



AUSGEO *news*



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You Australia's first for minerals
beauty!

BIG program
in Tanami-Arunta

Hints for BH-style finds

Also: Gawler granite study, uranium report release, save on spatial data...

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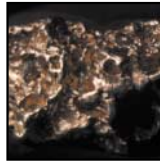
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Australia's mineral endowment includes some beautiful specimens. The velvet-green malachite (copper carbonate) houses cerussite (lead carbonate) and a sprinkling of tiny, white minerals. The rock is from Brown's Mine, Rum Jungle in the Northern Territory. It was collected by Don McColl in July 1977 and is on public display in the foyer of Geoscience Australia headquarters.

For the latest on Australia's mineral endowment see pages 3 to 14.

Photo: Andrew Campbell

EXPLORATION COSTS— PROSPECTS *Australia figures well*



Photo: BeVax Resources NL

Australia attracts more mineral exploration investment than any other single country. Geoscience Australia's Lynton Jaques and Mike Huleatt explain why and indicate how Australia maintains its competitive edge.

Mineral and energy exports have contributed more than \$500 billion to Australia's wealth over the past 20 years.¹ In 2000–01 these exports were worth \$55.6 billion (up 27% on the previous year). They currently constitute 47 per cent of Australia's merchandise exports and 37 per cent of total exports including services. They comprise eight of Australia's 'top 10' commodity exports.²

As well, roughly \$2 billion a year is earned from the export of high-technology mining products and services,¹ and the mineral industry pays around \$5 billion in taxes, royalties and transport levies annually to government.

Global picture

Worldwide mineral exploration expenditure has fallen sharply in recent years. The industry is undergoing major structural changes in response to globalisation, low metal prices, intense competition for risk capital, and poor rates of return on investment.³ Even in Australia, mineral exploration expenditure is currently at a 20-year low in real terms (figure 1).

In addition to the decline in exploration, mineral deposits are becoming harder to find. Rates of discovery of economic mineral deposits, especially the giant or world-class deposits on which the industry is built, have fallen and costs of discovery have risen.^{4,5} To sustain the industry, new deposits must be found to replace those that are mined out.

The cost of investment in mineral exploration must be offset by the value of discovered resources. Exploration often is only marginally economic because the costs of discovering and delineating deposits consume the profits generated from mining.⁶ The cost of discovery of an ore body is therefore critical.

Figure 1. Australian mineral exploration expenditure 1970–2000 (in 2000–01 dollars) derived from the Australian Bureau of Statistics quarterly survey of mineral and petroleum exploration expenditure.

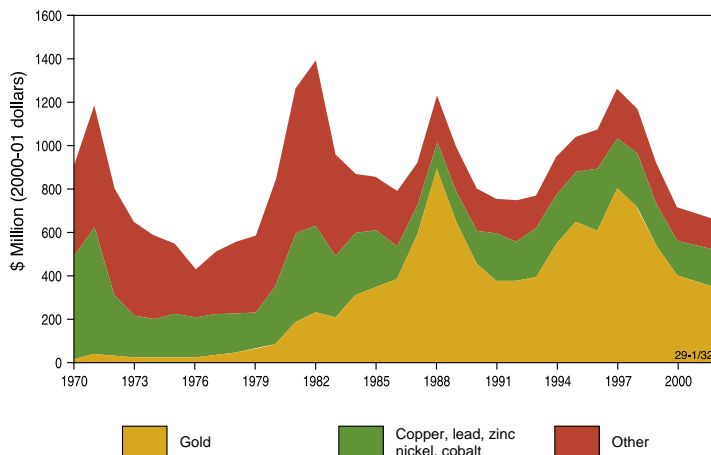
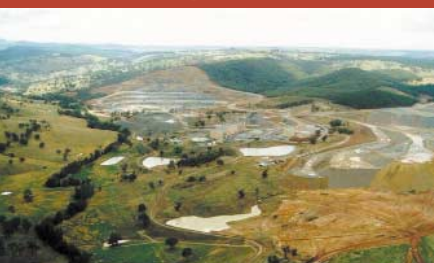


Photo: Newcrest Mining Ltd





Internationally competitive

Annual surveys by the Metals Economics Group show that Australia has maintained its global share of exploration spending (approximately 17.5% of global expenditure³) and continues to attract more exploration spending than any other country (see article on page 12). Reasons for its success include high prospectivity, an excellent record of discoveries, and very attractive find rates.

The cost effectiveness of exploration in Australia from 1990–2000 for a range of mineral commodities is shown below. Figures are based on the cost of addition to Australia's mineral resource base, both through new discoveries and extensions to existing deposits. The major sources of data are Geoscience Australia's identified resources database⁷, and the Australian Bureau of Statistics quarterly reports of mineral and petroleum exploration expenditure. Unless stated otherwise resources are based on reported global resource estimates, and include both economic and sub-economic resources.

Gold

Australia's gold mining industry has grown enormously in recent years. It is now Australia's fourth most valuable commodity export. Exploration and mining companies spent \$4719 million on gold exploration during 1990–2000. This represents 60 per cent of total exploration expenditure in that period. Gold exploration peaked in 1996–1997 when it comprised 63 per cent of total exploration expenditure (which also peaked that year at \$1148 million).

In the same period 8034 tonnes of gold were added to the resource inventory (figure 2) of which 6168 tonnes were in the economic category (table 1). Some 2249 tonnes (28%) of these were from new discoveries. More than 25 significant new gold discoveries were made in this period of which at least 10 (table 2 & figure 3) are in the world-class category (i.e., they contain at least 100 tonnes of gold in-situ).⁸

Table 1. Additions to Australia's gold resource inventory 1990–2000

Resource type	Economic demonstrated resources	Total resources
Additions to existing deposits		5784 t
New discoveries		2249 t
Total economic gold resources added	6168 t	8034 t

The Cadia gold-copper system near Bathurst in central New South Wales is one of the largest new discoveries. It is estimated to have an in-situ resource of 576 tonnes of gold and 2.35 million tonnes of copper.⁹

Other major increases in gold resources were announced for Boddington (Wandoo, 610 tonnes of gold) and St Ives (240 tonnes of gold) in Western Australia. In addition to the larger deposits listed in table 2, more than 40 other gold deposits discovered in this time were brought into commercial production and several more recent discoveries are undergoing detailed exploration and feasibility studies.

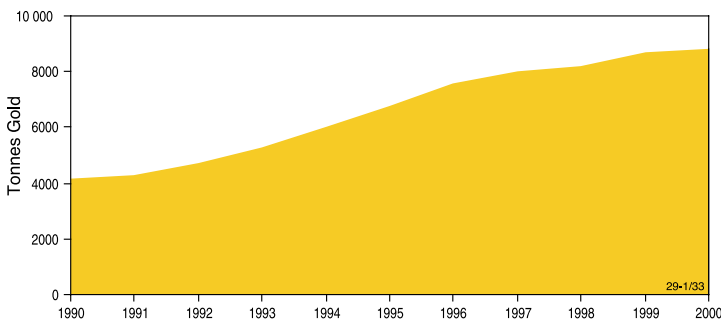


Figure 2. Australia's gold inventory in the period 1990–2000 (includes all categories of resources).

Additions to the resource base were made at a highly favourable average cost of \$21 per ounce (1999–2000 dollars). The major rise in gold production over the period has resulted in a net decline in the rate of growth of gold resources in the past three years. Without further successful exploration, Australia could possibly enter a period of resource decline.⁷

Base metals (cobalt, copper, lead, nickel & zinc)
The base metals sector, especially nickel, has undergone major changes in the past 10 years. Australia's nickel production capacity and nickel exploration have been boosted by three lateritic nickel plants in Western Australia—Murrin Murrin, Cawse and Bulong—that use new pressure-acid leach technology, and the discovery of new nickel sulphide deposits (table 3).

New discoveries have greatly enhanced Australia's nickel resources (figure 4), particularly those in the laterite category. Australia has the world's largest economic demonstrated resources of nickel. In addition to larger deposits, a number of smaller, high-grade nickel sulphide deposits (including Silver Swan, Emily Ann, Miitel and Cosmos Deeps, all found in the Yilgarn Craton of WA in the 1990s) were brought into commercial production. Several more recent finds are still being explored.

Additions were also made to Australia's copper, lead and zinc resources as a result of significant new discoveries made in the early 1990s. Unfortunately lead and zinc resources declined in the latter part of the period because of high levels of production.

Copper discoveries made in the period include the Cadia–Ridgeway and Ernest Henry deposits (table 3), which are now in full production. (Ridgeway is scheduled for commissioning in February.) Also in production are the two world-class lead-zinc discoveries made in the Mt Isa Inlier: Cannington (lead-zinc-silver) and Century (zinc-lead-silver).

Cannington is now the world's largest and lowest cost, single-mine producer of lead and silver. It produces about seven per cent of the world's lead. Century is one of the world's largest zinc mines, producing about seven per cent of world zinc output. The

Table 2. New, world-class gold (>100 t gold) discoveries 1990–2000

Deposit	Gold resource	Discovery year
Kanowna Belle (WA)	176 t	1990
Callie (NT)	134 t	1991
Bronzewing (WA)	103 t	1992
Cadia Hill (NSW)	179 t, 0.43 Mt copper	1992
Cowal (NSW)	135 t	1992
Jundee–Nimary (WA)	241 t	1992
Sunrise Dam (WA)	205 t	1993
Cadia East, Cadia Far East,		
Cadia Quarry (NSW)	279 t, 1.65 Mt copper	1994
Ridgeway (NSW)	118 t, 0.37 Mt copper	1996
Wallaby (WA)	156 t	1998

Table 3. Selected base metal deposits discovered 1990–2000

Deposit	Resource	Discovery year
Cannington (Q)	5.1 Mt lead, 1.9 Mt zinc, 235 kt silver	1990
Century (Q)	12.7 Mt zinc, 1.8 Mt lead, 48 kt silver	1990
Ernest Henry (Q)	1.8 Mt copper, 90 t gold	1991
Magellan (WA)	4 Mt lead	1991
Miitel (WA)	0.04 Mt nickel	1991
Cadia–Ridgeway (NSW)	See gold table	1992
Bulong (WA)	0.95 Mt nickel (laterite)	1993
Cawse (WA)	1.8 Mt nickel (laterite)	1993
Murrin Murrin (WA)	3.5 Mt nickel (laterite)	1994
Yakabindie (WA)	1.5 Mt nickel	1994
Emily Ann (WA)	0.08 Mt nickel	1996
Harmony (WA)	0.17 Mt nickel	1998
Cosmos Deeps (WA)	0.03 Mt nickel	2000

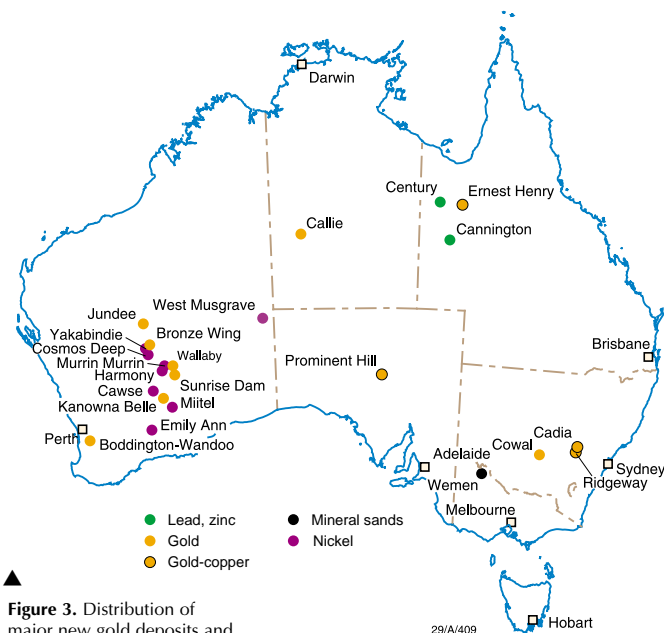
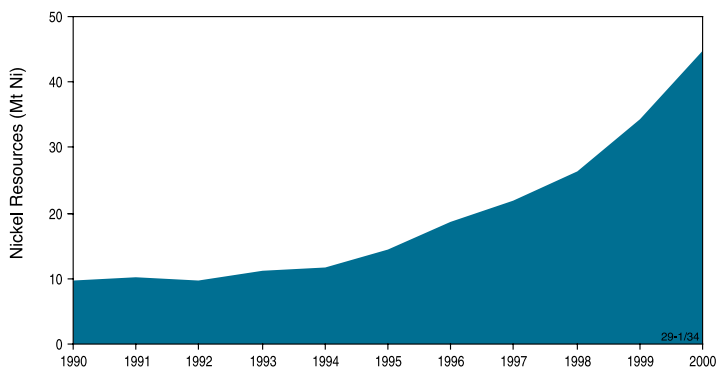


Figure 3. Distribution of major new gold deposits and selected other deposits discovered in the period 1990–2000.

Figure 4. Australia's nickel resource inventory in the period 1990–2000



Highly prospective

Australia's mineral resource inventory for most commodities has increased substantially over the past 10 years. Spectacular growth in gold and nickel resources, significant increases in mineral sands (particularly ilmenite) and tantalum, new world-class deposits and new mines highlight the continent's prospectivity and show why Australia is the leading country for global exploration spending.

But record levels of production for a number of commodities mean that net growth in total resources for some commodities is declining and increased exploration is required to sustain the industry.⁷

Significant parts of Australia remain under-explored, especially remote regions under shallow cover. Two recent significant discoveries highlight the high prospectivity of such areas (figure 3).

