Australian Government
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AUSGEO news
ISSUE 93 Mar 2009

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ISSUE 93 Mar 2009

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AUSGEO news
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CEO comment

Neil Williams – CEO Geoscience Australia

The United Nations Commission on the Limits of the Continental Shelf confirmed the location of the outer limit of Australia's continental shelf last year (see *AusGeo News* 90). This decision means Australia is the first country to be in a position to proclaim the outer limits of its continental shelf. However the continental shelf is only one of a number of maritime zones that make up Australia's marine jurisdiction and the article in this issue explains the characteristics and rights associated with these zones as well as the impact of national legislation and treaties with neighbouring counties.

There is also an article on the compilation of the recently-released new digital seamless surface geology map of Australia. This baseline dataset will be invaluable for national and regional evaluation of resources, as well as environmental management and land-use decision making. Another major new continental-scale product, the Radiometric Map of Australia dataset (see *AusGeo News* 92), was released by the Minister for Resources and Energy, The Hon. Martin Ferguson AM MP, on 22 February.

I am pleased to report that the seismic survey covering several frontier areas off the coast of southwest Western Australia (outlined in *AusGeo News* 92) has recently concluded after acquiring over 7000 line kilometres of seismic data as well as geological samples. During the marine reconnaissance survey in the same area, the research team collected more than 200 000 square kilometres of multibeam bathymetry – this covers an area almost the size of the state of Victoria. The data collected will make a major contribution to our assessments of the petroleum prospectivity, geological setting and environmental significance of these areas.

Geoscience Australia has successfully collaborated with state and Australian Government emergency management agencies to manage tsunami risk in Australia. There is an article outlining a major partnership with Fire and Emergency Services Western Australia to raise community awareness and provide the scientific knowledge on which emergency managers can base their planning and preparation for tsunami.

There is also an update on mineral exploration in Australia. Although Australian and global mineral exploration reached record highs during 2008, the end of the commodity boom (a consequence of the global economic downturn) is likely to see a sharp drop in exploration expenditure in the immediate future.

Over the last five years Geoscience Australia has been providing advice to government about the physical properties of the seabed and water column in Australia's Exclusive Economic Zone. This issue also includes a report on the preparation of the draft assessments of both Key Ecological Features and adjacent environments in the North-west Marine Region off Western Australia.

As usual we always appreciate your feedback and I encourage you to use the online rating mechanism with each article.

Neil Williams

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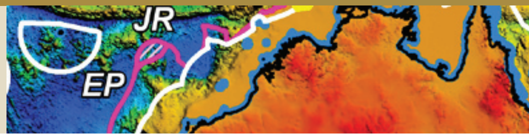
Setting Australia's limits

Understanding Australia's marine jurisdiction



Philip Symonds, Mark Alcock and Colin French

On 9 April 2008, the Commission on the Limits of the Continental Shelf adopted recommendations confirming Australia's entitlement to a continental shelf beyond 200 nautical miles from the coastline (extended continental shelf) of some 2.56 million square kilometres. This is an area slightly larger than the land area of Western Australia and one-third the size of the Australian continent.

The Commission is a body established under the United Nations Convention on the Law of the Sea (UNCLOS) and meets at the United Nations in New York. The recommendations marked the culmination of 15 years of intensive scientific, legal and diplomatic work and commitment from a number of Australian Government agencies, particularly through a close partnership between Geoscience Australia and the Department of Foreign Affairs and Trade and the Attorney-General's Department.

"Australia now has a secure regime within which to manage the resources and environment of virtually all parts of its continental margins, associated plateaus and ridges, and adjacent ocean basins. "

The decision means Australia is the first country to be in a position to proclaim the outer limit of its continental shelf on the basis of the recommendations of the Commission. A proclamation establishing that outer limit will be made in the near future under the *Seas and Submerged Lands Act 1973*, which is administered by the Attorney-General's Department.

The continental shelf, however, is only one of a number of zones that make up Australia's marine jurisdiction. Other important zones are also derived from UNCLOS and national legislation, as well as arising out of treaties with neighbouring countries.

Defining the limits

Usually when people consider what constitutes a maritime country they start from the geographical perspective associated with the shape and size of the landmass and the often familiar outlines of their coastlines. Indeed, as a matter of international law, it is the coastline and not the size of the landmass which is important. From a geoscience perspective, maritime States can be viewed quite differently according to the geological and crustal characteristics that underpin them. These characteristics can extend for vast distances beyond the coastline and underlie the shelf, terraces, plateaus, slopes and rises of the continental margins of countries. In reality, limits of countries are governed by national and international rules and arrangements based on legislation, treaties and customary international law. These limits include the sovereign territory of the country as well as jurisdictional zones associated with various sovereign rights assigned to the country under international law.

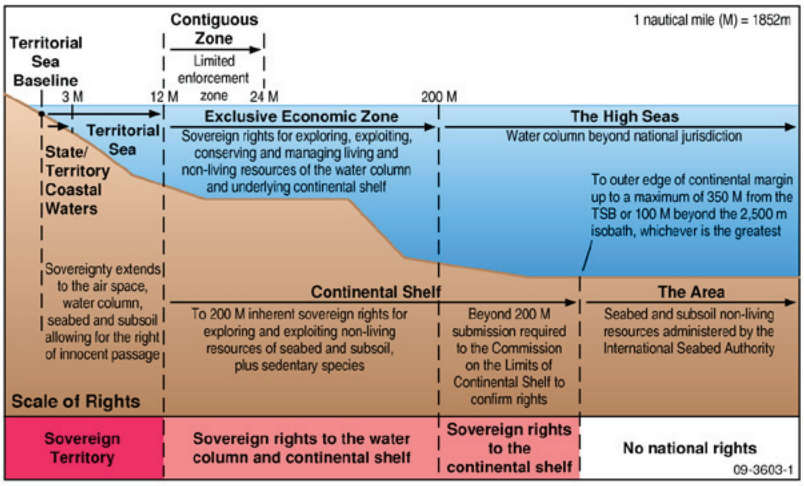


Figure 1. Maritime zones and rights under the 1982 United Nations Convention on the Law of the Sea (UNCLOS).

The different descriptions of countries based on any of the above perspectives can, of course, change over time. Geographical and geological descriptions are dynamic, and can be affected by tectonics, climate change, and erosional and depositional processes. These can all alter the shape and location of a coastline, and the geological characteristics of a landmass and its submerged prolongation beneath the sea. The political and legal descriptions of countries can also change.

In recent years, UNCLOS has been the major influence on the maritime zones of countries and the rights and responsibilities associated with those zones. The adoption of UNCLOS in 1982 marked the culmination of many years of negotiations involving over 150 States. The Convention established a comprehensive legal framework for the regulation of all ocean space. It covers a diverse range of issues such as the offshore limits of national jurisdiction, access to the seas, navigation, protection and preservation of the marine environment, exploitation and conservation of living resources, exploitation of non-living resources, seabed mining, and scientific research.

UNCLOS zones and rights

UNCLOS provides for the establishment of successive jurisdictional zones that extend over the continental margin and ocean basins adjacent to maritime nations. The characteristics and rights associated with these maritime zones (shown in figure 1) are as below:

- **Territorial Sea** – extends not more than 12 nautical miles from the territorial sea baseline (TSB). A coastal State has sovereignty over this zone (just as it has sovereignty over its land territory) – it includes the water column, seabed and subsoil, as well as the airspace above it. In the territorial sea, this sovereignty is subject to the right of innocent passage of foreign vessels.
- **Contiguous Zone** – this is the next 12 nautical miles beyond the territorial sea in which a coastal State may exercise control over customs, immigration and quarantine matters.
- **Exclusive Economic Zone (EEZ)** – extends beyond the territorial sea to not more than 200 nautical miles from the TSB. Within the EEZ, a coastal State has sovereign rights for the purposes of exploring and exploiting, conserving and managing the natural resources (living or non-living) of the water column, seabed and subsoil. This is not full sovereignty.
- **Continental Shelf** – extends beyond the territorial sea to 200 nautical miles from the TSB, or beyond that to the outer edge of the continental margin as defined in Article 76 of UNCLOS. In this zone a coastal State has sovereign rights for the purposes of exploring and exploiting mineral and other non-living resources of the seabed and subsoil, together with sedentary living organisms.
- **High seas** – the area beyond national jurisdiction in which all States have freedom of navigation and overflight, and,

subject to other parts of the Convention, the freedom to lay cables/pipelines, construct artificial islands/installations, fish and conduct scientific research.

- **The Area** – seabed and subsoil beyond national jurisdiction. The Area and its non-living 'mineral' resources are the common heritage of mankind and are managed on behalf of mankind by the International Seabed Authority – a body established under UNCLOS.

The sovereign territory of a country only extends to the limits of its territorial sea. Beyond that the UNCLOS maritime zones are associated with the various exclusive and non-exclusive sovereign rights and duties outlined above and no sovereign territory is involved. Under UNCLOS all member States have the obligation to protect and preserve the marine environment. In particular, coastal States' sovereign rights under UNCLOS to exploit resources in their national jurisdictions must be exercised consistent with their duty to protect and preserve the marine environment.

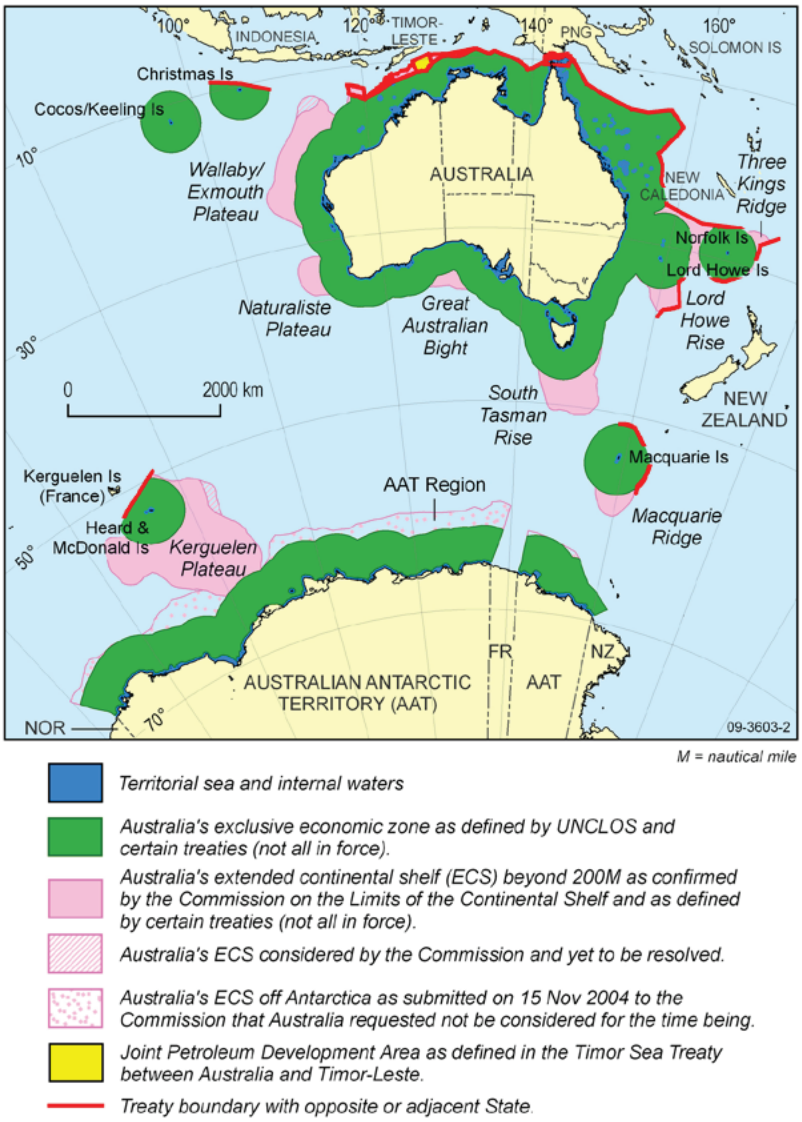


Figure 2. Depiction of the various UNCLOS zones and limits that comprise Australia's marine jurisdiction.

Ultimately, the outer limit of national marine jurisdiction, particularly for the broad zones such as the EEZ and continental shelf, is defined in two main ways. Where there is overlapping jurisdiction between opposite or adjacent States, it is subject to delimitation through negotiations and agreement to achieve an equitable solution based on international law, and is normally confirmed by a treaty between the States. Where it involves areas facing open ocean adjacent to the high seas and the Area, it is subject to rules set out in international conventions, the most important of which is UNCLOS.

Australian maritime jurisdictions and boundaries

In addition to the various international UNCLOS maritime zones discussed above, there are other national maritime zones that are peculiar to Australian legislation. This national framework is a result of an agreed division of responsibilities between the Australian Government and the state/Northern Territory governments.

