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Editor

Stephen Ross

Graphic Design

Maria Bentley

Web Design

Maria Bentley

Graphics and GIS

Geographics Team

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Geoscience Australia

GPO Box 378

Canberra ACT 2601 Australia

Cnr Jerrabomberra Avenue &

Hindmarsh Drive

Symonston ACT 2609 Australia

www.ga.gov.au

Acting Chief Executive Officer

Dr Chris Pigram

Subscriptions

Online subscriptions

<http://www.ga.gov.au/about-us/news-media/subscribe/index.jsp>

Editorial enquiries & Feedback

Steve Ross

p: +61 2 6249 9263

f: +61 2 6249 9926

e: ausgeo@ga.gov.au

Sales Centre

p: +61 2 6249 9966

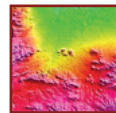
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GPO Box 378

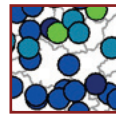
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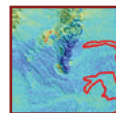
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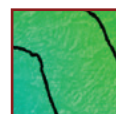


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CEO comment



Dr Chris Pigram – Acting CEO Geoscience Australia



Since the last issue of *AusGeo News*, Neil Williams has announced his intention to retire as CEO of Geoscience Australia. During his time here, firstly as an Associate Director at the Bureau of Mineral Resources (a predecessor of Geoscience Australia) in 1991–92 and as CEO since 1995, Neil has presided over many major changes in the organisation (see below). I see his main legacies to the agency as:

- A strong client and stakeholder focus which means we are now held in high regard by these groups.
- The concept of multi-disciplinary team approaches to the challenges and priorities of the government of the day. This approach has now extended across the organisation beyond the scientific disciplines.
- The organisation’s sphere of influence with government departments and agencies has grown enormously as we adopted new functions and emerged as a stronger agency with increased capacity.

On behalf of our stakeholders and the staff at Geoscience Australia I wish Neil, and his wife Margaret, well for an active and fulfilling future.

This issue of *AusGeo News* includes a progress report on Geoscience Australia’s Onshore Energy Security Program, which provides pre-competitive information to support mineral and energy resource exploration, and is now entering the final 15 months. The Program is now focussing on the delivery of data and project outcomes, including the release of data from: the Paterson Province and Pine Creek Orogen airborne electromagnetic surveys; seismic reflection, gravity and magnetotelluric surveys in South Australia; the southern Georgina Basin deep crustal seismic and magnetotelluric transect; and the National Geochemical Survey of Australia. Preparations are now well-advanced for acquisition along the Kidson–Paterson Seismic Line in Western Australia that is designed to better define the petroleum potential of the Canning Basin. These projects have been undertaken in close collaboration with the relevant state geoscience agencies.

There is also a report on the catchment sampling and compilation of the Preliminary Soil pH map of Australia. The map utilised data gathered during the sample collection phase of the National

Geochemical Survey of Australia. Another valuable aid to natural resource management reported on this issue is the Hydrogeological-Landscape framework. The framework has previously been used for addressing land and water quality associated with salinity but is now being used for a broad range of natural resource applications.

Significant sandstone-hosted uranium deposits are located in paleochannels and mineralisation is often concentrated in a number of specific sites within them. The article examines the geology of deposits in the Lake Frome region (Australia) and the Monument Valley and White Canyon districts in the United States.

In Australia heights above sea level are referenced to the Australian Height Datum (AHD). The widespread use of Global Positioning Systems (GPS) receivers for accurate positioning and navigation in Australia has led to an increasing demand for a method of combining the speed of GPS data acquisition and the practicality of the AHD. The article outlines the development of AUSGeoid09 which provides a solution.

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

Dr Neil Williams announces departure

Dr Neil Williams, the Chief Executive Officer of Geoscience Australia, announced in December 2009 that he would be taking leave from January 2010 pending his retirement towards the end of 2010.

Dr Williams' association with Geoscience Australia goes back to 1967–68 when he served as a summer vacation student with one of the agency's predecessors, the Bureau of Mineral Resources (BMR) during his study as an economic geologist. He received his Bachelor of Science (Hons) at the Australian National University (ANU) in 1969 and undertook PhD studies at Yale University as a Fulbright Scholar. He completed his PhD in 1976 and returned to the ANU where he worked for five years as an academic specialising in the genesis of sediment-hosted base-metal deposits.

He then joined the Mount Isa Mines group of companies working for 10 years as a mineral explorer, ultimately becoming the company's Chief Geologist. Dr Williams joined the BMR in January 1991 when he became Associate Director of the Minerals and Environment Group. He relinquished this position when he became Executive Director of the newly-formed Bureau of Resource Sciences (BRS), which included the mineral and resource assessment functions of the BMR in October 1992.

Appointment as CEO

Dr Williams was appointed CEO of the successor to BMR, the Australian Geological Survey Organisation (AGSO), in April 1995. His appointment led to a period of intense change which included:



Dr Neil Williams, CEO of Geoscience Australia, with The Hon. Martin Ferguson, AM MP, Minister for Resources and Energy and Minister for Tourism, following the launch of the Geological TimeWalk at the Geoscience Australia building on 24 November 2009.

- a new focus on science and its capability as a tool to deliver government programs
- greater emphasis on client and stakeholder needs
- the use of partnerships to help Geoscience Australia deliver its programs
- application of the 'strong inference' science paradigm to improve the agency's work.

The shaping of Geoscience Australia

The role of the agency was broadened, initially through the return of the petroleum and mineral resources branches from the BRS in 1998 and a merger with the Australian Surveying and Land Information Group (AUSLIG) in 2001. The return of the resources functions included providing technical advice for the administration of petroleum exploration and development in Commonwealth offshore waters and policy associated with minerals, petroleum and coal exploration. The merger brought topographic mapping and remote sensing capabilities into the agency.

Recognition of the expansion of the organisation's role beyond mapping and surveying was reflected in the change of name to Geoscience Australia in August 2001 and the Australian Government's recognition that geoscience was fundamental to understanding natural hazards in urban areas, land management in



rural and coastal areas and management of the marine environment.

This broadened capability was further recognised through Geoscience Australia's joint involvement with the Bureau of Meteorology and Emergency Management Australia in the Australian Tsunami Warning System. The system, which became operational in June 2009, had been set up following the Indian Ocean tsunami on 26 December 2004.

Major achievements under his leadership

Dr Williams' continuing efforts to promote Geoscience Australia as an important contributor to ensuring Australia's economic future has resulted in the agency having a central role in the Government's offshore and onshore energy security programs. The government allocated \$61 million in its 2003 budget for work over four years from 2004 to 2007 to provide pre-competitive information to support industry's search for a new oil province.

This program was followed by a further \$134 million in new funding in August 2006 to gather pre-competitive data during the four years to 2011. Of this, \$75 million was allocated for continuation of offshore frontier basin research to identify a new oil province. The remaining \$59 million was allocated for the application of the latest geophysical imaging and mapping technologies to attract investment in exploration for onshore petroleum, geothermal and mineral energy sources such as uranium and thorium.

Under Dr Williams' stewardship Geoscience Australia also played a major role in preparing a submission to the United Nations Commission on the Limits of the Continental Shelf in 2008 which resulted in 2.56 million square kilometres being added to Australia's continental shelf. The submission represented the culmination of 15 years of cutting-edge work in collaboration with the Attorney-Generals Department and Department of Foreign Affairs and Trade in which Geoscience Australia was responsible for the surveys, data analysis and interpretation required to delineate the outer limits of the extended Continental Shelf.

There have been significant changes and many new functions adopted during the period of Dr Williams' leadership. These have ensured that Geoscience Australia is a stronger agency with increased capability and a greater range of roles and functions than at any other time in its history. These have included: development of the National Geoscience Agreement which is a collaborative geoscience mapping agreement with the states and Northern Territory, compilation of continent-wide geophysical maps and datasets, embedding geoscience

as an essential input to natural resource mitigation strategies, providing a three-dimensional geological framework to facilitate more effective exploration beneath regolith and sedimentary cover, and taking a lead role in the development of the geoscience aspects of carbon sequestration.

Recognition of his dedication

The quality of his leadership was recognised when Dr Williams was awarded The Public Service Medal on 26 January 2006 for 'outstanding public service in the provision of geoscientific advice to government, geoscience services, industry and the public'. The medal is recognition of his consistent dedication in performing a demanding job to the highest standard and making a major contribution to the Australian community.

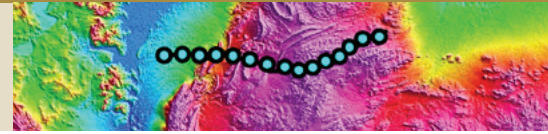
Dr Williams' legacy has been to reshape a respected mapping agency into a highly capable geoscience agency focused on the priorities of the government which is respected nationally and internationally for its capability and excellence.



Onshore Energy Security Program maintains momentum

Delivering data and improved scientific understanding

Ned Stolz



Geoscience Australia's Onshore Energy Security Program (OESP) is a five-year program announced in August 2006 designed to reduce risk in exploration and support development of Australia's onshore energy resources. The program received funding of \$58.9 million to acquire and deliver pre-competitive geophysical and geochemical data as well as value-added geological interpretations and other products for the exploration industry. Projects within the scheme were implemented either at the national scale or were focussed on particular geological regions identified as having the potential to host undiscovered energy resources. The main components of the Program are:

- An Australia-wide airborne geophysical survey (AWAGS) to improve the quality of airborne radiometric and magnetic datasets for uranium and geothermal energy exploration.
- A national geochemical survey to provide consistent baseline information about chemical concentrations in the crust, particularly radioelements such as uranium and thorium.
- Regional scale (between 100 and 1000 kilometres) deep crustal reflection seismic surveys targeting areas prospective for hydrocarbon, uranium, and geothermal energy resources.
- Regional-scale airborne electromagnetic (AEM) surveys targeting areas with potential for uranium mineralisation.
- A national project aimed at improving the quality of pre-competitive data and knowledge for targeting geothermal energy systems.
- Regional scale interpretations of the geodynamic framework of major energy provinces based on seismic, potential-field, and other geoscientific datasets.

As the OESP has moved into its final two years the program is focussing on the delivery of data and project outcomes to the resource exploration industries. A full description of OESP projects can be found on the Geoscience Australia website and new data releases and updates are announced through Geoscience Australia's monthly newsletter *Minerals Alert*.

Completed projects and major products

New radiometric map of Australia

The new Radiometric Map of Australia (see *AusGeo News* 92 and 95) was produced by levelling and merging hundreds of separate airborne radiometric surveys using a national baseline dataset derived from the AWAGS survey (Minty et al 2009). The map was launched by the Minister for Resources and Energy, the Hon. Martin Ferguson AM MP, during the Australian Society of Exploration Geophysicists 20th International Conference and Exhibition in Adelaide during February 2009.

The availability of the new merged radiometric data via the Geophysical Archive Data Delivery System (GADDS) on the Geoscience Portal website led to an increase in downloads of digital data from 21 000 megabytes in January 2009 to 58 000 megabytes in March 2009. The radiometric dataset covering the Australian mainland and Tasmania (over 73 gigabytes of data) is too big to be delivered via the web; however, 65 clients have requested the full data be copied onto a portable hard-drive.

The new Radiometric Map of Australia and its application to energy and mineral exploration and other land use issues featured in several conference presentations given by Geoscience Australia staff during 2009. They included a keynote address by the recently-retired CEO, Dr Neil Williams, at the AusIMM Uranium Conference in Darwin, which can be viewed through the Geoscience Australia website.

The results from the AWAGS survey have also been incorporated into the soon-to-be-released 5th edition of the Magnetic Anomaly Map of Australia. The very long flight lines of the AWAGS survey give an accurate coverage of the intermediate wavelengths (150 kilometres to 400 kilometres) of the Earth's crustal magnetic anomaly field. This provides an important constraint when merging over 800 separate airborne magnetic survey grids together to produce the new national map. The new edition of the map exemplifies how Geoscience Australia constantly improves the quality of pre-competitive datasets available to industry.

“National and regional projects are now well advanced and most are processing, analysing, modelling and reporting on acquired data.”

North Queensland geodynamic interpretation

The North Queensland geodynamic framework interpretation was one of the first major regional projects delivered under the OESP. The project was undertaken in collaboration with the Geological Survey of Queensland (GSQ) and culminated in a very successful workshop in Townsville in July 2009 which was attended by over 80 industry, research and government stakeholders. The workshop summarised the acquisition, processing and interpretation of 1176 kilometres of deep reflection seismic data and magneto-telluric (MT) data—one of the largest deep crustal seismic interpretation projects ever undertaken! The project also included results from modelling and inversion of magnetic and gravity data, solid geology interpretation, and construction of a 3D geological model for the North Queensland region. Extended abstracts from the workshop are included in the Proceedings of the AIG Northern Queensland Exploration and Mining 2009 conference (Camuti and Young 2009). Results from the project are also included in Geoscience Australia Records 2009/29 (Chopping & Henson 2009) and 2009/30 (Kositcin et al 2009).

A summary of the interpretation outcomes, including the implications for energy exploration, was featured in *AusGeo News 96*. Key results were:

- discovery of the Millungera Basin beneath the younger Carpentaria Basin

- imaging of a major crustal boundary at the eastern margin of the Mt Isa Province
- detecting an interpreted fossil subduction zone to the west of the Etheridge province.

These results have been favourably received by explorers in the region, with some companies incorporating the new models into their targeting criteria. To follow up the project outcomes, GSQ have recently acquired another 240 MT stations in the Mt Isa region. They include 50 stations designed to resolve the structure of the Millungera Basin and the Geological Survey of Queensland expects to release the MT results during 2010.

Current projects and recent data acquisition

Geoscience Australia's Airborne Electromagnetic Project has already released contractor-supplied data from the Paterson and Pine Creek regions, and is currently inverting these data and compiling complementary datasets for interpretation and release in 2010 and 2011.

The Geodynamic Framework Project is now collaborating with Primary Industries and Resources South Australia to interpret over 1300 kilometres of seismic reflection, gravity and MT data in South Australia. The National Geochemical Survey of Australia has completed sample collection and is now delivering preliminary results such as the Preliminary Soil pH map of Australia.

Paterson Province AEM Survey, Western Australia

Regional Airborne Electromagnetic (AEM) surveys are a major component of the OESP because of their ability to map basement rocks, and identify key features associated with uranium and other mineral system prospectivity. The Paterson AEM survey in north-west Western Australia is the first AEM project to be delivered under the OESP. The survey comprises 29 200 line-kilometres covering a region of 49 000 square kilometres, which includes the Kintyre uranium deposit, the Nifty copper mine and the Telfer gold mine. Production of value-added and interpretation products from the survey is continuing. A drillhole database used to assist with interpreting the Paterson AEM data has been released as Geoscience Australia Record 2009/31 (Roach 2009). The database includes locations for over 6500 publicly-available drillholes in the Paterson region and logs for over 4300 of these holes (figure 1).

The AEM data are being interpreted using sample-by-sample layered earth inversion (LEI) products due for release in April 2010

using an algorithm developed at Geoscience Australia (Brodie and Sambridge 2006). LEI products include located data, geo-located conductivity depth sections, depth slice grids, elevation slice grids and an inversion report. The inversion report will include a model description, a selection of data products and validation using public domain drillhole logs. Another important product to be released is the per cent data influence (PDI), which measures the change in the inverted conductivity relative to the change in the reference model, based on results of two fit-for-purpose inversions. The PDI is used as a skin between the data-driven and the model-driven results of the inversion, and has been incorporated into all LEI products. Since the PDI indicates the effective depth penetration of AEM, Geoscience Australia has created an AEM 'Go-map' based on the PDI gridded to a depth of 500 metres.

Staff involved in the AEM project will present key results from the Paterson AEM survey to industry and other stakeholders at a one-day workshop in Perth planned for April 2010. In late 2010 Geoscience Australia plans to release an interpretation report describing the geological and energy implications of the Paterson Province AEM survey. The report will highlight the use of regional AEM surveying for decreasing exploration risk in frontier exploration areas as well as its application in more mature exploration terrains.

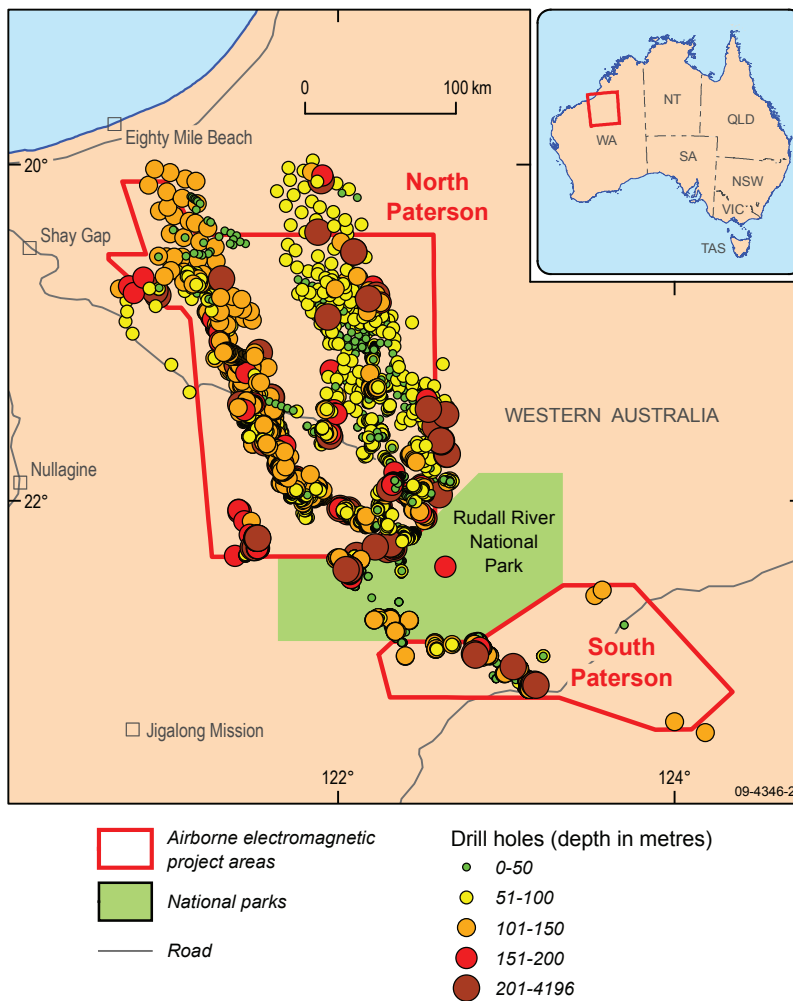


Figure 1. Location and depth of drillholes included in the recently-released database shown with the survey boundaries of the Paterson AEM survey data. Inset map shows the location of the Paterson AEM region in northwest Western Australia.

