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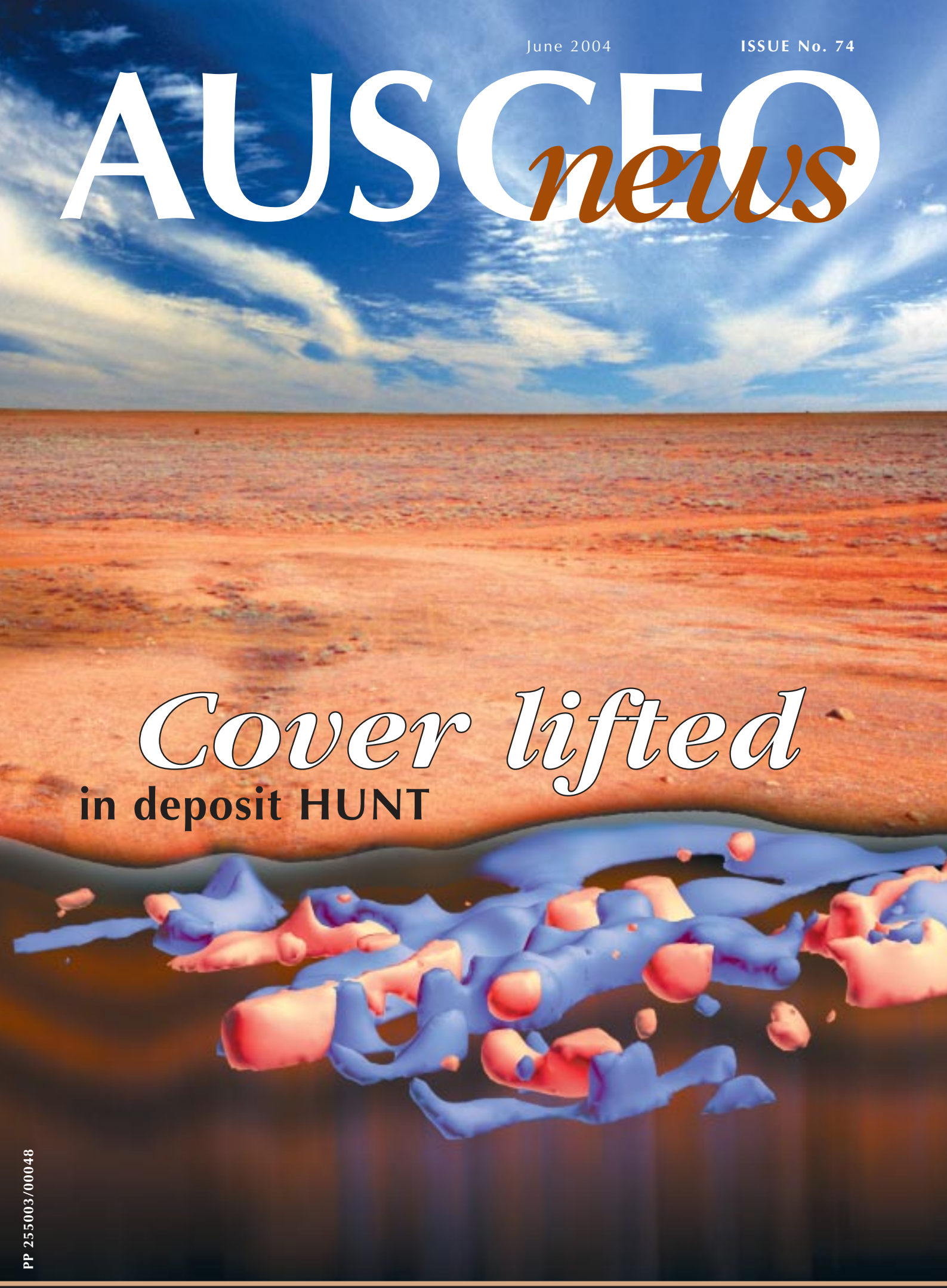
AUSGEO news



Cover lifted in deposit HUNT

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Seismic clues, geochemical evidence, inversion models & much more inside...

AUSGEO News
June 2004 Issue no. 74

Australian Government
Geoscience Australia

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Australia has a thick cover that makes it difficult for mineral exploration, particularly when the terrane is flat with little or no outcrop. Drill-holes must be carefully targeted, because drilling through 500 metres of cover adds more than $50 000 to the cost of a drill-hole.

In this issue we lift the cover on some of the latest tools and methods being studied and tested by Geoscience Australia to reduce mineral exploration risk, and show how we are trying to give you access to our data for free and in real time.

Cover: Design by Katharine Hagan using images from Nick Williams, Patrick Lyons & Jim Mason





Recent improved metal prices and a brighter outlook for the mineral industry have resulted in the first increase in global mineral exploration since 1997. The increases in metal prices have been fuelled mainly by China's increased imports to support its industrialisation program, but exacerbated by a shortage of new projects due to low levels of mineral exploration in the past five years.

The upturn was reflected in a record attendance at the major Prospectors and Developers Association of Canada International Convention, Trade Show and Investors Exchange in March, as reported in this issue of *AusGeo News*.

There has been a small increase in mineral exploration in Australia, even though Australia's share of global exploration expenditure has slipped from an average of around 18 per cent over the previous decade to 15.5 per cent in 2003. This decline is likely to have an impact on the discovery of resources and the longer term capacity of the resources sector to contribute to the economy, particularly to the balance of trade.

Australia's Identified Mineral Resources 2003, released recently, highlights the need to discover more gold and base-metal resources to replace those mined out. The major challenge faced by industry in finding new resources in Australia is the difficulty of exploring terranes with extensive regolith and sedimentary cover.

With a few notable exceptions, such as Olympic Dam, most Australian mineral deposits have been found in areas of outcrop, commonly by surface-prospecting methods. There is every reason to believe that large areas of the Australian continent beneath regolith and sedimentary cover are as prospective for minerals as the adjacent areas of outcrop.

Under the National Geoscience Agreement with State and Territory Geological Surveys, Geoscience Australia's minerals program is acquiring information on mineral systems and providing a three-dimensional geological framework to facilitate more effective exploration of such areas. Inside this issue are results of our regional projects that showcase some developments to tackle the challenges faced by explorers seeking buried or concealed deposits.

Two items highlight how crucial geophysical surveys are to establishing the geology at depth. The article on the Gawler Craton describes mapping geophysical anomalies to assist the search for new copper-gold deposits like Olympic Dam. In this region, we are applying new methods for inversion of potential field data to extract the maximum information from geophysical surveys—and with some success.

In the article about the McArthur Basin seismic survey we explain why, contrary to earlier beliefs, the McArthur River silver, lead and zinc deposit does not lie at the edge of a major depositional trough but rather is part of a much larger sedimentary system that is now adjacent to a previously unrecognised fold and thrust belt. Both of these studies have important implications for mineral exploration.

Also in this issue are new geoscience products to support mineral exploration, including geophysical data from recent surveys in the Burakin and Belele areas, and other data that can be downloaded free via the internet.

Comment

Neil Williams

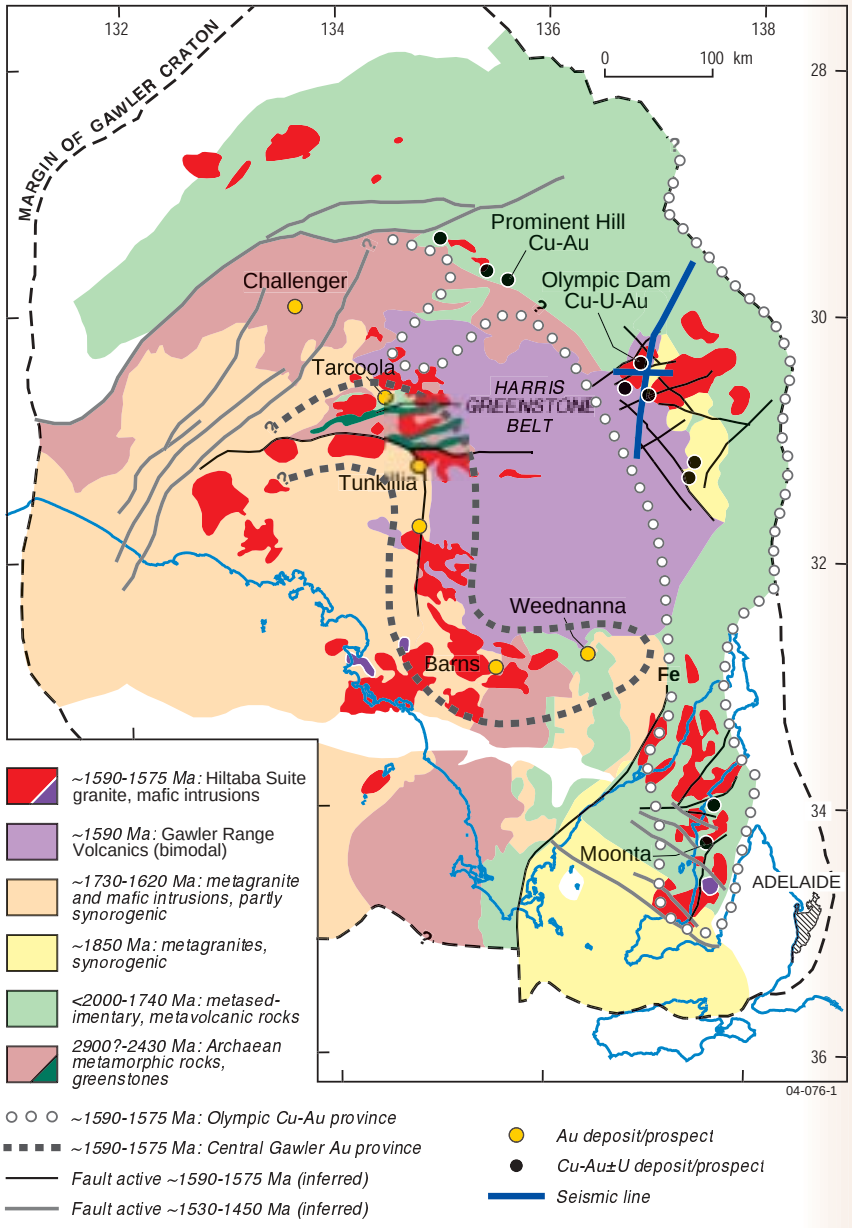
NEIL WILLIAMS
CEO Geoscience Australia

The lowdown on Gawler copper & gold

Locating an economic ore deposit blanketed by tens or hundreds of metres of sediment and weathered rock, even one the size of the two-billion-tonne Olympic Dam deposit is a huge challenge. But the problem is being tackled in South Australia's Gawler Craton by Geoscience Australia and its collaborators, PIRSA and CRC LEME, using a combination of geophysical, geological and geochemical tools.

By mapping the regional geological indicators of copper, gold and nickel mineralisation through cover in prospective regions, the collaborators plan to provide explorers with spatial guides to the location of concealed mineralisation.

At this stage the work focuses on two major metallogenic belts: the Olympic copper-gold province along the eastern margin of the Gawler, and the central Gawler gold province (figure 1).



Basement mapping

The first step in mapping the almost entirely concealed basement geology of the Gawler Craton involved compiling available drill-hole and geophysical information, and re-processing numerous aeromagnetic and gravity surveys to produce seamless regional coverages.

A series of 1:500 000 scale maps of three key areas were then produced from these data (Olympic Dam region, Yorke Peninsula, and Harris Greenstone Belt), and from re-logging drill core and new dating of key rock units. These two-dimensional maps of crystalline basement geology form the basis of a new 1:1 million scale Gawler Craton tectonic map.

Regional geological cross-sections were the next step, which involved geophysical modelling of rock property and potential field data, and new software for automated mapping of strong contrasts in geophysical properties that can occur across a fault.

◀ **Figure 1.** The basement geology (pre-1500 Ma) of the Gawler Craton, and the location of Geoscience Australia's main study areas. The geology is simplified from the new 1:1 million scale Interpreted Crystalline Basement map by PIRSA and Geoscience Australia.

Olympic copper-gold

The Olympic Dam region was selected for 2.5-dimensional and subsequent three-dimensional model building because it is a 'typical area' for iron-oxide copper-gold (IOCG) deposits. Key results of this work are listed in table 1.

The three-dimensional modelling of the Olympic Dam region has progressed enormously with the recent acquisition of 250 line kilometres of seismic data and the application of constrained inversion modelling of regional magnetic and gravity data (see inversion article). Both the main seismic line and a 50 kilometre orthogonal line passed within a couple of kilometres of the Olympic Dam deposit.

The data clearly image Neoproterozoic (1 billion to 550 million year old) and younger sedimentary basins overlying Gawler Craton basement, deepening to the north-east. The Burgoyne batholith, host to the Olympic Dam deposit, is a sheet-like body, whereas the underlying basement is transgressed by several major crustal structures.

The 3-D inversion models that differentiate volumes of magnetite- and hematite-bearing (and/or sulphide-mineralised) rock from least-altered host rock will interest explorers of IOCG deposits (figure 2). For the iron-oxide-rich Olympic Dam region these are really 3-D maps of hydrothermal alteration, and a template for mineral exploration.

Huge volumes of rock in the Olympic copper-gold province have been hydrothermally altered, making it difficult to target the most prospective parts. By combining the inversion-generated 3-D alteration maps with geochemical and mineralogical zoning, Geoscience Australia has developed a new method to help target higher-grade mineralisation.

The general method has been tested in the Titan prospect, 30 kilometres north of Olympic Dam, by a junior exploration company. Five deep diamond-holes have been drilled at Titan, and the best result to date is 5 m @ 1.1% Cu and 0.25 g/t Au. Although sub-economic, this occurs in a breccia zone of hematitic alteration in once magnetite-rich rock, which was anticipated from modelling.

Central Gawler gold

Even though gold was discovered at Tarcoola in the early 1900s, very little was known of the geology and style of gold mineralisation in the central Gawler due to the extensive cover. Indeed, the extent of the central Gawler gold province is still unknown (figure 1), but it is emerging as one of Australia's newest gold belts.

In the past few years blind mineralisation has been located mainly through drilling gold-in-calcrete anomalies. Recent results at Baggy Green prospect, five kilometres east of the blind Barns discovery, highlight the province's potential with intersections of 8 m @ 4.8 g/t and 11 m @ 2.3 g/t (holes 30 metres apart). Further north, Helix Resources recently announced a resource of 730 000 ounces at their Tunkillia deposit, and plan to start open-cut mining in 2005.

Table 1. Key results of work to date in the Olympic Cu-Au province

- The crustal architecture is dominated by north-west- and north-east-trending major faults in the Olympic Dam region, some of which were important during mineralising and magmatic events around 1590 Ma.
- There were three (~1850, 1740–1760 and 1570–1600 Ma) tectono-stratigraphic events in the Olympic Dam region.
- Geophysical modelling is consistent with north-east-dipping contacts between inferred Archaean and Palaeoproterozoic basement units, intruded by pancake-like early Mesoproterozoic Hiltaba granites.
- Two significant alteration types that are characteristic of the Olympic Cu-Au province have been mapped and dated (~1570–1600 Ma): high-temperature magnetite-bearing, and low-temperature hematite-bearing alteration. Cu-Au mineralisation is better developed in hematitic alteration where the two alteration regimes are adjacent.