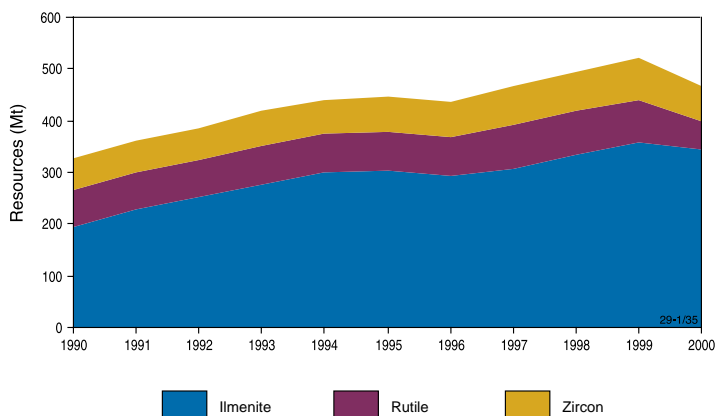
The nickel-copper sulphide mineralisation discovered in 2000 by WMC Resources Ltd in the Giles Complex of the remote Musgrave Ranges (WA) is apparently of similar style to the major Voisey's Bay deposit (Canada). And the copper-gold-uranium mineralisation reported from the Prominent Hill prospect in the Mt Woods Inlier of the northern Gawler Craton (SA) by Minotaur Resources in 2001 has features similar to the giant Olympic Dam deposit some 150 kilometres to the south-east. Exploration is continuing at both prospects. Resource figures are not yet available.

The high prospectivity of such areas, the diversity of mineral deposit types, and recent advances in exploration technology (such as new airborne electromagnetic and airborne gravity gradiometer systems⁸) provide a good basis for continued exploration and discovery of minerals in Australia.

Best practice

Australia has an enviable record of successful discovery of new resources. Some of this success can be contributed to a strong collaborative research and development effort between industry and government.¹ This model, where the private-sector invests in and undertakes exploration using the knowledge framework supported by government, is widely regarded as the 'world's best practice'.

Figure 5. Australia's mineral sands (ilmenite, rutile and zircon) resource inventory in the period 1990–2000



Geoscience Australia helps ensure Australia is internationally competitive in mineral exploration through four main activities:

1. Acquisition and release of new regional geoscientific maps and spatial and other digital datasets either alone or in partnership with State/Territory counterparts under the National Geoscience Agreement;
2. Publication of national geoscientific maps, spatial and other datasets, syntheses and resource assessments;
3. Research, often in collaboration with industry and universities through Cooperative Research Centres, aimed at developing new geological concepts to enhance the effectiveness of exploration; and
4. Technical promotion of investment opportunities in Australia, in partnership with the States and Northern Territory.

Mining is now a global enterprise and increasingly Australia has to compete internationally for (scarce) risk capital for mineral exploration. Promotion has become important.

In March, Geoscience Australia will again coordinate the Australian governments' technical promotion at the Prospectors and Developers Association of Canada annual International Convention, Trade Show and Investors Exchange. This event is the largest mining meeting of its type in the world (see article on page 17 of this issue).

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Photo: Sons of Gwalia

Tanami–Arunta *appearances may be deceptive*



In the heart of the Northern Territory lies the Tanami desert: red, hot, with large, flat expanses of low scrub. Not far away in the Arunta, the landscape is different: high ranges separated by plains. The perceived mineral potential of the Tanami desert differs from the Arunta as much as the landscape. Yet beneath the façades, there are many similarities.

David Huston and a team of scientists from Geoscience Australia and the Northern Territory Geological Survey are looking into what governs mineral prospectivity in the Arunta and the Tanami.

The Tanami desert is one of Australia's emerging gold provinces (figure 2). It includes the Callie deposit, the largest Palaeoproterozoic deposit known in Australia and one of the plums in a recent takeover battle for Normandy Mining. In contrast, the Arunta seems to be the Tanami's poor cousin, lacking major deposits of any commodity. Yet the geology of the Tanami and the Arunta have many similarities. Both areas are dominated by Palaeoproterozoic sequences, mainly of turbidites and other sedimentary rocks that have been extensively intruded by granitoids. The question therefore is whether many of the regional differences are superficial.

In July 2000 Geoscience Australia and the Northern Territory Geological Survey (NTGS) joined forces in a three-year project (the North Australia Project) to study how this southern part of the North Australia Craton formed and how its geological evolution influenced mineral potential. The project is based in the Minerals Division of Geoscience Australia.

The project team's current analyses and studies are outlined below. The work requires close collaboration between Geoscience Australia and the NTGS, and in some cases exploration companies.

REGIONAL PROGRAMS

Regional synthesis

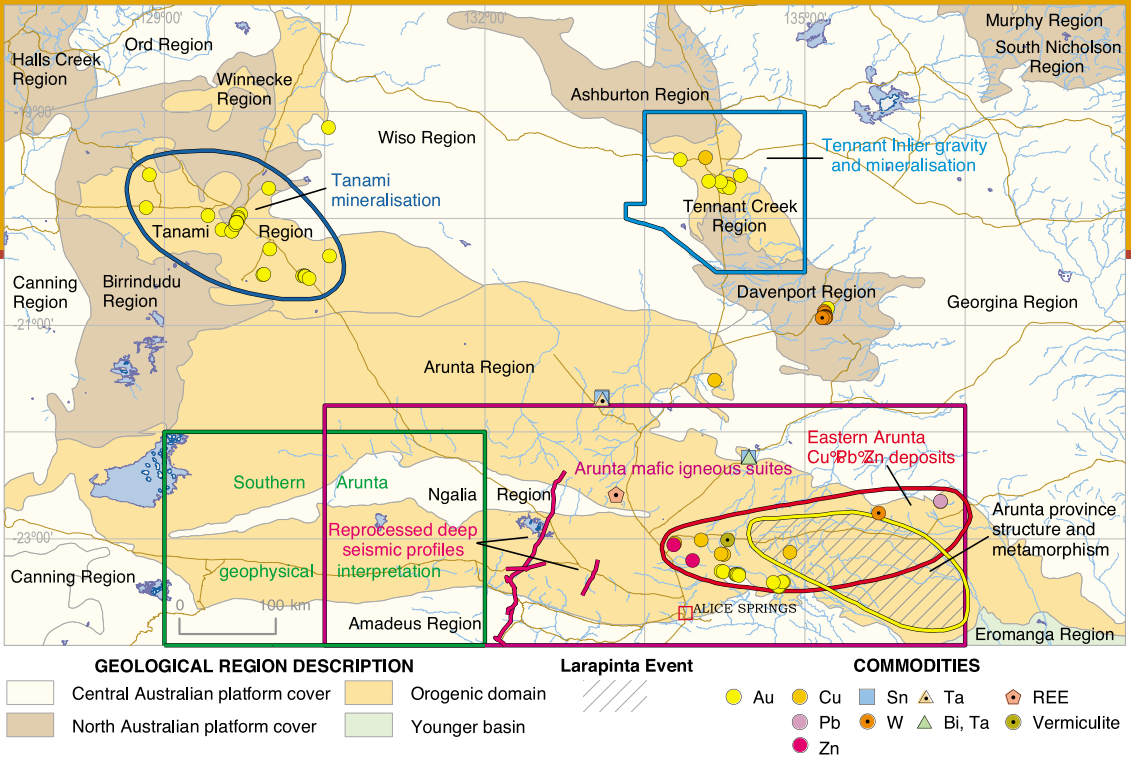
A set of geographical, geological and geophysical data covering the North Australia Project area is being compiled into a GIS (Geographic Information System). A preliminary version of the GIS was demonstrated at AGES (the NTGS Annual Geoscience Exploration Seminar) last March. A metamorphic facies map, which forms a layer in the GIS, was released late last year. Figure 3 is an image from the GIS showing the RTP (Reduced-To-Pole) aeromagnetic data for the project area. This was merged from data acquired by NTGS and Geoscience Australia using algorithms developed by Geoscience Australia. The GIS will be released and updated progressively via the web, beginning in April with the release of a digital version of the metamorphic facies map.

Geochronology

The project provides regional geochronological data to support the NTGS mapping program in the Arunta and the Tanami, and for resolving specific scientific questions such as the age(s) of mineralisation. When the NTGS began its regional mapping programs in the Arunta and the Tanami, the quantity of age data was quite limited. It comprised a few, very detailed studies in restricted areas, and even fewer regional studies. There were almost no data available for the Tanami region.

Most of the project's efforts involve SHRIMP (Sensitive, High-Resolution Ion MicroProbe) uranium-lead analysis of zircon (figure 4a). But other analyses ($^{40}\text{Ar}/^{39}\text{Ar}$, Pb isotopes and Nd-Sm isotopes) are also being applied. The SHRIMP work so far has concentrated on providing age constraints to support NTGS mapping. Ongoing and future studies will focus more on specific problems, including the ages of intrusion and metamorphism of mafic intrusions, the age of gold mineralisation, and the age and provenance of the turbiditic metasediments that are common in the Arunta and the Tanami. From April onwards, geochronology results will be released on the project's web page every three months (www.ga.gov.au/projects/ then select the North Australia Project). Users can access the information free of charge.

▼ **Figure 2.** Geological regions showing where the North Australia Project research is being conducted.



Mineral potential

Various parts of the project area are being assessed for such commodities as gold, diamonds and base metals. The targeted areas have known mineral systems, although in some cases no known occurrences have been reported (but they have favourable geologic environments). A qualitative method of assessment, similar to the one used in the Regional Forestry Agreement areas, will be used for these studies. This assessment will be conducted using the NTGS mineral occurrence database (MODAT) and the GIS, combined with more detailed mineral system analysis developed in other settings.

Larapinta event

One of the most exciting developments in the geology of central Australia in recent years was the discovery (by workers at Adelaide University, Latrobe University and the Australian National University) that the Harts Range Group, originally thought to be Palaeoproterozoic in age, was

Neoproterozoic and younger. Moreover, researchers defined a previously unknown Ordovician granulite facies metamorphic event in these rocks.

In collaboration with the Research School of Earth Sciences (ANU) and Adelaide University, project member David Maidment is undertaking PhD studies to establish the extent of these young rocks and the nature of the Larapinta metamorphic event (figure 2). The results of this study have implications for the geologic history of the eastern Arunta and the assembly of central Australia.



GEOPHYSICAL DATA

Potential field interpretation

The project is providing interpretations of potential field geophysical data (aeromagnetics and gravity) to assist NTGS regional mapping in the south-west Arunta. Interpretations of the Mt Rennie, Mt Leibig and Lake MacKay 1:250 000 sheets have been completed and will be incorporated into NTGS reports. An interpretation of the Mount Doreen sheet is in progress. Because of the extensive regolith cover, potential field data are essential for interpreting the geology in the south-west Arunta.

Tennant Inlier gravity

In the Tennant Inlier, the project has acquired four-kilometre (or better) gravity data in collaboration with the NTGS and exploration companies (figure 2). This data has been released free of charge. To improve geological understanding of the Tennant Inlier and controls on mineralisation, gravity data and aeromagnetic data will be used to construct a three-dimensional model of the survey area in mid-2002.

The Tennant Inlier is highly mineralised (containing high-grade, ironstone-hosted Au-Cu-Bi deposits). The region was the subject of an extensive NTGS mapping program and ore genesis research by various universities in the 1990s.

Seismic line modelling

Four lines in the Northern Territory have been proposed for possible land seismic data acquisition (from discussions at AGES 2001). One is in the Batten Trough and three are in the North Australia Project area.

Gravity and aeromagnetic data are being used to model the geology along these lines. The results will be used in conjunction with other constraints to determine the viability of the proposed seismic acquisition lines. This will be reported at AGES in March.

Seismic re-interpretation

Some 210 kilometres of land seismic data acquired in 1985 across the southern boundary of the Arunta (in the Hermannsberg and Napperby 1:250 000 sheets) are being re-interpreted. The initial interpretation successfully identified the geometry of the Redbank fault as a thrust at depth. With new seismic data processing methods, the resolution can be improved for geological features at depth.

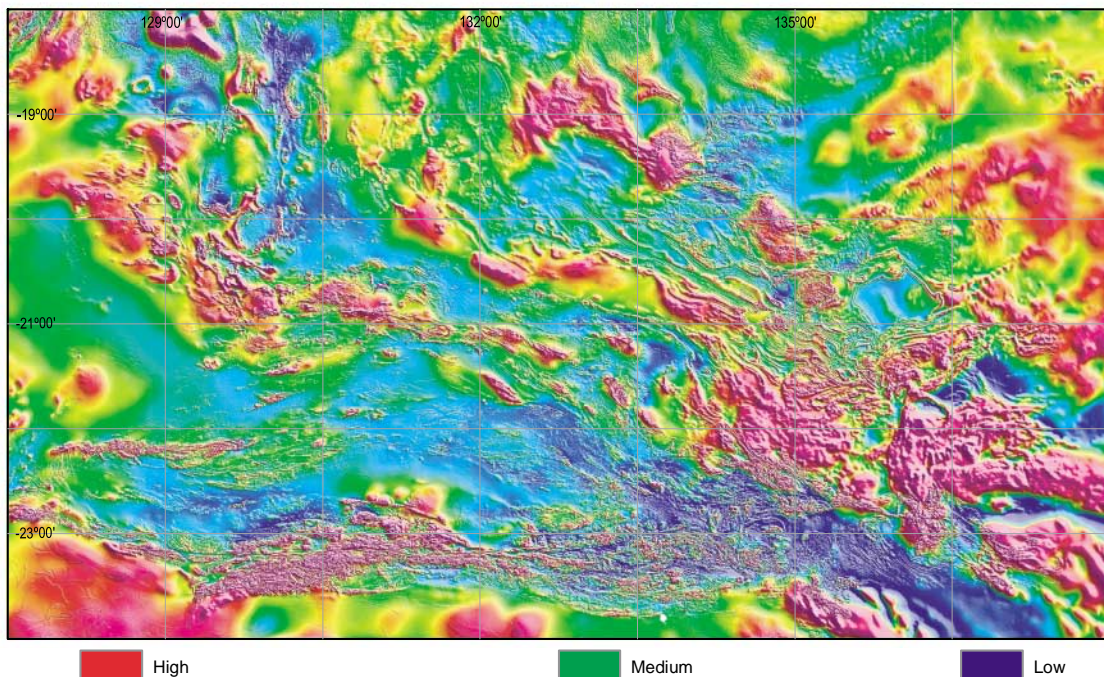
Existing data have been reprocessed, and their interpretation will be released at AGES.