Coastal waters is the area between the territorial seabed baseline (TSB) and a line three nautical miles seaward of the TSB (figure 1), as well as waters (internal waters) lying between the land and the TSB but outside the constitutional limits of the Australian states and Northern Territory as defined in the 'Letters Patent' for each state in the mid 1800s. As a result of the Offshore Constitutional Settlement in 1983, title to the seabed and rights to the water column within this zone is vested by legislation in the adjacent state or territory. The states and the Northern Territory were also accorded legislative powers over that area. Responsibility for offshore areas beyond three nautical miles remains with the Australian Government. Thus, for Australia, there has been some division of responsibility over the 12 nautical mile territorial sea. Adjacent to Australia's states and the Northern Territory, the UNCLOS 12 nautical mile territorial sea is divided into a three nautical mile state or territory jurisdiction (outer part of the coastal waters) and a nine nautical mile Australian Government jurisdiction extending beyond the coastal waters (figure 1). Adjacent to Australia's external territories the full 12 nautical mile territorial sea is under Australian Government jurisdiction.

Australia has negotiated maritime boundaries with several neighbouring countries (figure 2) and these boundaries define the limits of sections of Australia's jurisdiction in these areas. Clockwise from the northwest these negotiated boundaries are with: Indonesia (1971, 1972, 1997), Papua New Guinea (1978), Solomon Islands (1988), France (1982), and New Zealand (2004). The 1997 maritime boundaries with Indonesia off northern and northwestern Australia, and between the islands of Java and Christmas Island are contained in a treaty which is signed but not yet ratified. Further negotiations may be necessary with France for the area to the northeast of Norfolk Island. Australia has also negotiated maritime arrangements with Timor-Leste, including a Joint Petroleum Development Area under the Timor Sea Treaty of 2002 (figure 2).

Australia also has three neighbouring claimant States (Norway, France and New Zealand) adjacent to the Australian Antarctic Territory (figure 2). To date no boundaries have been delimited with any of these States in this region. The boundaries between the adjacent claimant States are shown unofficially as equidistance (median) lines in figure 2, extending out to sea from the onshore sectoral boundaries to the limits of the various maritime zones.

The continental shelf was the first maritime zone expressly claimed by Australia, in 1953. Australia proclaimed a 200 nautical mile exclusive fishing zone (the Australian Fishing Zone) with effect from 1 November 1979, extended its territorial sea to 12 nautical miles with effect from 20 November 1990, proclaimed a 200 nautical mile EEZ with effect from 1 August 1994, (including adjacent to the Australian Antarctic Territory) and proclaimed a 24 nautical mile contiguous zone with effect from 7 April 1999. The limits and rights associated with all of these zones are set out in the *Seas and Submerged Lands Act 1973*, and were amended through the *Maritime Legislation Amendment Act 1994* to align Australia's marine jurisdictional zones with those contained within UNCLOS when UNCLOS entered into force for Australia on 16 November 1994. The 1994 Act also resulted in a change to the definition of the outer limit of the continental shelf from an approach that reflected the 1958 Convention on the Continental Shelf to one based on Article 76 of UNCLOS.

Confirmation of Australia's continental shelf submission

Where the natural prolongation of Australia's land territory extends beyond 200 nautical miles and entitlement to an extended continental shelf exists, a submission seeking confirmation of that entitlement was required to be made to the Commission on the Limits of the Continental Shelf. Australia lodged its submission with the Commission on 15 November

Table 1. Areas of Australia's land and maritime jurisdiction, including areas of extended continental shelf confirmed by the recommendations of the Commission on the Limits of the Continental Shelf on 9 April 2008.

Land	**Area million km2**	
Australia and island external territories		7.69
Australian Antarctic Territory		5.90
Total Australia/island territory/AAT land area		*13.59*
Internal waters (IW)		
Approx. internal waters [1]	0.24	
Approx. additional marine areas within the limits of States [2]	0.02	
Approx. total marine area landward of territorial sea baseline (TSB)		***0.26***
Coastal waters (CW)		
Internal waters [1]	0.24	
Area 3 nautical miles seaward of TSB	0.15	
Total area of CW		***0.39***
Territorial sea (TS)		
Australia and island external territories		0.68
Australian Antarctic Territory		0.17
State (coastal waters) 3 nautical mile portion of TS	0.15	
Commonwealth portion of TS	0.70	
Total area of territorial sea (full 12 nautical mile zone)		***0.85***
Exclusive economic zone (EEZ)		
Australia and island external territories		8.15
Australian Antarctic Territory		2.04
Total area of EEZ		***10.19***
Continental shelf		
Continental shelf to 200 nautical miles (200CS)		**10.19**
Extended continental shelf (ECS)	**Submitted**	**Confirmed**
Australia and island external territories (see figure 1 for locations)	2.69	2.56
Argo	0.01	0.01
Great Australian Bight	0.07	0.07
Kerguelen Plateau [3]	1.19	1.13
Lord Howe Rise	0.27	0.26
Macquarie Ridge	0.08	0.08
Naturaliste Plateau	0.15	0.14
South Tasman Rise	0.31	0.30
Three Kings Ridge	0.05	0.05
Wallaby and Exmouth Plateaus [3]	0.56	0.52
Australian Antarctic Territory - Australia requested the Commission not consider this region for the time being	0.68	
Total area of submitted extended continental shelf	3.37	
Total area considered by the Commission and yet to be resolved [3]	0.08	
Total area lost during examination by the Commission [4]	0.05	
Total area of confirmed extended continental shelf (ECS)		***2.56***
Total area of confirmed continental shelf (200CS+ECS)		***12.75***
Australia's confirmed UNCLOS marine jurisdiction (TS+EEZ+ECS)		
Australia and island external territories		11.39
Australian Antarctic Territory		2.21
Total area of Australia's confirmed marine jurisdiction		***13.60***
Australia's full confirmed marine jurisdiction (including marine areas landward of TSB to coast – approx. 0.26 mill. km²)		*13.86*
Australia's maximum possible marine jurisdiction (including areas not yet resolved and areas landward of TSB to coast)		*14.62*
Australia's complete jurisdiction (land + full confirmed marine)		
Australia and island external territories		19.34
Australian Antarctic Territory		8.11
Total area of Australia's complete, confirmed jurisdiction		***27.45***

[1] Approximate area only of internal waters landward of the TSB as it includes many inter-tidal areas between the coastline and lowest astronomic tide (LAT).
[2] Approximate area that includes features such as Spencer Gulf and Gulf of St Vincent that are within the limits of South Australia.
[3] Region considered by the Commission, confirmed in part, but containing some unresolved issues.
[4] As a result of discussions with the Sub-commission and the deliberations of the full Commission some minor changes to the outer limit occurred reducing the submitted area of extended continental shelf by 0.05 million km^2.

2004 and was the third country to do so. On 9 April 2008, the Commission meeting at the United Nations in New York adopted recommendations confirming Australia's entitlement to an extended continental shelf of some 2.56 million square kilometres (95 per cent of the area submitted) encompassing nine distinct regions (see table 1; figure 2; *AusGeo News* 90).

The submission, the largest and most complex lodged to date, covered ten areas (a total of 3.37 million square kilometres). The Commission agreed to Australia's request that it not consider for the time being, the region adjacent to the Australian Antarctic Territory (0.67 million square kilometres) because of the special legal and political status of Antarctica under the Antarctic Treaty. Seven of the nine regions submitted by Australia were confirmed, some with slight amendment. A further two regions were adopted with small reductions (3 per cent of the area sought). The Commission felt there was insufficient available evidence to justify the full continental shelf associated with two distinct undersea features (the Williams Ridge in the Kerguelen Plateau region and Joey Rise in the Wallaby and Exmouth Plateaus region). However, Australia has an option to make a new or revised submission for these two areas (figure 3).

After proclamation, a description of the continental shelf boundary will be deposited with the Secretary-General of the United Nations and with the Secretary-General of the International Seabed Authority.

Australia now has a secure regime within which to manage the resources and environment of virtually all parts of its continental margins, associated plateaus and ridges, and adjacent ocean basins. The outer limit of Australia's full marine jurisdiction is now largely in place except for: the area off the Australian Antarctic Territory, two small areas associated with the Joey Rise and Williams Ridge that are subject to a potential new or revised submission, and a small area of potential continental shelf delimitation with France to the northeast of Norfolk Island. Further, a permanent seabed delimitation between Australia and Timor Leste has been set aside for up to 50 years, or longer if both countries agree, under the Treaty on Certain Maritime Arrangements in the Timor Sea.

Characteristics of the marine jurisdiction

The area of Australia's marine jurisdiction and its component parts is set out in table 1, and shown in figures 2 and 3. The area of Australia's confirmed marine jurisdiction (water column and seabed beyond the territorial sea baseline) is 13.60 million square kilometres, and the full confirmed marine jurisdiction beyond the coast itself is about 13.86 million square kilometres – about 1.8 times the size of Australia's continental landmass. Even when the Australian Antarctic Territory is included (to give a total land area of 13.59 million square kilometres) Australia has as much maritime jurisdiction as land territory. Australia's total territorial sea is 0.85 million square kilometres, its EEZ jurisdiction with water column rights is 10.19 million square kilometres, and its confirmed area of extended continental shelf jurisdiction beyond 200 nautical miles is 2.56 million square kilometres.

The size of Australia's marine jurisdiction is in the top three in the world along with the USA and France. In fact, Australia is custodian of about 3.8% of the oceans, and about 9.1% of the land, and with a full land and marine jurisdiction of 27.45 million square kilometres is custodian of about 5.4% of the Earth's surface.

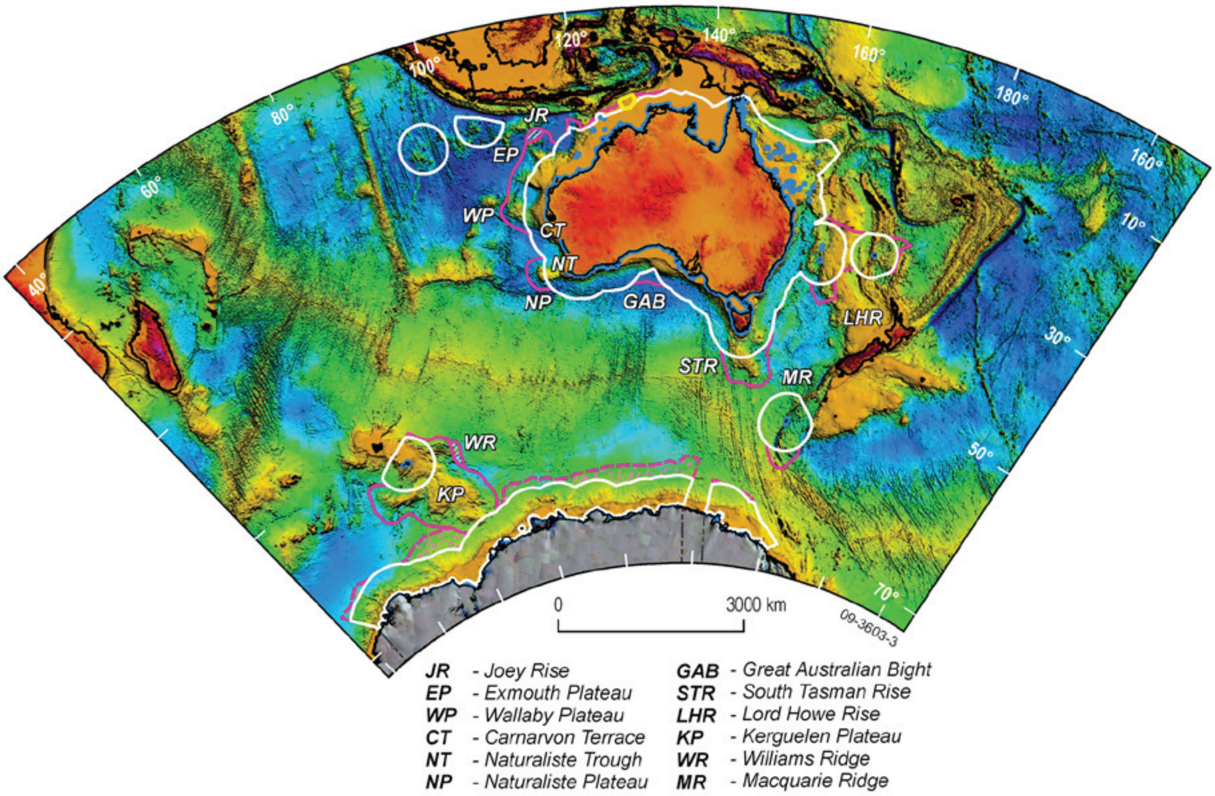


Figure 3. Depiction of Australia's marine jurisdiction and associated seafloor morphology. This image indicates the form of the submarine features that lie within the jurisdiction. The characteristics of the various marine zones can be deduced from figure 2.