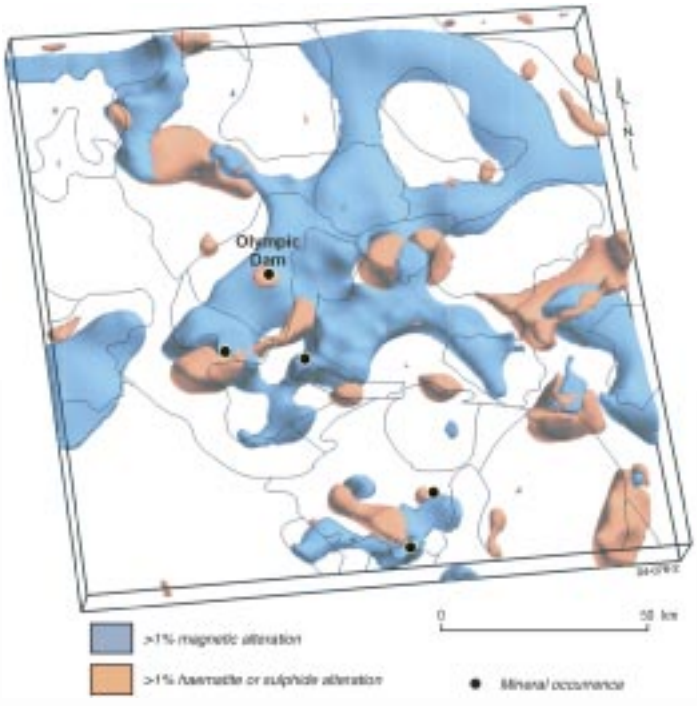


Figure 2. An oblique view of a 3-D inversion model of regional potential field data interpreted as magnetite- and hematite- or sulphide-alteration, in the Olympic copper-gold province. The Olympic Dam copper-gold deposit and four other copper-gold-uranium occurrences are shown, as well as the outlines of basement units from a previous 2-D interpretation. The depth of the model volume is 10 kilometres.

Thick cover

no obstacle to geophysical inversion

The major physical impediment to exploring for mineral deposits in Australia is the thick cover that conceals crystalline basement. Drilling through 500 metres of cover adds more than $50 000 to the cost of a drill-hole, so every drill-hole must be carefully targeted. As cover deepens, the search for economic mineral deposits must rely on geophysical methods.

We can 'see' what is under the cover by measuring small variations in Earth's gravitational and magnetic fields. These reflect variations in the distribution of density and magnetisation within the subsurface rocks.

High-quality gravity and magnetic data have been acquired for large areas of Australia, and are available from Geoscience Australia's Geophysical Archive Data Distribution System (http://www.ga.gov.au/gadds/).

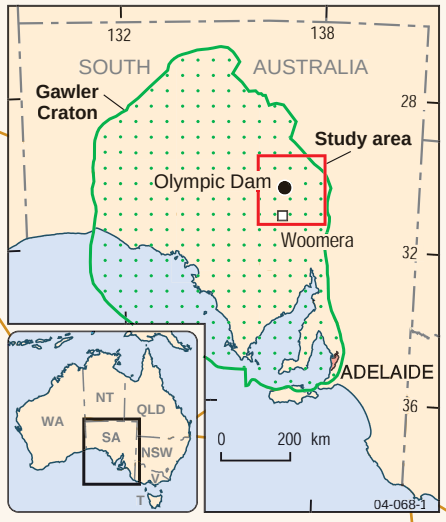


Figure 1. Locality map showing the Gawler Craton and the study area

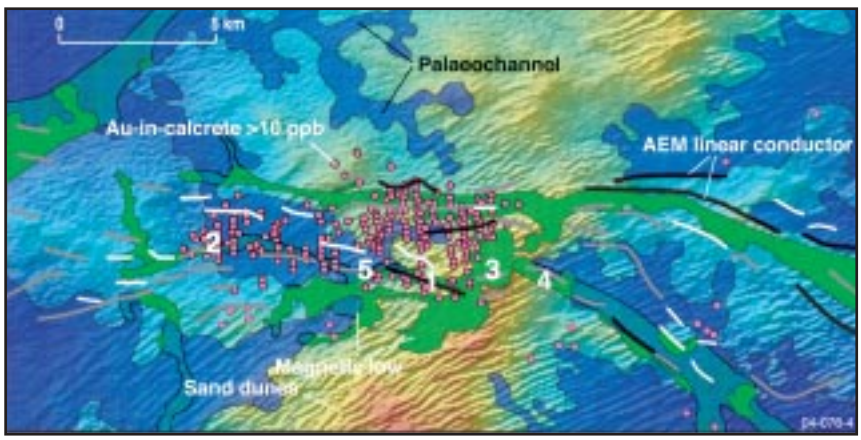


Figure 3. Ranked gold mineralisation targets in the Tunkillia district, central Gawler gold province (Tunkillia deposit is #1). Note the linear sand dunes in the red-yellow-green coloured digital elevation background. Palaeochannels (deep blue) underlie the sand cover. Linear AEM conductors and low-magnetic zones (green) are interpreted in the basement, and partly represent hydrothermal alteration zones. Calcrete data courtesy of Helix Resources

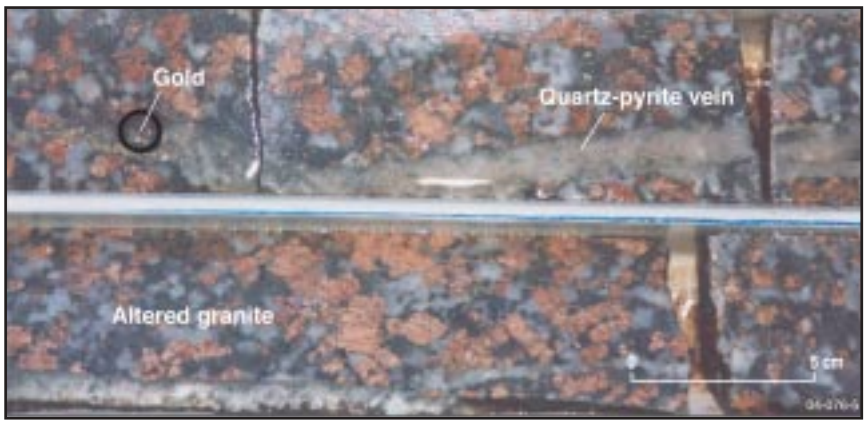


Figure 4. Drill core from the Tarcoola gold deposit, central Gawler gold province. The gold grain is in a quartz-pyrite vein hosted by sericite-chlorite-hematite altered granite.

Geoscience Australia and its collaborators have begun to unravel the spatial and temporal controls on the gold mineralisation. In 2000 they acquired airborne electromagnetic (AEM) data over the Tunkillia prospect, Challenger gold district and Moonta copper-gold district, which are being integrated with other tools to assist exploration.

At Tunkillia, new exploration targets were generated using AEM data, drill-hole and calcrete geochemistry, groundwater geochemistry, alteration mineralogy, potential field data, and geomorphology (figure 3). This exploration methodology, including ranking of gold-in-calcrete anomalies, is applicable elsewhere in the central Gawler.

Some results from work involving isotopic age dating show the gold in the Tarcoola deposit is about 1.6 billion years old (maximum age ~1645 Ma and a minimum age of ~1580 Ma). Hyperspectral logging of drill core and chips, calibrated against petrographic observations, suggest a pattern in alteration from sericite-pyrite in gold mineralised zones outwards into chlorite ± epidote ± hematite zones. This pattern will be tested and refined with further work. It also appears that gold occurs in quartz-sulfide veinlets (figure 4) and in sheared

Gawler application

To help explorers decide where to drill, Geoscience Australia is using inversion of gravitational and magnetic field data to build a three-dimensional model of the basement rocks in the eastern Gawler Craton in South Australia. This highly prospective region, known as the Olympic copper-gold province, includes the Olympic Dam deposit some 530 kilometres due north of Adelaide (figure 1). Olympic Dam lies beneath more than 300 metres of sedimentary cover.

The inversion modelling method and associated software were developed at the University of British Columbia Geophysical Inversion Facility in Canada. Most inversions to date have concentrated on small volumes at mine- or district-scales. But Geoscience Australia has adapted the method to regional-scale data sets.

A fundamental property of gravitational and magnetic fields is that an infinite number of distributions of density or magnetisation within the Earth can produce identical fields above the surface. If small numbers of geologically plausible solutions are to be achieved, inversions must be constrained with geological knowledge gained from as many sources as possible—for example, drill-holes, seismic surveys, and comparisons with areas of outcrop.

Because mineralisation in the Olympic copper-gold province is associated with magnetic and non-magnetic iron-oxide alteration, with higher densities than the surrounding rocks, inversion models show where anomalous volumes of alteration are located. Even coarse-scale inversions, with 1 km x 1 km x 0.5 km cells, show anomalous alteration associated with all known mineral occurrences (figure 2 main article).

The Gawler inversion results are being integrated with geochemical, geological and seismic data sets to infer the distribution of undiscovered mineralisation. As more high-quality geological data become available, this method of alteration mapping may prove useful to explorers in other prospective districts.

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Palaeoproterozoic (2500 to 1600 Ma) granitoids associated with CO_2-bearing hydrothermal fluids.

Many other studies into the geology of the central Gawler are also under way. Early results will be reported by Geoscience Australia, PIRSA, CRC LEME, and universities at the Gawler Craton: State of Play 2004 conference in Adelaide on August 4–5. On the following day, the Gawler Seismic Workshop will be devoted to the release and discussion of new seismic data from the Olympic Dam region. (See advertisement below.)

For more information phone Roger Skirrow on +61 2 6249 9442 or e-mail roger.skirrow@ga.gov.au.

See also www.ga.gov.au/rural/projects/gawler.jsp

Seismic clues to basin shape

The southern McArthur Basin in the Northern Territory contains a relatively undeformed succession of rocks that host the McArthur River (HYC) silver-lead-zinc deposit. For a better picture of the architecture of the basin in which this deposit formed, a deep seismic reflection survey was undertaken across the Batten Fault Zone in late 2002 (figure 1).

This east–west seismic survey was about 110 kilometres long, beginning 15 kilometres outside of Borroloola and extending westwards along the Borroloola–Roper Bar road to the Bauhinia Downs region (figure 2). A 17 kilometre north–south cross line was also acquired.

Key results of the survey, due to be published by Geoscience Australia later this year, shed light on the basin's evolution and suggest that the Batten 'Trough' is a misnomer and that the McArthur River deposit is part of a much larger sedimentary system than previously thought.

Thick strata

In the seismic data, the middle part of the succession (McArthur Group) gradually thickens towards the east, and the preserved upper part (Roper Group) increases in thickness to the west. At the eastern end of the seismic profile, the entire succession is essentially horizontal and at least eight kilometres thick, including 3.2 kilometres of McArthur Group and one kilometre of the lower part of the Roper Group. In the west the succession is at least nine kilometres thick, of which about 1.3 kilometres is McArthur Group and five kilometres is Roper Group (figure 3).

The Batten Trough may be inappropriately named because it was unlikely to be a separate depositional basin. The sedimentary succession appears to continue in both directions away from the implied boundaries of the 'trough'.

Faults

The seismic profile is dominated by a series of west-dipping faults. These are most likely part of a major thrust belt that had propagated eastward. Displacement on the thrusts diminishes to the east, and the frontal thrust of the system occurs about six kilometres west of the Emu Fault Zone with only minor displacement. The rock mass east of the Emu Fault probably acted as a buttress.

The Emu Fault seems to be a near-vertical fault with horizontal (strike-slip) movement. The Narwinbi Fault that links into the Emu Fault is also interpreted as a near-vertical strike-slip fault (figure 2).

The Roper Group forms the western limb of the Bauhinia monocline, which developed above the most western thrust ramp in the seismic data. The thrust faults formed after the Roper Group was deposited. The thrusts continue at depth beyond the western limit of the seismic profile, and this part of the thrust belt is hidden beneath younger cover (figure 3).

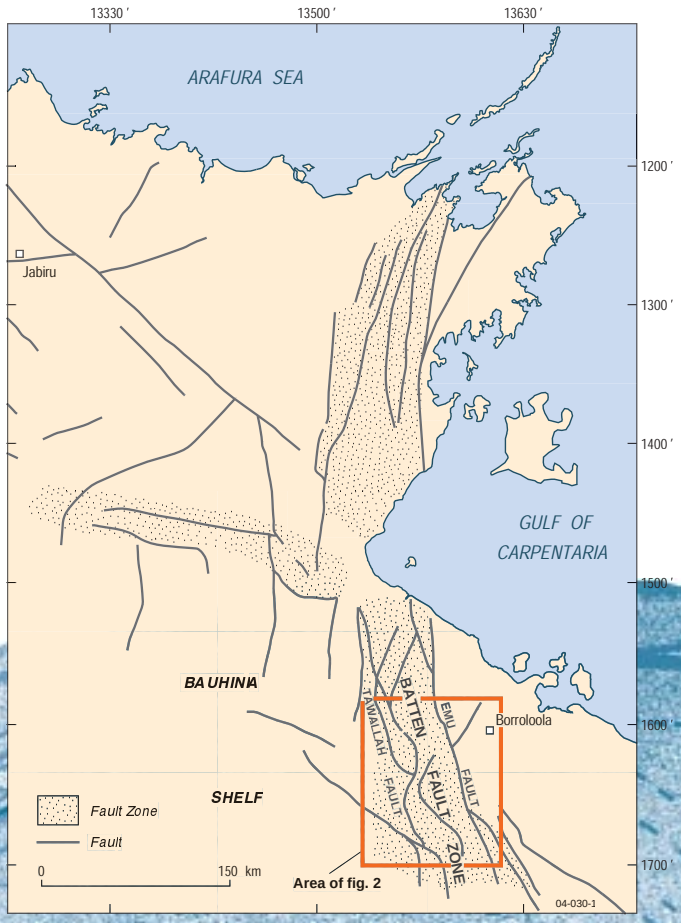
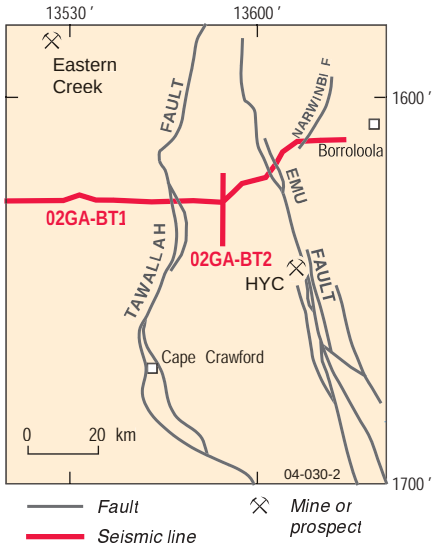


Figure 1. The Batten Fault Zone was the location of a deep seismic reflection survey, undertaken to unravel the complex architecture of the southern McArthur Basin that began to take shape 1800 million years ago.



▲ **Figure 2.** The east–west seismic survey extended westwards along the Borroloola–Roper Bar road to the Bauhinia Downs region. The north–south cross line and the HYC (Here's Your Chance) silver-lead-zinc deposit are also shown.

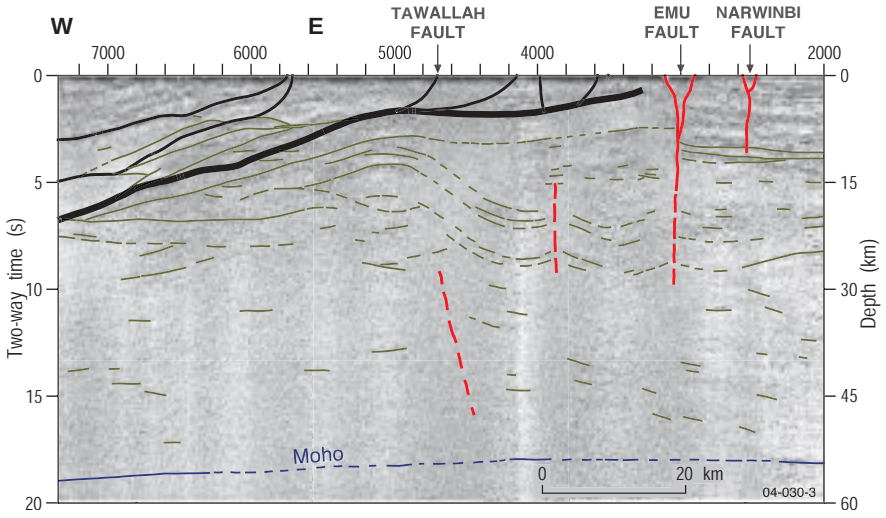
Mineral potential

The seismic data support some components of current models for the McArthur River deposit, including the geometry of the Emu Fault and a possible aquifer system. But there are major differences, such as the geometry of the Tawallah Fault (figure 1).

