currently in stock (except some recent releases)	$32.45

If publications are out of print, a copy can usually be supplied for the cost of reproduction.

For more information phone the Sales Centre on +61 2 6249 9966 or freecall 1800 800 173 (Australia only)

Extra imagery options *from* ACRES

Advanced technology sensors on board NASA's Earth Observation 1 (EO-1) satellite are offering extra imagery options to users of remotely sensed data.

EO-1 was launched in November 2000 in the same orbit as Landsat 7 to test land-imaging instruments. EO-1 orbits at an altitude of 705 kilometres, and although it tracks about one minute behind Landsat 7, the craft are physically about 450 kilometres apart.

Three instruments on EO-1 collect multi-spectral and hyper-spectral images in coordination with the Enhanced Thematic Mapper (ETM+) on Landsat 7. Geoscience Australia provides imagery from two of these sensors: Hyperion and Advanced Land Imager (ALI). These sensors have unique capabilities to identify and map physical and chemical properties of the Earth's surface which are not possible using other multi-spectral satellites.

The formation flying capability of the EO-1 spacecraft and the overlay of the swath width for the different instruments are shown in figure 1.

NASA's Hyperion sensor was the first to collect hyper-spectral data from space. It provides a complete spectral range from 0.4 to 2.5 µm in 220 bands, with six per cent absolute radiometric accuracy, covering a 7.7 by 42 kilometre swath with 30-metre spatial resolution. Such comprehensive spectral resolution permits very detailed land-cover classification and has many scientific and commercial applications. It has significant potential for:

- accurate remote mineral mapping
- forest health and infestations monitoring
- forest productivity and yield analysis, and inventory and harvest planning
- crop-yield prediction and monitoring of crop health and vigour
- contaminant mapping and monitoring, and
- vegetation-stress mapping and analysis.

Hyperion's advantages over similar airborne sensors (even though its signal-to-noise ratio is lower than that of airborne sensors) include: global data that can be acquired year round at a relatively low cost to the end user; and consistent illumination characteristics because EO-1 has a well-defined, sun-synchronous orbit.

The ALI sensor demonstrates improved Landsat spatial (10 metre Panchromatic) and spectral resolution (10 bands) capturing a 37 by 42 kilometre area. It has the potential to reduce the cost and size of future Landsat-type instruments by up to five times.

Hyperion and ALI scenes are available from Geoscience Australia's remote sensing centre, ACRES, through a special arrangement with the United States Geological Survey. Under this arrangement, there are up to five acquisition attempts to acquire imagery with less than 25 per cent cloud cover over the area of interest.

For details phone Alan Forghani on +61 2 6249 9111 or e-mail alan.forghani@ga.gov.au or visit www.ga.gov.au/acres/

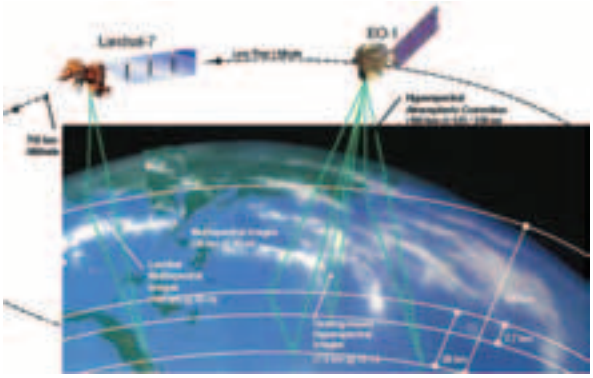


Figure 1. Schematic of the satellite's coverage, from EO-1/ Hyperion Science Data User's Guide, 2001

Figure 1. An example of a GeoTIFF image (band 4) over Sydney, New South Wales, acquired by Landsat 7

Landsat data *available in* GeoTIFF format

Landsat 5 and Landsat 7 ortho-corrected and map-oriented images (from single scene up to triple scenes) are now available in Geographic Tagged Image File Format (GeoTIFF).

Geoscience Australia has introduced this format in response to feedback from satellite imagery users, and its adoption by industry using GIS and remote-sensing applications. Prices will remain the same as other Landsat data formats supplied by ACRES.

Major advantages of GeoTIFF include the capability to embed a wide range of geo-referencing information (e.g. projection and datums) as compliant descriptive tags (metadata), and its ability to be viewed in a range of GIS software.

