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Celebrating 20 years AUSGEO news
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In brief

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CEO comment

Dr Chris Pigram – CEO Geoscience Australia

Welcome to Issue 100. This issue includes an article relating to Geoscience Australia's programs to provide pre-competitive information to support the mineral exploration industry as well as reports on a survey in Kalgoorlie to inform earthquake risk and mitigation, spatial information management and our Education Program.

The Yilgarn Craton in Western Australia is one of Australia's key mineral provinces, producing more than half of the gold and most of the nickel mined in Australia. Our article reports on the series of projects conducted by Geoscience Australia in the eastern Yilgarn Craton in collaboration with the Predictive Mineral Discovery Cooperative Research Centre between 2001 and 2008. Many of the new findings from the research challenge previous paradigms regarding the tectonics and geological architecture, as well as the relationship of gold to structure, magmatism and metamorphism.

This issue also reports on the survey of earthquake damage in Kalgoorlie following the earthquake on 20 April 2010. The survey captured street view imagery of 12 000 buildings and followed this with a detailed field survey. This information will make a significant contribution to our knowledge of earthquake vulnerability.

Geoscience Australia's National Geographic Information Group has recently undertaken a significant strategic review of its operations with a view to providing improved access to up-to-date geographic information for government and the community. The article outlines the cultural shift involved from being a provider of data and products to a geographic information content integrator, provider and enduring custodian. This is against a background of increasing collaboration between government mapping agencies and a requirement by government for fundamental data to be more intelligent and specific.

The Education Centre at Geoscience Australia's headquarters in Symonston ACT welcomed its 50 000th student visitor in March this year. The Centre is one part of our Education Program and our article examines our science education and awareness-raising activities at the local, national and international level. It also outlines some exciting new collaborations which are providing students with a real world context for learning within the school environment.

It is now 20 years since publication of the first issue of *AusGeo News*. Over this period, the magazine has chronicled the changes in the agency as it adopted a greater range of functions serving a wider range of clients and stakeholders in government, industry and the community. This issue includes a review of the many new functions the agency has assumed since December 1990.

Finally, I wish to thank all our readers for your continuing support and extend best wishes for the festive season and the New Year.

Australian Government
Geoscience Australia

Celebrating 20 years AUSGEO news ISSUE 100 Dec 2010

Archean gold mineral systems in the eastern Yilgarn Craton

New knowledge to assist area selection and targeting

Richard Blewett

Introduction

The eastern Yilgarn Craton of Western Australia is Australia's premier gold and nickel province (figure 1), and has been the focus of geological investigations for over a century. Geoscience Australia, in conjunction with collaborators in the Predictive Mineral Discovery Cooperative Research Centre, conducted a series of projects between 2001 and 2008 (Y4 Project team 2008). This article summarises the new findings from the research; many of which challenge previous paradigms regarding the tectonics and geological architecture, as well as the relationship of gold to structure, magmatism and metamorphism. Although the research was based on the Yilgarn Craton, the results have general implications for other Archean terranes and mineral systems.

"Although the study was based on the Yilgarn Craton, the results have general implications for other Archean terranes and mineral systems."

Predictive mineral discovery

The main goal of the research was to develop a comprehensive mineral systems understanding for gold in the eastern Yilgarn Craton, and to use this knowledge for predictive mineral discovery. A methodology was developed of four nested scales of prediction: 1) craton/province; 2) district/camp; 3) deposit; 4) ore shoot.

This article presents the second, or district-scale prediction, which resulted in the generation of a new gold target map (figure 1) for the eastern Yilgarn Craton. The details are presented in Czarnota and others (2010a).The map represents the culmination of mineral systems analysis, it encapsulates the critical processes of the geodynamics, architecture, fluid sources, fluid pathways and drivers, and gold deposition mechanisms.

The critical processes were translated into a series of independent proxies that could be regionally mapped. Four separate maps were generated in a GIS (geographic information system). The first map defined the pre-gold endowment, and used the crustal age and the metamorphic distribution. The second map defined the key features of a major lithospheric extensional event, including identifying the main detachments and associated transfers, mantle magmas and deep structures in gravity and mantle tomography. The third map defined the contractional inversion features, and included the fault network, upper plate distribution and 3D shape of granite domes. The fourth map defined the regional alteration associated with loss-on-ignition in geochemical datasets and redox gradients defined from petrography and field site mineralogy.

These four maps were then integrated, resulting in the generation of this new target map for gold without the input of any gold deposit layer (figure 1). The map predicted 75 per cent of the known gold in less than five per cent of the total area. Importantly, the map identified

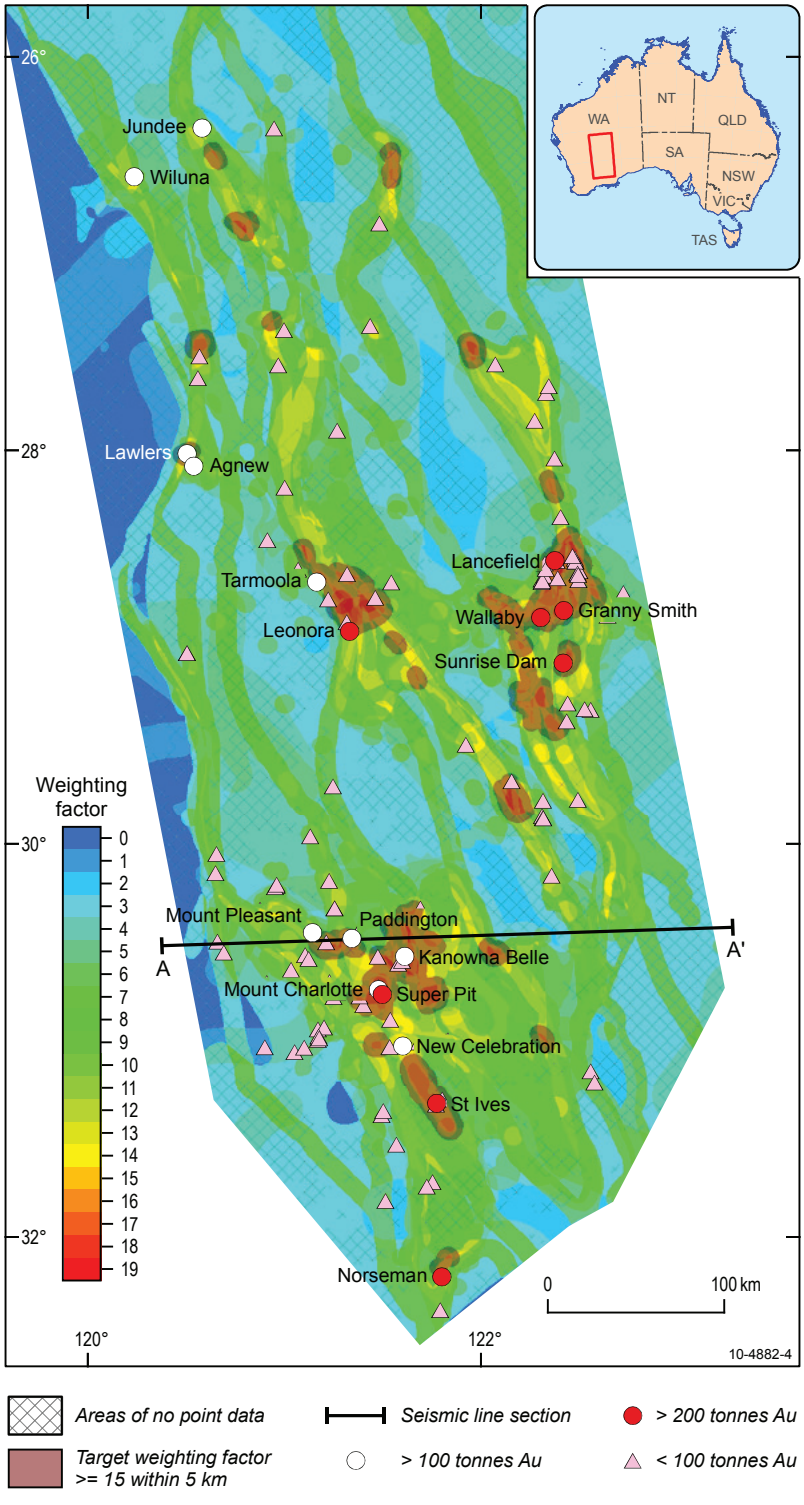

Figure 1. Map of the gold prospectivity of the eastern Yilgarn Craton overlain with known deposit locations (after Czarnota and others, 2010). The map has successfully predicted most of the known major gold deposits and is a positive test of the mineral systems understanding. High weighting factor areas (yellow to red colours) are most prospective for gold mineralisation. The brown areas represent a weighting factor score of 15 or more, with a five kilometre buffer. These areas contain 75 per cent of the known gold mineralisation in only 5 per cent of the study area. A number of new target areas with no known significant gold mineralisation are also identified – these represent new gold targets. The section line A–A' is revealed in figure 4.

all the major gold camps, thus confirming which critical processes are needed to form a giant gold deposit. The map revealed a number of areas that were not known for hosting large deposits, but had all the favourable ingredients – these represent new target area opportunities. The datasets used to map the critical process proxies are revealing in themselves; they inform on data requirements for successful prediction and exploration.

Tectonic setting and metamorphic evolution

The tectonic or geodynamic setting of most Archean terranes is controversial, with a number of competing hypotheses. For example, some researchers suggest that plate tectonics did not operate during early Earth history, or at least not in the way we understand it today. Nevertheless, first order constraints regarding the tectonics of the eastern Yilgarn Craton are provided by the following:

1) synthesising the main elements of the geodynamic system
2) mapping the fundamental boundaries
3) determining the metamorphic evolution.

Czarnota and others (2010b) have synthesised the main elements of the eastern Yilgarn Craton into a new integrated framework in time and space. The synthesised elements included the stratigraphy,

magmatic history, metamorphism, mineralisation, and structural geology, together with extensive geological and geophysical maps. The synthesis highlighted the interdependence of the system, where a change in one element is accompanied by a synchronous change in all other elements. This synthesis allows the key features of the gold mineral system to be placed in context, leading to better predictions (figure 1).

Fundamental map patterns are revealed by a new crustal age map (figure 2), which is based on measurements in granites of rare-earth isotopes of samarium and neodymium. The map shows that the eastern Yilgarn Craton consists of a series of NNW-striking belts of variable age, which developed on the edge of the Youanmi Terrane, an older continental block to the west (Cassidy and Champion 2004).

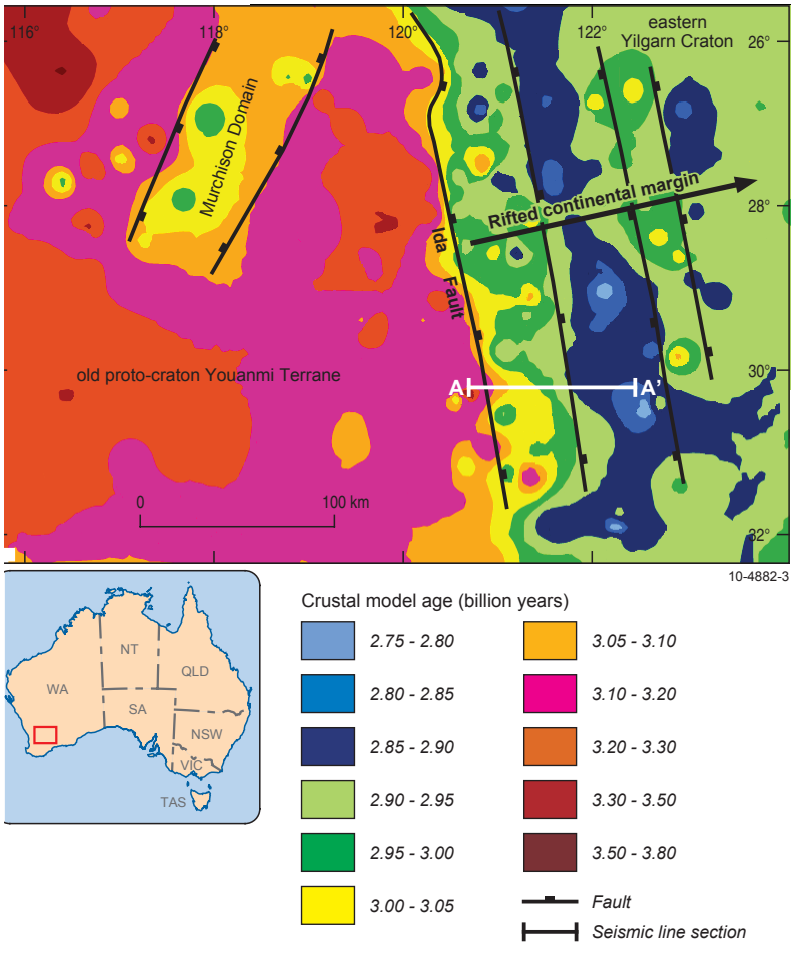

Figure 2. Crustal (model) age map of the Yilgarn Craton measured from samarium and neodymium isotopes in granites. The values are given in billions of years (or Ga), and are calculated as a two-stage depleted mantle isochron (after Cassidy & Champion 2004). The warm colours are the oldest crust. The cool colours are the youngest crust. The map shows the fundamental terranes and domains, and their boundaries, of the Yilgarn Craton. The eastern Yilgarn Craton, a zone of relatively young crust, developed on the extended margin of the old 'Youanmi' Terrane proto-craton. The section line A–A' is revealed in figure 4.

The patterns of change in crustal age are the result of variable degrees of crustal contamination caused by the variable thickness of the underlying extended basement and, as such, map the fundamental structures of the region. Areas of intermediate thinning and age (2.90 to 3.05 Ga or billion years) are the most endowed in gold and nickel.

The recent metamorphic work by Goscombe and others (2009) marks one of the most significant new advances in understanding the region's geodynamic evolution. This metamorphic study is probably the most comprehensive of any of the world's Archean terranes, and it provides new constraints on this poorly understood Eon. Previously, the eastern Yilgarn Craton was thought to record a single prograde metamorphic cycle as a consequence of crustal thickening from continent to continent collision. It has now been shown that five discrete metamorphic events occurred, with large variations in peak metamorphic crustal depths (12 to 31 kilometres). The metamorphic evolution can be viewed with stages of crustal growth, thermal priming of the crust, lithospheric extension, and finally inversion and reactivation. The work has major implications for metamorphic fluids and their role, or not, in gold transport and deposition.

The combined constraints challenge previous models involving exotic strike-slip terranes and obduction settings,

and support simpler rifting/back-arc extensional settings. They suggest that the eastern Yilgarn Craton developed on the rifted margin of an old continent, with the influence of a mantle plume.

Lithospheric architecture

The new understanding of the eastern Yilgarn Craton has benefited from a concerted effort to acquire high-quality geophysical data, and to integrate the architecture from the scale of the thin section (figure 3a), to drill core (figure 3b), to outcrop (figure 3c) to whole lithosphere (figure 4). Potential field data and limited seismic reflection data had been available up to the year 2000. Over the last decade there has been an increase in the availability of seismic reflection data, which has been augmented by passive seismic (tomographic) and magnetotelluric data (figure 4). Together, these geophysical datasets provide information on the architecture/structure of the crust and upper mantle, and they reveal anomalous features beneath the main gold camps (Blewett and others 2010). The development of the architecture can be linked to the geodynamic synthesis; together they provide a 4D understanding of the system, and improved predictive capacity (figure 1).