The new data expand the potential for 'McArthur style' base-metal deposits within and east of the Batten Fault Zone, and the presence of a major thrust belt opens up the possibility for other types of base-metal deposits (e.g. Mississippi Valley types and equivalents to the Century deposit that may have formed by topographically driven fluid flow). Under cover to the west, in the core of the thrust belt there may be potential for orogenic gold deposits.

The Australian National Seismic Imaging Resource (ANSIR) conducted the seismic survey for Geoscience Australia, the Northern Territory Geological Survey and the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRC). The short, north–south cross line was acquired in collaboration with Anglo American.

For more information phone Russell Korsch on +61 2 6249 9495 or e-mail russell.korsch@ga.ov.au



▶ **Figure 3.** A deep-crustal seismic image across the southern McArthur Basin, to a depth of approximately 60 kilometres, shows the interpreted geometries of the Tawallah, Emu and Narwinbi faults.

Findings beg further study into

Tanami gold

The two-year North Australia project in the Arunta and Tanami regions wraps up this month. So what have the project's geochronology, geophysical interpretation and modelling studies added to what is known about the evolution of central Australia and its mineral potential?

The Arunta had a violent history of at least six tectonothermal events 2.5–1.6 billion years ago (the Palaeoproterozoic period). It was thought that all rocks in the Arunta were of this age—until recent studies found some rocks formed in a big event about a billion years later. These findings alter thoughts on the evolution of central Australia 520–400 million years ago.

During the Palaeoproterozoic, the Arunta was the active margin of the North Australia Craton which encompasses much of north Australia from Mount Isa in Queensland to the Kimberley region of Western Australia. After this period, things quietened down until about 520 million years ago when the Arunta tried to split apart.

In the Harts Range Metamorphic Complex (HRMC: known extent indicated by line 9 on figure 1)[1], granitic magmatism about 520 million years ago (the Stanovos event) overlapped in time with rift-related mafic magmatism. This initiated the Larapinta seaway, which extends from the Canning Basin in the west to the Warburton Basin in the east. The separation eventually failed, and rifting was terminated by the high-grade metamorphism of the 460-million-year-old Larapinta event.

At this stage, the exploration implications of this new understanding of the central Australian geology are unknown.

To better understand the age and extent of the earliest events that shaped the North Australia Craton, project collaborators held a workshop in Alice Springs in May last year. Preliminary results of this synthesis are shown in figure 1. Full results will be available on-line next month from Geoscience Australia.

Mineralisation

The numerous small deposits of gold and base metals discovered to date in the eastern Arunta have generally been classified into one type: metamorphosed volcanic-hosted massive sulphide (VHMS) deposits[2]. In the eastern Arunta, three deposit types of different ages and origin were found.

Most are VHMS deposits associated with volcanics and sediments deposited about 1.8 billion years ago (line 7, figure 1). Other types include iron-oxide copper-gold (IOCG) deposits that relate to the Yambah igneous event at about 1.78 billion years, and carbonate replacement deposits possibly related to the Inkamulla igneous event at about 1.75 billion years. This work suggests that the eastern Arunta may have potential for additional IOCG deposits.

There is also a question about whether the lode gold mineralisation in the Tanami to the north occurred at the same time as the Strangways orogeny in the Arunta. If so, the deformation and fluid flow caused by this mountain building perhaps generated similar mineralisation in the Arunta and elsewhere in the craton.

A geochronological traverse (box 6, figure 1) from the Davenport Ranges (i.e. the craton interior) to the Strangways Range (i.e. plate margin) was conducted to test this concept.

Initial argon/argon results show that copper-gold mineralisation in the Davenport Ranges and Barrow Creek region formed about the same time as local granite intrusions and the end of the Strangways orogeny. Uranium-lead zircon geochronology is under way to test correlations among rock units in the Davenport Ranges and the Arunta.

Tanami gold

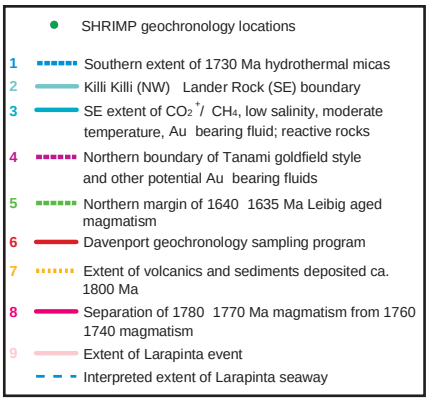
Work in the Tanami has focused on the architecture and genesis of gold mineral systems. This involved regional fluid studies and developing a three-dimensional geological model to help determine controls on lode gold mineralisation.

The model consists of 19 geological cross-sections. These sections were combined with basement interpretation maps and other data sets to interpolate regional structures and features (figure 2). The three-dimensional geological model, including two-dimensional data sets (geophysical images, solid geology maps, geochronology data, and mineral occurrence locations) can be manipulated over the web (www.ga.gov.au/map/web3d).

To evaluate the regional extent of lode gold mineral systems in the Tanami–north Arunta regions, quartz veins were sampled and fluid inclusion and argon/argon studies were carried out.

Two regions with different fluid chemistries were identified (figure 1). The region south of line 3 is characterised by gas-poor, low to moderate temperature (<250°C), and highly saline fluids, aged 1.51–1.43 billion years. These fluids are not consistent with known gold-mineralising fluids.

The region south of line 4 contains fluids of varying temperature (200–540°C) and high salinity—characteristics similar to those related to intrusion-related gold deposits[3]. There are at least two generations of veining. One vein set has ages of 1.63–1.48 billion years, while a few regionally isolated ones have ages of 1.17 billion to 910 million years.



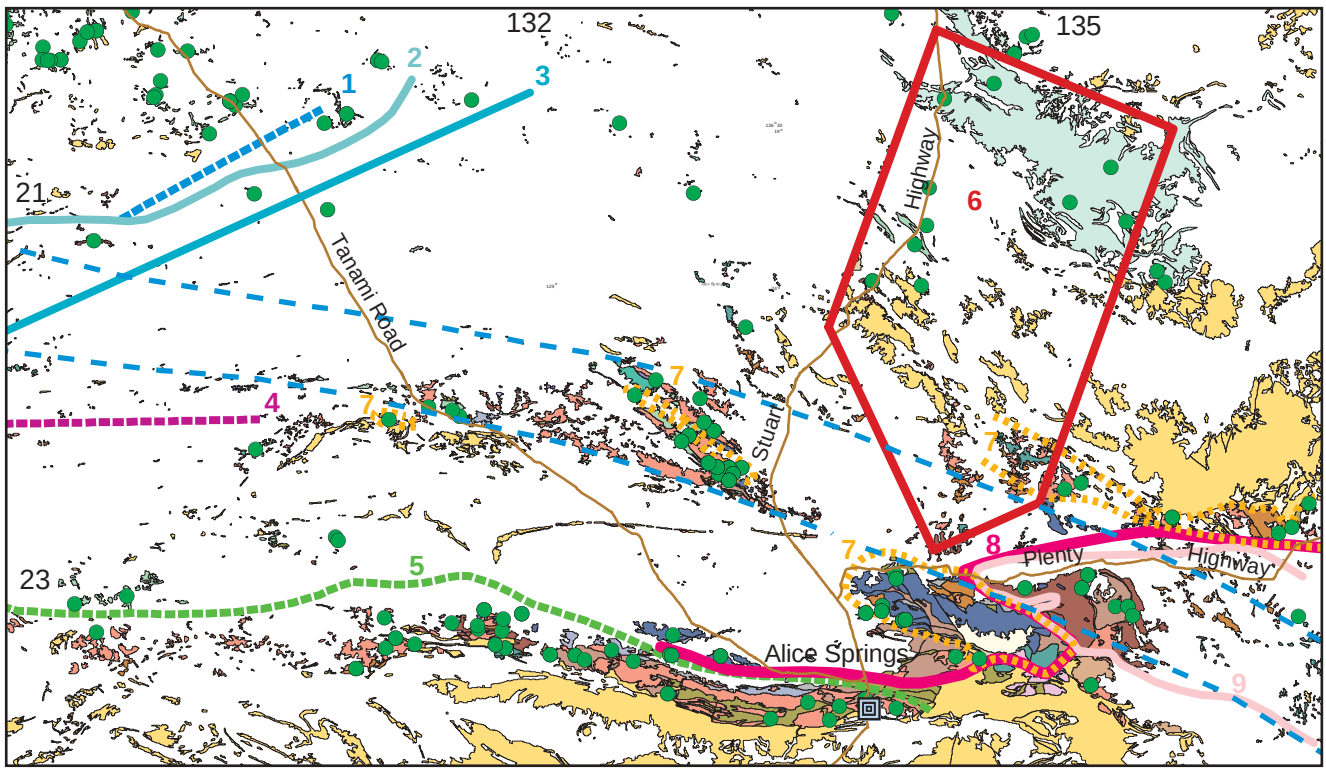


Figure 1. Summary of events that shaped the Arunta–Tanami regions, which were identified in the Alice Springs workshop in May 2003, and locations of the North Australia project work

New project

Each study opens up more lines of enquiry so a two-year project to further investigate controls on lode gold mineral systems in the Tanami, involving Geoscience Australia and the Northern Territory and Western Australian Geological Surveys, will start in July.

The project includes a seismic survey to be carried out later this year by the Australian National Seismic Imaging Resource (ANSIR), once agreement is reached with traditional Aboriginal owners. Seismic data will add to understanding about the Tanami architecture and extend the existing three-dimensional model across the Western Australian section of the Granites–Tanami complex.

The proposed survey comprises four lines of about 650 kilometres, depending on budgetary constraints (figure 3). A long north-west trending line (line 1) and two cross lines (lines 2, 3 and 4) traverse most major geological features of the region and ensure many major structures are crossed more than once.

Adding to this work will be geochronology studies to refine the ages of some rock units and mineralisation so that structural events across the Tanami can be correlated. There will be work that focuses on mineralising processes along the northern margin of the Tanami and in Western Australia, and some sequence stratigraphy to test, among other things, its potential for locating chemically reactive host rock (to gold mineralisation).

The North Australia project was a National Geoscience Accord project involving Geoscience Australia and the Northern Territory Geological Survey that commenced in July 2000. Project work has complemented the Northern Territory's field mapping programs in the Tanami and Arunta.

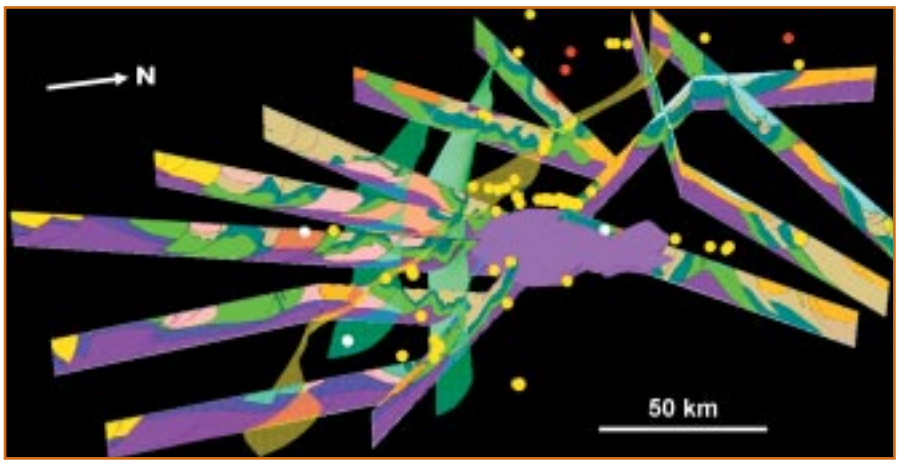
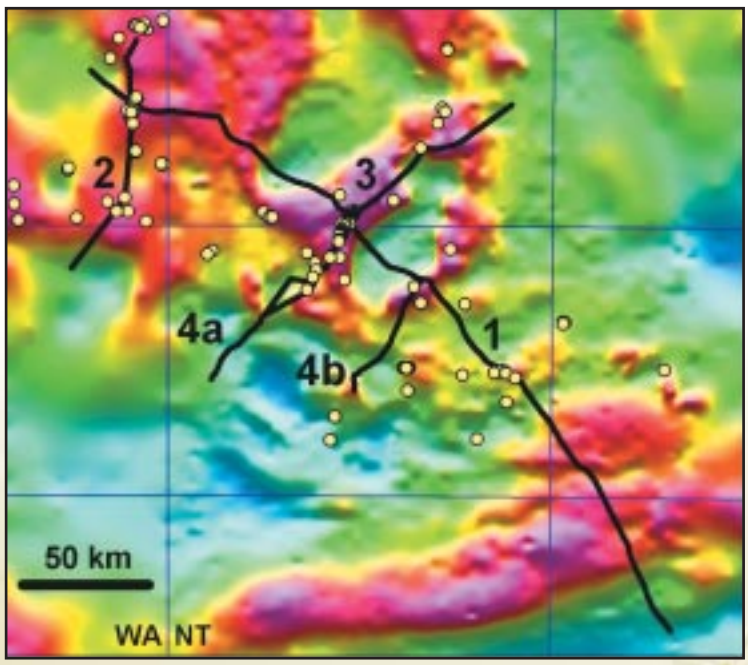


Figure 2. A snap shot of the Tanami 3-D model showing the 2-D modelled sections, selected fault planes and the Frankenia granite dome. Mineral occurrences are shown as dots.

Figure 3. Gravity image of the Tanami region showing the proposed seismic lines and gold occurrences (yellow dots)



References

1. Maidment DW, Williams IS & Hand M. 2004. The Harts Range Metamorphic Complex—a Neoproterozoic to Cambrian metamorphosed rift sequence in the eastern Arunta region. Darwin: Northern Territory Geological Survey, record 2004-0001.
2. Warren RG & Shaw RD. 1985. Volcanogenic Cu-Pb-Zn bodies in granuloites of the central Arunta Block, central Australia. Journal of Metamorphic Geology; 3:481–499.
3. Thompson JF & Newberry RJ. 2000. Gold deposits related to reduced granitic intrusions. Reviews in Economic Geology; 13:377–400.

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GRANITE HOSTS focus of new mineral project

Granites are implicated in much of eastern Australia's mineral endowment. Hence the considerable research over the past 15 years into the chemistry and characteristics of magmatic systems that formed these granites and associated minerals.

The oxidation state, porosity and structure of wall rocks, too, have been studied. But one frequently overlooked factor—the host rock—deserves better attention, and much more than simply looking at levels of intrusion and surface exposure.

Mineralisation can occur up to three kilometres from the granite body, which suggests the host rocks play a part. The mineralogical composition of the country rocks that hosted the granites may contribute to metal precipitation and be critical for a fertile mineral system.