However this format is not without it challenges. GeoTIFF lacks a definitive format specification, and software packages vary in their ability to correctly read the geo-referencing information that accompanies each product.

To assist customers, ACRES encourages interested users to download sample data to ensure that the GeoTIFF projection options are supported by users' image processing software. This is particularly important for clients wanting to order products using the GDA94 datum option in UTM and equi-rectangular projections.

For more information about imagery in GeoTIFF format phone Alan Forghani on + 61 2 6249 9111 or e-mail alan.forghani@ga.gov.au or visit www.ga.gov.au/acres/

Mineral occurrence portal
UP AND RUNNING

The quick way to access information about Australian mineral deposits is the Mineral Occurrences Web Mapping portal (www.geoscience.gov.au/geoportal/minocc/), which went live in June this year. It draws on data from all relevant state and territory databases.

The portal allows users to zoom, pan, search and display a national overview of mineral occurrence information, together with geology, infrastructure, topography and image backdrops (gravity, magnetics, LANDSAT, and seamless Topo 250K). It offers spatial and non-spatial search tools with nationally agreed attributes. The attributes include:

- Occurrenceno – a unique Geoscience Australia identifier
- Sourceno – a unique state/territory identifier
- Name – of occurrence
- Project – mining centre or group of occurrences if available
- Commodities – a list of significant commodity names (National Standard endorsed by Chief Government Geologists)
- Class – indicates whether it is an occurrence, deposit or mine
- Location – state, longitude and latitude (eastings and northings can be provided)
- Accuracy – in metres
- Source – state/territory survey name and local database name.

These attributes can be accessed and printed directly from the database or by querying the map. The database query also allows clients to download an ascii-comma-delimited file, which can be opened in client software (e.g. MS Excel or GIS). The full set of attributes is available from the state/territory databases.

A simple guide on how to use the web maps is available from the on-line help system.

Note: All stakeholders have agreed to adopt a national commodity list, however naming conventions and class types have not yet been standardised.

For more information phone Neal Evans on +61 2 6249 9698 or e-mail neal.evans@ga.gov.au

FAR NORTH *latest option in digital surface geology*

A digital version of the surface geology of the base-metal-rich Mount Isa Inlier, western Cape York, and Torres Strait islands has just been released by Geoscience Australia. The release is the next instalment of the 'Surface geology of Australia' 1:1 million-scale, digital data set that can be downloaded from the web.

The new release covers a geologically diverse part of Australia that has high exploration potential for many commodities. It provides an excellent regional context to known mineralisation and should therefore assist exploration, particularly in adjacent areas with thin cover.

The oldest rocks in the area covered by the new release are Palaeoproterozoic in age and crop out in two main regions: the Mount Isa Inlier in the south, and the Murphy Tectonic Ridge/McArthur Basin to the north-west.

The Mount Isa Inlier is host to major mineral deposits in places such as Mount Isa Mines–George Fisher (Cu, Pb, Zn and Ag), Century (Zn), Ernest Henry (Cu, Au), Cannington (Pb, Zn and Ag), Osborne (Cu, Au) and Tick Hill (Au). Neoproterozoic sediments of the South Nicholson Group cover the Murphy Tectonic Ridge and Mount Isa Inlier.

Centre established for VIRTUAL GEOCHEMICAL MODELLING

A Virtual Centre for Geofluids and Thermodynamic Data, that uses a single entry point for the storage and retrieval of data relevant to geofluids, was established at Geoscience Australia in mid-July.

The Predictive Mineral Discovery Cooperative Research Centre (*pmd**CRC) set up the Virtual Centre to help meet a long-term objective: the creation of a computational environment to simulate the 4-D evolution of mineral systems.

The data include thermodynamic data for geologically related substances (minerals, aqueous species, and gases—the FreeGs database), as well as empirical data on fluid inclusions from various geological settings. The built-in systems for data manipulation include algorithms for quantitative interpretation of fluid-inclusion data.

Thermodynamic data relevant to the regolith environment, which can be seamlessly merged with high temperature–pressure data, were contributed by the Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRCLEME).