Implications of this jurisdiction

Australia has sovereign rights for resources across a vast marine jurisdiction: however, many parts of the jurisdiction are remote, poorly known, and lie in water depths of 1000 to 4500 metres (figure 3). Previous and current petroleum exploration has mostly occurred in the relatively shallow waters of the territorial sea and inner parts of the EEZ and continental shelf. There are very few areas of Australia's marine jurisdiction that can be regarded as mature for petroleum exploration, and most parts are still underexplored, particularly by international standards.

It is now apparent that all Australia's continental margin sedimentary basins with petroleum potential will lie within the newly confirmed marine jurisdiction. The deep water parts of the continental margin include significant frontier petroleum exploration areas. Many of these areas are poorly surveyed and are generally not included in conventional estimates of undiscovered resources. Several regions, in particular the Exmouth Plateau, Naturaliste Trough, Great Australian Bight, South Tasman Rise and Lord Howe Rise regions, are known to have petroleum potential (figure 3).

Geophysical surveys undertaken by Geoscience Australia over many years for both delineation of the continental shelf and petroleum resource evaluation have defined sedimentary basin systems in these regions. Some of these basins have similar characteristics to basins already explored in adjacent, shallow water areas that are known to contain oil and gas resources.

Geoscience Australia's surveys acquired a large amount of bathymetric, seismic reflection, gravity and magnetic data over some of the more remote parts of Australia's margins. This provided the necessary bathymetric and sediment thickness data to support Australia's continental shelf submission. These data provided a significant improvement in understanding the geology and resource potential of the outer parts of Australia's marine jurisdiction. They also highlighted a number of frontier areas that have recently been the focus of Geoscience Australia studies under its 'Big New Oil' (2003 to 2007: see *AusGeo News* 87) and the current 'Offshore Energy Security' programs (see *AusGeo News* 90).

Areas such as the Capel and Faust Basins of the northern Lord Howe Rise in Australia's remote eastern frontier (see *AusGeo News* 89), and most recently the Exmouth and Wallaby Plateaus, the Carnarvon Terrace and the Naturaliste Trough off western and southwestern Australia (see *AusGeo News* 92) have now been surveyed using modern exploration tools. Though other parts of Australia's jurisdiction, such as the Macquarie Ridge, do not have any petroleum potential, they do have considerable significance because of their living resource, environmental and scientific values.

By having comprehensive limits to its national jurisdiction, Australia now has the opportunity to regulate and manage a range of activities within its maritime zones under guidelines laid down in UNCLOS. Much remains to be done to adequately assess and manage the resource potential and environmental values of the vast area of seafloor that now lies within Australia's marine jurisdiction. Australia's control of nearly 4 per cent of the global ocean provides rights and responsibilities that will create significant opportunities for resource and environmental managers, engineers, scientists and all those with an interest in the long-term sustainability of both the onshore and offshore parts of Australia.

Acknowledgements

This article was prepared in consultation with the Attorney-General's Department (Bill Campbell QC, First Assistant Secretary, Office of International Law) and the Department of Foreign Affairs and Trade (Todd Quinn, Executive Officer, Sea Law, Environment Law and Antarctic Policy Section).

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Related articles/websites

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www.ga.gov.au/ausgeonews/ausgeonews200806/inbrief.jsp#inbrief1

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www.ga.gov.au/ausgeonews/ausgeonews200806/offshore.jsp

AusGeo News 92: Energy Security Program update - Surveys off southwest Western Australia
www.ga.gov.au/ausgeonews/ausgeonews200812/energy.jsp

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New digital geological map of Australia

Seamless national baseline dataset released

Ollie Raymond

A new seamless, digital, surface geology dataset covering Australia at 1: 1 million scale was released during simultaneous launches across the country on 16 December 2008 (figure 1). The map, which has fully integrated depiction of geological features across borders, will provide an invaluable baseline dataset for national and regional evaluation of resources as well as environmental management and land use decision-making.

The compilation of a seamless surface geology map of Australia at 1:1 000 000 scale commenced in 2001. Since then, more than twenty geologists, GIS technicians and stratigraphic indexers have combined their efforts to produce the most detailed, informative and consistent national geology coverage available (figure 2). The new data replaces the 1:2 500 000 scale digital map published by Geoscience Australia in 1998. The improved coverage in the new dataset is exemplified by an increase from 8 000 to 247 000 polygons, and the increase from 200 to around 5 900 described geological units in the new data.

In the past, geological information frequently failed to match up across jurisdictional boundaries because of differences in data acquisition methods and geological interpretations that could have been published decades apart. This national project was undertaken with the full co-operation of the geological surveys of each Australian state and the Northern Territory who provided their most recent map data for the national compilation as well as their advice in resolving stratigraphic issues.

Initially, it was planned to compile the map from existing regional geological maps between 1:500 000 and 1:2 000 000 scale. However, it became apparent early in the project that these regional maps were usually fairly old (1970s and 1980s) and that the geological information on them was of poor quality considering the geological mapping programs undertaken by the federal, state and Northern Territory geological surveys in the last 20 years. Consequently, much of the new Australian geology dataset has been compiled from the most recent 1:250 000 scale mapping. In some areas where the 1:250 000 maps were out of date, the compilers used 1:100 000 or even 1:50 000 scale source maps. Although compiled from these detailed geological maps, the national data have been simplified for use at 1:1 000 000

Figure 1. Geoscience Australia CEO Neil Williams launching the new seamless geology of Australia dataset at Geoscience Australia on 16 December 2008.

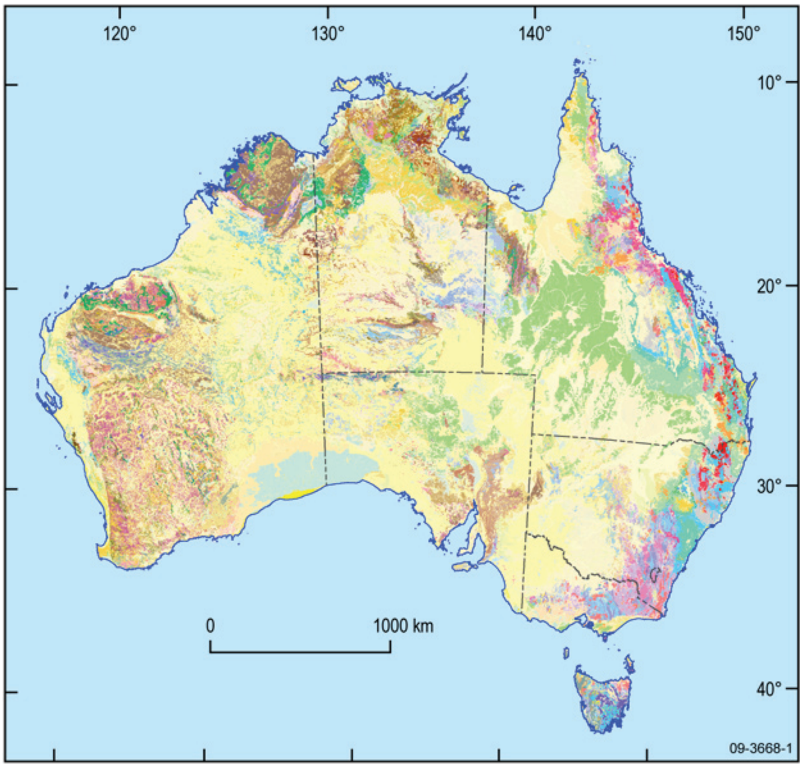

Figure 2. An overview of the new digital surface geology of Australia dataset.

scale and generally have a spatial accuracy of between 200 metres and one kilometre depending on the quality of the original source data.

An important and time-consuming task for the compilation team was matching the geological information between more than 400 source maps which could be up to 40 years apart in age. Considerable time had to be invested in resolving stratigraphic mismatches across map tile and jurisdictional boundaries. Sometimes satellite imagery and geophysical data, such as gamma-ray spectrometry and magnetics, were also used to resolve edge-matching discrepancies and to reposition poorly located geological data on the oldest maps.

The standardisation of unit classification and descriptions was particularly important for the unconsolidated regolith materials which cover a large proportion of the Australian continent. Regolith mapping has advanced considerably over the last few decades, particularly with the advent of remote sensing imagery. A simple standard scheme for regolith unit compilation, based largely on the classification of Grimes (1983), was used for the new national map.

The new dataset contains comprehensive descriptions of around 5900 lithostratigraphic units (figure 3). These unit descriptions include a unique stratigraphic name and number which provides a link to the Australian Stratigraphic Units Database, which is the authoritative repository of Australian geological unit descriptions.

Other digital attributes include a stratigraphic parent-child hierarchy, a text description of the unit, maximum and minimum ages, and lithological classifications. Faults and stratigraphic boundaries are also coded in the database. The dataset also includes comprehensive metadata describing the origins of the source data.

The new data are designed primarily as a digital tool for GIS applications. It is not planned to issue a printed map—a paper map of Australia at 1:1 000 000 scale would be almost 4 metres tall! The Australian geology data are also available to view on the OneGeology portal website. This international project aims to provide national scale geology data freely via the internet for users across the world using agreed international digital data standards. The data is currently displayed as a Web Map Service (WMS) with the national geological coverage of many other nations. Geoscience Australia will be moving towards providing the data as a Web Feature Service (WFS) using the GeoSciML data standard (GeoScience Markup Language; Simons et al 2008) in the near future.

The new 1:1 000 000 scale data is available for free download from the Geoscience Australia website in shapefile and ESRI export formats. The data is packaged for internet delivery

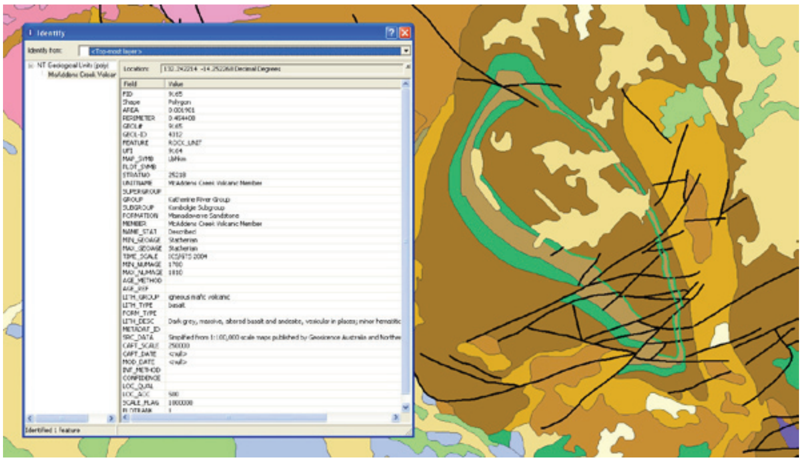

Figure 3. An example of attribute data for a geological unit in the 1:1 000 000 scale surface geology of Australia dataset.

in individual state and territory portions because of the large size of the whole-of-Australia dataset. The data can also be ordered on DVD from the Geoscience Australia Sales Centre. Individual state-wide portions of the national dataset were released as they were completed, commencing with Tasmania and Victoria in 2004. Updated editions of some of the previous releases (Tasmania, Victoria, New South Wales and Queensland) were released as compilation standards improved during the project.

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Simons BA, Bellier C, Brodaric B, Cox SJD, Fusejima Y, Janjou D, Johnson BR, Laxton JL, Raymond O & Richard SM. 2008. GeoSciML 2.1.0: Significant changes and additions to the CGI–IUGS geoscience data model. Abstracts, 33rd International Geological Congress, Oslo.

Related websites/articles

Surface geology of Australia 1:1 000 000 scale

www.ga.gov.au/minerals/research/national/nat_maps/nat_geol_maps.jsp

Australian Stratigraphic Units Database

www.ga.gov.au/oracle/stratnames/index.jsp

OneGeology portal website

portal.onegeology.org/

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Australian mineral exploration peaks

Lynton Jaques and Mike Huleatt

Australian and global mineral exploration reached record highs during 2008 but appear set to drop. Expenditure on Australian mineral exploration reached a record $2461.4 million in 2007-08 according to the Australian Bureau of Statistics (ABS). This was an increase of nearly 44% on the previous year and a record in both current and constant dollars, significantly exceeding the last three exploration peaks including the peak associated with the broad-based commodity boom of 1981-82 (figure 1). However the end of the commodity boom—a consequence of the global economic downturn—is likely to see a sharp drop in future exploration expenditure.