A Golden Corridor, stretching from St Ives to Wiluna (figure 1), is defined by a regional anticlinorium whose limbs are marked by outward dipping shears that connect to deep faults. Granite-cored domes are nested within this regional structure, providing a favourable focussing architecture for deep fluids.

The seismic character of the crust is interpreted to be dominated by extensional features—such as core complexes—contrasting earlier interpretations of contraction and thrust duplexes above a single detachment.

A fast shear-wave velocity body is mapped at a depth of 120 kilometres (figure 4), which is interpreted as delaminated lower crust. The process of delamination is interpreted to be a driver of the D_3 extensional event, which saw the start of major gold deposition and the development of the main dome-and-basin map patterns. Steps and changes in this velocity body are interpreted as mantle structures. The magnetotelluric data reveal anomalously enhanced conductivity beneath the Golden Corridor, which is interpreted to reflect large-scale fluid alteration (figure 4).

New developments in software and hardware now permit realistic 3D inversions of potential field data, and the results can be visualised in 3D on a standard desktop computer. By integrating these geophysical datasets with geological maps, new 3D geological maps were constructed (figure 4). These maps delineate the granite-cored domes which dominate the regional architecture (Blewett and Hitchman 2006). Many domes nucleated about early growth

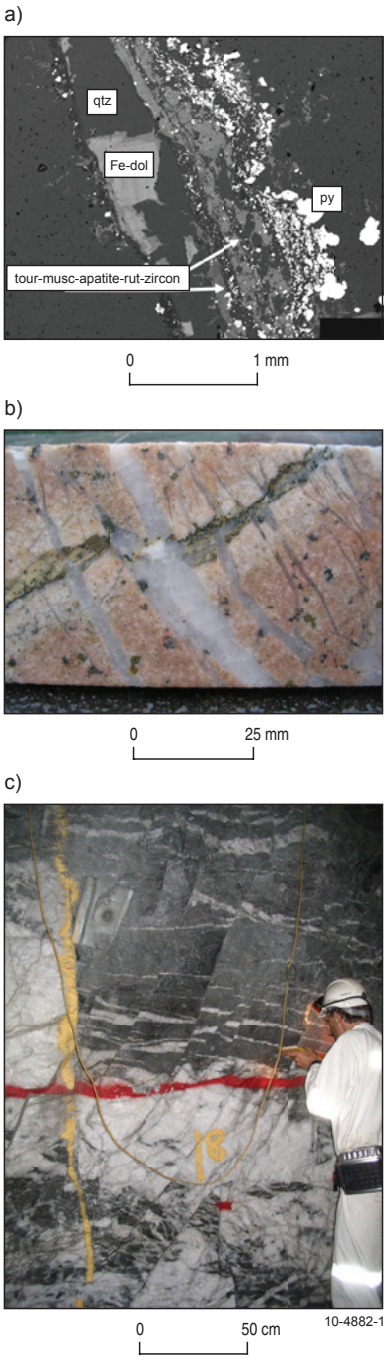

Figure 3. Illustration of the variety of scales mapped in the eastern Yilgarn Craton: a) thin section scale with contrasting fluid chemistry inferred from the mineralogy determined in this back-scattered SEM image of gold ore at Sunrise Dam; b) drill core scale with multiple generations of veins and alteration in mineralised quartz-feldspar porphyry from St Ives; c) outcrop scale mapping underground at Agnew.

faults, which also controlled the stratigraphy. Such faults, when inverted, became the location of major gold deposits, such as the Superpit at Kalgoorlie, at Wallaby and Kanowna Belle (figure 1).

Structural evolution

The eastern Yilgarn Craton gold deposits are structurally controlled, so knowledge of the structural evolution can lead to enhanced prediction (figure 1). Using an improved geochronological framework, a revised structural history was developed (Blewett and Czarnota 2007). The new history better integrates the stratigraphy and the 3D architecture, with six key Archean deformation events (D_1 to D_6). From this new understanding, a series of observations and interpretations are made:

- D_1 extension was E- to ENE-directed, reflecting the shape of the eastern continental margin, and dominated the period 2720–2670 Ma. This event established the fundamental NNW-trending architecture and the crustal age map patterns (figure 2); it also influenced all subsequent deformational events. Growth faults developed during this time were important for the early nickel and later gold mineralisation.
- The bulk crust was built during D_1 into three gravitationally unstable layers. The upper layer consisted of dense mafic rock-dominated greenstone. The middle layer consisted of less dense and thermally-weak granite. The lower layer consisted of a dense residue from the mid-layer granite melts.
- ENE-directed D_2 convergence commenced around 2665 Ma, perpendicular to the extensional margin. Folds and thrusts attest to some crustal thickening, but this rapidly led into major extension, as D_2 contraction triggered a reorganisation of the density distribution of the crust.
- The lower crust delaminated during D_3, allowing mid- and upper-crustal core complexes and domes to develop, thus minimising the unstable potential energy. Late-stage clastic basin successions were deposited in the hangingwall of deep-penetrating extensional shear zones, together with intrusion of magmas from a metasomatised mantle source. These late-stage basin successions are a feature of many granite-greenstone belts (for example in Canada, Africa and India), and they are commonly synchronous with gold mineralisation. Both the D_1 and D_3 extensional events ruptured the crust. Together, they developed the deep-penetrating fault system (figure 4) that facilitated access to metasomatised mantle melts (as seen in deep seismic profiles and magnetotellurics).
- Convergence returned after 2655 Ma, with a series of far-field stress switches from an ENE (D_{4a}) to an ESE orientation (D_{4b}). This stress switch was also responsible for north-directed thrusts (previously called D_5), which developed along dome hinges as accommodation of regional sinistral strike-slip faulting within mostly inter-dome high-strain shear zones. Final NE–SW convergence (D_5) saw mostly dextral strike-slip faulting – much of it in the brittle domain. Weak extension (D_6) is the final Archean tectonic event.

"New findings argue against the traditional view, including new knowledge of the structure, metamorphism, magmatism and chemistry …"

Gold mineralisation

The traditional orogenic gold or lode-gold model argues for gold to be deposited during contraction, from hydrothermal fluid derived from the metamorphism of mafic greenstones. New findings argue against the traditional view, including new knowledge of the structure, metamorphism, magmatism and chemistry. These insights lead to better predictive capacity (figure 1).

The metamorphic evolution does not support a late-stage metamorphic fluid hypothesis, at least for all the gold. The regional M2 metamorphic event was of moderate pressure and temperature, and was closely linked to the emplacement of voluminous granite batholiths, not major crustal thickening. This M2 event accounts for much of the available metamorphic fluid, and it was generated some 15 to 20 million years before the main gold deposition. Geochemical modelling shows that the devolatilisation of greenstones releases only short-duration, low-volume fluids. The resultant rock mass is left dry and unable to subsequently contribute significant fluid to any later event. Multiple gold events are observed, meaning that metamorphic fluids may have been involved in one of the gold events, but not all. Thus, metamorphic fluids derived from mafic greenstones were unlikely to be a major fluid source.

"The gold deposits are restricted to the shear planes of the extensional foliations, and they have very deep but narrow ore shoots developed parallel to the stretching direction."

Three end-member fluids are interpreted to account for the range of oxygen, sulphur and carbon stable isotopes, the range of redox conditions inferred from these, and from the chemistry of the alteration mineralogy (figure 3a). Within vein systems, fluid dominates over wall rock so that the chemistry reflects different sources of fluids and not necessarily the influence of reactions with local wall rocks (figure 3b). An emerging picture of the role of possible mantle fluid reservoirs is provided by studies of the noble gases, especially those at St Ives and Sunrise Dam. This is a significant finding.

Gold deposits are traditionally described from contractional settings, hence the name orogenic gold. However, gold with characteristics analogous to the classical orogenic type also occurs in extensional shear zones, with key examples found at Leonora, Lancefield, Lawlers and Kunanalling (figure 1). All these gold deposits developed in D_3 shear zones, as the large granite domes were exhumed as core complexes. The gold deposits are restricted to the shear planes of the extensional foliations, and they have very deep but narrow ore shoots developed parallel to the stretching direction. The largest of these deposits occur where the oldest stratigraphy is exposed and/or high-pressure rocks are exhumed. They also nucleate from any outward projecting apophyses on the margin of the dome, especially where this apophysis comprises a mantle-derived pluton. The host rocks are the exhumed fragments of the old basement, with pressures up to 8.7 kilobar (around 30 kilometre depth). These core complexes indicate significant reordering of the crust across these extensional faults, and they are the largest structures in the eastern Yilgarn Craton, reaching the Moho in some places (figure 4). They are gold-bearing because of the dynamic permeability created during extension. These are a new and under-explored gold play, and they need to be targeted differently to the more common contractional settings.

The D_3 gold deposits developed synchronous with emplacement of gold-enriched magmas sourced from a metasomatised mantle and the deposition of late-stage basin successions. The magmas also provided a source of oxidised fluids. The late-stage basin successions are characterised by a high thermal gradient and unusual tight anticlockwise M3a pressure-temperature-time paths. Their contained fluids were reduced. Extension drives basin fluids downwards, providing contrasting fluids to the oxidised magmas. Chemical contrasts favour gold deposition, either as fluids mix (figure 3a), or where

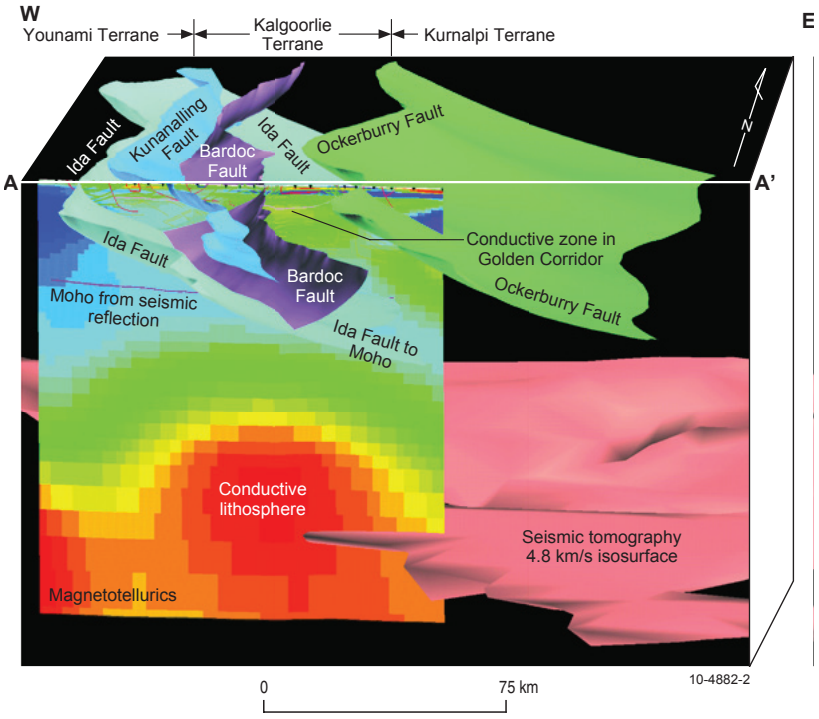

Figure 4. Lithospheric-scale section view across the eastern Yilgarn Craton at a latitude just north of Kalgoorlie's Superpit (A–A' in figures 1, 2). The brightly coloured image striking east–west is a conductivity map of the crust and upper mantle as measured by magnetotellurics. The warm colours are conductive regions – interpreted as alteration – such as within the Golden Corridor. The buff coloured feature in the lower right of the image is the fast seismic velocity body at around 120 kilometres depth. This is the interpreted delaminated lower crust. The green, blue and purple planes are the major faults of the region, some extend to the Moho. The location of the terranes are named.

one fluid encounters a host rock of contrasting redox or chemistry (figure 3b). Regional redox maps of alteration mineralogy illustrate the size of the footprint to these large-scale hydrothermal systems (Czarnota and others 2010a; Goscombe and others 2009).

Following lower crustal delamination during D_3, a broad uplift of the eastern Yilgarn Craton occurred. This regional exhumation during D_4–D_5 is recorded by widespread low-pressure M3b assemblages (~one kilobar) and was associated with regional retrogression and alteration. Shallow crustal levels favour mostly brittle deformation over ductile deformation. Brittle deformation favours dilation, especially in regions of structural complexity. A succession of stress switches (D_{4b} and D_5) were imparted onto this complexity, and resulted in a succession of gold depositional events (Czarnota and others 2010b).

Low-Calcium, or potassic, granites are high-temperature crustal melts that were emplaced at high levels across the entire Yilgarn Craton. They mark the decompression and uplift of the exposed crust to high crustal levels (less than three kilometres), and their emplacement commenced some 10 to 15 million years after the inferred delamination of the lower crust. The time delay is consistent with the likely thermal diffusivity through the crust. The result was the effective transfer of heat and heat-producing elements into the upper crust, effectively cratonising the Yilgarn (Czarnota and others 2010b).

The 3D maps show that multi-phase granite-cored domes lie at varying depths beneath all the giant gold deposits. These vertically-zoned systems may have provided fluids from depth into the cores of the domes through the same pathways that earlier, small volume magmas had passed (Blewett and others 2010).

Conclusions

The project goal, to develop a mineral systems understanding for gold in the eastern Yilgarn Craton and to use the knowledge for predictive mineral discovery, was successfully met. Targets and recommendations from this work have resulted in new discoveries and extensions to known mineralisation, which extend mine life. There are generic learnings from this work that are applicable to other mineral systems in Australia.

Acknowledgements

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The author

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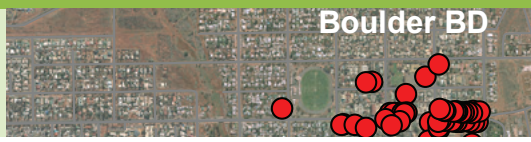
Survey of Kalgoorlie earthquake damage

Assessing the vulnerability of older buildings



Martin Wehner, Mark Edwards and Neil Corby

Australia has a low seismicity (or rate of occurrence of earthquakes) when compared to countries located along tectonic plate boundaries such as New Zealand or Indonesia. Seismic risk, however, is the combination of hazard, community exposure and infrastructure vulnerability. Older unreinforced masonry buildings are a particular subset of the built environment which may contribute disproportionately to community risk. Documented information on the damage to buildings caused by earthquake events is fundamental to understanding this risk.

