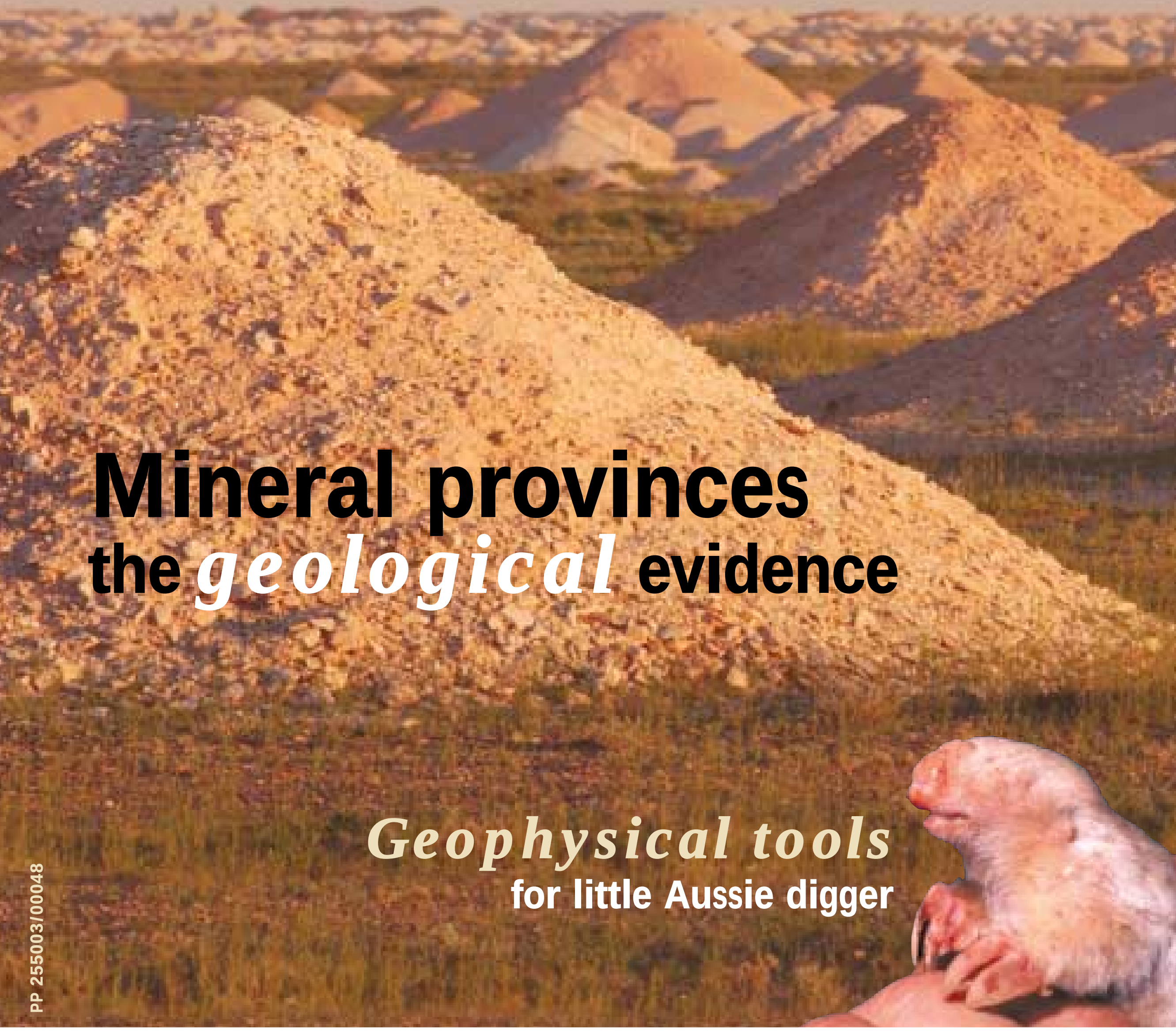
DECEMBER 2002 ISSUE No. 68

# AUSGEO *news*

GEOSCIENCE AUSTRALIA

## CORAL REEFS & *hydrocarbon seeps*



## Mineral provinces
## the *geological* evidence

## *Geophysical tools*
## for little Aussie digger

PP 255003/00048

***Also**: Australian islands double in size, map maker honoured, demand up for spatial data*

**AUSGEO News**
**December 2002**
**Issue no. 68**

**Editor** Julie Wissmann

**Graphic Designer** Karin Weiss

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**Geoscience Australia**
GPO Box 378
Canberra ACT 2601 Australia

cnr Jerrabomberra Ave & Hindmarsh Dr
Symonston ACT 2609 Australia

Internet: www.ga.gov.au

***Chief Executive Officer***
Dr Neil Williams

**Subscriptions**
*Dave Harris*
Phone +61 2 6249 9333
Fax +61 2 6249 9982
E-mail dave.harris@ga.gov.au

**Sales Centre**
*Dave Harris*
Phone +61 2 6249 9519
Fax +61 2 6249 9982
E-mail sales@ga.gov.au

GPO Box 378
Canberra ACT 2601 Australia

**Editorial enquiries**
*Julie Wissmann*
Phone +61 2 6249 9249
Fax +61 2 6249 9926
E-mail julie.wissmann@ga.gov.au

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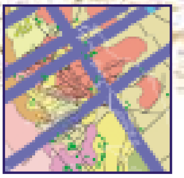
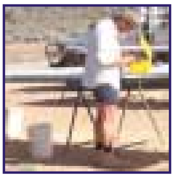
# CONTENTS



*An opal-hearted country that hides untold mineral wealth. Australia's geology hosts much of the world's lead, zinc and silver resources, and enormous deposits of gold, copper and uranium. What factors caused such riches?*
*Geoscience Australia comes up with some interesting findings in its search to understand the geological evolution of Australia and provide high-quality pre-competitive geoscientific information that attracts mineral exploration Down Under.* *See pages 16–28.*

***Photo:*** *Arthur Mostead*






Australian mineral exploration is at its lowest level of expenditure in 20 years and Australia has lost its place as the world's leading country for mineral exploration to Canada, despite continuing discoveries across the continent.

The concern is whether the level of investment in mineral exploration in Australia is adequate to sustain the industry into the future.

Gold is Australia's major metal commodity export. If under investment in gold exploration continues, coupled with the very high rates of gold production, the resource could be depleted.

The Commonwealth Government has taken action to address the issues and problems associated with current levels of exploration in Australia. Minister for Industry, Tourism and Resources, the Honourable Ian Macfarlane recently announced two initiatives: the House of Representatives Industry and Resources Committee Inquiry into 'Resources exploration impediments' and the Minerals Exploration Action Agenda.

Already, the House of Representatives inquiry has attracted a considerable number of submissions. And the first meeting of the Strategic Leaders Group was held in November, under the leadership of the Minerals Action Agenda Chair, Mr Peter Lalor.

High-quality pre-competitive geoscientific information is crucial to maintaining Australia's competitive position in attracting mineral exploration investment and providing a basis for new resource discovery.

Inside this issue of *AusGeo News* are some results of work by Geoscience Australia to support mineral discovery. Most of this work is done in collaboration with state and territory geological surveys, under the National Geoscience Agreement.

Also in this issue is an article about the impact of the Commonwealth Government's Spatial Data Access and Pricing policy, introduced in September 2001. This policy benefits the mineral resources industry, particularly junior explorers and consultants, by making data critical to project generation available at a very low cost or free via the web.

There has been a big increase in the uptake and use of Geoscience Australia's information and databases, especially airborne geophysical data, since the policy was introduced.

# Comment

Neil Williams

**NEIL WILLIAMS**
CEO Geoscience Australia

# CORAL & REEFS hydrocarbon seeps

Some say oil and water don't mix, yet on Australia's North West Shelf they have an old and remarkable association, which led to the development of reefs and other coralline communities along Australia's western and northern coast.

**Geoscience Australia sedimentologist, Kriton Glenn outlines what has been happening.**

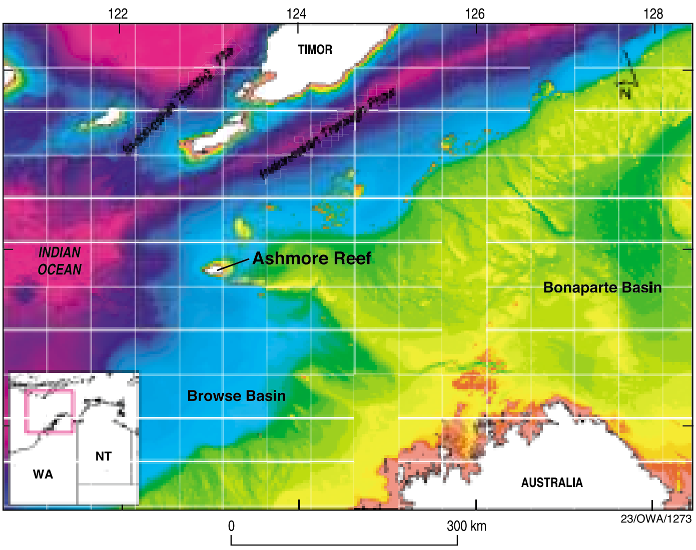
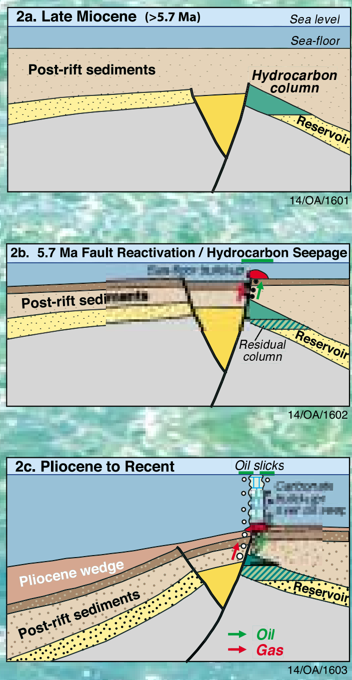



**Figure 1.** Map showing the location of Ashmore Reef and the Indonesian Through Flow

**Figures 2 a–c.** A three-stage model illustrates how the geology is breached (a), hydrocarbons escape and corals colonise the hardened build-ups around the lip of the seep (b), and the reef builders keep up with rises in sea level (c).




About 5.7 million years ago, the Australian plate collided with the Eurasian plate. The collision furthered the formation of the Timor Trough and focused the flow of a huge volume of hot, low salinity water from the western Pacific Ocean through the Indonesian archipelago, and southwards to mix with the Indian Ocean (figure 1).

As the plates collided, cracks formed in the crust and hydrocarbons seeped to the surface. Whenever sea levels are low, such as the last glacial maximum about 18 000 years ago, water is stored as ice at the poles and Australia's north-west continental shelf is exposed. In these periods, the hydrocarbons seep onto the exposed land and gases are vented directly into the atmosphere.

When sea levels are high, such as the present day, ocean covers the seeps and water pressure restricts the hydrocarbon flow. The thermocline traps some hydrocarbon, but a significant amount rises through the water column where it is digested by bacteria. The rest surfaces as gas or an oil slick, which generally evaporates fairly quickly.

As the bacteria and other benthic organisms that are digesting the hydrocarbons die, their skeletal remains and sediments slowly form a solid mound around the seep. Coral spawn colonise this hard surface, rather than the adjacent loose sand and sediments (figure 2). The reef builders establish their robust architecture on the hard surfaces and keep up with sea level rise.

## Biological input

There is no other place on Earth where a huge volume of tropical water banks up and flows from one ocean to another at more than 10 million cubic metres a second. It is called the Indonesian Through Flow, and it helps warm the Indian Ocean. It is a conduit for genetic material to Australia's western coast.

Although Ashmore Reef is in the Indian Ocean, it is surrounded by very warm Pacific Ocean water. The water's salinity is diluted by heavy rainfall near the Equator before it flows south. Sometimes the water temperature is greater than 30 degrees Celsius, and this makes reef growth quite remarkable because most corals die out when water is 28–29 degrees Celsius. The water is rich with marine life including coral and fish spawn.

Ashmore Reef is a marine protected area because of its rich biodiversity and range of endemic species. It is a stopping point for many migratory animals including birds and turtles, and is a critical habitat for dugong and other marine life. The area also has the highest population density of sea snakes in the world. Genetic components from both oceans and Ashmore Reef seed many reefs and other habitats along Australia's western shores, some as far south as Perth.

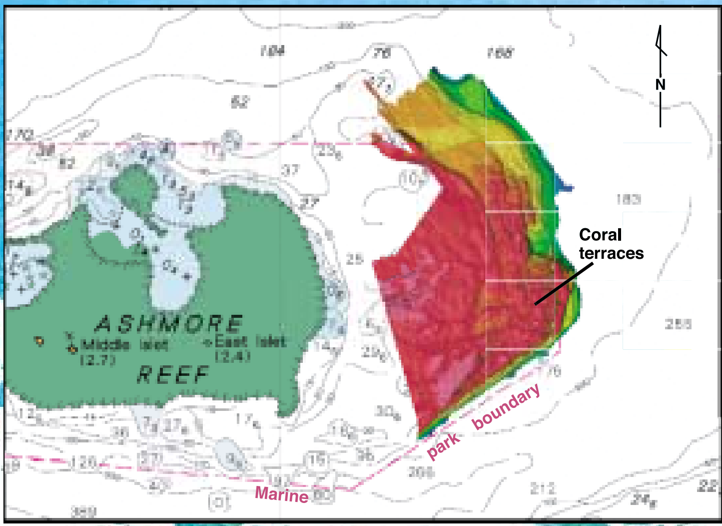



**Figure 3.** Coral terraces on the eastern side of Ashmore Reef. The youngest terraces are in red and the oldest are shown in bright green. The present-day reef is dark green. Image supplied by the Royal Australian Navy Hydrographic Office .

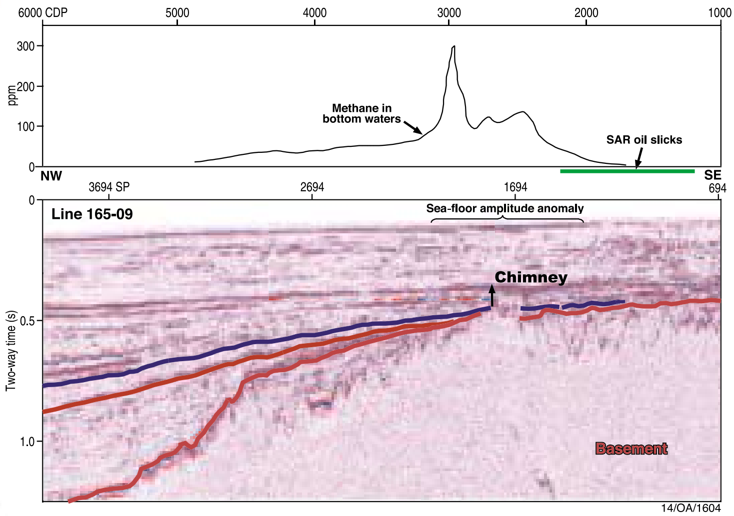



**Figure 4.** Sediments are pinched out, a chimney forms, and hydrocarbons leak into the ocean.

## Coral terraces

Sea level has not risen steadily over time. It has been going up and down in stages, and the reef builders of Ashmore have kept pace, recording the changes in their architecture.

