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Geoscience Australia

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CEO comment

Neil Williams – CEO Geoscience Australia

This issue of *AusGeo News* features a wide variety of articles covering Geoscience Australia's contribution to natural resource management and conservation, protection of Australia's borders, and the upgrading of ground infrastructure to improve the accuracy and precision of key geodetic techniques. There is also information on a range of new products to assist mineral and energy resource explorers.

There is a report on research into the physical and chemical conditions and the ecological character of the Coorong to identify groundwater discharge and its possible impact on water quality. The Coorong and Lower Lakes are major interconnected coastal water bodies between the Murray River and the Southern Ocean. Changes in the flow regime and water quality have led to degradation of habitats and the ecological character of the region.

Geoscience Australia recently released the OzCoasts website, the largest central source of coastal information and data in Australia. The website will support natural resource management and the conservation of Australia's coastal zone, estuaries and near-shore environments.

Australia has one of the largest Economic Exclusion Zones (EEZ) in the world. In addition to our contributions to the search for indications of active petroleum systems and documenting of marine diversity and habitats, Geoscience Australia recently collaborated in a trial to evaluate the viability of monitoring the EEZ by satellite.

I am pleased to report that final data for the offshore Tasmania magnetic and radiometric surveys covering Bass Strait and the northwest and southwest offshore areas has been released. Seismic reflection surveys in the Gawler and Curnamona provinces and Arrowie Basin in South Australia were completed in July and an airborne electromagnetic survey in the Pine Creek region (Northern Territory) commenced in August. These surveys are part of Geoscience Australia's Onshore Energy Security program to stimulate and support industry's search for new resources. Details were included in *AusGeo News 90*.

This issue also includes reports on a number of newly released products to encourage mineral and energy resource exploration in Australia. They include:

- The third edition of the Gravity Anomaly Map of the Australian region which features greatly improved coverage of areas of economic and scientific interest
- Australia-wide Proterozoic mafic-ultramafic map which documents the 30 major magmatic events and associated mineral deposits which will be of interest to explorers searching for nickel, platinum-group elements, chromium, titanium and vanadium
- Digital surface geology dataset (1:1 million scale) for South Australia which places important mineral deposits, such as Olympic Dam and Prominent Hill, in their regional geological context.

A significant part of this work was undertaken with the state and territory geoscience agencies under the National Geoscience Agreement.

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

Neil Williams

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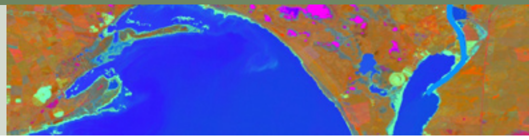
Identifying groundwater discharge in the Coorong (South Australia)



Multi-disciplinary study maps major indicators

Ralf R. Haese, Laura Gow, Luke Wallace and Ross S. Brodie

The Coorong, and the Lower Lakes (Lake Alexandrina and Lake Albert) in South Australia are major interconnected coastal water bodies between the Murray River and the Southern Ocean (figure 1). During the 1940s, five barrages were constructed between Lake Alexandrina and the opening to the ocean to establish a reservoir of potable water in the Lower Lakes. As a consequence, freshwater inflow from the Murray River to the Coorong became restricted. In addition, freshwater delivery through the Murray River has declined over decades but more markedly during recent years, leading to an increase in salinity levels in the Coorong.

Degradation of habitats and the ecological character of the region have been associated with these changes in the flow regime and water quality. This has become a major concern given the ecological value of the region, particularly in providing highly diverse habitats for migratory birds, rare plant and fish species.