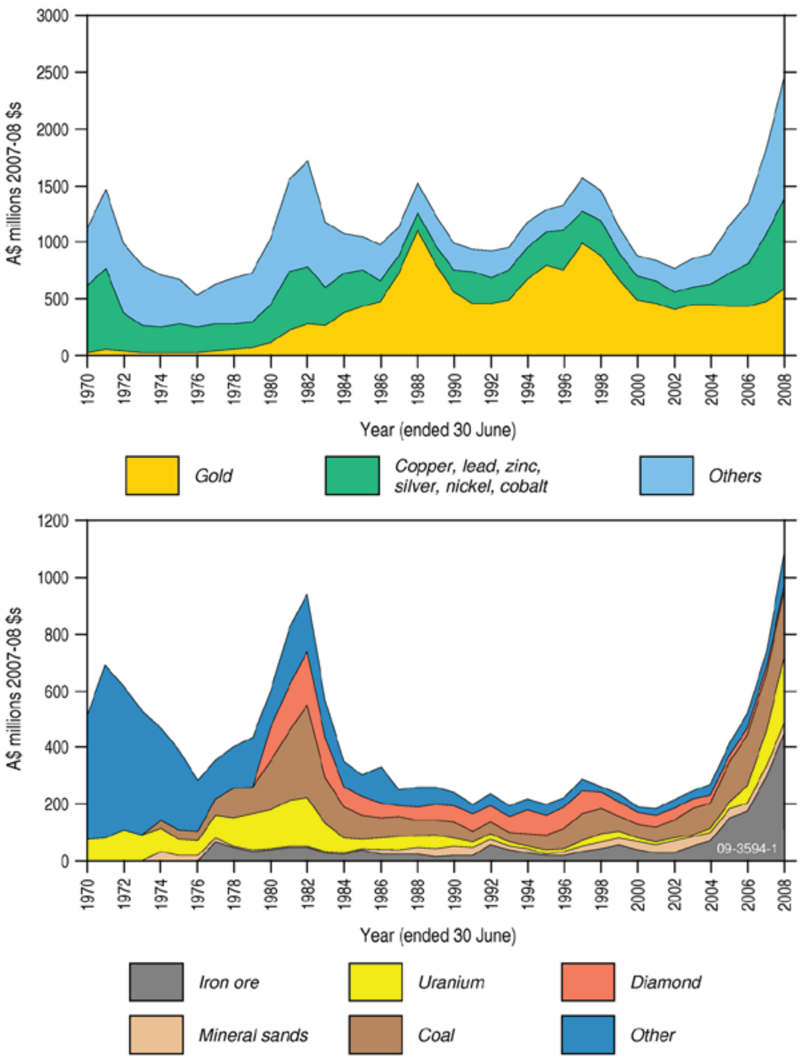

Figure 1. Australian mineral exploration expenditure in constant 2007-08 dollars (Based on Australian Bureau of Statistics data deflated by Consumer Price Index).

Australian mineral exploration

Base metals were again the major exploration target in 2007-08, having overtaken gold in 2006-07, as spending rose 41% to $783.4 million with nickel up 67% to $303.3 million, zinc-lead-silver up 34% to $186.6 million, and copper exploration expenditure rising 25% to $293.5 million. This was a record in constant dollar terms, exceeding spending at the peak of the 'nickel boom' in 1970-71 and the peak in base metal (and other) exploration in 1981-82. Iron ore exploration spending rose 58% to reach a record $449.8 million. Coal exploration was up 21% to $234.8 million, the highest in real terms since 1981-82 and the third highest ever recorded. Uranium exploration spending doubled in 2006-07 and more than doubled again in 2007-08 to reach a record $231.6 million, significantly exceeding (in constant dollar terms) the last peak in uranium exploration in 1981-82.

Gold remained the dominant commodity targeted in 2007-08 but, in contrast to the last two major peaks in exploration which were based on gold exploration, gold's share of total exploration spending fell to 24% ($592.7 million), its lowest level since the peak of the last broadly-based mining boom in 1981-82 (figure 1). This fall, despite recent high gold prices and increased gold exploration, is due to growth in spending on base metals, iron ore, coal and uranium in the recent broadly-based mineral commodity 'boom'.

Spending increased in each state and the Northern Territory. Western Australia remained the dominant destination attracting $1259.8 million, an increase of 50%. In Queensland spending rose by 46% to $397.8 million while in South Australia an increase of 36% saw spending rise to $355.2 million. The increases in other states and the Northern Territory were: New South Wales up 32% to $189.9 million, Victoria up 14% to $93.7 million, Northern Territory up 44% to $132.7 million while spending in Tasmania rose by 37% to $32.4 million.

Exploration drilling

Exploration drilling totalled 9.756 million metres in 2007-08, an increase of 1.301 million metres (15%) from 2006-07. This continued the trend of increased exploration drilling evident since the trough in mineral exploration in 2001. Drilling levels remain below the peak in 1996-97 which was associated with large amounts of shallow drilling for gold. The 2007-08 drilling data show a continuing strong emphasis on brownfields exploration that has become most pronounced since 2003 with only 40% of drilling last year targeting new deposits (figure 2).

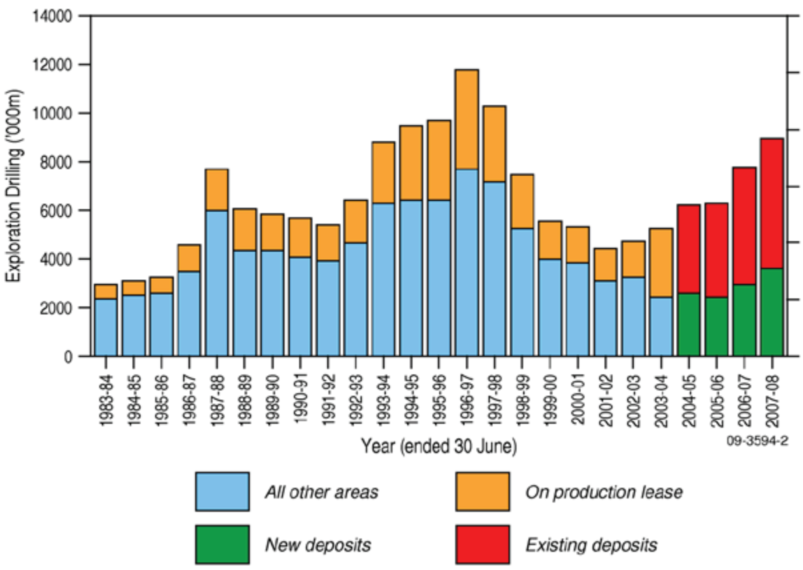

Figure 2. Mineral exploration drilling in Australia in thousands of metres (Source: Australian Bureau of Statistics. Note the change in ABS definitions in 2003 from 'on production lease' and 'all other areas' to 'search for new deposits' and 'exploration at existing deposits').

The peak in exploration expenditure

The September quarter 2008 survey by the ABS showed a continued increase in Australian mineral exploration expenditure with a 22% increase over the September 2007 quarter. This increase–half of that recorded for the 2007-08 financial year–is reflected in the modest growth (up 2.6%) in the ABS trend estimate which maintains the growth that began in the June quarter of 2002 but at a much slower rate. In contrast with recent years, the 2008 September quarter exploration expenditure was down (about 6%) on June quarter figures, further indicating a slowing in exploration. A slowing in exploration is also evident in the exploration drilling data where, unlike recent years, the number of metres drilled in the September quarter drilling was down slightly on that for the June quarter.

Exploration spending in the September quarter was either in progress or committed well before the full impact of the global financial crisis and the decline in mineral commodity prices was realised in the latter months of 2008. Nevertheless, the slowing in exploration already evident is likely to mean that the September quarter represents the peak of exploration in the current cycle.

These high levels of exploration spending, although focussed on brownfields (see below) and diluted by high costs of exploration services, staff and fuel in recent years, have resulted in a significant number of new drill intersections of mineralisation being reported by companies. Many of these are of economic grade and are the focus of ongoing exploration programs. These and other highlights of mineral exploration are contained in Geoscience Australia's annual review of mineral exploration for 2008 (see link below).

Record world mineral exploration

The latest annual survey by the Metals Economics Group of Canada (MEG) estimates that world non-ferrous mineral exploration budgets reached a record US$13.2 billion in 2008, an increase of 26% on 2007 figures. MEG estimates world budgets for non-ferrous mineral exploration, including uranium, was US$14.4 billion. However, MEG noted that cut-backs in exploration late in 2008 as the global financial crisis gathered pace and metal prices fell heavily may result in actual expenditure over the year being less than budgeted.

The MEG survey, which covered 2 085 companies, indicates that global base metals exploration (41% of non-ferrous mineral exploration) rose significantly in 2008 to overtake gold exploration (39%) for the first time since the MEG surveys began in 1989. Copper again was the dominant commodity, accounting for 57% of base metal exploration budgets in 2008. World uranium exploration budgets in 2008 totalled US$1.2 billion, about 8% of total world mineral exploration budgets and a 23% increase over 2007. Canada and Australia accounted for 38% and 23% of uranium exploration budgets, respectively.

Australia's share of global non-ferrous mineral exploration budgets rose to 13.6%, up from 11.9 % in 2007. This growth in Australia's share of world non-ferrous mineral exploration budgets in 2008 continues the recovery (commenced in 2007) from levels that had almost halved over the previous 10 years (figure 3). Including uranium, Australia's share of world non-ferrous mineral exploration budgets was 14.4% (US$2080.9 million), reflecting the high levels of uranium exploration in Australia. Australia retained its position as the country with the second highest share of exploration budgets after Canada. On the world regions basis used by MEG, Australia was again ranked fifth after Latin America, Canada, Africa, and the 'Rest of the World'. According to the survey, 56% of the non-ferrous mineral exploration budgets for Australian-based companies in 2008 was for exploration in Australia. The survey included 519 companies with non-ferrous exploration budgets of more than US$100 000 which were exploring in Australia. This compares with 512 companies in the 2007 MEG survey.

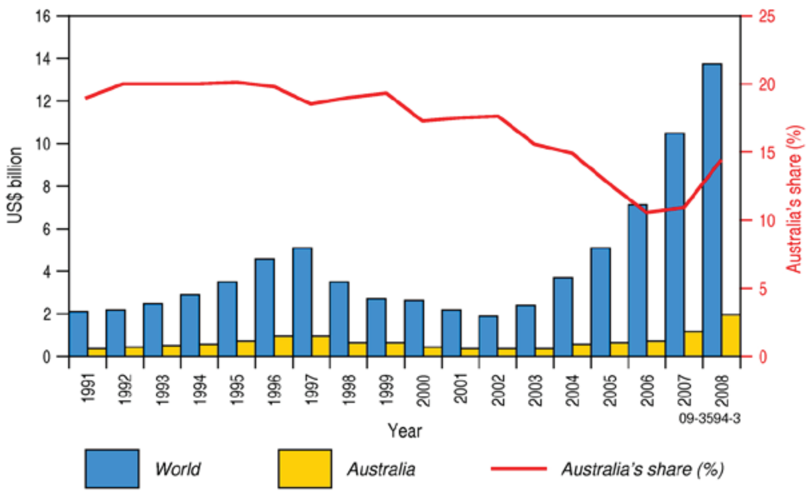

Figure 3. World non-ferrous mineral exploration budgets (in US dollars) and Australia's estimated share as a percentage (Source: Metals Economics Group. Note that only the 2007 and 2008 MEG surveys include uranium).

Focus on brownfields exploration

Both globally and in Australia the increase in mineral exploration since 2003 has been strongly focussed on brownfields projects. The 2008 MEG survey highlighted the continuing dominance of brownfields exploration world-wide, especially late-stage exploration which accounted for about 42% of budgets. Grassroots exploration fell to a new low of 36% of exploration budgets, down from around 50% of budgets in 2003. This strong focus on exploration at known deposits since the upturn in mineral commodity prices is evident in the ABS drilling data (figure 2) and in total mineral exploration expenditure (figure 4). The focus on brownfields has been driven by the strong demand and shortfall in supply stemming from under-investment in exploration and mine development in the previous decade which pushed mineral prices to record highs. The ABS data for 2007-08 show a modest increase in exploration for new deposits with 41% of total spending, up from 36% in 2006-07. An increased commitment to greenfields exploration is needed to discover the next generation of mineral deposits and new mineral provinces that will underpin future production.

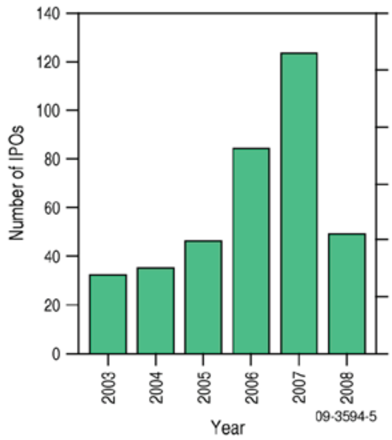

Figure 5. Number of Initial Public Offerings (IPOs) for mineral exploration in Australia each year since 2003 (Source: Company reports to the Australian Securities Exchange).

Exploration outlook

Underpinning the recent boom in world mineral exploration has been the high commodity prices, largely driven by demand from China. The record level of world investment in mineral exploration in 2008 reflects the earlier prevailing high prices and, hence, probably marks the peak of the current cycle.