When sea level is rising, corals grow upwards. When sea level is stable, corals grow outwards. As sea level falls, reefs die leaving cliffs of limestone. When sea level rises again, marine life re-inherits the limestone.

Royal Australian Navy hydrographic vessels recently swath mapped the ocean floor near the eastern side of Ashmore Reef and passed the information to Geoscience Australia. The Navy images reveal a series of submarine coral terraces (figure 3). This is exciting new data for scientists because the terraces represent true sea level. The ages of the coral terraces will confirm the rate of sea level rise, and when it was stable.

Unlike coral terraces elsewhere in the world, the geologically young Ashmore Reef terraces are not related to tectonic events because the region has been relatively tectonically stable for the past 20 000 years.

For more information phone Kriton Glenn on +61 2 6249 9379 or e-mail kriton.glenn@ga.gov.au. For details about the use of SAR phone Geoff O'Brien on +61 8 8303 3502 or e-mail geoff.obrien@ncpgg.adelaide.edu.au

At present, the crests of Ashmore Reef are rimmed with algae. Coral detritus and sand have been building up behind the reef front for more than 1700 years. An extensive reef flat is prograding into the lagoons behind the reef, at a fast infill rate of 0.3 to 0.73 centimetres a year. Carbon dating of parts of Ashmore Reef shows that sea level has been stable for the past 2000 years.

## Hydrocarbon seeps

The hydrocarbon seeps on the North West Shelf lie in water depths of five to 450 metres, although most are at 70 to 200 metres depth. Water pressure at 70 metres is 117 psi (810 kpa). At 200 metres it is 310 psi (2128 kpa). Despite this pressure, hydrocarbons are escaping to the surface and transient oil slicks up to 25 kilometres long and two kilometres wide are regularly observed in the area.

Anecdotes from official boats in the region report a sea thick with algae shortly after an oil slick appears, which is sometimes followed by thousands of red crabs. The spatial association and true relationship between the food webs and the hydrocarbon seeps, however, are yet to be determined.

Geoscience Australia has used two methods to trace seeps on the North West Shelf. Seismic surveys are employed to depict sub-surface sediments where the geology is 'pinched', forming chimneys through which hydrocarbons escape (figure 4). SAR or synthetic aperture radar is used to locate oil slicks on the sea surface.

With SAR, a beam is bounced from a satellite to the ocean surface and back again. Backscatter signals show when the beam passes over different matter such as oil. When an oil slick is seen, the chemistry of water around it and from the ocean floor can be analysed to determine such information as methane levels.

Although more primary investigation is needed, work is well under way to chart the seep sites and gain a better understanding of the hydrocarbon to coral reef to food web relationships along the North West Shelf.

Scientists and representatives from industry and institutions including Geoscience Australia, the Australian Institute of Marine Sciences, Environment Australia, and various museums and universities met in Darwin in late November to discuss possible joint research projects on the North West Shelf.

Since 1994, Kriton Glenn has regularly visited Ashmore Reef with Environment Australia, the Australian Customs Service, the Royal Australian Navy, and the Australian National University as a marine geoscientist and educator. Much of his research has been conducted with former member of Geoscience Australia, Dr Geoff O'Brien.

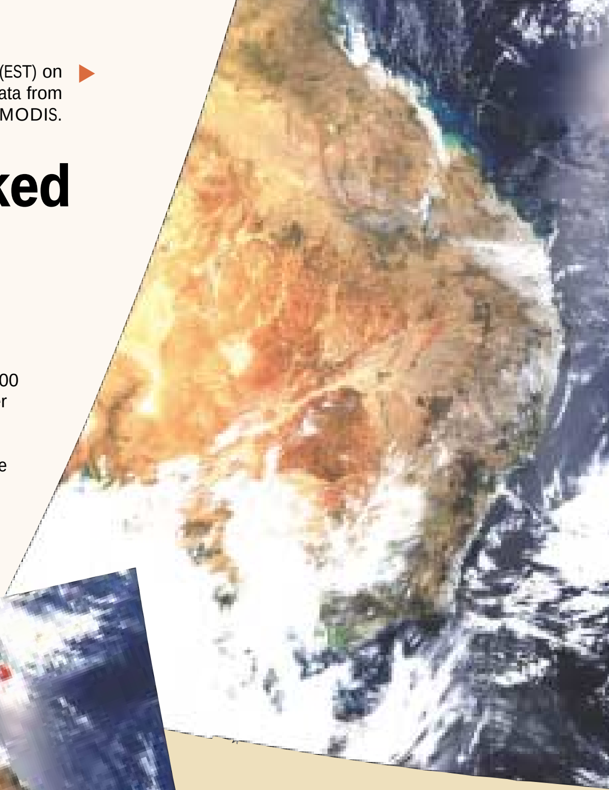


Figure 1. Before the dust storm, about 10 a.m. (EST) on October 22. Geoscience Australia acquired the satellite data from NASA's Terra satellite, via an on-board sensor called MODIS.

# HUGE dust storm tracked in satellite images

The red dust that blanketed eastern Australia on October 23 was captured in a series of satellite images acquired by Geoscience Australia.

Millions of tonnes of topsoil were whipped up by a dust storm that stretched from Mt Isa in north-west Queensland to Tasmania. It was the worst in Australia for 30 years.

The dust storm was 1500 kilometres long and 400 kilometres at its widest, and reached 2500 metres into the atmosphere.

Wind gusts of more than 80 kilometres an hour travelled across parched, drought-stricken land, smothering coastal cities and towns with red dust before moving into the Tasman Sea. Some dust reached New Zealand's Fox and Franz Joseph glaciers.

Visibility was poor during the dust storm, with Sydney's media reporting 150 micrograms of dust per cubic metre of air. A reading of 50 mcg/$m^3$ is considered high.

The dust comprised particles of quartz, koalinite, illite, calcite and other minerals that were about 50 microns in size.

Melbourne experienced a bad dust storm in 1983 and Brisbane in 1987, but they weren't as large as this one.

Australia is in drought because of an El Niño. Some crops have failed and in areas there is little vegetation for stock and native animal grazing. Large bare areas expose the soil and upper part of the regolith to wind erosion.

The Australian continent has been drying out for the past 20 000 years and has experienced many El Niño events. Evidence of large dust storms like October's is found in the geology of eastern Australia in parna (wind-blown dust) units about 18 000 years old, at the peak of the last ice age.

Over summer Geoscience Australia prepares a lot of satellite imagery for fire and emergency services and the media, to alert people to bushfires and dust storms.

Figure 2. During the dust storm, about 11.00 a.m. (EST) on October 23. The dust storm is the pale yellow band that stretches from the Gulf of Carpentaria, across Queensland, and tapers off near Sydney.

*Teachers: For ideas on how to use this article in the classroom see www.ga.gov.au/education. You will also be interested in Geoscience Australia's latest education resource,* **Weathering and Erosion,** *designed for students in Years 5–12. For more information phone Cindy Hann on +61 2 6249 9673 or e-mail cindy.hann@ga.gov.au*

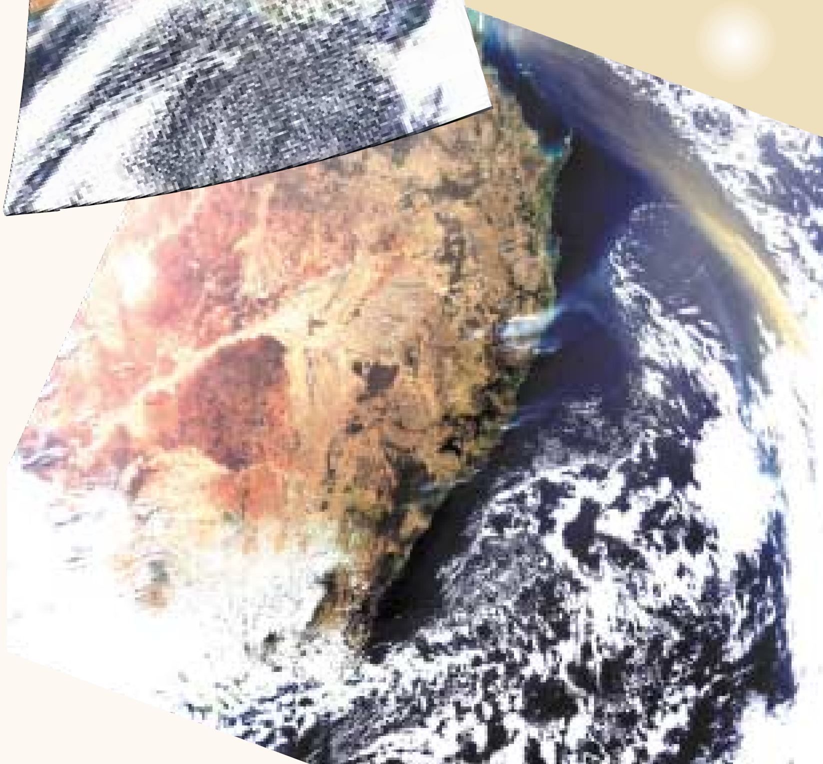


Figure 3. After the dust storm, about 9.45 a.m. (EST) on October 24. The dust storm has moved out to sea.

# *New isotope equipment* proves a gas for coal

Gas from Queensland coal seams is attracting exploration interest, as is Geoscience Australia's new isotopic equipment to analyse the gas and determine its origin.

Australia's first commercial production of coal seam gas began in May this year from Permian coal in Santos' Scotia field in Queensland. Some major and many smaller companies are also exploring Jurassic coals and dry gas from oil shales.

Coal seam gas is novel as the coals generally act as both source and reservoir.

Typically, most of the gas is methane caused by microbial activity or by geothermal heating over time. The thermogenic methane is associated with wet gas and oil generation, which traditionally supports natural gas in conventional sandstone reservoirs.

Carbon dioxide ($CO_2$) content in coal seam gas is quite variable and its origin can be either inorganic or organic.

## Geoscience input

At a meeting in Canberra two years ago, Geoscience Australia and state/territory petroleum groups initiated the informal Onshore Petroleum Promotion Group to share information about Australia's onshore prospectivity. The group looks at common scientific problems and ensures that any scientific support from Geoscience Australia is maximised and shared.

Several geochemical projects have been developed since that initial meeting, mostly dealing with vagrant oils. The most recent study on the origin of coal seam gas began in July 2002.

This study is a joint initiative between Geoscience Australia and the Hydrocarbon Geoscience Group of the Queensland Department of Natural Resources and Mines. The department is coordinating the gas sampling with industry. Geoscience Australia is analysing the samples.

The sampling involves conventional natural gas and gas from coal seams in the Bowen and Surat basins. The conventional gas samples include severely biodegraded gas, high $CO_2$ gas, very wet gas, and very dry gas.* There are plans to sample coal seams in other localities as well, from Late Permian and Jurassic coals and/or associated interbedded sands.

Geoscience Australia will subject the individual gas components (methane, wet gas and $CO_2$) to carbon isotopic study, as well as hydrogen isotope analysis if time allows. The combination of molecular and isotopes studies is a powerful tool for defining sources for the hydrocarbon components.

The analysis will be completed by July 2003 with a final report available by the end of next year.

* *For more information read Boreham CJ. 1995. Origin of petroleum in the Bowen and Surat basins: Geochemistry revisited. APEA Journal; 35(1):597–612.*

**For details phone Tony Stephenson on +61 2 6249 9472 or e-mail tony.stephenson@ga.gov.au, or phone John Draper on +61 7 3362 9340 or e-mail john.draper@nrm.qld.gov.au**

## GEOCHEMICAL CAPABILITIES EXPANDED

A new stable isotope mass spectrometer has expanded Geoscience Australia's petroleum and environmental geochemistry capabilities. It can fingerprint oil and gas, and organic matter in water by isolating the components, carbon, hydrogen, nitrogen and sulphur.

Geoscience Australia has been analysing carbon composition for some time. But the equipment now allows research into deuterium, the stable isotope of hydrogen, which is a key component of all hydrocarbons.

Through geochemical work by Geoscience Australia, stable carbon isotopes became an important tool for assessing Australia's hydrocarbon resources, to correlate oil and gases, and examine their sources and maturity.

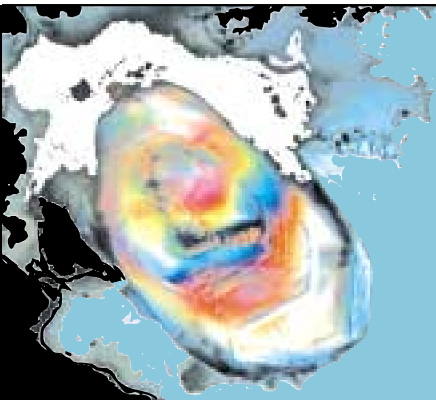
The ability to study deuterium composition of individual compounds in oil and gas adds greatly to an examination of petroleum systems and products.

It is a new technique and Geoscience Australia is building its understanding of the strengths of this tool. Initial studies of oils, source rocks and formation waters from several basins around Australia indicate that it will be useful in distinguishing oil families that may appear similar based on other common parameters.

Geoscience Australia has also purchased new analytical equipment to expand the range of applications for the stable isotope instruments. It now has the capacity to analyse solid and liquid samples for a range of stable isotopes including Carbon-13, Nitrogen-15, and Sulphur-34.

This new capability will be used in many Geoscience Australia projects. It will be applied to petroleum as well as marine and estuarine sediments.

**For more information phone Graham Logan on +61 2 6249 9460 or e-mail graham.logan@ga.gov.au**



*Wherever you are this festive season may you enjoy peace and goodwill...*

seasons greetings

**Thank you for your interest in Geoscience Australia and your readership of *AusGeo News*. We look forward to your continued support in 2003.**

▶ **Top right:** Aerial photograph of the McDonald Islands taken on March 11, 1980 from a helicopter aboard the *Cape Pillar.*

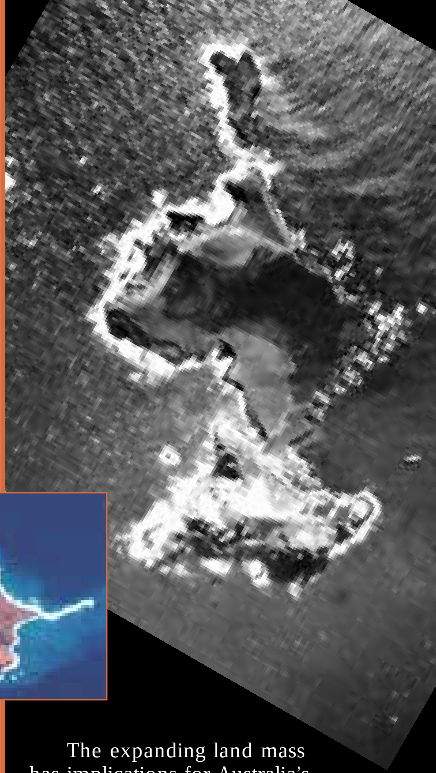
▼ **Insert:** Satellite imagery of the McDonald Islands from Landsat 7 EGM data acquired on November 6, 2001.

# Volcano DOUBLES SIZE of Australian islands

Australia's McDonald Islands have doubled in size because of recent and possibly ongoing volcanic eruptions, and it appears that the separate islands of McDonald Island and Flat Island are now one.