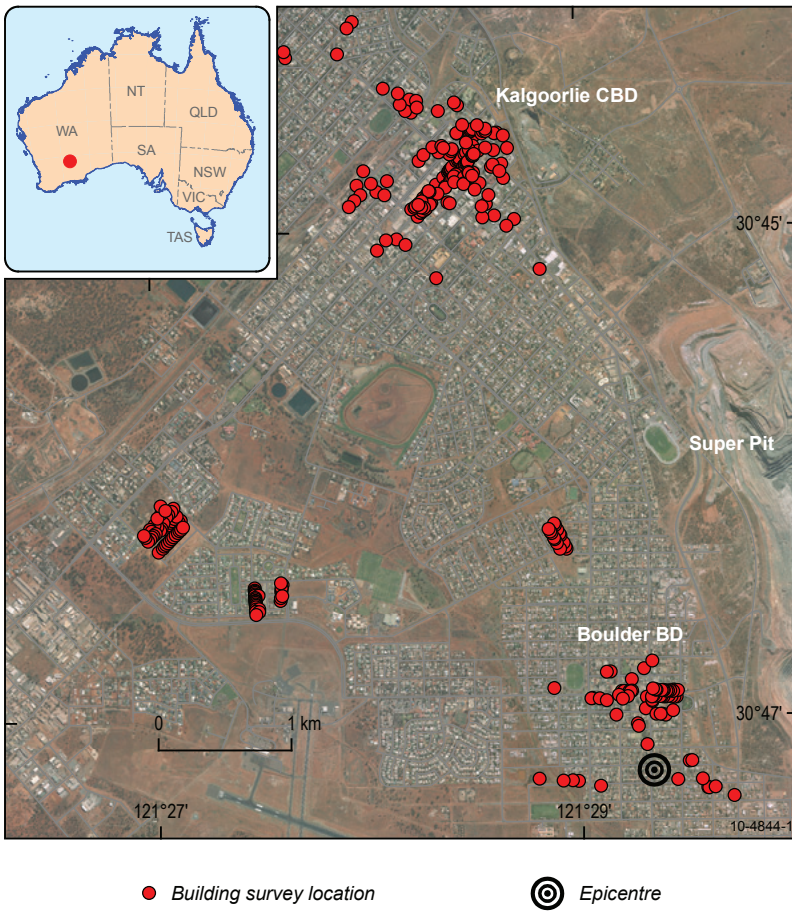


Figure 1. View of Kalgoorlie showing the epicentre of the 20 April 2010 earthquake and the location of the buildings surveyed between 18 and 22 May 2010. The 'Super Pit' open cut mine workings which are over 500 metres deep are visible to the right of the aerial view.

The earthquake

On the 20 April 2010 a magnitude 5.0 (M_L) earthquake shook the Western Australian goldfields town of Kalgoorlie. The earthquake was shallow (1.7 kilometres) and was located immediately south of the business district of the Kalgoorlie suburb of Boulder (figure 1). The severity of ground motion was found to vary markedly across the town with the older masonry building stock in Boulder experiencing a greater intensity of shaking than the corresponding building stock in the Kalgoorlie business district four kilometres away. The event has provided the best opportunity to examine the earthquake vulnerability of Australian buildings since the Newcastle Earthquake of 28 December 1989 more than twenty years ago.

Conducting the survey

Following the earthquake Geoscience Australia arranged a staged collaborative survey to capture information which would contribute to our knowledge of earthquake vulnerability. The initial reconnaissance team of two specialists from Geoscience Australia captured street-view imagery of 12 000 buildings

within Kalgoorlie between 28 April and 1 May. The team used a vehicle-mounted camera array developed by Geoscience Australia known as the Rapid Inventory Collection System (RICS). In total 230 000 geo-referenced high resolution images were captured within the urban area. This work was complemented by a detailed field survey which was conducted on foot between 18 and 22 May. Survey information was recorded using hand-held mini-computers which allowed the team of nine engineers and geographic information system (GIS) specialists to capture data about the damage caused. The team included two earthquake engineering researchers from the University of Adelaide and the University of Melbourne respectively. Over 400 buildings in four age categories were surveyed and assessments were made of the felt intensity in those locations. The survey locations are also shown in Figure 1.

Figure 2. Damage caused to a hotel in Boulder. The damage is typical for two storey unreinforced masonry buildings with toppling of parapets either outwards into the street or inwards through the roof. This building also sustained other types of damage such as cracking over doors and windows and substantial cracking to internal masonry walls.

"Preliminary findings from this work have shown that older masonry buildings are particularly vulnerable to the nature of the ground motion experienced in the Kalgoorlie event."

The findings

The field team found that the severity of shaking in the Boulder business district was approximately 6 on the Modified Mercalli scale. This level of shaking caused widespread damage to unreinforced masonry buildings built before World War One. The loss of chimneys, gables and parapets was widespread as well as extensive cracking of walls (figure 2). The timing of the event at 8:17am was fortunate as falling masonry would have landed on school children walking through the area if the earthquake had occurred just 15 minutes later. Only a few minor injuries resulted. More modern masonry residential buildings also experienced some damage. The severity of shaking beneath the Kalgoorlie business district was approximately 5 on the Modified Mercalli scale causing only slight damage to older masonry buildings. Preliminary findings from this work have shown that older masonry buildings are particularly vulnerable to the nature of the ground motion experienced in the Kalgoorlie event. Furthermore, more contemporary cavity brick construction was found to experience greater damage than equivalent wooden-framed construction, though damage was light.

Further analysis will incorporate information gleaned from seismic recordings of aftershocks that were obtained by Geoscience Australia over a period of 47 days following the earthquake. The work will also include estimates of the repair costs derived from the survey data that can be linked to the predicted shaking. The objective will be to derive the greatest benefit from the survey effort to inform future assessments of earthquake risk and mitigation.

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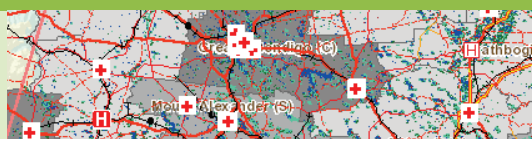
Future directions for mapping in Geoscience Australia

Demand for more intelligent and specific data



Greg Scott and Andrew Beer

Geoscience Australia's former National Mapping Information Group has undertaken a significant strategic review of its operations over the last year. The review covered many areas of operations with the focus on:

- maximising the group's potential to serve its stakeholders and clients
- improving workflows and processes
- creating more opportunities for staff
- improving flexibility and responsiveness

The Group has emerged from the review with a clear focus on its role in Australia's contemporary spatial environment. From 1 July 2010 the Group implemented a transition to a new structure, with an immediate restructure of work units and a fresh new name –National Geographic Information Group (NGIG).

The new name better represents the changing role that the group has as a steward of national authoritative geographic information. It positions NGIG to assist the Australian Government to get the most value and benefit from geographic data, including building upon the 'capture once, use many' approach, and providing improved access to up-to-date geographic databases for government and the community.

"… providing improved access to up-to-date geographic databases for government and the community."

Benefits for stakeholders and users of spatial information

Geoscience Australia's role as the authoritative custodian of topographic data continues. The organisation's traditional role as a mapping agency is strengthened by focussing on the needs of the community through assisting government agency programs (that benefit by using spatial data) to deliver their outcomes.

Non-government producers of spatial information have not been neglected either. They benefit from a focus on government-driven needs which is shown by the reality that previously, mapping might not be undertaken in many remote areas because of limited budgets and such a large area to map–onshore Australia has an area of around 7.7 million square kilometres.

A recent example is the release by Geoscience Australia of maps of Australia's iconic Red Centre. These maps would not have been published had it not been for the policy needs of government. They were part of the National Landscapes initiative—a partnership between Tourism Australia and Parks Australia—which identifies and promotes distinctive and inspirational destinations to domestic and international visitors. The area is experiencing increasing visitor numbers and the new maps will enhance visitor safety in this remote and rugged area.

Geoscience Australia produced four multi-purpose maps with more reliable and relevant information for the experience seeker visiting the Red Centre (figure 1). They were compiled in consultation with Australian Government and Northern

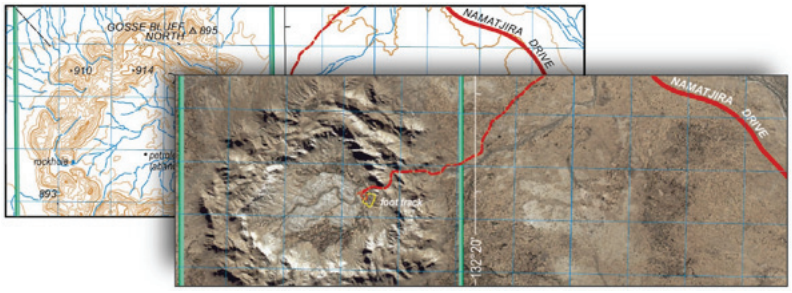


Figure 1. A section of a National Landscapes map (West MacDonnell National Park) which includes a topographic map and satellite image of the area. While these maps are useful for visitors to the area they are also invaluable for emergency managers.

Territory government agencies including Parks Australia, Department of Resources, Energy and Tourism, and the Northern Territory Parks & Wildlife Service.

These maps also provide police, fire fighters, medical and other emergency services as well as natural resource managers, with relevant and up-to-date geographical information for these areas. This is particularly important for the coordination of search and rescue missions or dealing with bushfires and other natural disasters in such a remote area.

The data compiled from the National Landscapes and other mapping projects has been incorporated into the national topographic database and eventually becomes updated GEODATA. This data is commonly acquired by industry as base data for many of the tourist and other maps that this sector produces.

A collaborative approach

However, Geoscience Australia's role goes beyond data custodians and map makers. It is also responsible for managing or chairing a number of national spatial information bodies and is an advocate for the introduction of new technologies to allow the sharing and broad dissemination of spatial information.

The Intergovernmental Committee on Surveying & Mapping (ICSM) secretariat is part of the National Geographic Information Group. Under the umbrella of ICSM, the Group is responsible for chairing a relatively unknown but important government consortium–the Permanent Committee for Topographic Information (PCTI). Its members are officials from Australian Government, state and territory spatial agencies as well as the Department of Defence. This committee is also responsible for the National Topographic Information Co-ordination Initiative (NTICI).

The NTICI is a successful framework which ensures a collegiate approach to the topographic mapping of Australia. The Initiative's role is to take a whole-of-government approach to the collection, integration, dissemination and maintenance of topographic and related information to meet the needs of government and the public.

This initiative has ensured significant coverage of new and revised topographic data. In some cases new datasets have been created for areas previously devoid of GIS data while in other instances, information up to 30 years old has been significantly updated. Geoscience Australia has funded many of these data capture and revision programs under NTICI, but it is a partnership–neither the state and territory jurisdictions nor Geoscience Australia would have had the ability to capture such data themes alone.

Applying this collaborative approach to future topographic mapping would incorporate a distributed data sharing arrangement. Such an arrangement would have multiple benefits including: leveraging smart enabling technologies, improving turnaround times, harmonised specifications, a continuing focus on maintenance of priority themes and areas, and integration of NTICI data into jurisdictional and Geoscience Australia databases as 'single point of truth'. In contrast a 'stovepipe' approach to data management within agencies denies users and themselves the opportunity to benefit from all the available data.

New horizons

NGIG's mission to 'provide authoritative geographic information services and products to inform evidence-based decision making, government policy, industry development needs and community wellbeing' might seem a broad mandate. However the agency is clear about the boundaries of its role and influence. Geoscience Australia does not undertake cadastral or state-type mapping nor does it compete with private enterprise. Geoscience Australia's focus is to fill the national 'public good' geographic information space. It aims to stimulate and promote the value and use of spatial data and provide support for the growth of private organisations working in the spatial information arena.

Geoscience Australia also has a role as advocate for the integration of spatial information into government programs, through collaboration with government agencies, providing technical expertise and business acumen to underpin policy analysis, service delivery and informed decision making.

Technology has totally changed people's thinking and is now a capability that is not only relied on, but is expected to provide answers to problems in the future. There is wide recognition of the need to produce data and cartographic products much more easily from a single database. In addition, geographic information is now more mobile, with data and user-generated content at the fingertips of users and being harnessed as social networks are built in a growing consumer-led environment. Although simple, these services are extremely effective in delivering content to the broader community.

Spatial data supporting government

Australian governments are increasingly demanding more efficient and effective service delivery, policy monitoring and evaluation, all underpinned by a strong evidence base to enable better informed decisions. The spatial environment is becoming increasingly more valuable and relevant to government agencies and the community. However, many government agencies do not effectively use spatial data, technologies and services to support their business or policy evidence base. Geoscience Australia is recognised as the Australian Government's 'spatial agency', and the realisation of the benefits of spatial technologies is growing, bringing with it greater expectation that we will be able to readily support and deliver on such technologies.

The last 12 to 18 months in particular have seen an increasing trend in requests to Geoscience Australia from a diverse portfolio of government departments for the development of spatial product and service delivery (figure 2). These requests cover the areas of water resources, climate change, social inclusion, energy, defence, health, transport, information management, and emissions trading.

The majority of these spatial products are underpinned by fundamental spatial information, including topography-related themes. However, this is changing as we are now seeing a requirement for this fundamental data to be more intelligent and specific (figure 2). Thus for water-related data the national water networks now need to be represented as connected hydrological networks that flow, with every segment of stream assigned to a catchment hierarchy (figure 3). These same requirements are producing data that is more detailed, authoritative, and temporal. There are increasing requirements for 'scalable' data, from the national to the local level.

Conclusion

The major need is for mechanisms to acquire and grow data availability and visibility, and to 'capture once, use many'. We must utilise and leverage the existing strengths and recognise the advantages of data custodianship, especially in the state jurisdictions where we have national spatially embedded data.

The NTICI should continue to be the most effective mechanism for maintaining and improving the existing investment in Australia's topographic mapping. There is now an increasing reliance by all government mapping agencies on data produced through this collaboration. With the expected continuation of this

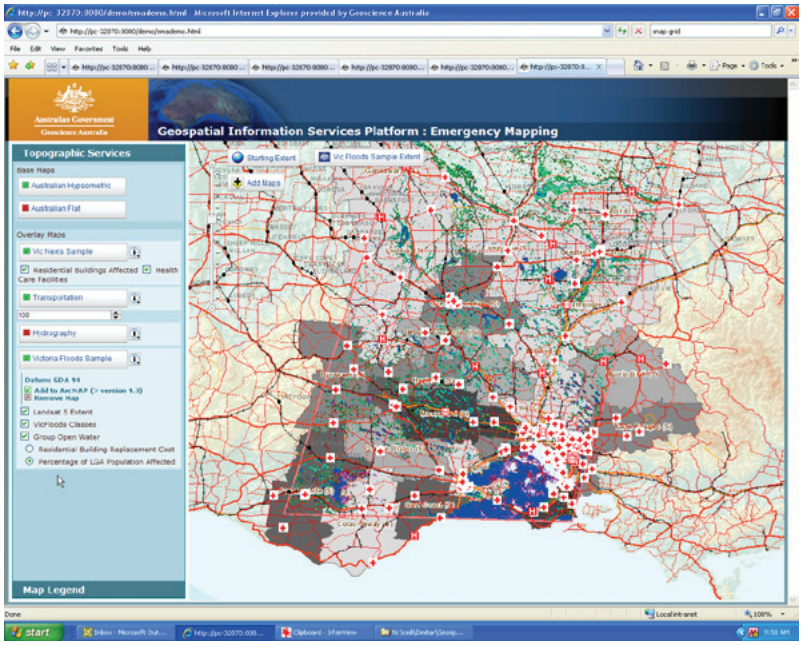


Figure 2. An example of emergency mapping showing flooding in central Victoria. Fundamental spatial data is overlain with maps showing the extent of flooded areas, location of health care facilities and information on affected residential dwellings (from Geoscience Australia's NEXIS database) by local government area.