Since then mineral prices have fallen substantially (commonly more than 60%) from the peaks reached over the last several years as a consequence of increased supply and lessening demand during 2008. Gold is the exception as gold prices have remained high and world production has fallen. Further falls in mineral commodity prices are widely anticipated in early 2009 as a consequence of the world economic downturn precipitated by the global financial crisis (ABARE 2008, World Bank 2009). Falling demand for minerals has seen reductions in mine output at a number of mining operations, mine closures, and deferral of new and/or expanded mining projects world-wide. More than 20 mines were closed in Australia in 2008 and many others reduced output resulting in substantial job losses.

There has also been a reduction in the ability of companies to raise equity capital for mineral exploration. In 2008 there were only 49 initial public offerings (IPOs) raising some $490 million on the Australian Securities Exchange for mineral exploration. Though this is half the number of successful IPOs in 2007 (122) the total amount raised was close to that of 2007 ($520 million) mainly as a consequence of one unusually large raising in 2008 of $125 million. Figure 5 shows the steady increase in the number

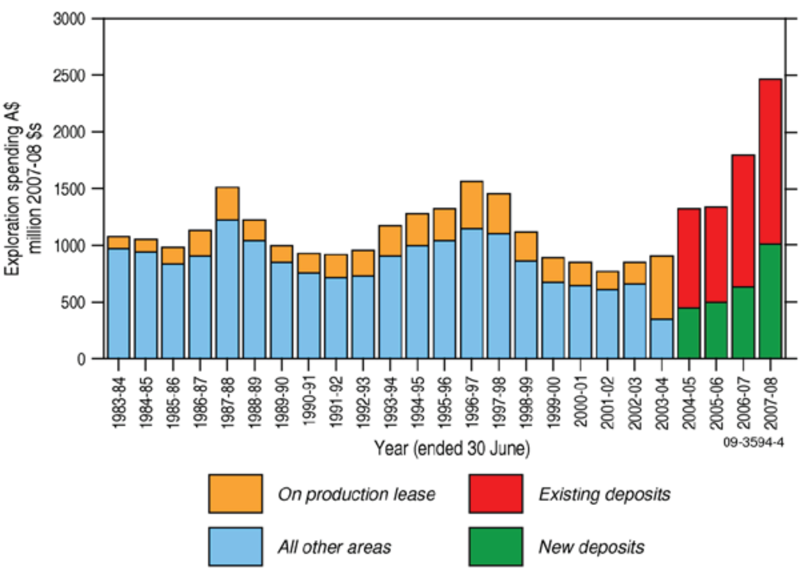

Figure 4. Mineral exploration expenditure in Australia according to category (Source: Australian Bureau of Statistics. Note the change in ABS definitions in 2003 from 'on production lease' and 'all other areas' to 'search for new deposits' and 'exploration at existing deposits').

of IPOs for mineral exploration in Australia over the past 5 years followed by the sharp reduction in 2008.

The combined impact of lower commodity prices and reduced availability of equity capital is likely to result in a reduction in exploration activity in the immediate term. Gold may be the exception as high gold prices and the devaluation of the Australian dollar have renewed interest in gold projects. Beyond that, however, the outlook for mineral commodities is more positive. ABARE (2008) forecasts a gradual strengthening of world economic growth and increased demand for energy and mineral commodities commencing in the second half of 2009. The World Bank suggests that 'ongoing shortages in the sectors that provide exploration and exploitation services, and the long lags between initial investments and the coming on-stream of new production, mean that supply conditions may remain relatively tight in the oil and metals sectors and that prices, although declining, are unlikely to fall to their 1990s levels' (World Bank 2009, page 65).

The long lead times to discover new mineral deposits and develop new mines mean that exploration requires a longer term view. Effective exploration–especially greenfields exploration and discovery of new deposits–is needed to maintain and grow Australia's resource base to support future mineral production when demand returns, recognising that the bulk of Australia's current mineral production comes from deposits found more than 20 years ago.

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Annual review of mineral exploration 2008
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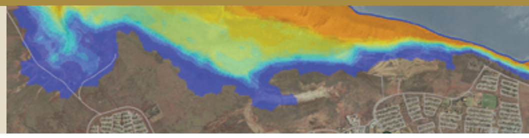
Scientific expertise and emergency management

Successful collaboration for safer communities



Jane Sexton, Ole Nielsen, David Burbidge and Trevor Dhu

Geoscience Australia's Risk and Impact Analysis Group has been working together with state and Australian Government emergency management agencies in recent years to help build safer communities in Australia by developing tools and information to underpin our planning and preparation for tsunamis.

"The effective collaborations with state and Australian Government emergency management agencies have been underpinned by quality science."

Science and emergency management

Effective emergency management for natural disasters comprises four key processes: planning, preparation, response and recovery. The planning and preparation components are typically applied before a natural hazard event occurs whilst the response and recovery components are applied during and after an event. The two main actions during the planning and preparation phases are:

- development of mitigation strategies
- education to create community awareness of the risks associated with natural disasters.

The response and recovery phases involve community action such as evacuation and post-disaster clean-up operations, as well as rebuilding of infrastructure and social networks.

Geoscience Australia plays an important role in supporting effective emergency management in the planning and preparation stages. The key activity underpinning the development of mitigation strategies is the assessment of risk from natural hazards. Currently, the agency has a program to monitor and assess earth-surface processes which pose a risk to Australia and to develop and apply methodologies for risk modelling.

Geoscience Australia has adopted a quantitative 'all-hazards' approach to understanding impact and risk from natural hazards. This approach aligns with current Australian emergency management practices where plans are also developed in an 'all-hazards' context. Consequently, the processes described here for tsunami planning and preparation apply to other hazards as well.

Partnership to understand risk and raise awareness

The tragic events of the Indian Ocean tsunami on 26 December 2004 highlighted shortcomings in the alert and response systems for tsunami threats to Western Australia's (WA) coastal communities. To improve community awareness and understanding of tsunami hazard and potential impact for Western Australia, the Fire and Emergency Services Authority of WA (FESA) established a collaborative partnership with Geoscience Australia in which scientific knowledge and emergency management expertise was applied to identified communities.

This partnership relied on effective communication between scientists, emergency managers, data custodians and the community as well as the development and implementation of a best practice methodology. As a result of this, tsunami preparation and emergency response plans have been formulated following community engagement workshops which increased stakeholder awareness of the science involved as well as the risk of tsunami.

Scientific process and the big questions

The scientific process was driven by the information requirements of emergency managers and local land-use managers which had been identified during workshops across the state. Their specific questions included:

- the maximum credible tsunami
- the likelihood of large tsunami
- the time between the earthquake event and arrival at the coast
- the extent of inundation from a tsunami impact
- the likely damage
- the likely differences if the tsunami arrives at the location at different tide levels.

It is not currently possible to determine the extent of inundation for the entire length of the Western Australian coastline because of the time required to collect all the necessary bathymetry data and run the numerical models for the selected tsunami events. As a result, a prioritisation process was necessary to decide which locations would be selected to determine in detail the inundation extent and impact. Each tsunami scenario consists of a tsunami event, a tide level and a community.

FESA worked with Geoscience Australia to develop a systematic prioritisation process based on best available evidence of potential tsunami threats. A key input was provided by Geoscience Australia through the development of the Western Australian Tsunami Hazard Map that identified regions where the offshore hazard (defined as minimum wave height for a given probability of exceedance) was highest (Burbidge et al 2008: see link below). In conjunction with a community profiling process undertaken by FESA, a number of communities were then prioritised for detailed assessments.

The tsunami hazard map not only served as an input to the prioritisation process, it also allowed the selection of possible tsunami events for each community. Once a number of 'worst-case' scenario events were chosen, the remaining questions could then be addressed for the identified locations (Stevens, Hall and Sexton 2008). This was mainly through using inundation maps (see example in figure 1). The assessment also included an additional output from the modelling which was based on maps showing maximum flow speed from the tsunami scenarios. While initial attention had focused on the onshore impact of tsunamis on communities,

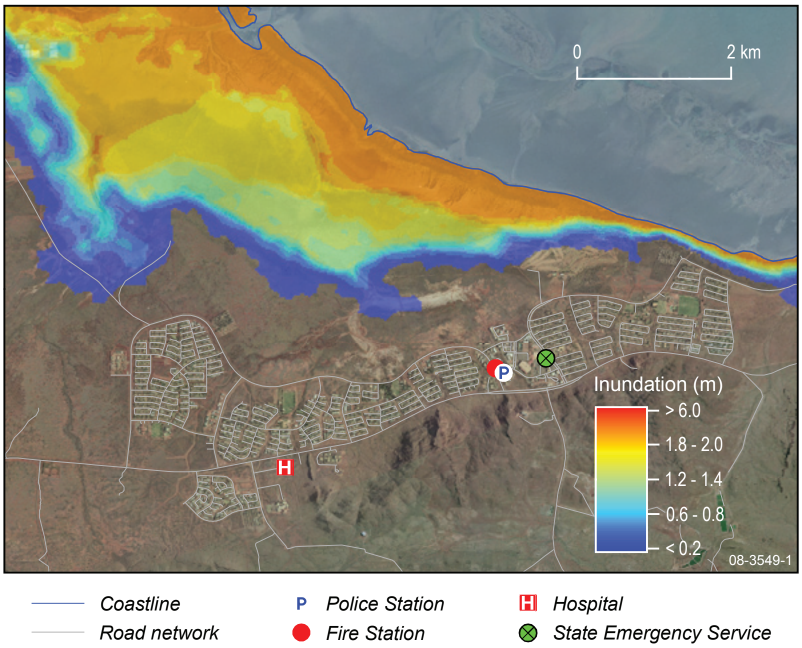


Figure 1. Maximum inundation map at Highest Astronomical Tide. Image courtesy of Landgate.

the noticeable offshore threat resulting from strong currents generated by tsunamis were also taken into account.

With modelled results in hand, FESA and Geoscience Australia conducted stakeholder workshops to discuss the best approach, identify key areas of interest and seek feedback on the credibility of the results, to determine if the inundation results were believable. This is vital as the community itself has a more detailed understanding of their local area than central agencies. Another key aspect of the workshops was to ensure that the results were understood in context. That is, the results were produced for selected events only, and did not necessarily represent all possible scenarios in which a tsunami event occurs. The results were indicative only and were only one component in any decision-making process.

Community awareness and education

Emergency Management Australia (EMA), an agency of the Australian Government, is charged with the development of community awareness and education products at a national level. This supports the capability of the state and territory agencies in planning and preparing for tsunami risk. As a result of collaboration between EMA, the Bureau of Meteorology and Geoscience Australia, the Introduction to Tsunami for Emergency Managers workshop (ITEM) was developed. ITEM provides information on the detection, alert and warning processes, the tsunami science, the risk modelling methodology as well as emergency management arrangements. The underlying intent of ITEM is to 'train the trainers', whereby the relevant state and territory agencies can then further provide tsunami awareness and education within their communities.

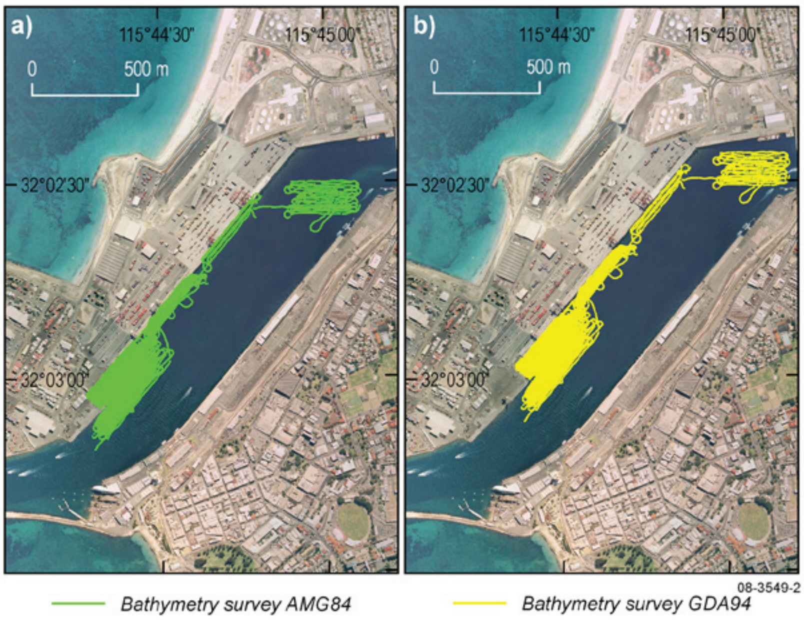


Figure 2. Data errors: datum issues in bathymetry (a) AMG84 and (b) GDA94. Image courtesy of Landgate. Bathymetry supplied by Department for Planning and Infrastructure, Western Australia.

Geoscience Australia also assisted in raising community awareness and strengthening ties with local emergency services in partnership with FESA through a recent graduate project in Onslow, Western Australia, (*AusGeo News* 89). A community-specific tsunami awareness brochure produced by the Geoscience Australia graduates was distributed to key community and emergency personnel during information-sharing presentations at community meetings.