These differences were discovered last month by Geoscience Australia during a routine check of Australia's maritime boundaries in the Southern Ocean.

Geoscience Australia's Bill Hirst was comparing an aerial photograph of the McDonald Islands taken in March 1980, with satellite imagery from Landsat 7 data acquired in November 2001, when he noticed that the islands had changed shape.



The islands area of 1.13 square kilometres is now thought to be 2.45 square kilometres. Some features have disappeared.

Nobody knows exactly what has been happening because the McDonald Islands are inviting only to penguins, seals and seabirds. They are remote, uninhabited and people have landed on the islands twice since a British sealer sighted them in November 1833.

The McDonald Islands have cliff-lined coasts and are surrounded by rocky shoals and reefs that are treacherous for boats and landing parties. They lie in stormy seas where temperate water from the Indian Ocean meets icy Antarctic water. Most days are cloudy, making it very difficult to obtain satellite imagery and photographs of the islands. Maximum temperatures average three degrees Celsius, and wind gusts can reach 210 kilometres an hour.

Two Australian scientists made the first landing in 1970 by helicopter from the French Antarctic ship *Gallieni*. Their 20-minute visit was to check whether there were fur seals, which had been wiped out years earlier on nearby Heard Island.

The second landing, in March 1980, was from the *Cape Pillar*. National Mapping charted the boat to survey the Heard Island–Kerguelen region, and fix the positions of islands and rocks in the region. They also planned to take aerial photographs of Heard and McDonald islands.

The small shore party, which included a botanist, biologist, geologist and surveyor, landed by helicopter and amphibious vehicle. They stayed ashore for six days to record their observations, while the ship sailed its survey lines with the helicopter aboard because the poor weather was unsuitable for aerial photography.

The senior surveyor onshore was Geoscience Australia's John Manning. He named many features of the McDonald Islands.

He says he would like to return to the McDonald Islands to check some of his old trig points and see what has changed.

'Thelander Point doesn't appear to be an appropriate name now, Williams Bay seems to be filled in, and The Needle may be gone', he says.

'Windward Point is no longer a point because there are about 400 metres of new land in front of it. The tumultuous bay I called Cauldron is now full of rock, and Flat Island is probably joined to McDonald Island by a shingle comprising gravel and pumice.'

Other new features appear to be a volcanic hill and a spit to the east of the island similar to one on Heard Island. Macaroni Hill was once the highest point with an elevation of 212 metres.

The McDonald Islands are located at 53.02° South and 72.36° East. They are about 1500 kilometres north of Antarctica, 4700 kilometres south-east of Africa, and 4100 kilometres south-west of Perth, Australia.

The nearest land is Heard Island, 43.5 kilometres to the east. Mawson Peak on Heard Island's mountain Big Ben is Australia's other active volcano. Heard, McDonald and the Kerguelen group of islands are exposed parts of the submarine Kerguelen Plateau.

Australia formally claimed the McDonald Islands in 1947 and in 1950 their sovereignty was transferred from the United Kingdom to Australia. They were World Heritage listed in December 1997 because of their pristine sub-Antarctic ecosystems and their geological activity.

The waters around the islands are teaming with Patagonian toothfish, Mackerel icefish, Grey rockcod and Unicorn icefish. Colonies of Macaroni and Gentoo penguins breed and feed from these islands.

The expanding land mass has implications for Australia's 200 nautical-mile exclusive economic zone and its territorial sea, which extends 12 nautical miles offshore.

The McDonald Islands are named after Captain McDonald, who sited Heard and McDonald islands from the brig *Samarang*, in January 1854. His wife was on this voyage and wrote the following about McDonald Island in her journal:

'It must be twin to Desolation Island for it is certainly a frigid looking place'.


**For more information phone John Manning on +61 2 6201 4352 or e-mail john.manning@auslig.gov.au**

# *Field day* for policy makers

On Monday morning October 11, a small group of policy makers from Environment Australia and the Department of Industry, Tourism and Resources in Canberra took a different route to work.

They flew by helicopter over the Gippsland, landed on a Bass Strait oil rig, returned to an onshore gas plant, before taking a plane to Canberra.

The roundabout route had a purpose. Geoscience Australia, with the support of Esso Australia (ExxonMobil) and Woodside, were exposing key Commonwealth Government personnel not trained in the geosciences, to the petroleum industry.

The visits were part of Geoscience Australia's two-day Oil and Gas field trip that began on the Sunday at Sale in Victoria. This area was chosen because of near-shore rigs, and because 65 million years ago, Bass Strait looked like the Sale area today.

Under the tutelage of petroleum geologist Dr Marita Bradshaw and two other Geoscience Australia staff, the six Commonwealth Government officers visited wetlands and beaches to learn about oil source rocks, shore drifts, and why Sale has the environment to eventually be a petroleum province.

Visits to the West Tuna Platform and the Longford Gas Plant gave the Commonwealth Government officers insights into petroleum exploration. A presentation by Woodside's Exploration Manager for Southern Australia, Ian Longley provided them with feedback on Australia's energy resources policies.

Dr Bradshaw's talks demonstrated how geoscience research helps petroleum exploration companies and the Commonwealth Government to make informed decisions about Australia's petroleum resources.

**For more information about the Oil and Gas field trip phone Mary Walsh on +61 2 6249 9236 or e-mail mary.walsh@ga.gov.au**

**Top:** Dr Bradshaw talks about the geology of the Gippsland lake district.

**Above left:** Dressed to tour the Longford Gas Plant

**Above right:** Dr Bradshaw gets down to the basics of oil formation.

## EVENTScalendar

*Compiled by Steve Ross*

### Australian Map Circle 31st Annual Conference

*Australian Map Circle*

2 to 5 February, Macquarie University, Sydney

*Contact:* Bill Stinson, Library, Macquarie University, Sydney NSW

**phone +61 2 9850 7541**
fax +61 2 9850 7513
e-mail bstinson@library.mq.edu.au

### ASEG 2003 – Growth through Innovation

*Australian Society of Exploration Geophysicists*

16 to 19 February

Convention Centre, Adelaide

*Contact:* SAPRO Conference Management, PO Box 6129 Halifax St, Adelaide SA 5000

**phone +61 8 8227 0252**
fax +61 8 8227 0251
e-mail aseg2003@aseg.org.au
*www.aseg.org.au*

### PDAC 2003 Convention & International Trade Show

*Prospectors & Developers Association of Canada*

9 to 12 March

Toronto, Canada

*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 2003 Conference & Exhibition

*Australian Petroleum Production & Exploration Association*

23 to 26 March

Conference & Exhibition Centre, Melbourne

*Contact:* Suzanne Nicholls, APPEA Ltd, GPO Box 2201, Canberra ACT 2601

**phone +61 2 6267 0906**
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e-mail feedback@appea.com.au
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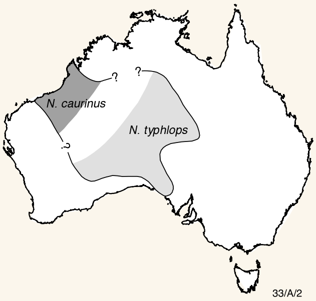



**Above:** Mary Pan of Watarru (Mt Lindsay) holds an itjaritjari she captured. The mole was released where it was found and its movements were monitored for 72 hours. It was active during the afternoons and evening, and provided key recordings of the distinctive tunnelling signature.

**Top:** Researchers and Earthwatch volunteers are mapping the backfilled tunnels of itjaritjari.

# Little Aussie digger makes *waves* in the desert

The small marsupial mole that lives in the red dunes and sand plains of central and north-western Australia is more elusive than the Scarlet Pimpernel.

Rarely seen, itjaritjari (southern marsupial mole, *Notoryctes typhlops*) and kakarratul (northern marsupial mole, *N. caurinus*) live almost entirely underground and, unless you live in one of Australia's deserts, you will only see them in museums as none have been kept alive in captivity for long.

Although marsupial moles live underground, they don't seem to form permanent tunnels or burrows. They tunnel for transport and the underground larvae and insects on which they feed but backfill the passage as they go. Blind and built for propulsion through sand rather than above ground movement, marsupial moles occasionally surface where they are prey to feral cats and foxes, as well as dingoes, birds of prey, snakes and goannas.

Scientists fear that the small mammals, with an adult weight of between 30 and 60 grams, are endangered. For a couple of years they have been trying to determine the conservation status and identify threats to the southern marsupial mole in particular. But the moles' elusive habits make them very difficult to study.

Monash University Research Associate in Biology, Dr Joe Benshemesh has been leading a collaborative research project to study the ecology of itjaritjari. The project involves Anangu-Pitjantjatjara Land Management, the Department of Environment and Heritage (South Australia), Earthwatch Institute, the Natural Heritage Trust, Monash University and Geoscience Australia's ANSIR (Australian National Seismic Imaging Resource). The project was started in 2001 and will continue for another two years.

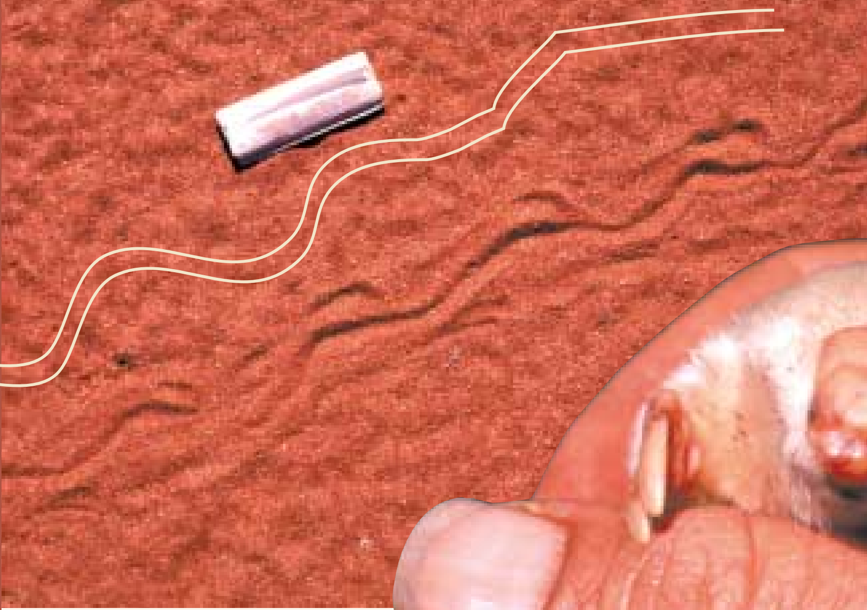
The study is located in the remote Anangu-Pitjantjatjara Lands on the edge of the Great Victoria Desert. The researchers work closely with the Traditional Owners, relying on their tracking skills and knowledge to locate itjaritjari. They also examine predator scats and search for signs of a surface visit, because marsupial moles leave a distinct triple track on the desert sand with their two hind feet and stumpy tail.

Researchers dig survey trenches and excavate backfilled passages to map itjaritjari movement. But they also need a method of observing live moles in their underground habitat. Recently they found what they were seeking in the high-tech skills and tools of geophysicists.

Even though marsupial moles are small, geophones and seismic recorders can pick up vibrations from their tunnelling. These vibrations create a pattern unique to marsupial moles. The Anangu-Pitjantjatjara people captured itjaritjari for researchers to record tunnelling signatures and identify patterns.

Using ANSIR geophones, the researchers set up a grid of seismic sensors to monitor itjaritjari movements. Geophones are placed 10 metres apart in triangular grids that are each about a third of a hectare. A marsupial mole in any grid is always within six metres of at least one geophone. The geophones are manned around the clock with the help of Earthwatch volunteers.

The data however are collected manually, and this is a slow process. As well, it is difficult to distinguish different individuals and determine movement rates with a manual method.



**Left:** The marsupial mole leaves a distinct triple track on the desert sand with its two hind feet and stumpy tail.

ANSIR Operations Manager, Geoscience Australia's Tim Barton is working with a team of researchers from Monash University to develop an automatic tracking system. The plan is to use a 32-channel acquisition system capable of simultaneously picking up and recording all geophone signals in a grid, and to develop software to track mole locations and movements. Eventually, a computer in the field may identify itjaritjari by their distinctive tunnelling signature and track them automatically. The system will allow researchers to monitor itjaritjari in the wild more effectively and for longer periods.

Marsupial moles are fast burrowers and can dig to depths greater than 2.5 metres. They use their nose pad and front feet to excavate sand, and their hind feet to propel them forward. The front feet have two claws, enlarged for digging, and the back feet are webbed to help drag sand behind them as they move. They are active day and night.

Other than the nose pad and tail, moles are covered in luxuriant fur that reduces friction through the sand. The neck vertebrae are fused to make the body more rigid and suitable for pushing through sand. The stumpy furless tail braces the spine while digging.

Itjaritjari are only 10 to 12 centimetres long. Nothing is known of their social structure, and scientists are unsure how boy meets girl in their subterranean world. They make a low-intensity squeaking sound, which is presumably for communication.

Marsupial moles are unrelated to placental moles of the Northern Hemisphere, even though they resemble some of them. Marsupial moles never have to drink and, unlike most mammals, they do not seem to regulate their body temperature greatly. They breathe the air between grains of sand.

Females have a rear-facing pouch to keep out the sand, and there are two teats. Itjaritjari and kakarratul are not closely related to any other marsupial, having diverged some 64 million years ago.

There are physical differences between itjaritjari and the smaller kakarratul, such as the size of the nasal pad and lower teeth.

**For more information phone Joe Benshemesh on +61 8 8953 7138 or e-mail jbenshemesh@bigpond.com or phone Tim Barton on +61 2 6249 9625, e-mail tim.barton@ga.gov.au**

**The field switchboard:** Each socket (A to P2) represents a geophone placed 10 metres apart. On rotation, each geophone is listened to for one minute until an itjaritjari is detected. To cover about a third of a hectare, researchers need two or three of these switchboards.

**Below:** As a child Robin Kankanpakantja, Traditional Owner of Walalkara listened to ijaritjari in the dunes. Nowadays he uses modern technology to listen for mole tunnelling.

# Map maker acknowledged for *public service*

**Above:** Ruth Dodd pictured with Geoscience Australia CEO, Neil Williams, at the dinner for recipients of the Public Service Medal, on October 29 in Canberra.

No-one would tell Ruth Dodd to get lost, not in Australia anyway. She knows just about every place and landmark on the Australian continent, and she can certainly read maps.

For the past 34 years, Dodd has ensured that our topographic maps are well drawn, with few errors, and cover every part of Australia. She was recently awarded the Public Service Medal for her services to Australia through mapping.

But it has been many years since Dodd has drawn a map, because as the Manager of Geoscience Australia's Topographic Mapping, she organises others to produce them.

Geoscience Australia's topographic maps are not drawn in-house. Instead, Dodd prepares work packages of three to six maps, and on a monthly basis she calls tenders, assesses the bids and recommends which contractor should be allocated the work. Dodd is also on the small team that assesses a map when it is completed to decide whether it passes muster.

At present, the 1:250 000 scale topographical maps of Australia are being revised. There are 513 maps in this series and by November this year, 440 maps had been updated.