METALLOGENIC PROGRAMS

Tanami gold

The Tanami desert was known to have gold as far back as the early 1900s. But it was only in the mid-1980s that modern exploration resulted in major discoveries in The Granites, Dead Bullock Soak and the Tanami goldfields. Since then, the Tanami region has become one of Australia's premier Proterozoic gold provinces, with the discovery of the Callie deposit in 1991 (>5 million ounces total resource).

▼ **Figure 3.** Reduced-to-pole aeromagnetic image of the North Australia Project area, which was constructed from data collected by NTGS and Geoscience Australia and merged by Geoscience Australia algorithms.



Despite the importance of this province, 'public domain' information about the regional geology and mineral deposits was limited. In 1999, NTGS commenced a regional geologic mapping and metallogenic program to fill in the gap. Scientists from Geoscience Australia's North Australia Project joined this program in July 2000 to provide specialist skills in ore genesis and geochronology.

Preliminary results have been released (*AGSO Research Newsletter*, no. 34; and as an NTGS record via www.dme.nt.gov.au/ntgs/). Final results will be released next year as an NTGS bulletin.

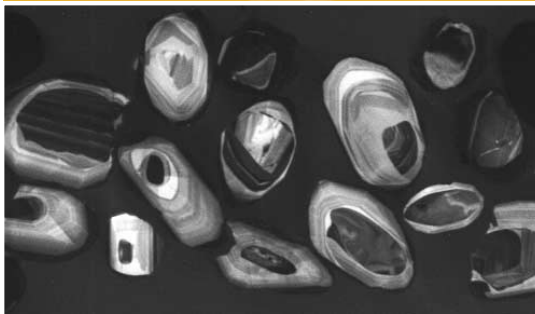
The deposits in the Tanami goldfield formed at a much higher crustal level (1.3–1.5 km) than deposits in The Granites goldfield (3.8–7.5 km) and at Callie (3.2–5.8 km). As well, deposits from Callie and The Granites are characterised by CO₂-rich fluids typical of lode gold deposits (figure 4b), but the Tanami fluids lack significant CO₂.

Because many deposits lie in or near granites, exploration models for the Tanami region have inferred a close genetic link between gold and granite. The granites have been dated at 1825–1795 million years old. However, preliminary argon-argon (⁴⁰Ar/³⁹Ar) results from ore-related biotite indicate an age of 1720–1700 million years. This suggests that the mineralisation might not be genetically linked to the granites. Instead it may be genetically related to fluid migration driven by the evolving Strangways Orogeny.

These alternative ages are being further tested with SHRIMP analysis. Results of these ongoing geochronology studies will be presented at AGES in March.

Arunta mafic intrusions

There is a number of large mafic intrusions in the southern part of the Arunta region (e.g. Mt Hay). Such bodies elsewhere in the Proterozoic of Australia are known to contain nickel-copper and PGE mineralisation. A geochemical program was initiated to assess the potential of these intrusions and determine their ages.



◀ **Figure 4a.** Photomicrographs showing complex zircons from the Arunta

Initial results (*AGSO Research Newsletter* no. 34 and Geoscience Australia record 2001/39—available on the project web page) indicate spatial variations in the potential of these intrusions. In the central and west part of the southern Arunta, the intrusions are sulphur-rich with the potential for orthomagmatic nickel-copper-cobalt mineralisation. In the east, the intrusions are sulphur-poor with the potential for PGE mineralisation.

Recent exploration has identified anomalous PGE associated with several of the mafic intrusions in the eastern Arunta. Geochronological studies are in progress, with results to be reported at AGES in March.

Eastern Arunta base metals


High-grade metasediments and metavolcanic rocks in the eastern Arunta contain a number of small copper-zinc-lead deposits, the largest of which are at Oonagalabi and Jervois. These largely strataform deposits historically have been considered volcanic-hosted massive sulfide accumulations, but the metamorphic and structural overprints make any classification of these deposits problematic.

NTGS and Geoscience Australia are documenting the distribution and character of the deposits to provide constraints on their origin, and to assess the potential of the eastern Arunta for significant copper-zinc-lead deposits. NTGS will present the initial results at AGES in March.

For more details about the North Australia Project phone David Huston on +61 2 6249 9577 or e-mail david.huston@ga.gov.au ☐

▶ **Figure 4b.** Photomicrographs of CO₂-rich fluid inclusions from The Granites goldfield





Australia's *one* for mineral exploration

Australia is still the number one destination for mineral exploration.

Although world exploration budgets in 2001 (totalling US\$2.2 billion) were 15 per cent lower than in 2000, Australia marginally increased its share to 17.5 per cent and maintained its position as the world's the leading country for mineral exploration.¹

Australian mineral exploration expenditure rose by one per cent to \$683.3 million in 2000–01, the first increase in annual exploration spending in four years.² Spending rose in all jurisdictions except Victoria (fell 3.3% to \$32.7 million) and the Northern Territory (fell 17.4% to \$47.5 million).

Western Australia was the main target with 62.1 per cent (\$424.1 million) of total spending, which is slightly more than last year (61.4%). Spending in other states was also encouraging: Queensland \$83.1 million (up 0.6%), New South Wales \$57.2 million (up 1.8%), South Australia \$29.6 million (up 31.0%) and Tasmania \$9.2 million (up 4.5%). The boost in South Australia reflects increased exploration in the Musgrave Ranges (Ni, Cu, PGM), Gawler Craton (Cu, Au), and Murray Basin (mineral sands).

Spending rose for all groups except gold, iron ore, and uranium in 2000–01. Despite a slight fall in gold's share of total spending, it remains the major target (\$370.2 million). Spending on base metals (Cu, Pb, Zn, Ag, Co and Ni) increased by 5.4 per cent to \$165.4 million.

Significant growth was recorded for coal (reached \$41.3 million, up 16.7%) and mineral sands (\$23.6 million, up 9.7%, which is a record for mineral sands). Diamond expenditure was up 6.7 per cent to \$31.8 million. Uranium exploration fell by 28.2 per cent to \$8.4 million, and iron ore was down by 21.2 per cent to \$23.4 million. The combined expenditure for all other commodities was \$19.3 million, an increase of 15.6 per cent.

EXPLORATION SUCCESSES

Gold & gold-copper

Last year's discoveries demonstrate why Australia is a prime target for gold exploration. New mineralisation was found across many regions and in a variety of mineralisation styles, and deep mineralisation was discovered beneath known mineralised bodies.

The most significant discovery was by Minotaur Resources Ltd, operator of the Mt Woods Joint Venture in South Australia's Gawler Craton. The company reported Olympic Dam style copper-gold-uranium intersections from the Prominent Hill prospect between Olympic Dam and Coober Pedy (SA).

The major intersection was 107 metres at 1.94 per cent copper and 0.66 grams/tonne gold, which included 35 metres at 3.86 per cent copper and 0.63 grams/tonne gold. Deeper in the same hole, an intersection of 57 metres at 1.28 per cent copper, 0.66 grams/tonne gold, 2.0 grams/tonne silver, 0.57 per cent rare earths (cerium+lanthanum) and 495 ppm uranium was recorded.

The copper mineralisation occurs as chalcocite disseminations and thin veins in a haematite matrix in the upper parts of the hole. At depth, it is in chalcopyrite and bornite. The hole tested partially coincident gravity and magnetic anomalies.

The discovery demonstrates the enormous mineral potential of the Gawler Craton and the benefits of junior-major company joint venture exploration (Minotaur–BHP Billiton).

At Cadia (near Orange in NSW), Newcrest Mining Ltd encountered 100 metres at 3.9 grams/tonne gold and 0.32 per cent copper. This was within a broader interval of 222 metres at 2.3 grams/tonne gold and 0.3 per cent copper at the Cadia Far East prospect. The company also announced the first resource estimate for the prospect as an inferred resource of 200 million tonnes at grades of 1.1 grams/tonne gold and 0.41 per cent copper.

At the Waugh prospect near the Mount Olympus gold mine (south-east of Paraburdoo, WA) near-surface bonanza grade gold intersections were discovered. Sipa Resources International NL reported high-grade intersections at depths of less than 30 metres. Intersections include 15 metres at 57.2 grams/tonne gold from 21 metres (including three metres at 233 grams/tonne gold from 22 metres), and 16 metres at 74.8 grams/tonne gold from 41 metres (including six metres at 186 grams/tonne gold from 41 metres).

Copper, lead, zinc & silver

At Gossan Hill (Murchison Province, WA), Normandy Mining Ltd reported excellent exploration results with high-grade mineralisation outlined in the new Amity, Catalpa and Hougoumont orebodies.

Normandy has defined an inferred resource of 2.4 million tonnes at 14.7 per cent zinc in the Amity body and 0.96 million tonnes at 17.7 per cent zinc in the upper zone of the Catalpa orebody. A drill intersection some 400 metres deeper yielded 5.9 metres at 29.6 per cent zinc indicating the potential for deeper ore.

In the Hougoumont orebody, a zinc resource of 1.88 million tonnes at 19.4 per cent zinc and 3.5 grams/tonne gold has been delineated. There is an additional copper-rich zone with an inferred resource of 2.37 million tonnes at 3.1 per cent copper.

Results from Gossan Hill confirm that the deposit is a significant Archaean volcanic-hosted massive sulphide deposit.

Diamond

The release of high-resolution airborne geophysics over much of the North Australian Craton, mainly by the Northern Territory Geological Survey, and easier access to open-file databases created a mini diamond exploration boom in the Territory. Three major global diamond explorers (De Beers, Rio Tinto and BHP-Billiton) and five junior companies (Tawana, Astro, Elkedra, Flinders and Striker) are now active in the region.

Nickel

Exploration continued in a number of provinces for lateritic nickel deposits and for komatiite-hosted nickel sulphide deposits in the Yilgarn. The main focus though was the mafic-ultramafic Giles Complex (Western Australia, near the South Australian and Northern Territory borders).

Preliminary interpretations by WMC Resources Ltd at the Nebo and Babel prospects in its West Musgrave project (Giles Complex) suggest that both prospects are part of a 4.5 kilometre long mineralising system. Significant variations in the thickness and grade of mineralisation have been reported.

Drilling at the Babel prospect encountered a higher-grade disseminated sulphide unit with a true thickness of up to 21 metres and grades of up to 0.8 per cent nickel, 1.4 per cent copper and 0.34 grams/tonne Pt+Pd.

New drilling results in Wingellina are also encouraging. Acclaim Exploration's project (south-west of three state borders, WA-SA-NT) yielded an impressive intersection of 144 metres of nickel oxide at a grade of 1.4 per cent nickel. Acclaim also reported the discovery of a new, thick basal ultramafic unit that will be explored for nickel in 2002.

Mineral sands

Exploration activity continued to centre on the coarse-grained strandlines in the Murray Basin in New South Wales, Victoria and South Australia. Global resources of the area have increased to about 80 million tonnes of heavy minerals as additional strandlines continue to be discovered.

Platinum group metals

Active exploration for Platinum Group Metals (PGM) continued in 2001, particularly in the East Kimberley and west Pilbara regions. At the Munni Munni project, Helix Resources Ltd announced a new resource estimate of 1.3 million ounces of PGM+gold, 43 000 tonnes of copper and 23 000 tonnes of nickel in 13.5 million tonnes of ore. A \$5 million feasibility study is in progress.

In another important development, Platinum Australia Ltd announced a new resource of 64 million tonnes at 1.7 grams/tonne PGM+gold at the Panton project (WA).

Tantalum

Australasian Gold Mines NL reported encouraging exploration results from the Mt Deans prospect in the Dundas Hills, 10 kilometres south of Norseman (WA). Drilling encountered significant tantalum intersections including six metres at 117 grams/tonne Ta₂O₅ and 13 metres at 210 grams/tonne Ta₂O₅. The mineralisation occurs in pegmatite veins associated with small granitic intrusions that post-date the tectonic events that facilitated the emplacement of gold mineralisation in the area.

MIXED OUTLOOK

There are mixed signals concerning the outlook for exploration. The Australian Bureau of Agricultural and Resource Economics (ABARE) believes a sustained period of higher mineral prices will be required for a significant improvement in outlook. It expects price recovery to occur in late 2002.

The small increase in Australian exploration spending for 2000–01 was the first significant positive outcome on annual spending since the last peak in 1996–97. But ongoing rationalisation within the industry is reducing combined exploration budgets when compared with the pre-amalgamation budgets of the individual companies.

A more positive prognosis is that some 15 mineral resource companies have listed on the Australian Stock Exchange (ASX) in 2001, and others are waiting listing. Further, in November the Australian Gold Council/Hartley

EXPLORATION *highlights* of the year

- The global downturn in mineral exploration continued in 2001 as planned worldwide expenditure fell to US\$2.2 billion from US\$2.6 billion in 2000.
- Australia is the world's leading exploration destination with 17.5 per cent of world mineral exploration budgets.
- Mineral exploration in Australia in 2000–01 totalled \$683.3 million, the first increase (in current dollars) in exploration spending since 1996–97.
- Western Australia was the leading state for exploration with expenditure of \$424.1 million. Gold was the major target accounting for 54 per cent of all exploration spending.
- The Australian geoscience web portal (www.geoscience.gov.au) improved access to government-generated geoscientific data and information.
- Encouraging exploration results were reported from across Australia, including copper-gold-uranium from the Mt Woods Joint Venture (SA), nickel from Wingellina in the Giles Complex (WA), and gold from the Waugh prospect (WA).
- New or increased resources were reported at several gold, gold-copper, base metal, nickel, diamond, mineral sands, PGM and tantalum deposits.

Poynton Explorers Index hit a record high after rising 25 per cent in the month. This compares with the S&P/ASX All Resources Index growth of only five per cent. These factors, with an anticipated recovery in the United States and lift in metal prices later this year, suggest a more positive outlook than has been the case in recent years.

Exploration will remain focused on established mineral provinces such as the Yilgarn Craton, Mount Isa Inlier, Lachlan Fold Belt, Broken Hill-Olary region and the Murray Basin. But there is likely to be increased interest in newer provinces such as the Tanami-Arunta, Gawler Craton, Kimberley, and Musgrave Ranges because of recent exploration successes. The traditionally targeted minerals (gold, nickel, copper, zinc, mineral sands and diamond) will attract attention, and the current high levels of interest in mineral sands should continue for the short to medium term.