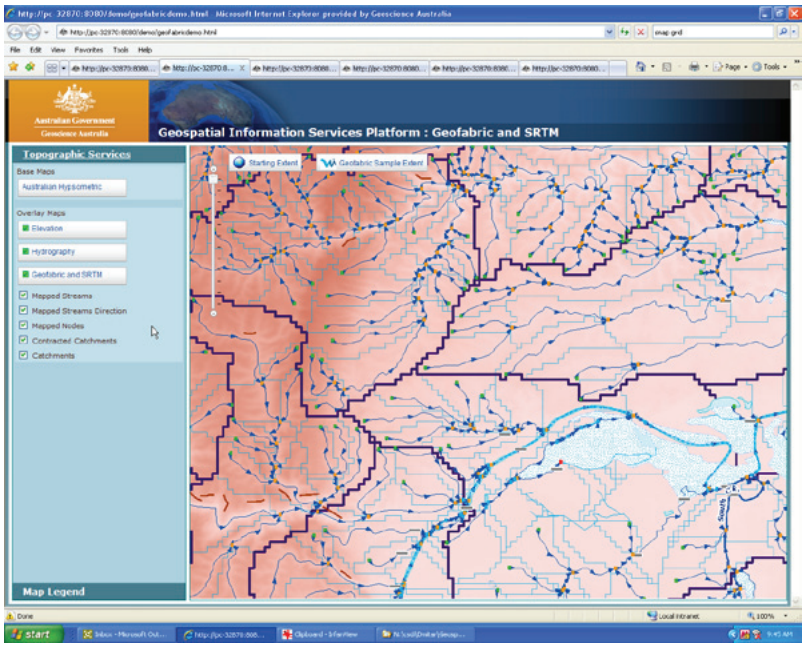


Figure 3. Geoscience Australia is developing spatial products for an increasingly diverse range of government agencies. This map depicts the water networks as connected hydrological networks, includes the direction of flow and assigns each segment of stream to a catchment hierarchy.

successful initiative into the future, it is envisaged that over time, data maintenance across all scales rather than base data capture, will become the focus for mapping authorities in all jurisdictions. However, this cooperation and coordination needs to be efficient and effective, rather than be seen as a data maintenance burden.

There is an additional benefit that the greater the level of participation and cooperation, the greater the potential for a coordinated approach to value-adding of the national spatial framework.

The NGIG is optimistic about the role it can play in promoting the value of spatial information. Maintaining a sustainable topographic mapping program in Australia requires a cultural shift from provider of data and products to a geographic information content integrator, provider and enduring custodian.

Three main factors needed to achieve this shift include:

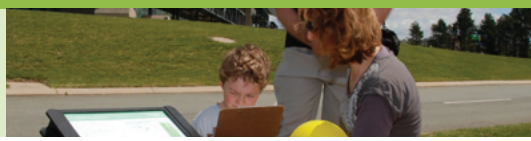
- a program of partnerships through collaboration with other agencies and businesses
- improvements in and leveraging of technology
- changes in the way that governments do business.

For more information

email ausgeomail@ga.gov.au

The real science experience

Promoting awareness of the geosciences



Kate List

Geoscience Australia has an extensive program to promote awareness and knowledge of the contribution that geoscience makes to the Australian economy, management of the environment, and the identification and mitigation of the impact of natural hazards. Geoscience Australia contributes to and supports a number of science education and awareness raising activities locally, nationally and internationally. These include the agency's Education Centre, professional development sessions for teachers, Open Days, and participation in relevant events such as Earth Science Week, National Science Week and the annual National Youth Science Forum.

Geoscience Australia's Education Program began with a broad aim of promoting earth science to school students. A dedicated Teacher Education program was inaugurated in 1996 by the Australian Geological Survey Organisation (the predecessor of Geoscience Australia). Its main activities were the development of teacher resources and provision of training and field excursions for teachers across Australia. By 2004 the program had developed and distributed teacher resource kits and educational material to more than a thousand primary and secondary schools around Australia.

The Education Centre

The Program expanded following the opening of the Earth Science Education Centre, a dedicated area within the agency's headquarters at Symonston ACT, on 11 October 1999. The Centre is staffed by trained educators, science communicators and geologists and offers structured hands-on activities with a science and geography curriculum focus for visiting school groups and special interest groups. A range of activities which enable students to experience real science have been made possible with the full support and direct involvement of many of Geoscience Australia's scientific and technical staff. These activities showcase the cross-disciplinary nature of geoscience, use authentic scenarios and involve Geoscience Australia's data, technology, equipment and geoscientists.

The Education Centre has continued to encourage a new generation of Australians to understand the earth sciences and become involved in geoscience. In March 2010 the Centre welcomed its 50 000th student visitor since opening in 1999 (figure 1). As the number of school excursions to the Centre has increased, the Program's focus has shifted to providing tailored visits for school students.

Figure 1. Geoscience Australia's Education Centre welcomed the 50 000th student visitor in March 2010.

A new attraction, a Geological TimeWalk was installed in the grounds of the agency's headquarters in November 2009. The one kilometre long walk celebrates and explains the immense age and geological diversity of the continent with information plaques marking each geological time interval (figure 2). The period since modern humans appeared on Earth represents less than the final five centimetres of the walk. Significant rock and fossil specimens have been sourced from around Australia

to complement the TimeWalk by illustrating important aspects of the geological history. A range of resources relating to the TimeWalk are available for free download from the Education web pages.

Public events and programs

In 1999 the agency also took on the leadership of international Earth Science Week (ESW) celebrations in Australia to encourage earth science awareness through participation by Australian universities, museums, industry and schools. Geoscience Australia has continued to promote celebrations through the production and distribution of an annual ESW poster, national student ESW competitions (such as *Geologi*), an annual Open Day at the agency's headquarters and a dedicated web page.

The national *Geologi* Short Film Competition has become a highlight of Earth Science Week celebrations since 2007 with the official screening of the winning entries and the presentation of awards at Geoscience Australia's headquarters. The competition is hosted by Geoscience Australia and the Australian Science Teachers Association (ASTA).

Figure 2. The Geological TimeWalk located at the front of the Geoscience Australia building in Symonston, ACT. Information plaques, which mark each geological time interval, have been spaced along the one kilometre walk and emphasise key events in the formation of Earth including five major mass extinctions.

This year more than 250 students from primary and secondary schools across Australia produced and submitted 60 short films for the competition. The films were judged on their science content, creativity and promotion of the theme highlighting the role earth sciences play in our interactions with an ever-changing Earth.

Film topics included natural hazards (such as earthquakes and volcanoes), Australia's natural resources, geological time and the formation of the Earth.

Geoscience Australia's annual Open Day is currently held during Earth Science Week. This year's Open Day saw around 1250 visitors participate in a variety of displays, activities and tours demonstrating how geoscience is being applied to some of Australia's most important challenges.

Curriculum development

In recent years, the work program of the agency has provided the background material and content for both school visits and teacher professional development sessions. Program context and relevance have been achieved by delivering initiatives which showcase and maintain strategic alignment with the agency's science programs. Geoscience Australia is supporting the implementation of the Australian Curriculum (particularly science and geography subject areas) through involvement

in the curriculum consultation process. Members of the Education Program team attend annual national science and geography teacher conferences to present teacher development workshops, participate in seminars or display at trade exhibitions. Staff also presented at the Australian Earth Sciences Convention in Canberra in July 2010.

The Office of Spatial Data Management (OSDM) is currently in discussions with Education Services Australia regarding the potential use of spatial resources across all subject areas in the school curriculum. Initially these services will be extended to Year Five and Year Six students. OSDM and Education Services Australia are keen to develop linkages with organisations interested in supporting the use of spatial capabilities within the education sector. Geoscience Australia is working to build on and develop further other partnerships with the education sector by making the relevance of its science to the Australian Curriculum more explicit and improving access to Geoscience Australia's science, data and products. The future looks promising for geoscience education with all stakeholder groups supporting and gaining improved access to online data and products.

Special events and professional development

Annual National Youth Science Forum visits to Geoscience Australia provide students with an opportunity to engage in real science, with geoscientific staff, in a working science environment. This year participants undertook an exercise designed by the agency's Carbon Capture and Storage project to determine the most suitable location for a carbon storage site. In previous years students have worked in groups using a range of geoscientific methods and equipment to ascertain the most likely location for a new gold deposit (figure 3).

Over the past year, the Japanese Science Teacher Association and Australian Science Teachers Association as well as the pilot Australian Science Teacher Summer School have participated in teacher development sessions at Geoscience Australia. Their visits included tours of the Joint Australian Tsunami Warning Centre and the Sensitive High-Resolution Ion Microrobe (SHRIMP) facility which produces high quality data about the age of Australian rocks. Architecture students also visit regularly to inspect the building's solar passive design and geothermal heating and cooling system.

Figure 3. Visiting students gain a hands-on experience in the interpretation of geological maps during a National Youth Science Forum program visit to Geoscience Australia.

Collaboration with schools

For the past three years, Geoscience Australia has been using ANUGA (free and open source hydrodynamic modelling software) to demonstrate numerical modelling concepts and basic hydrodynamic theory to Year 9 science students through the Science Experience. The Office of Spatial Data Management is currently piloting ANUGA for use in the high school environment at one school in the ACT. This has been achieved with the support of scientific and technical staff who are users of ANUGA within Geoscience Australia. It is planned to make an 'ANUGA package' including software, user guide and lesson plans available through Geoscience Australia's education web pages.

A scientific partnership has been established between Geoscience Australia and the Research School of Earth Sciences at the Australian

National University to aid in Sciences à l'École', an international initiative of the French Ministry of Education to install seismometers in schools. Telopea Park School/Le Lycée Franco-Australien de Canberra joined this international network with the installation of a seismic station within the school on 25 July 2008. The recorded signals, reflecting regional or global seismic activity, feed into an online database, creating a genuine seismic resource centre and a real world context for learning. This station is station number 44 in a network which now numbers 51 stations, and is the third in the Southern Hemisphere and the first in the Asia-Pacific area.

"The recorded signals … feed into an online database, creating a genuine seismic resource centre and a real world context for learning."

The French initiative is part of a broader challenge to encourage students' interest in science and steer them towards scientific studies and professional careers. Future applications of this development extend to an Australian 'Seismometers in Schools' program. The objective is to install 40 seismometers in schools across the nation to contribute to earth science awareness in school-age students through the formation of a national seismic education network. The project was initially funded by AuScope with Geoscience Australia and the Australian National University's Research School of Earth Sciences. AuScope is funded by the National Collaborative Research Infrastructure Strategy which utilises the practical applications of science to build bridges between the research communities and all Australians.

Future directions

While the value of delivering science in context and *in situ* to students cannot be underestimated, there is one significant limitation – access. A major challenge for the education program will be to ensure that our resources are accessible to and reach the widest possible audience. Geoscience Australia is working to build a culture of online innovation and collaboration by improving access to our data, information and products beginning with the adoption of Creative Commons licensing for online products. Obviously collaboration will be pivotal to the future success of Geoscience Australia's education program.

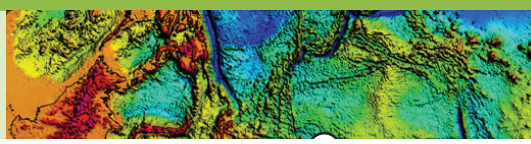
At its most fundamental level, raising community awareness of geoscience has the capacity to save and change people's lives. Although it is difficult to measure the broader impact of Geoscience Australia's education and awareness-raising activities, there is evidence that these activities play a significant part in combating the decline of interest in the study of geoscience by students and university graduates. The success of the education program, in conjunction with our cadetship and graduate recruitment programs, can be seen with a number of Geoscience Australia's current staff having either first visited the Centre as school students, participated in Geoscience Australia's National Youth Science Forum visits or applied for cadet or graduate positions within the Agency.

Related articles/websites

Geoscience Australia's Education website
www.ga.gov.au/education/

A chronicle of change

AusGeo News celebrates 20 years



Stephen Ross

AusGeo News, Geoscience Australia's quarterly online magazine, commenced publication in December 1990 as a bimonthly newsletter. It was designed to keep the clients of the then Bureau of Mineral Resources, Geology and Geophysics (BMR) in the minerals and petroleum exploration industries, government, education and conservation informed. Content included 'research results, program changes, staff movements, new publications and data releases' or the three 'Ps' (people, programs and products). Since then *AusGeo News* has informed readers about the progress of the agency's programs and products and significant structural changes (including two name changes). It has also chronicled the adoption of a greater range of functions serving a wider range of clients and stakeholders in government, industry and the community.

"It has also chronicled the adoption of a greater range of functions serving a wider range of clients and stakeholders in government, industry and the community."

'A New Approach'

The newsletter was inaugurated following the Woods Review of the BMR in 1989. The Review recommended that BMR move towards a stronger survey and mapping role which reflected industry's needs and priorities. There was also a clear recognition that geoscience was relevant to the consequences of resource development and use as well as environmental issues. In accordance with a major recommendation of the Review, the early issues of AusGeo News had a major focus on outputs of the National Geoscience Mapping Accord (NGMA).

The newsletter promoted the agency's first name change in 1992 when BMR became the Australian Geological Survey Organisation (AGSO). Subsequently the magazine's content was expanded to include details of presentations by AGSO staff at major industry and professional conferences (the fourth 'P'). An external earnings target of 30 per cent of the agency's 1994/95 Budget allocation led to the inclusion of *AusGeo International* as an insert. It reported on geoscientific services AGSO provided for foreign government agencies (Argentina, Fiji and Oman) and projects funded by the Australian International Aid and Development Agency. The latter included an assessment of groundwater pollution in Nepal, earthquake mapping in Fiji and the establishment of an earthquake monitoring network in Papua New Guinea.

More than a newsletter

The newsletter began to move beyond its original format following the introduction of full colour in 1997 and increased graphic design input. It also included brief articles explaining the new technologies and techniques being used to undertake major projects. The magazine format introduced in 2000 soon evolved so that each issue had several main articles. Each issue also included separate

sections for In brief and product news reports as well as an Events calendar. The readership target was broadened beyond industry and stakeholders to include the 'interested reader' with a science or technical background but not necessarily in the same discipline as the writer.

The reporting of 'research results' increased after the AGSO Research Newsletter ceased publication in 2001 and *AusGeo News* became a quarterly publication. Reporting on the broad work program which saw geoscience as fundamental to mitigating the effects of natural hazards in urban areas, land management in rural and coastal areas, and management of the marine environment was included. This broader role was reflected in the change of name to Geoscience Australia in August 2001. It was followed by the merger with AUSLIG (Australian Surveying and Land Information Group) which brought together two organisations with large spatial data holdings. Consequently the magazine's content further expanded as *AusGeo News* reported on programs and products related to topographic mapping and satellite imagery and the application of spatial and other data more broadly.

Figure 1. Front covers and Contents pages showing the transformation of *AusGeo News* from a newsletter to online magazine between 1990 and 2010. The column at right includes some of the memorable items and articles during this period.

An online version of *AusGeo News* in HTML and pdf versions was introduced in 2005. This opened up the publication to a much wider readership since readers could download specific articles and external organisations or collaborating agencies could link directly to individual articles of interest to their readers. Authors could also include links to earlier articles to provide background or explanation for their articles.

In many respects *AusGeo News* has chronicled the changes in the activities of the agency as it expanded beyond its original mapping and surveying role (figure 1). BMR had provided much of the geoscientific information that had underpinned petroleum and mineral resource exploration and development in Australia. However by 1991 geoscience was becoming a fundamental input into a wide range of national priorities such as mitigation of natural hazards and environmental problems such as land degradation.

In addition to providing high-quality pre-competitive data and information to identify and promote new potential hydrocarbon areas to the international oil industry, the petroleum and marine program has:

- contributed to Australia's submission to the United Nations Commission on the Limits of the Continental Shelf
- acquired offshore geoscience information to increase our knowledge of seabed environments and marine habitats.