Companies that win the work are supplied with a lot of information about the area to be mapped. They are given older editions of the maps, recent satellite imagery, and clips of relevant material from some 30 databases that Geoscience Australia accesses or maintains. These include databases on railways, national parks, Aboriginal land and reserves, aircraft facilities, reefs and mines.

For consistency across the maps, contractors are also given specifications that describe how to apply symbols for features in the landscape. For example, there are rules on water courses that state that 'perennial water courses must have held water for nine out of 10 years' and that 'a channel must be verified by satellite imagery'. The specifications also include guidelines on what makes maps too detailed for their scale.


Dodd's research staff spend a lot of time checking details for the work packages before they are assigned, and to answer contractor queries once the work is under way. They comb through databases and web sites, phone homesteads in remote areas to locate features, and ask Automobile Associations whether a road is sealed or unsealed.

'We contact all sorts of people to verify all sorts of things', says Dodd.

The first maps revised are the oldest maps and those in regions that have undergone the most changes. BAE Systems, Aspect North, Fugro Spatial, Sinclair Knight Mertz, Integraph and Photo Mapping are the current contractors.

Geoscience Australia follows accepted cartographic forms used by other mapping agencies and geological surveys, with a couple of differences.

'Some countries depict freeways in a bright blue, whereas we tend to show our roads in red', says Dodd.

Dodd is also working on some new map symbols, for wind farms and aquaculture.

'The convention for windmills on European maps is a cross on a stick, but that is close to our wind pump symbol', says Dodd, 'so we are considering a triangle with three blades for a wind farm.

'But we are thinking about using a descriptive note rather than a symbol for aquaculture, because it may include different fish and shellfish.'

So what set Dodd on the road to managing Australia's most recognised and used series of maps?

After technical school training in Darlinghurst, Sydney, Dodd became an interior designer with the Architects Branch of Public Works in New South Wales.

'I did the colour schemes and selected furnishings for government buildings such as schools, police stations and hospitals', says Dodd.

'But after a while it became too routine and boring.'

Dodd then joined street-directory company HEC Robinson (later Universal Press), where she could apply her design skills and strong sense of colour to the practicality of maps.

In 1968, Dodd and her husband moved to Canberra, where she gained a job as a drafting assistant in what is now Geoscience Australia's National Mapping Division. She soon qualified as a drafting officer and has remained with National Mapping ever since.

'There has never been a dull moment as far as I am concerned', she says.

'I love it. I get a lot of pleasure out of handling maps, looking at them, and being part of their design.'

So does Dodd take a break from maps when travelling and on holidays?

'I never go anywhere without a map.

'When we travel we often take the back route or the round about way along all the tiny roads.

'Even when travelling from Canberra to Melbourne, we will take a slightly different route or go down through the mountains.'

And who determines the route?

'I always navigate', she laughs. 'For some reason, friends ask me to read the maps.'

Dodd does not have a favourite map, but she admits that she prefers the 1:100 000 scale topographic map.

'There is so much more detail with a scale of one centimetre to a kilometre rather than 2.5 kilometres to a centimetre.'

It has taken almost seven years to update the 1:250 000 series of topographical maps of Australia, and before the revision is completed the cycle starts again.

But these maps are no longer just paper products. They are now available as digital data. Each map is a tile in the GEODATA TOPO-250K series 2.

The database that stores these tiles is being developed so that tiles can be seamlessly 'stitched' together and web users can view and download much bigger areas than that shown on a single paper map. This capability will be in place towards the end of 2003.

Dodd was presented with the Public Service Medal by Australia's Governor General on September 21 at Government House for her outstanding contribution to the Australian public through mapping. She was one of 46 recipients of the award on this year's Queen's Birthday Honours list.

**For more information phone Ruth Dodd on +61 2 6201 4380 or e-mail ruth.dodd@auslig.gov.au**

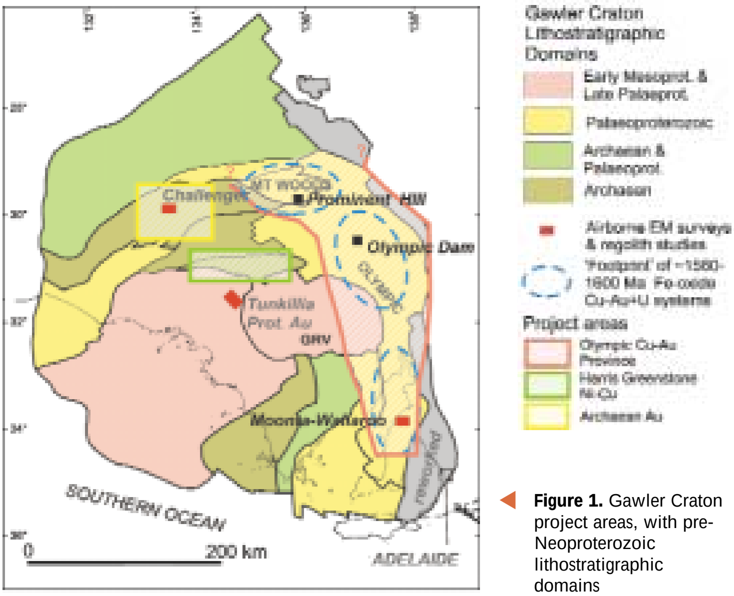
# *In-depth study* of mineral provinces evolution

Much of the world's lead, zinc and silver resources, and Australia's gold, copper and uranium mineral wealth are hosted in the 1.5–2.5 billion year old strata of northern, central and southern Australia. What factors and events caused such a rich endowment in rocks of this age?

To answer this question and thereby reduce exploration risk, a better regional- and terrane-scale understanding of the geological evolution of Australia during the Palaeoproterozoic and early Mesoproterozoic is needed.

From 1995 to 2000, Geoscience Australia undertook regional framework studies of the Mount Isa region. These studies underpin fluid migration research currently under way in AMIRA project P552. Two and a half years ago, Geoscience Australia commenced two major regional studies of the geological evolution of the Gawler Craton of South Australia and the Tanami –Arunta region of central Australia.

This article provides recent results of these two regional projects, and the advances being made in constraining the age of tectonically driven events associated with the early Proterozoic rocks of southern, central and northern Australia.



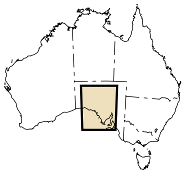



**Figure 1.** Gawler Craton project areas, with pre-Neoproterozoic lithostratigraphic domains

## GAWLER PROJECT

The Gawler Craton's extensive regolith and sedimentary cover limits what is known about the basement geology. This affects perceptions of the region's prospectivity and also exploration.

In July 2000 Geoscience Australia and the Office of Minerals and Energy Resources South Australia (MER) began a program to develop a regional geological and metallogenic framework for discovery of Proterozoic copper and gold deposits, and Archaean gold and nickel deposits. This involves identifying and mapping in 3D, where possible, the key regional, spatial, and temporal controls on the formation of selected mineral systems. Complementing this program are regolith studies, aimed at developing more effective methods for exploration through the cover.

Currently, the major focus is the Olympic copper-gold province that includes the Olympic Dam, Mt Woods and Moonta-Wallaroo regions (figure 1). Regolith studies, including airborne EM surveys, have been undertaken around Challenger, Tunkillia and Yorke Peninsula.

Area selection parallels that done in exploration. The initial aim is to define regions that are most prospective and fertile for selected mineral systems.

Geoscience Australia's team of 14 geoscientists and technical staff is collaborating with staff at MER, CSIRO, CRC LEME and several universities. Other modules of the project include:

- Relationship between gold mineralisation and magmatism in the Tarcoola goldfield (PhD study, GA–ANU)
- Nickel-copper-platinum group elements potential of the Archaean Harris Greenstone Belt (GA–MER)
- Regional geological setting of the Archaean Challenger gold deposit (GA–MER)
- Copper-gold metallogeny of the Mt Woods Inlier (PhD study, CODES–GA–MER).

### Exploration under cover

To understand mineralisation in the regolith, the contrasting geological and regolith settings of Challenger gold, Tunkillia gold, and Moonta-Wallaroo copper-gold districts were selected for pilot studies.

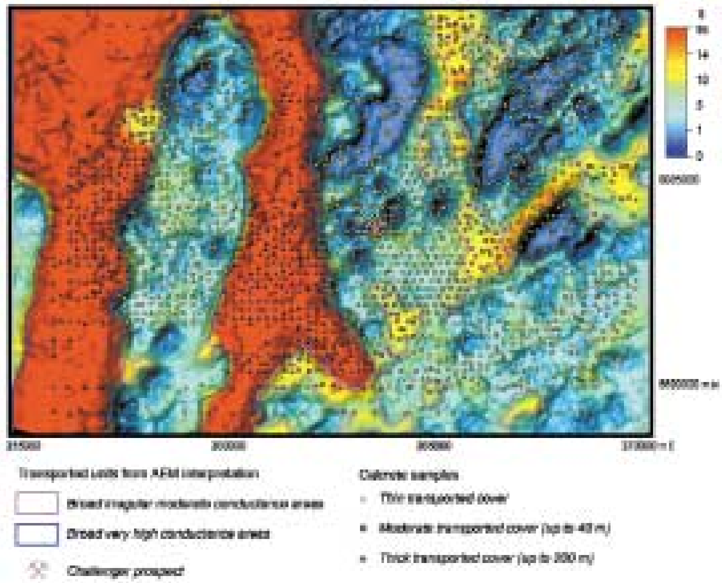



**Figure 2.** Regolith conductance image for the Challenger area, overlain by calcrete sample locations classified according to the thickness of transported cover interpreted from AEM.

Integrating airborne EM data, aeromagnetics, geomorphology, hydrology, regolith, groundwater geochemistry, and basement geology added greatly to understanding post-mineralisation modification (figure 2). The results for Challenger and the airborne EM data are available on Geoscience Australia's web site. Key outcomes of the regolith pilot studies are:

- 3D delineation of palaeochannels, which allows discrimination between transported and in-situ regolith volumes to depths of 100–200 metres;
- Identification of groundwater reservoirs and flow paths (e.g. mine water supply at Challenger);
- Mapping depth to fresh rock;
- Delineation of hydrothermal alteration zones and other basement units that weather differently to surrounding rocks (e.g. kaolinitic alteration);
- Direct detection of basement-hosted conductors.

District-scale airborne EM, if acquired relatively early in an exploration program, can achieve considerable cost savings, because it complements other data sets used in the screening and helps prioritise areas for subsequent geochemical sampling and drill testing.

### Proterozoic copper-gold systems

The Olympic copper-gold province is a metallogenic belt that is more than 500 kilometres long (figure 1). The province is typified by three known regions or 'footprints' of early Mesoproterozoic hydrothermal and magmatic activity: the Mount Woods Inlier (including Prominent Hill), the Olympic Dam region, and the Moonta-Wallaroo-Roopena region (figures 1 & 3).

There may be extensions of the Olympic Cu-Au province in the northern Gawler Craton. Each footprint contains characteristic high- to low-temperature iron-oxide-bearing hydrothermal alteration, copper-gold mineralisation, and felsic to mafic intrusions of the Hiltaba Suite (~1590 Ma), with or without the Gawler Range Volcanics.

Integration of 3D geology and structure with studies of hydrothermal fluids and geochronology has improved understanding of regional controls on the location of copper-gold systems. A model of the crustal architecture of the central Olympic Cu-Au province (figures 4a–c) was built by re-interpreting new grids of gravity and magnetic data in plan and section. The model incorporates data obtained from drill core, 27 new zircon ages and six argon-argon ages, density and magnetic susceptibility, and specialised processing of geophysical data.

The basement to the Stuart Shelf is now seen as the northerly continuation of major lithostratigraphic units of the south-eastern Gawler Craton (figure 3). Conjugate north-east- and north-west-trending transtensional faults controlled the emplacement of Hiltaba Suite granitoids at about 1595–1580 Ma. At least some of these structures also acted as fluid pathways. They are evident in magnetic datasets as zones of demagnetisation.

The Jubilee Fault, passing through the Olympic Dam deposit, is interpreted as one such structure. These pathways are expected to have linked metal and fluid sources with sites of deposition, and are currently being investigated.

Argon dating of hydrothermal sericite associated with hematite-chlorite-carbonate alteration, from a drill hole about 80 kilometres south-east of Olympic Dam, supports a hypothesis of regional flow of oxidised fluids at about 1590 Ma. This event is recognised in all three footprints of the Olympic province, and overprinted higher temperature alteration characterised by either magnetite-rich calcsilicate-alkali feldspar alteration or magnetite-biotite alteration.

Although copper-gold-uranium ore at Olympic Dam and mineralisation at Prominent Hill is associated with hematisation, the high-temperature fluids associated with regional (weakly mineralised) magnetite alteration carried more than 500 ppm copper. Efficient deposition from these fluids, to form copper ore, would require strong physical and/or chemical gradients, such as differences in temperature, redox, sulphur or salinity.

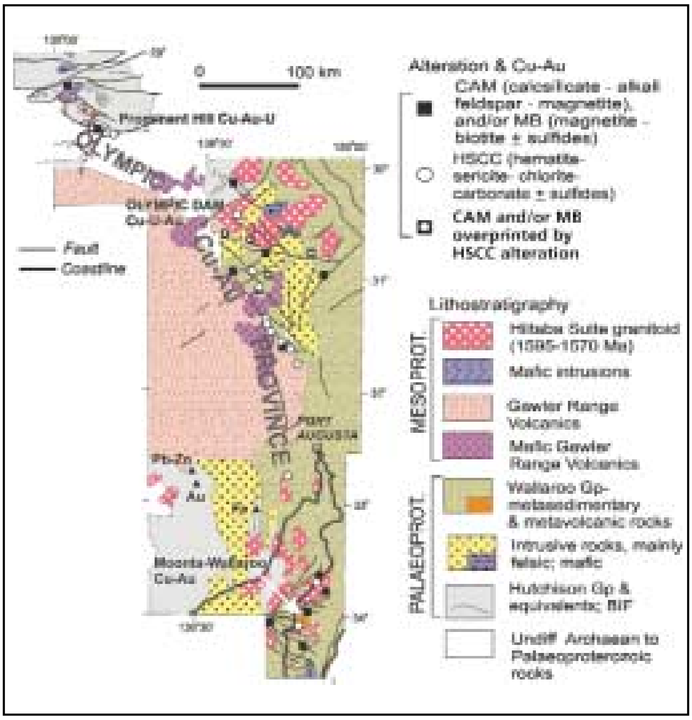
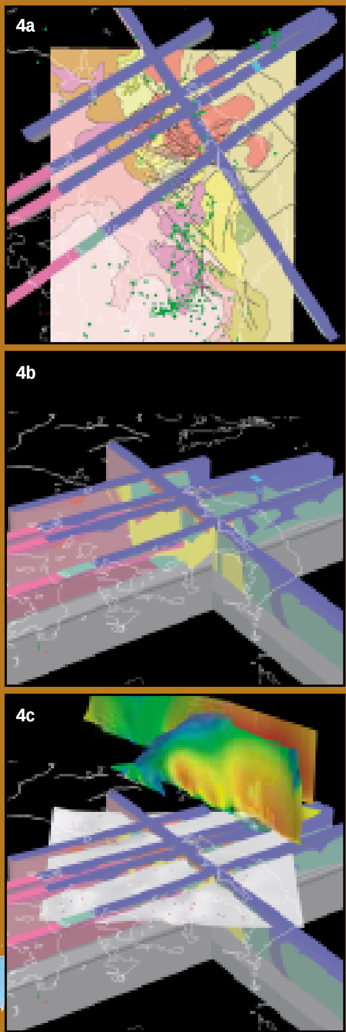
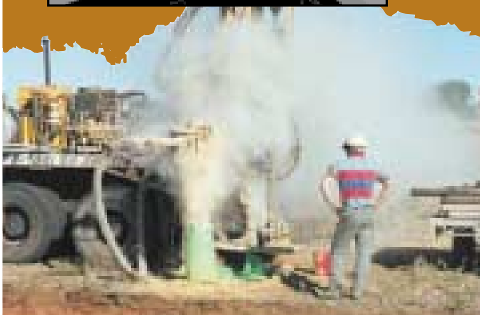



**Figure 3.** Interpreted basement geology (pre-Neoproterozoic) of the Olympic Cu-Au province, and distribution of hydrothermal alteration types in drill holes

**Figure 4.** 'Snapshots' of the central Olympic Cu-Au province in 3D. **4a:** A plan view of interpreted basement geology map (width 200 km, lake outlines in white) with locations of anomalous copper shown as green circles, and a grid of four NE-SW cross-sections and one NW-SE cross-section interpreted from gravity and aeromagnetic data. **4b:** Oblique view (from south) showing the five interpreted cross-sections. **4c:** A surface of depth-to-magnetic source (grey sheet with sources shown as red dots). The two rainbow-coloured sheets represent the locii of strong gradients in gravity data.