QUICK, FREE SERVICE

Geoscience Australia and its State/Territory counterparts launched the Australian governments' geoscience web portal on November 8. The portal offers users a single entry point to government geoscience data, information and services. It reduces the hassles of trawling through multiple web sites to find data. Entry to the portal is via www.geoscience.gov.au.

In September last year the federal government announced initiatives to promote the development of Australia's spatial information industry. Consequently, government geoscience agencies are progressively providing free online access to a range of national spatial datasets including topography, geology and geophysics. (See page 26.)

For more information phone Mike Huleatt on +61 2 6249 9087 or e-mail mike.huleatt@ga.gov.au

1. Metals Economics Group annual survey
2. Australian Bureau of Statistics

#1



Geoscience A BIG HIT

Geoscience was a big hit with 34 teenagers who visited Geoscience Australia's Canberra headquarters on January 23 as part of the National Youth Science Forum.

In a fun session on earthquakes, students hit the ground with a sledge-hammer and timed seismic waves as they bounced from bedrock to a geophone on Geoscience Australia's front lawn.

By varying the distance between the geophone and source shot (sledge hammer and base plate) roughly 10 times at three-metre intervals, students calculated that the bedrock is 5.2 metres below the grass.

The students, who are about to enter their final year of high school, elect to spend two weeks of their school holidays in Canberra visiting science facilities. These include the Australian National University's Science Faculty and John Curtin

School of Medicine, the Therapeutic Goods Administration, CSIRO, the Australian Federal Police Forensic Services, and the Mt Stromlo Observatory.

This was the second group to visit Geoscience Australia this year. Thirty-four other students visited on January 9.

The students attend public and private schools around Australia. A few also come from New Zealand, Canada and South Africa. Rotary clubs and numerous science agencies and companies sponsor the forum.

Geoscience Australia has been involved in the National Youth Science Forum since 1984.

For more details phone Cindy Hann on +61 2 6249 9673 or e-mail cindy.hann@ga.gov.au



Zoom home from Mars and beyond

Visitors to the Mars exhibit at the National Museum of Australia can take a live satellite tour of Australia and zoom in on their suburb thanks to Geoscience Australia.

Live satellite images of the Australian continent are fed daily to the museum's 'To Mars and beyond' exhibit by Geoscience Australia's ACRES (Australian Centre for Remote Sensing).

Satellites passing over Australia transmit data to a receiving dish near Alice Springs. The ACRES data are processed into visual images and sent via high-speed communication links to the museum where they are projected onto a large screen within minutes of initial image capture.

The images are from four satellites that take about 10 minutes each to pass over Australia from north to south. Live feeds can be seen between 10 a.m. and 12.30 p.m. They are then replayed throughout the day.

TO
MARS
AND
BEYOND
SEARCH FOR THE ORIGINS OF LIFE

NATIONAL
MUSEUM OF
AUSTRALIA

Museum visitors in December and January were able to watch live images of the bushfires that blazed across New South Wales and the Australian Capital Territory. The images showed huge smoke drifts and the damage to the landscape (see article on page 28).

Geoscience Australia's other major contribution to the exhibit is the interactive Space Telescope.

Visitors can zoom in on satellite images of anywhere in Australia and compare the imagery with same-scale maps of the region. The resolution of the Space Telescope allows visitors to identify 'their place' from space—right down to their suburb.

Most of the satellite images in the Space Telescope are a mosaic of 369 satellite scenes acquired by ACRES from the Landsat 7 satellite between July 1999 and September 2000.

The Space Telescope also contains a limited set of very detailed images of central Sydney, Canberra, Melbourne and Perth taken by the Ikonos satellite at a resolution of one metre. At this resolution, objects such as cars are clearly seen. The Space Telescope was developed in collaboration with ER Mapper, CSIRO, GeoImage, MapInfo and Space Imaging.

Other features of the 'To Mars and beyond' exhibit include a virtual 3-D tour to Mars, an opportunity to touch a piece of Mars, and the space suit worn by Australian astronaut Andy Thomas.

'To Mars and beyond' is in Canberra at the National Museum of Australia until May 26. The exhibit then moves to Museum Victoria from June 26 to October 21.

For more information phone Louise Elliott on +61 2 6201 4332 or e-mail louise.elliott@ga.gov.au

GOLD COUNTRY

traversed for in-depth view



Regional traverse

The regional deep seismic traverse (named 01AGSNY01) forms an east-west transect that extends from Leonora, through Laverton, White Cliffs, Yamarna and Lake Yeo before trending north-eastwards (01AGSNY3) into the Officer Basin sediments and underlying Yilgarn Craton. It was positioned to understand the crustal architecture beneath the Leonora-Laverton-Yeo Lake region, the Eastern Goldfields region, and the overlying shallow structure of the western Officer Basin.

Wide-angle (passive listening) recording techniques were also used along this traverse. Wide-angle techniques provide information about the velocities at which seismic waves travel through the rocks.

Velocities are a more useful pointer to rock composition at depth than reflection data, which are used to image structure.

More than 500 kilometres of multi-fold deep seismic reflection data were collected late last year in the Eastern Goldfields, Western Australia, by ANSIR's (Australian National Seismic Imaging Resource) 60 000-pound vibroseis trucks and 240-channel seismic recording equipment.

Four hundred and thirty kilometres of the multi-fold seismic reflection data were acquired along a regional traverse through the granite-greenstone terrains of the northern Yilgarn Block. Images were collected to approximately 50-kilometres depth. Thirty kilometres of the seismic data also were acquired in the highly mineralised Laverton Tectonic Zone.

The work will help build a three-dimensional picture of the region's crustal structure. It should contribute to an improved geological and metallogenic framework for the northern part of the Eastern Goldfields.

Laverton traverses

The Laverton Tectonic Zone investigation focused on two short traverses in the Granny Smith-Wallaby region (01AGSNY2) and the Sunrise Dam (01AGSNY4) area.

Two major gold-producing companies in the region (AngloGold and Placer Granny Smith) funded the traverses in conjunction with the University of Western Australia and the Minerals and Energy Research Institute of Western Australia. Geoscience Australia, UWA and the companies that funded the traverses are currently processing and interpreting the data. The results of this work will be confidential for 18 months.

Survey expectations

The regional seismic data are being processed and interpreted by Geoscience Australia and the Geological Survey of Western Australia. The results will help answer questions about the crustal geometry of the region, its mineral systems and geodynamic history.

Already there is considerable information on the structure of the greenstones at depth from previous seismic work further south in the Kalgoorlie region. On the basis of that work, the new data are likely to produce images of:

- the thickness of the granite-greenstone sequence, and the topography on any basal detachment surfaces;
- the geometry of faults;
- the shape of granites (depending on the type of rock into which the granite intruded);
- the internal structure within the greenstone sequences; and
- deformation surfaces and histories.

This new work will contribute to crustal structure studies of the Yilgarn Block, and research into similarities and differences between and within the various terrane subdivisions. Data will be useful for determining whether tectonic models based on seismic imaging in the Kalgoorlie region apply to this part of the Yilgarn Block. The data should also provide insights into why mineralisation occurs where it does, because the seismic method used can image fluid pathways through the crust.

Geoscience Australia carried out the seismic work for the Predictive Mineral Discovery Cooperative Research Centre, which will use the results in multidisciplinary research aimed at reducing exploration risk.

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

Australia's great mate, says mineral promotion team



A small Geoscience Australia team heads to Toronto from March 10–13 to promote mineral exploration and run the Australian governments' display at the world's largest mineral conference, the annual PDAC (Prospectors & Developers Association of Canada) International Convention, Trade Show and Investors Exchange.

The GA team (Lynton Jaques, Mike Huleatt and Roy Towner) will be promoting Australia as the world's premier destination for mineral exploration. They will emphasise the factors that significantly reduce risk for explorers working in Australia. These include the high-quality research being done by GA and its collaborators, Australia's huge potential for mineral discovery and its excellent track record, and the wealth of superior geoscientific information about Australia that is readily available, particularly via the internet.

All States and the Northern Territory will be represented in the government display. The State and Northern Territory geoscientific agencies will complement GA's national promotion by showcasing developments in their jurisdictions favourable to mineral explorers.

The governments' display will be part of a larger Australian pavilion coordinated by GeoJag Australia. Non-government organisations in the Australian pavilion will be AME Mineral Economics, the legal firm of Blakiston Crabb, Intrepid Geophysics, CODES, Gekko Systems and Encom Technology.

The PDAC convention was first held in 1932. It is now the largest event of its type in the world. Last year it attracted more than 7000 delegates.

The convention will have an extensive technical program with sessions covering topics such as world exploration hot spots, new technologies and techniques in exploration, commodity and market outlook, new discoveries and developments, and mining finance. Technical papers are a major component of the technical program, and this year will include a paper on Australian exploration over the past decade by Lynton Jaques and Mike Huleatt.

At least 350 organisations are expected to take part in the trade show. As well as government geoscience and regulatory agencies, there will be exhibitions from mining and exploration companies and a wide range of service and support companies. The exhibitors come from around the globe. Last year more than 70 countries had displays.

This year some 170 mining companies ranging from juniors to majors are expected to exhibit in the Investors Exchange, and like every other exhibitor they will be promoting their activities to potential investors. Stock exchanges, brokers and financial institutions will also have exhibits.

The second World Mines Ministries Forum (WMMF) will be held in Toronto immediately after PDAC for government officials, non-government organisations and mineral industry companies. The program includes both plenary sessions and workshops where participants will discuss the following topics:

- Mining and people;
- Creating a positive investment climate;
- The role of geoscience in attracting investment;
- Governance issues in the mining sector/ Mining, minerals and sustainable development; and
- Regulator's workshop: Dealing with voluntary codes of conduct.

Further details about the WMMF can be obtained from www.wmmf.org. Details of the convention and trade show are available from the PDAC website at www.pdac.ca.

For more information about the Australian governments' activities at PDAC phone Mike Huleatt on +61 2 6249 9087 or e-mail mike.huleatt@ga.gov.au



MINING CONFERENCE CUT SHORT

Mining 2001 Resources Convention held in Melbourne on November 7-9 ended abruptly. Lights went off. Speakers lost power. And delegates went home a couple of hours early on the final day. Nevertheless, convention delegates say it was a huge success.

The convention began with a comprehensive review of the outlook for gold and other metals. Banking and other financial institutions then delivered several papers on investment risks and financing of developments. And there was an interesting paper that examined the benefits of flow-through shares to the exploration industry in Ontario, Canada.

In the second auditorium, 14 junior companies involved in the exploration for gold, base metals, mineral sands and platinum-group elements presented up-to-date information on developments within their companies.

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Exploring Australia program

The second day of the convention was devoted to mineral exploration science. Geoscience Australia sponsored this program.

The keynote address was delivered by Geoscience Australia's Chief Executive Officer, Dr Neil Williams. In his paper titled 'Australian mining exploration: Challenges for the 21st century', Dr Williams indicated that Australia's research and development effort in exploration will concentrate on:

- New data-acquisition tools that allow explorers and geoscientists to probe further beneath the Earth's surface;
- New analytical methods for interpreting both existing and new geoscience data; and
- New exploration models that overcome the predictive weaknesses of current models.

Geoscience Australia staff presented other papers during the day, including Dr Peter Southgate (Proterozoic basins of the North Australian craton and their base metal potential), and Dr Dean Hoatson (Platinum-group elements and Ni-Cu-Co mineralisation in Precambrian layered mafic-ultramafic intrusions: New opportunities).

Industry speakers covered topics that ranged from geophysical technology and computer visualisation of exploration data, to gold, base metals, tantalum and investment. PowerPoint slides from most papers are available at www.mining2001.com.au.

Diamond event

A highlight of the second day was the 'diamond event'. Companies involved in diamond exploration (particularly in Australia) presented 14 papers. Several companies displayed diamonds that they have recovered during exploration. There was even a 'guess how many carats' competition.

Geoscience Australia added to the event by displaying new maps of Australia's potential diamond-bearing pipes, and Dr Lynton Jaques spoke about Australia's diamond potential.

Geoscience portal launch

During lunch on the second day, Dr Williams launched the Australian geoscience web portal. The portal provides a single entry point to the web sites of Australian government agencies involved in geoscience. After the official launch, many delegates visited Geoscience Australia's trade display to test the portal.

Trade display

More than 80 booths were in the trade display. Exhibitors included Geoscience Australia and State/Northern Territory geological surveys, mining and exploration companies, and the finance and service sectors. Several countries also had a presence in the trade display, including Mexico, Ghana, Canada, Greenland, Mozambique and New Zealand.

Special events

A special breakfast was held on the final morning to acknowledge the role women have played in the mining industry. Mrs Joyce Werekko-Brobby, Chief Executive Officer of the Ghana Chamber of Mines was one of the guest speakers.

During lunch on the final day, economic commentator Mr Robert Gottlieb offered his thoughts on world markets and Australia's role in these markets over the coming year, especially resources.

Premature closure

The convention's final session was cancelled because of a power failure. A fire in Melbourne's Central Business District cut electricity supply at 2.00 p.m.

Mining 2001 Resources Convention attracted 600 delegates. It coincided with Mining Week in Victoria, and the 150th anniversary of gold discovery in Australia. It was the second time the conference has been held. The first, Mining 2000 was also in Melbourne.

Symposium shows off latest in basins research

After two years' planning, the Eastern Australasian Basins Symposium for the oil and gas industry took place in Melbourne on November 25–28. Victoria's Minister for Energy and Resources, Candy Broad opened the symposium saying there was revitalised interest in eastern Australia because of recent discoveries in the Otway Basin by Santos, Beach Petroleum, Origin Energy and Woodside Australian Energy.

'The region is on the world's radar', she said.

The symposium drew together the latest research and a lot of new and improved data on the petroleum geology of south-eastern and eastern Australia, Papua New Guinea and New Zealand. The goal was to draw attention to the region's petroleum potential.

Geoscience Australia made a major contribution in sessions on the frontier areas—in particular, Lord Howe Rise, South Tasman Rise and the Great Australian Bight.