"In many respects *AusGeo News* has chronicled the changes in the activities of the agency as it expanded beyond its original mapping and surveying role."

The agency has developed new geological mapping to stimulate investment in minerals exploration in cooperation with the states and the Northern Territory through the National Geoscience Mapping Accord. This collaboration has seen the development of continent-wide maps, such as the magnetic anomaly map, the gravity anomaly map and the recently-completed radiometric map (figure 4), as well as the first digital seamless surface geology dataset covering Australia. The agency has provided a three-dimensional framework to facilitate more effective exploration beneath regolith and sedimentary cover.

Other major changes over the last twenty years include:

- Geoscience has become an essential input to natural resource mitigation strategies and natural resource management. The agency is also involved in several projects to better understand and manage Australia's groundwater resources.
- The agency has developed a new approach to the assessment of risk and community vulnerability to natural hazards such as earthquakes, volcanism, landslides, and coastal/river erosion. It has also become a major contributor to tsunami science and warning systems in the Australasian region through the agency's contribution to the Australian Tsunami Warning System.
- Support for natural disaster management through providing timely information on the location of bushfires and floods as well as monitoring the effects of climate change.
- Provision of geographic information for government purposes, including emergency management, defence, marine zone management, public access and industry development, through the national mapping program.

Offshore petroleum and marine geoscience

The main functions of the agency's petroleum and marine programs in the 1990s were to identify and promote new potential hydrocarbon areas to the international petroleum industry. This work resulted in major regional syntheses of the Browse and Bonaparte basins on the North West Shelf. The regional knowledge generated during these projects still underpins

acreage release in these areas. At the same time there was research into the geological and geochemical processes affecting the marine environment, climate change and sea-level change and the establishment of Australia's seabed jurisdiction (*AusGeo News* 2). Consequently the agency became a major contributor to Australia's submission to define the outer limits of its jurisdiction under the UN Convention on the Law of the Sea. Australia is the first country to be in a position to proclaim the full outer limit of its continental shelf. Basic offshore geoscience information acquired by the agency is also contributing to seabed mapping and the identification of seabed habitats to support regional marine planning and the establishment of a national representative system of marine protected areas.

During the period 1985 to 1998 the agency chartered a research vessel *Rig Seismic* which carried out 68 surveys in support of AGSO's marine geoscience program (*AusGeo News* 46). Almost all of these surveys (64) acquired seismic data while 21 acquired geological samples (including cores up to 10 metres long) as well as geochemical samples of both the water column and seafloor sediment (7 surveys).

The search for a new oil province

Since 2000 the focus for petroleum exploration opportunities has shifted to areas outside currently active producing areas to 'frontier' basins. At the same time the Program changed from a survey mode of operation to targeting particular issues. The Australian Government's 2003 Budget allocated $61 million over four years (2004 to 2007) to provide pre-competitive information to support industry's search for a new oil province. This funding initiated a new phase of offshore data acquisition and the preservation of the

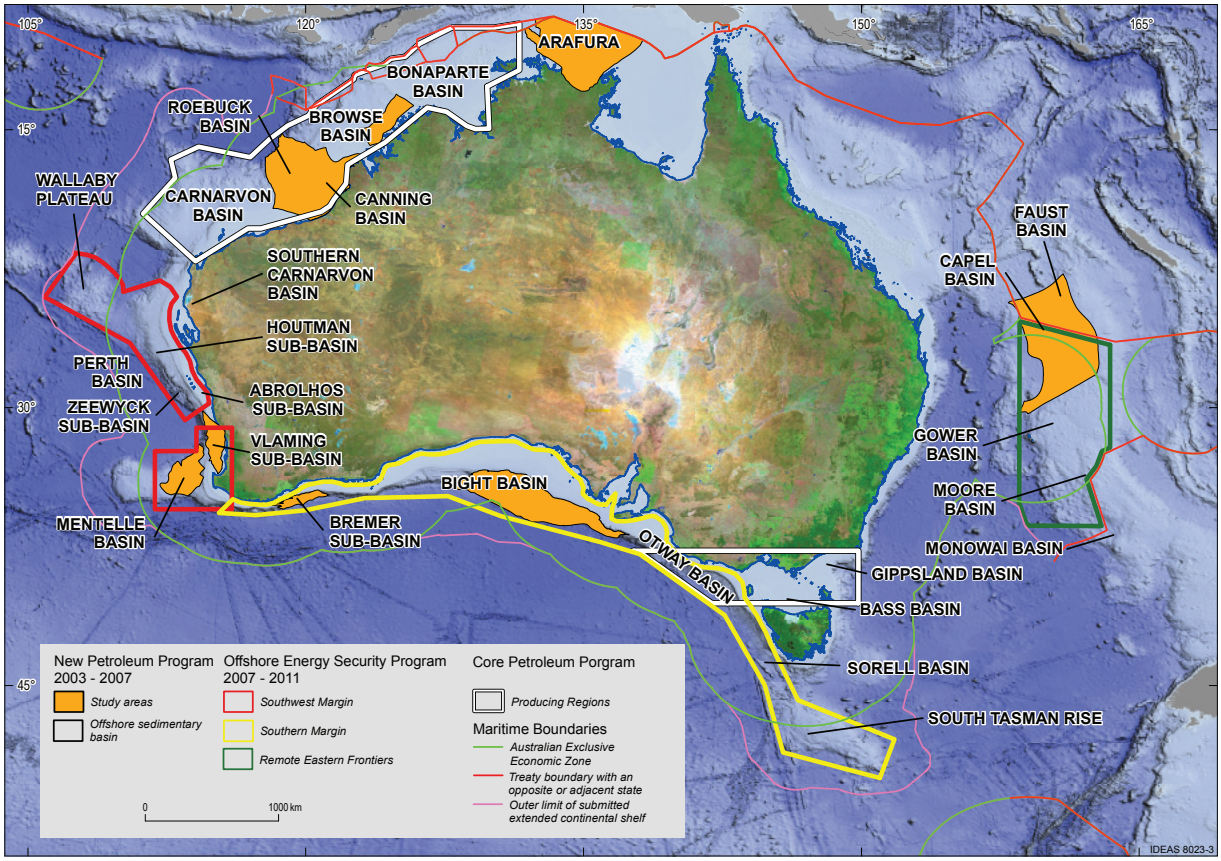


Figure 2. Offshore frontier basins targeted for geophysical and geological data acquisition under the New Petroleum Program ('Big New Oil') between 2003 and 2007 and the Offshore Energy Security Program from 2007 to 2011.

agency's extensive petroleum data archive (*AusGeo News* 77) as well as maintaining the core petroleum program.

The first frontier basins to be assessed were the Southwest frontiers, which included the Mentelle Basin and the Bremer and Vlaming sub-basins off southern Western Australia, and the shallow-water northern Arafura Basin off the Northern Territory (*AusGeo News* 81). Seismic data acquired in the first two areas marked the first seismic surveys in those areas in almost 30 years. The agency also investigated potential natural hydrocarbon seepage around Australia using a combination of approaches including remote sensing (*AusGeo News* 75). A marine reconnaissance survey of the Bight Basin in early 2007 targeted the collection of potential source rocks interpreted from 2D seismic lines. Dredge samples recovered a world-class Cenomanian–Turonian source rock with total organic carbon (TOC) values up to 6.9 per cent (*AusGeo News* 87).

The Offshore Energy Security Program was allocated $75 million in new program funding for the period 2007 to 2011 to continue the offshore frontier basin research (figure 2). The Program focussed on the Remote Eastern Frontiers (including the Capel and Faust basins), the Southwest Margin (including the Mentelle Basin and sub-basins of the North Perth Basin and southern Carnarvon Basin) and the Southern Margin including the Bass, Sorell, and deepwater Otway basins. The resulting data packages will enable explorers to assess the petroleum potential of these areas, provide the base data for future acreage releases and support the assessment and management of marine habitats. The Program also included the development of petroleum systems models for the 'Producing regions' of the North West Shelf.

The Southwest Margins Project in 2009 included a seismic survey, which acquired over 7000 line kilometres of seismic data and a marine reconnaissance survey which acquired new geophysical data as well as geological samples over a vast area. The marine reconnaissance survey collected more than 200 000 square kilometres of multibeam bathymetry – an area almost the size of the state of Victoria (*AusGeo News* 94). The survey included several frontier areas including the Wallaby Plateau, Zeewyck Sub-basin and Mentelle Basin as well as poorly explored areas of the southern Carnarvon Basin and northern Perth Basin (figure 2).

Recent petroleum prospectivity assessments

Geoscience Australia scientists have recently released assessments of the geological evolution and petroleum prospectivity of the Capel and Faust basins (*AusGeo News* 99) and the frontier Mentelle Basin (*AusGeo News* 98). These assessments will guide future scientific and resource exploration in these areas.

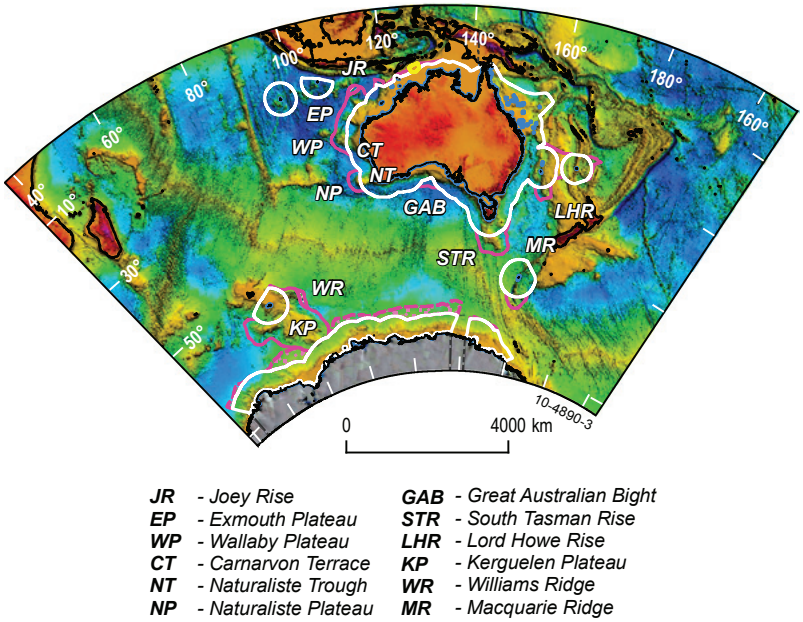
A regular feature of *AusGeo News* since 2005 has been details of the areas offered for release as part of the annual release of Offshore Acreage for petroleum exploration.

Last year also saw the first release of offshore areas designated specifically for the assessment of their greenhouse gas storage potential (*AusGeo News* 94)

Australia's marine jurisdiction

Geoscience Australia played a major role in preparing Australia's submission to the United Nations Commission on the Limits of the Continental Shelf in 2008. The Commission confirmed the location of the outer limit of Australia's continental shelf in nine distinct marine regions, which entitles Australia to large areas of continental shelf beyond 200 nautical miles (see *AusGeo News* 90). This means Australia now has jurisdiction over an additional 2.56 million square kilometres of the seabed (approximately the same size as Western Australia). In these areas, Australia has exclusive rights to what exists on the seabed, including oil, gas and biological resources (*AusGeo News* 93).

The submission was the result of a close partnership between Geoscience Australia, the Attorney General's Department and the Department of Foreign Affairs and Trade.



JR - Joey Rise
EP - Exmouth Plateau
WP - Wallaby Plateau
CT - Carnarvon Terrace
NT - Naturaliste Trough
NP - Naturaliste Plateau
GAB - Great Australian Bight
STR - South Tasman Rise
LHR - Lord Howe Rise
KP - Kerguelen Plateau
WR - Williams Ridge
MR - Macquarie Ridge

Figure 3. Australia's marine jurisdiction and associated seafloor morphology. Australia is the first country to be in a position to proclaim the outer limit of its continental shelf. This image indicates the form of the submarine features that lie within the jurisdiction.

It marked the culmination of 15 years of cutting-edge work, carried out under Geoscience Australia's Law of the Sea and Maritime Boundaries Advice project. The project involved analysis of new data gathered on 17 marine surveys conducted over eight years in some of the most remote and inhospitable parts of the world's oceans (figure 3).

The Law of the Sea surveys commenced in 1994 and by mid-1998 had collected about 30 000 kilometres of deep-seismic data and surveyed five of the seven areas requiring new data (*AusGeo News* 44). Later surveys included Australia's eastern limits to the east of Norfolk Island (*AusGeo News* 57), Macquarie Ridge, southeast of Tasmania (*AusGeo News* 58), and off the Australian Antarctic Territory. In total about 70 000 line kilometres of data were acquired.

Seabed mapping

The agency has been acquiring and collating bathymetric data for the Australian marine jurisdiction since 1963. Geoscience Australia became national co-custodian, with the Royal Australian Navy, for all Australian bathymetry data (*AusGeo News* 80). Geoscience Australia generated a 250 metre spatial resolution bathymetric grid (0.0025 decimal degree) in 2005 to meet client requests and has utilised data from subsequent surveys and from external sources to produce a new version in 2009 (*AusGeo News* 95).

Geoscience Australia is making a major contribution to marine research to help characterise and protect Australia's valuable marine environment. Australia is at the forefront of research to develop methodologies to predict marine biodiversity using geoscience information on the nature of the seabed (*AusGeo News* 84). A range of physical properties such as bathymetry, sediment grain size and seabed temperature are being used to define and map regional 'seascapes'. Appropriate biological data are also being incorporated with these physical data to improve their accuracy (*AusGeo News* 93).

Geoscience information for mineral resources

National datasets

Airborne geophysical surveys have become increasingly important for exploration as it provides credible insights into the subsurface geological architecture at both the regional and specific area scales. Geophysical data provides a cost effective means of visualising aspects of the Earth's subsurface over a large area through the inversion of geophysical data which is combined with known geological features to produce a 3D model (*AusGeo News* 96).

Data from 600 000 gravity stations (or reference points) was used for compilation of the first gravity anomaly map of Australia released in June 1992. By comparison, the third

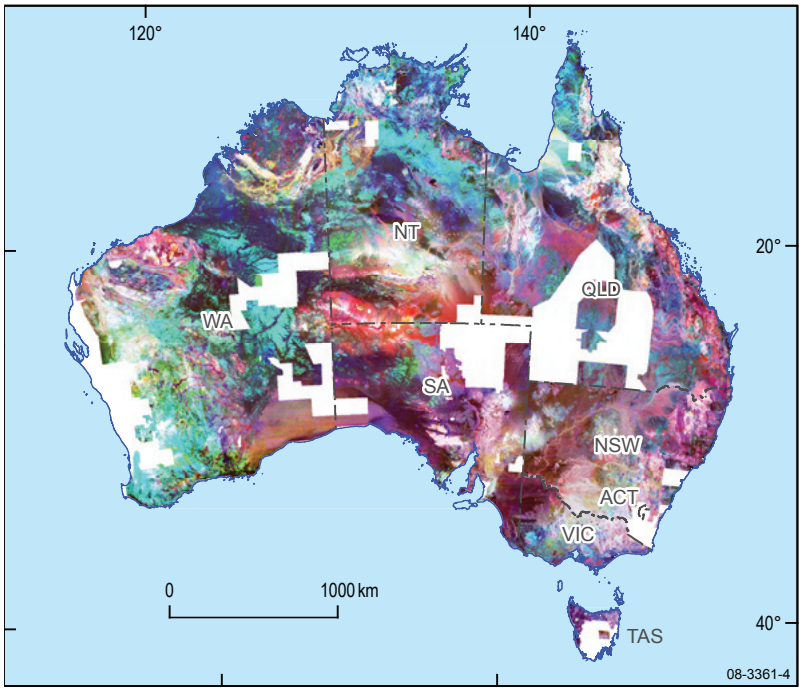


Figure 4. The Radiometric Map of Australia, released in early 2009, provides new insights into uranium prospectivity. The database is derived from levelled and merged composite potassium (red), uranium (blue) and thorium (green) grids. It will directly assist energy, geothermal and mineral resources exploration as well as assist environmental mapping.

edition, released in 2009, was produced from 1.4 million gravity stations (*AusGeo News* 91). The first edition of the magnetic anomaly map of Australia was released in 1993. This map was based on 5.4 million line kilometres of data which had been gathered since 1951. The fifth edition released in 2010 included an estimated 27 million line-kilometres of survey data which is eight million line kilometres more than the previous edition released in 2004 (*AusGeo News* 99). This edition also included results from the Australia-wide Airborne Geophysical Survey, a major output from Geoscience Australia's Onshore Energy Security Program.