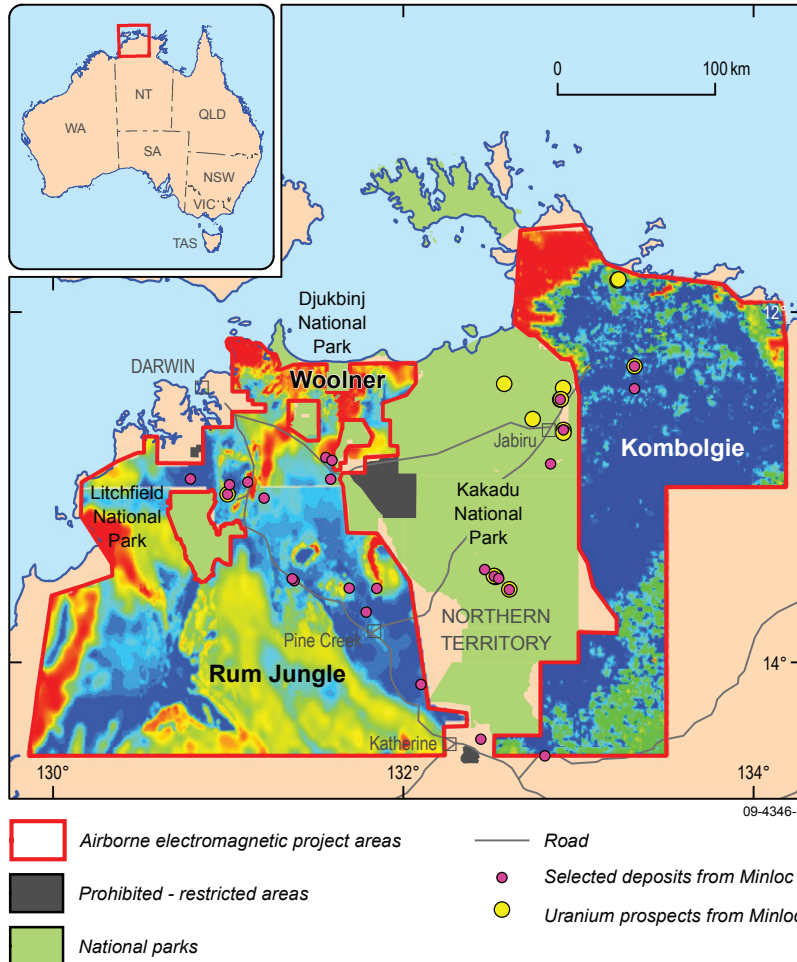


Figure 2. The Pine Creek AEM Survey regions in the Northern Territory of Australia showing selected uranium and mineral deposits associated with example EMflow 40-60 metres and EMflow 45-60 metres conductivity grids from the Woolner–Rum Jungle and Kombolgie survey areas respectively. Cool colours indicate resistive areas while warm colours indicate conductive zones.

Pine Creek Airborne Electromagnetic Survey, Northern Territory

The Pine Creek Province in the Northern Territory is highly prospective for unconformity-related uranium deposits. Here the Mesoproterozoic Kombolgie Sandstone of the McArthur Basin unconformably overlies Archean to Paleoproterozoic granites and metasedimentary rocks of the Pine Creek Orogen. There is also potential for sandstone-hosted uranium (Westmoreland style) deposits where the Oenpelli Dolerite intrudes Kombolgie Sandstone. The area south of Rum Jungle has a potential for buried Cenozoic palaeovalley-hosted uranium; however, further evaluation is required to establish the existence of suitable structures in the region.

There are many currently known uranium occurrences in the Pine Creek region, with the main deposits being: Ranger, Jabiluka, Koongarra and Narbarlek in the Alligator River area; Dysons and

Whites in the Rum Jungle area; and Coronation Hill in the South Alligator Valley area. All these deposits are located below the Kombolgie unconformity within Paleoproterozoic metasedimentary rocks.

The Pine Creek AEM survey was the largest regional AEM survey ever undertaken in Northern Australia, and possibly one of the largest anywhere in the world. This survey covered more than 75 000 square kilometres. The flight line spacings employed during this survey are a combination of 1.66 kilometre and 5 kilometre spacings and were designed to target those areas with the highest prospectivity in the region. The Pine Creek survey is divided into two major parts, namely an eastern portion and a western portion, as shown in figure 2. The western portion includes the Woolner Granite and Rum Jungle areas. The eastern portion is mostly the Kombolgie Plateau and associated near-escarpment foothills and slopes, but also includes the northern coastal plain extending as far north as the Cobourg Peninsula.

In the western portion the TEMPEST AEM fixed-wing system was used whereas in the eastern one the VTEM helicopter-based system was used. The processed survey data from the west may better highlight subsurface geological features, such as unconformities, which are possibly related to uranium mineralisation. Elsewhere, and towards the eastern area,

possible palaeovalley-hosted and other structure-related uranium mineralisation could play a more important role. Contractor-supplied survey data are now available for download via a link on the AEM Project webpage which can be accessed through the Geoscience Australia website.

To facilitate interpretation of the AEM responses, subsurface electrical conductivity predictions are derived from the AEM survey data using Geoscience Australia's LEI algorithm. An example LEI model from the Woolner Survey Area is shown in figure 3. A drillhole database has been constructed incorporating the deeper mineral exploration drillholes and water bores across the survey area. These are being integrated with other data-layers in 2D and 3D to support the AEM data interpretation processes.

The processed and interpreted Pine Creek AEM datasets will help define the presence and extent of conductive units in the Pine Creek Orogen, and the depth to the known unconformity between the Pine Creek Orogen and the Kombolgie Subgroup. In addition, they will enable more reliable predictions of the depth and extent of the Woolner Granite and Koolpinyah Dolomite.

Interpretation of the AEM data will help identify and characterise a range of mapped and unmapped major geological structures that may have served as mineralising fluid pathways. Palaeovalleys may also be mapped in the survey region and an estimate of the thickness of Mesozoic–Cenozoic sedimentary cover derived.

The OESP projects in the Pine Creek and Paterson areas, have delivered reliable, pre-competitive AEM data to the exploration industry, and have improved the scientific understanding of the energy resource potential of the region.

Gawler–Curnamona geodynamic interpretation

This regional interpretation project focuses on the uranium and geothermal energy potential of the Gawler and Curnamona provinces in South Australia. Three deep crustal reflection seismic lines were acquired in June and July 2008 (see figure 4):

- the Gawler Line (08GA-G01) across Eyre Peninsula from east of Streaky Bay to just south of Port Augusta

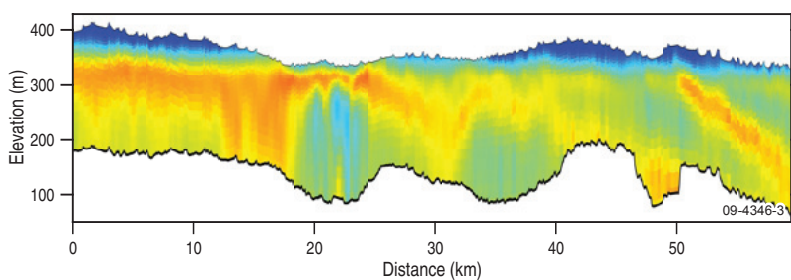


Figure 3. An example of a Geoscience Australia layered earth inversion (LEI), for an area near the Woolner Granite, showing resistive Cretaceous cover and a strong, easterly-dipping conductive unit in the far right of the image. Cool colours indicate resistors while warm colours indicate conductors.

- the Arrowie Line (08GA-A01) which crosses the Arrowie Basin to the north of Port Augusta
- the Curnamona Line (08GA-C01) which runs south to north across the Frome Embayment and terminates on the Mt Painter Inlier.

Magneto-telluric data were collected along the Gawler and Curnamona Lines to image the electrical conductivity structure of the deep crust. Refraction seismic data were collected along the Gawler line using source-receiver offsets of up to 70 kilometres which allowed seismologists to estimate the seismic velocities of the deep crust.

In January 2009, Primary Industries and Resources South Australia (PIRSA) provided funding which enabled completion of a fourth line (09GA-CG1) which links the Gawler and Curnamona provinces across the Flinders Ranges. This line provides a connection between the Gawler and Arrowie Seismic Lines and an east-west seismic line acquired over the Curnamona Province in 2003–04 (03GA-CU1). Consequently there is a deep crustal seismic transect from the western Eyre Peninsula through to Broken Hill.

Processed seismic data and sections from these four lines can now be downloaded from the Geoscience Australia website. Results over the Arrowie Basin have generated interest from a

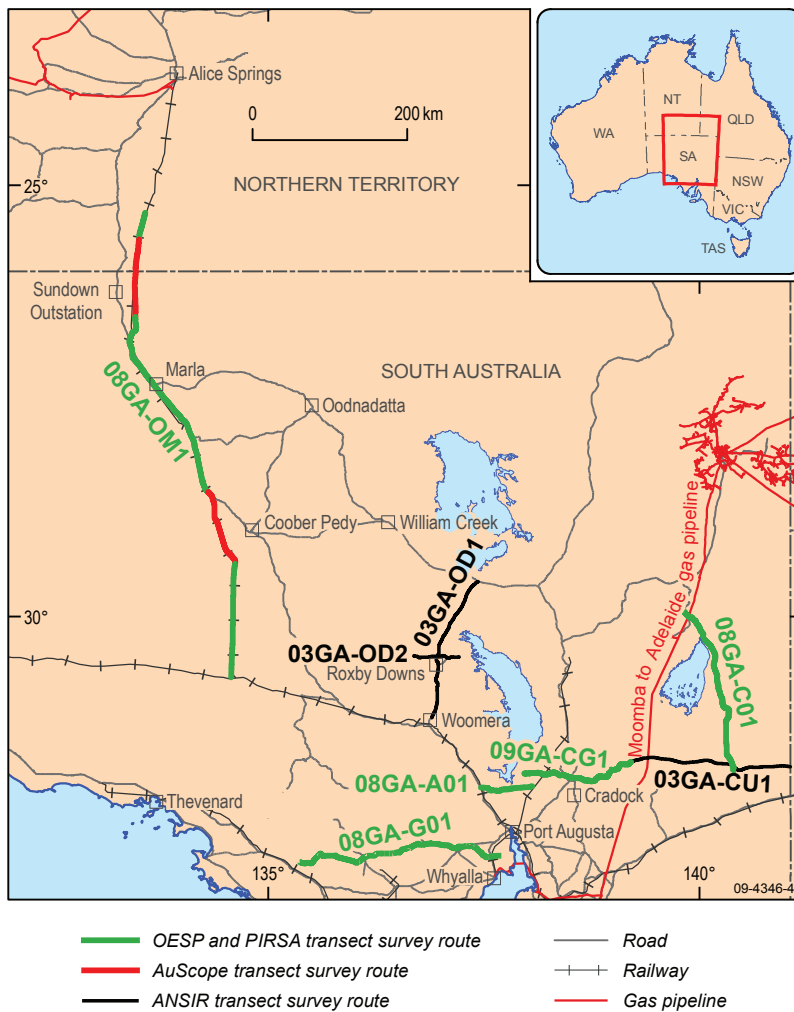


Figure 4. Location map of northern South Australia showing the seismic traverses acquired under the OESP and AuScope programs as well as pre-existing seismic traverses.

number of companies which are actively exploring for hydrocarbons, minerals, and geothermal energy resources. The Gawler Line crosses an interpreted magnetic domain containing Archean granites recently dated by Geoscience Australia and PIRSA as being some of the oldest in Australia (about 3100 million years: see *AusGeo News* 92). The Archean domain within the predominantly Proterozoic age rocks of the Gawler Craton may have major implications for the geodynamic interpretation of the region. These include the potential to host base-metal, iron-ore and uranium deposits.

Acquiring MT data at 10 kilometre station spacings along the transects was a major component of the Gawler–Curnamona surveys. The OESP is the first program in over two decades in which Geoscience Australia scientists have been directly involved in acquisition, processing and interpretation of MT measurements. MT data along the east-west Gawler line were acquired in a collaborative project between the University of Adelaide and Geoscience Australia.

The acquisition of data along the Link line was a collaborative project between PIRSA, Geoscience Australia and the University of Adelaide. The data along the north-south Curnamona line were acquired for Geoscience Australia on contract. Processing and preliminary interpretation of the MT data for these surveys will be completed this year and results will be incorporated into the geodynamic analysis of the Gawler and Curnamona provinces. Figure 5 shows MT station locations in South Australia and a conductivity-depth section derived from the MT measurements along the Curnamona Transect (08GA-C01). The image shows conductive near-surface sediments of the Frome Embayment in the top of the section, south of the more resistive Mt Painter Inlier. The conductive zone at depth on the southern end of the transect is interpreted as rocks of the Willyama Supergroup. Images of the conductivity structure of the crust are highly complementary to the structural information provided by the reflection seismic data.

Interpretation of the seismic sections has now commenced in collaboration with geologists from PIRSA. Seismic and MT data are being integrated with other geological and geophysical data, including 3D inversions of the gravity and magnetics. Results of the regional interpretation will be released during a workshop on 6 May 2010 following the South Australia Resource and Energy Investment Conference (SAREIC) in Adelaide.

Gawler–Officer–Musgrave–Amadeus (GOMA) Seismic Line

This project is a collaborative effort between Geoscience Australia (as part of the OESP), AuScope (funded by the National Collaborative Research Infrastructure Strategy: NCRIS), PIRSA, and the Northern Territory Geological Survey (NTGS). The line (08GA-OM1) extends south to north from Tarcoola in South Australia to 200 kilometres south of Alice Springs, crossing the northern margin of the Gawler Province, the eastern end of the Officer Basin, the eastern end of the Musgrave province and the southern margin of the Amadeus Basin (figure 4).

Both the Officer and Amadeus Basins are considered to be under-explored for hydrocarbons. Exploration during the 1960s and 1970s identified hydrocarbon shows in these Neoproterozoic to Paleozoic

basins but since the discovery of commercial oil and gas in the Cooper–Eromanga province in the late 1960s, only limited exploration has been carried out. The Amadeus Basin is the only Neoproterozoic–Paleozoic province currently producing hydrocarbons in Australia.

The seismic survey was completed in December 2008 and follows the Adelaide–Alice Springs railway line. Reflection seismic, MT and gravity data were acquired. The seismic line will significantly contribute to understanding basin initiation, architecture and evolution. It is anticipated that the processed data will allow the delineation of structural styles in great detail and highlight unconformities and reactivated faults. The delineation of deep structures will lead to an improved understanding of the geological controls on the deposition of sedimentary strata and thermal history of potential hydrocarbon source rock intervals.

The AuScope contribution to the project, funding an additional 200 kilometres, enabled the acquisition of a continuous 634 kilometre long data transect from the Gawler Province to the Amadeus Basin. This line crosses the interpreted geodynamic boundary between the South Australian Craton and the North Australian Craton and is anticipated to stimulate further research into the fundamental structural architecture of the Australian continent.

The GOMA data are currently being processed with the seismic data scheduled for release in June 2010. Interpretation will involve

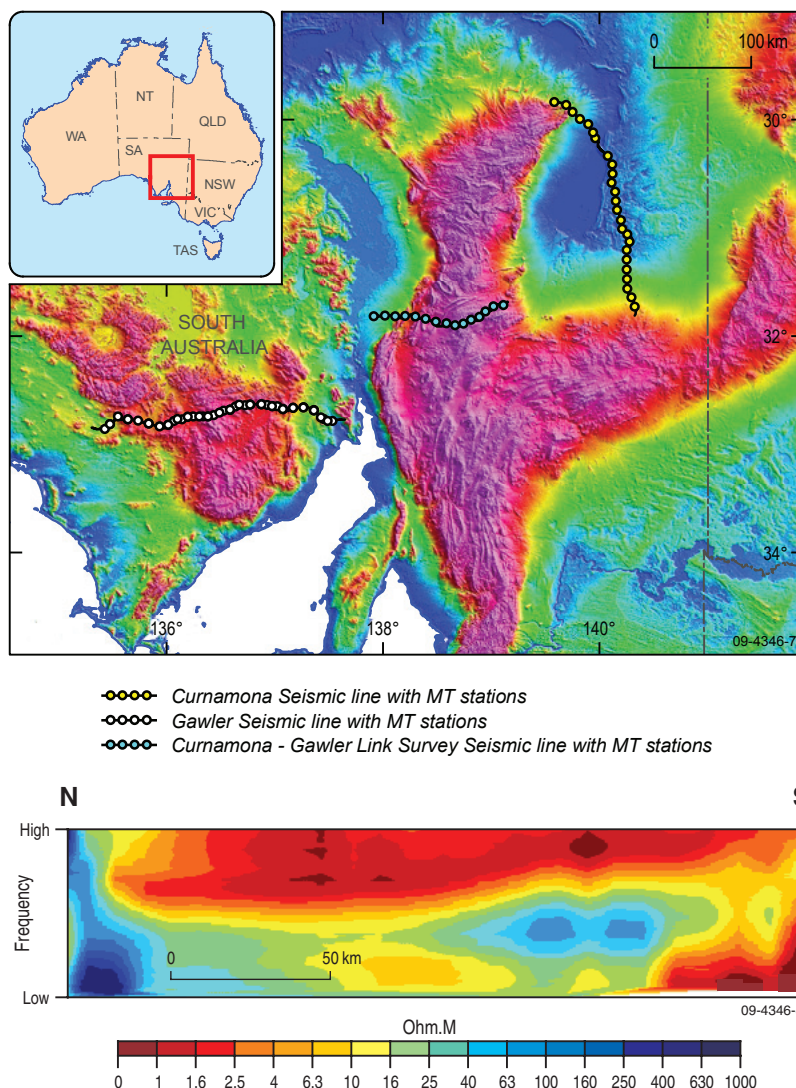


Figure 5. MT station locations in South Australia. Pseudosection of apparent resistivity from MT measurements along the Curnamona transect (yellow dots). North is to the left. Conductive near-surface sediments of the Frome Embayment are clearly imaged in the top of the section, south of the more resistive northeastern extremity of the Flinders Ranges. At the southern end of the transect the Willyama Supergroup appears conductive at depth.