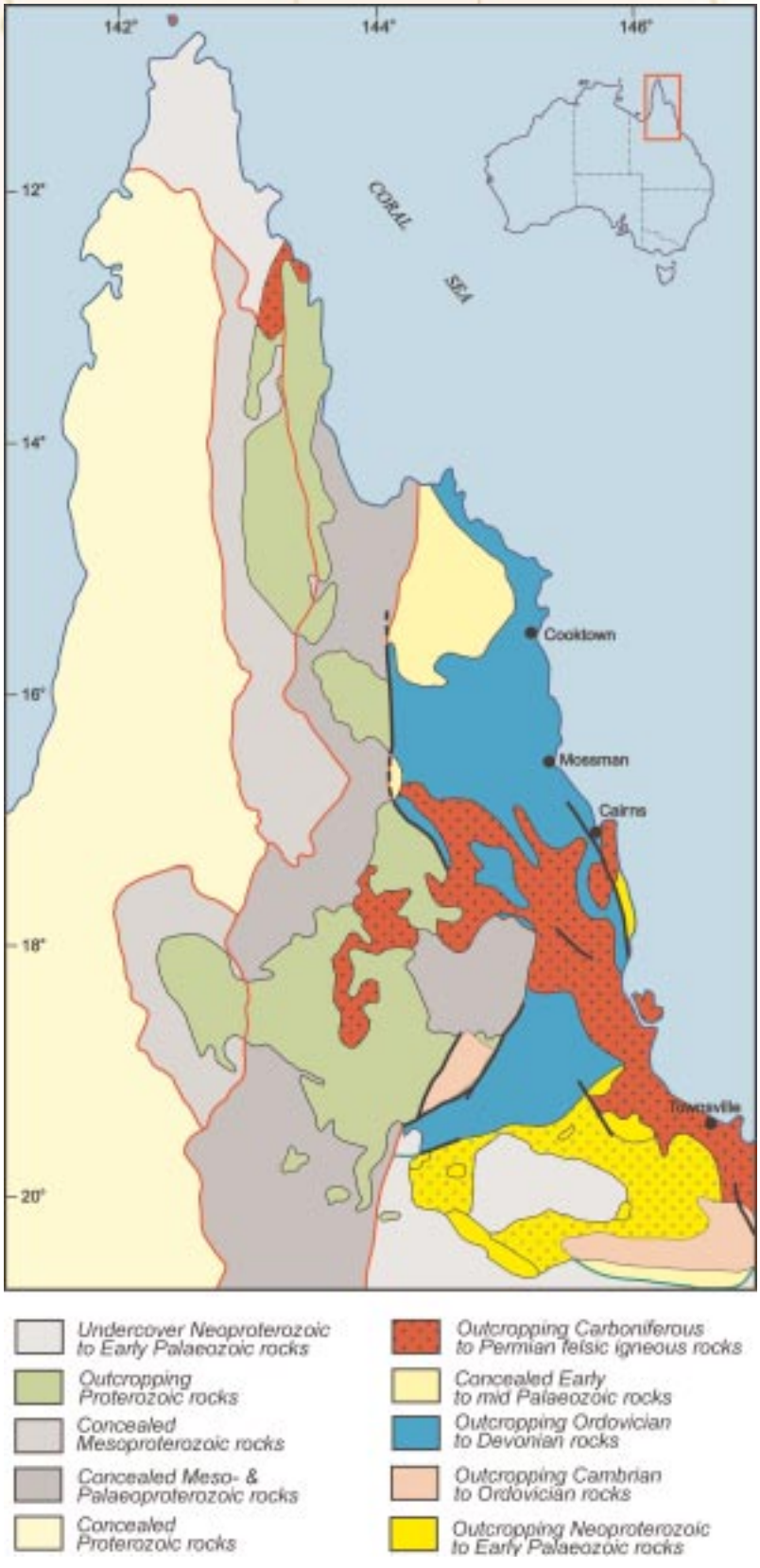
Many significant deposits are hosted by rocks rich in magnetite, graphite and/or sulphide (reduced mineral types). Also certain deposits seem to be restricted to a particular host. Iron-oxide copper-gold and porphyry copper deposits are found in settings where host rocks contain little or no reduced carbon minerals (e.g. graphite).[1] Gold-only deposits seem to occur where the host rocks are carbonaceous and reducing conditions prevail.[2]

Cooperative project

To address the shortcoming, Geoscience Australia is collaborating with state geological surveys and Phil Blevin of Petrochem Consultants in a new project to assess the metallogenic potential of major Australian Phanerozoic granite suites and their host rocks.

The project will synthesise publicly available geoscience data to provide a better basis for targeting granite-related gold/ base-metal mineralisation in eastern Australia. The data should help companies looking for new deposit styles, particularly the recently proposed intrusion-related gold.

The project draws on previous Geoscience Australia studies of igneous rocks in north Queensland



▲ **Figure 1.** The 2003–04 program of the 'Phanerozoic granite and host-rock metallogeny in eastern Australia' project focuses on the geology of north Queensland.

and Australian Proterozoic granites, as well as industry-sponsored projects (AMIRA projects P147B, P425, P426 and P515).

The igneous data set (GRANITE) will include a wide range of mineralogical, geophysical, geochronological, chemical, metallogenic association, and classification (suite, supersuite) data. The country-rock data set (HOSTROCK) will include data on lithology, mineralogy, geophysical properties, geochronological age and metamorphic grade.

All units, igneous and host rock, are uniquely identified by STRATNO (stratigraphic unit number), which relates to Geoscience Australia's Australian Stratigraphic Names database—the primary national standard for geological names. Project data will be linked to all digital data sets (independent of scale) that contain STRATNO.

Current focus

The current program concentrates on granites and associated rocks from the north Queensland region (figure 1), for a number of reasons.

Extensive work has already been undertaken in this area, there is a recent synthesis of geoscience information for the region (published as Bulletin 240: North Queensland geology[3]), and it is one of the next stages in Geoscience Australia's seamless digital geology coverage of Australia. As well, north Queensland hosts significant mineralisation of various styles, including those interpreted to be intrusion-related gold deposits[4].

A similar granites data collation project is being carried out in New South Wales by the state geological survey and Phil Blevin. A project on granites and host rocks of Tasmania is planned.

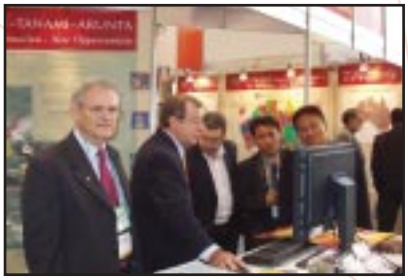
As data become available, they will be incorporated into the larger body of work to assist in the prediction and better targeting of mineralised sites for a range of commodities and new classes of deposits.

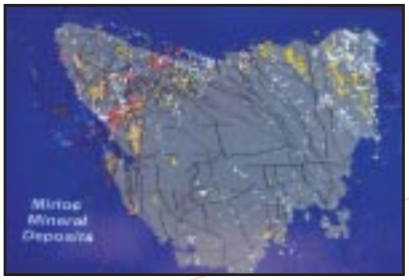
Anyone interested in contributing to the granites project can phone Dave Champion on +61 2 6249 9215 or e-mail david.champion@ga.gov.au.

References

1. Haynes DW. 2003. Are magmas sources of most or all metals in iron-oxide copper-gold and related ore types? In Blevin P, Jones M, & Chappell B, eds. Magmas to mineralisation: The Ishihara Symposium. Geoscience Australia, record 2003/14: 75–76.
2. Wyborn LA. 2003. Assessing the metallogenic potential of Proterozoic granite suites from first principles. In Blevin P, Jones M, & Chappell B, eds. Magmas to mineralisation: The Ishihara Symposium. Geoscience Australia, record 2003/14: 149–154.
3. Bain JH & Draper JJ. 1997. North Queensland geology. Canberra: Australian Geological Survey Organisation, bulletin 240; Queensland Department of Mines and Energy, geology 9.
4. Baker EM & Andrew AS. 1991. Geologic, fluid inclusion and stable isotope studies of the gold-bearing breccia pipe at Kidston, Queensland, Australia. Economic Geology; 86:810–830.

Big presence at world's premier MINERAL EXPLORATION SHOW





The highest metal prices in more than a decade coupled with the first increase in global mineral exploration in five years ensured record attendance at this year's Prospectors and Developers Association of Canada (PDAC) international convention in Toronto from March 7–10.

PDAC 2004 attracted about 9200 participants from 89 countries and covered all aspects of mineral exploration, as well as mining finance and investment.

There was an air of optimism for exploration and mining in the near term, based on continuing strong demand for metals from China and signs of a global economic recovery.

Bullish outlook

PDAC 2004 built on the improved outlook for mineral exploration evident at PDAC 2003 with the Metals Economics Group of Canada reporting the first increase in global mineral exploration budgets since the post-1997 slump.

Metal prices—notably nickel, gold, copper, lead and tin— are at or near their highest prices in a decade. The increases are driven by the decline in metal stockpiles due largely to a huge rise in China's metal imports in recent years. Chinese imports of copper rose by more than 10 per cent in 2003 and nickel and iron ore by 30 per cent.

Metal prices are expected to remain strong over 2004–05 in response to continuing demand from China, an upturn in global economic activity, and a paucity of planned new projects due to low levels of exploration in recent years. Some analysts spoke of a new 'long-term bull market in metal prices' driven by the industrialisation of China.

Last year there were also major increases in mining equity finance, particularly in Canada where the Toronto Stock Exchange and Toronto Venture Exchange raised US$4.1 billion. Figures released at PDAC indicate substantial capital-raising for mineral exploration by junior companies which is likely to bring increased exploration activity in 2004.

Australia on show

The PDAC Trade Show attracted a record 600 plus exhibitors with 294 exhibitions. A further 330 companies showcased their company and exploration projects in the adjacent Investors Exchange.

Geoscience Australia coordinated the Australian governments' technical promotion in the Australian Pavilion, which was shared with Australian mineral exploration service companies such as ENCOM Technologies, Intrepid Geophysics, Gekko Systems, Australian Mineral Economics, and Gravity Capital. GeoJAG Australia coordinated the Australian company participation.

The exhibition was supported by a grant from the Department of Education, Science and Training (DEST) International Showcasing Programme, an element of the Innovation Access Programme, designed to showcase Australian science, engineering, technology and innovation capabilities internationally.

The governments' theme 'Australia – more to explore, more to discover' promoted our premier mineral provinces: Curnamona, Gawler, Kimberley, Lachlan, Mt Isa–McArthur, Musgrave, Murray Basin, New England, Pilbara, Tanami–Arunta, and Yilgarn, as well as Tasmania.

The province-based display was supported by demonstrations of fast internet access to the governments' pre-competitive geoscience information. This was augmented by maps highlighting Australia's gold and nickel resources and potential.

A feature of the exhibition was the recently completed three-dimensional model of Tasmania that includes all available geoscience and exploration results. It provided an excellent overview of Tasmania's mineral deposits in relation to the geology.

Geoscience Australia also presented a paper on Australia's nickel sulphide resources and potential in the technical program. It was one of 118 presentations covering PDAC's major themes: commodities and outlook, China, gold, nickel, new discoveries, and geophysics. Several Australian mining and technology companies also gave presentations.

Prior to PDAC, Geoscience Australia and the state and territory geological surveys made company visits and presentations in Vancouver and Toronto. This program was coordinated by the Austrade office in Vancouver.

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EVENTS calendar

17th Geophysical Conference & Exhibition
Australian Society of Exploration Geophysicists & Petroleum Exploration Society of Australia (NSW Branch)
15 to 19 August
Convention & Exhibition Centre, Sydney
Contact: Conference Action, PO Box 576, Crows Nest NSW 1585
phone +61 2 9437 9333
fax +61 2 9901 4586
e-mail aseg-pesa2004@conferenceaction.com.au

2nd Eastern Australasian Basin Symposium
Petroleum Exploration Society of Australia
19 to 22 September
Convention Centre, Adelaide
Contact: Rob Bulfield, SAPRO Conference Management, PO Box 187, Torrensville SA 5031
phone +61 8 8352 7099
fax +61 6 8352 7088
e-mail scm@sapro.com.au

Predictive Mineral Discovery under Cover
Society of Economic Geologists & others
27 September to 1 October
University of Western Australia, Perth
Contact: Ms Jocelyn Thom, Secretariat SEG 2004, PO Box 80, Bullcreek WA 6149
phone +61 8 9355 2164
fax +61 8 9355 2164
e-mail jaytee@iinet.net.au

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

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

Landing compasses calibrated

▲ A selection of airline compasses and compass theodolites, recently calibrated by Geoscience Australia

▲ Geoscience Australia staff certifying a compass swing bay

Geoscience Australia has long been calibrating compasses for Australia's defence forces. In 2002 Qantas, Australia's largest passenger airline, asked the organisation to calibrate its standard landing compasses. Geoscience Australia has continued to calibrate aircraft and other compasses since that time.

Geoscience Australia performed the certification of a compass swing bay at the airline's maintenance facility to check if the site had a constant, unvarying magnetic field across it and was free of magnetic deviations.

All aircraft have a compass in the cockpit, but magnetic fields caused by other instruments, electric currents and even the aircraft itself can affect the cockpit compass and produce inaccurate readings. Corrections must be applied to the cockpit compass readings to determine the magnetic bearings of the aircraft.

The corrections are derived by comparing the compass in the aircraft with a standard compass outside the aircraft while the aircraft is on a compass swing bay. This is carried out for a series of orientations of the aircraft, in a procedure known as 'swinging' the aircraft. The standard compass which is used in the swinging procedure must also be carefully calibrated, and this is done by Geoscience Australia.

Geoscience Australia calibrates these standard compasses at the Canberra Geomagnetic Observatory at Kowen Forest, near Canberra. The compass is set on an observation pier and magnetic readings are taken every 15 to 30 degrees around the compass circle.

Correction values for each reading of the compass are then determined by calculating the accurate magnetic bearing and correcting for any natural changes in the magnetic field during the observations, by analysing data from the continuously recording Canberra Observatory magnetic variometer system.

Stress levels *examined*

Two years on and it is time to measure our stress levels again. In May 2002, Geoscience Australia and colleagues from Western Australia and New Zealand set up 49 episodic GPS (global positioning system) stations in Australia's most seismically active area in Western Australia. The aim was to measure changes in Australia's crust over a two- and five-year period.

The group measured the precise position of 49 locations spread over a 250 by 400 kilometre wheat-growing area of Western Australia—an area that has been Australia's most seismically active region for around 30 years. These measurements were to set the base level for future comparisons.

Seismic activity like earthquakes, indicate where Australia is deforming. The measurements taken at the 49 stations are expected to show the size, direction and whether deformation is uniform over the region or constrained to a narrow fault zone.

Scientists in New Zealand, Canada and Japan have found evidence of deformation in their countries. But Australia is different. It is an ancient continent with a thick layer of soil and sediment and any evidence that has surfaced, such as a fault or scarp, is often weathered and difficult to study. However, scientists know from borehole stress measurements and earthquake activity that the southern half of Australia is being squeezed in an east–west direction.

During May, geodesists from Geoscience Australia undertook the second epoch GPS campaign for this project.

'We had a survey party in the field observing high-accuracy GPS data at six of the original sites to reinforce the observations taken two years ago at those core sites,' says Gary Johnston, Geodesist, Geodetic Operations project.

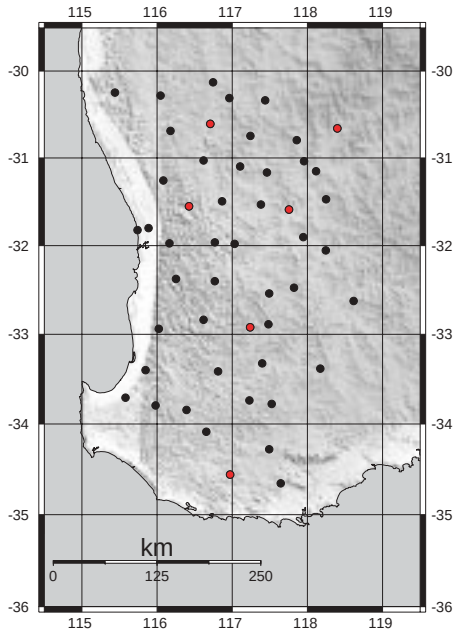
'This work, which has just been completed, may also give us an initial estimate of whether we are going to detect any lateral motion between the six sites.'

The new data will soon arrive at Geoscience Australia, where it will be quality assessed and reformatted. It will then be processed by the Space Geodesy Analysis Centre to determine the current coordinates of the survey monuments.

'Comparison of the new results with those from two years ago will give us an estimate of relative site motion', he says.

The GPS survey of Western Australia's south-west seismic zone is being undertaken by Geoscience Australia, in collaboration with the New Zealand Institute of Geological and Nuclear Sciences, Western Australia's Department of Land Administration, Curtin University, and the University of Western Australia.

A summary of the analysis and results from this survey will be published in an upcoming edition of *AusGeo News*.



For more information on the latest GPS survey phone Gary Johnston on +61 2 6249 9049 or e-mail gary.johnston@ga.gov.au. For information about the SWSZ neotectonics project contact Mark Leonard on +61 2 6249 9357 or e-mail mark.leonard@ga.gov.au

STROMLO **reopens**

The Mt Stromlo Satellite Laser Ranging (SLR) facility in Canberra has been rebuilt more than a year after its destruction in the January 2003 bushfires. Ian Macfarlane, the Minister for Industry, Tourism and Resources, opened the new facility on April 1.