Other major continent-wide datasets include:

- The new digital seamless surface geology map of Australia at 1:1 million scale released in late 2008 (*AusGeo News* 93)
- The first Radiometric Map of Australia (figure 4) which will directly assist exploration for uranium and thorium as well as supporting the assessment of geothermal resources (*AusGeo News* 92)
- The Proterozoic and Archean mafic-ultramafic maps which document the major magmatic events and associated mineral deposits across Australia (*AusGeo News* 96).

A new era of cooperation

Compilation of the geological and geophysical continent-wide maps was undertaken with the state and territory geoscience agencies under the National Geoscience Agreement. Its predecessor, the National Geoscience Mapping Accord (NGMA), was developed in the early 1990s to produce a second generation of geological maps, in digital format, at 1:250 000 scale (and in places 1:100 000 scale) covering onshore Australia. Its objective was to stimulate investment in mineral exploration through collaboration between BMR (on behalf of the Australian Government) and the state and Northern Territory government geoscience agencies. The first major study inaugurated under the Accord was the North Queensland Project (1990 to 1996) which was reported in the first issue of *AusGeo News*.

Major features of the initial NGMA projects were: a collaborative, multi-disciplinary approach and the research could be used not only for the assessment of resource potential but also the development of conservation strategies. Other collaborators included Cooperative Research Centres, CSIRO, universities and mineral exploration companies. The multi-disciplinary approach has also become the hallmark of consequent studies by the agency.

Major NGMA projects have included:

- '**TASGO**' was a joint project to characterise the large-scale geological structure of Tasmania to augment the detailed mapping undertaken by Mineral Resources Tasmania (*AusGeo News* 23).

- **Broken Hill Exploration Initiative** (1995 to 2003) was undertaken with the New South Wales and South Australian geological surveys to promote mineral exploration and further discovery in the Broken Hill mineral province (*AusGeo News* 24).
- **Northern Australian Basins Resource Evaluation** (1995 to 2000) focussed on the major petroleum and mineral systems operating between the Victoria River Basin (Northern Territory) and Mount Isa (Queensland: *AusGeo News* 23).
- **The Pilbara Project** (1995 to 2000) investigated the structural uniqueness of the Pilbara Craton in Western Australia to encourage exploration for stratabound base-metal deposits and attracting new interest in exploration for precious metals (*AusGeo News* 56).

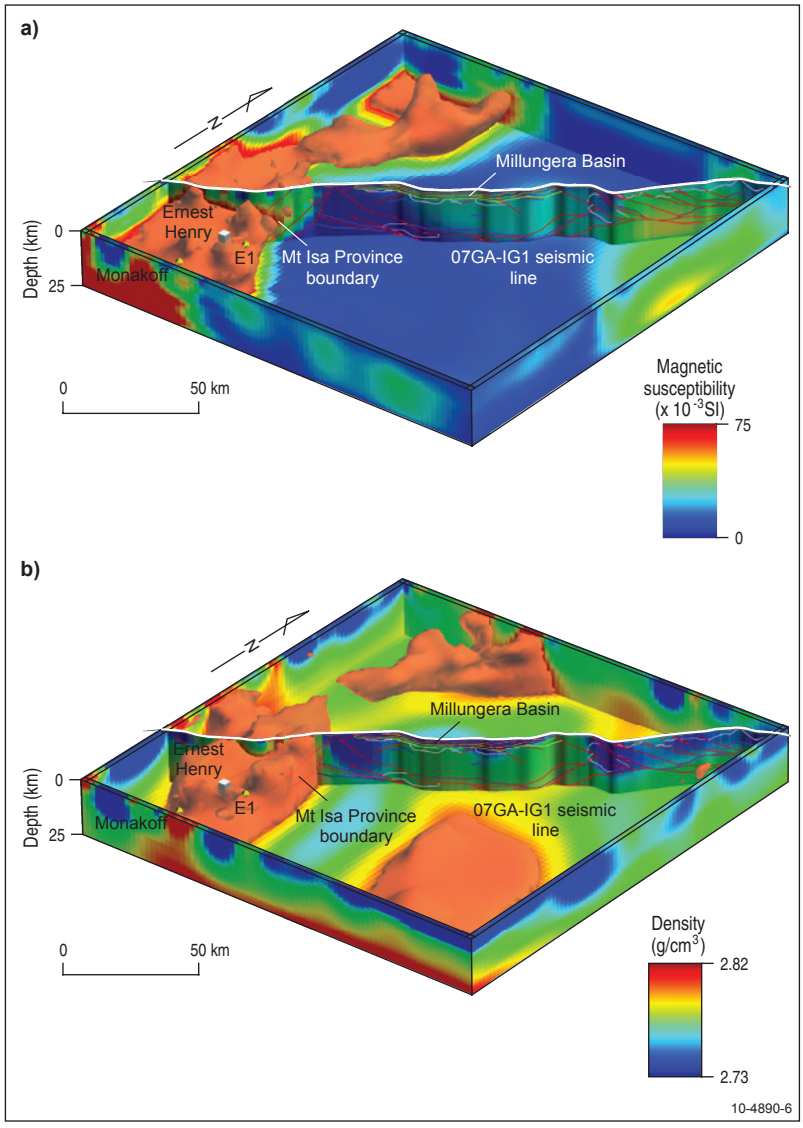


Figure 5. Geophysical inversion is a new method for generating a 3D physical property model capable of explaining observed geophysical data. The ability to visualise subsurface geological features and materials over a large area is a critical time and money saving tool for mineral explorers.

- **The Gawler Craton Project** (2000 to 2003) was a research program to determine the regional-scale processes that formed ore and preserved economic-sized mineral deposits. It focussed on the Olympic Dam copper-gold-uranium province, the central Gawler and the area around the Challenger gold deposit in South Australia (*AusGeo News* 61).
- **The North Australia Project** (2002 to 2004) examined how its geological evolution influenced the mineral potential of the region particularly the gold deposits of the Tanami region (*AusGeo News* 74).
- **Tanami region gold mineral systems** (2004 to 2006) evolved from the North Australia Project and directly targeted controls on lode gold mineralisation (*AusGeo News* 79).

This close collaboration with the state and Northern Territory geological surveys has continued under Geoscience Australia's Onshore Energy Security Program which commenced in 2006. The Program involves the application of the latest geophysical imaging and mapping techniques to attract investment in exploration for onshore petroleum, geothermal and energy resources (such as uranium and thorium). The Program has demonstrated the large-scale application of the seismic method and inversion

techniques (figure 5) to the unravelling of the three-dimensional geology of mineral-bearing rocks below the surface (*AusGeo News* 96).

The Program's projects include the Australia-wide airborne geophysical tie-line survey (AWAGS 2) and the National Geochemical Survey of Australia supported by targeted regional-scale projects in specific areas. These include:

- deep crustal reflection seismic surveys targeting prospective areas in South Australia, Northern Territory and Queensland such as the Gawler Craton, Georgina Basin and north Queensland
- airborne electromagnetic surveys targeting areas with potential for uranium mineralisation such as the Paterson Province in Western Australia, Pine Creek in the Northern Territory, and Frome region in South Australia
- national geothermal energy systems research
- interpretation of the geodynamic framework of major energy provinces such as the Gawler and Curnamona provinces in South Australia.

"Geoscience Australia is currently contributing to several research projects involving groundwater resources."

The North Queensland Project (2006 to 2009) identified fundamental new crustal boundaries and provinces in North Queensland and pointed to areas of previously unknown potential for iron oxide-copper-gold, lode gold, uranium and geothermal energy (*AusGeo News* 96). Geoscience Australia has also contributed scientific expertise to exploration initiatives funded by individual states and territories.

Environmental management and risk mitigation

Natural resource management

The last twenty years have embedded geoscience as an essential input to natural resource mitigation strategies to help sustain the productive base of our agricultural industries. They have included managing problems such as land degradation caused by soil erosion and salinisation. The agency contributed to the Gilmore Project on the eastern margin of the Murray-Darling Basin in western New South Wales (*AusGeo News* 59).

Airborne electromagnetic data was used to provide information on likely areas for salt accumulation. This data when integrated with biophysical data (such as bedrock geology and regolith data) as well as hydrogeological and hydrogeochemical data provided the best information on rates of movement for groundwater and salt (*AusGeo News* 76). The regolith is the loose weathered material that sits between Earth's surface and bedrock. The project also utilised 3D computer modelling techniques to map and visualise the regolith in 3D. This data highlighted those areas in danger of salinisation if current practices were maintained.

The Hydrogeological-Landscape framework, which had been developed for addressing land and water quality issues, is currently being used for a broad range of land use, remedial re-vegetation intervention, and engineering strategies for salinity management and natural resource management applications (*AusGeo News* 97).

Groundwater resources

Geoscience Australia is currently contributing to several research projects involving groundwater resources. They include the Broken Hill Managed Aquifer Recharge Project which is mapping and characterising the groundwater aquifer (or underground storage) systems near Menindee Lakes in western New South Wales. It is part

of a government commitment to improve water efficiency at Menindee Lakes and secure Broken Hill's water supply. The project is acquiring new data to determine whether the use of groundwater resources is sustainable and aquifer storage is practicable. (*AusGeo News* 95). The agency is also leading the Water for Australia's Arid Zone (Palaeovalley Groundwater) Project which has been funded by the National Water Initiative which is funding projects that improve Australia's national capacity to measure, monitor, and manage our water resources. The project is undertaking detailed field studies to better understand the fundamental characteristics and behaviour of groundwater resources in Australia's arid zone. Palaeovalleys are geologically ancient river valleys which no longer function as active surface water systems (*AusGeo News* 93).

"The project's risk assessment methodology has been adapted to Australia's counter terrorism and critical infrastructure protection activities …"

Community vulnerability

In 1995 the National Geohazards Vulnerability of Urban Communities (or Cities) Project was launched. Applied research would assess the risks posed to Australian communities by geohazards, such as earthquakes, landslides, floods, tsunami, and severe winds. The research identified appropriate applications to mitigate these risks such as engineering standards, building codes, planning constraints and the development of appropriate emergency management plans.

Early studies included multi-hazard risk assessments for a number of Queensland communities including Cairns, Mackay, and Gladstone as well as southeast Queensland. The Cairns study, for example, developed a multi-risk assessment which added risk of earthquake, flood, cyclone, wind and storm tide to produce 'community total risk maps' (*AusGeo News* 59). A major multi-hazard risk assessment study of Perth, undertaken in collaboration with federal, state and local government agencies, was released in 2005 (*AusGeo News* 80). These studies incorporated measures of vulnerability, resilience and probability of occurrence. This study has provided a valuable reference for the Western Australian Fire and Emergency Services Authority.

The project's risk assessment methodology has been adapted to Australia's counter terrorism and critical infrastructure protection activities. Safeguarding Australian communities from natural hazards was made a research priority following the Council of Australian Governments *Natural disasters in Australia* (2002) report. It called for a 'nationally consistent system of data collection, research and analysis to ensure a sound knowledge base on natural disasters and disaster mitigation'.

A major Geoscience Australia output has been the National Exposure Information System (NEXIS) which collects, collates and maintains nationally consistent and best available exposure information. It requires detailed spatial analysis and the integration of available demographic, structural and statistical data (*AusGeo News* 88). Information from NEXIS has already been applied for a range of threats to communities and infrastructure along Australia's coast, including sea level rise and extreme weather.

Geoscience Australia is also now contributing significantly to Australia's international aid program through natural hazard risk assessments to identify areas and countries in the Asia Pacific region at high risk from one or more natural hazards (*AusGeo News* 90).

Tsunami warning system

An article in the September 2004 issue (*AusGeo News* 77) discussed how massive earthquakes in the subduction zone off Sumatra, where the Australian plate is subducted beneath the Eurasian plate, had the potential to cause tsunamis large enough to affect north-western Australia and the entire Indian Ocean basin (figure 6). The Indian Ocean tsunami of 26 December 2004 was the most devastating

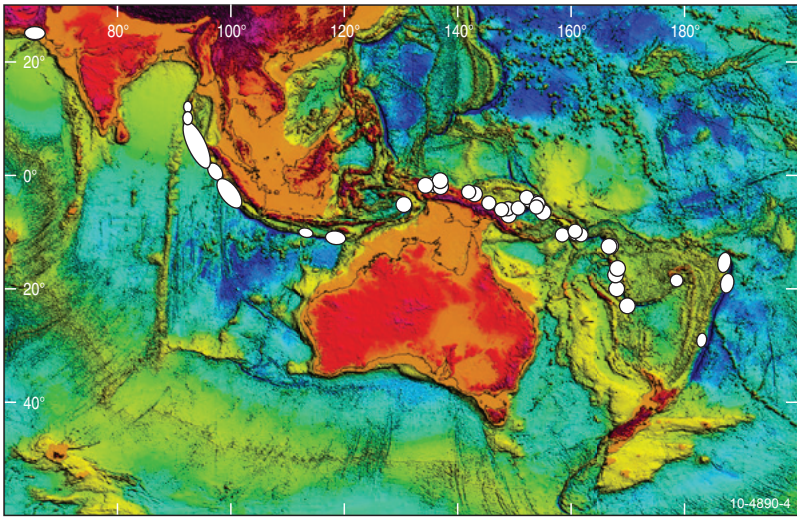


Figure 6. The map shows the major tectonic plate boundaries and location of historic tsunamigenic earthquakes in our region. The tsunami threat originates from the system of subduction zone plate boundaries (or ocean trenches) extending through Indonesia, New Guinea, Vanuatu, Fiji, and the trench systems to the north and south of New Zealand.

earthquake-tsunami event in recorded history. At the time of the tsunami Australia relied on the Australian Tsunami Alert System which provided a limited notification and warning capability. Consequently the Australian Government provided funding in its 2005-06 Budget for the development of an Australian Tsunami Warning System which would contribute to an Indian Ocean Tsunami Warning System.

The agency was allocated funding of $21 million over four years to build on the existing domestic capabilities of Geoscience Australia's seismic monitoring and analysis systems. This included upgrading existing seismic stations, building new seismic stations and gaining access to real-time digital seismic data from new and existing international seismic networks. The system was developed using the scientific and technical expertise at Geoscience Australia, the Bureau of Meteorology and Emergency Management Australia. It became fully operational in June 2009 (*AusGeo News* 96).