Jane Blevin gave a keynote address on the hydrocarbon prospectivity of remote frontier areas in offshore east and south-east Australia. Phil Symonds (on behalf of Peter Hill) and Phil O'Brien (for Neville Exon) reported on the regional geology and petroleum potential of sedimentary basins around Tasmania.

Phil Symonds also reported on the outer limits of Australia's resource jurisdiction off eastern Australia. And Clinton Foster (for Geoff O'Brien & others) spoke about evaluating regional seal capacity and hydrocarbon migration in south-eastern Australia.

Barry Willcox and Jacques Sayers gave two presentations on the regional petroleum geology of the Lord Howe Rise. Their paper 'Geological framework of the Lord Howe Rise' won the symposium's 'best paper runner up' prize. A paper by Neville Exon & others on the petroleum potential of deep-water basins around Tasmania won the 'editor's award'.

In the session on the Great Australian Bight, Geoscience Australia staff had papers on source rock character and distribution (Struckmeyer & others) and geochemical comparisons between asphaltites and Cretaceous source-rock analogues (Boreham & others). Several GA staff contributed to a paper on the geochemistry and charge history of a palaeo-oil column at Jerboa-1, Eyre Sub-basin (Ruble & others).

In total, there were eight presentations by GA staff as senior authors, and three further presentations to which GA staff contributed.

The Eastern Australasian Basins Symposium was convened by the Victoria–Tasmania Branch of the Petroleum Exploration Society of Australia (PESA). It attracted 327 registered delegates from many countries including Papua New Guinea, Malaysia, Indonesia, Singapore, the Philippines, Canada, New Zealand, the United States and Australia.

The symposium's trade exhibition had 32 booths. Geoscience Australia's booth, with its backdrop of a 3-D digital elevation model of eastern Australia, attracted many visitors.

The Symposium Proceedings, sponsored by Geoscience Australia, comprise 660 pages of conference papers. These were released at the symposium and are proving to be a major reference for information about the petroleum geology of eastern Australasian basins.

**For more details phone
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heike.struckmeyer@ga.gov.au**

EVENTS calendar

Compiled by Steve Ross

■ PDAC 2002: Convention & International Trade Show

Prospectors & Developers Association of Canada

10 to 13 March
Toronto, Canada

Contact: Prospectors & Developers Association of Canada, Floor 9, 34 King Street East, Toronto, Ontario M5C 2X8, Canada

phone +1 416 362 1969

fax +1 416 362 0101

e-mail info@pdac.ca

www.pdac.ca

■ AAPG 2002: Annual Meeting & Exhibition

American Association of Petroleum Geologists

10 to 13 March
Houston, Texas

Contact: American Association of Petroleum Geologists, PO Box 979, Tulsa Oklahoma 74101-0979, USA

phone +1 918 560 2679

fax +1 918 560 2684

e-mail convene@aapg.org

www.aapg.org

■ APPEA 2002: Conference & Exhibition

Australian Petroleum Production & Exploration Association

21 to 24 April
Convention & Exhibition Centre, Adelaide

Contact: Julie Hood, APPEA Ltd, GPO Box 2201, Canberra ACT 2601

phone +61 2 6267 0906

fax +61 2 6247 0548

e-mail feedback@appea.com.au

www.appea.com.au

■ Mapping Sciences Conference 2002

Mapping Sciences Institute, Australia

12 to 15 May
Carlton Crest Hotel, Melbourne

Contact: Organisers Australia, PO Box 2393, North Brighton VIC 3186

phone +61 3 9595 0259

fax +61 3 9596 2538

e-mail melbourne@orgaus.com.au

www.mapping-sciences2002.conf.au

■ 16th AGC–Geoscience 2002

Geological Society of Australia

30 June to 5 July
Convention & Exhibition Centre, Adelaide

Contact: Organising Committee, 16th AGC, PO Box 6129, Adelaide SA 5001

phone +61 8 8227 0252

fax +61 2 8 8227 0251

e-mail 16thagc@sapro.com.au

www.gsa.org.au

Granites and volcanic rocks in South Australia's Gawler region are attracting attention because some are associated with very large ore deposits. It seems one event nearly 1.6 billion years ago ruptured the geology and triggered the formation of many minerals, including gold. Anthony Budd is researching granite intrusions in the central Gawler Craton to come up with ideas on why some granites are mineral rich and others are barren.

Rich INTRUSIONS in hard rock study

Products of the Gawler Range/Hiltaba volcano-plutonic event (GRHVP¹) occur throughout large areas of the Gawler Craton (figure 1), including the Stuart Shelf and the Mount Woods Inlier. It is early Mesoproterozoic in age (~1595–1585 million years old²) and comprises I-type granites (the Hiltaba Suite) and volcanics (the Gawler Range Volcanics, GRV). These range in composition from basalt to rhyolite-granite, but are dominantly felsic in character.

The GRHVP is associated with many ore occurrences, including the giant Olympic Dam deposit (copper, gold, uranium and silver). Gold deposits at Tarcoola and Tunkilla are possibly related to the GRHVP. So, too, are prospects such as South Lake, Earea Dam, Weednanna Hill, Glenloth, Myall, Sheoak, and Barns, as well as others in the Tarcoola goldfield (Boomerang, Soyuz, Daly's Dream).

Other minerals (e.g. copper, tin, silver, lead, zinc, and arsenic) occur with the gold. Lead-zinc-silver mineralisation occurs at Menninie Dam³ and Telephone Dam on the southern margin of the Gawler Ranges.

Uranium-lead dating at Olympic Dam show that mineralisation is the same age as the GRHVP (at ~1590 Ma¹). Less is known about the relationship between the GRHVP and mineralisation in other parts of the Gawler Craton.

Mineralisation styles

Geochemical variations in the granites are possibly associated with differences in mineralisation.⁴ In the eastern Gawler Craton, where copper-gold deposits like Olympic Dam are located, the granites are more strongly fractionated and oxidised. In the central Gawler Craton, where less-fractionated and less-oxidised granites are more common, mineralisation is generally gold-dominated (e.g. Tarcoola).

Geoscience Australia in collaboration with PIRSA (Department of

Primary Industries and Resources, South Australia) is investigating the regional and district-scale constraints on the formation of copper and gold mineralisation in the Gawler Craton. Genetic links between the GRHVP and significant mineralisation in the Tarcoola goldfield are being investigated as part of this project. Researchers are looking for criteria that will help them discriminate between 'fertile' intrusions and those leading to barren hydrothermal systems.

Tarcoola goldfield

The Tarcoola goldfield contains a variety of mineralisation styles, ranging from quartz reefs crosscutting the Tarcoola Formation (1656±7 Ma⁵) to quartz veins crosscutting host intrusive rocks (e.g. Perseverance deposit). In places, gold is disseminated in granite.⁶

Total gold production from the Tarcoola deposit at December 1986 was nearly 2400 kilograms (average grade of 37.5 g/t gold).⁶ Most of the gold came from quartz reefs in the Tarcoola Formation.

The Tarcoola Formation in the mine area dips south at between 35° and 50° and strikes approximately east. Steeply dipping gold-bearing reefs occupy fault fissures approximately normal to the bedding and in conjugate fractures striking north-north-west and north-north-east.

Quartz reefs

The gold-bearing quartz reefs are up to two metres wide and 250 to 300 metres long, with a vertical extent of at least 100 metres. They contain abundant crushed xenoliths of quartzite and carbonaceous siltstone. The reefs can be narrower within thick-bedded quartzite and broader within thin-bedded carbonaceous siltstone and quartzite.

Rich gold values have been obtained where quartz veins crosscut carbonaceous siltstones. The ore contains silver, and locally abundant sulphides of copper, lead, zinc and arsenic. Reefs characteristically have erratic gold values both laterally and vertically, and contain very fine- and coarse-grained gold. Isolated intersections of up to eight metres at 131.2 grams/tonne of gold were obtained in drilling conducted in 1987.⁷

The quartz reefs were emplaced in response to basement fault movement probably associated with granite intrusion.⁶ Compression at a later date produced strike-slip movement along the quartz reefs and reverse faults parallel to the strike of the sediments.

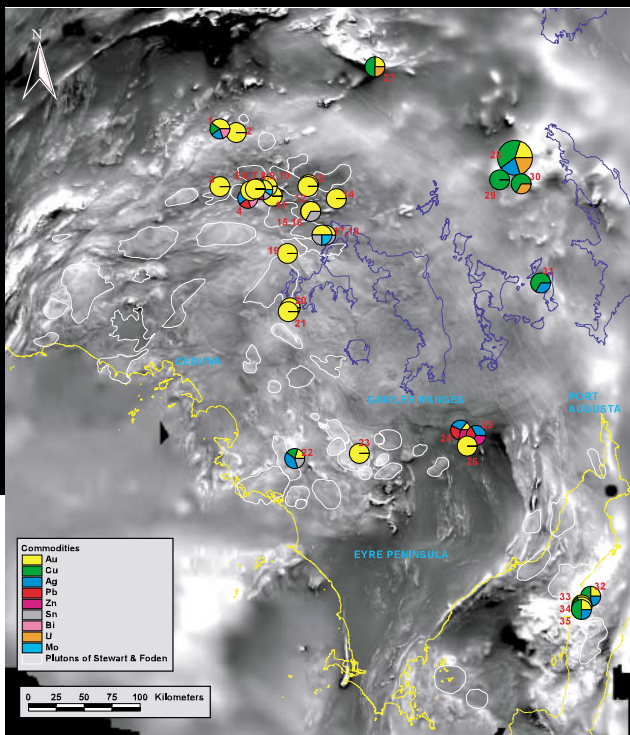
Ore fluids

Fluid inclusion studies on vein quartz from the Blocks Mine, and Sullivan and Fabian reefs report that mineralisation-related inclusions had homogenisation temperatures from 119° to 388°C (median value of 250°C or 290°C^{8,9}). Salinities are low to moderate (0–8 wt% sodium chloride equivalent). Variable liquid-vapour ratios suggest heterogeneous trapping of a parent liquid containing carbon dioxide.

Intrusives

Granite of the Hiltaba Suite intrudes the folded Tarcoola Formation along a strike length of 11 kilometres with a contact that is sub-parallel to the strike of the sediments. Daly and others report that the granites and sediments are intruded by 'late-stage dacite and andesite dykes',⁶ (although from my observations at the Perseverance deposit, the granites and intermediate intrusives shared mutual intrusive contacts).

Homogeneous lead isotope signatures have been recorded for



◀ **Figure 1.** Mineralisation associated with the Gawler Range/Hiltaba volcano-plutonic event, and identified plutons in the central Gawler Craton.¹³ The pie chart segments represent the relative abundance of metals.

compared with GRHVP intrusives at other gold prospects (possibly Tunkillia, Weednanna and Barns) and with intrusives in the Olympic copper-gold sub-domain (figure 1).

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pyrite, galena and native gold separated from quartz veins that intruded into the Tarcoola Formation.¹⁰ Lead isotope ratios are indistinguishable from the mineralisation signature for feldspars separated from the adjacent Hiltaba-style granite. This indicates that the granites were a metal source, or that the ore-forming fluids were in lead-isotopic equilibrium with the granites.

Recent results

Work to date by Geoscience Australia on the Perseverance deposit shows that the dominant intrusive is a coarse-grained hornblende-biotite monzogranite (with about 70 wt% silica). Drilling has also identified fine- to medium-grained amphibole/pyroxene monzodiorite (52–62 wt% silica), with lesser amounts of fine- to medium-grained sparsely K-feldspar-phryic biotite monzogranite (with 72–75 wt% silica). The intrusives show mutually interpenetrating contacts, indicating that they are the same age. Geochemistry suggests that the monzodiorites are a cumulate, and the monzogranites are a fractionate of an intermediate parental magma.


Textural and mineralogical changes in the granites are not reflected in whole-rock geochemistry, indicating that alteration was closed-system (based on the samples taken). An exception is the strong sericite-quartz alteration, which has resulted in almost total sodium loss with some potassium gain. Whole-rock gold values correlate (within the small dataset) with this strong sericite-quartz alteration. Alteration and mineralisation appear to have occurred as a single event, with limited fragmenting of the rocks.

Future work

Future work will focus on the intrusion-hosted mineralisation. It will involve fluid inclusion, dating and stable isotope studies, and further characterisation of mafic and felsic intrusive petrology and magmatic-hydrothermal evolution.

To better understand which intrusive systems in the Gawler Craton are likely to have mineral prospects, the Tarcoola deposit will be studied in light of models such as the 'intrusive-related gold systems model'.^{11,12} As well, the Tarcoola intrusives will be

Anthony Budd is conducting this research within the Gawler Mineral Promotion Project at Geoscience Australia, and as a PhD candidate at the Geology Department of the Australian National University.

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Structural search could boost Broken Hill-style finds

Geoscience Australia and the Department of Primary Industries and Resources South Australia (PIRSA) recently began a two-year project to look at the deformational history and tectonic evolution of Palaeoproterozoic rocks in the Outalpa Inlier, South Australia. These rocks are a westward continuation of the Willyama Supergroup, from Broken Hill into the Olary region (figure 1). They include the extensive 'Bimba formation'—a marble and calc-silicate dominated unit known for its high base-metal content (lead, zinc, manganese, copper and cobalt).

Geochronological studies recently confirmed that this unit correlates with the Ettlewood Calc-silicate in the Broken Hill Group.¹ Consequently, detailed structural investigations have begun around Ameroo Hill where gossanous calc-silicate units are common.

Redox boundary

The Bimba formation in the Ameroo Hill area is associated with an important redox boundary. This boundary is visible in aeromagnetic images of the Olary region. Several recent mineral discoveries have been located elsewhere in the Olary region along this boundary (e.g. Kalkaroo, White Dam, Portia—see figure 1). Because of its obvious economic significance, it is under detailed structural investigation to clarify its origin and the extent to which it is structurally and/or stratigraphically controlled.