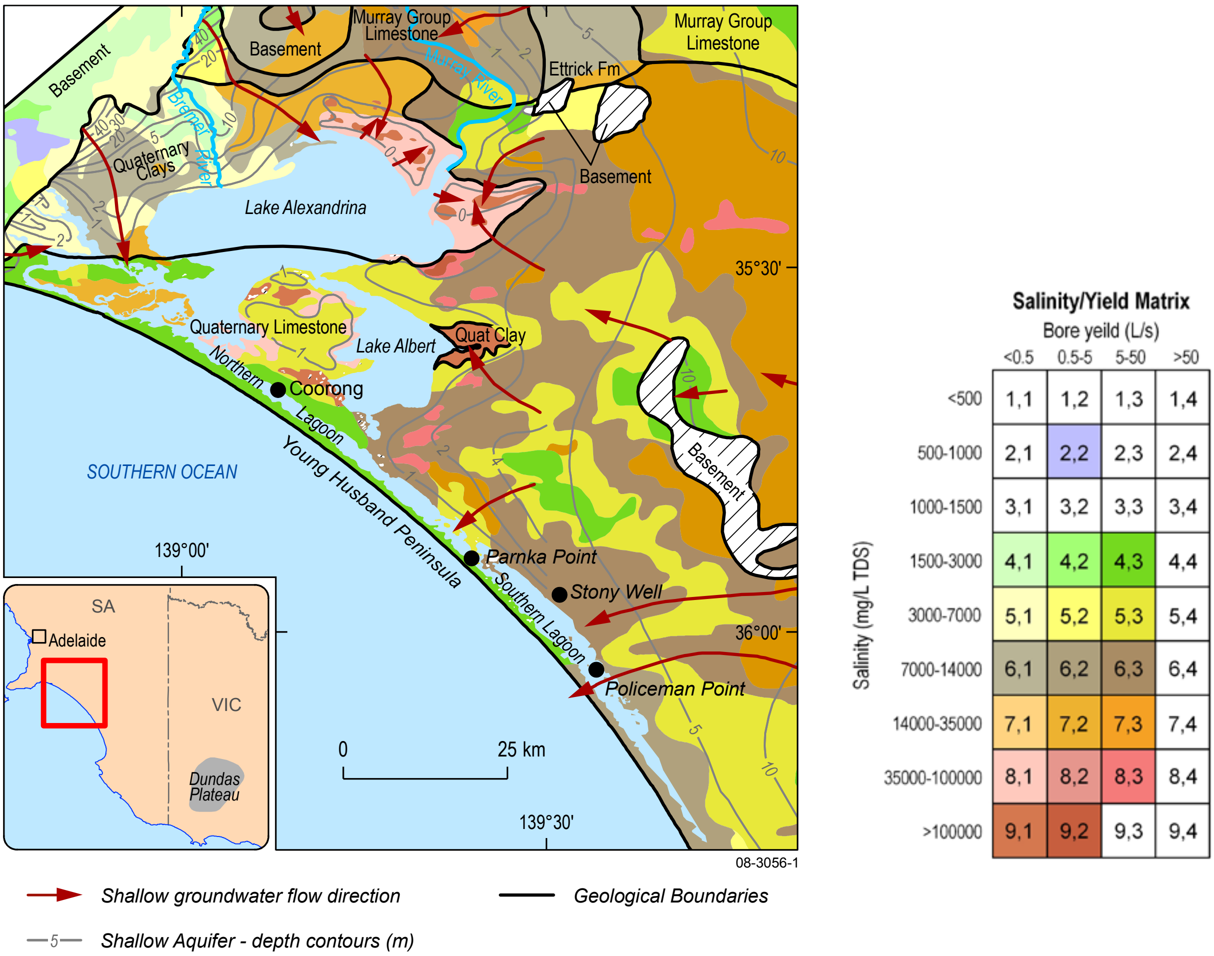


Figure 1. Hydrogeological map of the Coorong Lagoon and Lower Lakes Region (based on Barnett 1991, Barnett 1994, Cobb & Barnett 1994).

The need to protect the Coorong and Lower Lakes region was formally acknowledged in 1985, with designation onto the Ramsar List of Wetlands of International Importance.

Research into the physical and chemical conditions, and the ecological character of the Coorong and the Lower Lakes is currently being undertaken as part of CSIRO's Flagship for a Healthy Country involving CSIRO, the University of Adelaide, Flinders University, the South Australian Research and Development Institute and Geoscience Australia. Geoscience Australia undertook an initial field survey to the Coorong in August 2007 to identify nutrient sources and sinks. Preliminary field observations suggested the potential importance of groundwater discharge for water quality in the Coorong. In order to evaluate the possible occurrence of groundwater discharge along the Coorong more systematically, three approaches were taken and the results are presented below:

- A literature and data review on the regional groundwater system
- Interpretation of remote sensing data (Landsat 5 TM)
- Field observations and measurements of groundwater seepage.

Hydrogeology of the Coorong and Lower Lakes region

The Coorong and Lower Lakes are located in the south-western edge of the Murray Geological Basin. The significant aquifers (or geological formations which hold water) in this region are the Quaternary and Murray Group Limestone sequences, and the deeper confined Renmark Group sands. The limestone sequences are in good hydraulic connection (Barnett 1994) and form the shallow watertable aquifer. The Renmark and Murray Groups are separated by a series of confining clay aquitards (Brown et al 2001).