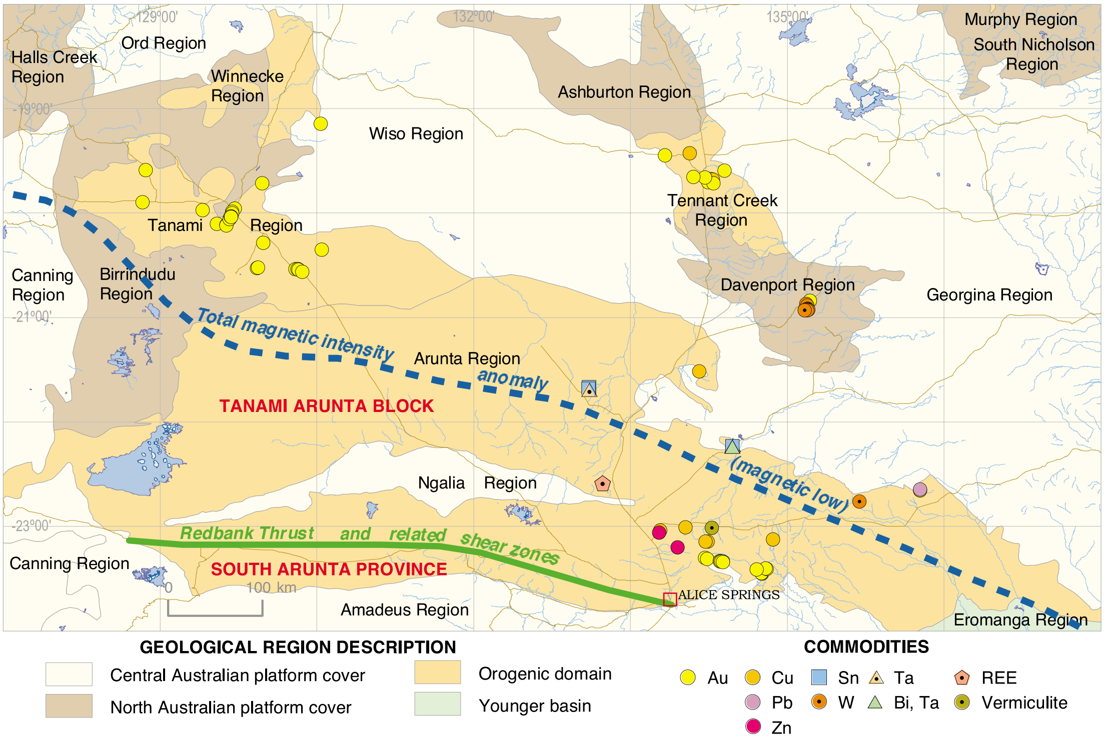
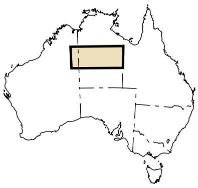



**Figure 5.** Distribution of the Tanami, Arunta and Tennant Creek regions showing the location of major inferred boundaries, rocks affected by the Larapinta event, important mineral deposits and selected areas of active exploration



The two end-member regimes may be evident in geophysical data sets as juxtaposed magnetic highs and lows, each with coincident gravity highs. At Prominent Hill, the best copper mineralisation lies in a gradient across two contrasting geophysical and chemical regimes.

New uranium-lead ages for the higher temperature alteration from the Moonta-Wallaroo district and in the Mt Woods Inlier (Manxman prospect) are within error of the timing of oxidised fluid flow. This indicates that the copper-gold hydrothermal systems of the Olympic copper-gold province are compressed in time and space, with rapid uplift possibly causing superposition of shallower alteration styles over assemblages formed at deeper crustal levels. Regional and local structural settings where such contrasting lithological and hydrological environments were juxtaposed are, therefore, favoured sites for fluid-rock reaction or fluid mixing causing deposition of copper-gold ore.

## NORTH AUSTRALIA PROJECT

The Tanami province, which straddles the Northern Territory–Western Australia border (figure 5), is one of the hottest gold plays in Australia. Gold was discovered in 1901, but modern, systematic exploration did not begin until 1969. The first modern production of gold in the Tanami began in 1987 and it has grown enormously with a production of 600 000 ounces predicted in 2002.

Over the past decade, Tanami's high potential has attracted gold mining giants AngloGold and Barrick into the area to join the established producer Newmont. Gold assets in the Tanami were one of the key drivers to last year's takeover battle for Normandy, which was eventually won by Newmont.

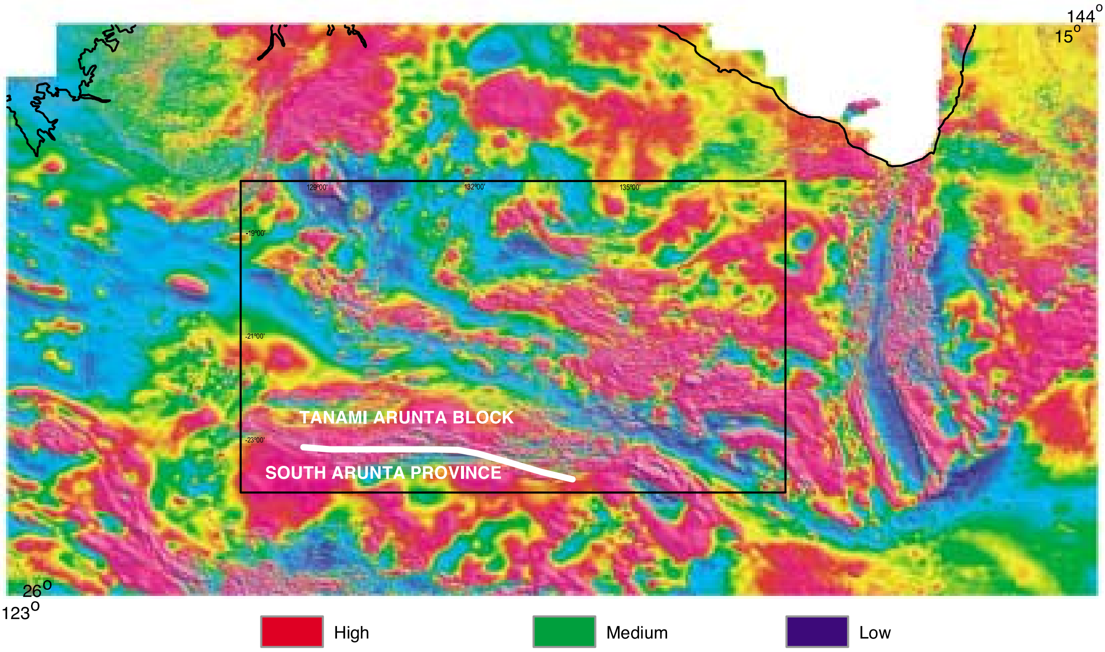



**Figure 6.** Aeromagnetics of the Tanami, Arunta and Tennant Creek regions. Note the broadly east–west-trending, linear magnetic low.

The Arunta, to the south, is seen as a poor cousin. However, this perception may be changing as Newmont, in joint venture with Tanami Gold, is pursuing gold in the Lake MacKay region. A joint venture involving major and junior companies is also exploring for base metals in the eastern and southern Arunta.

Geoscience Australia, in partnership with the Northern Territory Geological Survey, began an assessment of the North Australian Craton just over two years ago.

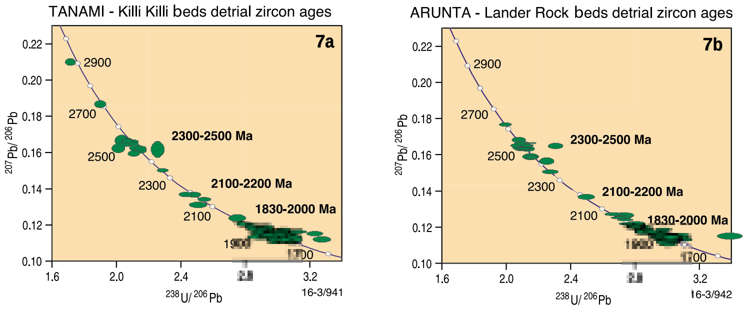
## Province correlation studies

The Tanami region and Arunta Inlier were considered separate geological entities. The boundary was defined by a very strong, linear, demagnetised zone traceable from the Canning Basin in the west, to the southern boundary of the Mt Isa Inlier in the east (figure 6). The project's work suggests that this magnetic feature is not a fundamental boundary, but an overprint from a later, possibly Phanerozoic, event.

Zircon age distribution patterns are identical from the Killi Killi beds, an extensive turbiditic package in the Tanami, and the Lander Rock beds, a similar unit in the northern Arunta (figures 7a & 7b). They have similar maximum depositional ages (ca 1840 Ma) and similar spikes in detrital zircon ages. The Late Strangways Orogeny affected the Arunta at about 1730 Ma. Recent work indicates that this orogeny extended into the Tanami, with intrusion of granite, rubidium and strontium re-setting, and biotite crystallisation occurring at about 1730 Ma.

A more likely boundary for the North Australia Craton is the Redbank shear system in the southern Arunta Inlier. Geoscience Australia geochronological data and mapping by the NTGS indicate that these shears separate the Tanami–Arunta block from the South Arunta province (figure 5), which is characterised by younger and possibly more primitive crust with quite a different deformation history.

Another important change in understanding the geology of the North Australia Craton has been the recognition that an Ordovician granulite (Larapinta) event has affected the Harts Range Group in the eastern Arunta. The Harts Range Group is Neoproterozoic to Cambrian age, and not Palaeoproterozoic as previously thought. The North Australia project, in collaboration with Australian National University and Adelaide University, is delimiting the extent of the Larapinta rocks, their tectonic origin and ramifications to exploration.




Figures 7a & 7b. Comparison of detrital zircon populations from the Killi Killi and Lander Rocks beds

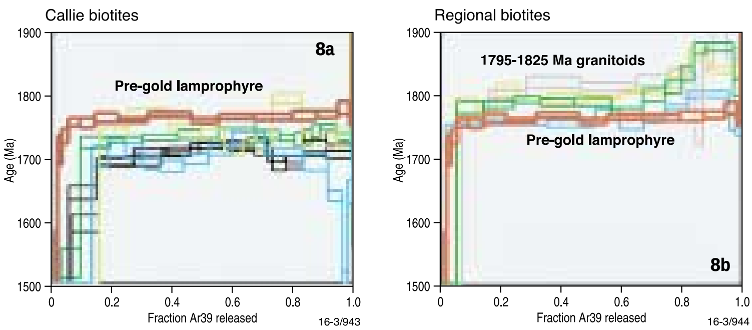
## Gold in the Tanami

In the late 1990s, NTGS began a program of regional mapping and acquisition of geophysical data in the Tanami region. Geoscience Australia assisted through gravity acquisition and specialist geochronological services. When the project began, Geoscience Australia increased its activity in the Tanami and included studies of the ore fluids, geochemistry, and geochronology of ore deposition.

Interim results from this research indicate the possibility of multiple gold mineralising events in the region. Early epi- to mesozonal deposits are possibly associated with granitoid intrusion at around 1810 Ma (e.g. Tanami district). The later mesozonal deposits at around 1730 Ma (e.g. Callie and The Granites) possibly occurred as a distal thermal effect of the Late Strangways Orogeny. Alteration sericite from the Carbine deposit in the Tanami district has a total fusion argon-argon age of 1810 Ma, whereas flat portions of argon-argon spectra from gold-related biotite at the Callie deposit indicate an age of around 1730 Ma (figures 8a & 8b). Additional geochronological investigations are under way to further test these hypotheses.

Fluid and geochemical data also support a history of different gold mineralising events. The fluid characteristics of the Tanami district differ substantially from those of Callie, The Granites, and Groundrush. The Tanami deposits formed from low temperature, gas-poor fluids high in the crust. The other deposits formed from higher temperature, gas-rich fluids deeper in the crust.

Differing host rocks and thermodynamic modelling indicate that a number of processes caused gold deposition. These include fluid mixing, boiling, reduction or effervescence caused by interaction with graphitic sediment, and desulphidation by reaction with iron-rich wall rocks. The results point to a number of structural and lithological traps for gold.




Figures 8a & 8b. Argon-argon spectra of hydrothermal biotites from the Callie deposit compared with a spectrum from a biotite-rich lamprophyre with the ore veins cut and with biotite from regional granitoids.

## Eastern Arunta base metal

Since their discovery in the late 1950s, base metal prospects in the eastern Arunta have been enigmatic, mainly due to the granulite facies metamorphism that overprinted the Strangways Metamorphic Complex hosting these deposits. Work done by the Bureau of Mineral Resources (Geoscience Australia's predecessor) in the 1970s indicated that these prospects were metamorphosed volcanic-associated massive sulphide (VAMS) deposits. The NTGS and Geoscience Australia re-examined these deposits to establish the potential for base metals in the eastern Arunta.

Most prospects in the stratigraphically lower part of the Strangways Metamorphic Complex appear to be VAMS deposits that formed around 1800 Ma, as suggested by previous researchers. However, Oonagalabi appears to be a carbonate-replacement deposit, and Johnnie's Reward prospect appears to be an iron-oxide copper-gold deposit. The Strangways Metamorphic Complex therefore has the potential for base metal deposit types other than VAMS.

## PROTEROZOIC EVENTS PROJECT

The previous sections show that many of Australia's Proterozoic regions contain a complex but periodic history of sedimentation, magmatism, tectonism, metamorphism, fluid flow and mineralisation. Time-space-event plots provide valuable insights into the geological history and processes in these regions and help identify events associated with mineralisation. They also provide the basis for event correlations between regions, and plate tectonic models of the evolution of the Australian Proterozoic.