Deformation

Stratigraphy in the Ameroo Hill area incorporates one or more unconformities, and has been deformed at least four times (pre-Adelaidean deformation: D1–D4). The Bimba formation immediately overlies one unconformity. Typically, it coincides with the transition of a variably oxidised succession of migmatitised psammopelitic gneisses, quartz-albitites, calc-albitite, and minor calc-silicate rock (Curnamona Group) into an overlying sequence of psammopelitic schist that is increasingly graphitic towards its base (Strathearn Group).^{2,3}

Isoclinal folding and low-angle thrust faulting in these two sequences are primarily the result of the D2 deformation. This brought about widespread structural repetition of lithological units as well as local thickening and thinning of the Bimba formation. In some localities this unit is completely missing, such that psammopelitic rocks of the Strathearn Group rest against oxidised rocks of the Curnamona Group. It is not always clear whether this contact is the result of deformation or non-deposition.

Complicated picture

Two additional episodes of more upright folding and associated shearing (D3–D4) complicate the regional structure, making the outcrop pattern complex. As well, there is a layer-parallel foliation of uncertain origin related to the first deformation phase that has been deformed by the D2 structures.

Ignore the regional structure and you might miss further economic deposits of lead, zinc and other minerals in the Olary–Broken Hill region, warns Geoscience Australia's George Gibson.

To further complicate the picture, lead-zinc-copper mineralisation in the Outalpa Inlier is not confined to a single horizon. In some areas (e.g. south-west of Ameroo Hill) the most obvious gossans are associated with a five to 20 metre thick calc-silicate unit lying some tens of metres below the Bimba horizon. A sequence of thin-bedded psammittic schist separates them.

The calc-silicate unit is part of the underlying Curnamona Group (Ethiudna subgroup?) and is a secondary target for mineral exploration. It is commonly manganiferous as well as sulphide rich. It can be distinguished from the overlying Bimba formation because it occurs within a sequence of composite biotite gneisses (meta-sandstone) that also host a thin but regionally persistent quartzite layer.

Effective exploration

The most effective drilling programs and exploration strategies are likely to be those that target mineralisation at more than one stratigraphic level. This should include sub-Bimba depths, because the original stratigraphy may have been substantially modified by deformation. Exploration models that ignore regional structure, and thrust faulting in particular, may never realise the mineral potential of rocks that are buried beneath shallow tectonic cover.

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The two-year study of the Outalpa Inlier by Geoscience Australia and PIRSA is part of the Broken Hill Exploration Initiative. For further details phone George Gibson on +61 2 6249 9727 or e-mail george.gibson@ga.gov.au

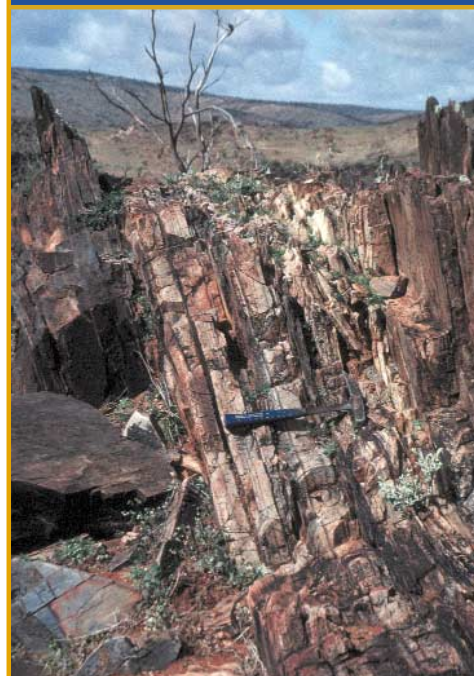
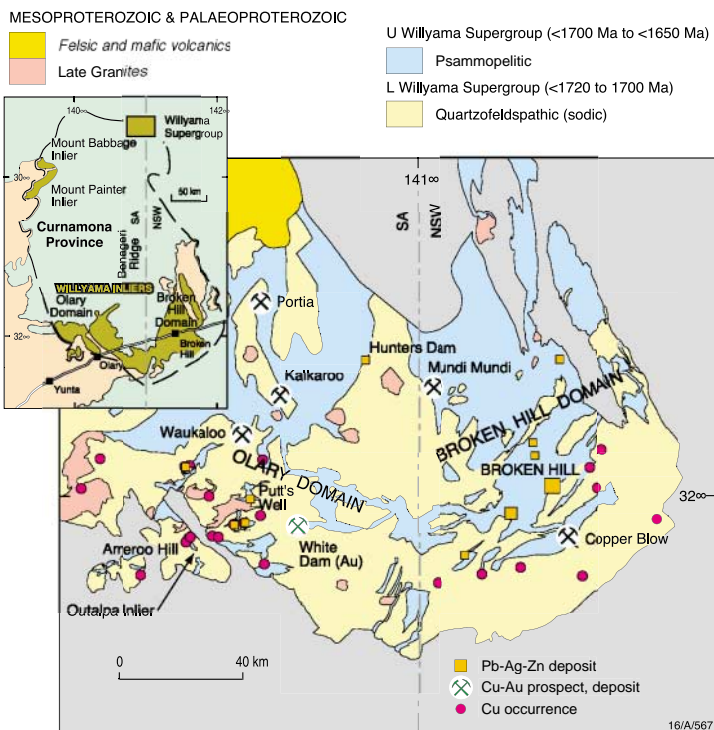
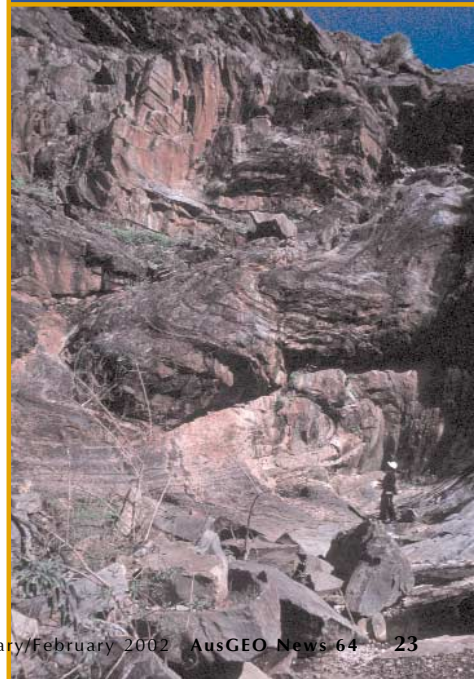


Figure 1. The distribution of the Palaeoproterozoic Willyama Supergroup (inset) and the location of principal copper-gold and silver-lead-zinc mineral deposits in southern part of the Curnamona Province. Many of these deposits are located at or near the contact between two metasedimentary sequences. The lower sequence is sodium altered and composed mainly of quartzofeldspathic rocks (top photo). The upper one is dominated by psammopelitic compositions (bottom photo).

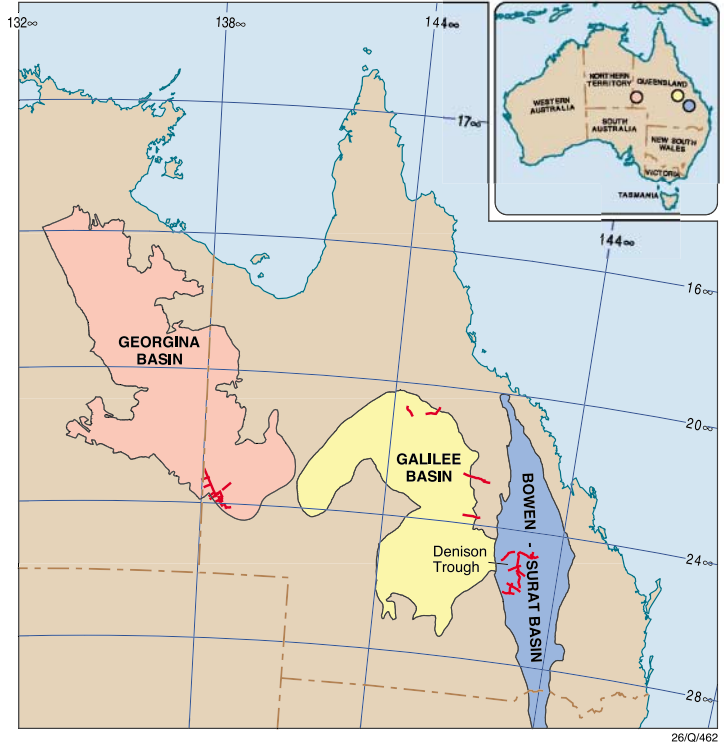


Re-processed seismic data a **BIG** improvement

Seismic reflection data from three regional surveys in Queensland, acquired between 1976 and 1979, have been improved extensively due to some recent re-processing at Geoscience Australia. The survey data provide insights into the geology of the Galilee and Georgina Basins and the Denison Trough.

Galilee Basin (L108): This 1976 survey comprises 220 kilometres of six-fold dynamite data for the Clermont–Alpha and Pentland–Hughenden areas of the Galilee Basin. The survey was carried out to investigate the geological relationship between the Galilee Basin and the older, underlying Drummond and Adavale Basins. The data were recorded over four traverses with 24 channels per shot and a group interval of 83.3 metres.

Figure 1. Location map of recently reprocessed seismic data



Antarctic bulletin

SUMMARISES RESEARCH OVER 40 YEARS

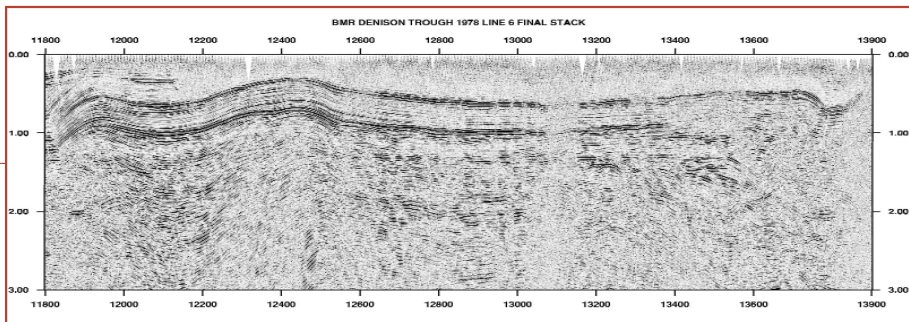
Geoscience Australia's Bulletin 247 is the definitive text on the geology of Antarctica's Prince Charles Mountains. The book draws together geological studies in the region by Australian and Soviet/Russian expeditions over the past 40 years.

The Prince Charles Mountains of MacRobertson Land are a 600-kilometre cross-section through the metamorphic rocks of the Precambrian East Antarctic Shield. The mountains comprise three distinct geological terranes that are Archaean to Neoproterozoic in age. Also present are Palaeozoic granites and mafic dykes (including lamproites), Permo-Triassic sediments with coal measures, and Mesozoic and Cainozoic mafic and alkaline ultramafic igneous rocks.

The Precambrian rocks and their Phanerozoic structures are related to the assembly and break up of the ancient continents of Rodinia and Gondwana. Equivalent continental terranes are found in Western Australia, India and Madagascar.

Bulletin 247 is a 212-page, soft-cover book. It contains extensive geochemical and petrographic information, many new isotopic age determinations, and interpretations of the geological history of the region.





◀ **Figure 2.** Example of improved data from the Denison Trough

Georgina Basin (L109): The aim of this 1977 survey was to investigate the nature and structure of the Toko Syncline (south-eastern Georgina Basin) and the Toomba Fault on the south-west margin of the syncline. Some 285 kilometres of two-dimensional seismic data were recorded over 14 traverses in the Toko Syncline. Data were six-fold using dynamite as a source, either in drill holes or ploughed in as Geoflex. The recordings were either 24 or 48 channel, and group interval was 41.66 or 83.33 metres.

Denison Trough (L111 & L112): Data were recorded in 1978 and 1979 over nine traverses in the Rolleston–Injune area of the Denison Trough. The aim was to provide stratigraphic information from the Permian sequence and delineate the configuration of the trough. Generally, data quality was

good to very good in the southern part of the survey but poor to fair in the northern part. The 440 kilometres of six-fold CDP reflection data were recorded at 41.66 metres group interval using a 48-channel DFS IV system.

The data are now available in SEG Y format on several types of media, as ‘shot’ records or enhanced ‘final stack’ records. They are easily read on any seismic viewing package and can be plotted, viewed and interpreted at any required scale. The data can be purchased for the cost of transfer (\$99) plus postage and handling.

Geoscience Australia has been acquiring onshore seismic reflection data in Australia since the late 1940s. The early surveys were of a pure reconnaissance nature where quality was unknown and spot tests were carried out either to ascertain reflectivity or to test some geophysical anomaly. The recording was done on either paper or magnetic tape in an analogue format.

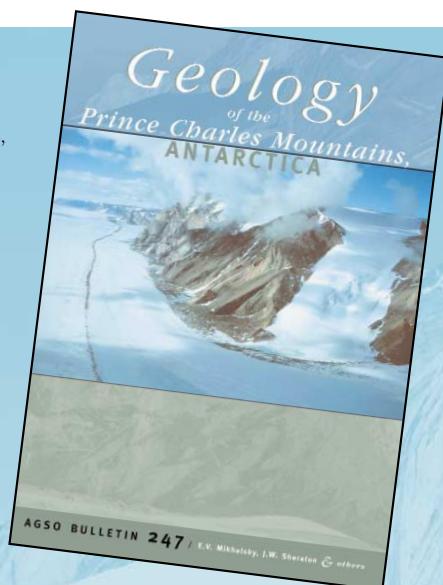
Surveys conducted in the 1970s and 1980s were of a regional scale to investigate the extent of sedimentary basins. Geoscience Australia purchased its first digital recorder in 1975, and has since collected some 11 000 line-kilometers of data on the continent.

Nowadays the seismic reflection technique is proving a useful tool for those trying to determine how mineral systems formed.

For more information about these data sets or to purchase data phone David Johnstone on +61 2 6249 9446 or e-mail david.johnstone@ga.gov.au 📧

The book includes 190 black and white figures and photographs, 26 tables (including 200 chemical analyses) and a coloured geological map (55 x 75 cm).

Bulletin 247 is a significant addition to Antarctic geoscience literature. It substantially increases understanding of the geological evolution of the Prince Charles Mountains, and marks an unprecedented collaboration of Australian and Russian scientists. The book is a must for geologists with interests in Antarctic geology, igneous and metamorphic petrology and geochemistry, and continental reconstructions.