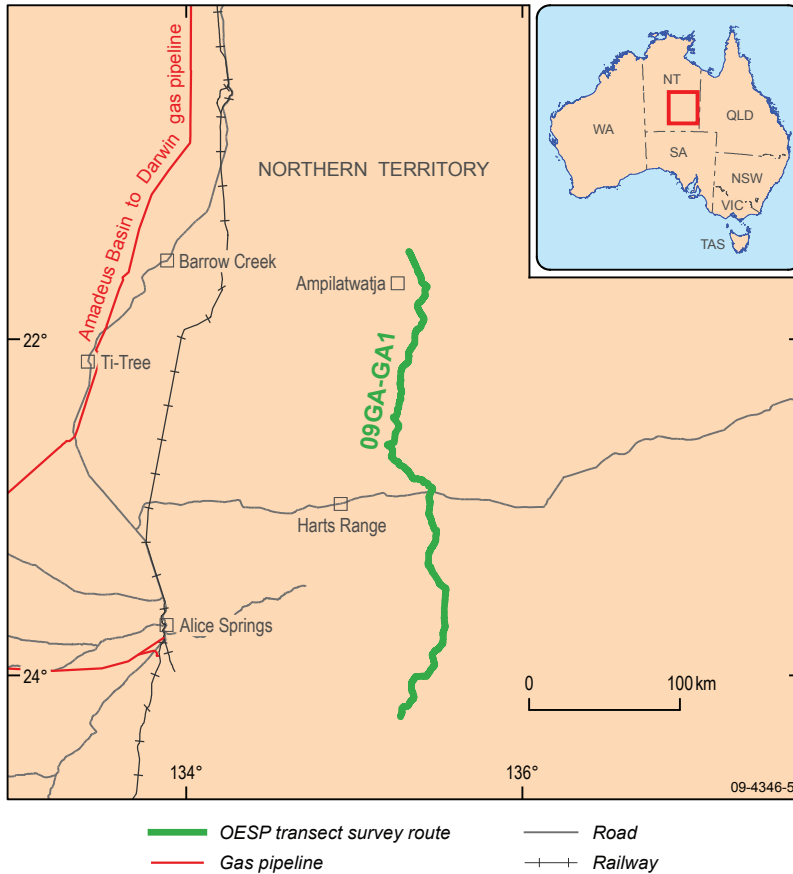


Figure 6. Location map for the Georgina–Arunta Seismic Line (09GA-GA1) in central Australia. Total line length is 373 kilometres.

geologists from Geoscience Australia, PIRSA, AuScope, University of Adelaide and others. The interpretation results will be released at a stakeholders’ workshop coinciding with the PIRSA Explorers Day Seminar in Adelaide in December 2010.

Georgina–Arunta Seismic Line

The southern Georgina Basin in northern Australia has a demonstrated prospectivity for hydrocarbons, but exploration is still at a frontier stage, with minimal seismic data available. In July 2009 a deep crustal reflection seismic and MT transect (09GA-GA1) was completed across the basin in the Northern Territory (figure 6). Interpretation of results from the survey will provide an architectural framework for evaluating the geological history of the basin. This should lead to a better understanding the petroleum system(s) that operated in the area. The data will also assist in understanding the origins of base-metal mineralisation which occurs in this region.

To the south of the basin, the line also crosses the exhumed core of the Alice Springs Orogeny in the Arunta Region. This portion of the Arunta Region has numerous magmatic-hosted uranium prospects, but there is only a poor understanding of the development and setting of this mineralisation or its potential to form larger deposits. Preliminary images of the seismic data show reflections

that may represent large-scale structures developed during the orogeny, and could provide an insight into the plumbing systems that generated uranium mineralization.

Seismic and MT data are currently being processed and interpretation is planned to commence in collaboration with the NTGS in late 2010. Interpreted results should be available at the 2011 AGES (Annual Geoscience Exploration Seminar) in Alice Springs.

National Geochemical Survey of Australia (NGSA)

The sample acquisition phase of this project is now complete and all 1314 samples have arrived at Geoscience Australia in Canberra. Sampling was successfully completed at 86 per cent of the planned sampling sites. Some sites in Western Australia and South Australia were not accessible because of cultural heritage issues. The sample medium chosen was the overbank sediment at the outlet of major drainage catchments.

Preparation of samples for assay at the Geoscience Australia laboratories is now well underway and analysis should be completed by June 2010. Preliminary results such as a Preliminary Soil pH map for the Australian continent are now available, and final data and interpretations will be released from June 2011 onwards. For a more detailed account of progress on the NGSA, please see the article on the Preliminary Soil pH map of Australia in this issue of *AusGeo News*.

Upcoming data acquisition

Kidson–Paterson Seismic Line

The Canning Basin in northwestern Australia represents a vast geological frontier. The Kidson Sub-basin is a southern depocentre (or area of maximum deposition) in the onshore Canning Basin and is thought to contain up to seven kilometres of Early Ordovician to Cretaceous sediments. This represents the most complete stratigraphy in the region as very little data from previous exploration efforts are available and are relatively old. Geological constraint is limited to a small number of exploration wells, most of which had been located without any reference to seismic information.

Since a thick sequence of Ordovician sediments is likely to include mature source rocks, the Kidson Sub-Basin may represent a major hydrocarbon province with possible analogies to those encountered in China's Tarim Basin. For this reason, the sub-basin is being targeted in a major deep reflection seismic acquisition project in 2010. This will be the final seismic acquisition by Geoscience Australia as part of the OESP.

Funding for the project has been secured, and includes a significant contribution from the Geological Survey of Western Australia (GSWA) under their Exploration Incentive Scheme (EIS). A proposed transect of over 750 kilometres along the Canning Stock Route (figure 7)

extends from the Crossland Platform in the northwest to the Paterson Province in the southwest. Negotiation by Geoscience Australia and GSWA staff in late 2009 has ensured the cooperation of the region's traditional owners.

The Kidson–Paterson Seismic Line will be one of the most logistically difficult projects ever undertaken by Geoscience Australia. The region is extremely remote with poor roads and sparse infrastructure. The Canning Stock Route is very narrow and crosses a number of sand dunes which will present a challenge to moving seismic equipment and vibroseis trucks. Accommodation and messing for the acquisition crew will also be difficult because of lack of water and suitable campsites. Despite these challenges, a reconnaissance of the track has been undertaken and planning is well underway.

The acquisition crew is expected to mobilise in the Canning region in May 2010. The survey is expected to take four months to complete and will be the most expensive onshore seismic project Geoscience Australia has undertaken. Other seismic data acquisition being managed by Geoscience Australia in Western Australia during 2010 includes an AuScope–GSWA funded line in the Capricorn Region between the Pilbara and Yilgarn cratons (about 570 kilometres) and a GSWA-funded Line in the northern Yilgarn Craton (about 600 kilometres).

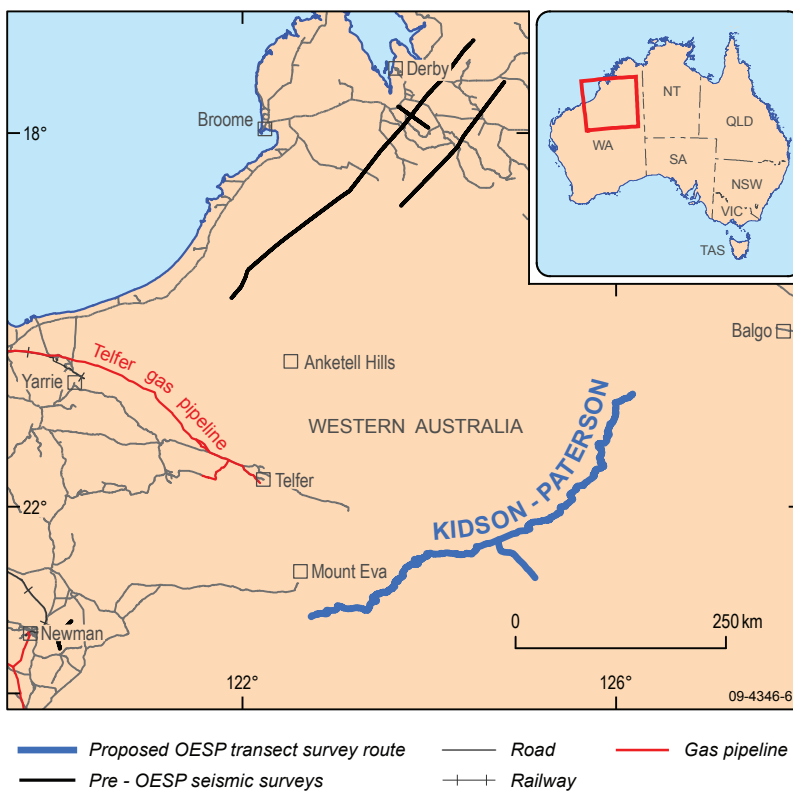


Figure 7. Location map for the planned Kidson–Paterson Seismic Line in north-western Australia. Length of the proposed line shown is 776 kilometres.



Conclusion

The OESP has now been underway for more than three years and has successfully released a number of datasets which demonstrate the relevance of its programs to the resource exploration sector. National and regional projects are now well advanced and most are processing, analysing, modelling and reporting on acquired data. Though the datasets and products are focussed on hydrocarbon, geothermal and uranium energy systems, they will also be useful to companies exploring for base-metals, gold, and other commodities. These outputs can also be applied to land-use management and groundwater assessments. Upcoming acquisition, particularly the Kidson–Paterson Seismic Line, will ensure that the OESP maintains its momentum through the full five-year program, and continues to assist and encourage explorers in the search for new energy resources.

For more information

Onshore Energy Security Program

phone Ned Stolz on +61 2 6249 9753

email ned.stolz@ga.gov.au

Airborne electromagnetic surveys

phone Nick Williams on +61 2 6249 5807

email nick.williams@ga.gov.au

Seismic acquisition

phone Jenny Maher on +61 2 6249 9896

email jenny.maher@ga.gov.au

National Geochemical Survey of Australia

phone Patrice de Caritat on +61 2 6249 9378

email patrice.decaritat@ga.gov.au

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Related articles/websites

Onshore Energy Security Program
www.ga.gov.au/minerals/research/oesp/index.jsp

Geophysical Archive Data Delivery System (GADDS) on the Geoscience Portal website
www.geoscience.gov.au/

A New Radiometric Map and Data Set for Australia: Implications for Uranium Exploration. Presentation by Dr Neil Williams, CEO Geoscience Australia
www.ga.gov.au/servlet/BigObjFileManager?bigobjid=GA14450

Geoscience Australia's Airborne Electromagnetics Project
www.ga.gov.au/minerals/research/national/aem/

Seismic Acquisition and Processing Project
www.ga.gov.au/minerals/research/national/seismic/

AusGeo News 92: New Radiometric Map of Australia
www.ga.gov.au/ausgeonews/ausgeonews200812/radiometrics.jsp

AusGeo News 92: Foundations of South Australia discovered
www.ga.gov.au/ausgeonews/ausgeonews200812/gawler.jsp

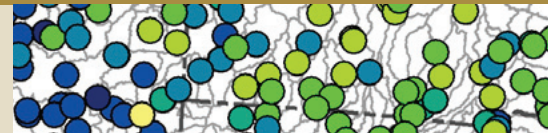
AusGeo News 95: Radiometric Map of Australia provides new insights into uranium prospectivity
www.ga.gov.au/ausgeonews/ausgeonews200909/radiometric.jsp

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

AusGeo News 97: Preliminary Soil pH map of Australia
www.ga.gov.au/ausgeonews/ausgeonews201003/soil.jsp

Preliminary Soil pH map of Australia

New dataset will support resource evaluation and environmental monitoring



Patrice de Caritat, Michelle Cooper, Gary Burton¹, Roger Fidler², Geoff Green³, Emily House⁴, Colin Strickland⁵, Joseph Tang⁶ and Andrew Wygralak⁷

Data gathered in the field during the sample collection phase of the National Geochemical Survey of Australia (NGSA) has been used to compile the *Preliminary Soil pH map of Australia*. The map, which was completed in late 2009, offers a first-order estimate of where acid or alkaline soil conditions are likely to be expected. It provides fundamental datasets that can be used for mineral exploration and resource potential evaluation, environmental monitoring, landuse policy development, and geomedical studies into the health of humans, animals and plants.

Background

Since their inception in the 1960s, regional geochemical surveys have proven to be a reliable tool for mineral exploration, particularly as a complement to other regional, national or continental-scale geological and geophysical datasets. However, until now there has been no geochemical coverage for the whole of Australia.

The National Geochemical Survey of Australia (NGSA) project was initiated in late 2006 as part of Geoscience Australia's Onshore Energy Security Program (Johnson 2006). The Program provides pre-competitive data and knowledge to support exploration for energy resources in Australia. As a spin-off, the NGSA will also establish a baseline geochemical database and atlas, which will find applications in various disciplines. The NGSA is carried out in collaboration with each of the state and Northern Territory geoscience agencies.

Sampling strategy

Catchment outlet sediments, which are similar to floodplain sediments in most cases, were the target sampling material for the NGSA. This sampling medium has been widely used in overseas geochemical surveys because it is representative of the average regolith composition in a catchment (Ottesen et al 1989). Catchments are sampled as close as possible to their lowest point (usually their outlet). Small coastal catchments and small islands were not included in the survey.

For the NGSA, catchment outlet sediments were sampled at two depths. Firstly a Top Outlet Sediment (TOS) sample is taken between zero and 10 centimetres below the surface or root zone if applicable. Then a Bottom Outlet Sediment (BOS) sample, representing an interval of about 20 centimetres is taken from a depth between around 60 and 80 centimetres (on average). Both types of samples are composites homogenised from a shallow soil pit (TOS) or a minimum of three hand-augered holes (BOS). Samples were taken from a total of 1192 catchments covering about six million square kilometres or over 80 per cent of the area of continental



Figure 1. Field sampling at the point of collection: Inoculo™ field pH kit (inset) and measurement of the pH of two soil samples.

¹Geological Survey of New South Wales. ²Primary Industries and Resources South Australia. ³Mineral Resources Tasmania. ⁴GeoScience Victoria. ⁵Geological Survey of Western Australia. ⁶Geological Survey of Queensland. ⁷Northern Territory Geological Survey.

Australia across all states and territories. The average sampling density for the area sampled is approximately one sample every 5500 square kilometres. Sample collection and preparation were carried out in accordance with a Field Manual (Lech et al 2007) and a Sample Preparation Manual (Caritat et al 2009) compiled for the survey.

Determining the soil pH

The field pH, which forms the basis of the *Preliminary Soil pH map of Australia*, was determined in the field by the saturated paste method using Inoculo™ field pH kits developed by CSIRO (figure 1). The field pH method entails:

- saturating a small amount of soil (about one cubic centimetre) with a universal indicator
- mixing soil and indicator to form a paste
- lightly dusting the saturated paste with white barium sulfate powder
- waiting one minute for the indicator to react with the soil
- matching the colour of the powder to a chart with half pH unit increments.

To some extent this empirical method depends on the user's ability to match colours and on lighting conditions; it also only has a resolution of one half of a pH unit and hence is a relatively 'coarse' measurement. Therefore, results should be considered a 'first pass' only. Preliminary comparisons with (a) pH values determined in the lab using solutions with a ratio of one unit soil to five units water, and (b) with pH estimates derived from visible near-infrared spectroscopy, however, suggest general correlation and overall robustness of the field pH data. The data is based on one site per catchment and cannot, therefore, inform on intra-catchment pH heterogeneity.

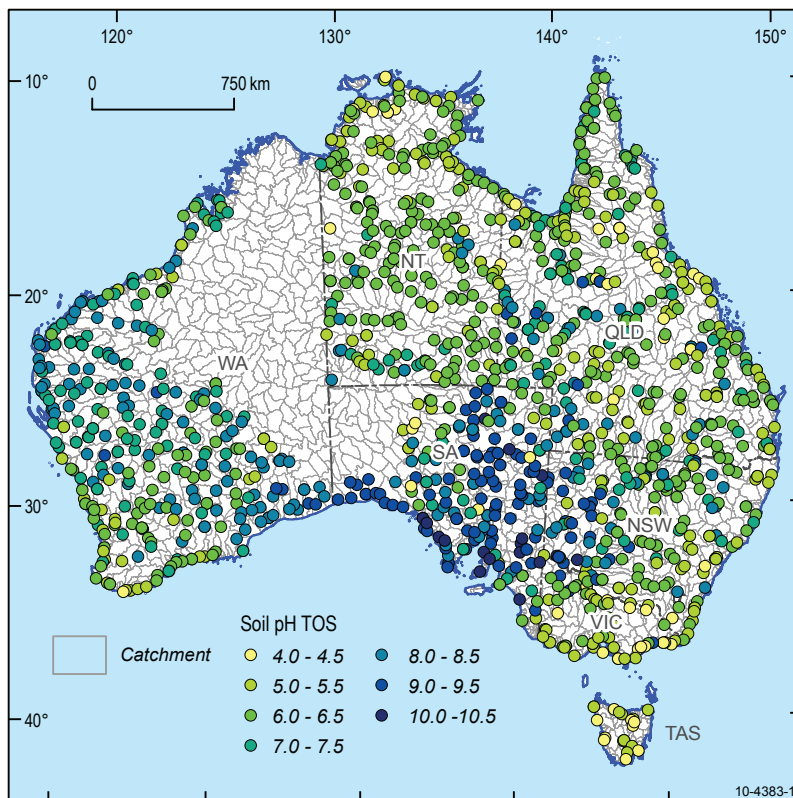


Figure 2. Distribution of soil pH values determined in Top Outlet Sediments (TOS) by the National Geochemical Survey of Australia. The symbols are coloured according to the pH recorded at the sampling site.

Results

The NGS field pH data has been compiled into a data file and maps, which are available through the Geoscience Australia website. Figure 2 shows the raw point data for the TOS soil pH at the point of collection. The downloadable maps also include a catchment-based representation (mosaic map) of this data, as well as presenting the BOS sample data in both formats.

The *Preliminary Soil pH map of Australia* will be useful to many stakeholders, including those involved in mineral exploration, agriculture, natural resource management, and infrastructure protection. Metal mobility in the near-surface environment is strongly influenced by pH

conditions. Soil acidification (Brennan et al 2004) and alkalisation (Wong et al 2008) are increasingly important problems for agriculture and soil protection in Australia as they impact on soil productivity, soil toxicity, and element deficiency. The map will also potentially be useful in studies of surface water, soil water, and groundwater quality assessment and prediction. There is evidence of a correlation between areas with high soil pH values found during the NGSa project and areas previously identified as containing extensive soil carbonates (figure 3: Chen et al 2002), particularly with the BOS samples.

More information on the project is available through the Geoscience Australia website (see below) or in Caritat et al (2008).

For more information

phone Patrice de Caritat on +61 2 6249 9378

email patrice.decaritat@ga.gov.au

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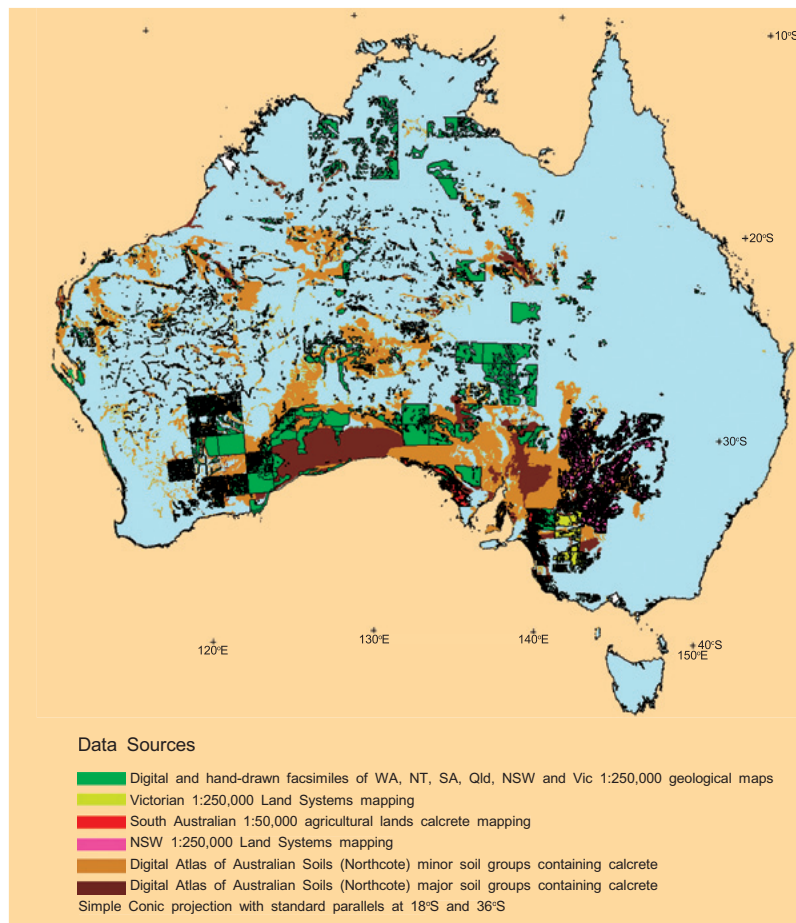


Figure 3. Distribution of regolith carbonate in Australia, shown mostly as brown shades (Chen et al 2002).