The run-up survey conducted by Geoscience Australia after the 17 July 2006 tsunami impact at Shark Bay in Western Australia also assisted FESA's community awareness and education activities by providing the first fully documented tsunami impact on Australia. The tsunami destroyed several campsites, inundated up to 200 metres inland and transported a 4WD vehicle ten metres. The survey found widespread erosion of roads and sand dunes, deposition of fish, starfish, corals and sea urchins well above the regular high-tide mark, as well as extensive vegetation damage indicating a run-up height exceeding seven metres. This event has 'made it real' for emergency managers and provided a local example to illustrate the difference between wave height (the amplitude of the approaching wave) and run-up height (the highest point on shore that was inundated). Typically, the latter is much greater than the former. This activity also demonstrated the role of tsunami geology in understanding tsunami hazard and risk.

Underpinning science

The effective collaborations with state and Australian Government emergency management agencies have been underpinned by quality science. The tsunami risk modelling methodology has undergone continuous development since 2005 (Nielsen et al 2006) and relies on understanding the sources that generate tsunamis, the propagation of tsunamis through the ocean, as well as their behaviour as they reach the coast and flow onshore. This knowledge is then combined with information about particular communities (Nadimpalli 2007) to assess the potential impact of an event. This methodology can be described in five key steps:

1. ***Define a source model.*** The first step involves identifying potential tsunami sources —earthquake, landslide, volcano or meteorite—and modelling the magnitude and frequency of tsunami they generate.
2. ***Simulate the tsunami using a deep-water propagation model.*** Once a tsunami is generated it often has to travel across an expanse of ocean to reach the coastline of interest. This process is modelled by a deep-water propagation model, which simulates the tsunami from the source to the shallow water off the coast of interest, typically 100 metre water depth. If the tsunami source is very close to the community of interest, this step may be omitted.
3. ***Simulate the tsunami in shallow-water and onshore using an inundation model.*** Once the tsunami enters shallow water, typically defined as a depth of 100 metres or less, an inundation model is used to simulate the tsunami as it approaches land and flows onshore. Inundation models use a more sophisticated numerical technique than deep-water propagation models, reflecting the more complex flow patterns observed as tsunamis are affected by local bathymetry and topography or even buildings.
4. ***Define structural vulnerability models.*** Vulnerability is a broad measure of the susceptibility to suffer loss or damage. Structural vulnerability models describe the type and amount of damage that a particular type of structure may experience from a given tsunami.
5. ***Combine with an exposure database for the area of interest.*** To understand the impact a tsunami may have on a community, it is necessary to know which buildings and infrastructure are potentially exposed to the tsunami. This information is held in an exposure database (Nadimpalli 2007).

In summary, the tsunami risk assessment process combines the results of the hazard modelling (which areas of the community would get wet, how deep the water would get and how fast it would move) together with vulnerability models (how buildings and people will respond to the water level and flow) with the exposure database (where buildings are located as well as their characteristics) to allow us to estimate the number of people and buildings affected by a given tsunami.

Limitations of the risk assessment approach

In communicating model outputs it is important to stress that 'models are only a representation of what may happen'. From the mathematical description of the model to its computational implementation and further to the model's inputs, a series of assumptions have been made. The methodology itself is underpinned by an evolving science of tsunami modelling and Geoscience Australia has made efforts to validate the individual components of the methodology using wave tank experiments (Nielsen et al 2005) and tide gauge data where available. A recent model of the 2004 Indian Ocean tsunami impact at Patong Beach has also validated the modelling methodology using an historic event. As data becomes available, further validation tests will be conducted.

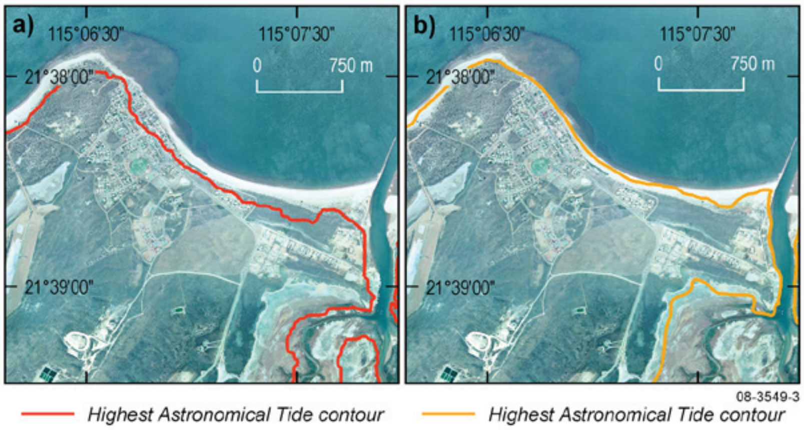


Figure 3. Data errors: accuracy in topography. Image shows highest astronomical tide contour for two data sets (a) 30 metre Digitial Terrain Elevation Data Level 2 and (b) Landgate 20 metre Orthophoto Digital Elevation Model. Image courtesy of Landgate.

The FESA-Geoscience Australia partnership has played a crucial role in highlighting the importance of high quality bathymetric and topographic elevation data when it comes to estimating tsunami impact at the community level. FESA's networks within state and local government have proved crucial in sourcing the best available data and supporting metadata. However, some of the data has gaps and verification of its quality has not always been easy or possible (figures 2a, b and 3a and b).

Summary

Geoscience Australia has worked in partnership with state and Australian Government emergency management agencies to manage tsunami risk in Australia. In particular, the FESA and Geoscience Australia partnership has improved community safety in WA by raising community awareness and providing a solid platform of knowledge, on which emergency managers can base their planning. These plans are therefore based on a realistic and quantitative understanding of the likely consequences of a tsunami. The project has also served to emphasise and highlight phenomena associated with tsunami that must be managed for an effective response, such as, large currents and localised extreme run-ups. In order for Geoscience Australia to effectively collaborate in this way, the underpinning science has to be continually tested for its quality.

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Jane Sexton was a Distinguished Geoscience Australia Lecturer (DGAL) for 2008, and this article is based on her DGAL presentation.

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Shark Bay tsunami impact, 17 July 2006.

www.ga.gov.au/image_cache/GA10828.pdf

Tsunami threat map (Fire and Emergency Services, Western Australia)

www.fesa.wa.gov.au/internet/default.aspx?MenuID=372

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AUSGEO news
ISSUE 93 Mar 2009

Classifying regional seascapes in the northwest

Key ecological features to inform marine management

Rachel Przeslawski and Inke Falkner

Geoscience Australia has been providing the federal Department of the Environment, Water, Heritage and the Arts (DEWHA) with information about the physical properties of the seabed and water column in Australia's Exclusive Economic Zone over the last five years. This information has included the derivation of 'seascapes' which consist of a range of physical properties such as bathymetry, sediment grain size and composition, and seabed temperature (Whiteway et al 2007).

The agency has recently provided the department with scientific advice on draft Key Ecological Features (KEFs) in the North-west Marine Region (Falkner et al in press) which were identified for their potential environmental significance. The advice involved assessments of both the KEFs and adjacent environments including Cuvier and Argo abyssal plains, Scott and Exmouth plateaus, the Cape Range, Cloates, Mermaid, Bower, and Oates submarine canyons, Wallaby Saddle, Glomar Shoals, Scott Reef and the last glacial shoreline at about 125 metres water depth (figure 1). Physical and biological data for each KEF and their adjacent area were sourced from national databases, museums, and individual researchers. Biological information for all of the deep-sea KEFs was anecdotal and consisted of museum records of a few invertebrate and fish species at a small number of locations.

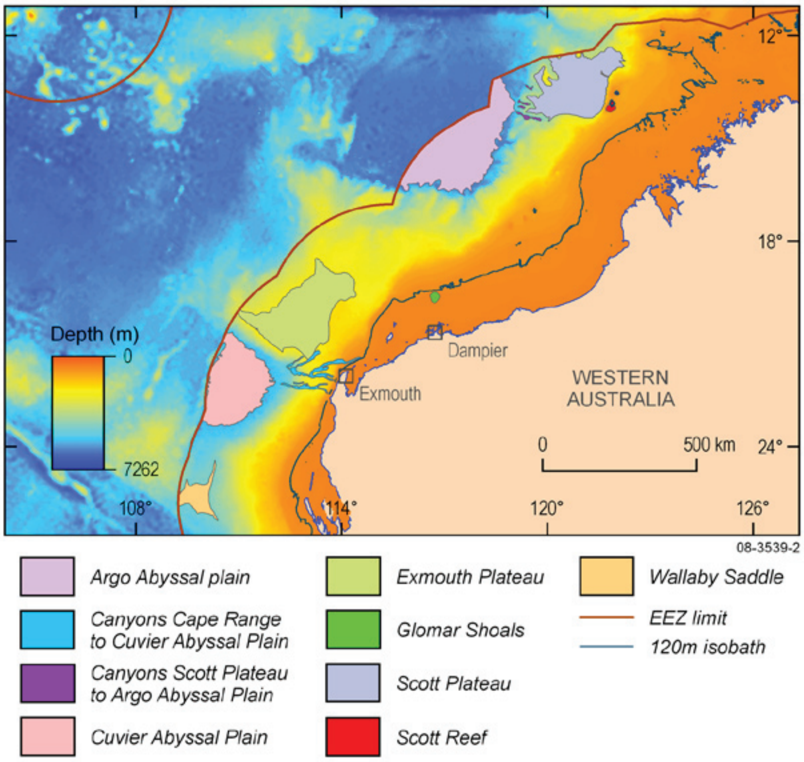

Figure 1. The draft Key Ecological Features of the North-west Marine Region.

Physical data were more robust and enabled the derivation of new regional seascapes for the northwest region, in which multiple physical factors were combined to produce a map of likely seabed habitat types (Whiteway et al 2007). These seascapes and associated analyses suggest that the abyssal plains, Wallaby Saddle and Scott Reef each represent a unique habitat type within the region. Though the other KEFs include seascapes which occur in other parts of the region, all of them are considered significant for their representativeness.

The comparatively shallow Glomar Shoals yielded sufficient biological data on bottom-dwelling fish to incorporate into

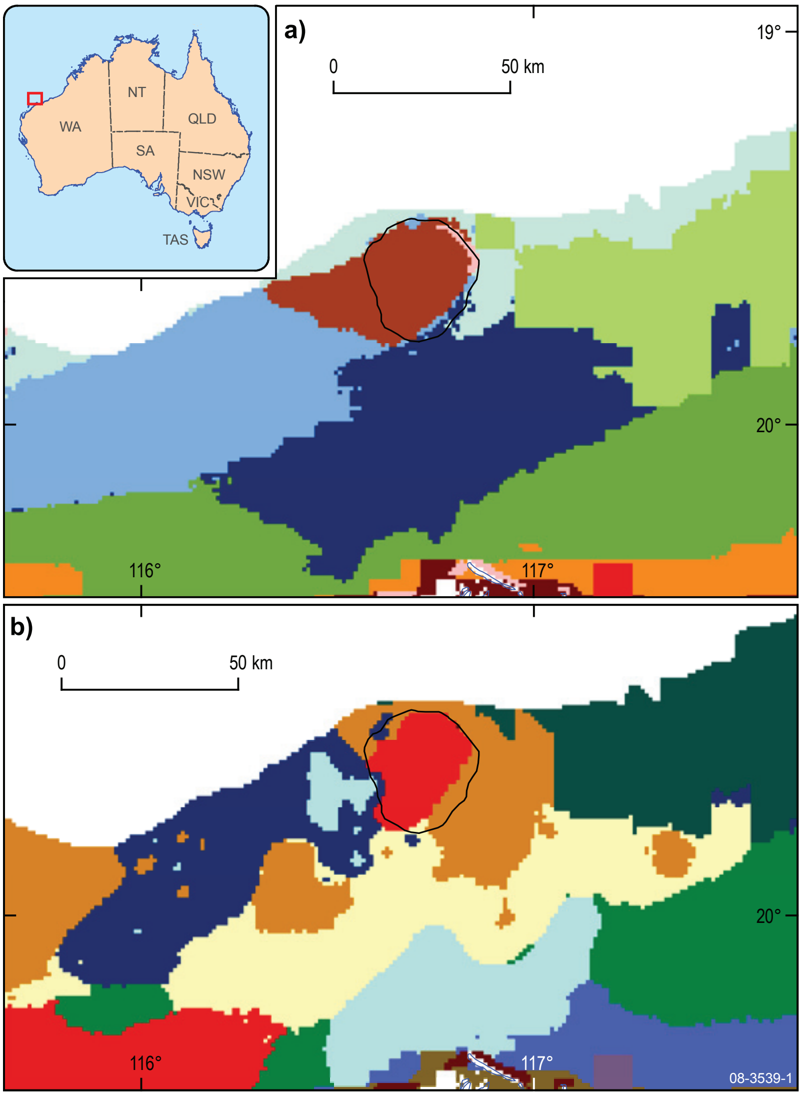

Figure 2. Comparison of seascapes from Glomar Shoals and surrounds from an analysis (a) excluding biological data and (b) including biological data. The black line outlines the Glomar Shoals.

a seascape analysis of this KEF and its immediate surrounds. In order to compare the effects of biological integration, two seascape maps of the Glomar Shoals were generated with and without the biological layer (figure 2). For the seascapes with biological data incorporated, a biodiversity index was used as an additional layer in the analysis. This is the first time biological data has been included in the derivation of seascapes. Importantly, the inclusion of the biological layer resulted in habitat classes that more closely matched the actual geomorphology (or landform) of Glomar Shoals (figure 2). These results suggest that more accurate seascapes may be derived by integrating appropriate biological data with physical data, at least at the regional scale used here.