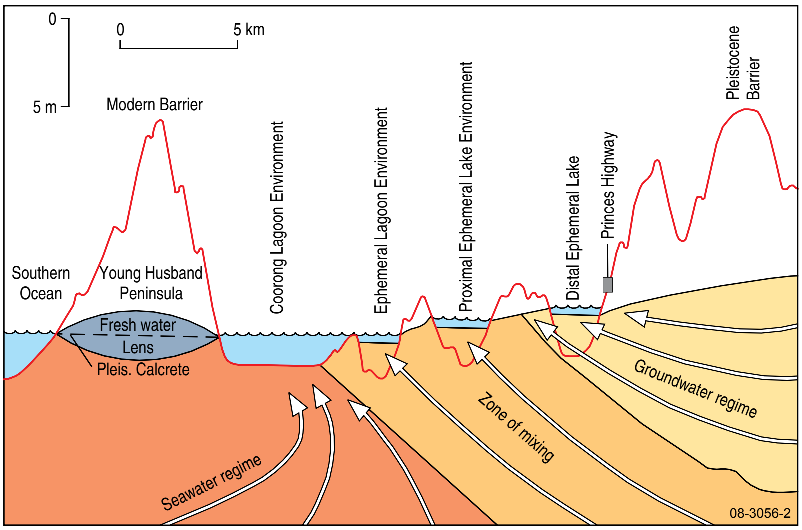


Figure 2. Generalised cross section of the Coorong Lagoon and the coastal plain indicating the groundwater/seawater interface (from Van der Borch et al 1975). Note the perched freshwater lens.

A hydrogeological map of the Lower Lakes and Coorong region (figure 1) and the associated description have been derived from three previously compiled map sheets (Barnett 1991, Barnett 1994, Cobb and Barnett 1994). Major processes such as groundwater recharge and discharge, dryland salinisation, irrigation and groundwater/surface water interaction were identified within this region. The map uses a matrix approach to display salinity and yield characteristics for the shallow aquifer. Dryland salinity in the region is a major land degradation problem on the low-lying coastal plain, where clearing of native vegetation has led to a rising watertable. The risk of salinisation is most prevalent where depth to the watertable is less than two metres.

As was originally concluded by O'Driscoll (1961), groundwater flows radially from the zone of recharge at Dundas Plateau in the east, northward to the Murray River (Tyler et al 1983) or westward, discharging to the Coorong, the Lower Lakes or low-lying salinised areas (Barnett, 1994), demonstrated by the potentiometric contours (figure 1). A groundwater-seawater conceptual model has also been developed for the Coorong (Von Der Borch et al 1975). The model (figure 2) shows the following sequence of water bodies:

- a typical saltwater wedge intruding from the ocean
- fresher, lower density, terrestrial groundwater located above seawater
- a large mixing zone at the groundwater-seawater interface, with discharge at the surface.

The model also explains the occurrence of ephemeral lakes and freshwater-dependent vegetation communities ('soaks').

On the western side of Lake Alexandrina, the watertable is within a Quaternary clay which overlies and semi-confines the limestone aquifer. Elsewhere in low-lying areas around the Lower Lakes, the watertable occurs in organic-rich clays which were deposited when the Lower Lakes expanded in response to a higher sea level about 6000 years ago. These areas contain highly saline groundwater (>100 000 milligrams per litre) due to strong evaporative discharge which has lowered the watertable below sea level. The watertable contours show that these areas are the focus for regional groundwater discharge in preference to the Lower Lakes which are at a higher level of 0.75 metres Australian Height Datum (AHD). Lower Lake levels have subsequently declined in the 14 years since the publication of these map sheets.