Although the Virtual Centre primarily serves the *pmd**CRC, it will be useful to the wider geochemical community. Most of the thermodynamic data can be interrogated by the general public, and access to the non-confidential data from the fluid-inclusion database can be arranged through Geoscience Australia.

The ultimate goal of the Virtual Centre is to be an efficient, on-line collaborative tool for data exchange among interested geoscientists.

The latest Virtual Centre web pages contain links to the new FreeGs Thermodynamic Database and Reports pages. These are supported by a web-enabled Thermodynamic Calculator for FreeGs that delivers a number of derived values (such as Gibbs free energies of database species and log *K* values of chemical reactions, across a wide range of temperature and pressure conditions). These values can be plugged into the user's geochemical modelling package.

In future developments, users will be able to output the 'primary' and re-calculated thermodynamic and fluid inclusion data using eXtensible Markup Language (XML).

For more information phone Evgeniy Bastrakov on +61 2 6249 9293 or e-mail evgeniy.bastrakov@ga.gov.au or visit the Virtual Centre at www.ga.gov.au/rural/projects/geofluids.jsp

Georgina Basin sediments, predominantly of Cambrian age, cover the Mount Isa Inlier and South Nicholson Group. These sediments host phosphate deposits at Duchess and Lady Annie, south-east and north of Mount Isa respectively. These rocks are partially covered by Jurassic to Cretaceous sediments of the Carpentaria–Karumba Basin.

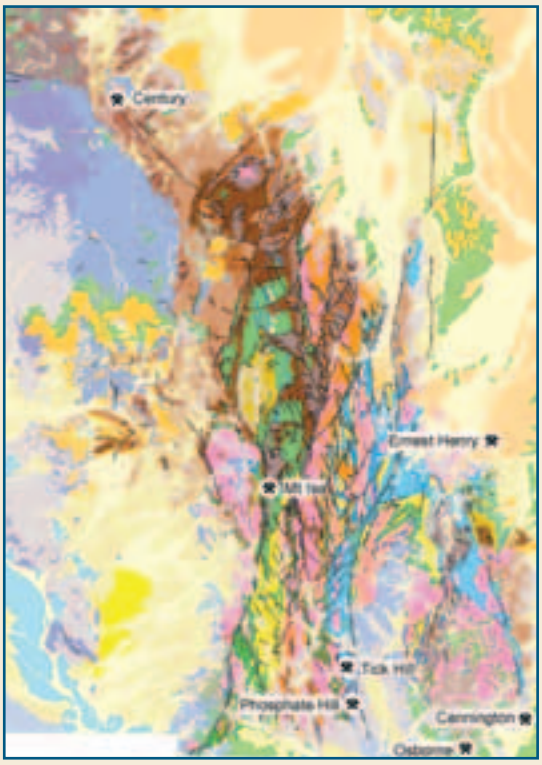
Granite and felsic volcanics of Carboniferous age crop out on the tip of Cape York and in the Torres Strait. Minor Quaternary basalt is present on the eastern Torres Strait islands. Cainozoic sediments and laterite are the most extensive surface units within the mapped area. Extreme weathering in north-western Cape York has led to the development of extensive bauxite deposits.

The digital data in the new release were compiled mainly from regional maps (1:500 000 and 1:1 million scale) produced by the Geological Survey of Queensland and Bureau of Mineral Resources/Geoscience Australia. They were updated with the second edition 1:250 000 geology, and limited interpretation of Landsat and gamma-ray spectrometric data, including Xstrata Copper Exploration's coverage of the Mount Isa Inlier area.

The digital data are intended for use at 1:1 million scale and have a spatial accuracy of approximately one kilometre. Geological unit polygon attributes include age, stratigraphic names and descriptions, Geoscience Australia's stratigraphic index numbers, and summary lithology to provide extra flexibility in search options.

The new release and earlier releases of Tasmania, Victoria and southern Queensland can be downloaded from Geoscience Australia's web site.

For more details phone Alan Whitaker on +61 2 6249 9702 or e-mail alan.whitaker@ga.gov.au



MORE WEB UPDATES
for mineral regions

A lot more information is available on Geoscience Australia's web site about the North Australia Craton, with updates to existing data sets and the recent release of a new record.