Geoscience Australia's Marine & Coastal Environment Group continues to investigate the utility of seascapes to map Australia's marine biodiversity, including integrating biological data into seascapes at national, regional, and local scales as in this project. Our assessment of the value of the northwest KEFs and associated seascape maps will be used by DEWHA to support the establishment of a national representative system of marine protected areas as well as other conservation measures in the North-west Marine Region.

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in brief

Illuminating the bathymetry around Christmas Island

Geoscience Australia's recent marine reconnaissance survey off the coast of Western Australia (see *AusGeo News* 92) has already yielded some unexpected bonuses. After leaving Singapore the RV *Sonne* with a research team of 25 scientists and technical officers sailed close by Christmas Island en route to the survey area.

Once in Australian territorial waters the research team commenced acquiring multiple data sets, including multi-beam swath data, gravity and magnetic data and water column data. This data allows us to image the seafloor and assists in characterising the seabed, assisting ongoing marine planning and management of the area.

This opportunity yielded a stunning dataset of detailed bathymetry not previously evident from existing nautical charts. The new data reveals the dramatic submarine architecture of the volcanic-based pinnacle reef, which is Christmas Island, emerging from water depths of more than 5000 metres (figure 1).

Generally, the shoreline of Christmas Island is strongly embayed with four main erosional features. These features are found on all sides of the island and were formed when landslides slid into the sea, leaving prominent remnant headlands. One of the largest marine landslides is on the northern side of the island. Here a large slump scar was found with an extensive debris field fanning northward. This indicates a significant submarine failure (or underwater landslide) of tens of cubic kilometres.

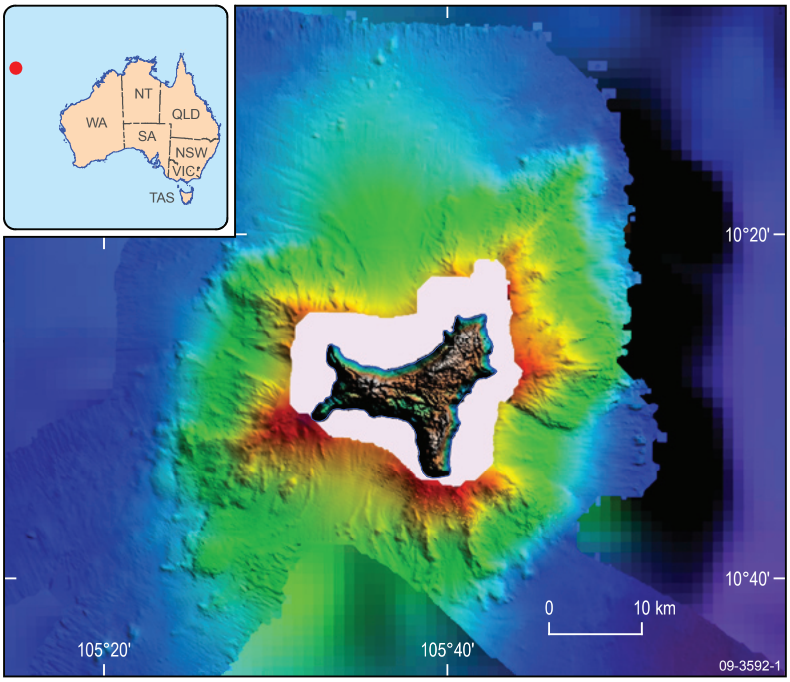

Figure 1. Bathymetry around Christmas Island based on data gathered on the 2008–09 Geoscience Australia surveys.

The eastern side of Christmas Island is dominated by a precipitous rugged blocky seafloor while the south-eastern flank is dominated by the scarp of another submarine failure with a debris field several kilometres long. The western side of the island is characterised by two headlands separated by another smaller submarine failure.

The data acquired has increased our knowledge of this important Indian Ocean territory and the surrounding seamounts. This will enhance the agency's knowledge base and will be used for research by several Geoscience Australia programs. They include geohazards (for the study of tsunami) as well as Law of the Sea and maritime boundaries and environmental management.

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Graduate project takes Geoscience Australia to Dalwallinu

Each year Geoscience Australia's new graduate recruits develop and undertake a group project to promote the agency's key priorities as well as further strengthen ties with a local community. The 2008 graduate project followed an invitation to give a presentation about research Geoscience Australia is conducting in the Dalwallinu Shire, and provide resources for the proposed Dalwallinu Environmental Interpretive Centre. Dalwallinu is a small township located in Western Australia, 254 kilometres northeast of Perth, and is the administrative centre for the Shire.

The project was undertaken because of the relatively high level of seismicity recorded in the area of Dalwallinu and its surrounds are of interest to Geoscience Australia. Australia's most damaging earthquake (M6.8) occurred in Meckering, 198 kilometres south of Dalwallinu, in 1968 and another large earthquake (M6.0) hit the small town of Cadoux (102 kilometres southeast of Dalwallinu) in 1979. These were followed by an earthquake swarm at Manmanning (10 kilometres south of Cadoux) in February and March of 1982. Consequently, Geoscience Australia collects geological and geophysical data in the Dalwallinu region to assess earthquake hazard and to better understand seismic activity in the area.

Geoscience Australia also collects airborne geophysical and digital elevation data, aerial photography, and satellite imagery in the Dalwallinu region. The data are used to better understand the regolith and the subsurface geology, and to assist natural disaster impact assessment, land use planning, mineral and geothermal exploration, and future resource development.

The main activities of the project were:

- Design and production of interpretive public displays for the proposed Centre (figure 1) showing: the geological history of the area, earthquake monitoring and its application to risk assessment, the extent and damage from recent seismic events, acquisition of geophysical data (aeromagnetic, radiometric, gravity and seismic) and its interpretation, and soil distribution and composition.
- Presentations to school groups and the general community in Dalwallinu to highlight the importance of geoscientific data acquisition and how this benefits the community.

The interaction between members of the local community and the graduates during the community presentations and the field trip has strengthened relations between Geoscience Australia and the Shire of Dalwallinu. Members of the Shire Council were particularly impressed by the team's professional and engaging manner in their presentations to the school and general community and their ability to respond to audience queries on a range of topics at the appropriate level.

Figure 1. Some of the display material relating to earthquake monitoring and data acquisition in the Dalwallinu area prepared by the graduate team.

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Related websites/articles

Shire of Dalwallinu

www.dalwallinu.wa.gov.au

Understanding Australia's arid zone palaeovalley systems

Geoscience Australia is taking a major role in an innovative research project to better understand the characteristics and behaviour of groundwater resources in Australia's arid areas. Water for Australia's Arid Zone – *Identifying and Assessing Palaeovalley Groundwater Resources* (also known as the Palaeovalley Groundwater Project) is a four-year project which commenced in April 2008. Project funding of $4.935 million was provided through the Raising National Water Standards program which is administered by the National Water Commission. The program supports the Australian Government's National Water Initiative through funding projects that improve Australia's national capacity to measure, monitor and manage our water resources.

Currently, there is only limited information available on the fundamental characteristics of palaeovalley systems (see information box) and their contained groundwater resources for most parts of arid Australia. The Palaeovalley Groundwater Project is directly addressing this significant knowledge gap by undertaking detailed field studies at several demonstration sites in the arid zone. The knowledge *in brief*

gained during this investigative work will be used to develop a national strategy for the sustainable utilisation and management of Australia's palaeovalley groundwater resources.

Geoscience Australia is working closely with government agencies from Western Australia, South Australia and the Northern Territory to ensure the success of these hydrogeological investigations. The first workshop meeting of the Technical Advisory Group (TAG) assembled for the Project was held in October 2008 at Glen Helen Station in the western MacDonnell Ranges about 130 kilometres from Alice Springs in central Australia. Thirteen representatives from six of the collaborating agencies (Western Australia Water; Northern Territory Department of Natural Resources, Environment, the Arts and Sport; Primary Industries and Resources, South Australia; Northern Territory Geological Survey; Geological Survey of Western Australia and Geoscience Australia) attended the workshop.

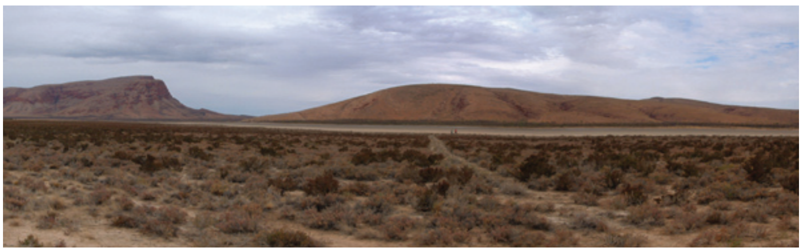
The workshop program included a one-day field trip followed by two days of presentations, discussions and debate around the central theme of arid zone palaeovalley systems. Glen Helen was chosen to host the workshop primarily because of its proximity to several of the Project's field investigation sites which allowed participants an opportunity to view, discuss and debate the many challenges relating to understanding and managing outback groundwater resources. The main objectives of the technical workshop were to:

- Evaluate existing datasets and identify the main knowledge gaps, scientific and technical issues, and groundwater resource needs relevant to the Project.
- Develop working models of different palaeovalley types and aquifers, representing the range of geological and climatic settings across arid and semi-arid Australia.
- Discuss the merits of the nominated field demonstration sites, with a view to selecting sites for future fieldwork investigations.

The lively discussions involving the TAG participants provided a solid basis for the future scientific direction of the Project. In particular, the TAG endorsed an initial focus of collating and analysing existing geoscience data and information relevant to palaeovalleys in South Australia (SA), Western Australia (WA) and the Northern Territory (NT). These include the eastern margin of the Eucla Basin (SA), the Tanami region (WA and NT), Paterson Province (WA), the Murchison–Gascoyne region (WA), Musgrave Province (SA, WA and NT), the Haast Bluff Aboriginal Land Trust (NT) and the Ti Tree Basin–Willowra area (NT). Based upon these initial studies, the final selection of demonstration sites for further field-based investigations will be made by the TAG during their next meeting in 2009.

Palaeovalleys

Palaeovalleys are geologically ancient river valleys which no longer function as active surface water systems. Palaeovalleys in outback Australia were originally formed when climatic conditions were different than they are today. An example is the Eocene epoch (about 56 to 34 million years ago) when rainfall levels were significantly higher and much of the present-day outback was covered by rainforests. Although surface water no longer flows in most of the palaeovalleys, the sediment which has filled the river channels commonly forms good quality aquifers which are capable of storing significant quantities of groundwater. In many desert areas of Australia, the groundwater resources contained in palaeovalley aquifers may be the only reliable supply of potable water available to remote water users such as aboriginal communities and pastoral stations.



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New Radiometric Map of Australia

The new full-colour Radiometric Map of Australia was released by the Minister for Resources and Energy, The Hon. Martin Ferguson AM MP, on 22 February 2008 The map is part of a range of digital radiometric products that will directly assist exploration for uranium and thorium as well as heat flow studies and the assessment of geothermal resources. It will also benefit environmental studies and soil and geological mapping.

The new map has been developed by combining more than 450 individual surveys into a single seamless compilation which shows the distribution of the radioactive elements potassium, uranium and thorium across the continent. It shows potassium in red, uranium in blue and thorium in green with the colours combined according to the relative concentrations of the radioelements. The radiometric responses and patterns in the ternary images largely reflect the surface geochemistry and mineralogy of bedrock and regolith materials. The map creates new opportunities for scientists and explorers to relate geochemical patterns in a specific area to similar patterns observed in another part of Australia.