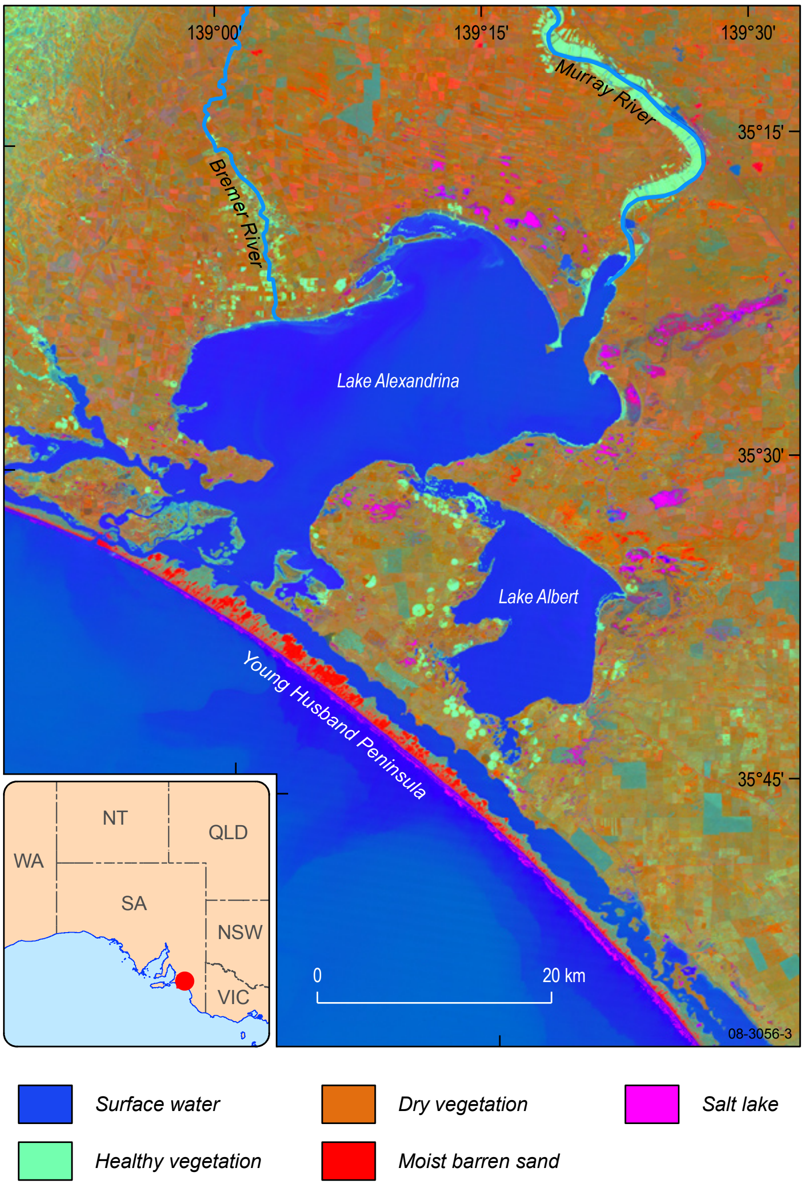


Figure 3. Tasselled Cap Transform of Landsat 5 TM imagery for December 1993.

Groundwater processes identified by remote sensing

Groundwater processes have the potential to influence wetland hydrology and ecosystems. In this study, remote sensing was used to map indicators of groundwater discharging at the surface, the presence of a shallow watertable or sustained soil moisture. For example, persistent vegetation health, particularly through prolonged dry periods, can be an indicator of groundwater influence. To this end, Landsat 5 Thermal Mapper (TM) imagery was used to detect seasonal and annual changes in vegetation health within the region, using a combination of well-established algorithms (Normalised Difference Vegetation Index, Normalised Difference Water Index and Tasselled Cap Transforms).

The Tasselled Cap Transform of Landsat 5 TM imagery for December 1993 is shown in figure 3. Orange represents dry vegetation, blue is surface water and green indicates healthy vegetation. The latter effectively maps irrigated agriculture, particularly bordering the Murray and Bremer Rivers. Relatively healthy riparian vegetation in these areas also has a similar signal but does not conform to the regular dimensions observed of agricultural regions. These riparian regions may represent a localised shallow watertable. Salt lakes, distributed around the edges of the Lower Lakes are indicated as pink.

Figure 4. Thermal based classification of the Coorong and Lower Lakes region. Red areas are groundwater discharge zones.

Other image processing suggests that it is not the availability of saline groundwater that is supporting vegetation in these areas, but seasonal fresh surface water. Along the Younghusband Peninsula, red areas are exposed moist sand dunes and green areas are relatively healthy native vegetation. In this case, dune vegetation is accessing a perched freshwater lens (figure 2), rather than the regional watertable.

Thermal imagery was also used to identify groundwater discharge areas, soil moisture and surface water extent. This is possible, because the summer daytime surface temperature of water is cooler than soil and rock, damp soil is cooler than dry soil, and discharging groundwater is cooler than surface water. A series of classifications were thus produced for the region based on thermal signatures (figure 4). Areas that become clearly evident include irrigated crops (rectangular or circular dark brown areas) and the salt lakes (irregularly shaped dark brown and light blue areas bordering the Lower Lakes). Importantly, relatively cool zones of surface water, indicated in red, are prevalent in the southwest of Lake Alexandrina and south of Parnka Point in the Coorong. These are interpreted as potential sites of significant discharge of cooler groundwater into the surrounding water bodies. Direct groundwater discharge may be

Figure 5. Observed features in the field (February 2008) giving evidence for past and current groundwater discharge in the South Lagoon. (a) Carbonate tube 'tufa' at Policeman Point; (b) stranded pools at Stony Well; (c) active seep showing agitated sediment south of Parnka Point (see figure 1).

occurring elsewhere, however it is difficult to detect temperature contrasts in the deeper waters of Lake Alexandrina. The thermal Landsat band used is also of low resolution (30 metres) and more detailed interpretation could be produced from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery, particularly with the comparison of daytime and night-time scenes.