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Related websites/articles

Preliminary Soil pH map of Australia may be accessed through the National Geochemical Survey of Australia

www.ga.gov.au/ngsa

Hydrogeological-Landscapes system: a framework for managing water resources

National datasets support natural resource management

John Wilford, Allan Nicholson¹ and Greg Summerell¹



An understanding of hydrological processes is vital when addressing issues such as water availability, water quality and ecological management, particularly when groundwater-dependent ecosystems are involved. Consideration of water sustainability within the context of climate change, population growth and socio-economic development requires holistic and more sophisticated water management approaches. It is against this background that a Hydrogeological-Landscape framework for more effective management of natural resources has been developed. The framework is used to divide the landscape into areas that have similar hydrological characteristics. The use of the term *Hydrogeological* highlights the importance of geology to hydrologic processes, whereas the use of the term *Landscape* highlights the importance of landforms and regolith (or the weathered material above bedrock).

The Hydrogeological-Landscape framework concept

The Hydrogeological-Landscape framework (HGL) builds on the groundwater flow system (Coram 1998; Walker et al 2003) framework that was developed approximately 10 years ago—primarily to assist in the management of groundwater salinity. The Hydrogeological-Landscape framework is a broad, all encompassing entity which accommodates all forms of water flow (surface, inter-flow and groundwater flow). Hydrogeological-Landscape Units (HGLU) integrate information on lithology, bedrock structure, regolith (including soils), landforms, climate (including rainfall, seasonality, evaporation) and vegetation (figure 1). These components

all influence, to greater or lesser degrees, the recharge, transmission, storage and discharge characteristics of a particular hydrological system. The HGL concept has been developed for upland erosional landscapes (such as where hill slopes have a major control on water movement) as documented here; however, it also has the potential to be applied to depositional settings.

Hydrogeological-Landscape frameworks are compiled over a range of spatial scales ranging from landscape facets that may describe, for example, local changes along a hill slope through to regional systems spanning hundreds of kilometres. This multi-scale approach addresses the fact that both hydrologic systems and management strategies are intrinsically linked across different scales. For example, most local flow systems are nested within larger ones and most local land management strategies ideally need to be integrated into regional programs and goals. Different datasets or criteria are used in defining the HGL units across these different spatial scales. At the broadest scale major bedrock types, structural and architectural elements (such as a flat lying sedimentary unit or a fractured granite), landform and climatic characteristics are used. Whereas

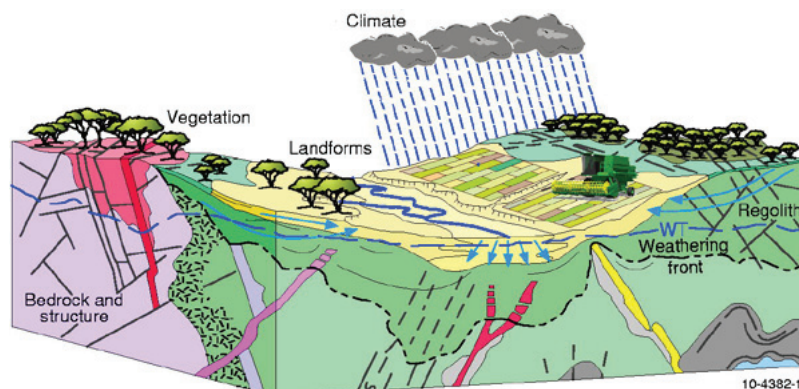


Figure 1. Factors influencing surface and groundwater movement and storage.

¹ Department of Environment, Climate Change and Water, New South Wales

at local scales regolith/soil type and thickness, morphology (hill slope: steepness, curvature and length) and lithostructure (for example, lithologies, fabrics and structures) are used. The latter components assert local controls on water movement and storage and, therefore, provide spatially-explicit information on hydrological processes to support farm-scale management strategies.

Key elements of the framework

Some of the key elements in building a HGL framework included bedrock type, regolith and landform. Geological attributes are derived from state and national scale geological maps (*AusGeo News 93*), whereas regolith and landform components are derived mainly from modelling of gamma-ray radioelement imagery and digital terrain analysis. Emissions of gamma-rays from Earth's surface will largely reflect the geochemistry of bedrock as well as weathering processes and regolith materials. The gamma-ray imagery together with terrain relief has been used to predict the degree to which the landscape has been weathered (Wilford 2010). This approach enables delineation of regolith and bedrock-controlled hydrological systems which typically have very different porosity and permeability characteristics (figure 2). The gamma-ray data uses the new radioelement map of Australia (*AusGeo News 92*) which enables quantitative assessment of the distribution of potassium, equivalent thorium and equivalent uranium in exposed bedrock and regolith.

Landforms, slope facets, valley constrictions and seepage zones are derived from a range of digital terrain process techniques including topographic wetness index (TWI), the UPNESS index from the Fuzzy Landscape Analysis Geographic Information System (FLAG) model (Summerell et al 2005) and a multi-resolution index of valley bottom flatness (MRVBF: Gallant & Dowling 2003).

Central West Catchment HGL map

The Hydrogeological-Landscape map of the Central West Catchment in New South Wales (figure 3) illustrates how this new framework is providing key baseline information for managing water quality in the catchment. The Central West Catchment, which is about 1.5 million hectares in area, is a north-west draining subdivision of the Darling River system and includes the Macquarie and Lachlan rivers. The

region falls within the jurisdiction of the Central West Catchment Management Authority which provided financial support for the HGL mapping in the catchment.

Hydrological characteristics within the Central West Catchment are highly variable, reflecting a diversity of climate, geology, vegetation, landform and regolith. The development of the regolith in the catchment varies greatly and typifies many erosional landscapes in Australia where older and more recent landscapes are juxtaposed. Some of the thickest regolith in the catchment is associated with partially preserved palaeo-surfaces that reflect weathering during the Tertiary or older. The palaeo-surfaces are mainly preserved along the south, south-west catchment divide (around Molong, Orange), and in lower parts of the catchment where the rates of erosion are relatively low (around Dubbo and lower reaches of the Cudegong River). Many of these deeply weathered landscapes are associated with sluggish groundwater flow systems, waterlogging and salt scalding.

This HGL map delineates areas with similar hydrological characteristics across different landscape scales. The multi-scaled structure of the HGL framework allows for a broad assessment of recharge, discharge and water quality characteristics over the whole catchment, as well as targeting specific sub-catchments for on-ground actions (for example, targeting high salt producing sub-catchments). Each HGL unit is linked to a conceptual hydrological cross-section which describes surface, inter-flow and groundwater flow characteristics, as well

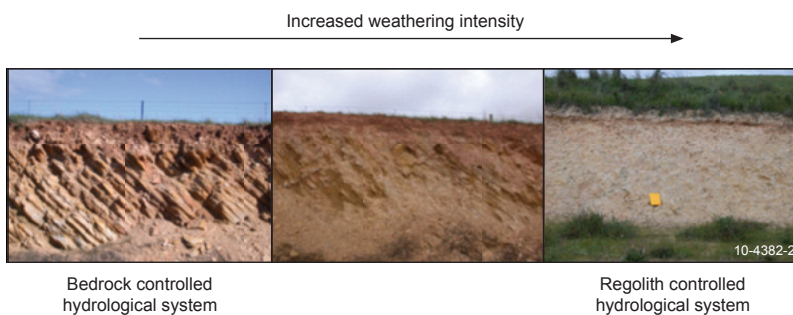


Figure 2. Transition from bedrock to regolith-controlled hydrological systems with increasing weathering intensity from fractured bedrock (left) to residual clay (right).

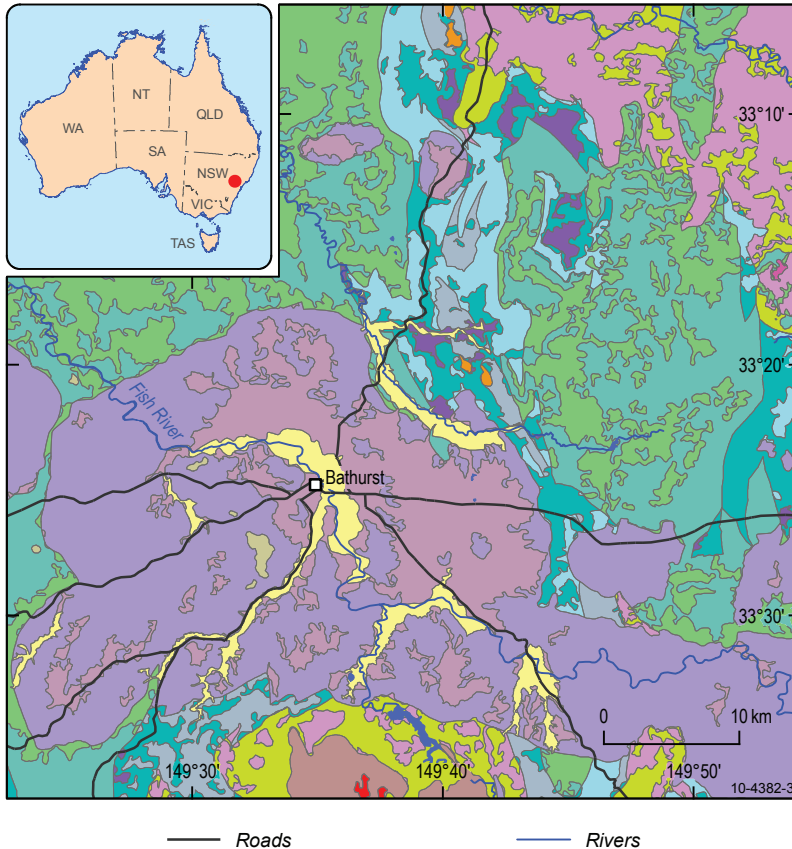


Figure 3. Part of the Central West Catchment Hydrogeological-Landscape (HGL) map. The colours represent areas with similar recharge, transmission, storage and discharge characteristics.

as management approaches for specific parts of the landscape. Such options might include the location of interception plantings to control recharge for salinity management. The HGL framework can be used to support a range of land use, remedial re-vegetation intervention and engineering strategies for salinity management or other natural resource management activities. The combination of climatic attributes, weathering intensity and geology within the HGL framework enables predictions of salt storage and export within different parts of the catchment. The HGL approach also has applications in the urban environment where it can be used to better understand salinity processes effecting infrastructure and water quality.

Although the HGL concept has mainly been used for addressing land and water quality associated with salinity to date, the framework was originally developed to assist with a broad range of natural resource management issues. The New South Wales Department of Environment, Climate Change and Water is currently using or assessing the HGL approach for a number of different natural resource management applications including assessment of:

- soil degradation—sodicity, acidity, acid sulphate soils, and soil erosion
- soil carbon
- surface and groundwater interaction in the landscape
- biodiversity and vegetation
- landscape processes with non-floodplain wetlands such as hanging swamps.

The HGL approach is currently being assessed for application in other catchments in New South Wales and has the potential to be developed as a national framework.

For more information

phone John Wilford on
+61 2 6249 9455

email john.wilford@ga.gov.au

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Related articles/websites

AusGeo News 93: New digital geological map of Australia
www.ga.gov.au/ausgeonews/ausgeonews200903/geological.jsp

AusGeo News 92: New Radiometric Map of Australia
www.ga.gov.au/ausgeonews/ausgeonews200812/radiometrics.jsp

Exploring for sandstone-hosted uranium deposits in paleovalleys and paleochannels

Subhash Jaireth, Jon Clarke and Andrew Cross

Significant sandstone-uranium deposits are located in fluvial (or river) sediments filling ancient river channels known as paleochannels. These often occur within buried valley systems cut into bedrock which are known as paleovalleys.

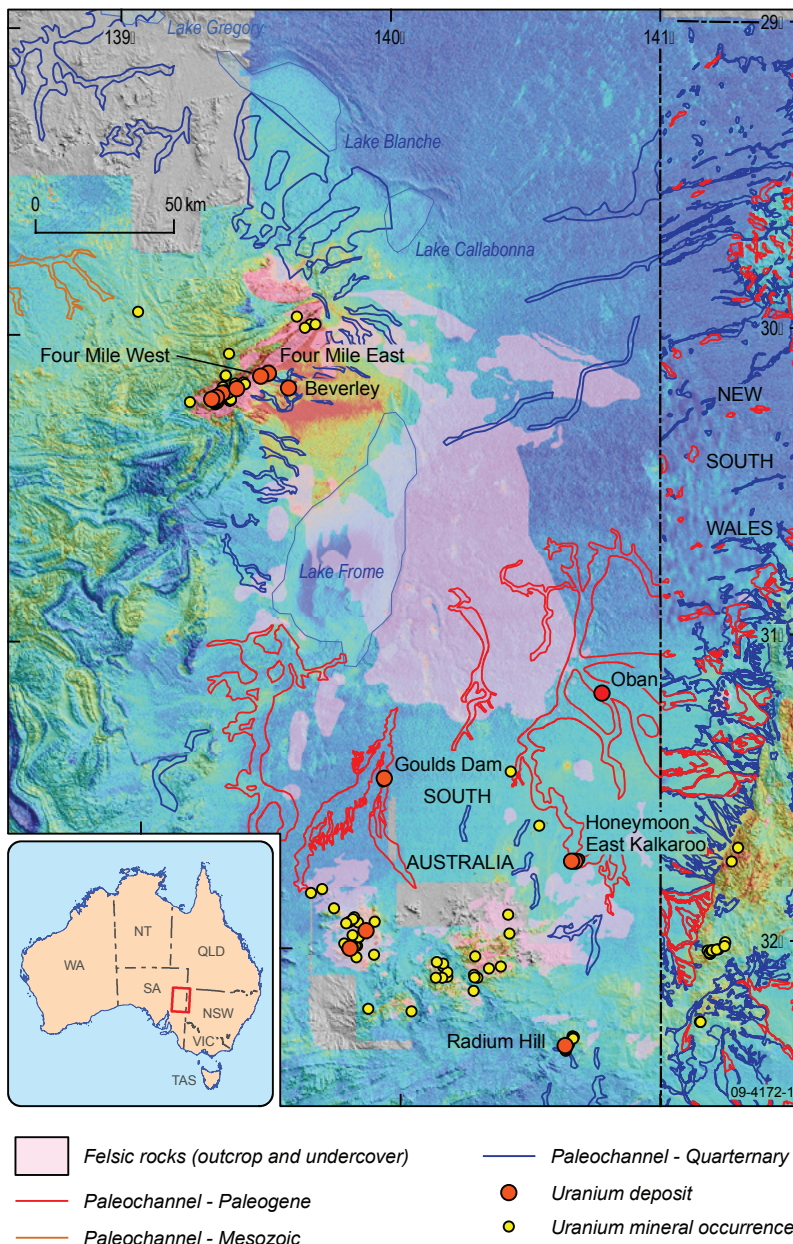
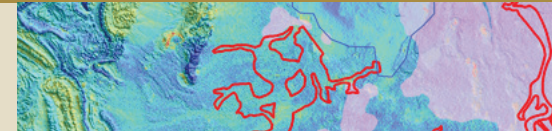


Figure 1. Distribution of paleochannels and paleovalleys in the Lake Frome region. The data for South Australia are after Hou et al (2007). Paleochannels in New South Wales are defined roughly on the basis of the distribution of Cenozoic sediments in the 1:1 million scale Surface Geology of Australia map.



This article briefly outlines the geology of sandstone-hosted uranium deposits in paleovalleys and paleochannels in the Lake Frome region (Australia) and Mountain Valley and White Canyon districts (USA). Uranium deposits in the two areas are commonly localized at the confluences and intersections of channels and/or near bends. It is possible that the location of deposits at these sites is caused by several inter-related factors such as the presence of basement scours, predominance of coarse-grained sediments, and abundance of organic material.

The Lake Frome region

Eocene to Miocene paleochannels and paleovalleys host several uranium deposits in the Lake Frome region (figure 1). The Eocene paleochannels running generally south-north are filled with Eyre Formation sediments. They incise the Proterozoic to Cambrian basement and are covered by Miocene lacustrine (or lake) and fluvial sediments. The main valleys with channels are generally five to ten kilometres wide and extend for more than 200 kilometres, sometimes joined by smaller tributaries. The general gradient of the channels in the south to north direction varies between 1.3 metres per kilometre to 2.1 metres per kilometre in the Billerloo channel (Ellis 1980).

The sediments in these channels were sourced from the Proterozoic basement in the Curnamona Province (Ellis 1980). They comprise an interlayered sequence (70 to 80 metres thick) of sands, silts and clays with most of the organic material concentrated in the basal part of the lower sands filling scours in the basement rocks. These sands also contain abundant pyrite.

Uranium occurrences and deposits often occur at bends (Honeymoon and East Kalkaroo) and/or the site of confluences with tributaries (such as Goulds Dam and Oban; figures 1 and 2). The general shape and orientation of the channels is controlled by basement rocks and structures. According to Skidmore (2005), mineralisation at the Honeymoon deposit is located close to a bend where the channel breached a ridge along a fault zone (figure 2).