As part of the reopening, the Minister announced a significant AusIndustry Research and Development grant of $8.3 million to Electro Optic Systems. The Company will offer long-term debris management services to the space industry, allowing satellite operators to manoeuvre spacecraft around debris hazards.

The Stromlo facility was originally built in 1998 at a cost of $6 million. It is linked to a network of approximately 40 similar facilities around the world and is one of only six in the southern hemisphere. Geoscience Australia operates Mt Stromlo and another SLR facility at Dongara, Western Australia, using NASA equipment.

The SLR instrument at the facility measures distances between a laser telescope on the Earth's surface and mirrors on passing satellites.

The SLR transmits a short laser pulse through the telescope to passing satellites equipped with retro-reflectors. The time it takes for the pulse to travel from Mt Stromlo to the satellite and back again measures the distance between the Earth and the satellite, with the precision of better than one centimetre.

With the establishment of the new SLR observatory, Geoscience Australia is considering re-establishing the absolute gravity facility at a new modern site close to the SLR observatory, which, if it goes ahead, could be built before 2005.

CYCLONES : TOWARDS A *spatial risk analysis*

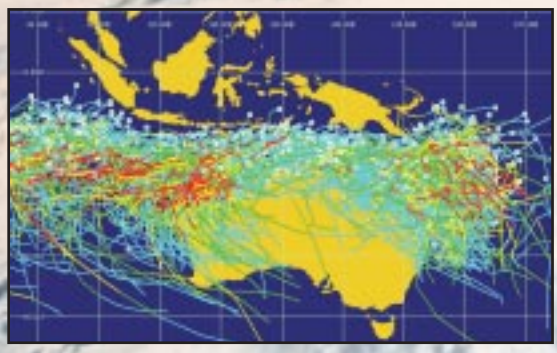


Figure 1. The tracks of more than 900 cyclones that occurred in the Australian region from 1907 to 2001. Different colours represent different strengths: red are systems with hurricane force winds; yellow are those with storm force winds; green are gale force winds; and blue are below cyclone strength (or there was no pressure datum in the database).

Cyclones are a major natural hazard for Australia estimated to cost on average $266 million a year or almost a quarter of Australia's annual natural disasters bill[1]. With such high costs, there is a need to determine where cyclones are likely to occur and to assess the risk they pose to communities.

Geoscience Australia is developing mathematical models that simulate the location of a cyclone, its path and wind characteristics. As a first step, it has undertaken a statistical analysis of cyclone origins around Australia using historical data.

The analysis draws on Bureau of Meteorology information about more than 900 cyclones in the Australian region from 1907 until the end of the cyclone season on June 30, 2001.

The dataset contains the path and such attributes as the central pressure and direction of each cyclone (figure 1).

Statistical distribution

The white circles in figure 1 indicate cyclone origins: where a cyclone was generated, first observed, or upgraded from a tropical depression. Figure 2 shows the number of cyclones on a five by five degree grid of latitude and longitude. But the distribution displays multiple peaks, necessitating a non-parametric statistical technique to obtain an estimate of the true spatial distribution of cyclones.

Geoscience Australia has applied a non-parametric method called kernel density estimation[2] to the historical data (figure 3).

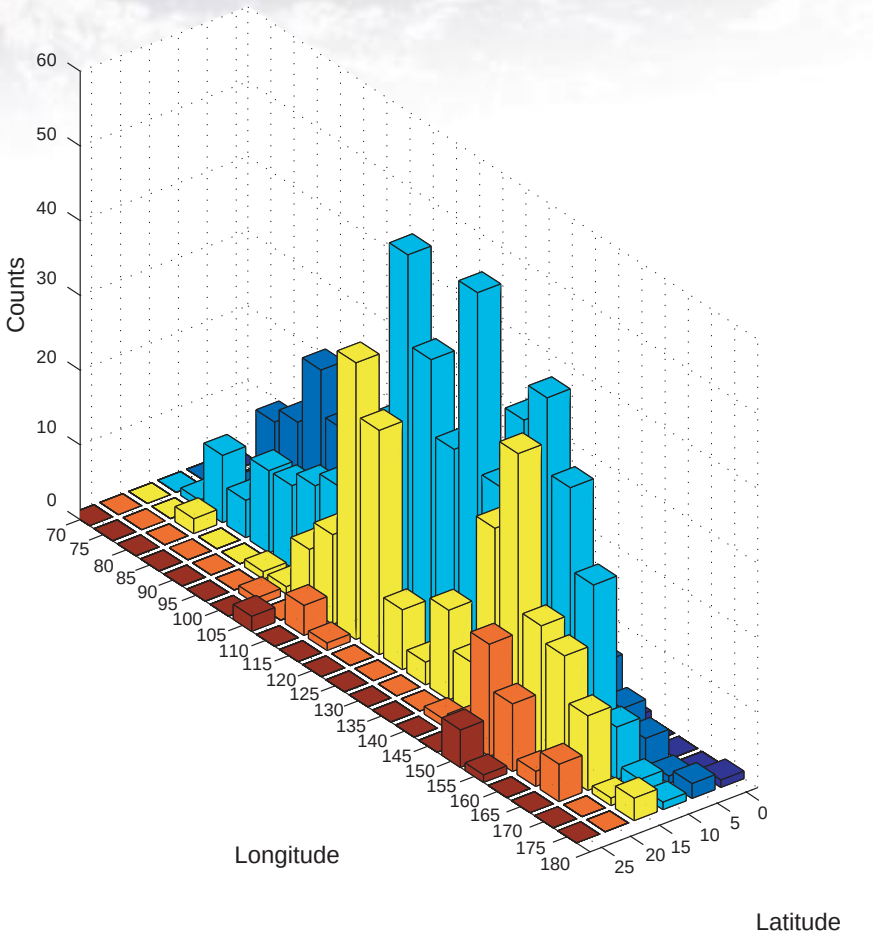


Figure 2. The number of cyclone origins on a 5 x 5 degree grid of latitude and longitude

Sampling algorithm

Based on conditional probability theory, Geoscience Australia created a two-dimensional sampling algorithm to establish the most likely location for a cyclone to develop.

The sampling result is shown in figures 4 a–c. The similarity between 4b and 4c shows the accuracy of the sampling algorithm. This effective and efficient computational sampling algorithm for generating cyclone origins is an important part of the probabilistic cyclone risk assessment undertaken at Geoscience Australia.

References

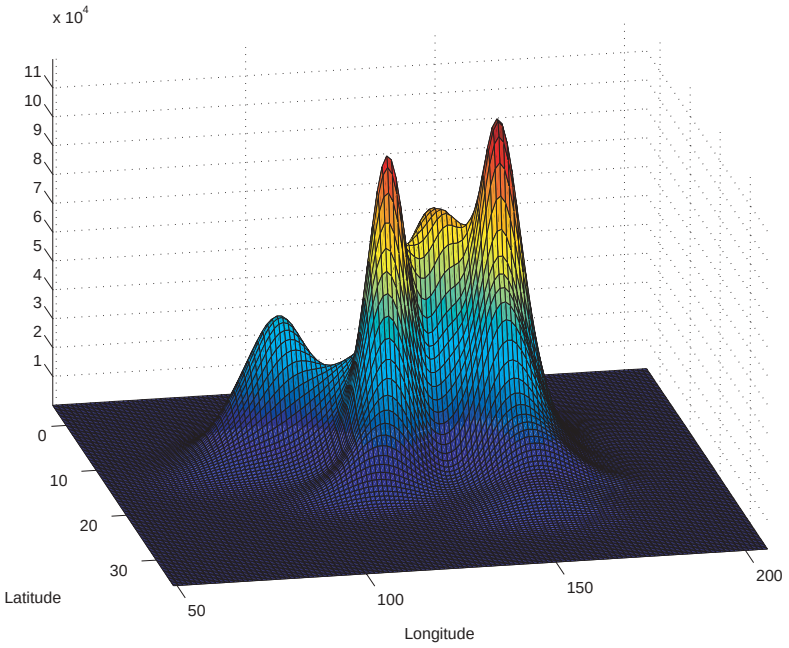
1. Bureau of Transport Economics. 2001. Economic costs of natural disasters in Australia. Canberra: Bureau of Transport Economics, report 103.

   From 1967 to 1999 the total cost of tropical cyclones in Australia was approximately $8.8 billion in 1999 prices (aggregated from events each costing $10 million or more), averaging $266 million per year. This is 24 per cent of the total cost of natural disasters for the same period in Australia.

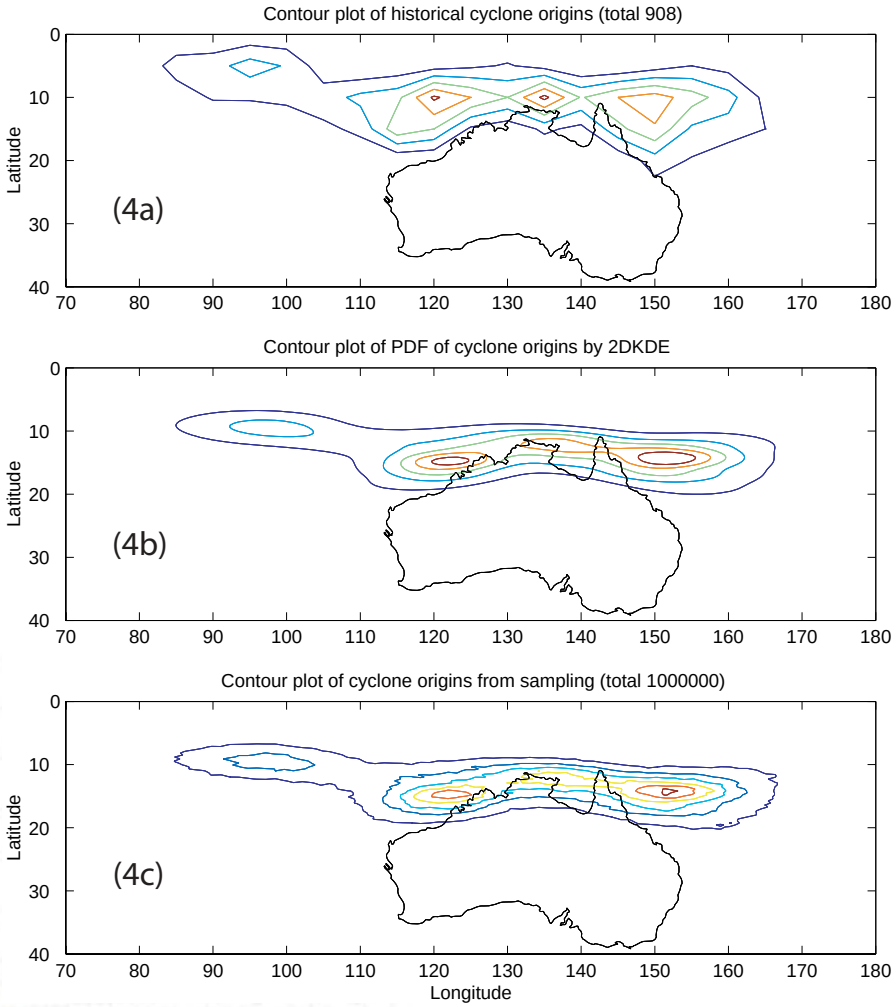
2. Silverman BW. 1986. Density estimation for statistics and data analysis. London: Chapman & Hall.

Geoscience Australia acknowledges the contributions of Joe Courtney from the Bureau of Meteorology

Former Geoscience Australia employee Xun Guo Lin was the author of this article. For more information phone Matt Hayne on +61 2 6249 9536 or e-mail matt.hayne@ga.gov.au

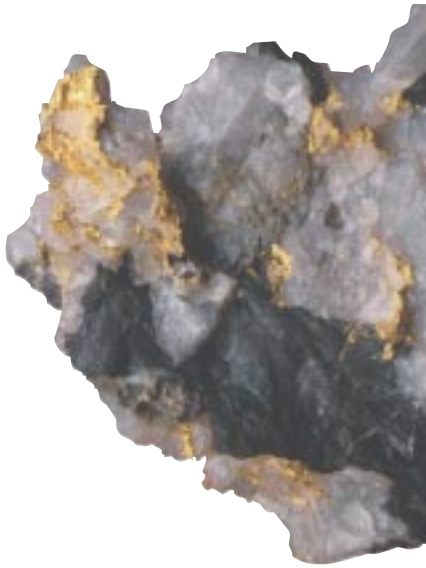


▲ **Figure 3.** The PDF (probability density function) of cyclone origins estimated by a bivariate normal kernel density with adaptive bandwidth



▲ **Figure 4.** Contour plots of: a) historical cyclone origin counts on a 5 x 5 degree grid; b) the PDF of cyclone origins estimated by kernel density; c) cyclone origins generated by one million random samples drawing from the PDF estimated by kernel density.

Chemical reasons for lode-gold associations



Geoscience Australia has been carrying out geochemical modelling of processes that formed lode-gold deposits in two of Australia's premier mineral provinces—the Yilgarn Craton and Lachlan Fold Belt—to predict the likelihood of finding similar deposits elsewhere within and outside these regions. The results support observations about the distribution of lode-gold deposits, notably a preferential association with mafic rocks and greenschist facies metamorphism.

Although the architecture, timing and structural characteristics of lode-gold mineral systems are relatively well understood[1], there are a number of observations that need a chemical explanation.

Lode-gold deposits formed under a wide range of temperature–pressure conditions (200 to >600° C, <1–4 kbar) from fluids with broadly similar ratios of the major molecular components (i.e., H_2O+NaCl+CO_2±CH_4±N_2), isotope ratios, and ore geochemistry. The fluids are characterised by low salinity (usually between 3 to 7 wt % NaCl equivalent), with CO_2 contents most frequently ranging from 10 to 25 mol%.

Lode-gold deposits are hosted by a wide range of rock type, ranging from ultramafic and mafic intrusives and extrusives, turbiditic and conglomeratic sedimentary sequences to granites. The dominant hosts, at least in the Yilgarn craton, seem to be mafic rocks (figure 1).

Although these deposits formed over a wide range of temperature–pressure conditions, most lie in areas that have undergone upper greenschist to lower amphibolite facies metamorphism (figure 2). This, together with a predominance of deposits with brittle-ductile transition structural features, suggests that there are specific crustal environments that are more prospective for lode gold systems.

Chemical modelling

Equilibrium chemical modelling simulates the processes of gold mobilisation, transport and deposition. This type of modelling was applied to lode-gold systems of the Yilgarn Craton and Lachlan Fold Belt to:

1. Evaluate whether common crustal-fluids can transport and deposit gold over a broad range of crustal temperatures and pressures in a range of host rocks;
2. Evaluate whether fluids that have been equilibrated with mafic host rocks can produce alteration patterns typical for lode-gold deposits;
3. Compare the relative effectiveness of the common host rocks as desulfidation gold traps.

Yilgarn lode gold

The Archaean lode-gold deposits of the Yilgarn Craton have almost all the features of lode-gold mineralisation listed above.

Common minerals of alteration assemblages that formed at temperatures below 400° C, which are in proximity to the vein systems and fault/shear zones, include ankerite/dolomite, albite, white mica (muscovite/paragonite), chlorite, and pyrite. The actual assemblage is controlled by initial bulk composition of the immediate host rock.

The real origin of the nature of the gold-bearing fluids is still contentious. Available isotopic data suggest a mixed source of fluid components and channelised fluid flow from deep sources below the greenstone belts.

There are two main hypotheses for the origin of the fluids: metamorphic devolatilisation of rocks during prograde metamorphism, or devolatilisation of granitic rocks during their crystallisation.