Field observations and measurements of groundwater discharge

Several indications of groundwater discharge are often visible in the field including the precipitation of minerals (typically carbonates and iron oxides) at the groundwater–surface water interface, the presence of water bodies without surface water inputs, and the occurrence of visible seeps. After initial indications of groundwater discharge were observed during a survey of the Coorong in August 2007, a second survey in February 2008 targeted field groundwater discharge features. The low water levels of the Coorong at the time of the survey sub-aerially exposed many of the normally inundated features.

Carbonate deposits were found to be pervasive along the eastern shore of the Coorong's South Lagoon (figure 5a). These deposits often take the form of cylindrical tubes (5 to 100 centimetres diameter) commonly known as 'tufa' which are indicative of groundwater discharge. The tufa in the Coorong are composed of concentric carbonate laminations millimetres thick, suggesting cyclic accretion. Tufa were found adjacent to the majority of bays and headlands, generally within 100 metres of the shoreline, forming either elongated reefs that parallel the coastline or shelfs that extend from the shore into the lagoon. The size and extent of the tufa indicate groundwater has occurred throughout the history of the Coorong and may have been much greater in the past.

Stranded pools were also common along the eastern shore of the South Lagoon, and often associated with tufa (figure 5b). As a result of low water levels prevalent during the survey, the main water body of the Coorong was typically tens to hundreds of metres from the shoreline. Stranded pools of water disconnected from the main water body persisted. The pools were typically several metres wide running parallel to the coast line with strings of pools stretching for kilometres. The presence and extent of stranded pools indicate the presence of groundwater discharge even under drought conditions.

Visible seeps were observed at several sites within the Coorong's South Lagoon (figure 5c). Like the tufa and stranded pools, the seeps were located at the edge of the Coorong within 100 metres of the shoreline. The seeps were identified by the agitation of sediments as groundwater flowed rapidly upwards, and by the difference in density between surface water and the inflowing groundwater. Individual seeps were several centimetres in diameter and spaced several centimetres to metres apart. Direct measurement of groundwater discharge showed high flow rates of 38 to 246 $lm^{-2}\ h^{-1}$ from visible seeps but also high flow rates of 11 to 38 $lm^{-2}\ h^{-1}$ where visible seeps were not present. This, in conjunction with tufa and stranded pools, indicate that visible seeps are only the surface expression of a much larger groundwater discharge zone that extends along the eastern shoreline of the Coorong's South Lagoon.

Conclusions

Near the southwest margin of the Murray Basin, shallow, unconfined limestone aquifers and a deeper confined sand aquifer are found. The upper aquifer is recharged at the Dundas Plateau from where groundwater flows westward into the Coorong and the ocean. In the vicinity of the Coorong, a mixing zone between groundwater and underlying seawater is formed and has surface exposure at distinct locations forming ephemeral lakes and distinct vegetation communities ('soaks'), particularly at the southern end of the Coorong. These soaks can be identified by remote sensing techniques, using vegetation health and soil moisture as indicators.

Groundwater discharge is widespread in the south lagoon of the Coorong judging by the distribution and abundance of features such as tufa, stranded pools, and active seeps. Significant active seepage was measured at three sites along the south lagoon even where sediments were not agitated. Active seeps can also be identified using thermal imagery. A major groundwater discharge site was identified on this basis just south of Parnka Point, where active seeps have been observed in the field.

It remains unknown how much groundwater is currently discharged into the Coorong, therefore the impact of groundwater on water quality in the Coorong remains speculative. Given the size and abundance of tufa and the extended drought period over recent years, groundwater discharge was likely an important factor affecting flow and water quality in the Coorong in the past.

For more information

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Acknowledgements

We wish to thank Sebastien Lamontagne (CSIRO) for lending us field instruments and demonstrating their use in the field.

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Von der Borch CC, Lock D & Schwebel D. 1975. Ground-water formation of dolomite in the Coorong region of South Australia. Geology (May): 283-285.

Related websites

Nutrient sources and sinks in the Coorong (Geoscience Australia)

www.csiro.au/partnerships/CLAMMGApartnership.html

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Safeguarding Australia's borders

Geoscience Australia contributes to satellite surveillance

Mike Pasfield

Australia has one of the largest Exclusive Economic Zones (EEZ) in the world. The total area being larger than the nation's land area. Parts of the EEZ extend from Heard and McDonald Islands in the southwest to Norfolk Island in the east and from the Arafura Sea in the north to the Australian Antarctic Territory in the south.

The Border Protection Command (BPC), which is part of the Australian Customs Service, has responsibility for protecting Australia's offshore maritime areas within the EEZ, overseeing surveillance and response operations. The BPC is specifically responsible for coordinating and controlling operations to protect Australia's national interests against maritime security threats such as: illegal exploitation of natural resources, illegal activity in protected areas, unauthorised arrivals, prohibited imports/exports, maritime terrorism, piracy, compromising biosecurity and marine pollution.