The Four Mile East deposit and Pepegooona prospect in the northern Lake Frome region, are also hosted by the Eocene Eyre Formation (Heathgate Resources 2009). Although a paleochannel

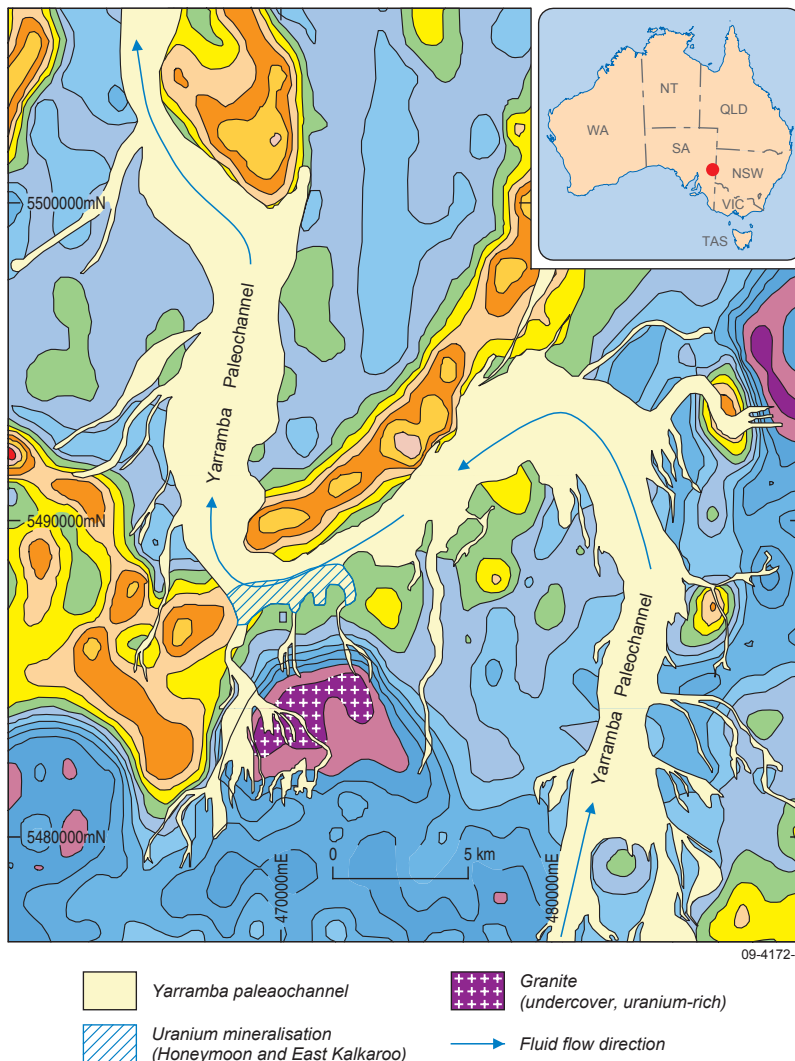


Figure 2. Bends in the main Yarramba Paleochannel and location of mineralisation at the Honeymoon and East Kalkaroo deposits. Paleochannel plotted over gravity high (0.5 mgal residual gravity contour). Modified after Skidmore (2005).

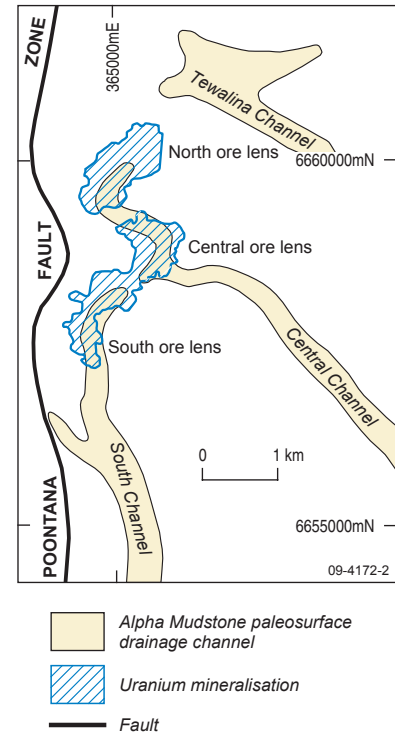


Figure 3. Map of the Beverley uranium deposit (mineralisation outlined) and inferred paleochannels within the Namba Formation. Uranium mineralisation is located in the Beverley Sands unit (modified after Heathgate Resources 1998).

setting for them is not clear at this stage, the location of Four Mile East deposit in a northeast trending valley-like embayment indicates possible similarities with a paleovalley setting.

Mineralisation at the Beverley deposit (figure 3) is hosted by the Beverley Sands unit of the Miocene Namba Formation. The mineralised sequence of sand and mudstone fill a channel into the organic-rich Alpha Mudstone (figure 3). Although anomalous uranium is found throughout the channel, ore zones are located at the bends of the main north-south channel and/or near the points of confluence with tributaries (figure 3). The main channel is up to one kilometre wide and filled with 90 to

170 metres of Miocene sediments overlain by 80 to 150 metres thick cover of Quaternary sediments of the Willawortina Formation.

The shape of the paleochannel is determined by a series of faults, such as the Poontana Fault, and the movement of sediments along it has created a system of valleys and rises. The provenance of infill sediments is not clear, although a general north-south trend of the main channel indicates that the sediments could have been derived from the Proterozoic basement to the south of the channel. Palynological studies record a Late Oligocene to Pliocene age (possibly between around 25 and 6 to 4 Ma or million years; Wulser 2009).

Tabular mineralisation is located predominantly at or near the contact with the underlying Alpha Mudstone, primarily because the mudstone is rich in organic material (plant fragments and carbonised wood). Uranium–Lead dating of coffinite and secondary carnotite defines the age of mineralisation between 5.3 and 3.1 Ma (Wulser 2009). Mineralisation thus seems to have occurred just after the deposition of sediments infilling the Beverley paleochannel.

Monument Valley and White Canyon Districts, USA

The Monument Valley and White Canyon districts near the southeastern border of Utah have produced around 3900 tonnes of uranium oxide (U_3O_8) and 4500 tonnes of vanadium (V_2O_5) at average grades of 0.32 per cent and 0.25 per cent U_3O_8 and 0.23 per cent and 0.94 per cent V_2O_5 (Dahlkamp 1993).

Mineralisation is hosted by the Late Triassic Chinle Formation which is 50 to 600 metres thick and consists of fluvial sediments deposited in braided and meandering river channels. The mineralised channels were incised into the Moenkopi Formation sediments by streams flowing generally northward from a highland area in southern or central Arizona and southern New Mexico (figure 4). The sediment infill was derived from the exposed granitic and felsic volcanics in the highlands. An increase in the volcanic activity in the highland area coincided with the deposition of younger sediments in the Chinle Formation (Malan 1968). Prior to the deposition of the overlying Monitor Butte Member, the earlier flood plain and channel sediments were thinned or completely removed by erosion (figure 4).

All major deposits are confined to the thin Shinarump Member of the Chinle Formation with a few extending downwards in the underlying Moenkopi Formation. The ore-bearing Shinarump Member is composed of lenticular beds of sandstone, conglomerate, siltstone and mudstone with abundant

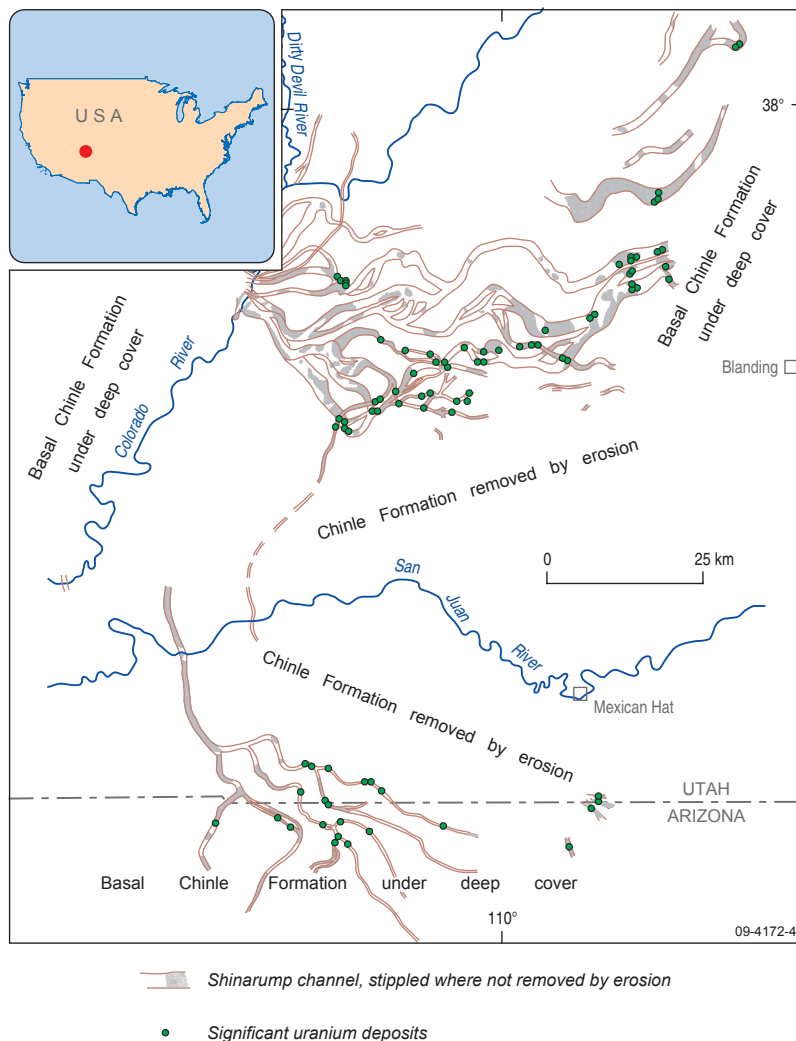


Figure 4. Shinarump channel system in the Monument Valley and White Canyon districts, Arizona and Utah. Modified after Malan (1968).

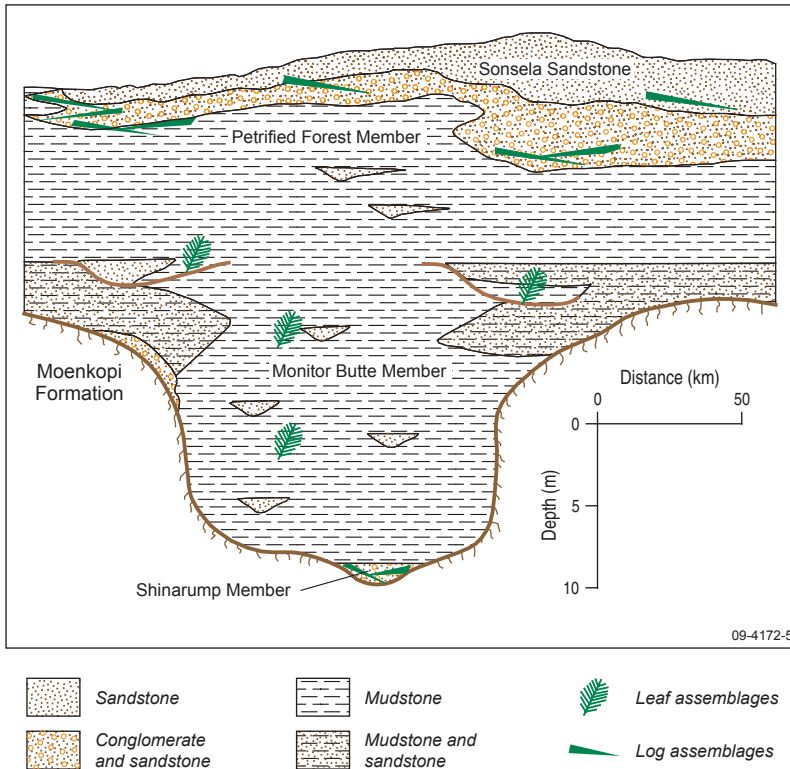


Figure 5. Schematic cross-section of the Painted Desert paleovalley showing stratigraphic relationships of members of the Chinle Formation. Uranium mineralisation is located predominantly in the Shinarump Member. Modified after Demko (2003).

fragments of carbonised and locally silicified wood. Uranium deposits are commonly localised at confluences and intersections of channels and/or near bends. This is interpreted to be caused by stronger currents able to cut deep scours in the basement (Young 1964). Within braided channels coarser sediments (sandstone and conglomerate) were deposited where the channel was narrow and gradients high, whereas carbonaceous-rich mudstone was deposited in channels which were broad, meandering and of low gradient. As the gradients lowered the filled scours were covered by layers of silt and carbonaceous mudstone (Malan 1968).

According to Young (1964), radiometric ages indicate that mineralisation was initiated at around 180 Ma and was remobilised several times by ground water flowing through the channel.

Factors controlling mineralisation

This brief comparison of two areas with sandstone-hosted uranium deposits in paleovalleys and paleochannels shows that mineralisation is often located at the bends and/or sites of confluences of the main channel with tributaries, frequently occupying basement scours filled with coarser sediments. In some deposits tabular mineralisation is located at the contact with organic-rich underlying silt and mudstone. This preferred location could be the result of several inter-related factors which include:

- Changes in the rates of stream flow at the bends and at the sites of confluence determining the type of sediments (sand versus silt) infilling the channel, which in turn determine differences in the permeability of sediments.
- A drop in the rates of stream flow at the inside of bends and at the sites of abandoned channels, channel-widening and bar-heads that favour the trapping of woody material. The presence of large woody debris at these sites can enhance the concentration of benthic organic matter at the bends incorporated later by the sediment-infill (Abbe & Montgomery 1996; Daniels 2006).
- The presence of tributaries flowing into the main channel that can provide an additional hydrological link with local uranium-rich source rocks. For instance, at the Honeymoon deposit a uranium-rich granitoid, intersected in the basement in the upland area of a northward running tributary to the main channel, is proposed as a potential source rock by Skidmore (2005; figure 2). This link with the source rock is important and can explain why uranium mineralisation in the Monument Valley and White Canyon Districts is confined primarily to the Shinarump Member although the overlying younger sediments in the channel contain abundant organic material (figure 5).
- The presence of coarser sediments, particularly in the scours, which may be enriched in uranium-rich detrital minerals sourced from

the erosion of felsic rocks in the upland area, and hence provide an additional local source of uranium.

- The location of ore zones within basement scours increases chances of their preservation by isolating them from interacting with oxidised groundwaters flowing through the sandy aquifers.

The shape and gradients of paleochannels can be used to ascertain the location of the source of sediments and the direction of sediment transport. They can also assist in determining the location of possible source rocks of uranium and the direction of fluid flow of uranium-bearing fluids. In general, uranium-rich fluid will flow along the channel, however if the sandstone uranium system is generated after the channel is filled and covered by younger sediments, fluid can flow across the channel system. It is important to establish the direction of fluid flow at the time of mineralisation because it can help to determine the location of oxidation-reduction front as well as the ore zone within the aquifer.

Implications for exploration

This summary of sandstone-hosted uranium deposits in paleovalleys and paleochannels shows that mineralisation is often located at a number of specific sites within the paleochannels. Consequently exploration of such deposits will benefit by focusing on the following features of the system:

- Meandering bends of channels (including abundant channels), sites of confluence with tributaries, sites of channel-widening, bar-heads, and scours in the basement rocks.
- Architecture of the basement (topography, rock-types, and structures), which often influences the shape and orientation of the channels.
- Basement rocks, some of which may contain source of uranium. Geophysical methods such as gravity and aerial electro-magnetic surveys can be useful to map the basement.
- Paleo-flow direction in the channel, because it can help to determine the position of bars and of sites rich in wood debris.
- The presence of organic-rich fine-grained sediments infilling the channel because in addition to the basement scours, they can also provide favourable sites for uranium mineralisation.

Acknowledgments

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For more information

phone Subhash Jaireth on
+61 2 6249 9419

email subhash.jaireth@ga.gov.au

AUSGeoid09: Converting GPS heights to AHD heights

Improving access to Australia's vertical datum

Nicholas Brown

Knowing your height above sea level is important. Height information is essential for a wide range of activities: town planners use it to avoid building hospitals in flood zones, mountain climbers use it to ensure they have enough oxygen for their trip and aircraft pilots need it to land safely. In Australia, heights above mean sea level (MSL) are referenced to the Australian Height Datum (AHD). The AHD was established by setting the mean value observed at 32 tide gauges around Australia between 1966 and 1968 to a height of 0.000 metres. Levelling techniques were then used to transfer heights relative to MSL across Australia.

Global Positioning System (GPS) receivers, which are now widely used for accurate positioning and navigation in Australia, use a different reference surface known as the ellipsoid. The ellipsoid is a simplified approximation of the Earth that looks like a basketball which has been slightly squashed at the top and bottom. Unfortunately, the ellipsoid is not directly compatible with the AHD. Consequently, there has been an increasing demand for a method of combining the speed of GPS data acquisition and the practicality of the AHD. AUSGeoid09 is the answer; it offers significant productivity gains for GPS users by allowing

them to compute AHD heights either in the field in real time or back in the office.

AUSGeoid09 is a three dimensional model used to convert ellipsoidal heights (as observed by GPS) to AHD heights to within ± 0.050 metres accuracy across most of Australia (figure 1). For example, if you use a GPS receiver to compute the height of your house, it will provide you with the ellipsoidal height. By subtracting the value of the AUSGeoid09 model at the latitude and longitude of your house, you can compute the AHD height. AUSGeoid09 is still undergoing final testing before its release in mid-2010. Before describing how AUSGeoid09 was developed, it is worth explaining some basic concepts and how they are interrelated.

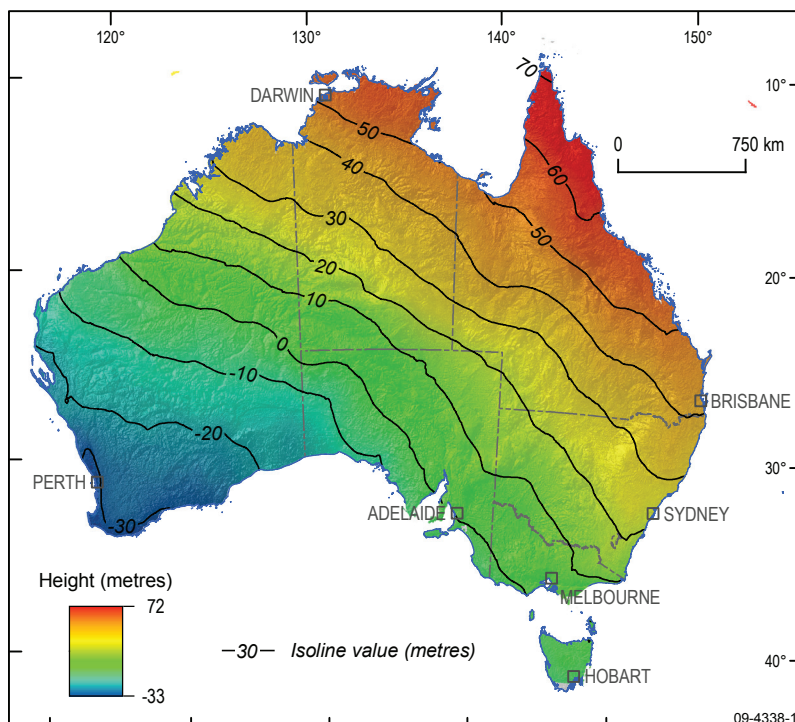


Figure 1. AUSGeoid09 allows GPS users to convert between GPS heights and AHD heights. In southwest Australia, the AHD is up to 33 metres below the ellipsoid and in northwest Australia the AHD is up to 72 metres above the ellipsoid.

Understanding the Geoid

What is a geoid?