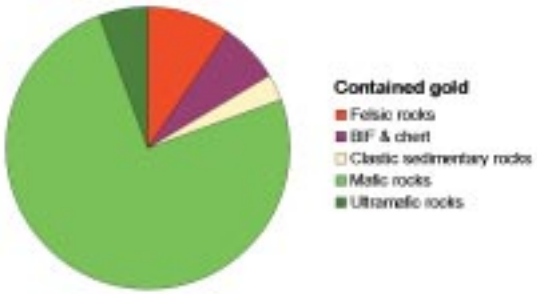


Figure 1. Relative gold resources (production plus reserves) and nature of host rocks to gold mineralisation in the Archaean greenstone belts of the Yilgarn Craton[2]

Lachlan lode gold

Most gold deposits in the Lachlan Fold Belt are hosted by turbidites. Except for a few gold deposits within the contact aureoles of granitoids, deposits typically occur in sub-mid greenschist metamorphic-grade terranes. They are structurally controlled and commonly associated with antiformal structures.

Vein mineral assemblages are simple, consisting of quartz (>95%) and minor carbonate, chlorite, phengite, albite, apatite, rutile and sulfides. Alteration features are subtle but consist of carbonate spotting, sulfide porphyryblasts, silicification, and minor amounts of carbonate, chlorite and sericite.

The ore-bearing fluids had low salinities (typically <6 wt.% NaCl eq.), contained varying amounts of CO_2 ± CH_4 ± N_2, and reached temperatures of up to 400° C.

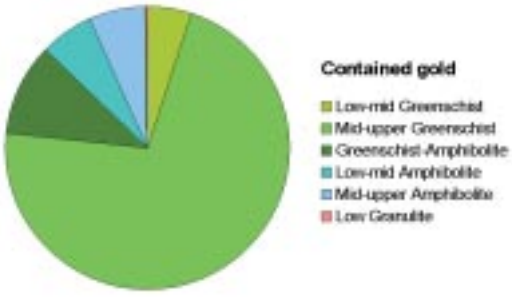


Figure 2. Proportions of total gold productions and known resources from terrains of different metamorphic grade[2]

Theoretical modelling

Simulation of geochemical processes relevant to the formation of lode gold deposits has been completed for a 15-component system (H-O-Cl-C-S-Na-K-Ca-Mg-Fe-Si-Al-Ti-Ag-Au). The chosen chemical system was sufficient to reproduce the rock-forming mineral assemblages that can control or affect gold solubility in most natural environments. Modelling was performed in the temperature–pressure (TP) region of 300–600° C and 1–3 kbar, and incorporated three distinct stages:

1. Initial equilibration of the generic lode gold H_2O-CO_2-NaCl fluid with an excess of a rock assumed to be representative of the fluid source region. This rock-buffered regime constrains the overall chemistry of the fluid;

2. Monitoring changes in fluid composition, which had been isolated from the source rock and was undergoing cooling and decompression. This fluid-buffered regime approximates the focused fluid flow within the fault systems and veins;

3. Examining the processes of alteration and mineralisation as this fluid infiltrated potential host rocks.

For each calculation point along a specified TP path, the chemical speciation (the combination, abundance, and composition of all stable phases) was determined—both in a closed multi-component system, emulating the fluid-source region, and in an open system, emulating the focused fluid flow within the fault and alteration zones.

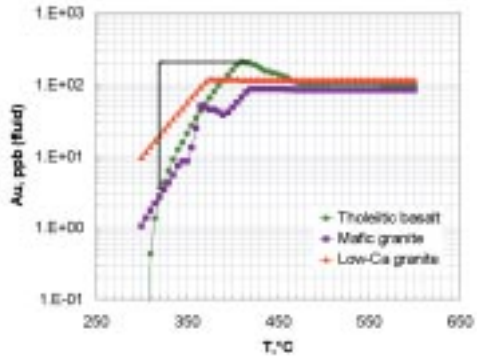


Figure 3. Total gold solubility calculated for fluid-rock equilibria with different Yilgarn rock types at rock-buffered conditions. The arrows show the gold-bearing capacity of the fluid isolated from the basaltic rocks at ~420° C prior to its reaction with the possible host rocks at 320° C.

Yilgarn results

Gold solubility was calculated for three major magmatic rock types related to the Yilgarn lode-gold deposits: tholeiitic basalt, mafic granodiorite, and low-Ca granite. The first two are statistically important hosts for lode-gold mineralisation, with the metamorphosed tholeiitic basalt often advocated as a source of the H_2O-CO_2-NaCl fluids. The initial water-to-rock ratios were specified either by the reactions of metamorphic devolatilisation or by setting them to reasonably small values (~0.01/-0.03).

Fluid buffering reactions at low water-to-rock result in gradual evolution of the fluid composition, reaching the archetype composition of orogenic lode-gold fluids (in terms of the H_2O-CO_2-NaCl sub-system) at about 450° C. The best match of H_2O:CO_2 ratios was observed for equilibrium with tholeiitic basalts, lending support to the devolatilisation model for the origin of the fluids.

The modelling results imply a different efficiency of gold mobilisation and precipitation at different crustal levels. At low water-to-rock ratios and high temperatures (>400° C), the calculated solubility of gold is high enough (e.g. >200 ppb) to completely scavenge native gold from the magmatic host-rocks (figure 3). The calculations support speculations that most high-temperature Archaean ore-fluids were probably undersaturated in gold in their source region.

The rock-buffered series of calculations illustrate that different rock types are characterised by different concentrations of total gold in equilibrium fluid at the conditions of gold saturation (i.e., at temperatures below 370 to 400°

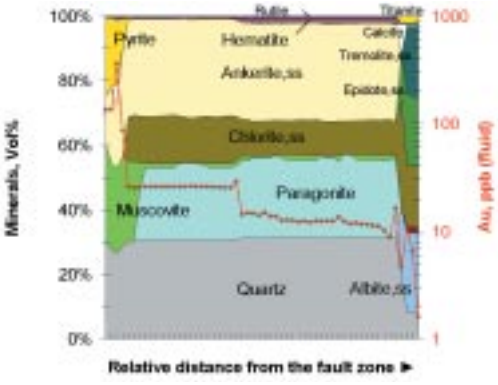


Figure 4. Results of modelling near-fault alteration zones in a typical host rock in the Yilgan Craton. Interaction of the fluid initially equilibrated with tholeiitic basalt at rock-buffered conditions at 420° C, with the same tholeiitic basalt at 320° C. The near-fault zoning is consistent with generalised empirical observations and deposition of gold in response to fluid-desulfidation reactions.

C, figure 3). In other words, they will have different capacities to trap gold.

Below 400° C, they can be ranked in increasing order from low-Ca granite through tholeiitic basalt to mafic magnetite-bearing granodiorite. However, all have the capacity to precipitate gold at TP conditions pertinent to greenschist facies metamorphism.

Near-fault alteration of rocks was modelled to test whether the common fluid sourced from metamorphosed basalts can be responsible for gold deposition and typical alteration haloes. As shown in figure 4, fluids initially equilibrated with tholeiitic basalt at about 400° C can produce typical alteration haloes at greenschist-grade metamorphic conditions. Thus, a granitic source of fluids may not be necessary to produce alteration assemblages dominated by quartz, sericite±paragonite, and ankerite. In turn, water–rock interaction will result in gold precipitation due to desulfidation reactions.

Lachlan results

A similar approach was employed to analyse the mineralisation conditions of the lode-gold deposits of the of the western Lachlan Fold Belt. The generic gold-bearing fluid was first equilibrated with the underlying Cambrian mafic volcanics. Then the flow of this equilibrated fluid up through crustal faults and into the surrounding host turbidites was simulated.

The results agree with geological observations: most of the gold is precipitated in quartz veins in response to a separation of gas and liquid phases due to a drop in fluid pressure. The predicted alteration assemblage forming the host turbidites (quartz, muscovite, K-feldspar, chlorite, albite and calcite with pyrite and arsenopyrite located closer to veins) agrees fairly well with the alteration patterns observed around these deposits. There is only a slight decrease in gold solubility due to water–rock interaction as most of the gold has already been precipitated in the veins.

Exploration implications

1. Rock-buffered gold-bearing fluids are undersaturated with gold at high temperatures (>400° C), permitting gold transport over long distances (figure 3). Gold deposition in high-grade metamorphic terrains may require special conditions.

2. Gold can be transported without precipitation over long distances along fluid-buffered paths within major fault zones under lower greenschist TP conditions (figure 3), unless special conditions such as fluid immiscibility are encountered.

3. Metamorphic fluids expelled via devolatilisation reactions of mafic rocks can produce typical alteration haloes under greenschist-grade metamorphic conditions at lower temperatures and pressures. Water–rock interaction will result in gold precipitation due to fluid desulfidation reactions (figure 4).

4. A granitic source of fluids may not be necessary to produce alteration assemblages dominated by quartz, sericite±paragonite and ankerite, typically observed within orogenic lode-gold deposits.

5. Rock bulk chemistry controls the composition of equilibrium fluids, making some rock types more efficient traps for gold deposition (figure 3)—possibly explaning why mafic magnetite-bearing granitoids have an affinity for gold mineralisation.

6. Localisation of gold within the veins irrespective of the reactivity of the immediate host rocks is consistent with the upper crustal levels where temperature and pressure will favour fluid immiscibility in the H_2O-NaCl-CO_2 system. However, such terrains will probably require mafic basement to provide the source of typical lode-gold bearing fluid.

References

1. Hagemann S & Brown P, eds. 2000. Gold in 2000. Reviews in Economic Geology; 13:559.
2. Groves D, Knox-Robinson C, Ho S & Rock N. 1990. An overview of Archaean lode-gold deposits. In: Ho S, Groves D & Bennett J, eds. Gold deposits of the Archaean Yilgarn block, Western Australia: Nature, genesis and exploration guides. Perth: University of Western Australia, 2–18.

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Interoperability - ENABLING DATA ACCESS *in real time*

Because of government initiatives in Australia, a lot of pre-competitive geoscience data are free via the internet, mostly as downloadable files from the custodial organisations. This wealth of information helps make Australia an attractive and competitive place to explore, but gaining access to the latest data in real time and in standardised formats can be a big problem.

During the recent Minerals Exploration Action Agenda inquiries, industry highlighted problems in gaining access to pre-competitive geoscience information. It said that existing information was commonly incomplete and fragmented across eight government agencies, each with its own information management systems and structures. For industry and its service providers, these disparate systems lead to inefficiencies and cause higher costs.

Together, government and industry need to develop and implement nation-wide protocols, standards and systems that provide for internet-based access to all exploration-related data, including government-generated pre-competitive geoscience data and industry-generated exploration data.

Web services and grid computing are the key technological changes. The grid is an information and services infrastructure being built on the first-generation internet and the world wide web. It is transforming computing from an individual and corporate activity to a global capability by linking digital processors, storage systems and software.

Systems which link these distributed hardware and software resources stored on multiple machines from multiple vendors have to communicate without human intervention. They must 'interoperate' through applications that 'machine read' data in real time from distributed sources.

New generation

First-generation internet standards essentially allow only for the downloading of data. Most manipulation, integration, processing and analysis take place using local resources and/or data that are locally hosted. As data sets get larger and more complex, so do the computational resources required to process the data. In any industry, such larger-scale resources are increasingly only available to the major industry players.

In a fully interoperable system, the user searches the web for data sets that meet their search requirements. These data are returned in real time from one or more separate suppliers as an integrated data set that is formatted as programmable objects. As the data are preformatted to international standards they can be passed on-line to applications that can read such standards for real-time processing.

Australian exemplars of such sites include OZCAM, a portal that links 11 Australian natural science museums for user queries based on species name. Data returned from sites around Australia can be displayed either as dots on a map or as a list of specimens. Other sites include the Community Access to Natural Resources Information (CANRI) portal which brings together in real time key environmental information distributed among many sites, including New South Wales government agencies and other organisations such as the Australian Antarctic Division.

Industry benefit

The geoscience community has been slow to adopt interoperable technology. Pre-competitive minerals exploration data are fragmented across government agencies, each with its own information management systems and structures. If users in an exploration company want data on a national-scale topic they commonly have to go to each agency, download the data in eight different formats and then integrate it locally to a coherent format for their in-house applications.

In a fully interoperable system, data would be combined in real time into a single coherent format that conforms to the international standards for data interchange (e.g. XML). This will save many hours, if not days, in first locating the relevant data sets from each site, downloading each individually, and then converting each one to a consistent format prior to processing. As well as cost savings, the user always accesses the latest versions of the data.

Modelling ore-deposition processes under cover is increasingly important to fundamental exploration. To have realistic models, there is a need to simulate ore deposition on real-world, complex, district- to regional-scale mineral systems processes.

Such modelling and simulation scenarios helped the direct drilling of gold mineralised intersections at the Kewell prospect in the Stawell district. But to take it to a more advanced level, requires multidisciplinary, computationally intensive methodologies that can link data, applications and computational systems from distributed resources 'interoperably' in real time.

First steps

In July 2003, more than 170 people from government geoscience, environmental and spatial data agencies, research organisations, industry and consultancies attended a national workshop to develop a strategy for building a Solid Earth and Environmental Sciences Grid. The goal was to address the issue of 'transparent access' to data and knowledge about the Australian landscape, and to canvass the available and potential technologies offered by the grid. A key outcome was that participants agreed to work together to upgrade data repositories and to link them through a common, interoperable language.

This understanding to create a SEE Grid 'community of practice' has led to more formal initiatives such as a project for a Technology Roadmap for Implementing Interoperability of Geospatial Data Delivery for the Australian Minerals Industry. This project is supported by AusIndustry's Innovation Access Program and the Minerals Council of Australia, and is being conducted by a consortium from CSIRO Exploration and Mining, the CRC for Predictive Mineral Discovery, Social Change Online and Geoscience Australia. Recently it gained support from government geological surveys through their Government Geoscience Information Policy Advisory Committee (GGIPAC).

The project has developed close links with similar international activities such as the GEON project in the United States and the National Environmental Research Council Data Grid which is a British e-science project.

The project's work will be made available through the Australian geoscience portal for review and comment.

Systems 'language'

The eXploration and Mining Markup Language (XMML) is an XML-based encoding for geoscience and exploration information. XML is the basic syntax for structured information transfer via the web.

The XMML project was initiated by CSIRO and Fractal Graphics in 2000 to develop a data-transfer encoding that facilitated exchange among desktop applications, networked computers, and organisations. The XMML specification is published on the web at www.seegrid.csiro.au /twiki/bin/view/xmml/webhome. It is based on the more generic Geography Markup Language (GML), developed by the Open GIS Consortium and is being standardised as ISO 19136. GML provides:

- a basic meta-model, based on features, properties, objects and values;
- a regular XML encoding pattern;
- a large number of utility components, particularly concerning geometry, topology, temporal, and coordinate reference systems, that are common to all geographic data;
- conformance with ISO 19100 series standards;
- compatibility with the Web Feature Service interface;
- potential for integration with data expressed in other GML-based languages; and
- compatibility with national Spatial Data Infrastructures.

The establishment of the SEE Grid community has benefited the XMML project through complementary language development. These languages include: the Assay Data Exchange (ADX) reporting language, GPML2 language for plate-tectonics data, and Geoscience Markup Language (GSML) which integrates text data with spatial data and links to data-stores.

ADX has been taken up by ALS Chemex (assay laboratories) and incorporated directly into the Metech Acquire mining database software. Interoperability between users of these organisations' services will be improved as a result. Other laboratories have also expressed interest in taking up the new standard.

Global foundation

The advanced nature of the XMML project has led to direct engagement with international initiatives from the Open GIS Consortium, and the International Union of Geological Sciences (IUGS).

At a meeting of representatives of 15 geological surveys in Edinburgh in November 2003, a number of efforts to develop a geoscience data model were presented. As well as XMML, these included the North American Data Model, the Digital Geoscientific Spatial Model from Britain, France's Geological Data Management, and various map-data models. Apart from XMML most efforts had been initiated in a less-connected era, when the possibility of real-time sharing and combining data from networked services had not been a major design goal.

The XMML project was recognised as the most technically mature effort in web-compatible encoding for geoscience data. As a result, the XMML approach and encoding patterns were adopted by the IUGS as the basis for the development of an international model, under the auspices of the recently formed Commission for Geoscience Information. Thus XMML will be standardised through the IUGS Commission on Geoscience Information.

Parallel activities

There are at least three other closely related, formalised activities that have the potential to benefit the Australian mining industry.