Figure 1. Surveillance areas monitored from Geoscience Australia's ground stations at Hobart and Alice Springs.

Geoscience Australia recently collaborated with the BPC in a satellite surveillance trial to evaluate the viability of monitoring sections of the nation's vast EEZ using remote sensing satellites. In their 2007–08 Portfolio Budget Statement, the BPC was tasked with monitoring 8.15 million square kilometres of the EEZ using aerial and satellite surveillance. This task was proving difficult because of the world-wide shortage of qualified pilots and operational restrictions on some of the available satellites. Consequently, BPC initiated discussions with Geoscience Australia seeking to utilise its tracking and data processing systems to reach the Budget targets.

In 2007 the BPC signed a contract with a subsidiary of the French Space Agency–Collecte Localisation Satellites (CLS) of Toulouse, for the provision and processing of Synthetic Aperture Radar (SAR) data from the Canadian Radarsat-1 and European Envisat satellites for ship monitoring and detection in areas of Australia's EEZ. These satellites have onboard recorders that can capture data in any part

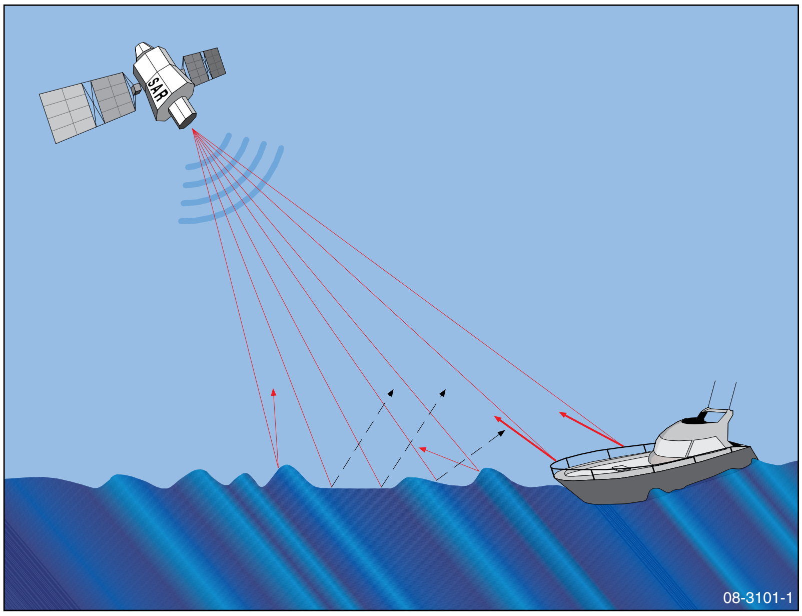

Figure 2. Synthetic Aperture Radar detection of a ship. The satellite emits a radio signal which is reflected back to the satellite's sensor.

of the globe and download it when the satellite is in view of one of the operators' ground stations. However, the onboard recorder on Radarsat-1 was operating below its designed capacity, limiting its ability to record and deliver imagery data back to Canadian ground stations. Geoscience Australia overcame this problem by tracking Radarsat-1 and downlinking data from the satellite when it was within view of Geoscience Australia's ground stations at Alice Springs and Hobart. Geoscience Australia then processed the data before delivering the images to CLS (figure 1).

"The ship's wake creates turbulence and areas of smoother water that stand out from the surrounding ocean."

Satellite-borne Synthetic Aperture Radar (SAR) uses microwave radio frequency transmissions to create an image of the earth's surface and any objects that are present. Microwave energy is beamed towards an area of interest and the reflected signals are captured by the satellite's sensor (figure 2). SAR can operate night or day, and through clouds, fog and rain and is therefore well suited to ship detection and monitoring of large areas of ocean. Also, most SAR Satellite sensors can vary their beam modes to either scan large areas in lower resolution or to focus on small areas in high resolution. Processed SAR imagery may depict a ship in various ways, dependant upon weather conditions, ship orientation and construction, and beam focus.

One way of detecting ships is by detecting the ship's wake. The ship's wake creates turbulence and areas of smoother water that stand out from the surrounding ocean in a SAR image. The bow of a ship when pushing the water aside also creates a wave known as the Kelvin wake (figure 3). This wave emanates from either side of the bow and forms a distinct part of the ship's SAR signature.

Ships are usually moving targets, so it is important to report the detection of a ship *as soon as possible after satellite overpass*. Initial testing showed that it could take more than six hours from detection to reporting. However Geoscience Australia was able to streamline the process, reducing data transfer time from the tracking stations, the processing time at Geoscience Australia, and the transfer time from Geoscience Australia to Toulouse. A number of processing steps were also automated, and overall delivery times were reduced by almost half.