The Australian Proterozoic Events project is drawing together data and understanding from Geoscience Australia's current and recently completed Minerals and Geohazards Division projects to provide the most up-to-date tectonostratigraphic information for the Mount Isa and McArthur basins, the Arunta and Tanami inliers, and the Gawler and Curnamona cratons.

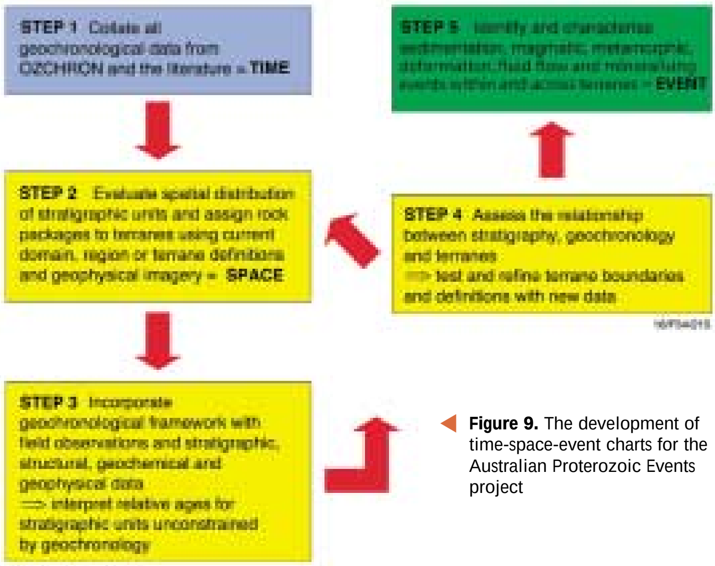



**Figure 9.** The development of time-space-event charts for the Australian Proterozoic Events project

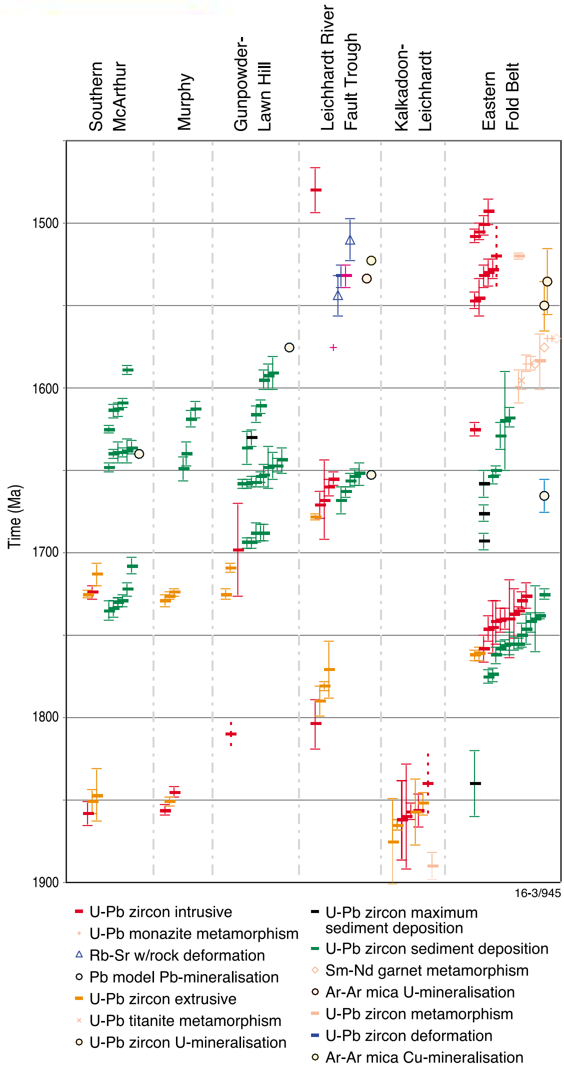



**Figure 10.** Time-space plot for the Mount Isa Inlier and Southern McArthur Basin. Solid lines indicate errors on geochronological ages, and dashed lines indicate correlative or maximum depositional ages. The stratigraphic units within each region are ordered according to age. Many sources were used to construct the time-space plot.

## Time-space-event plots

Figure 9 summarises the approach used to construct time-space-event plots for Australian Proterozoic regions. The basis is geochronological data (including K-Ar, Ar-Ar, Rb-Sr, Nd-Sm, U-Pb isotope data) from Geoscience Australia's OZCHRON database, and the literature. These data are used to constrain the age of stratigraphic units, and the timing of metamorphism, deformation, and fluid flow within a region.

Time-space plots have been compiled for the Mount Isa Inlier and Southern McArthur Basin, Arunta and Tanami inliers and the Gawler Craton. See figure 10 for an example of the information recorded in the plots.

The aim is to identify and characterise major periods of geological activity, or events, within each terrane. The plots can then be used to identify terranes, boundaries and/or events requiring further scientific investigation, and new or more focused targets for mineral prospectivity.

On a national scale, the plots will allow the development of event correlations between different Proterozoic areas. They are prerequisites for descriptions of tectonic settings and continent-wide plate reconstructions during the Australian Proterozoic. They will also allow identification of provinces for the Geoscience Australia Provinces database and provide the basis for the development of a national Events database.

**For more information about Geoscience Australia's minerals projects:**

**Gawler project—Roger Skirrow, tel. +61 2 6249 9442 or e-mail roger.skirrow@ga.gov.au Web address www.ga.gov.au/rural/projects/gawler.jsp**

**North Australia project—David Huston, tel. +61 2 6249 9577 or e-mail david.huston@ga.gov.au Web address www.ga.gov.au/rural/projects/20010917_41.jsp**

**Australian Proterozoic Events project—Peter Southgate, tel. +61 2 6249 9206 or e-mail peter.southgate@ga.gov.au or Narelle Neumann, tel. +61 2 6249 9429 or e-mail narelle.neumann@ga.gov.au**

# *Geoscience an asset* to natural resource management

Australia's future depends on the sustainable use and management of its natural assets. Land use and natural resource management decisions must be based on a sound understanding of the systems in which these assets occur.

Individual decisions are usually the responsibility of states or local governments. But the Commonwealth has an interest in outcomes, and collects and manages a wealth of information that could be used to underpin the decisions.

There are significant gaps in our understanding of most natural systems and the impacts of human activity on environment and climate. There is a need to move from a largely symptomatic to a more strategic approach, and this requires multi-disciplinary studies.

Geoscience should play an important role because:

- The geology exerts major controls on such factors as the physical and chemical features of soils, erosion, groundwater, topography, scenery, vegetation, and distribution of mineralisation.
- Geoscience approaches and technologies, most commonly applied in mineral exploration, can decrease risks in land-use and natural resource management decisions. It can provide important insights into landscape evolution and what is happening below the top metre or so.
- Geoscience Australia's activities in relation to land-use and natural resource management are conducted mainly through the Cooperative Centre for Landscape Environments and Mineral Exploration (CRC LEME). Through CRC LEME, key staff are heavily involved in the National Action Plan for Salinity and Water Quality, and in developing other environmental applications for regolith geoscience.

Geoscience Australia is also exploring opportunities to contribute to an information base for decisions on natural resource management and land use. It is exploring two scenarios.

- Collaboration with one or more state geological surveys on projects with a land-use and natural resource management focus, as an extension of the successful National Geoscience Agreement initiative.
- Integration of wide-ranging geoscience studies with studies by land, water, environmental and other agencies into a demonstration project to show what can be achieved through a multi-disciplinary, multi-agency approach.

The latter scenario requires a range of groups to agree that a demonstration project is warranted, and to commit resources to it. It should draw on information and techniques from CRCs, other research groups, and government agencies responsible for decision making.

Geoscience Australia's contributions could involve information management, geochemical surveys, geophysical interpretations and modelling.

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

# *Mineral exports* a near record, but 2nd for exploration

Gold is Australia's number one metal commodity export, but it had to take silver for world mineral exploration in 2002. After a decade as the world's leading exploration destination, Australia lost its number one position to Canada this year (figure 1).[1]

Canada's share of world exploration budgets rose from 16.6 per cent in 2001 to 18.3 per cent in 2002. Australia's share increased marginally from 17.5 per cent to 17.6 per cent,[1] which is good news when global and national mineral exploration continue to decline. World exploration budgets fell by 13 per cent to US$1.9 billion for calendar year 2002 (down from US$2.2 billion).

Canadian exploration budgets benefited from the interest in diamonds, a reduction in overseas expenditure by Canadian companies in favour of Canada, from a shares scheme that delivers tax benefits to investors rather than the company, and new government geoscience programs.

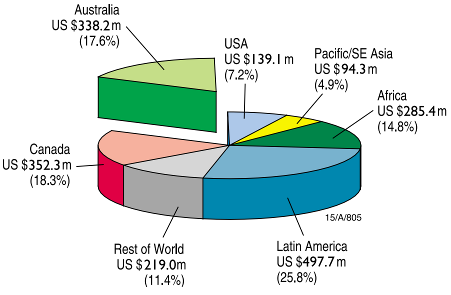



**Figure 1.** Global mineral exploration budgets 2002[1]

## AUSTRALIAN EXPLORATION

Despite mineral resource exports worth $55.4 billion in 2001–02,[2] mineral exploration expenditure for the financial year 2001–02 fell by six per cent to $640.6 million.[3] This was the lowest current dollar result since 1992–93. In constant dollar terms, this was the lowest level of exploration spending since 1978–79 (figure 2).

Western Australia remained the dominant state (figure 3), but its spending fell by 10 per cent. New South Wales spending fell by almost 16 per cent and Tasmania's by 57 per cent. Exploration expenditure rose in the other states and the Northern Territory, with the greatest increase in Queensland (up almost 12% on the previous year).

Gold remained the dominant commodity (figure 4), but with a slight reduction (down about 3%) in its share of total spending. Mineral sands exploration was at a record level of $33.2 million, reflecting the continuing high level of activity in the Murray Basin.

Other commodities showing significant changes in expenditure levels on the previous year were copper (up ~27%), coal (up 20%), silver-lead-zinc (down ~37%), and nickel (down ~26%).

## AUSTRALIAN OUTLOOK

Australian mineral and energy resource exports are forecast to rise by about four per cent in 2002–03, to a record $57.8 billion[3], on the back of improved metal prices and continued near-record levels of production. Even though Australian mineral exploration expenditure throughout 2002 will be lower than in 2001,[1] there are signs that the outlook will improve for mineral exploration next year.

### Metal prices

Gold has dominated Australian mineral exploration since 1986–87 (figure 2). Gold prices have increased significantly over average 2001 prices, with ABARE forecasting an increased average price of around US$307 per ounce for the whole of 2002, followed by a decline to around $295 per ounce in 2003. These higher gold prices, especially in Australian dollar terms, should increase exploration activity.

The Australian Gold Council/ Deloitte Touche Tohmatsu 2002 Gold Investment Survey predicts a 25 per cent increase in gold exploration spending in 2002–03. Several global gold majors (notably Barrick Gold and Newmont Australia) have also indicated likely increases in gold exploration budgets. However, increased gold exploration spending tends to lag behind increased gold prices by 12–18 months.[4] Significantly increased exploration spending therefore is unlikely before the March or June quarter of 2003.

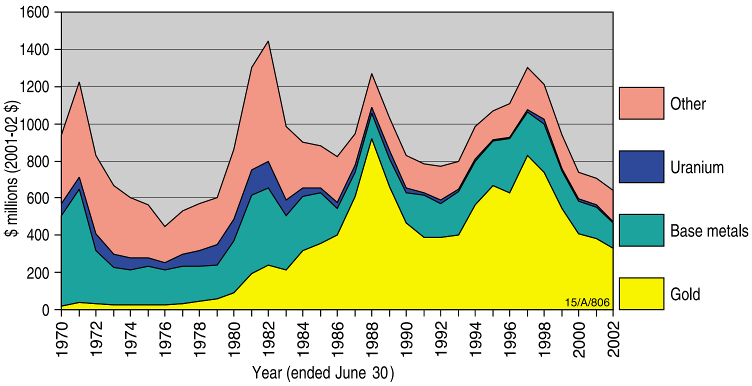



**Figure 2.** Australian mineral exploration expenditure in constant 2001–02 dollars. Based on Australian Bureau of Statistics data deflated by a Consumer Price Index provided by ABARE.

The outlook for base metal prices is improving, but depends on global economic recovery. ABARE predicts significant price rises for base metals in 2003–04.[3] A significant increase in demand for base metals (especially nickel), notably from China, is forecast by other commodity analysts. This suggests that base metal exploration spending will not dramatically improve in the short term, but prospects appear brighter for the medium term.

## Budgets & raising capital

Over the past 20 years, most exploration funds spent in Australia have come from domestic sources. Recent mergers and acquisitions have slightly increased the proportion of funding from other sources.

The Metals Economics Group 2002 Survey indicates that just under 72 per cent of Australian mineral exploration budgets in 2002 came from local sources, compared with 74 per cent reported for 2001.[1] Of the 221 surveyed companies exploring in Australia, only five had 2002 exploration budgets of US$10 million or more. More than 70 per cent had exploration budgets under US$1 million, and these accounted for less than 20 per cent of total exploration spending.

Junior companies historically have played an important role in Australian mineral exploration, and they are taking on a new role as the operating partner in strategic exploration alliances with major mining companies.[5] Juniors rely heavily on capital raising to fund exploration, but many are gaining exploration funds (or equity placements) though alliances, joint ventures and partnerships with majors.

The number of mineral exploration floats on the Australian Stock Exchange increased substantially early in 2002, but has since dried up. This was after several years of very low levels of capital raising by mineral resource companies. The funds raised in each float have been relatively small (~$4 million).[4] These are important contributions to exploration, but an increase in exploration budgets of the larger companies is required to substantially raise Australian exploration expenditure.

## Exploration 'hot spots'

Most of the world's largest exploration and mining companies are engaged in exploration in Australia, either on their own or in joint ventures with junior companies.

Exploration is widely spread across the Australian continent, with much of the known mineral provinces under title or application for a wide range of mineral commodities. The Yilgarn Craton, which attracts about 40 per cent of total Australian exploration effort (~9% of global exploration) continues to draw exploration, as do other major established mineral provinces such as Mt Isa, the Lachlan Orogen in central western NSW, and the Broken Hill region, because of their proven endowment.

Recent discoveries have highlighted the potential and the under-explored nature of a number of 'newer' provinces, notably the Murray Basin (mineral sands), the north-east Gawler Craton (copper-gold), the Tanami region (gold), the east Kimberley (nickel, base metals, platinum), and the Musgrave Ranges (nickel, copper). Other emerging mineral provinces include the Ashburton and the north Kimberley provinces (gold).

Discoveries in frontier provinces such as the Gawler, Tanami and Musgraves highlight Australia's exploration opportunities. These discoveries combined with highly favourable discovery costs, especially for gold, provide compelling reasons for continued exploration in Australia.

Australia must build on its inherent advantages and high prospectivity to recover its position as the world's number one exploration destination.