The agency has become a major contributor to earthquake and tsunami science and warning systems in the region. It has also collaborated with Fire and Emergency Services Authority Western Australia to raise community awareness and provide the scientific knowledge upon which emergency managers can base their planning (*AusGeo News* 93).

Estuaries and coastal

From the early 1990s the agency carried out studies of sediments and nutrients that threaten coastal and marine ecosystems in waterways around Australia. Studies included Moreton Bay (Queensland), Wilson Inlet and Swan River estuary (Western Australia), Wallis Lake and Myall Lakes (New South Wales) and, Fitzroy River estuary (Queensland). Research was funded by industry and state and regional governments and the data was being used to develop estuarine management plans.

In 2000 and 2001 the agency was involved in taking an inventory of Australian estuarine conditions for the National Land and Water Resources Audit (*AusGeo News* 65). This involved mapping the distribution of different sedimentary environments in 960 Australian estuaries. The results of the research were added to the OzEstuaries database which had information on every estuary and coastal waterway in Australia. The section also contributed to the Cooperative Research Centre for Coastal Zone, Estuary and Waterways Management which compiled the OzCoast component of the CRC website.

OzCoast and OzEstuaries were merged to become part of the new OzCoasts website, the largest central source of coastal information and data in Australia, which was released in August 2008. The data and information available through the website supports natural resource management and the conservation of Australia's coastal zone, estuaries and near-shore environments (*AusGeo News* 91). Recent additions have included a beach database search capability and the Smartline system. The Smartline has many uses for environmental planning, climate change adaptation and hazard assessment.

Geoscience Australia also carried out research into the physical and chemical conditions and the ecological character of the Coorong to identify groundwater discharge and its possible impact on water quality. The Coorong and Lower Lakes are major interconnected coastal water bodies between the Murray River and the Southern Ocean in South Australia (*AusGeo News* 91).

Emergency response and Earth monitoring

Sentinel is an internet-based satellite mapping tool which provides timely information on the location of bushfires across Australia. The system was developed during bushfires in New South Wales and the Australian Capital Territory in early 2002 and operation of the system passed from CSIRO to Geoscience Australia in 2005.

Geoscience Australia acquires satellite data from satellites with thermal infra-red sensors to detect hotspots which indicate bushfires.

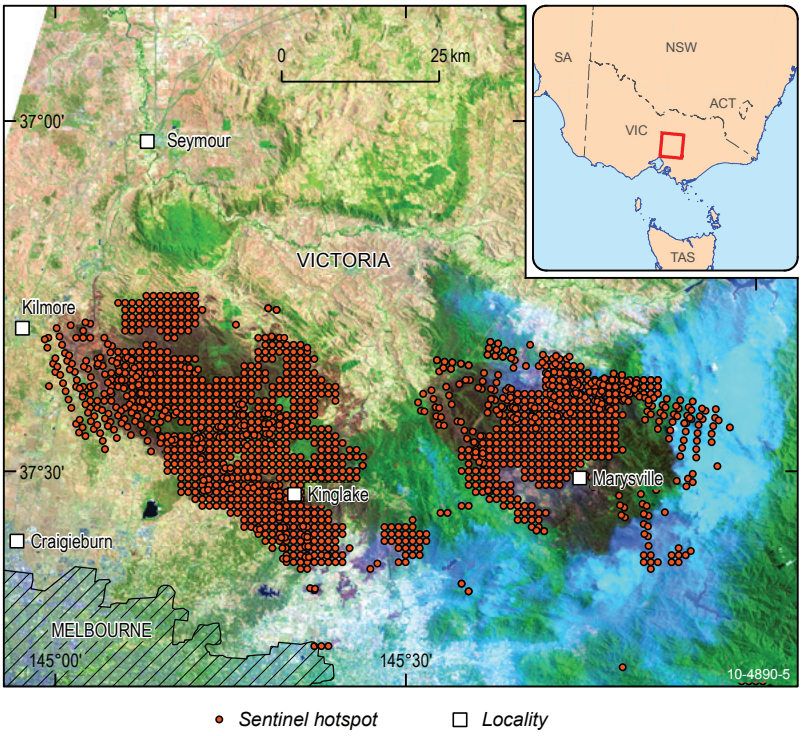


Figure 7. The Sentinel system uses satellites with thermal infra-red sensors to detect hotspots which indicate bushfires. This image depicts hotspots as red square dots overlaid on a satellite image of the Kinglake and Marysville fires in Victoria on 17 February 2009.

The satellites pass over the Australian continent each morning and afternoon and beam their information to Geoscience Australia's ground stations in Alice Springs. The images are analysed automatically by a computer to detect hotspots (figure 7). These satellite scenes are then used to produce maps showing the actual areas burnt, which are used by emergency managers, researchers and the media. During the Victorian bushfires in early 2009 over 5.2 million hits were recorded on Sunday 8 February (*AusGeo News* 94). Satellite imagery is also provided to complement local information available to emergency managers to determine the extent of flooding during major floods.

Satellites are also being used to capture environmental information across the entire Australian continent to assist dynamic land cover mapping. This will capture the pattern of change in the landscape and allow the land cover to be mapped, classified and studied as a dynamic system (*AusGeo News* 92).

Spatially enabling government and the community

The revised topographic mapping of the whole of Australia at 1:250 000 scale (Series 2) was completed in 2003. This was the first national coverage of the whole continent at the standard 250 000 scale available in both paper and digital versions (*AusGeo News* 71). A number of versions of seamless digital maps covering Australia have been released for professional, emergency management, and recreational uses including real-time navigation with global positioning systems (GPS) and backdrops for geographic information systems (GIS).

This data has provided the foundation for more specialised mapping and Geoscience Australia has diversified into providing geographic information for government purposes including emergency

management, defence, marine zone management, public access and industry development (*AusGeo News* 76). Examples include a pilot mapping program to maintain fundamental information for emergency workers initiated in 2004 and maps covering National Parks in Australia's Red Centre for the National Landscapes initiative—a partnership between Tourism Australia and Parks Australia—which identifies and promotes distinctive and inspirational destinations to domestic and international visitors (*AusGeo News* 99). Close collaboration with Australian Government and state government agencies has been a major feature of these programs.

Acknowledgements

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For more information

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From the Archives

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2009 Expanding our knowledge of North Queensland (Issue 96)
www.ga.gov.au/ausgeonews/ausgeonews200912/northqld.jsp

Fighting fire with satellite datasets (Issue 94)
www.ga.gov.au/ausgeonews/ausgeonews200906/fire.jsp

Setting Australia's limits (Australia's marine jurisdiction; Issue 93)
www.ga.gov.au/ausgeonews/ausgeonews200903/limits.jsp

2008 Identifying groundwater discharge in the Coorong (South Australia; Issue 91)
www.ga.gov.au/ausgeonews/ausgeonews200809/groundwater.jsp

Survey of remote eastern frontier basins completed (Issue 89)
www.ga.gov.au/ausgeonews/ausgeonews200803/survey.jsp

2007 New model for Tanami gold mineralisation (Issue 85)
www.ga.gov.au/ausgeonews/ausgeonews200703/tanami.jsp

Assessing prospectivity in offshore frontier basins (Issue 85)
www.ga.gov.au/ausgeonews/ausgeonews200703/offshore.jsp

2006 Preliminary assessment of Tropical Cyclone Larry (Issue 83)
www.ga.gov.au/ausgeonews/ausgeonews200609/larry.jsp

Mineral mapping with ASTER (Issue 82)
www.ga.gov.au/ausgeonews/ausgeonews200606/aster.jsp

2005 Why Australia has so much uranium (Issue 80)
www.ga.gov.au/ausgeonews/ausgeonews200512/uranium.jsp

The Boxing Day Tsunami (Issue 77)
www.ga.gov.au/ausgeonews/ausgeonews200503/tsunami.jsp

2004 Granites may be the key to unlocking Yilgarn history (Issue 75)
www.ga.gov.au/image_cache/GA5019.pdf

Findings beg further study into Tanami gold (Issue 74)
www.ga.gov.au/ausgeonews/archive/200406.jsp

2003 Topo map revision stitched up (Issue 71)
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2002 Conceptual models for national approach to estuary management (Issue 65)
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Ancient deltas key to Bight's oil potential (Issue 65)
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2001 Under cover work in Gawler to penetrate mineral secrets (Issue 61)
www.ga.gov.au/image_cache/GA17318.pdf

2000 Salinity surfaces as a geological problem (Issue 59)
www.ga.gov.au/image_cache/GA17320.pdf

Seabed images off south-east Australia a first (Issue 57)
www.ga.gov.au/image_cache/GA18911.pdf

in brief

Improving spatial data quality and access in the Philippines

The Philippines experiences a variety of natural hazards such as frequent earthquakes, volcanic eruptions, cyclones and annual monsoons (figure 1). These natural disaster events often have a significant social and economic impact.

Analysis of data relating to natural hazards is an essential tool in the mitigation of risks associated with natural hazards. Base data such as topography, bathymetry and digital elevation models at appropriate resolutions and in suitable formats are essential inputs to analytical work. However, availability and accessibility to these fundamental data are major challenges for emergency and disaster risk managers in the Philippines.

Geoscience Australia has been working in partnership with AusAID, Australia's Agency for International Development, and the Government of the Philippines since November 2008 to develop the capacity of the Government of Philippines' technical agencies to analyse and assess natural hazard risk and impact. This project is known as 'Enhancing Natural Hazard Risk Capacity in the Philippines' and is supported and funded by the AusAID Disaster Risk Reduction Unit in the Humanitarian Policy Section based in Canberra. This project also receives significant support and engagement from AusAID staff working at the Australian Embassy in Manila and on the Country Program Desk in Canberra.

Figure 1. Mount Pinatubo is a well-known dormant volcano in the Philippines. The project will help provide fundamental data needed by emergency managers for the mitigation of risks associated with natural hazards.

Working through existing Government of the Philippines mechanisms, this project has engaged with multiple agencies that are part of the Collective Strengthening of Community Awareness for Natural Disasters (CSCAND) agencies, a group that directly supports the National Disaster Risk Reduction and Management Council. The National Mapping and Resource Information Authority (NAMRIA) is responsible for acquisition, management and provision of much of the country's base data. NAMRIA is one of the CSCAND agencies and as part of this project, Geoscience Australia has recently provided technical assistance to NAMRIA as one component of the three-year project.

The NAMRIA work program

The project commenced with a scoping mission in May 2009 to identify specific areas where Geoscience Australia could provide technical assistance to NAMRIA. The scoping mission was a precursor to a work program conducted over the following 12 months. Areas identified for technical assistance included:

- A review of NAMRIA's data validation process to improve the speed of data production throughput and allow access to quality base data by CSCAND.

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- Development of an internal NAMRIA Spatial Data Infrastructure (nSDI) strategic and implementation plan to provide a blueprint for efficient management and dissemination of spatial data across NAMRIA.
- Establishment of a small topographic spatial database and internal web-map interface to this data as a pilot scheme to demonstrate the capability available to NAMRIA to enable online data delivery.

Geoscience Australia officers were embedded for total of six weeks in NAMRIA's headquarters in Fort Bonifacio and the office of the Hydrography Department in Binondo, Manila. In addition NAMRIA staff participated in a working visit to Geoscience Australia and the New South Wales Land and Property Management Authority (LPMA) in Bathurst. Geoscience Australia already has a strong collaborative relationship with the LPMA.

Improving access to spatial data

The nSDI Strategic Plan forms the centrepiece of this work. It was developed by establishing high-level baseline enterprise architecture and identifying key issues in relation to spatial data management and access in NAMRIA. The Plan also proposes a number of possible costed technology solutions and a governance framework around their implementation. If nSDI is adopted, the key benefits to NAMRIA would be:

- reduced duplication of data within the agency
- increased availability and accessibility of data to the CSCAND stakeholders
- a whole-of-enterprise view of data and approach to management of that data and supporting infrastructure
- increased ability to respond to the needs of stakeholders
- development of internal capability and leadership to undertake extension of the nSDI into the national spatial data infrastructure (NSDI).

The work completed for NAMRIA has multiple flow-on benefits and provides opportunities for all stakeholders. Greater access to data within a country prone to a variety of natural disasters will improve the ability to reduce disaster risk, prepare for disasters, respond and support relief and recovery efforts. The work has provided a platform to allow new projects to develop capacity, information and relationships between Geoscience Australia and the CSCAND agencies. In a broader sense Geoscience Australia's engagement in the region has strengthened the ties between the two countries.

For more information

email ausgeo@ga.gov.au

Related articles/websites

AusGeo News 90: Assessing natural disaster risk in the Asia-Pacific region
www.ga.gov.au/ausgeonews/ausgeonews200806/disaster.jsp

Natural Hazards Online
www.ga.gov.au/hazards/

in brief

Update on 34th International Geological Congress—AUSTRALIA 2012

Australia, on behalf of the Oceania region, is hosting the 34th International Geological Congress (IGC), in Brisbane from 5 to 10 August 2012. The Congress is being held at the highly acclaimed Brisbane Convention and Exhibition Centre (figure 1). The IGC represents a once-in-a-generation opportunity for Australia to showcase its geoscience strengths and fascinating geology to the world.

The 34th IGC will feature a wide ranging scientific program, with field trips, a large exhibition, training workshops and an education and outreach program. The Congress will also be the venue for the 2012 meetings of the International Union of Geological Sciences' Commissions, Task Groups and Joint Programs. In addition, the 34th IGC will incorporate the 2nd Young Earth Scientists (YES) congress and benefit from UNESCO patronage.

Sponsorship for the IGC is gathering momentum with commitments now in place from the Australian Agency for International Development (AusAID) and Vale, the world's second largest mining company.

Figure 1. The Brisbane Exhibition and Convention Centre is the venue for the 34th International Geological Congress—AUSTRALIA 2012.

Scientific Program

The overall Theme for the Congress is 'Unearthing our Past and Future – Resourcing Tomorrow'. This encompasses the crucial contributions of the geosciences in meeting societal needs and sustaining planet Earth.

Australia's experience in developing a strong and sustainable mineral and energy resources sector will underpin a program emphasising future mineral and energy supplies. Other major themes, which also reflect major challenges for countries in the Oceania region, will be climate change and its impacts on natural resource management and communities, and understanding and mitigating geohazards. A geoscience 'information supersession' —covering a range of topics from OneGeology (the online worldwide geological map) to data information/standards—is currently the most advanced element of the program.

There will be public lectures, student events and media engagement opportunities to ensure the main messages from the Congress reach the general public. The scientific program remains open for comment and we invite your suggestions.

Field trips

The 34th ICG is planning approximately 30 to 35 pre- and post-Congress field trips which will offer diverse opportunities to experience the fascinating geology of the region. These field visits will include all Australian states and the Northern Territory. In addition, field trips to New Zealand,

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Malaysia and New Caledonia and Papua New Guinea are being planned. There will also be a range of one-day tours available during the conference. The list of proposed field trips is available on the IGC website. Geoscience Australia will directly support two field trips (Mt Isa and Flinders Ranges) and provide advice for many others.