Since airborne surveys commenced in 1951 under Geoscience Australia's predecessor, the Bureau of Mineral Resources, the Earth's magnetic field and gamma-radiation from the ground has been measured over more than 80 percent of the continent. The airborne gamma-ray data had been collected as numerous separate surveys over

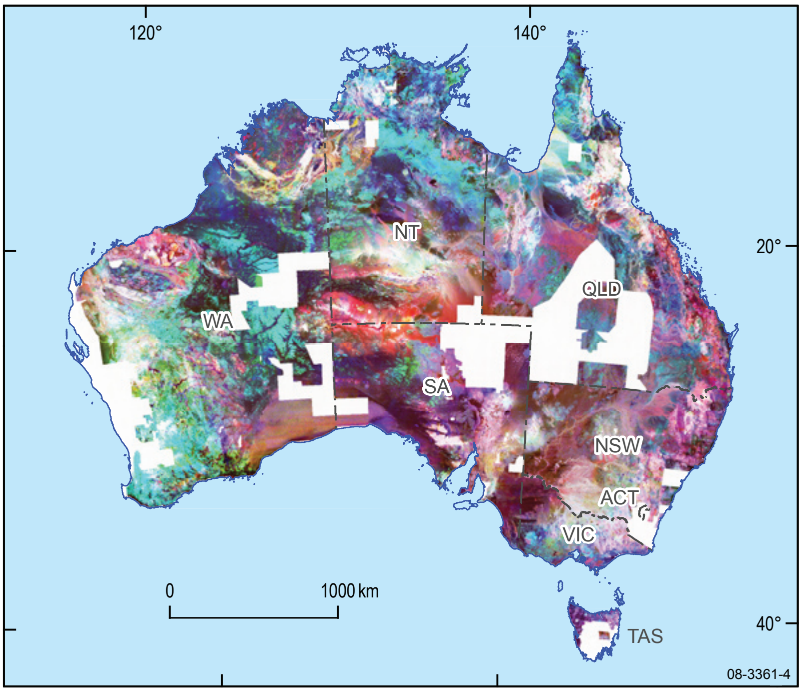

Figure 1. Ternary image of Australia (potassium in red, uranium in blue and thorium in green) derived from the new levelled National Radioelement Database.

many years and the equipment and procedures used evolved over time. Consequently, data from different surveys could not be easily compared because they could not be registered to a common datum or baseline.

Geoscience Australia's Onshore Energy Security Program, which commenced in 2006 to provide pre-competitive geoscience information to boost investment in exploration for onshore energy resources, provided an opportunity to solve this problem. As part of this program, Geoscience Australia commissioned UTS Geophysics to fly an Australia-Wide Airborne Geophysical Survey (AWAGS) at a cost of $2.6 million.

The survey covered the entire continent with north-south flight lines spaced 75 kilometres apart, and east-west tie lines spaced 400 kilometres apart. Gamma-ray spectrometric data, acquired at a height of 80 metres along the flight lines was processed according to international specifications and the final estimates of the concentrations of the radioelements comprise the new Australian radioelement baseline.

In collaboration with the state and the Northern Territory geological surveys, scientists at Geoscience Australia used the processed AWAGS data to bring all of the surveys in the national database to the new baseline. The levelled surveys were then compiled to produce a seamlessly merged single map for the whole continent underpinned by digital data at 100 metres resolution for each of potassium, uranium and thorium.

Copies of the map may be obtained from the Geoscience Australia Sales Centre. The gridded dataset can be downloaded free-of-charge in ER Mapper format from the Australian government's Geophysical Archive Data Delivery System (GADDS) download facility.

Related websites

Radiometric Map of Australia
www.ga.gov.au/minerals/research/national/radiometric/

Geophysical Archive Data Delivery System (GADDS)
www.geoscience.gov.au/gadds

For more information

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New geophysical datasets released

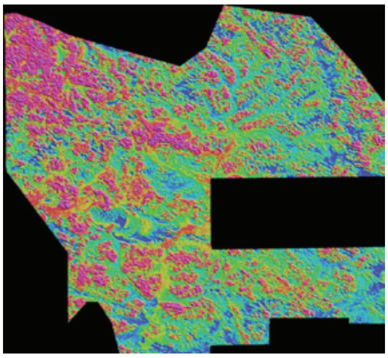
Datasets from five new airborne magnetic and radiometric surveys and three new ground gravity surveys have been released since November 2008. The data from these surveys can be interpreted to reveal the sub-surface geology of these areas and will be a valuable tool in assessing the mineral potential of the respective survey areas and will assist mineral exploration.

The South Kimberley airborne magnetic and radiometric survey covers the area in Western Australia where the Early Proterozoic Halls Creek Province meets the younger sediments of the Canning Basin. The Dumbleyung airborne magnetic and radiometric survey covers the soils and geology of the Waging, Dumbleyung, Kukerin, Kojonup and Katanning areas in southern Western Australia. This survey was funded by the South West Catchments Council (SWCC) in partnership with the Western Australian Department of Mines and Petroleum.

The Cooper Basin East & West airborne magnetic and radiometric surveys cover the Early Permian to Early Triassic Cooper Basin that underlies the Mesozoic Eromanga Basin in southern Queensland. The Normanton airborne magnetic and radiometric survey covers the Karumba Basin in northern Queensland.

The Westmoreland - Normanton gravity survey covers the Carpentaria and Karumba Basins, the Windimurra gravity survey covers the northern Yilgarn Province in Western Australia and the Central Arunta gravity survey covers the area where the Arunta Block meets the Amadeus and Georgina Basins in the Northern Territory.

All of these surveys were managed by Geoscience Australia on behalf of the relevant state geological survey. The data have been incorporated into the national geophysical databases. The point-located and gridded data for the surveys can be obtained free online using the Australian governments' Geophysical Archive Data Delivery System (GADDS).



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Related websites

Geological Survey of Queensland
www.dme.qld.gov.au/mines/about_us.cfm

Geological Survey of Western Australia
www.dmp.wa.gov.au

Northern Territory Geological Survey
www.nt.gov.au/d/Minerals_Energy/Geoscience/

product news

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

Survey	Date	1:250 000 map sheets	Line spacing/ terrain clearance/ orientation	Line km	Contractor
South Kimberley (WA)	January – October 2008	Lennard River (pt), Noonkambah (pt), Lansdowne (pt), Mount Ramsay, Mount Bannerman (pt)	400 m 60 m north – south	163 519	GPX Surveys Pty Ltd
Dumbleyung (WA)	March – November 2008	Dumbleyung (pt), Corrigin (pt).	100 m, 400 m 30 m, 60 m north – south	75 433	Fugro Airborne Surveys Pty Ltd
Cooper Basin East (Qld)	January – September 2008	Windorah (pt), Eromanga, Thargomindah, Bulloo, Quilpie (pt), Toompine (pt), Eulo (pt).	400 m 60 m north – south	215 769	UTS Geophysics Pty Ltd
Cooper Basin West (Qld)	November 2007 – November 2008	Birdsville (pt), Betoota (pt), Canterbury (pt), Barrolka, Durham Downs, Tickalara	400 m 60 m north – south & east – west	210 057	Fugro Airborne Surveys
Normanton (Qld)	April – September 2008	Galbraith (pt), Walsh (pt), Normanton (pt), Red River (pt).	400 m 80 m agl east–west	114 487	Thomson Aviation Pty Ltd

Table 2. Details of gravity surveys.

Survey	Date	1:250 000 map sheets	Station spacing, orientation	Stations	Contractor
Windimurra (WA)	August –September 2008	Cue (pt), Sandstone (pt), Kirkalocka (pt), Youanmi (pt), Ninghan (pt), Barlee (pt).	2 500 m east – west	6 041	Atlas Geophysics Pty Ltd
Westmoreland – Normanton (Qld)	May – August 2008	Mornington (pt), Westmoreland (pt), Burketown (pt), Normanton, Galbraith (pt), Walsh, Red River.	4 000 m east – west	6 411	Integrated Mapping Technologies Pty Ltd
Central Arunta (NT)	May – August 2008	Hermannsburg (pt), Napperby (pt), Mount Peake (pt), Alice Springs (pt), Alcoota (pt), Barrow Creek (pt), Hale River (pt), Illowga Creek (pt), Huckitta (pt), Hay River (pt).	500 m, 1000 m, 2000 m, 4000 m east – west	11 827	Atlas Geophysics Pty Ltd

NATMAP product range expands

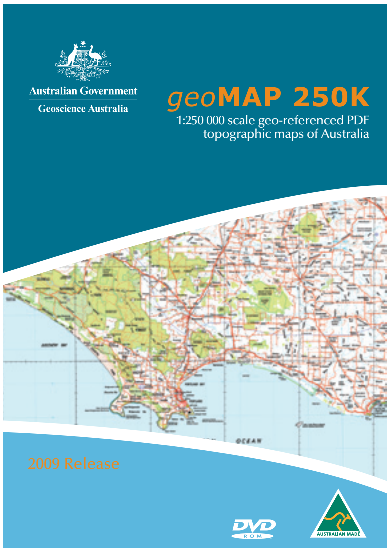
For many years Geoscience Australia's national topographic map series, known as NATMAPs, has provided the topographic information necessary to explore and develop our vast continent. The flagship product in the NATMAP range has been the 1:250 000 scale (250K) maps which are distributed as paper maps and digital data in a variety of formats.

A welcome and innovative addition to this range is ***geo*MAP 250K** which provides a modern digital approach to the delivery and use of maps. This new product has coverage of Australia at 1:250 000 scale in geo-referenced Portable Data Format (PDF) on a single DVD ROM. PDF is a widely used format created by Adobe Systems which uses software to view the information.

The geo-referencing capability of ***geo*MAP 250K** facilitates co-ordinate readout, measurement of distance and area, the import of overlay files and GPS tracking. A set of 20 000 alphabetically arranged bookmarks allows the user to quickly find locations across Australia. Alternatively, common pan and zoom tools allow navigation to a specific area. The index map includes hyperlinks which load a map when the user clicks on the map name. Moving to an adjacent map sheet is easily done by clicking on an adjoining area of the map on display.

To use the geo-reference capability of ***geo*MAP 250K**, additional software will be required. Both types of software are available for download free of charge and links to the software websites are included with the product.

The ***geo*MAP 250K** PDF maps are also available online via Geoscience Australia's award-winning MapConnect service. They are also available on DVD ROM from Geoscience Australia's Sales Centre.



For more information

phone Freecall 1800 800 173 (within Australia) or +61 2 6249 9966

email sales@ga.gov.au

Related websites

MapConnect

www.ga.gov.au/mapconnect/

events

Students go for gold

More than 60 senior secondary students visited Geoscience Australia's Canberra headquarters in January as part of the National Youth Science Forum program.

During the visit, students gained hands-on experience examining rock samples, interpreting maps and researching data from the remote gold fields of Western Australia. The visit introduced students to various aspects of the geosciences and was intended to encourage an interest in future study and careers in geoscience.

The students were divided into specialised groups for the exercise, with the task of locating potential gold deposits using various techniques used for mineral exploration. They reviewed maps showing gravity and magnetic attraction, examined thin slices of rock under a microscope, and used geographic information systems (GIS) to integrate different types of relevant data. The aim of this exercise was to demonstrate how the different disciplines of geoscience are combined to aid mineral exploration and develop a greater understanding of the Earth.

While at Geoscience Australia, students also had an opportunity to talk to staff involved in the Geoscience Australia cadetship and graduate programs, as well as discovering some of the various career opportunities on offer at Geoscience Australia.

Figure 1. Students checking the magnetic properties of rock samples.

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Figure 2. The students gained experience in the interpretation of geological maps.

events calendar

Western Australian Emergency Management Conference 2009	**16 & 17 April**
Perth Convention Exhibition Centre Contact: Anna Wood or Paula van't Riet, Conference Administrators, PO Box P1174, Perth WA 6844	p +61 8 9323 9328 f +61 8 9323 9470 e emconference09@fesa.wa.gov.au volunteers.fesa.wa.gov.au/emc2009
AMEC National Mining Congress 2009 Association of Mining and Exploration Companies	**21 & 22 May**
Perth Convention Exhibition Centre Contact: AMEC, PO Box 6337, East Perth, WA 6892	p 1300 738 184 (Within Australia) f 1300 738 185 (Within Australia) e events@amec.org.au www.amec.org.au
2009 APPEA Conference and Exhibition–Australian Petroleum Production and Exploration Association	**31 May to 3 June**
Darwin Convention Centre Contact: Julie Hood, APPEA Limited GPO Box 2201, Canberra ACT 2601	p +61 7 3802 2208 e jhood@appea.com.au www.appea.com.au
Marine Connectivity AMSA 2009 Australian Marine Sciences Association	**5 to 9 July**
Adelaide Convention Centre Contact: AMSA-SA	p +61 8 8207 5305 f +61 8 8207 5481 e sa.amsa@gmail.com www.amsaconference.com.au
7th International Conference on Geomorphology Australian and New Zealand Geomorphology Group (Inc.)	**6 to 11 July**
Melbourne Exhibition and Convention Centre Contact: Tour Hosts Conference & Exhibition Organisers, GPO Box 128, Sydney, NSW 2001	p +61 2 9265 0700 f +61 2 9267 5443 e geomorphology2009@tourhosts.com.au www.geomorphology2009.com
Spatial Sciences Conference 2009 Spatial Sciences Institute	**28 September to 2 October**
Adelaide Convention Centre Contact: ICMS Pty Ltd, 84 Queensbridge Street, Southbank, Victoria 3006	p +61 3 9682 0288 f +61 3 9682 0244 e ssc2009@icms.com.au www.ssc2009.com