To reduce reporting times even further the BPC, through its contractor CLS, installed an automated ship-detection system at Geoscience Australia. The output file from this ship detection system is a small subset of the full image data and, because it is greatly reduced in volume, is considerably faster to transfer to CLS in Toulouse for compilation of a ship report. The next step is for CLS to send the compiled report to the Regional Operations Centre for Surveillance and Rescue (CROSSRU), located on Reunion Island in the Indian Ocean, for validation by their expert analysts. Finally, a validated ship report including the date, time, location, speed, course and quite possibly the vessel's size, construction type and even its name and registration details, is forwarded to the BPC in Canberra. BPC then assess the need for further action which could include sending an aircraft or patrol vessel to intercept the ship, storing the data as evidence, or taking no action.

Ultimately the total time from detection to delivery of ship reports in Canberra was reduced to under two hours. Between November 2007 and March 2008 Geoscience Australia's systems were responsible for the delivery of more than 1100 ship detection reports to the BPC.

Figure 3. A turbulent wake usually indicates a ship is present. The light coloured line is the Kelvin wake.

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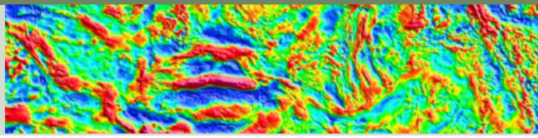
New Gravity Anomaly Map of the Australian Region



Improved coverage to encourage exploration for mineral and energy resources

Mario Bacchin, Peter Milligan, Ray Tracey and Phillip Wynne

Geoscience Australia has recently released a new full-colour Gravity Anomaly Map of the Australian Region at a scale of 1:5 million. It is the third edition of the map and replaces the edition released in 1997. The new map will be a valuable tool for explorers providing new insights into Australia's mineral and energy potential.

Continental Australia has a basic gravity station spacing coverage of 11 kilometres, with South Australia, Tasmania and part of New South Wales covered at a spacing of 7 kilometres. Victoria has station coverage of approximately 1.5 kilometres. Over the last ten years Australian, state and Northern Territory governments have funded exploration initiatives for the systematic infill of the continent at a grid spacing of 2, 2.5 or 4 kilometres to provide improved coverage in areas which are of scientific or economic interest.

The gravity grid used to create the new edition map was produced from 1.4 million onshore gravity stations which represents 600 000 more stations than was used for the 1997 edition. Many of these additional gravity stations have resulted from the government exploration initiatives mentioned above.

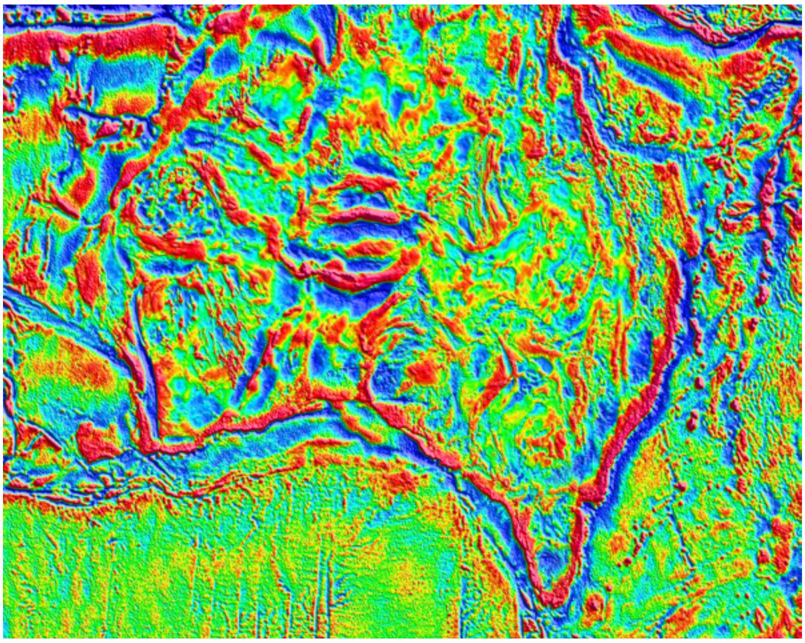


Figure 1. Section of the new Gravity Anomaly Map of Australia.

The new map covers the area from 8º S to 52º S and 100º E to 170º E. Data for the offshore region were extracted from the Marine Gravity from Satellite Altimetry dataset provided by Scripps Institution of Oceanography, California, United States of America.