1. Spatial Industry Interoperability Demonstration Project (IDP)

A series of test projects is being developed to show how interoperability of spatial data can help to better manage other business activities (mostly centred on emergency and incident management). The IDP primarily aims to promote awareness of interoperability and open standards and protocols within the Australian geospatial technology community. It will lead to a greater application of international open standards for spatial information processing in Australian industry and government, providing accessibility over the internet, at a lower cost than is currently possible.

The project is working with the AusIndustry–Minerals Council of Australia consortium to ensure that the open standard technologies developed can be applied to the mining industry sector.

2. Australian Earth and Ocean Network (AEON)

AEON is an emerging network of university and government researchers in the Australian Earth and Ocean domain led by Associate Professor Deitmar Muller at the University of Sydney. It is currently under consideration as an Australian Research Council research network. The disciplines covered by AEON will include exploration and mining, solid earth geophysics, marine science and long-term climate change, and issues related to marine defence.

Two broad themes of the network are to explore how to best create shared community computational/data-base infrastructures for process modelling, and extracting useful information from very high dimensional data sets, including image analysis.

AEON will coordinate close collaboration between the large-scale application developers in Australian and overseas universities, and will use data repositories linked through the Australian geoscience portal.

3. Grid technologies for the Geosciences

The Australian Partnership for Advanced Computing (APAC) recently approved a project on Grid Technologies for the Geosciences. Its aim is to identify and establish the geoscience community specific interoperability 'standards' for the APAC grid network. This will be achieved by collaboration with the APAC grid infrastructure projects and test-bed application development.

The project is focused on developing middleware and applications for accessing data through the Australian geoscience portal. It will ultimately assist in developing fundamental elements of software frameworks for modelling and simulating Earth Systems processes. Components of this project include: numerical codes for process modelling, management of large-scale jobs and workflow engines, federated data access, large-scale data storage, visualisation, and grid middleware services (single sign-on, security and remote access).

Interoperability is the key to real-time access to pre-competitive geoscience information that is currently fragmented in disparate and incompatible systems across Australian government agencies. The next generation of internet technologies offers opportunities to gain maximum benefit from the extensive range of geoscience and spatial digital information, to underpin exploration activities and research that are relevant to the minerals industry.

For more information phone Lesley Wyborn on + 61 2 6249 9489 or e-mail lesley.wyborn@ga.gov.au

Useful web sites

www.minerals.org.au/downloads/pdf/meaa_report_web.pdf
www.ozcam.gov.au/
www.canri.nsw.gov.au/
www.antdiv.gov.au/
www.mpimines.com.au/news/Gold_Acquisition_Not_Completed_030716.pdf
www.glassearth.com/news.html
www.seegrid.csiro.au/
www.geoscience.gov.au/
www.geosci.usyd.edu.au/research/marinegeophysics/AEON/index.html
www.geon.org

Broad interest in Open Day

Over 50 delegates representing most of the major and many of the smaller petroleum operators, service providers, consultants and government and scientific agencies attended the Geoscience Australia Petroleum Open Day on April 1.

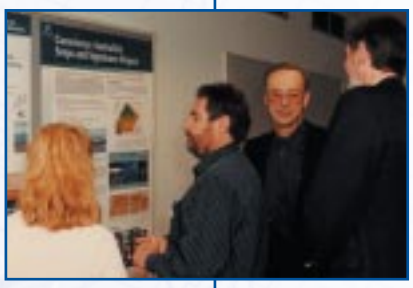
The Open Day followed the annual Australian Petroleum Production and Exploration Association (APPEA) conference and provided an opportunity for industry to see how the Australian Government's new petroleum funding is being spent. This new funding, announced in the 2003–2004 federal budget amounts to $61 million over four years and is the driver for many new and exciting petroleum studies.

The morning session was dedicated to new government initiatives and directions, and was opened by Dr Trevor Powell, Deputy CEO of Geoscience Australia and former Chief of the Petroleum and Marine Division. He outlined the process of obtaining the new funding and the major initiatives of Geoscience Australia's 'Big New Oil' program.

John Hartwell, Head of the Resources Division, Department of Industry, Tourism and Resources, spoke about the government's role, recent achievements and future priorities. Another speaker, Gerard Early, Head of Approvals and Wildlife Division, Department of Environment and Heritage, outlined the *Environment Protection and Biodiversity Conservation Act 1999* and its relevance to the petroleum industry.

Geoscience Australia presenters detailed the new initiatives being undertaken as part of the Big New Oil program, including:

- The Bremer Sub-basin geological sampling survey
- The hydrocarbon seepage survey and sampling of the Yampi Shelf
- Remastering of the entire national seismic survey data collection
- New directions in the delivery of petroleum data over the internet.



Delegates were shown a selection of rocks dredged from the Bremer Sub-basin in February and March this year and given an update on the preliminary results of the geochemistry and biostratigraphic analysis. The rocks analysed were mostly Jurassic in age with some Cretaceous samples present and their depositional environments ranged from fluvio-lacustrine to marine.

Initial results of the Yampi Shelf survey were also presented, showing the different lines of evidence used to locate and detect seepage. Images of ships' echo sounder and side-scan sonar showed very active seepage, with gas plumes rising in the water column to 50 metres. This seepage could be tied back to features observable in seismic data. The aim of the project has been to integrate seepage information from seismic data, features identified on the sea bed and information from remote sensing platforms. This will allow targeted sampling programs, which will provide samples for geochemical analysis.

In the afternoon the delegates moved through a series of discussion sessions with Geoscience Australia's scientists about their petroleum-related work. Activities included one-on-one demonstrations of Geoscience Australia's web-enabled petroleum databases and live feeds of satellite tracking. Other highlights included a three-dimensional visualisation and model of the Eyre Sub-basin and Bowen Basin using the new EDGE theatre, as well as tours of the laboratories and the vast seismic and well data repositories.

These sessions provided valuable feedback from industry on the Big New Oil program initiatives, and will greatly assist the planning and shaping of future programs and activities.

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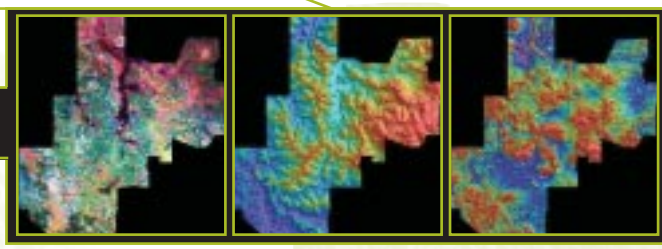
GEOPHYSICAL DATA
released for key WA regions



The latest airborne geophysical data releases cover Australia's most seismically active region, Burakin in Western Australia, and the Belele area which has high potential for gold mineralisation.

Burakin region

Geoscience Australia has released more than 147 000 line kilometres of airborne geophysical data over the Burakin area covering parts of the Ninghan, Moora, Bencubbin, Perth and Kellerberrin 1:250 000 sheet areas.

Knowledge derived from the geophysical data and other complementary data sets will be used to better understand bedrock control in an area of earthquake activity, assist in the mapping of the area's Archaean rocks, and a major drainage feature.

The data in this release are from a survey flown for Geoscience Australia by UTS Geophysics in June 2003, as well as three private-company surveys flown between December 1996 and February 1997.

The Burakin survey produced 46 500 line km of geophysical data. Flight lines were flown east–west and spaced 200/400 metres apart. The Mt Marshall, Lake Hillman and Goomalling private-company surveys produced 42 300, 19 400 and 39 000 line kilometres of geophysical data respectively. Flight lines were flown north–south and spaced 250 metres apart. All surveys were flown 60 metres above ground level.

The company surveys recorded magnetic gradiometer, gamma-ray spectrometer and elevation data, but no tie lines were flown for these surveys. Geoscience Australia had this data reprocessed with purpose-flown ties and then levelled the data with its own to create a combined data set for continuous coverage.

All data have been gridded using variable density gridding with a 40-metre fine cell and an 80-metre coarse cell size.

Belele area

The Geological Survey of Western Australia and Geoscience Australia have jointly released approximately 100 000 line kilometres of airborne geophysical data covering the Murchison region of Western Australia. The area covered was the entire Belele 1:250 000 sheet area and parts of the 1:100 000 sheet areas of Gould, Moorarie, Milly Milly, Boolardy, Meka and Noondie.

The area has high potential for gold mineralisation, but limited outcrop over the Belele region has hindered exploration. This new geophysical data will significantly assist the mapping of the region's Archaean geology and add to the tools being used to highlight exploration target areas.

This data set comprises magnetic, radiometric and elevation data from a survey flown for government in November 2003, which has been merged with three existing private company surveys, to provide continuous coverage over the Murchsion region. The resulting magnetic, radiometric and elevation data sets have a variable line spacing of 200 to 400 metres, gridded using an 80-metre cell size.

These digital data (point located and gridded) are available for free download from the web or on CD-ROM for $99 (includes GST) plus postage and handling.

For more information visit www.ga.gov.au/gadds. To order the CDs phone Freecall 1800 800 173 (in Australia) or +61 2 6249 9966, or e-mail mapsales@ga.gov.au

Shuttle data tested for digital elevation modelling

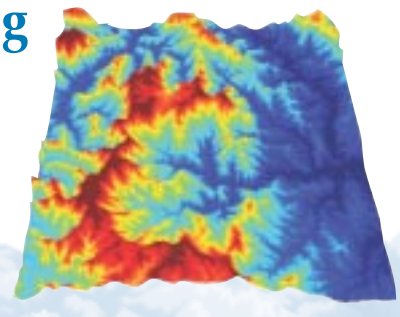
During an 11-day Space Shuttle mission in February 2000, the X- and C-band Synthetic Aperture Radar (SAR) instruments on board acquired interferometric SAR data covering most the Earth's surface. Digital elevation models (DEMs) produced from the X-band are now available for approximately 40 per cent of Australia's land surface.

Prior to the mission, the German Space Agency (Deutschen Zentrum für Luft und Raumfahrt) accepted Geoscience Australia's research proposal to investigate the quality of DEMs produced from the X-band data.

Geoscience Australia has commenced a comparison of the DEMs produced from data acquired by the X-band SAR instrument on board the Shuttle Radar Topographic Mission (SRTM), with the quality and resolution of comparable DEMs, including those produced from C-band SAR data. Initially the study area focuses on Canberra and surrounding areas.

The DEMs derived from the X-band SAR data show significant potential for a range of environmental and mapping applications, particularly in areas of flat to gentle undulating terrain. The height accuracy of most SRTM X-band DEMs is expected to be better than 10 metres (3σ).

The results of this evaluation will be an important part of a broader project that is investigating and identifying suitable data sources for an improved national DEM.



▲ **Figure 1.** A perspective view of a DEM covering an area between Canberra and the New South Wales south coast

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Annual MINERAL RESOURCE ASSESSMENT released

Geoscience Australia's annual assessment, *Australia's Identified Mineral Resources 2003,* which was released on-line in March 2004 provides an inventory of Australia's known mineral endowment and examines the level of exploration activity. It is used by governments, industry, the investment sector, and the broader community.

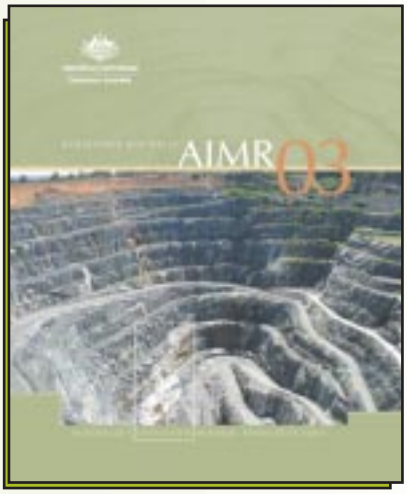
The publication categorises and reports on Australia's resources for all major and some minor mineral commodities. It provides information on the nation's future capacity to produce mineral commodities, and includes international rankings, summaries of significant exploration results, brief reviews of mining industry developments, and analysis of mineral exploration expenditure.

Australia's Identified Mineral Resources 2003 highlights the importance of monitoring Australia's future supply capability for gold, lead and zinc.

For gold, exploration results are encouraging as a variety of styles of new mineralisation continue to be found. However, a high proportion of the new economic demonstrated resources (EDR) is from known deposits or in their vicinity. At the 2002 rate of production, Australia's gold EDR was estimated to last around 20 years. For longer term sustainability of the gold industry, the rate of addition of economic resources must not fall. This will require increasing rates of discovery of new gold resources in greenfields regions.

Zinc EDR decreased overall by 5.6 per cent in 2002. The success of fine-grinding technology, however, has increased EDR for mines like Century and McArthur River through more efficient extraction of metals. At 2002 rates of production, EDR of zinc, lead and silver are all in the 20- to 25-year range. Ore reserves at existing large mines are likely to be exhausted within this time frame. To sustain Australia's position as a leading supplier of these commodities to world markets, one or more additional world-class deposits will need to be discovered within the next decade.

Australia's Identified Mineral Resources 2003 includes a systematic review of all commodities such as development accessibility at the time of assessment. Accessible EDR takes into account the legal and/or land-use factors that prevent development of mineral resources; for example, location within national/state parks, military training areas, environmental concerns and government legislation. The report also compares EDR (which reflect a long-term view on what is likely to be mined) with total ore reserves (which generally reflect a shorter term commercial industry outlook).



Australia's Identified Mineral Resources 2003 is free on-line through Geoscience Australia's web site and can be referenced in spatial context on a commodity-by-commodity basis through the Australian Mines Atlas at www.australianminesatlas.gov.au.

For more information phone Bill McKay on + 61 2 6249 9003 or e-mail bill.mckay@ga.gov.au

Mines e-atlas *even better*

Geoscience Australia's on-line interactive Australian Mines Atlas (formerly the National Atlas of Mineral Resources, Mines and Processing) is the first of its kind and allows an in-depth look at the minerals industry: its sustainability, performance and contribution to Australia's economic growth. It has three main sections: history of the minerals industry, information about all major and several minor mineral commodities, and map creation.

This extremely useful electronic atlas is being further developed and enhanced with support from the Minerals Council of Australia and the Department of Industry, Tourism and Resources' Regional Minerals Program.

The atlas allows users to search for mines and deposits and create maps with customised layers. The layers include topographic information (e.g. roads, rivers, airports and population centres), geoscience data (e.g. geology, gravity, terrain and magnetics), mineral processing centres, ports, major planned infrastructure projects, power stations, and satellite imagery covering most mines.

New enhancements

Use of the latest version of MapServer software will allow display of compressed raster images such as a complete satellite mosaic of Australia with 30-metre resolution. Data acquisition and compilation will appear in new thematic layers covering Aboriginal land, state forests, nature conservation parks, water supply reserves, Defence-prohibited land, and federal electoral boundaries. For ore reserves and mineral resources, there will be an advanced search function.

Mines and deposits referred to in the recently released Australia's Identified Mineral Resources 2003 can be visualised in a spatial context together with industry information, which is referenced through links to company web sites.

The atlas' web address is www.australianminesatlas.gov.au. User feedback ensures the atlas meets user needs, captures changes, and is updated in a timely manner. A feedback form is accessible from any screen of the web site.

For more information phone Bill McKay on + 61 2 6249 9003 or e-mail bill.mckay@ga.gov.au

New index for airborne geophysical surveys available

The 8th edition of the Index of Australian Government Airborne Geophysical Surveys was released in May 2004 in hard copy and digital formats. This edition contains a more comprehensive coverage of surveys than the previous issue, released in May 2003. Information about surveys before 2003 has been updated, and additional surveys have been included.

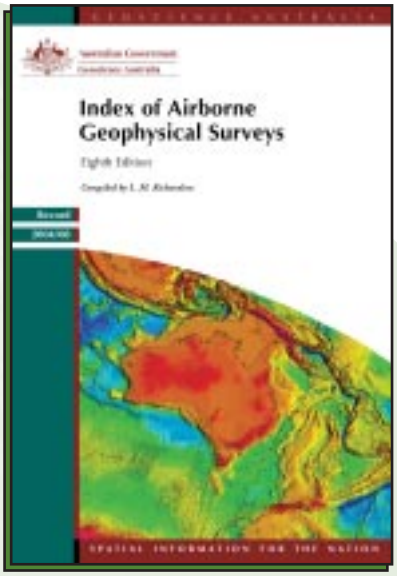
The hard-copy version of the index, published as Geoscience Australia record 2004/08, contains a summary of the major specifications of more than 900 airborne surveys. The digital version of the index is available in PDF format from the web (www.ga.gov.au/rural/projects/20010917_51.jsp).