**For further information phone Mike Huleatt on +61 2 6249 9087, e-mail mike.huleatt@ga.gov.au or phone Lynton Jaques on +61 2 6249 9745, e-mail lynton.jaques@ga.gov.au**

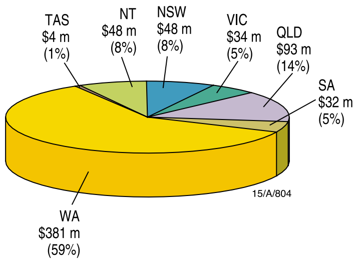



**Figure 3.** Distribution of mineral exploration expenditure in Australia for 2001–02 by jurisdiction[2]

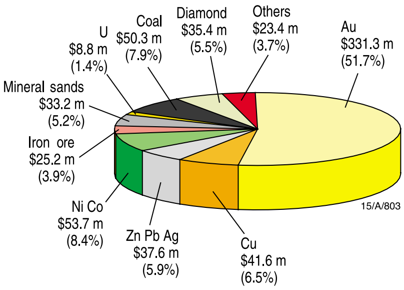



**Figure 4.** Distribution of mineral exploration expenditure in Australia for 2001–02 by commodity[2]

## References

1. Metals Economics Group. 2002. Corporate exploration strategies 2002. Halifax (Canada): MEG.
2. Australian Bureau of Statistics. 2002. Mineral and petroleum exploration, Australia. Canberra: ABS; 8412.0, June quarter.
3. ABARE. 2002. Australian commodities: Forecasts and issues. Canberra: Abareconomics 9, Sept quarter.
4. Jaques AL & Huleatt MB. 2002. Australian mineral exploration: Outlook improving but challenges remain. AusIMM Bulletin, Sept/Oct; 5:36–42.
5. Geoscience Australia. 2002. Submission to the House of Representatives Standing Committee Inquiry into Impediments to resource exploration, www.aph.gov.au/house/committee/isr/resexp/sub53.pdf

# *Major structures* for gold in seismic images of crust

There are at least three major crustal-penetrating shear zones, and a greenstone belt that is worth exploring for large mesothermal gold deposits in the north-eastern Yilgarn Craton in Western Australia.

These are some findings from Geoscience Australia and the Geological Survey of Western Australia, which used ANSIR facilities to acquire deep seismic reflection data in the Yilgarn last year.

**Geoscience Australia's Dr Bruce Goleby summarises findings.**

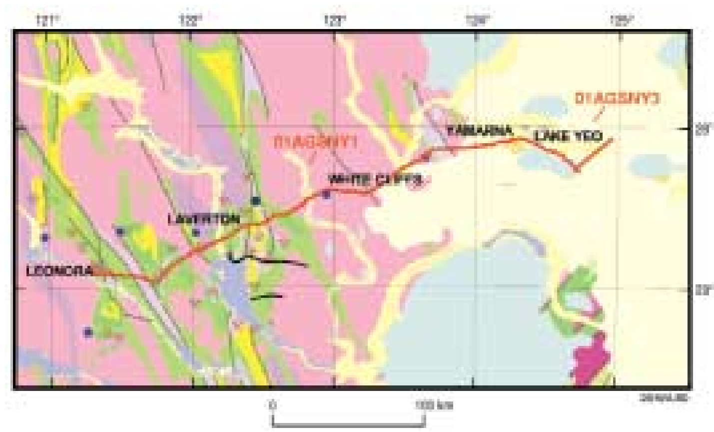



**Figure 1.** The north-eastern Yilgarn deep seismic reflection traverse in the Eastern Goldfields region in 2001. The deep seismic reflection traverse is shown in red. The blue dots are broadband instrument locations.

Deep seismic reflection data were collected along two east–west traverses (see figure 1). 01AGSNY1 was 384 kilometres in length. It started within the Sons of Gwalia gold mine lease near Leonora and extended eastwards, through Laverton and Yamarna, and finished within the Officer Basin to the east of Lake Yeo. 01AGSNY3 was 52 kilometres in length. It trended north-east, passing over the mineral exploration drill hole NJD1 and finished within the Officer Basin.

The data are characterised by several prominent features that suggest:

- a change in the thickness of the crust;
- the crust is subdivided into three broad layers;
- a prominent east dip to most reflections; and
- three east-dipping crustal-penetrating shear zones.

## Crustal thickness

There is a prominent sub-horizontal thin band of reflections that are interpreted as the Moho. The crust is approximately 40 kilometres thick in the north-eastern Yilgarn region, with an eastward thickening towards the Albany-Fraser Province (figure 2). The Moho is interpreted to be about 40 kilometres beneath the town of Leonora, deepening to about 46 kilometres at the eastern end of the traverse.

The eastward deepening of the Moho is due to a series of ramps and flats. The Moho is generally sub-horizontal for long sections before it ramps down over a short distance. The seismic character of the Moho is similar but deeper than that interpreted on the 1991 deep seismic traverse 91EGF01 in the Kalgoorlie region.

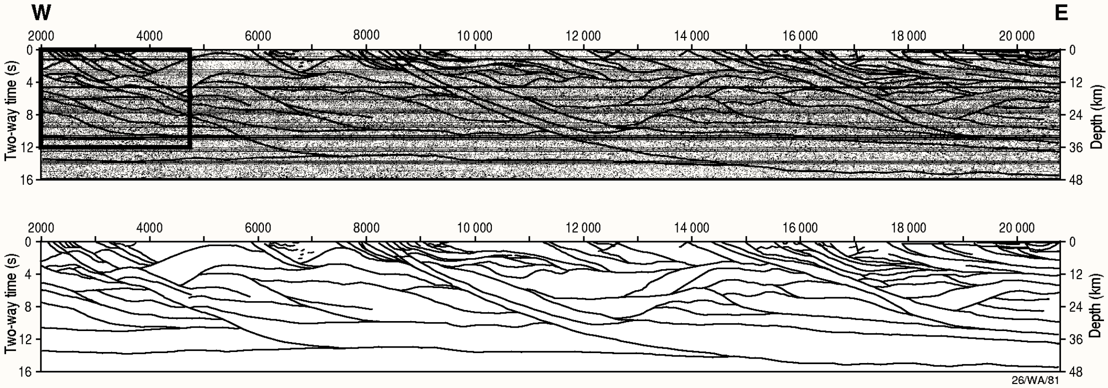



**Figure 2.** Northern Yilgarn interpreted seismic reflection section (top) and interpretation only (bottom)

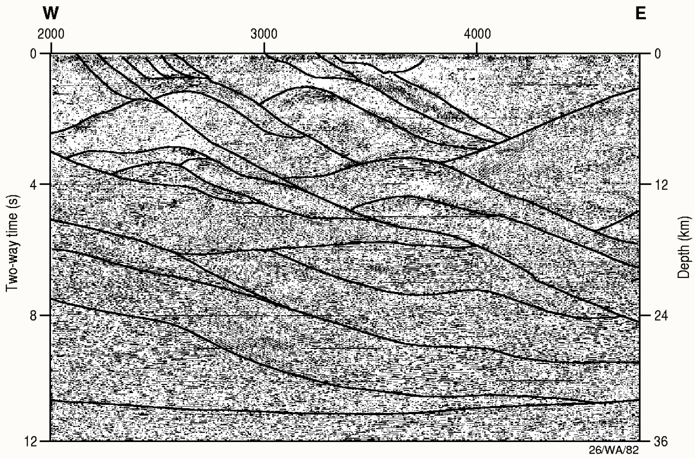



**Figure 3.** General view of the seismic line (data and interpretation) from the Raeside batholith to east of the Pig Well sequence. Note the prominent east-dipping reflectors in the upper crust and the thrust-duplex geometry.

## Crustal subdivision

The crust is subdivided into three sub-horizontal layers based on marked differences in seismic character (figure 2). The lowest layer is considered to be a ductile lower crustal unit. There are only two instances of dipping reflections and both relate to the deep penetrating shears. The upper surface of this layer is defined by a sharp change in reflection character to a zone with large packages of dipping reflectivity.

The seismic reflectivity in the middle layer is characterised by numerous prominent east-dipping reflections that can be subdivided into bodies that have similar seismic character. These large-scale, lozenge-like mid-crustal bodies suggest deformation has occurred.

The boundary between the middle and upper layers is diffuse and irregular in geometry. The upper layer is far more complex and variable in its seismic character.

## Easterly dip

There is a very pronounced east dip to most of the reflectivity seen along the seismic traverse, both in the middle and upper levels of the crust (figures 2 & 3). West-dipping features are imaged, but these are restricted to a few locations. The east-dipping reflections generally have a shallow dip, typically around 30º.

## Shear zones

Within this east-dipping fabric, there are three prominent east-dipping zones of reflectivity that transect the crust (figure 2). The shear zones are interpreted to represent some form of the Mount George Shear, the Laverton Shear and the Yamarna Shear. The shears can be traced from the surface to the lower crust and in two cases to the Moho.

The Laverton and Yamarna shears are more clearly defined, whereas the Mount George Shear appears to have been intruded by later granites or subsequent deformation. The Yamarna Shear dips at around 30º and is wider at the surface than at depth. All three shear zones have a complex geometry, suggesting several episodes of folding and faulting.

These shear zones divide the north-eastern Yilgarn into four distinct domains:

- the Ida Fault (further west) to the Mt George Shear;
- the greenstone-abundant Leonora to Laverton domain;
- the Laverton Tectonic Zone to the Yamarna granitic domain; and
- the Yamarna to Albany-Fraser domain.

At the western end of the seismic section, there are sets of east-dipping reflective bands (at approximately 6 s to 9 s two-way travel time). Assuming their dip does not change westwards, these bands project to the surface very close to the Menzies and Ballard faults.

## Crustal geometry

Where 01AGSNY1 and 01AGSNY3 intersect, there is an approximate 90º difference between line orientations. This provided an opportunity to obtain a three-dimensional image of the deeper crust and put some constraints on the shape of the interpreted deeper bodies.

The lozenges interpreted at depth are also lozenge-shaped in cross-section, which reflects the shapes seen on surface maps. The geometries shown by the geological maps are repeated at depth in both the strike and dip directions.

## Sedimentary basins

At the eastern end of the traverse, the seismic has clearly imaged the contact between the overlying Proterozoic and Phanerozoic sedimentary basins and the Yilgarn Craton basement. There is a shallow-dipping unconformity between the Archaean north-eastern Yilgarn basement and the Proterozoic and younger sedimentary rocks. This unconformity surface and another unconformity surface within the Neoproterozoic Officer Basin sedimentary rocks are planar, but appear to be cut by numerous faults. These faults may be reactivated Archaean structures, with the latest movement interpreted to be post-Proterozoic, especially at the eastern margin of the traverse. It is uncertain how far this deformational event extends westwards into the Yilgarn Craton.

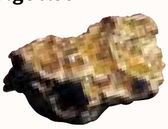
## Mineral potential

The world-class mesothermal gold deposits of the Leonora and Laverton districts are spatially associated with crustal penetrating east-dipping structures. These gold districts are located in the hangingwall of the major structures.

The Yamarna Shear, like the Mt George and Laverton shears, is a crustal-penetrating structure that dips shallowly to the east. Much of the Yamarna greenstone belt lies in the hangingwall position of the deep shear, suggesting that this rather poorly understood region is prospective for large mesothermal gold deposits.

Seismic reflection data generally image the latest structures in a terrane with a complex deformation history. If most mesothermal gold is late stage in the north-eastern Goldfields, then it is likely that the geometry imaged is a good representation of the geometry present at the time of mineralisation. The seismic reflection data are therefore critical to fluid flow modelling of the late-stage mesothermal gold system.

**For more information phone Bruce Goleby on +61 2 6249 9404 or e-mail bruce.goleby@ga.gov.au**



# *Call* for research proposals for EXPERIMENTS IN 2003 & *beyond*

## Submissions by FEBRUARY 17, 2003

The Australian National Seismic Imaging Resource (ANSIR), a major national research facility, seeks bids for research projects for experiments in 2003 and beyond.

ANSIR operates a pool of state-of-the-art seismic equipment suitable for experiments designed to investigate geological structures. ANSIR is operated jointly by Geoscience Australia and the Australian National University.

ANSIR equipment is available to all researchers on the basis of merit, as judged by an Access Committee. ANSIR provides training in the use of its portable equipment, and a field crew to operate its seismic reflection profiling systems. Researchers have to meet project operating costs.

Applicants should consult the web (http://rses.anu.edu.au/seismology/ANSIR/ansir.html) for details of the equipment available, access costs, likely field project costs, and the procedure for submitting bids. This site also includes an indicative schedule of equipment for projects that arose from previous calls for proposals.

The long-period portable instruments are in heavy demand, therefore potential users are urged to submit bids at the earliest opportunity. Spare capacity on short-period portable instruments in 2003 is anticipated.

Researchers seeking to use ANSIR from July 2003 should submit research proposals to the ANSIR Director by February 17, 2003.

ANSIR AUSTRALIAN NATIONAL SEISMIC IMAGING RESOURCE

***Enquiries should be directed to:***

- **Prof Brian Kennett, ANSIR Director, Research School of Earth Sciences, Australian National University, Canberra ACT 0200. Tel. +61 2 6215 4621 or e-mail ANSIR@anu.edu.au**

Figure 1. Data quality of the new 1:1 million scale (right) geology data sets has improved compared with the old 1:2.5 million scale (left) data.

# National Maps update

The National Maps project compiles national-scale data sets, maps and images from all facets of Australian geoscience. Geoscience Australia holds most data sets, but some key pieces are from other agencies. These data are modified to Geoscience Australia standards.

The data sets cover continental Australia and its territories, out to the marine jurisdictional boundaries. They include various outcrop and basement geology themes; regolith and landform classifications; mineral deposit, geochemistry, field observation and geochronology databases; magnetic and gravity anomaly grids and images; and topography and bathymetry data.

The National Maps project is compiling a seamless surface geology coverage of Australia at 1:1 million scale, with the cooperation of state and territory geological surveys. This will supersede the 1:2.5 million scale geology of Australia published in 1998 (figure 1). It will incorporate stratigraphic and other geological attribute information not previously captured in national compilations. A new bedrock geology (solid geology) compilation to accompany the surface geology data is planned.

The sedimentary and igneous provinces of Australia are also being captured at 1:1 million scale and attributed in a new Provinces database. Database attributes include age limits, parent and constituent units, relations to surrounding provinces, and igneous and sedimentary characteristics. The Provinces database in conjunction with the new national Events database will eventually provide a complete spatial and temporal geological framework of Australia.

## Internet delivery

The national geoscience data sets are available for free from the web (www.ga.gov.au/rural/projects/20011023_32.jsp). Project results, maps and other digital data can be viewed via on-line GIS pages, and downloaded from the Geoscience Australia web site.

Work is under way to enable many of the fundamental national databases (e.g. geochemical and geochronological analyses) to be queried directly via the internet. This will replace the current procedure of providing periodic database releases to customers.

Other developments in the near future include dynamic graphical presentation of data, such as graphical drill logs or concordia plots of geochronological data (figure 2). These on-line tools will allow users to query Geoscience Australia databases in real time and present the data in an easy-to-interpret format.