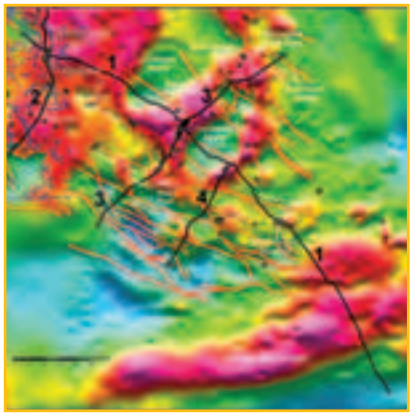
Geoscience Australia Record 2003/29 focuses on the extent and 3-D geometry of mafic intrusions in the southern Arunta Province. The analysis used geophysical data sets to identify a series of concealed mafic bodies along a prominent gravity ridge that includes the Andrew Young Hills Complex.

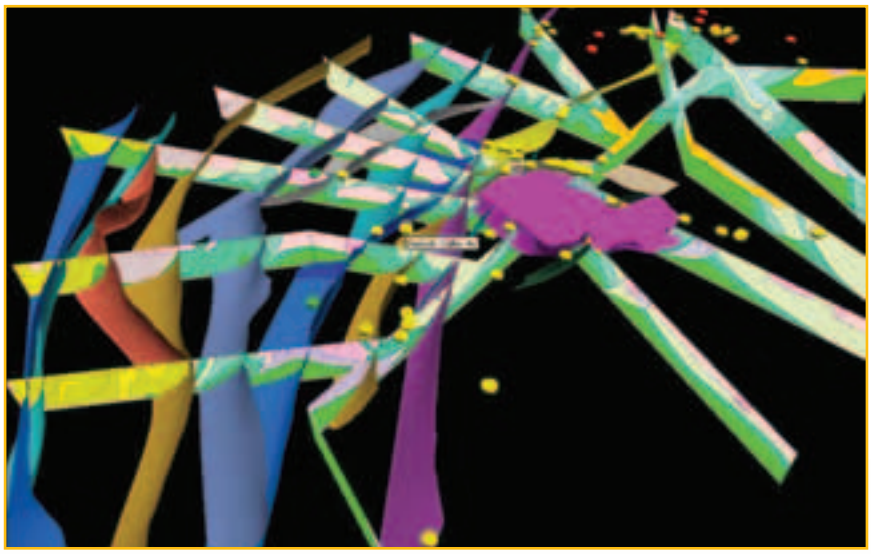
Two-dimensional forward modelling indicates that many of these bodies and the sub-cropping parts of exposed mafic bodies are buried less than 120 metres below the surface. Previous work in this area (Geoscience Australia Record 2001/39) indicated that they have potential for orthomagmatic nickel-copper deposits.

A proposal to acquire seismic data in the gold-rich Tanami region in 2004–2005 has also been posted on the web. The seismic data should provide a better understanding of the structural, stratigraphic and magmatic architecture that controls mineralisation. The proposal was put forward by a joint program involving Geoscience Australia, the Northern Territory Geological Survey and the Geological Survey of Western Australia.

The web-based Tanami 3-D model was developed to show the regional architecture and thereby assist gold exploration. It has been updated to include all major faults, magnetic strings, regolith geology and proposed seismic lines. It also has some new features to assist in viewing the model. The architecture in this model, which was developed by integrating forward modelling of potential field data with existing solid geology interpretations, provides a straw man which will be tested and refined using inversion and seismic methods.

The updated on-line GIS for the North Australia Project includes most available geochronological





data for the Arunta and Tanami regions. This has resulted in a 27 per cent increase in SHRIMP data (from 194 to 247 samples). The fluid-inclusion data collected in Geoscience Australia's studies of gold mineralisation have also been added. The updated data set should improve understanding of the evolution of the southern North Australia Craton and encourage a more critical assessment of exploration models for mineralisation (Au, Ni-Cu and Zn-Cu-Pb).

For more details phone Dave Huston on +61 2 6249 9577 or e-mail david.huston@ga.gov.au

Web addresses for new information about the North Australia Craton

1. Record 2003/29: www.ga.gov.au/rural/projects/record2003_29.jsp
2. Seismic data acquisition in the Tanami: www.ga.gov.au/rural/projects/tanami_seismic.jsp
3. Tanami 3-D model: www.ga.gov.au/map/web3d/tanami/index.jsp
4. On-line GIS: www.ga.gov.au/map/nap