An updated interactive database of metadata for Australian airborne geophysical surveys has also been released. Digital data files of the Index of Airborne Geophysical Surveys are provided in AEROMAP, ESRI Shape and MapInfo formats showing the coverage over Australia of Geoscience Australia and state government airborne magnetic, radiometric and elevation surveys. The metadata files have been updated to April 30, 2004, and provided as three separate digital zip files for clients who require support for AEROMAP, ArcView and MapInfo applications.

The PC-based Windows software package AEROMAP is continuing to be supported with updated survey metadata files. The software is provided as a single digital zip file, which contains one copy of the program and associated digital information.

The latest Australian airborne survey coverage information is also available free on-line via the Airborne Surveys Index database at www.ga.gov.au/oracle/argus.

Updated colour index maps showing the coverage over Australia of Geoscience Australia and state government airborne magnetic, radiometric and gravity surveys have also been released. The airborne magnetic and radiometric survey coverage maps discriminate between surveys employing flight line spacings of 500 metres and less, and wider line spacings. The maps also show state/territory borders and the names of 1:250 000 sheet areas.



To find out more about the index record, index maps, AEROMAP or digital data files phone Murray Richardson on + 61 2 6249 9229 or e-mail murray.richardson@ga.gov.au

Download the latest topographic coverage

GEODATA TOPO 250K Series 2 is a vector representation of the major topographic features appearing on 1:250 000 scale NATMAP topographic maps, designed for use by GIS professionals. Series 2 can be downloaded free from Geoscience Australia's web site and has rapidly become Geoscience Australia's most popular on-line data set, with almost 30 000 tiles being downloaded by more than 3500 registered users since it was launched in September 2003.

The data include a range of topographic features such as roads, railways, rivers, contours (50 m), vegetation, and reserved area boundaries (e.g. national parks and defence land). With access to appropriate GIS software, users can undertake a range of GIS analysis as well as producing attractive maps for use in reports and publications.

The data set is regularly updated with almost 50 updated tiles added since the launch. Updated data tiles cover areas such as Townsville, Cairns, Alice Springs, Mallacoota, Kangaroo Island and Grafton. Users can readily check the Geoscience Australia web site to ensure that they have the latest information for their area of interest.

As a convenient alternative (particularly for users with slow internet connections), the data can also be purchased on CD-ROM for $99 as individual state/territory based packages. Recent releases covering Western Australia and the Northern Territory means that all six CD-ROM packages covering the entire continent can now be purchased for $594.

For more information visit www.ga.gov.au/nmd/products/digidat/250k.htm

To order copies of the CDs phone Freecall 1800 800 173 (in Australia) or +61 2 6249 9966 or e-mail mapsales@ga.gov.au

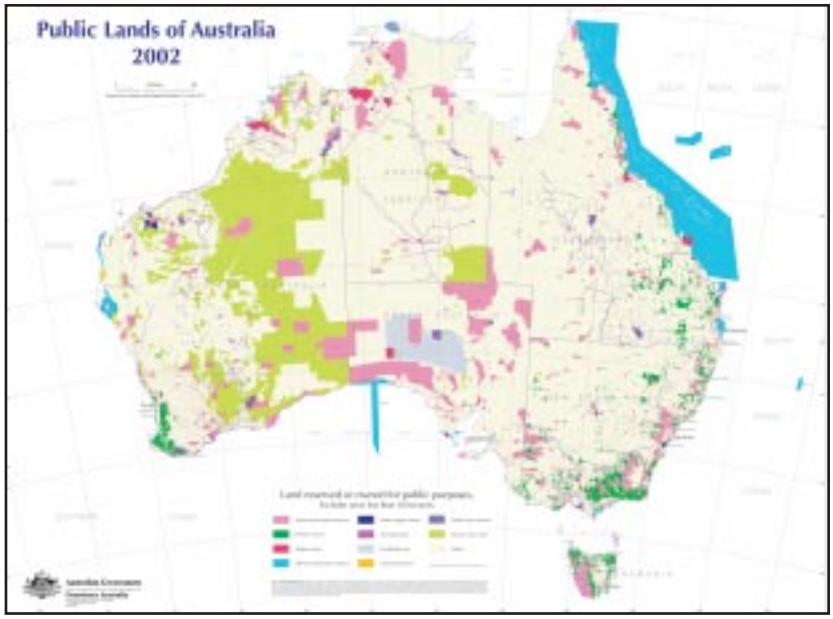
Public land map being *refreshed*

Geoscience Australia has begun to refresh the public land information on its Land Tenure map as the most recent version was produced in 1993. A preliminary version of the new map, Public Lands of Australia, is about to be displayed on the Geoscience Australia website. A comprehensive revision of the map will be undertaken during the year.

Assembling the information for national presentation at a nominal scale of 1:5 million is a massive undertaking, requiring cooperation with a large number of authorities across Australia.

Nearly three-quarters of Australia's land tenure is private land. The remaining public land is important for the management of public resources such as forests and minerals, environmental protection of nature conservation reserves and water supply catchments, defence activities, and reservations for special purposes such as communications, energy, transport and education.

There are vast swathes of vacant crown land which, as the name suggests, are largely unoccupied. The residual private land comprises freehold and leasehold undertakings, mostly used for pastoral activity.

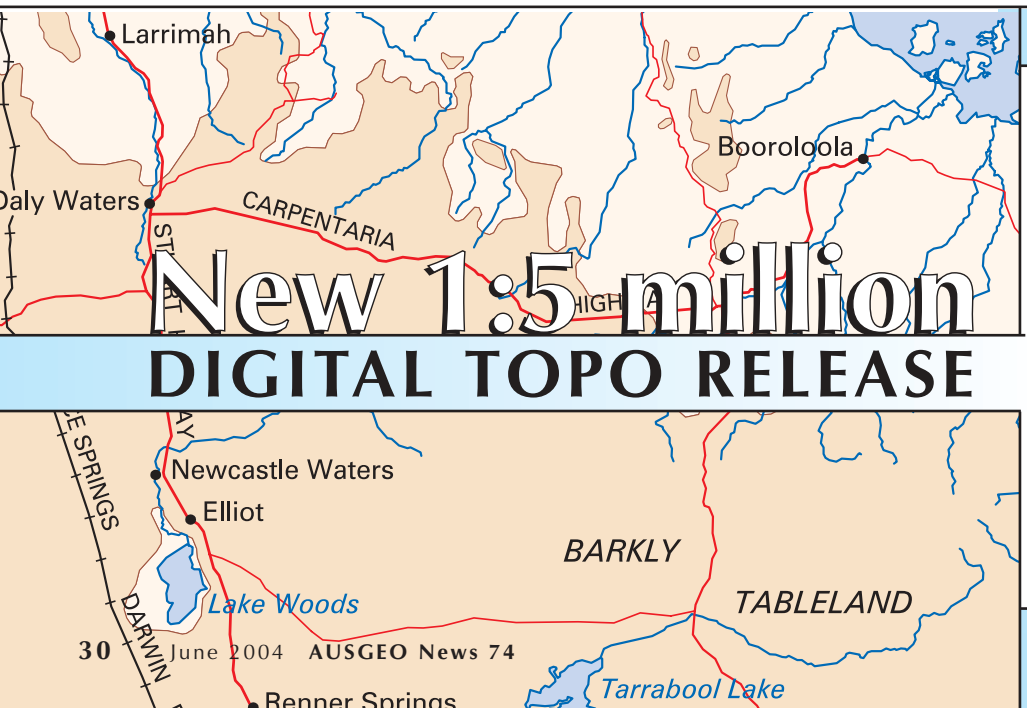


Showing fine detail on a map of this large scale is not possible due to the high level of generalisation required. However, the distribution of the various types of public land displayed has been considerably improved by reducing the minimum size of areas shown to 50 hectares from the previous 50 square kilometres.

Past users of the information have found this unique map to be valuable in presenting the diverse categories, proportions and distribution of public land across Australia.

Indigenous land categories (included in the 1993 map in support of the native title reconciliation process) will also be updated and presented as a dedicated map at a later time.

For more information phone Brian Polden on +61 2 6249 9466 or e-mail brian.polden@ga.gov.au



New 1:5 million DIGITAL TOPO RELEASE

Geoscience Australia has complemented its suite of quality GIS topographic datasets with the release of a new product, the GEODATA TOPO 5M. This marks the first release of digital data at 1:5 million scale, although a number of printed maps are available at this scale.

The data set includes features such as built-up areas, contours, drainage, seas, state borders, coastline, localities, offshore features, railways, roads, sand ridges, spot heights and water-bodies. The data are suitable for use at 1:5 million scale (1 millimetre on

Half-price Landsat 7 products on offer

Following an instrument failure on the Landsat 7 satellite on May 31 last year, Geoscience Australia and global remote sensing agencies suspended all data acquisitions until the exact cause of the anomaly could be found. The failure was due to a mechanical malfunction in the satellite's Scan Line Corrector (SLC).

Geoscience Australia's remote sensing group (ACRES) resumed data acquisitions on July 15 in SLC-Off mode, and successfully installed software to process Landsat 7 ETM+ SLC-Off products. The SLC problem has been minimised by interpolation and extrapolation techniques during processing of the raw signal data.

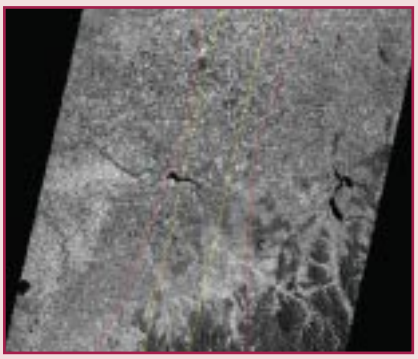


Figure 1. Two SLC-Off scenes mosaic (acquired at July and December 2003).
The image shows the increased unaffected area (no scan gaps) from a mosaic of two images. Yellow lines show the limit of unaffected area in the July image while red lines show the limit of unaffected area in the July–December mosaic.

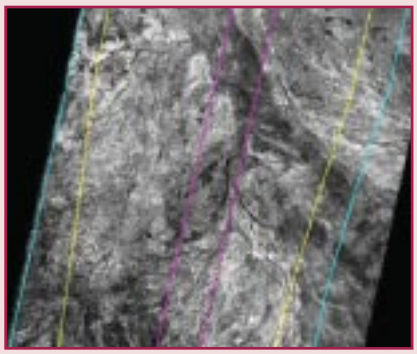


Figure 2. Three SLC-Off scenes mosaic (acquired at July, August and December 2003). The image shows the increased unaffected area (no scan gaps) from a mosaic of three images. The purple lines show the limit of unaffected area in the August image, the yellow lines show the limit of unaffected area in the August–July mosaic, and the light blue line shows the limit of unaffected area in the August–July–December mosaic.

Preliminary investigations show that if multi-temporal Landsat 7 imagery is 'mosaiced', the effects of SLC-Off are further reduced (see figures 1 & 2) as the mosaic will have less missing data than a single scene. The reduction in missing data in a mosaic is variable, however, and the outcome of a mosaic of any two scenes is difficult to predict. Further research into methods for filling the gaps from 'no data' areas by 'mosaicing' various SLC-Off scenes is currently under way.

To encourage use of the Landsat 7 SLC-Off products, a 50 per cent discount off the recommended retail price for all SLC-Off products is being offered for a limited time only. Please note that SLC-Off products are available for all processing levels and scene sizes as per regular Landsat 7 ETM+ products.

An on-line digital catalogue of all SLC-Off ETM+ data acquired by ACRES as well as information explaining the processing techniques outlined above are available on the Geoscience Australia website (www.ga.gov.au/acres/)

For more information phone ACRES Customer Service on +61 2 6249 9779 or e-mail acres@ga.gov.au

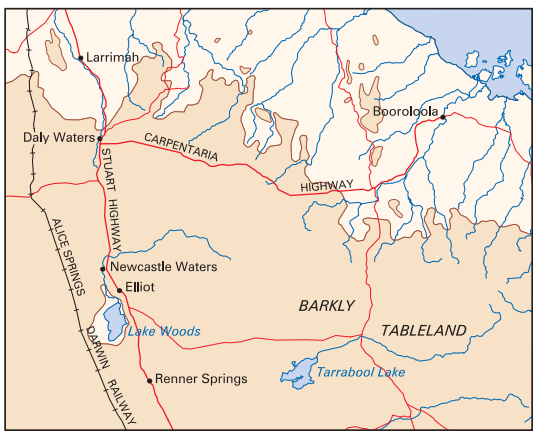
the map represents 5 kilometres on the ground) and smaller scales.

Much of the data has been derived from the GEODATA 1:2.5 million-scale data set. Appropriate features were selected and generalised for inclusion, as well as relevant updating. GEODATA TOPO 5M has been designed as a data set that would be useful as a stand-alone product or as an integral part of other mapping or GIS data products.

It is expected that a cartographically displaced version (where adjacent map features are slightly moved to assist map reading at a small scale) of this data set will be used as the base layer or as an integral part of a new series of thematic products that Geoscience Australia plans to develop.

As with all Geoscience Australia GEODATA products, users are assured of GIS compatibility, national consistency, quality assurance, comprehensive documentation and regular maintenance. Companion metadata and product user guides are also available for download.

For more information visit www.ga.gov.au/nmd/mapping/newmaps/



Geological provinces *on-line*

▲ **Figure 1.** The current coverage of sedimentary and igneous provinces in the Australian geological province database

▲ **Figure 2.** The provinces database web mapping and query page (www.ga.gov.au/oracle/provinces) showing an example of additional gravity, geochronology and petroleum field datasets displayed with provinces

Access to key information about Australia's geological make-up is now easier through the Australian Geological Provinces database and web site.

The database stores information and spatial data on geological provinces, which are the basic building blocks of the Australian continent and surrounding offshore regions.

Currently the database contains descriptions of many offshore sedimentary basins, as well as sedimentary and igneous provinces of parts of eastern Australia (figure 1). Data for other provinces will become progressively accessible as the database is populated.

The province outlines are captured at a nominal 1:1 million scale. Province types are categorised into sedimentary, igneous, structural, metamorphic, metallogenic, regolith and tectonic provinces. The various province types allow geologists to describe overprinting geological processes and events. A full explanation of the rationale behind the province types and descriptions can be found at www.ga.gov.au/oracle/provinces/scientific_summary.jsp

Province descriptions broadly include; age limits, parent and constituent units, relationships to surrounding provinces, mineral and/or petroleum resource information, reference information, and various tectonic, sedimentary, igneous, metamorphic and/or structural characteristics depending on the province type.

The ready availability of information about Australia's geological provinces will assist exploration for mineral and petroleum resources within Australia. Users will eventually be able to see a complete spatial and temporal geological framework of Australia, or customise their own data searches using the on-line query and display tools (figure 2).

Users can search for province descriptions by name, age, location, province type and contained resources just to name a few options. Province polygons can also be displayed and queried in the map window. Province description reports contain links to further reports on related provinces, constituent stratigraphic units and related images such as cross-sections, maps and stratigraphic columns.

Additional data sets, such as geophysics, geology maps, petroleum wells and mineral occurrences, can also be displayed in the map window. Many of these data sets can be queried along with the provinces. For instance, geochronology samples from Geoscience Australia's OZCHRON database can be displayed with a province (figure 2) and queried to see both summary and detailed analytical data. Petroleum well locations can also be displayed and queried for stratigraphic, facies, resource and organic chemistry data.

A new national Geological Events database is also being populated in conjunction with the Provinces database. Work is also under way to create time-space plots (stratigraphic columns) on-line, directly from the stratigraphic and event data stored in the Provinces and Events databases.

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