A geoid is a three dimensional surface of equal gravity (equipotential). Although there are an infinite number of these equipotential surfaces for the Earth, 'The Geoid' is often used to describe the equipotential surface which best corresponds with MSL. Across Australia, MSL and its onshore realisation, the AHD, correspond to within approximately ± 0.5 metres of 'The Geoid'; however, there is an offset mainly caused by the way the AHD was computed.

Why the AHD and The Geoid do not coincide

In establishing the AHD, the mean sea level at 32 tide gauges from all around the Australian coastline were assigned a value of 0.000 metres AHD. Given that the warmer/less dense water off the coast of northern Australia is approximately one metre higher than the cooler/denser water off the coast of southern Australia, the AHD is about 0.5 metres above The Geoid in northern Australia and roughly 0.5 metres below The Geoid in southern Australia (figures 2 and 3).

History of AUSGeoid models

All AUSGeoid models have been designed to assist GPS users to convert ellipsoidal heights to AHD heights. Older versions of AUSGeoid ('93, '98) are predominantly based on satellite and terrestrial gravity observations which were a best fit of The Geoid

over Australia (Featherstone et al 2001). These AUSGeoid versions, referred to as gravimetric geoids, do not account for the one metre offset trend between The Geoid and the AHD. As a result, when using these versions GPS users can only retrieve AHD heights to within ± 0.5 metres.

AUSGeoid09 is slightly different. Instead of only using gravity data, it also includes a geometric component developed from GPS and AHD data which describes the approximate one metre offset trend between the AHD and the gravimetric geoid. The gravimetric and geometric components are combined together into a single national grid with two kilometre resolution.

The addition of the geometric component means that the AUSGeoid09 model is no longer a true representation of The Geoid because it is not an equipotential surface. However, the AUSGeoid name is retained for familiarity.

Computing AUSGeoid09

The gravimetric component of AUSGeoid09 is a spherical harmonic synthesis of the Earth Geopotential Model 2008 (EGM2008), developed from satellite gravity observations plus 1.3 million points from Geoscience Australia's land gravity database. The geometric component of AUSGeoid09 sets it apart from its predecessors. The offset (O) between the AHD and the gravimetric geoid, which is positive when the AHD is above the gravimetric geoid, was derived at over 5000 points

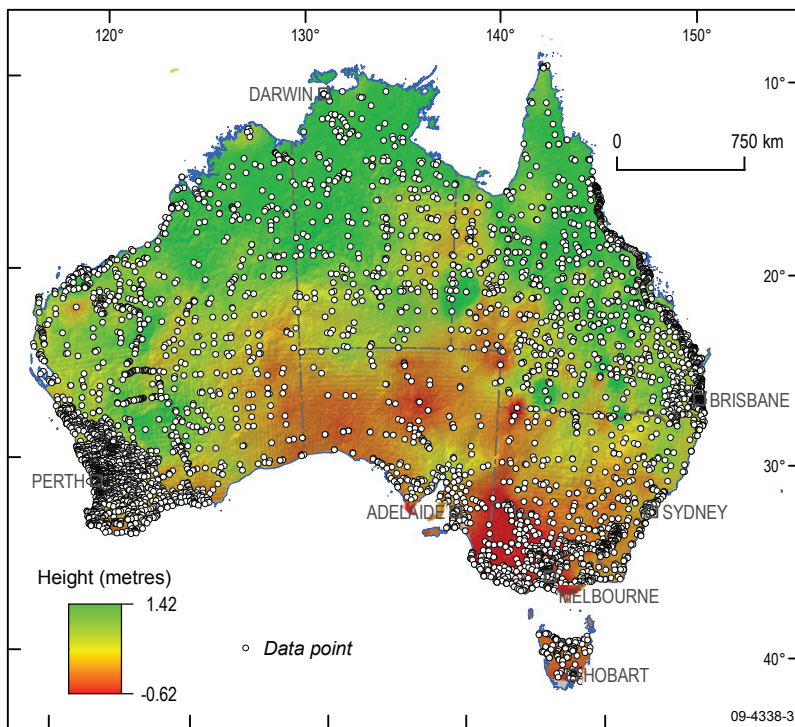


Figure 2. The offset between the AHD and The Geoid in Australia is caused predominantly by the difference in ocean temperature between northern and southern Australia.

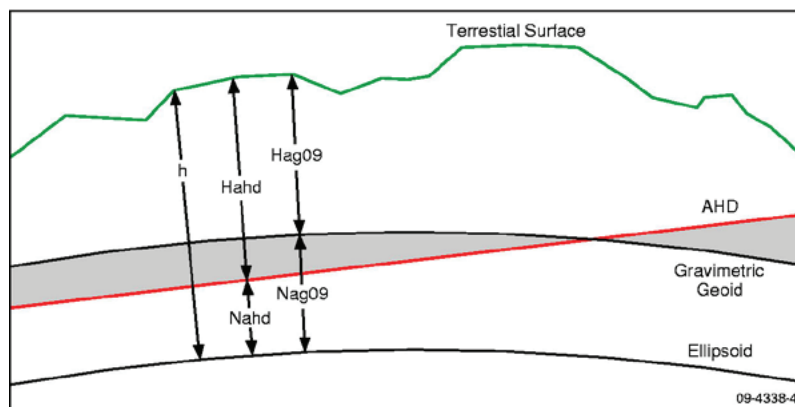


Figure 3. The different heights used to compute AUSGeoid09.

across Australia: $O = h - N_{ag} - H_{ahd}$ where h is the ellipsoidal height (from GPS observations), N_{ag} is the gravimetric geoid - ellipsoid separation (from the gravimetric geoid), and H_{ahd} is the AHD height (see figure 3). The geostatistical interpolation technique of Kriging was used to compute a regular grid of offsets which were added to the gravimetric geoid to produce AUSGeoid09.

How accurate is AUSGeoid09?

The AUSGeoid09 model has significantly improved a GPS user's ability to compute AHD heights across Australia. However, there are still some points which have 'misfits' exceeding a decimetre because of errors in the levelling network (Filmer and Featherstone 2009), land subsidence, long wavelength geoid anomalies, GPS errors or a lack of data (figure 4). Geoscience Australia and the state and territory survey authorities endeavour to resolve the cause of these misfits; however, given that in most cases the largest misfits occur in sparsely populated areas, the impact on the user is minimal.

The AUSGeoid98 gravimetric geoid is capable of converting a GPS ellipsoidal height to an AHD height within ± 0.364 metres across 65 per cent of Australia (Featherstone et al 2001). Through modelling the north-south trend between the gravimetric geoid and the AHD plus improvements in the underlying gravimetric geoid, AUSGeoid09 has reduced this uncertainty to less than ± 0.050 metres.

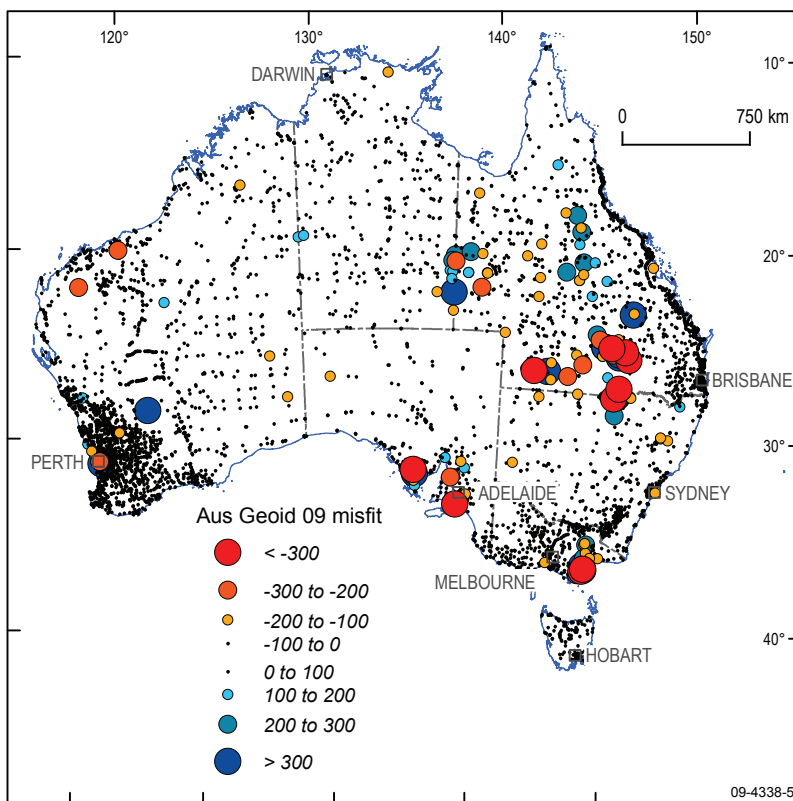


Figure 4. AUSGeoid09 fits well in the population centres, however large misfits still exist in some areas (units in millimetres).

The advantages for GPS Users

Until now, the capacity to accurately relate GPS heights to Australia's vertical datum has been the missing link for positioning. AUSGeoid09 now allows GPS users to compute an accurate AHD height in real time offering significant efficiency gains for industries such as mining, agriculture and construction. There are also advantages for those working in areas such as environmental management or natural hazard modelling as they are now able to easily and accurately capture AHD heights to generate new datasets or augment existing ones. In addition, AUSGeoid09 can be used with satellite imagery to shift the vertical datum of the imagery from the gravimetric geoid to the AHD. This increases the utility and potential applications of the imagery in areas such as tsunami inundation modelling, flood mapping and bush fire response.

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For more information

phone Nicholas Brown on +61 2 6249 9831
email nicholas.brown@ga.gov.au

Researchers collaborate on marine survey in Northern Australia

Geoscience Australia scientists recently teamed up with researchers from the Australian Institute of Marine Science (AIMS) to carry out a seabed mapping survey in the eastern Joseph Bonaparte Gulf off the coast of Australia's Northern Territory.

This survey was part of a three-year collaboration between the two organisations involving marine surveys off northern Australia using

Geoscience Australia's shallow water multibeam sonar system and AIMS' research vessel *RV Solander*.

The eastern Joseph Bonaparte Gulf was selected because its seabed environments are representative of the shallow banks and shoals and intervening channels common across the whole Gulf and, more broadly, the northern Australian shelf.

Environments spanning the outer to inner shelf in the gulf were mapped using the multibeam sonar system. This revealed a complex seabed characterised by shallow carbonate banks dominated by sponge gardens and deep channels (figure 1). There was

Table 1. Data and samples collected during the survey.

Data type	Total recovery
Geophysical data	
Square kilometres of multibeam sonar	1150
Line kilometres of sub-bottom profiler data	340
Samples	
Rock dredges	3
Surface grabs	118
Camera tows	45
Rotary cores	4
Vibrocore	16
Boxcores	2
Benthic sleds	45
Conductivity, turbidity and depth casts	23

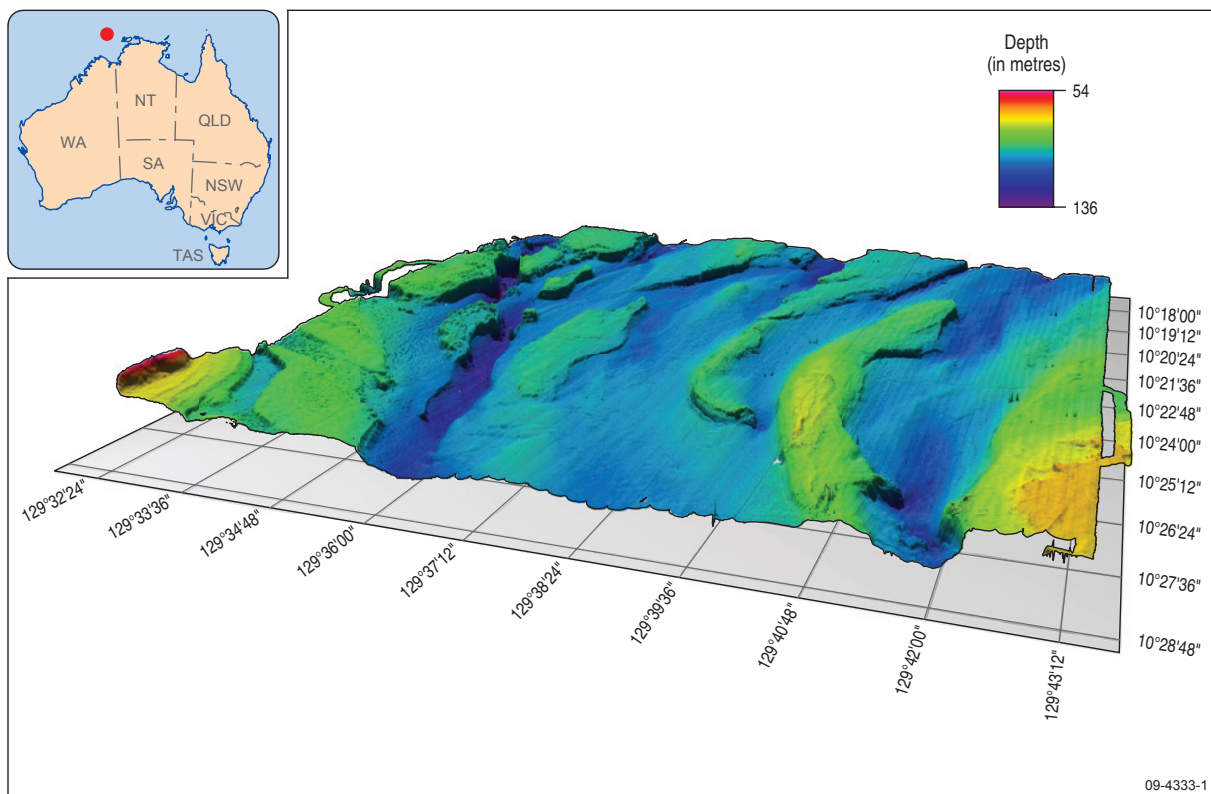


Figure 1. Perspective view of previously unmapped elongate banks and intervening channels on the eastern Joseph Bonaparte Gulf outer shelf.

also evidence of significant sediment transport across the banks. Seabed environments in a 200 metre deep channel were also mapped for the first time.

The survey also collected geological and biological samples as well as wave and tide current data and underwater video footage of seabed habitats. These data will help improve our understanding of seabed environments and habitats in the Joseph Bonaparte Gulf.

Information and data collected on the survey will be used to support the work programs of the Department of Resources, Energy and Tourism and Department of the Environment, Water, Heritage and the Arts. Data collected on the survey will be combined with existing data covering the whole Joseph Bonaparte Gulf to provide

a regional picture of seabed environments that can potentially be used to support resource development by industry and to characterise proposed marine protected areas.

For more information

phone Andrew Heap on
+61 2 6249 9790

email andrew.heap@ga.gov.au

Mapping the shallow-water bathymetry of the Great Barrier Reef

Australia's Great Barrier Reef covers in excess of 340 000 square kilometres and stretches for 2 600 kilometres along the eastern coast of Queensland, making it the largest coral reef in the world. The reef provides a significant economic contribution at both the state and national levels, primarily through the tourism and fishing industries, whilst also being the focus of considerable conservation and environmental management efforts. One of the important fundamental datasets for stakeholders in all of these activities is bathymetry or water depth.

Mapping the variable bathymetry of such a large marine area presents a number of challenges, both in terms of cost and practicality. Traditional ship-based methods, such as multi-beam sonar, are restricted to depths below about 15 metres and the cost of conducting such surveys can be prohibitive, particularly in remote areas. Laser Airborne Depth Sounding (LADS) is often used as a high-resolution bathymetry mapping tool, particularly in shallow water (between zero and 20 metres depth), to complement ship-based survey data. However, the acquisition of this data is costly, and not suited to the widely dispersed shallow water reef areas that characterise many areas of the Great Barrier Reef.

One alternative is the use of satellite imagery from the Japanese Advanced Land Observing Satellite (ALOS) operated by the Japan Aerospace Exploration Agency (JAXA). Data from the Advanced Visible and Near Infrared Radiometer Type 2 (AVNIR-2) sensor, offers a cost-effective tool to develop broad-scale shallow water bathymetry mapping techniques. In particular, the AVNIR-2 data is characterised by a large spatial coverage (a 70 kilometre swath width) and a high ground pixel resolution of 10 metres. This means that most of the Great Barrier Reef could be covered in approximately 25 ALOS scenes, while still retaining the fine-scale reef features.

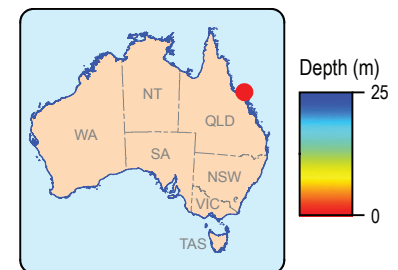
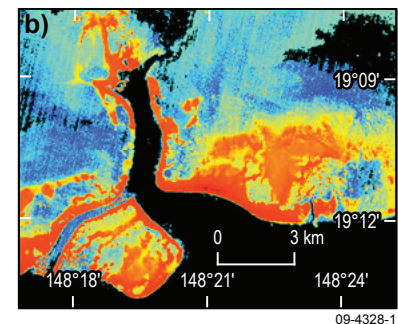
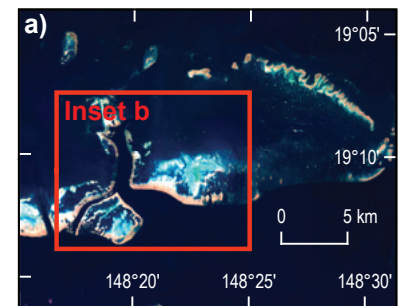


Figure 1. Bathymetry around Dingo Reef No. 1, Great Barrier Reef, derived from ALOS AVNIR-2 data.

The majority of available techniques using remote sensing to derive water depth have been based on empirical methodologies. These require known measurements over a range of depths in the study area to calibrate the algorithms being used. This becomes problematic in remote or extended areas, such as those in the Great Barrier Reef, where there is no available depth data for shallow areas.

To overcome this problem, researchers from Geoscience Australia are testing the use of a physics-based algorithm, which can derive bathymetry from the remote sensing signal without the need for known calibration depths. Assessment of the use of this technique with AVNIR-2 data has enabled the evaluation and development of mitigation solutions for problems such as excessive sun-glint, and the effect of reduced radiometric resolution with increasing depth.

Preliminary results have shown that this technique can derive shallow-water bathymetry to depths of approximately 20 metres,

which would deliver a valuable output to internal and external stakeholders engaged in environmental and economic research involving the Great Barrier Reef. This has the potential to develop into a broad-scale mapping capability across the agency.

For more information

phone Stephen Sagar on
+61 2 6249 9877

email: stephen.sagar@ga.gov.au

Smartline—mapping Australia’s coastal geomorphology

There is a growing need to identify those areas in Australia’s coastal zone which are potentially vulnerable to the impacts of climate change (Abuodha and Woodroffe 2006).