Bulletin 247: Geology of the Prince Charles Mountains, Antarctica is available from the Geoscience Australia Sales Centre for \$55 (includes GST) plus postage and handling. To purchase a copy please complete the enclosed order form and return it to the Sales Centre.

For more information phone John Bain on +61 2 6249 9282 or e-mail john.bain@ga.gov.au 📧

HUGE savings on SPATIAL DATA

The previous issue of AUSGEO News announced new prices this year for Geoscience Australia spatial data because of a change in government policy. Here is an update on some products and what can be downloaded free of charge from the web.

In line with the new spatial data pricing policy announced in September last year, the range, resolution and choice of formats for Geoscience Australia data available to the public are being expanded substantially this year. The public already can access 45 of Geoscience Australia's national data sets, which cover 35 geoscientific, cultural, infrastructure and other reference themes.

Since September a permanent FTP site has been established for faster access to data. This allows large files or many files to be download at once, bandwidth permitting. (Just point the browser or ftp client to <ftp.ga.gov.au/data/national>.)

MINERALS DATA

There has been a huge price reduction for data from the Minerals Division as shown below. Each CD now costs only \$99. Even better news is that many of the data will become available from the Geoscience Australia web site at no charge.

- North Queensland stream sediment geochemistry (was \$8750);
- North Pilbara GIS (2 CDs were \$4000);
- Mt Isa GIS (was \$9000);
- Complete coverage of Northern Territory digital geology at 1:250 000 scale (was \$26 900).

Minerals Division database developers also have compiled four CDs that provide a wealth of information about Australian mineral systems. They are:

1. OZCHEM (previously known as Rockchem)—the national whole-rock geochemistry database of major and trace-element analyses. Available in Microsoft Access, ASCII, Arcview and Mapinfo formats.
2. OZMIN—Australia-wide production and resource figures, updates for existing deposits and details about recent discoveries for more than 50 commodities, including coal. Included on this CD is MINLOC—fully referenced data on Australian mineral occurrences including the Mt Isa OZMIN special release. Available in Microsoft Access, ASCII, Arcview and Mapinfo formats.
3. OZCHRON—the national geochronology database of isotope analyses performed for age determinations. Available in Microsoft Access, ASCII, Arcview and Mapinfo formats.
4. Australian Stratigraphic Names—the national register of stratigraphic names including unit name, rank (e.g. member, formation, group), usage, history, currency, geological province, time range, parent unit, underlying and overlying units, boundary relations and geographic locations. Only available in ASCII format.

GEOPHYSICAL DATA

Geophysical data acquired by Geoscience Australia are subject to the new pricing policy and are available on CD.

The Index of Airborne Geophysical Surveys is a summary of specifications for government airborne geophysical surveys. For a free PDF version of this document e-mail a request to sales@ga.gov.au. For a list of the new product compilations, check the Geoscience Australia web site.

The Australian National Gravity Database has been upgraded. The 2002 edition on CD (which includes the Australian gravity grid) was released at the end of February for \$99. These datasets previously cost \$5500 for the database and \$2700 for the grid.

The national coverage of magnetic grid data also costs \$99—a huge price reduction from \$25 900.

DIGITAL GEOLOGY

Geoscience Australia's digital geology coverages of Australia at 1:100 000 and 1:250 000 scale are being compiled into collections of regional data. These will be released on CD and available from the web over the next few months. The first regional compilation CD to be released is the Yilgarn Craton. (See the table for a list of the coverages included on the CD.)



MARINE DATA

The Australian Bathymetry and Topography Grid was released in late February at the new price of \$198. This two CD package contains the latest edition of the grid at 0.01° (~1 km) cell size. Both binary and ASCII formats are included to suit the most common image processing and GIS applications. The grid eventually will be available free of charge from the web.

The topography is from Geoscience Australia's (formerly AUSLIG) second edition digital elevation model of Australia. The bathymetry is from digitised charts obtained from the Australian Hydrographic Service, swath bathymetry surveys, and other ship-track data of various vintages and navigational accuracy.

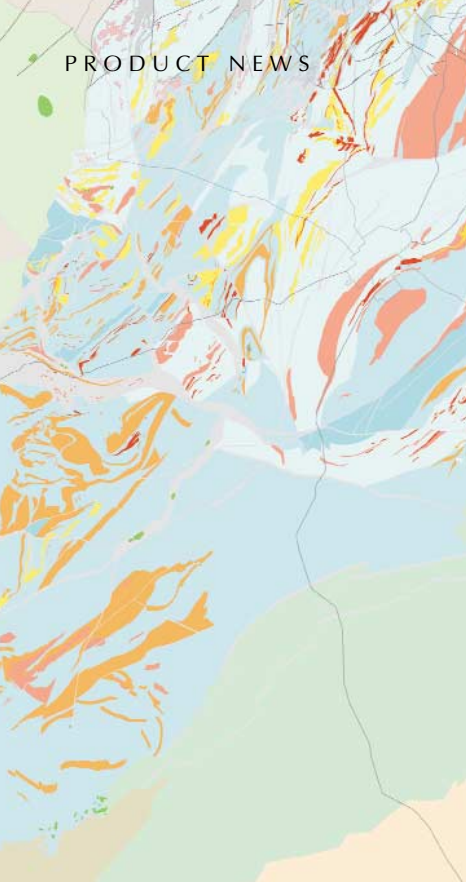
Work also is in progress to publish several Petroleum and Marine Division databases live on the web. These are:

1. STRATDAT—interpretive biostratigraphic data relating fossil zones to absolute time scales in selected onshore and offshore petroleum exploration wells. STRATDAT also includes well data such as sequence boundaries, formation tops and other log pick data.
2. ORGCHEM—a petroleum source-rock database featuring source-rock data taken from company well completion-reports and data obtained by the Isotope and Organic Geochemistry Laboratory at Geoscience Australia.
3. RESFACS—the petroleum reservoir database containing reservoir, facies and hydrocarbon data for locations within Australia.

If you are interested in client acceptance testing of this new web facility phone Sue Edgcombe on +61 2 6249 9545 or e-mail suzanne.edgcombe@ga.gov.au.

For more information about data availability and prices phone the Sales Centre on +61 2 6249 9519 or e-mail sales@ga.gov.au. Geoscience Australia datasets on CD now cost \$99 per CD plus \$7.50 postage and handling for each order within Australia. Wherever possible data will be available from the web so that material can be downloaded free of charge. ☑

Title	Scale	Available format
Ballard, edn 2 (Menzies sheet)	1:100 000	Arcinfo
Ballimore (Wiluna sheet)	1:100 000	Arcinfo, Mapinfo
Burtville (Laverton sheet)	1:100 000	Arcinfo, Mapinfo
De La Poer (Duketon sheet)	1:100 000	Arcinfo, Mapinfo
Kurnalpi regolith landform map	1:250 000	Arcview, Arcinfo
Lake Carey (Edjudina sheet)	1:100 000	Arcinfo, Mapinfo
Lake Violet geology (Wiluna sheet)	1:100 000	Arcinfo, Mapinfo
Lake Violet solid geology (Wiluna sheet)	1:100 000	Arcinfo, Mapinfo
Laverton solid geology	1:250 000	Arcinfo
Laverton (Laverton sheet)	1:100 000	Arcinfo, Mapinfo
Laverton geology, edn 2	1:250 000	Arcinfo
Leonora geology, edn 2	1:250 000	Arcinfo
Leonora regolith landform map	1:250 000	Arcinfo, Mapinfo
Leonora solid geology, prelim edn	1:250 000	Arcinfo
Leonora, edn 2 (Leonora sheet)	1:100 000	Arcinfo
McMillan (Laverton sheet)	1:100 000	Arcinfo, Mapinfo
Menzies regolith landform map	1:250 000	Arcinfo, Mapinfo
Minerie (Laverton sheet)	1:100 000	Arcinfo, Mapinfo
Mount Alexander (Leonora sheet)	1:100 000	Arcinfo
Mount Celia (Edjudina sheet)	1:100 000	Arcinfo, Mapinfo
Mount Keith solid geology (Sir Samuel sheet)	1:100 000	Arcinfo
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Mount Mason (Menzies sheet)	1:100 000	Arcinfo, Mapinfo
Mount Varden (Laverton sheet)	1:100 000	Arcinfo, Mapinfo
Munjeroo (Leonora sheet)	1:100 000	Arcinfo
Nabberu solid geology	1:250 000	Arcinfo, Mapinfo
Nambi (Laverton sheet)	1:100 000	Arcinfo
Sandalwood (Wiluna sheet)	1:100 000	Arcinfo, Mapinfo
Sir Samuel	1:250 000	Arcinfo
Sir Samuel solid geology	1:250 000	Arcinfo
Sir Samuel regolith landform map	1:250 000	Arcinfo, Mapinfo
Tate (Duketon sheet)	1:100 000	Arcinfo, Mapinfo
Urarey (Duketon sheet)	1:100 000	Arcinfo, Mapinfo
Wanggannoo (Sir Samuel sheet)	1:100 000	Arcinfo, Mapinfo
Weebo (Leonora sheet)	1:100 000	Arcinfo, Mapinfo
Wilbah (Leonora sheet)	1:100 000	Arcinfo, Mapinfo
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Wiluna regolith landform map	1:250 000	Arcinfo, Mapinfo
Yeelirrie (Sir Samuel sheet)	1:100 000	Arcinfo, Mapinfo
Yerilla (Edjudina sheet)	1:100 000	Arcinfo, Mapinfo



Broken Hill map

RELEASED AS A SEPARATE PRODUCT

A 1:100 000 scale lithological map of the Broken Hill region, released as part of the 'BHEI 2000 Curnamona Province GIS' CD-ROM, is available as a separate product.

The map is a lithological interpretation based on 1:25 000 scale geological maps by the New South Wales Department of Mineral Resources, detailed aeromagnetic and spectrometric data gathered by Geoscience Australia, gravity data extracted from the national database, and some drill-hole information.

The map provides a useful overview of lithological packages, including granitic and Potosi gneiss and metasedimentary rocks which are represented in terms of their pelitic to psammitic composition. Amphibolite horizons are included as a separate overlay. Adelaidean cover sequence units are modified from published 1:100 000 scale maps using aeromagnetic and spectrometric data.

The map is available as a print-on-demand product from the Geoscience Australia Sales Centre for \$40 (includes GST) plus postage and handling. To purchase a copy please complete the enclosed order form and return it to the Sales Centre.

For more details phone George Gibson on +61 2 6249 9727 or e-mail george.gibson@ga.gov.au

HOT STUFF: GA SATELLITE IMAGES AND MAPS

Australia was hot over Christmas–New Year, as were maps and satellite images of the bushfire-affected areas on the eastern seaboard generated by Geoscience Australia's National Mapping Division.

In the usually quiet days of December 28 to January 8, Geoscience Australia staff provided more than 3250 NATMAPs for State Emergency Services, New South Wales Rural Fire Service, the Fire Brigade, police, fire control centres and pilots. The maps were crucial to fighting the bushfires that swept across New South Wales and the Australian Capital Territory.

Fire authorities also had access to Geoscience Australia/ACRES (Australian Centre for Remote Sensing) satellite images taken about 800 kilometres above the Earth's surface by the SPOT series of satellite. These images showed the extent of the fire damage.

The first image (figure 1), acquired on December 27, shows a blended mosaic of eight SPOT 'quick looks' covering an area approximately 120 kilometres wide by 240 kilometres long that stretches from Wyong in the north to Jervis Bay in the south. Each 'quick-look' covers a 60-square-kilometre area. Healthy vegetation shows as bright red, forest as dark red, ocean and lakes as dark blue, burnt areas as black, and smoke as white.

The second image (figure 2), acquired from the SPOT satellite on January 8, shows the fire fronts in the south and the damage over the previous 12 days. The bushfires were under control when this image was acquired. It enables a very good 'before and after' comparison of the fire-ravaged landscape.

The January 8 image was published on the front pages of major Australian newspapers, the *Sydney Morning Herald* and *The Australian*. The *Daily Telegraph* published three images over the course of the bushfires. The images were posted on the Geoscience Australia web site, which generated inquiries from the media, including several international news agencies, and the public.

Maps and satellite imagery are useful fire-management tools. Before bushfire season, authorities can use satellite imagery to estimate fuel loads, and digital elevation data and NATMAPs to help assess likely fire paths and to plan access points and fire breaks. In many remote areas, the NATMAP 1:250 000 topographic series of maps are the most detailed available.

During prolonged fires such as those experienced in NSW over Christmas–New Year, the satellite imagery can be used to track the progress of fire fronts in near real time (provided a satellite passes over the location at the time). The imagery is also excellent for assessing damage once the fires have been extinguished.

Geoscience Australia Customer Support staff are on-call throughout the year to provide free maps in emergencies such as fires and floods, and for search and rescue operations.

To view satellite imagery and find out about Geoscience Australia products go to the web site (www.ga.gov.au). From here follow the National Mapping Division link.

For more information phone Customer Support on 1800 800 173 (free call within Australia only) otherwise +61 2 6201 4300, or e-mail mapsales@ga.gov.au

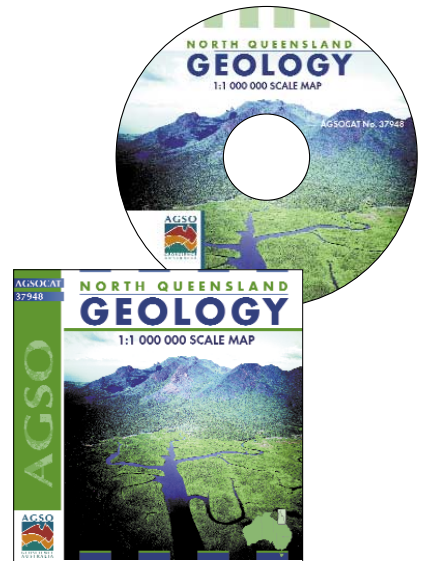
MORE OPTIONS WITH THE *NQ geology CD*

On one of its latest CDs, Geoscience Australia gives users a range of formats for the north Queensland geological map.