Workshops

Workshops held in conjunction with the IGC will be of two types: Professional fee-based workshops and training will reflect Australian and New Zealand international assistance objectives. The latter are aimed at attracting funding to support attendance by delegates from developing countries. Workshop topics being considered include sustainable mining, carbon sequestration, geohazards and groundwater. Geoscience Australia is playing a key role in securing funding for and organising these workshops.

Congress publications

Abstracts of papers presented at the Congress will be available through the IGC website, GeoRef and in DVD format. Although full papers will not be published by the Congress convenors may elect to arrange publication of papers in their symposia.

Products to be featured at the 34th IGC

Among the products planned for the Congress are:

- a book produced by Geoscience Australia entitled 'Shaping a continent-building a nation: a geology of Australia' an updated version of the digital 1:1million (and derivative) geological map of Australia
- new maps and books on the geology of several Australian states
- 3D maps of selected regions
- a structural map of the Pacific region (coordinated by the Commission for the Geological Map of the World).

Consideration is also being given to a structural/geodynamic/natural risks map of the South Pacific.

Congress website

The First Circular for the 34th IGC was released in October and can be accessed through the 'News' tab on the Congress website. Any readers who would like to make suggestions, volunteer their services, organise business meetings during the event, or simply register interest in attending should do so through the 34th IGC website (see below) using the 'Register your interest' tab.

For more information

email ausgeo@ga.gov.au
visit www.34igc.org

in brief

Shaping a continent–building a nation: a geology of Australia

Geoscience Australia is preparing to publish a new book on Australia's geology for the 34th International Geological Congress (IGC) to be held in Brisbane in 2012. **Shaping a continent–building a nation: a geology of Australia** will tell the story of Australia's geological evolution through the lens of human impacts–illustrating both the challenges and the opportunities presented by the 'lucky country'. The book is not proposed as a definitive authority on all aspects of Australia's diverse geology, nor will it follow the 'traditional' time-based treatment of the topic.

The underlying theme will be how Australia's unique geology has shaped the continent and thus impacted on the Australian people. The book will showcase the excellence of Australian geoscience and will integrate many geoscience disciplines into a systems framework to address many of the 'big questions' relevant to Australians. The book will be a high-quality product written for the broader geoscientific community which will include enduring and topical messages to society as a whole.

The opening two chapters will define Australia and Australians, and will set the spatial and temporal as well as cultural contexts for the remainder of the book. The following eight chapters will be arranged into themes around geological influences on society, environment and wealth.

- ***Living Australia*** is about the emerging understanding of how Australia's biosphere evolved through time and shaped Australia.
- ***Out of Gondwana*** considers the break up and creation of unique Australia as an island continent, and the northward drift towards Asia. The location of the various break-up basins hosting hydrocarbon resources has profoundly influenced the energy source choices made by Australians.
- ***Old, flat and red*** considers the formation of the unique Australian landscape and regolith, which has influenced the fertility of soils and water availability.
- ***Living on the edge–waterfront views*** explores the geological processes that shaped the iconic Australian coastline, and ultimately determined the location of population centres and associated infrastructure.
- ***Water–the nation's life blood*** considers why Australia is the driest inhabited continent and the role aridity has played in shaping the landscape, soils and demography.
- ***Foundations of wealth*** considers the mineral systems and the great wealth of resources which shaped early cultural Australia, economically drove the country, and developed much of the dry interior.
- ***Sustaining the wealth*** outlines the impact of bulk commodities, such as iron ore, hydrocarbons, coal and aluminium, through their enormous export earnings, job creation and effect on regional development.
- ***Deep Heat: meeting future energy needs*** considers geothermal and also nuclear options for energy in a carbon constrained world.
- ***The Epilogue*** ties the main themes of the book together.

The hardback book will be larger than A4 size with more than 500 pages printed in full colour. The beauty of the visual images of Australia's geology will be used extensively to illustrate the text. This book will make a significant contribution to promoting the theme of the 34th IGC meeting which is 'Unearthing our Past and Future – Resourcing Tomorrow' as well as presenting Australia's unique geology in a new light.

For more information

email ausgeo@ga.gov.au

Related articles/websites

34th International Geological Congress (IGC) AUSTRALIA 2012
www.34igc.org

product news

North Queensland energy potential revealed

An assessment of possible new energy resources in north Queensland has recently been released by Geoscience Australia. The potential for both uranium deposits and geothermal energy sources in the region are examined in *An assessment of the uranium and geothermal potential of north Queensland* (Geoscience Australia Record 2010/14).

The research was undertaken, using a geosystems approach, as part of Geoscience Australia's Onshore Energy Security Program. It utilised data and interpretations developed as part of seismic surveys conducted in the Mt Isa region in 2006 and the Isa-Georgetown-Charters Towers region in 2007 (see *AusGeo News* 96).

The study assessed five types of uranium mineral systems (unconformity-related, metasomatic deposits, uranium-bearing iron-oxide copper-gold deposits, magmatic-hydrothermal and sandstone-hosted deposits). Several regions outside of known uranium mineralised areas were identified as having significant uranium potential. Among the areas in the Eromanga and Carpentaria basins identified as having significant potential for sandstone-hosted deposits were:

- within the Eromanga Basin east of Cloncurry
- centred approximately 90 kilometres north of Hughenden
- around the township of Richmond.

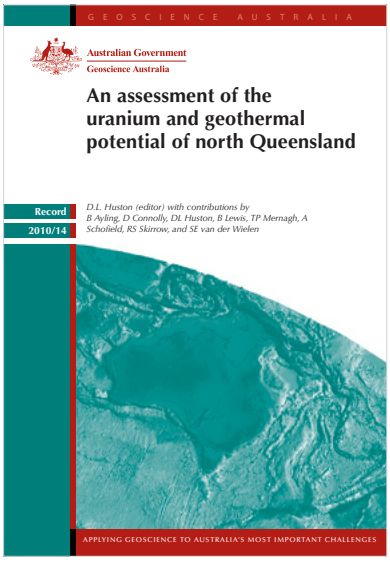
Other areas identified as having potential for other deposit types were:

- extensions of the Mount Isa uranium field to the north and south along bounding faults to the Leichhardt River Fault Trough
- extensions of the Cloncurry iron-oxide copper-gold district undercover to the south and, particularly, to the north along the inferred eastern boundary of the Mount Isa Province
- a northwest trending belt southwest of Cairns which is 50 kilometres wide by 200 kilometres long.

Two types of geothermal systems (hot rock and hot sedimentary aquifer) were assessed. Areas identified as having high potential for geothermal energy systems included the:

- Millungera Basin (a newly identified concealed basin)
- Eromanga Basin
- northwestern part of the Carpentaria Basin, near Burketown
- north-central Drummond Basin
- Galilee Basin.

The main objective of these studies is to provide background data that can be used by industry for exploration. However the data also provide new information that can be used in assessing the potential of north Queensland for uranium and geothermal resources using geosystems (that is, mineral and geothermal systems) methodologies in a GIS environment.



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www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69711

Related articles/websites

AusGeo News 96: Expanding our knowledge of North Queensland

www.ga.gov.au/ausgeonews/ausgeonews200912/northqld.jsp

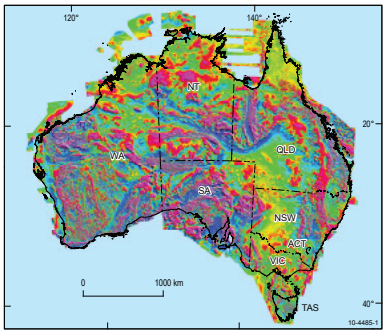
New Magnetic Anomaly Map of Australia

A new printed version of the Magnetic Anomaly Map of Australia at 1:5 million scale was released by Geoscience Australia in September 2010. The new edition contains an additional 115 survey grids acquired since the release of the fourth edition in 2004.

A new method has been used for matching the individual survey grids. A total of 795 individual grids have been matched and merged into the continent-wide grid. These grids include data from many new surveys with most acquired by the state and Northern Territory geological surveys. It is estimated that 27 million line-kilometres of survey data were acquired to produce this map which is eight million line-kilometres more than for the previous edition.

The accuracy of intermediate wavelengths has been increased using new independent airborne total-field magnetic data acquired in 2007 during the Australia-wide Airborne Geophysical Survey (AWAGS). The AWAGS survey was part of Geoscience Australia's Onshore Energy Security Program which is designed to reduce risk in exploration and support development of Australia's onshore energy resources.

The map and associated database provides insight into the distribution of magnetically susceptible minerals within the Earth's crust. Mineral explorers and researchers of the solid earth will find the new map of great value as it highlights the structures of the crust



buried beneath surficial cover (regolith) which can mask the underlying crystalline basement rocks. The magnetic expression of the basement is significant information for mineral explorers by providing important information to support interpretation of the nature and depth of the basement.

For more information

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=70282

events

SEISMIX 2010 Symposium

Staff from Geoscience Australia and the Research School of Earth Sciences at the Australian National University collaborated to organise the 14th International Symposium on Deep Seismic Profiling of the Continents and their Margins - SEISMIX 2010. This biennial meeting is the latest in a series of conferences which commenced in 1984 at Cornell University in the United States. The focus is on the acquisition and interpretation of seismic data across continents, their margins and deep ocean basins. This means structures related to natural resources or natural hazards that affect the lives of communities around the world can be imaged. The symposium was sponsored by the Specialist Group on Solid Earth Geophysics of the Geological Society of Australia, Geoscience Australia, the Australian National University, and IGCP Project 559.

The meeting was held in the Rydges Esplanade Hotel Cairns, between 29 August and 3 September, and was attended by eighty-four earth scientists from fifteen countries. During the week, 112 oral and poster papers were presented on seismic topics which ranged from large scale, deep crustal studies of continental margins and cratonic evolution, through to smaller scale seismic studies of petroleum, mineral and geothermal systems. New to the SEISMIX series was a small session on seismic investigations related to the sequestration of carbon dioxide. New developments in seismic acquisition, processing and modelling methods were also covered.

Figure 1. Delegates to the SEISMIX 2010 Symposium which was held in Cairns between 29 August and 3 September 2010.

The excellent technical program and discussions were complemented and strengthened by the relaxed environment, including a conference dinner at a local crocodile farm which was greatly enjoyed by the overseas visitors and locals alike.

An optional four day post symposium field excursion, led by Dr Ian Withnall from the Queensland Geological Survey and Dr Leonie Jones from Geoscience Australia, provided an opportunity for 25 keen earth-imaging scientists to traverse several deep seismic transects acquired by Geoscience Australia. They could examine the rock specimens and relate them to seismic sections acquired during the regional seismic transects from the 2007 Onshore Energy Security Program North Queensland Project (*AusGeo News* 96). The excursion inspired many stimulating discussions about seismic interpretation, and especially the position of the eastern continental margin of Australia in the neo-Proterozoic (600 million years), also referred to as the Tasman Line.

All delegates agreed that SEISMIX 2010 was a great success and very enjoyable. The next SEISMIX will be held in 2012.

For more information

email ausgeomail@ga.gov.au

Related articles/websites

AusGeo News 96: Expanding our knowledge of North Queensland
www.ga.gov.au/ausgeonews/ausgeonews200912/northqld.jsp

events

Celebrating Earth Science Week

The 13th annual Earth Science Week, an international initiative to promote the earth sciences and raise awareness of geoscience's contribution to the community, was celebrated between 10 and 16 October 2010 based on the theme 'Exploring Energy'. Geoscience Australia has participated in Earth Science Week activities for 12 years, hosting Australia's Earth Science Week website and coordinating Australia's celebrations, which include presentations, Open Days, school excursions and exhibitions.

The *Geologi* Short Film Competition, run in conjunction with the Australian Science Teachers Association, is a major Geoscience Australia contribution to Earth Science Week. Now in its fourth year, *Geologi*'s theme for 2010 was 'Ever-changing Earth' and asked students to explore the role Earth science plays in our interactions with an ever-changing Earth. Entries were received from every state and territory and more than 250 students participated. Awards for 2010 were presented in the Primary and Junior categories, with the Primary Gold *Geologi* won by Phillip Ebson, Flynn Martin and Jacob Lanmaid from Table Cape Primary School, Tasmania and the Junior Gold *Geologi* was presented to Morgan Mikulic, of Marist College, ACT.

Another of Geoscience Australia's Earth Science Week initiatives was the inaugural Top GeoShot Competition, which invited amateur photographers to submit their photographs illustrating the diversity and essence of Australian Earth science. Of the many spectacular entries received, twelve were selected as the Top Shots and were displayed in an exhibition in the Geoscience Australia Foyer and will be included on Geoscience Australia's Education website.

The culmination of Earth Science Week celebrations for Geoscience Australia was the agency's annual Open Day. A range of displays, tours and activities showcased the agency's research, and demonstrated how Geoscience Australia applies its research to some of the major challenges facing Australia. This year over 1200 visitors created their own sedimentary rocks, sampled groundwater of varying palatability, watched volcanoes explode and panned for gold as well as visiting Antarctica and taking a walk back through geological time…all on site at Symonston.

Figure 1. Morgan Mikulic, of Marist College, ACT, receives the Junior Gold *Geologi* from Dr Chris Pigram, CEO of Geoscience Australia. The presentation followed the screening of the successful entries in the *Geologi* Short Film competition during Geoscience Australia's Open Day on Sunday 17 October.

For more information

email ausgeomail@ga.gov.au

events calendar

NAPE Expo 2011	16 to 18 February
American Association of Professional Landmen GBR Convention Center, Houston, Texas, USA Contact: NAPE, 4100 Fossil Creek Boulevard, Fort Worth, Texas 76137 USA	P +1 817 306 7171 f +1 817 847 7703 e info@napeexpo.com www.napeexpo.com
PDAC 2011 International Convention & Trade Show	**6 to 9 March**
Prospectors and Developers Association of Canada Metro Toronto Convention Centre, Toronto, Canada Contact: PDAC, 135 King Street East, Toronto, Ontario M5C IG6	P +1 416 362 1969 f +1 416 362 0101 e info@pdac.ca www.pdac.ca
MSIA Conference 2011	**28 and 29 March**
Mapping Sciences Institute Australia University House, Australian National University, Canberra, ACT Contact: Mapping Sciences Institute, GPO Box 1696, Darwin NT 0801	P +61 2 9280 3400 e info@osdm.gov.au
2011 APPEA Conference and Exhibition	**10 to 13 April**
Australian Petroleum Production and Exploration Association Perth Convention & Exhibition Centre, Perth, WA Contact: Moira Lawler, APPEA Limited, GPO Box 2201, Canberra ACT 2601	P +61 2 6267 0906 e mlawler@appea.com.au www.appeaconference.com.au
AMEC Convention 2011	**28 to 30 June**
Association of Mining and Exploration Companies Inc Burswood Entertainment Complex, Perth, WA Contact: AMEC, PO Box 6337, East Perth, WA 6892	P +61 8 9225 4399 or 1300 738 184 (Within Australia) f +61 8 9221 9377 or 1300 738 185 (Within Australia) e events@amec.org.au www.amecconvention.com.au
XXV International Union of Geodesy and Geophysics General Assembly—Earth on the Edge: Science for a Sustainable Planet	**28 June to 7 July**
Melbourne Convention & Exhibition Centre, Melbourne, Victoria Contact: arinex pty limited, IUGG General Assembly Managers, 91–97 Islington Street, Collingwood VIC 3066	P +61 3 9417 0888 f +61 3 9417 0899 e iugg2011@arinex.com.au www.iugg2011.com

For more information on Geoscience Australia's involvement in the above events
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