The Smartline, developed by the University of Tasmania and managed by Geoscience Australia, is a fundamental dataset commissioned by the Australian Government Department of Climate Change for their National Coastal Vulnerability Assessment (NCVA). The Smartline represents the first attempt to consistently map the coastal geomorphology and physical stability of the entire

Australian coastline. The mapping of coastal substrates and landforms which have varying sensitivity to the impacts of climate change and sea level rise (such as erosion, slumping, rock falls, and dune mobility hazard), is a key component of a coastal vulnerability assessment.

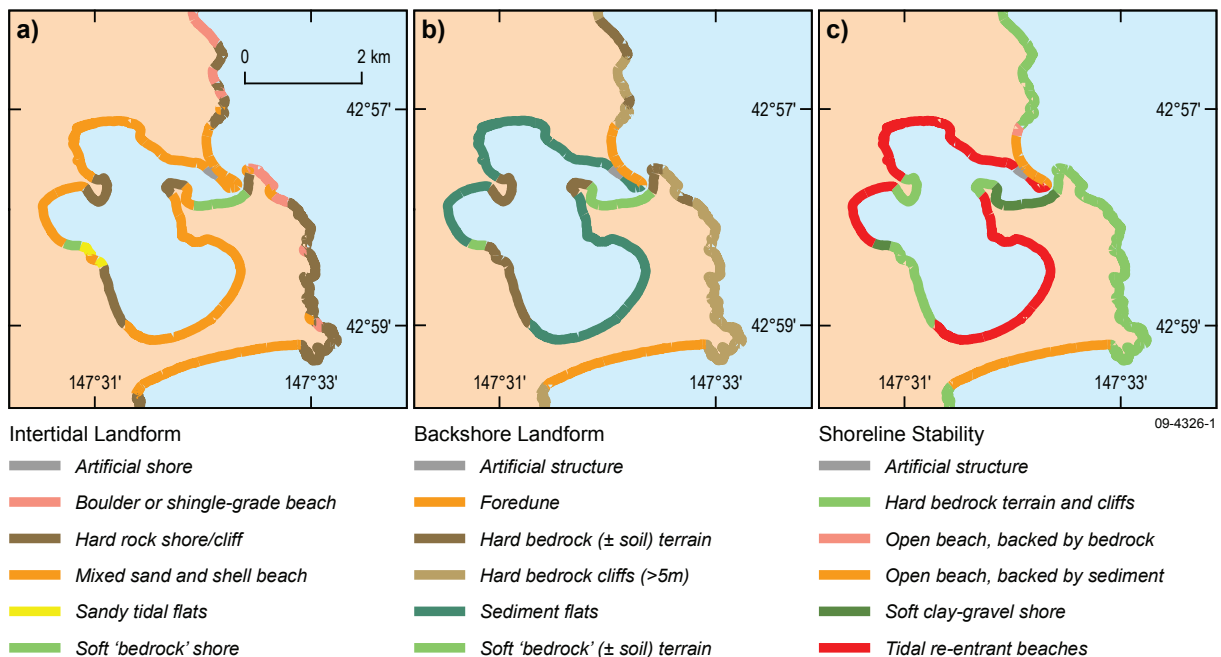


Figure 1. Simplified example of the Smartline intertidal landform, backshore landform and coastal stability classes.

Based on an approach developed by Sharples (2006) and expanded to incorporate the range of coastal landforms around Australia, the Smartline is a GIS format polyline that represents Australia's coastline at the mean high-water mark. The map was compiled by transferring information from over 200 pre-existing datasets (covering geology, habitat and geomorphology) onto a detailed coastline (figure 1). Using this information the Smartline is segmented each time a change in the geology, exposure, subtidal, intertidal, or backshore environment of the open coast occurs. By querying the landform and substrate information, sensitivity fields have been added to the dataset. These fields identify the potential susceptibility of each coastal segment to erosion and physical instability. By identifying soft (erosion-prone) coasts the Smartline has proved a useful tool for a first-pass coastal vulnerability assessment.

The Smartline has many uses for environmental planning, climate change adaptation and hazard assessment. The Smartline has made the first national identification of shorelines that are potentially susceptible to the impacts of climate change possible. It has also allowed for the identification of assets that are located within the vicinity of these potentially vulnerable shoreline types. Further, the Smartline has demonstrated the usefulness of geomorphology mapping to our understanding of how the coastal zone will respond to the impacts of global climate change such as sea level rise and an increased number of storms. Future development will focus on the addition of landform attributes for Australia's estuaries and coastal waterways.

Flood modelling tools reviewed

The average annual cost of floods to the community (excluding death and injury) over the period 1967 to 2005 has been estimated at \$377 million. When compared to the cost of severe storms, cyclones, earthquakes and bushfires they are Australia's most costly natural hazard (BITRE 2008). The development of tools, databases and models to support the identification and analysis of flood risk is therefore an important first step in reducing the cost of floods to the community. Two recent Geoscience Australia reports reviewed two flood modelling tools, the Australian Flood Studies Database and the inundation modelling tool ANUGA. The reviews were compiled following stakeholder consultation during 2008 and 2009 which sought feedback on the usefulness of these tools and explored options for their future development.

The Australian Flood Studies Database

Government and industry expend considerable resources to define flood areas in an effort to reduce the impacts of floods. This work usually includes the creation of reports detailing the methodology

For more information

phone Lynda Radke on
+61 2 6249 9237
email lynda.radke@ga.gov.au

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Related articles/websites

Smartline–National Coastal Landform and Stability Mapping Tool

www.climatechange.gov.au/en/publications/coastline/climate-change-risks-to-australias-coasts.aspx

OzCoasts website

www.ozcoasts.org.au



used, data sources and the results of the modelling. Though numerous reports are produced each year, there was

no centralised record of relevant studies undertaken in Australia at a state/territory or national level until 2004. The Australian Flood Studies Database was developed to address issues raised in the Council of Australian Governments' review of natural disasters, particularly the consistency of data collection and risk assessment. The database was made publically available through Geoscience Australia's website in 2006 following requests from local government.

Geoscience Australia reviewed the Australian Floods Studies Database in 2009 via an online questionnaire to determine if there was continued support from stakeholders. Three main recommendations were drawn from the survey responses and will be implemented with whole-of-government support. The major recommendations are that:

- the Australian Flood Studies Database is regularly updated and that the lead agency for floodplain management in each state or territory be responsible for updating at least annually
- the database's existing functionality and content is maintained and further enhanced (such as the addition of full reports)
- the database is further publicised.

The inundation modelling tool ANUGA

Geoscience Australia has also been leading the development of a software tool for modelling of two-dimensional water flows such as those arising from tsunami inundation. ANUGA is a collaborative effort of Geoscience Australia and the Australian National University and has gained increasing interest as a free and open source flood model. The development of ANUGA for flood modelling purposes has been guided and furthered through close consultation with a number of local government and consulting engineers.

The report highlights case studies where ANUGA has been used for flood modelling. This paper also makes two broad recommendations, including further:

- model validation and model comparison
- development of the ANUGA software to make it comparable with other two-dimensional flood models. The main priorities include the ability to model structures (culverts, pipe networks and bridges), the addition of a kinematic viscosity term and the inclusion of discharge as an inflow boundary condition.

For more information

phone Miriam Middelman-Fernandes +61 2 6249 9240
email miriam.middelmann@ga.gov.au

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www.bitre.gov.au/publications/38/Files/RegStats_2008.pdf

Related websites/articles

Review of the Australian Flood Studies database (Geoscience Australia Record 2009/34)

https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69365

Investing in the development of an open source two-dimensional flood modelling capability (Geoscience Australia Record 2009/36)

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69370

National catalogue of flood studies

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=61818

AusGeo News 82: New riverine flood hazard and risk studies available

www.ga.gov.au/ausgeonews/ausgeonews200606/productnews.jsp#product4

New map provides exploration pointers for nickel and platinum-group elements

Most of the world's very large economic deposits of nickel and platinum-group elements are found in mafic igneous rocks which are Proterozoic in age and part of exceptional Large Igneous Provinces (LIPs). To date, only one such major deposit has been discovered in Australia: the Nebo-Babel magmatic nickel sulphide deposit in the Musgrave region of central Australia, which contains more than one million tonnes of nickel metal. The discovery of other large deposits will require the identification, below cover, of the crustal-scale feeder systems of the most voluminous mafic-ultramafic magmatic events.

To encourage understanding of these very large magmatic systems, Geoscience Australia has released two new web-based map sheets that show the development of Australia's Large Igneous Provinces during the Proterozoic Eon 2500 to 542 Ma (million years).

Sheet 1 of the Australian Proterozoic Large Igneous Provinces map shows the solid geology and continent-wide distribution of the five major Proterozoic LIPs identified in Australia:

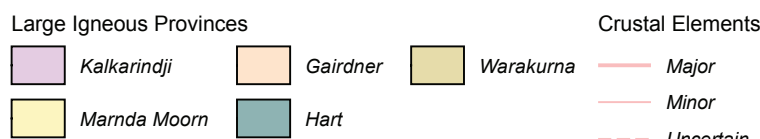
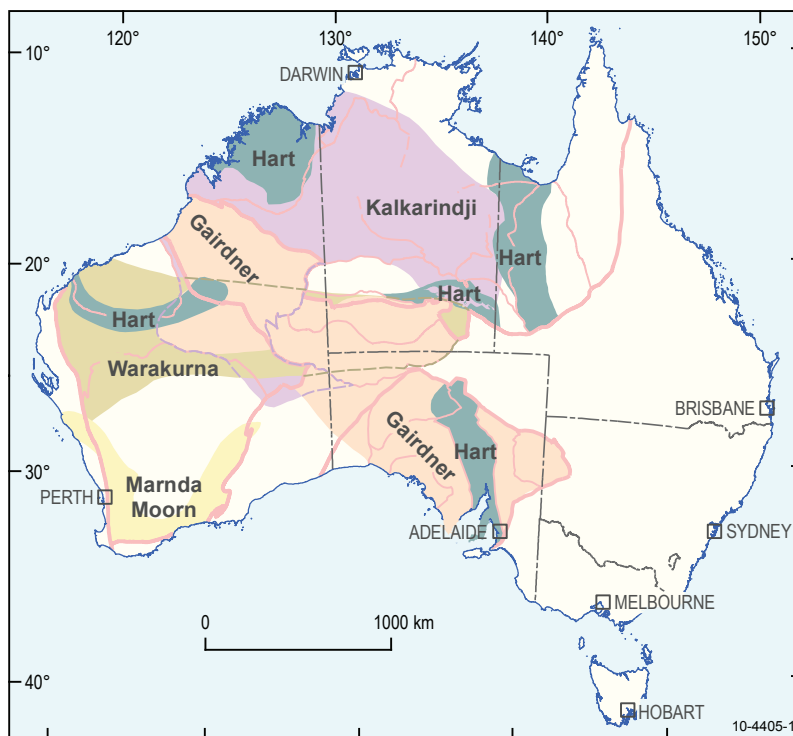


Figure 1. Collectively, the five major Proterozoic Large Igneous Provinces encompass more than half of the Australian continent. Their distributions are related to the Major Crustal Elements and reflect primary lithospheric structures.

- Hart (~1780 Ma), which extends from the Kimberley province in Western Australia to include large magmatic belts preserved across the west, north and south Australian Crustal Elements
- Marnda Moorn (~1210 Ma), which is preserved as a zone of dolerite dykes around the margins of the Yilgarn Craton
- Warakurna (~1070 Ma), which hosts the Nebo-Babel nickel discovery, and includes several large mafic intrusions in a belt across western and central Australia
- Gairdner (~825 Ma), which is preserved as lavas and subvolcanic intrusions in a northwesterly belt that transects the continent
- Kalkarindji (~510 Ma), which is the youngest, largest and best preserved of the LIPs, extending as lavas and intrusions across much of northern and central Australia.

The overlay of the five LIPs shows that they share important Crustal Element controls on their distribution. These provide indicators to possible locations of the crustal-scale feeder zones that have repeatedly channelled huge volumes of mafic-ultramafic magma, and could be targeted for magmatic ore deposit exploration.

Sheet 2 of the new map is an innovative Time Series that



plots the secular movement of mafic-ultramafic magmatic activity during the Proterozoic development of the Australian continent. The context of many smaller magmatic events shows the five LIPs sharing, and defining, Crustal Element controls that changed with time. This is another indicator of the prospectively mineralised magmatic feeder zones in the crust. Some other Proterozoic magmatic events which have the size that could indicate LIP status, but are not yet recognised as LIPs, have also been highlighted.

The new map should be studied together with the *Map of Australian Archean Mafic-Ultramafic Magmatic Events* and the *Map of Australian Proterozoic Mafic-Ultramafic Magmatic Events*. This comprehensive series of whole-of-continent maps provides a national framework for investigating under-explored and potentially mineralised environments to support the search for world-class nickel and platinum-group element deposits.

For further information

phone Jon Claoué-Long on +61 2 6249 9418
email jon.long@ga.gov.au

Related websites/articles

Map of Australian Proterozoic Large Igneous Provinces (Sheets 1 and 2)

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69213

AusGeo News 96: Revealing Archean mafic-ultramafic magmatism and mineral prospectivity across Australia

www.ga.gov.au/ausgeonews/ausgeonews200912/productnews.jsp#product2

AusGeo News 91: Revealing Proterozoic mafic-ultramafic magmatism in Australia.

www.ga.gov.au/ausgeonews/ausgeonews200809/productnews.jsp#product2

Maps available for download through the Geoscience Australia website

www.ga.gov.au/map/index.jsp

South Australian Seismic & MT Workshop 2010

Adelaide, 6 May 2010

NEW RESULTS TO BE RELEASED

This one-day workshop will present the results of new seismic and magnetotelluric data collected during 2008 and 2009 in the southern Gawler Craton & Curnamona Province of South Australia by Geoscience Australia and the Department of Primary Industries and Resources, South Australia.

When: Thursday 6 May 2010
Where: Hilton Hotel, Adelaide, South Australia
Costs: Free - but registration is required by Friday 16 April 2010
Contact: Narelle Neumann p: (02) 6249 9429 or e: Narelle.Neumann@ga.gov.au



Government of South Australia
Primary Industries and Resources SA



Australian Government
Geoscience Australia

New geophysical datasets released

Datasets from twelve new geophysical surveys which include the Canning and Eucla basins and Windimurra region in Western Australia, Cape York in Queensland, the Pine Creek Orogen and the Barkly region in the Northern Territory and the Jerilderie–Oaklands Basin in New South Wales have been released since October 2009.

These new airborne magnetic/radiometric, electromagnetic and gravity surveys provide basic geophysical data which can be interpreted to reveal the sub-surface geology of the survey area. The datasets will be a valuable tool in assessing the mineral potential of the respective survey areas and should stimulate mineral exploration.

The Seemore, Yampi–Derby, Broome, Central Canning, Mount Anderson–McLarty Hills and Cornish–Helena airborne magnetic and radiometric surveys and Windimurra gravity survey were managed by Geoscience Australia on behalf of the Geological Survey of Western Australia. The airborne magnetic and radiometric surveys were conducted under the Western Australian Government's *Exploration Incentive Scheme*.

The Cape York airborne magnetic and radiometric survey and gravity survey were managed by Geoscience Australia on behalf of the Geological Survey of Queensland and conducted under the Queensland Government's *Smart Mining–Future Prosperity* Program.

The Barkly gravity survey was managed by Geoscience Australia on behalf of the Northern Territory Geological Survey and conducted under the Northern Territory Government's *Bringing Forward Discovery* Initiative.

The Jerilderie–Oaklands Basin gravity survey was managed entirely by the Geological Survey of New South Wales and conducted under the New South Wales Government's *New Frontiers* Initiative.

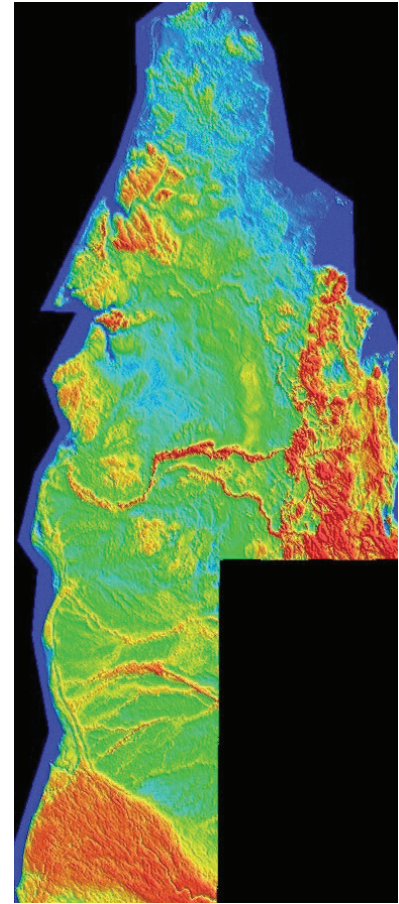
The Pine Creek–Kombolgie airborne electromagnetic survey in the Northern Territory was conducted as part of the Pine Creek Orogen component of Geoscience Australia's Onshore Energy Security Program. The Kombolgie data can be obtained free online by visiting the Free Data Downloads facility on Geoscience Australia's website or purchased on DVD for \$99.00 from the Geoscience Australia Sales Centre.

The magnetic, radiometric and gravity data have been incorporated into the national geophysical databases. The point-located and gridded data for these surveys can be obtained free online using the GADDS download facility.

For more information

phone Murray Richardson on +61 2 6249 9229

e-mail murray.richardson@ga.gov.au



Related websites

Geophysical Archive Data
Delivery System (GADDS)

www.geoscience.gov.au/gadds

Free Data Downloads facility
(Geoscience Australia)

www.ga.gov.au/products

Geological Survey of Western
Australia

www.dmp.wa.gov.au

Geological Survey of New South
Wales

www.dpi.nsw.gov.au/minerals/geological

Geological Survey of Queensland

www.dme.qld.gov.au

Northern Territory Geological
Survey

[www.nt.gov.au/d/Minerals_Energy/
Geoscience/](http://www.nt.gov.au/d/Minerals_Energy/Geoscience/)

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

Survey	Date	1:250 000 map sheets	Line spacing/ terrain clearance/ orientation	Line km	Contractor
Seemore (Eucla Basin 1) WA	June–September 2009	Seemore (pt), Loongana (pt).	200 m 50 m east–west	89 906	Thomson Aviation Pty Ltd
Yampi–Derby (North Canning 2) WA	June–September 2009	Yampi (pt), Derby (pt).	400 m 60 m north–south	66 700	GPX Surveys Pty Ltd
Broome (North Canning 1) WA	June–September 2009	Pender (pt), Yampi (pt), Broome (pt), Derby (pt).	400 m 60 m north–south	76 000	UTS Aeroquest Pty Ltd
Central Canning WA	June–September 2009	Anketell (pt), Joanna Spring (pt), Paterson Range (pt), Sahara (pt), Tabletop (pt), Percival (pt), Ural (pt).	800 m 60 m north–south	91 700	Fugro Airborne Surveys Pty Ltd
Mount Anderson–McLarty Hills (North Canning 3) WA	June–September 2009	Mount Anderson, McLarty Hills.	400 m 60 m north–south	98 200	UTS Aeroquest Pty Ltd
Cornish–Helena (East Canning 2) WA	June–October 2009	Mount Bannerman (pt), Cornish, Helena.	400 m 60 m north–south	123 910	Thomson Aviation Pty Ltd
Cape York Qld	April–October 2009	Thursday Island (pt), Cape York (pt), Jardine River (pt), Orford Bay (pt), Weipa (pt), Cape Weymouth (pt), Aurukun (pt), Coen (pt), Holroyd (pt), Rutland Plains (pt).	400 m 80 m east–west	238 900	GPX Surveys Pty Ltd

Table 2. Details of Pine Creek Orogen electromagnetic survey.