**For more information about the national geoscience datasets phone Ollie Raymond on +61 2 6249 9575 or e-mail oliver.raymond@ga.gov.au**

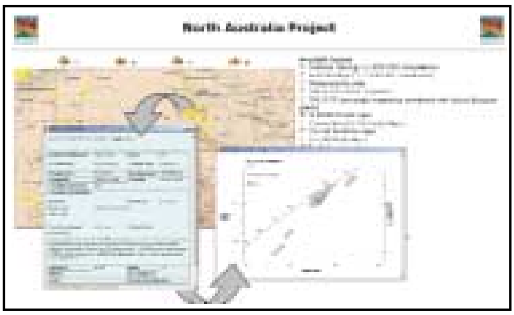
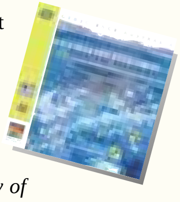



Figure 2. An on-line graphical query tool being developed at Geoscience Australia. Analyses from the national geochronology database are queried through an on-line GIS, presented in a report window, and a concordia diagram is constructed ‘on-the-fly’ from the selected data.



# CD SIMPLIFIES ESTUARY COMPLEXITIES



The science is complex, but the information is presented in a wonderfully simple way on a new Geoscience Australia CD titled *Australian estuaries and coastal waterways: A guide to the biogeochemistry of sediments and water.*

The CD uses animated cartoons and simple diagrams to describe plant problems in waterways. It has novel ways of demonstrating nutrient recycling in the microbial world, estuary food chains, and the processes that are fundamental to maintaining water and sediment qualities.

‘This CD is cutting edge biogeochemical research presented in a fun way’, says Geoscience Australia CEO Neil Williams.

‘It is difficult for communities to fully discuss environmental management if they cannot understand the science.

‘The CD will help people understand the processes happening in their estuaries and why they have problems such as smelly lakes and choked waterways’, he says.

The CD took 12 months to produce, but its genesis was a 1995 government report that identified sediments and nutrients from land clearing, and overcropping and grazing in coastal catchments, as major threats to inshore marine environments.

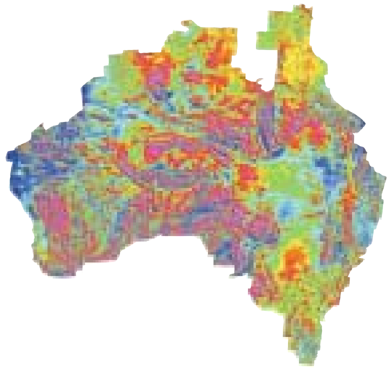
The CD information is in six chapters. These are Nutrients, Sediments and water, Classification of Australia’s estuaries, Conceptual models, For managers, and Case studies.

The two chapters (Classifications and Conceptual models) that illustrate how waterways function summarise some of Geoscience Australia’s work for the National Land and Water Resources Audit last year. The case studies in Port Philip Bay in Victoria, and Wilson Inlet in Western Australia, also present aspects of Geoscience Australia research.

Links to internet databases and relevant web sites are provided, and there is an optional voice guide. A glossary is included for those who are not familiar with the science terms used on the CD. The CD can purchased from the Geoscience Australia Sales Centre for $22 (includes GST) plus postage and handling.

**For more information phone David Heggie on +61 2 6249 9589 or e-mail david.heggie@ga.gov.au**

# Spatial data policy UPS DEMAND for products



The demand for spatial data sets from Geoscience Australia has risen sharply this year. Major price reductions, particularly for geophysical data, significantly broadened the groups accessing the data to include many new junior explorer and service provider customers.

The change is due to the Commonwealth Government policy on Spatial Data Access and Pricing that was introduced in September last year. Under the policy, fundamental spatial data are free over the internet or can be purchased as packaged products for the marginal cost of transfer.

Spatial data affected by the policy include geological, regolith, magnetic, gamma-ray, gravity, seismic, airborne electromagnetic, elevation model, bathymetric, certain topographic, geochemical, environmental and geohazards data.

Many of Geoscience Australia's national geoscience data sets went on-line in March, and the demand for some data products increased 50–100 times.

In the six months prior to the new policy, Geoscience Australia distributed 10 airborne geophysical data sets to industry. Six months after the policy (figure 1), 544 had been distributed including 27 grids of the magnetic map of Australia.

Other companies besides big mineral exploration and mining companies are now accessing the data in large numbers. Figure 2 shows that about 65 per cent of the aeromagnetic data sets distributed off line between March and August were to junior mining and exploration companies and consultants. Ten per cent of sales were to government agencies, research organisations, and consultant groups engaged in land resource and environmental management.

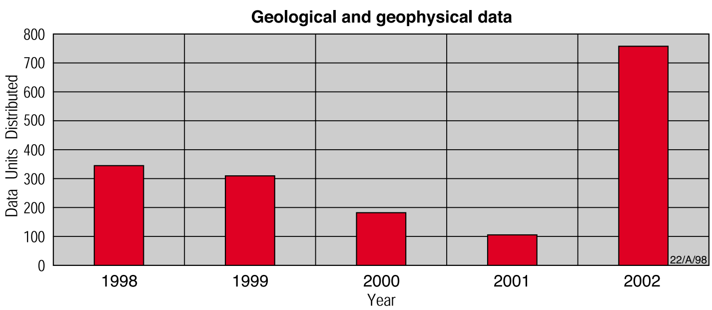



**Figure 1.** Sales of Geoscience Australia geological and geophysical data products

It is now also easier for state surveys and other organisations to distribute Geoscience Australia data as part of other products and in a reprocessed form if necessary. The Northern Territory Geological Survey began distributing reformatted Geoscience Australia airborne data in August, and in the first two months distributed about 120 data packages.

## Impact

The Commonwealth Government spatial data policy has been welcomed by industry. Mineral exploration in Australia is at a 20-year low (in real terms) with major reductions in exploration budgets and junior companies having problems raising funds for exploration.

The new policy enables junior companies to easily access Geoscience Australia data at a critical time. They have been using Geoscience Australia data in project generation, and many have gone on to develop joint ventures and/or strategic alliances with majors to undertake exploration.

# Latest map, *what a gem!*

Geoscience Australia has a great new product that will interest many readers. It is a map of Australian diamond deposits that was released in Perth on November 20 at Geoscience Australia's minerals exploration seminar.

The 1:5 million-scale map uses the Magnetic Anomaly Map of Australia as a base. It shows Australia's operating diamond mines, historic alluvial mines and selected occurrences of diamond, as well as more than 500 kimberlite, lamproite, lamprophyre, and alkali basalt bodies according to rock type and age of intrusion, discovered by companies over the past 30 years during diamond exploration.

Rio Tinto (formally CRA Exploration), De Beers Australian Exploration, Striker Resources and Kimberley Diamonds provided information for the map, which supplements data from public domain sources.

Information on world natural diamond production in 2001 is also shown, based on information published in the *Mining Journal* (August 2002) provided by Dr Luc Rombouts.

In 2001 Australia produced 22 per cent of the world's supply of natural diamonds by weight, almost entirely from the world-class Argyle deposit, which is one of Australia's major mines. Australia's share of the world's natural diamond production by value was only four per cent, however, because of the high proportion of industrial and cheap gem diamonds (relatively low value) in the Argyle production.

A small volume of diamonds was produced from the Merlin pipes in the Northern Territory and a new mine has recently opened at Ellendale in Western Australia.

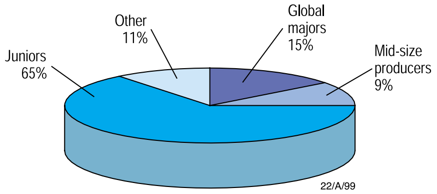



**Figure 2.** Distribution of aeromagnetic data sales for March–August 2002

David Harley, President of the Association of Mining and Exploration Companies said:

'Access to high-quality, pre-competitive geoscientific information is critical to junior companies who are playing an increasingly important role in mineral exploration.

'The Commonwealth policy on spatial data, and similar decisions by the states and NT, has been fundamental to opening up the availability and use of important government pre-competitive geoscientific data across the industry'.

Early this year, Southern Geoscience Consultants, a geophysical consulting group based in Perth purchased the complete set of Geoscience Australia airborne and gravity data. Company director, Bill Peters said this about the government's policy:

'Southern Geoscience Consultants is very happy with the new arrangements. The data are being used far more extensively than under the old policy.

'We commonly reprocess the located data and merge Geoscience Australia and client data to generate maps at varying scales used in both area selection and directly in exploration programs. This increases the cost-effectiveness of our clients' exploration and improves their chances of discovering new mines.'

## On-line access

Geoscience Australia is progressively making its fundamental data sets available free on-line as technology and resources allow.

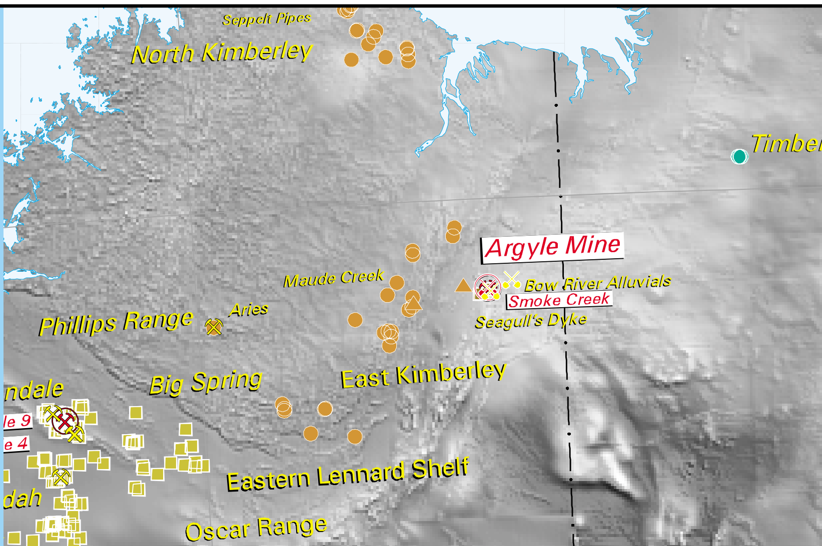
National topographic, bathymetric, digital elevation, and resources and environmental data, as well as the national geology, rock geochemistry, and geochronology databases can be accessed via the web. There are also some GIS-based on-line mapping systems that include geological and geophysical data at both national and project scales. For example, on-line GIS data are available for the Moonta and Olympic sub-domains of the Gawler Craton (www.ga.gov.au/map/gawler_olympic/), incorporating geological, geophysical and mineral prospect information.

Geoscience Australia's petroleum databases are on-line (*AusGeo News* 65, page 26), providing a powerful tool that incorporates petroleum well information with geological (biostratigraphy, facies and events), geochemical (maturation) and reservoir information.

The grided image of the magnetic map of Australia, the gravity grid of Australia and the gravity database can be downloaded from Geoscience Australia's FTP site. This can be time consuming because of large file sizes, but in the future users will be able to select easily manageable subsets of data.

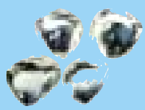
**For further information about Geoscience Australia's products contact Geoscience Australia Sales Centre on +61 2 6249 9519 or e-mail sales@ga.gov.au. For information on continental geophysical data sets contact Peter Percival on +61 2 6249 9478 or e-mail peter.percival@ga.gov.au.**

**Information about the Commonwealth Government's spatial data policy is available from the OSDM web site at www.osdm.gov.au.**




Paper copies of the map are available for $55 (including GST) from the Geoscience Australia Sales Centre by phoning +61 2 6249 9519 or e-mailing sales@ga.gov.au. A laminated map costs $77 (including GST). The map can be downloaded free from the web (www.ga.gov.au/rural.projects.NAP_results_products.jsp).

**For further information phone Lynton Jaques on +61 2 6249 9745 or e-mail lynton.jaques@ga.gov.au**



# NATMAP 250K update released on CD


Geoscience Australia has just released an updated version of the *NATMAP Raster 250K Mapsheets* as a two-CD set that includes 518 topographic map sheets covering the whole of Australia at 1:250 000 scale.

Users can search by latitude, longitude, grid coordinates, map names, place names or map numbers. All paper maps published up to June 30 this year are included on the CDs. More than 250 of these maps have been released since October 2000.

The images are in 24-bit colour, at a resolution of 200 dpi (equivalent to 32 metres). Most map images cover a grid of one degree of latitude by one and a half degrees of longitude (approximately 110 km x 130 km). Some extended sheets cover larger areas. Map insets are stored as separately georeferenced images.

*NATMAP Raster 250K Mapsheets* comes with map viewing software called RASTER VIEWER, which was developed in conjunction with CSIRO Mathematics and Information Sciences. RASTER VIEWER allows the user to zoom and pan over the maps.

The map roamer allows the user to follow a feature across map sheets by loading the neighbouring map at the map view scale and correct location. The whole map or the currently displayed area can be printed, in which case the coordinates of the top left and bottom right of the area and a scale bar are also printed.

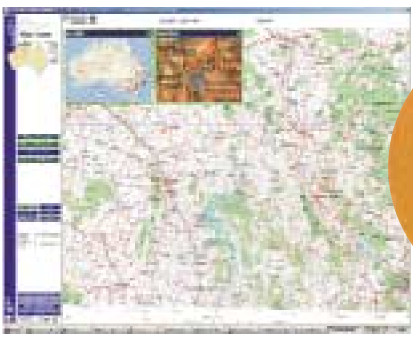
Each map image is georeferenced to Map Grid of Australia (MGA94) coordinates, which is ideal for measuring distances and areas. This means the maps can be used with GPS and GIS software.

Each map image is supplied with all surrounding map information including legend, scale bar, and technical information about the map and its projection. The map images are sourced from Geoscience Australia's 1:250 000-scale NATMAPs and the Department of Defence (Army) Joint Operation Graphics (JOG) series of maps. Maps covering Tasmania are reproduced with the permission of TASMAP (Tasmanian Government).

The user can choose to display coordinates in MGA, AMG and latitude/longitude, on either the Geocentric Datum of Australia (GDA94) or older Australian Geodetic Datum (AGD66).

The *NATMAP Raster 250K Mapsheets* CDs cost $99.00 (including GST). They are available from Geoscience Australia or its map retailers located throughout Australia.

**For further information phone Geoscience Australia Sales and Distribution on Freecall (within Australia) 1800 800 173 or +61 2 6249 9966, or e-mail mapsales@ga.gov.au**




# *Product catalogue* with this issue

Readers will notice a copy of the latest edition of the Geoscience Australia Product Catalogue has been enclosed with this issue of *AusGeo News* to provide an idea of the range of products available from Geoscience Australia following last year's merger of the former Australian Geological Survey Organisation and AUSLIG.

The catalogue includes information and pricing for geological and geophysical maps and data, petroleum and marine data, geohazards reports, and geodetic data sets, as well as printed topographic and thematic maps, digital map and digital elevation data, and remotely sensed data and satellite imagery. There are also many publications such as bulletins, records, atlases, National Parks guidebooks and educational materials.

Some of the products are now available free of charge on-line or are available on CD for the marginal cost of transfer because of the Commonwealth Government's policy to maximise the accessibility of spatial data (see the article on page 30).

Enclosed with each hardcopy catalogue is a CD with the catalogue text, sample data and other useful information about the listed products. Only the CD version has been distributed to overseas readers to reduce postage costs.

For additional copies of the catalogue phone the Sales and Distribution staff on Freecall (within Australia only) 1800 800 173 or telephone +61 2 6249 9966, or e-mail mapsales@ga.gov.au. The catalogue can also be downloaded at www.ga.gov/bridge/catalogue.jsp