The North Queensland Geology CD contains four digital versions of the printed map (Arcinfo 8.02, Postscript, TIF, and Adobe Illustrator 6). These options allow users to select the digital version that suits the intended application—for example: a text figure, lecture slide, desktop map or wall map. As well, the data set can be used for a range of scales from 1:250 000 to 1:5 million (although 1:1 million is optimum).

The Arcinfo version was revised in 2001 to include extra information about the more than 1800 named geological units, which are represented on the printed or hard-copy map by just 45 different units. These 45 units reflect logical age and lithology groupings, and were the result of a compromise between readability of the printed map at 1:1 million scale and useful information. The internal boundaries of grouped units were eliminated with this compromise, so in the 2001 Arcinfo version the identity of mapped units has been added to the information tables.

The CD (AGSOCAT 37 948) costs \$99 (includes GST). The printed map released in 1997 with *AGSO bulletin 240: North Queensland geology* is also available. The map (AGSOCAT 23 928) costs \$26.98 while the bulletin and map (AGSOCAT 24 162) cost \$148.50. To order these products please complete the enclosed order form and return it to the Geoscience Australia Sales Centre. Please add postage and handling to the prices.



**For more information phone
John Bain on +61 2 6249 9282 or
e-mail john.bain@ga.gov.au**

Figure 1. New South Wales is on fire. The SPOT satellite image taken on December 27 pinpoints the fire fronts (white billows of smoke). Copyright CNES 2002

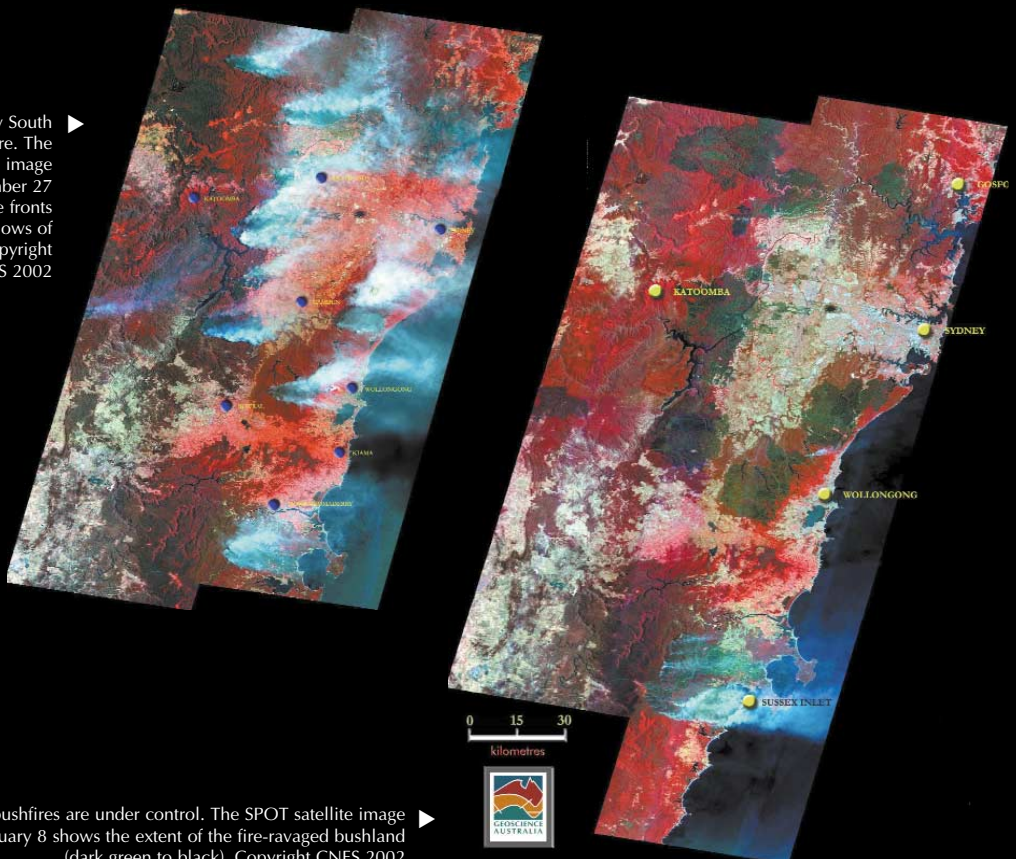
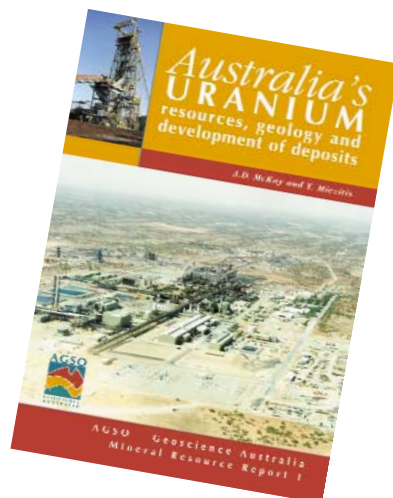


Figure 2. The bushfires are under control. The SPOT satellite image taken on January 8 shows the extent of the fire-ravaged bushland (dark green to black). Copyright CNES 2002

Major report on *uranium* *resources* available



The latest estimates of Australia's uranium resources have been released in a Geoscience Australia report titled, *Australia's uranium resources, geology and development of deposits*. The report shows Australia is the world's second largest producer of uranium and that most of Australia's resources are recoverable at costs of less than US\$40 per kilogram of uranium.

The report also describes the geology of the deposits and summarises the development of Australia's mines including Nabarlek, Ranger, Olympic Dam, Beverley and the mines that operated in the 1950s.

Recovery rates

Geoscience Australia estimates that Australia has 654 000 tonnes of uranium in reasonably assured resources (RAR) recoverable at costs of \leq US\$40/kg U, which is more than any other country's resource estimates in this category. Most of these resources are in six deposits:

- Olympic Dam (South Australia);
- Ranger, Jabiluka and Koongarra in the Alligator Rivers region (Northern Territory); and
- Kintyre and Yeelirrie (Western Australia).

When these estimates are included in RAR recoverable at \leq US\$80/kg U, Australia again tops the list with 667 000 tonnes or 29 per cent of world resources. (See figure 1.)

Uranium production

Australia's share of annual world uranium production increased from approximately one per cent (365 t U) in 1977 to 22 per cent (7579 t U) in 2000, making it the world's second largest producer of uranium behind Canada.

Australia has three operating uranium mines: Olympic Dam, Ranger and Beverley (see figure 2). The Beverley operation, Australia's first in-situ leach uranium mine, began production in November 2000. A year later, the Honeymoon in-situ leach proposal received government approvals for development.

A major expansion of the Olympic Dam operations was completed in early 1999, and in 1998 the Jabiluka project received approval for development following an environmental impact assessment process that lasted almost three years. The project is currently in a stand-by and environmental care and planning phase.

All of Australia's uranium is exported to countries in North America, East Asia and Europe to generate electricity.

Deposit types

Most of Australia's uranium is in four types of deposits: breccia complex, unconformity related, sandstone uranium, and calcrete deposits.

- Breccia complex deposits contain 65 per cent of Australia's total uranium resources. Nearly all of this is at Olympic Dam, the world's largest uranium deposit.
- Unconformity related deposits account for 20 per cent of Australia's total resources, mainly in the Alligator Rivers field (Ranger, Jabiluka, Koongarra), and in one deposit in the Rudall Province, Western Australia (Kintyre).
- Sandstone uranium deposits account for seven per cent of Australia's total resources, mainly in the Frome Embayment field, South Australia (Beverley, Honeymoon, East Kalkaroo, Goulds Dam) and the Westmoreland area, Queensland (Redtree, Junnagunna, Huarabagoo). Other significant sandstone-type deposits include Manyingee, Mulga Rock and Oobagooma in Western Australia.

- Surficial (calcrete) deposits comprise five per cent of Australia's resources, most of which are in the world-class Yeelirrie deposit. Other calcrete deposits include Lake Way, Lake Maitland and Centipede (Western Australia).

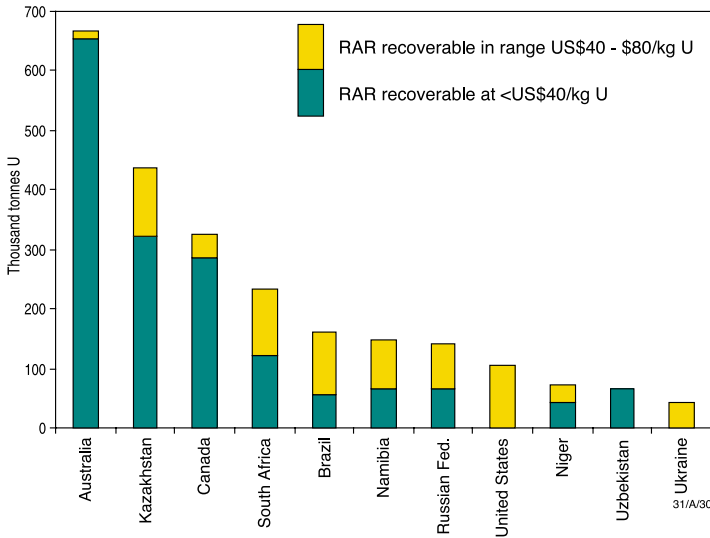
Purchase details

Australia's uranium resources, geology and development of deposits is available on CD-ROM for \$40 from the Geoscience Australia Sales Centre. To obtain a copy please complete the enclosed order form and return it to the Sales Centre. The report can be viewed on-line at www.ga.gov.au/pdf/RR0076.pdf.

Advisory role

Geoscience Australia is required under the Atomic Energy Act to advise the Commonwealth Government on uranium exploration and discovery. It provides technical advice to government on uranium mining proposals, usually in regard to the environmental impacts of these proposals. Environment Australia used technical assessments and advice from Geoscience Australia and the Bureau of Rural Sciences when considering the Beverley and Honeymoon projects.

Companies proposing to develop new uranium mines in Australia are required by legislation to complete an environmental impact assessment process. Projects must meet strict requirements relating to environmental protection, heritage and nuclear safeguards.



▲ **Figure 1.** The distribution of reasonably assured resources among countries with major resources

OECD Uranium Group

Geoscience Australia plays a major role in the Uranium Group convened by the OECD Nuclear Energy Agency and International Atomic Energy Agency. The Group comprises government representatives from more than 50 nations. These representatives include experts on uranium geology and resources (supply), and uranium demand for electricity generation. Geoscience Australia's Dr Ian Lambert was elected Vice-Chair of the Group at a meeting in Paris in October 2001.

The Group publishes a report 'Uranium resources production and demand' (commonly known as the Red Book) every two years. The next edition is due for release in mid-2002.

For more information phone Aden McKay on +61 2 6249 9230 or e-mail aden.mckay@ga.gov.au



▲ **Figure 2.** Australian uranium deposits and prospects



THOUSANDS MORE GRAVITY POINTS IN LATEST EDITION

Geoscience Australia has just released the 2002 edition of the Australian National Gravity Database, which has approximately 28 000 more gravity stations than last year's release.

The 2002 edition contains point data values in the area extending from 8°S to 48°S and 108°E to 162°E. All data are provided in GDA94 coordinates.

The digital data are supplied on one CD-ROM, which also includes the ER Mapper gravity grid of Australia that was released in June 2001. This grid is produced at a cell size of 0.5 minutes of arc (equivalent to approximately 800 metres).

Geoscience Australia's National Gravity Database contains about a million point gravity observations on the Australian mainland. These data have been collected from 1814 gravity surveys dating back to 1937. This repository of gravity information is a valuable national asset with importance to the mineral and petroleum exploration industries, geodesy and the international scientific community.

A copy of the National Gravity Database and grid can be purchased from the Geoscience Australia Sales Centre for \$99 (includes GST) plus postage and handling. To obtain a copy please complete the enclosed order form and return it to the Sales Centre.

For further information about the database phone Phillip Wynne on +61 2 6249 9463 or e-mail phill.wynne@ga.gov.au

Bight seabed

DESCRIBED IN NEW REPORT

Details about the seabed of the Great Australian Bight (GAB) are revealed in a report recently released by Geoscience Australia.

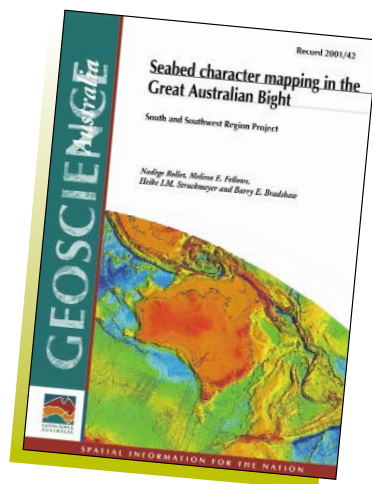
Record 2001/42 summarises the results of seafloor mapping in the GAB during 2000–2001 carried out as part of Geoscience Australia's South and South-west Regional Project. The aim of the research was to compile data that supports future Regional Marine Planning in the GAB. This involved gathering basic information on geomorphology and seabed character that could be used for biological, environmental and economic assessments.

The report describes the geomorphology of the entire south and south-west region, from west of Perth to Kangaroo Island. It shows that the major geomorphological features are the continental shelf, marine terraces (including the Eyre and Ceduna Terraces), and the continental slope and continental rise.

Descriptions of the GAB seabed character are based on the interpretation and mapping of echo facies (from available 3.5 kHz echo-sounding records) and acoustic facies (from high-resolution seismic data). Interpreted facies were 'ground-truthed' against seafloor samples where possible.

The facies distribution on the GAB continental margin and adjacent abyssal plain shows that geological inheritance is important because it influences the geomorphology and seabed character of the region.

Geoscience Australia record 2001/42 titled *Seabed character mapping in the Great Australian Bight* by Rollet, Fellows, Struckmeyer and Bradshaw can be purchased from the Geoscience Australia Sales Centre for \$33 (includes GST) plus postage and handling. To purchase a copy please complete the enclosed order form and return it to the Sales Centre.



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