Survey	Date	1:250 000 map sheets	Line spacing/ terrain clearance/ orientation	Line km	Contractor
Pine Creek – Kombolgie (VTEM®) NT	August–November 2008; April 2009	Cobourg Peninsula (pt) Junction Bay (pt), Alligator River (pt), Millingimbi (pt), Mount Evelyn (pt), Katherine (pt).	1600 m and 5000 m, 80 m (aircraft), 45 m (sensor), east–west.	8780	Geotech Airborne Pty Ltd

Table 3. Details of gravity surveys.

Survey	Date	1:250 000 map sheets	Station spacing, orientation	Stations	Contractor
Windimurra WA (Release of Infill Stations)	August–September 2008	Cue (pt), Sandstone (pt), Kirkalocka (pt), Youanmi (pt), Ninghan (pt).	2500 m east–west; Positioned centrally between the stations spaced 2500 m apart; collected for GSWA.	852 (Infill Stations)	Atlas Geophysics Pty Ltd
Barkly NT	June–October 2009	Daly Waters (pt), Tanumbirini (pt), Bauhinia Downs (pt), Robinson River (pt), Newcastle Waters (pt), Beetaloo (pt), Wallhallow, Calvert Hills, Helen Springs (pt), Brunette Downs, Mount Drummond (pt), Alroy, Ranken (pt), Frew River (pt), Avon Downs (pt).	4000 m east–west	9732	Atlas Geophysics Pty Ltd
Cape York Qld	May–September 2009	Thursday Island (pt), Cape York (pt), Jardine River (pt), Orford Bay (pt), Weipa (pt), Cape Weymouth (pt), Aurukun (pt), Coen (pt), Holroyd (pt), Ebagoola (pt), Cape Melville (pt), Rutland Plains (pt), Hann River, Cooktown (pt), Mossman (pt), Atherton	4000m east–west	10 315	Daishsat Pty Ltd
Jerilderie–Oaklands Basin NSW	June 2009	Hay (pt), Narrandera, Deniliquin (pt), Jerilderie, Bendigo (pt), Wangaratta (pt).	4000 m with some 2000 m infill, east–west	2350	Daishsat Pty Ltd

Hydrocarbon and geothermal prospectivity of central Australian basins

Geoscience Australia has recently released a report on the hydrocarbon and geothermal prospectivity of the basins of the central Australian region. The study examines the region, nominally constrained by 22.5°S 134°E and 31.5°S 144°E, where several systems of stacked basins lie beneath the extensive Mesozoic Eromanga Basin. These basins include: the Warburton, Cooper, Perdirk, Galilee, Simpson and Eromanga basins.

The Mesozoic Eromanga Basin, which blankets the entire region, has deep depocentres overlying and offset from the underlying Carboniferous–Triassic basins. The Eromanga Basin sequence is the



main oil producer of the couplet, with the dominant source being the underlying Cooper sequences.

This region, the most productive onshore petroleum province of Australia, has produced 5.5 Tcf (trillion cubic feet) of gas and 255 million barrels of oil since the 1970s. It also features world-class geothermal resources associated with underlying high heat producing (HHP) granites. These resources are currently being evaluated by Geodynamics at their Innamincka project where they have reached 'proof of concept' for extracting energy from hot fractured rock. Collectively, the geothermal and sustained petroleum potential of the Cooper–Eromanga Basin points to it continuing as one of Australia's energy production centres.

This report documents the context and characteristics of all related basins in this region and their petroleum potential to identify information gaps which remain as critical uncertainties that have suppressed exploration in these areas.

The report outlines the exploration history of the Cooper–Eromanga fields as a guide to future exploration, the basement and structural context, and the spatially-separate stacked basin systems.

Eastern Yilgarn Craton metamorphism study

Geoscience Australia has recently released a new report and map on the metamorphic evolution of the eastern Yilgarn Craton. This study will make a significant contribution to our understanding of the world-class gold mineral systems of the region.

The spatial and temporal patterns of the craton's metamorphic rocks provide fundamental insights into the history and likely tectonic setting of the region. They also outline the fluid history of the crust and associated mineralisation events. The study was initiated because metamorphic rocks:

- preserve a long and near-continuous record of orogenic history
- are the only source of information on crustal depths and paths of individual particles through the crustal column which recognise lithospheric thinning and thickening events
- are the sole source of information that tracks the long-term thermal evolution of the crust.

This research is underpinned by a comprehensive metamorphic database covering the entire eastern Yilgarn Craton, which was compiled from available mapping. The database includes: 14 500 sites with qualitative metamorphic information, and 470 new key sites with detailed quantitative metamorphic data, including pressure (P), temperature (T), temperature/depth ratio and pressure–temperature

Summaries of individual basins and their statistics are provided for reference as appendices.

For more information visit

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69150

Hydrocarbon and Geothermal Prospectivity of the Sedimentary Basins in Central Australia: Warburton, Cooper, Perdirka, Galilee, Simpson and Eromanga Basins (Geoscience Australia Record 2009/25)

www.ga.gov.au/image_cache/GA15314.pdf



paths. This is a unique compilation, and the authors are unaware of any other comparable study of a Precambrian terrane with this scope and magnitude. The continual evolution over time of fundamental metamorphic parameters has been constructed as evolution curves and integrated with the

deformation, magmatic, stratigraphic and mineralisation history of the craton.

This new study contrasts significantly with previous tectonic and metamorphic interpretations in the eastern Yilgarn Craton. In particular, there are large variations in peak metamorphic crustal depths (12 to 31 kilometres), and five metamorphic periods have been defined. Implicit in these metamorphic constraints are large displacement shear zones that juxtapose the different metamorphic domains, and provided the backbone architecture of the gold mineral system.

This research was undertaken between 2006 and 2008 as a project of the Predictive Mineral Discovery Cooperative Research Centre and is now available in the public domain.

For further information

phone Dr Richard Blewett on +61 2 6249 9713

email richard.blewett@ga.gov.au

Groundwater sampling and analysis made easier

Groundwater resources support many urban, rural and remote communities across Australia. The groundwater is received and stored in aquifers (rock or soil formations) which are a source of water for drinking, irrigation, stock supply, bottling and many other uses. Groundwater accounts for more than 30 per cent of Australia's total water consumption.

In some parts of Australia, the current rate of groundwater extraction is depleting the resource faster than it is being replenished. Consequently, understanding the basic processes about groundwater as well as the factors affecting its quantity and quality is vital for sustainable groundwater management.

This new field guide has been compiled to provide a comprehensive set of sampling guidelines that focus on a range of groundwater quantity and quality issues. The comprehensive and practical guidelines cover the basic elements of effective groundwater sampling in the field. They also provide simple and effective methods for monitoring groundwater systems as well as outlining procedures for sampling from the bore site to the laboratory. A uniform, accurate, and reliable set of sampling procedures should ensure greater confidence in the interpretation of any field based-data.

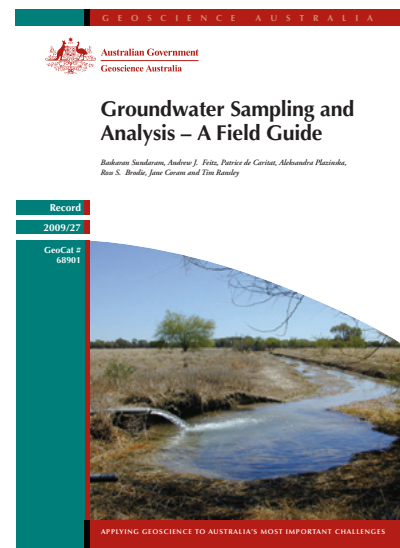
The authors were also mindful of the need to provide a comprehensive set of guidelines which can be used across a range of geoscientific disciplines. In addition to groundwater resource assessment and management, they include mineral exploration, geothermal energy resources, and carbon capture and storage.

Related websites/articles

Predictive Mineral Discovery
Cooperative Research Centre
www.pmdcrc.com.au

Metamorphic Evolution and
Integrated Terrane Analysis of
the Eastern Yilgarn Craton:
Rationale, Methods, Outcomes
and Interpretation (Geoscience
Australia Record 2009/23)
[www.ga.gov.au/products/servlet/
controller?event=GEOCAT_
DETAILS&catno=68806](http://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=68806)

Eastern Yilgarn Craton
Metamorphism and Strain map
[www.ga.gov.au/products/servlet/
controller?event=GEOCAT_
DETAILS&catno=69771](http://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69771)



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controller?event=GEOCAT_
DETAILS&catno=68901](http://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=68901)

Groundwater Sampling and
Analysis – A Field Guide
(Geoscience Australia Record
2009/27)

[www.ga.gov.au/image_cache/
GA15501.pdf](http://www.ga.gov.au/image_cache/GA15501.pdf)

A Geological TimeWalk for Geoscience Australia

The Minister for Resources and Energy and Minister for Tourism, The Hon Martin Ferguson AM MP, launched Geoscience Australia's Geological TimeWalk on 24 November 2009 to commemorate the 200th birthday of Charles Darwin and the 150th anniversary of the publication of his book, *On the Origin of Species*.

The TimeWalk, established in the grounds of Geoscience Australia's headquarters in the Canberra suburb of Symonston, has been designed to convey the vast period of time spanning Earth's 4600 million year history. Information plaques, marking each geological time interval have been spaced along the one kilometre walk, emphasising key events in the formation of Earth including five major mass extinctions.

'The Geological TimeWalk takes visitors on a unique journey where they can explore the geological, climatic and biological events that have shaped the Earth as we know it today', the Minister said during the official opening. 'It provides a physical dimension to help us appreciate the length of time and the complexity of the evolution of planet Earth'.

The TimeWalk has a uniquely Australian perspective and refers to the formation of some of Australia's iconic landscapes. These include the Warrumbungles in northern New South Wales, the Flinders Ranges in South Australia, and the Great Barrier Reef in Queensland which were all formed during the geologically recent Neogene Period, between 2.5 and 23 million years ago.

The TimeWalk also highlights the extraordinary age of some of our mineral resources. For example, the Hammersley Basin Banded Iron Formations in Western Australia, an important economic source of iron ore,

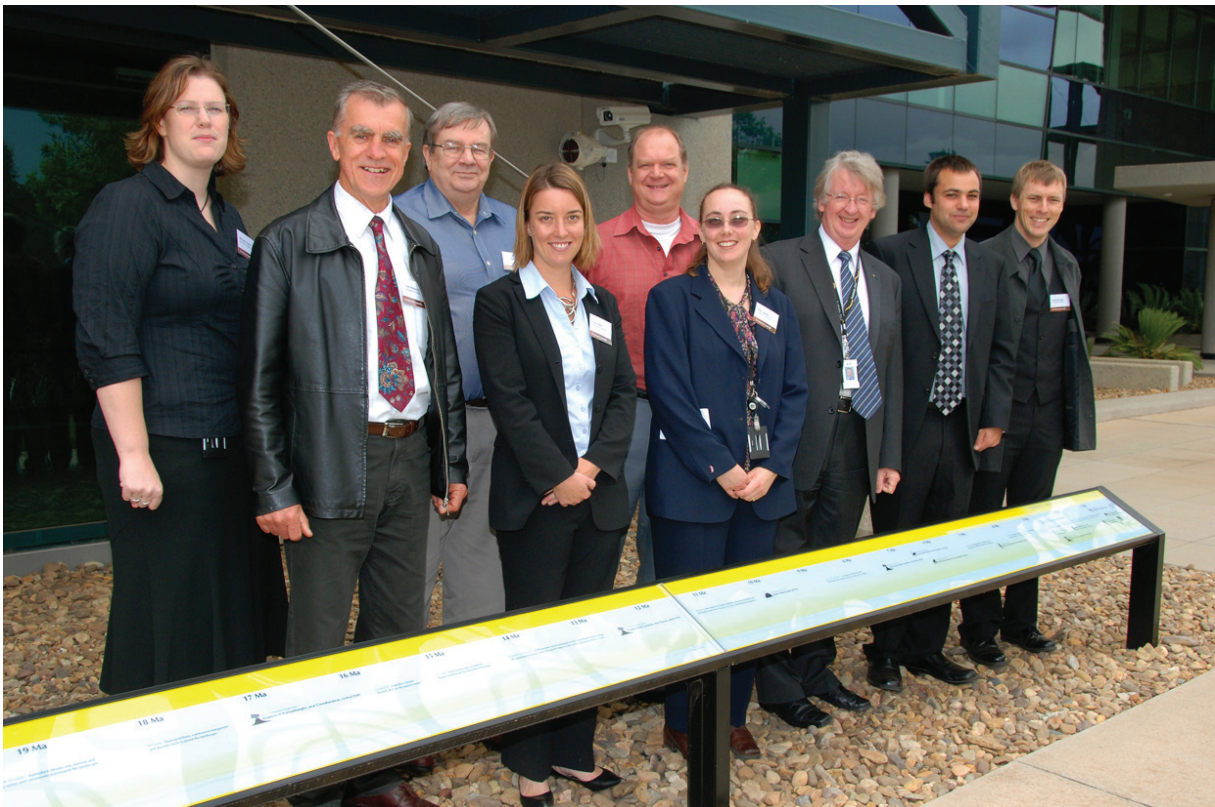


Figure 1. Dr Neil Williams, CEO of Geoscience Australia (third from right), with Geoscience Australia staff who contributed to the development of the Geological TimeWalk, following the launch on 24 November 2009.

were deposited in the Paleoproterozoic Era approximately 2500 million years ago.

Geoscience Australia plans to complement the TimeWalk with appropriate, significant rock, fossil and plant specimens sourced from around Australia to illustrate the geological history as well as the complexity and diversity of the continent.

A guidebook to be used in conjunction with the Geoscience Australia TimeWalk has also been developed. The guide provides a more detailed account of Australia's geological history and is available on request for TimeWalk visitors or as a free download through the Geoscience Australia website. A downloadable version of the information plaques are also available from the website as well as instructions for creating a TimeWalk.

Team Australia Geothermal a hit

The 33rd Geothermal Resources Council (GRC) Annual Meeting and Tradeshow was held at the Peppermill Hotel in Reno, Nevada from 5 to 8 October 2009. This is the largest annual geothermal industry gathering in the world and the 2009 meeting was attended by a record-breaking 1300 registrants. An additional 1000 visitors passed through the tradeshow.

Australia's high-profile promotion at the Tradeshow was designed to promote the developing industry in Australia and combined industry and government exhibitors using the 'Team Australia Geothermal' banner. The exhibitors included six geothermal exploration companies, three government agencies and two industry associations. Whilst this approach was something of a novelty to the American attendees, it proved highly successful with all the participating companies reporting significant responses.



Figure 1. The Team Australia Geothermal exhibitors, including Dr Andy Barnicoat and Dr Anthony Budd of Geoscience Australia (2nd and 3rd from left), following the presentation of the 'Best in Show' award.

The TimeWalk will be a focus for promoting awareness of geoscience as part of Geoscience Australia's education activities and public events programs and a popular drawcard for visitors to the national capital.

For more information

phone Fiona Slater on
+61 2 6249 9859
email education@ga.gov.au

The 'Team Australia Geothermal' booth concept and Australian-themed branding for the displays resulted in the awarding of the 'Best in Show' award to 'Team Australia Geothermal' by the organisers. This award was particularly pleasing for the Geoscience Australia attendees as the display was designed and prepared by Geoscience Australia staff.

Following the success of the Geothermal Resources Council promotion, 'Team Australia Geothermal' will be attending the World Geothermal Congress in Bali, Indonesia in April 2010. This will also provide an opportunity to promote the next World Geothermal Conference to be held in Melbourne in 2015.

For more information

phone Anthony Budd on
+61 2 6249 9574
email anthony.budd@ga.gov.au



XXIV FIG International Congress 2010	11 to 16 April
International Federation of Surveyors Sydney Convention & Exhibition Centre Contact: arinex Pty Ltd GPO Box 128, Sydney NSW 2001	p +61 2 9265 0700 f +61 2 9267 5443 e fig2010@arinex.com.au www.fig2010.com
World Geothermal Congress 2010	25 to 30 April
International Geothermal Association Bali International Convention Centre Contact: Organising Committee WGC 2010, Grha Bimasena, JI Dharmawangsa Raya 39, Jakarta Selatan, Indonesia	p +62 21 725 8668 f +62 21 7236 193 e secr@wgc2010.org www.wgc2010.org/working/index.php
Onshore Energy Security Program Gawler Workshop	6 May
Geoscience Australia and Primary Industries and Resources South Australia Hilton Hotel, Adelaide Contact: Narelle Neumann, Geoscience Australia, GPO Box 378, Canberra ACT 2601	p +61 2 6249 9429 e narelle.neumann@ga.gov.au www.ga.gov.au/minerals/research/ oesp/index.jsp
2010 APPEA Conference and Exhibition	16 to 19 May
Australian Petroleum Production and Exploration Association Brisbane Convention & Exhibition Centre Contact: Moira Lawler, APPEA Limited, GPO Box 2201, Canberra ACT 2601	p +61 2 6267 0906 e jhood@appea.com.au www.appeaconference.com.au
AMEC National Mining Congress	1 & 2 June
Association of Mining and Exploration Companies Inc Perth Convention Exhibition Centre 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.amec.org.au
Climate Adaptation Futures	29 June to 1 July
2010 International Climate Change Adaptation Conference Gold Coast Convention Centre Contact: Conference Secretariat, YRD (Aust) Pty Ltd, PO Box 717, Indooroopilly Qld 4068	p +61 7 3368 2422 f +61 7 3368 2433 e nccarf-conf2010@yrd.com.au www.nccarf.edu.au/conference2010
AESC 2010	4 to 8 July
Australian Earth Sciences Convention National Convention Centre, Canberra Contact: Conference Logistics, PO Box 6150, Kingston ACT 2604	p +61 2 6281 6624 f +61 2 6285 1336 e aesc@conlog.com.au www.aesc2010.gsa.org.au/
21st International Geophysical Conference & Exhibition	22 to 26 August
Australian Society of Exploration Geophysicists & Petroleum Exploration Society of Australia Sydney Convention & Exhibition Centre Contact: Conference Action Pty Ltd, PO Box 576, Crows Nest NSW 1585	p +61 2 9437 9333 f +61 2 9901 4586 e asec-pesa2010@conferenceaction. com.au www.aseg-pesa2010.com.au

For more information on Geoscience Australia's involvement in the above events
phone Suzy Domitrovic on +61 2 6249 9571 email suzy.domitrovic@ga.gov.au