The main image shows spherical cap Bouguer anomalies onshore and Free Air anomalies offshore after application to the original grid of a high-pass filter with a cut-off wavelength of 500 kilometres. To emphasize the expression of subtle anomalies, an artificial sun-angle 'illumination' from the northeast was used to modify both the saturation and intensity of the original colour image.

Gravity anomalies effectively show the density variations in the Earth's crust. High anomalies (red colours) indicate areas of above-average crustal density or a thinner crust (the crust is lighter than the underlying mantle); low anomalies (purple colours) indicate below-average crustal density or thicker crust. The depth of the crustal bodies having the anomalous density is indicated by the anomaly wavelength: finer, sharper anomalies indicate shallower bodies while broader, diffuse anomalies indicate deeper bodies.

The gravity grid incorporates improvements made to the data in the Australian National Gravity Database (ANGD). In 2008 data in the ANGD were changed to the new Absolute Gravity Datum 2007 (AAGD07) which superseded the previous ISOGAL84 datum. This new gravity datum was the end result of several years work by Geoscience Australia in creating an absolute datum for the Fundamental Gravity Base Station Network. Other improvements to the ANGD involved the use of ellipsoid heights relative to the GRS80 ellipsoid instead of geoid ground heights, the closed form of the theoretical gravity formula, the closed form equation for the Bouguer correction and a second order approximation for the Free Air correction. These improvements were made to provide more accurate Free Air and Bouguer anomalies and to remove long wavelength errors from the gravity data introduced when using geoid heights in place of ellipsoid heights.

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

For more information

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References

Tracey R, Bacchin M, & Wynne P. 2008. In preparation. AAGD07: A new absolute gravity datum for Australian gravity and new standards for the Australian National Gravity Database. Exploration Geophysics.

Related articles/websites

Gravity Anomaly Map of Australia
Geoscience Australia: Maps of Australia

Scripps Institution of Oceanography
topex.ucsd.edu/marine_grav/mar_grav.html

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

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National coastal website released

Major source of coastal information and data

Lynda Radke, Richard Mount (University of Tasmania) and Darren Skene

Geoscience Australia, the national custodian for coastal geoscientific data and information, launched the OzCoasts web-based database and information system in August. The website will contribute to improving natural resource management and the conservation of Australia's coastal zone, estuaries and near-shore environments.

The website was designed with input from over 100 scientists and resource managers from more than 50 organisations including government, universities and the National Estuaries Network. Each month approximately 15 000 unique visitors from more than 138 countries visit the website to view around 52 000 pages. Maps, images, reports and data can be downloaded to assist with estuary and coastal science, monitoring and management.

Range of information

Geoscience Australia developed OzCoasts in conjunction with the National Land and Water Resources Audit (NLWRA) and the former Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC). Previously known as OzEstuaries the website draws together a diverse range of data and information on Australia's coasts and estuaries (figure 1). The website includes links to the Climate Change, Capacity Building and Monitoring and Evaluation priority areas in the Implementation Plan for a National Cooperative Approach to Integrated Coastal Zone Management.

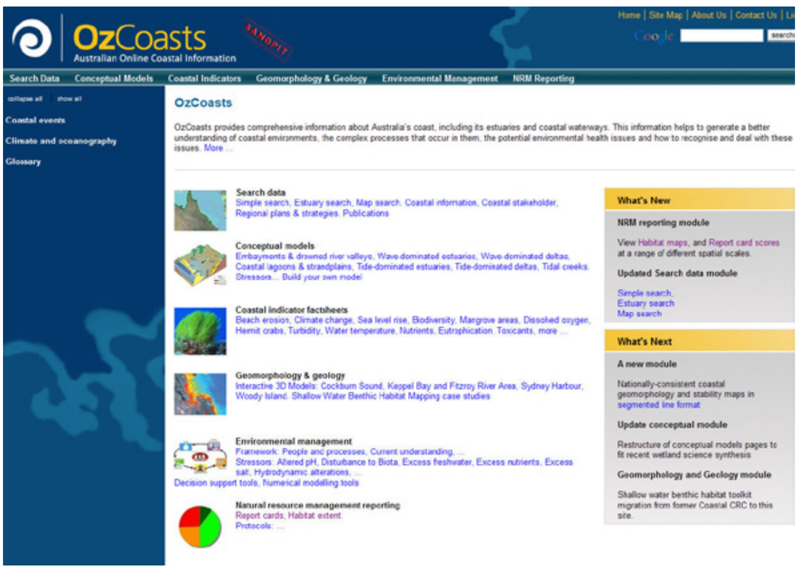


Figure 1. The home page and opening pages of the different modules include shorter and more precise text and shortcuts to key information and the most frequently visited pages.

OzCoasts currently consists of six inter-linked modules: Search data, Conceptual models, Coastal Indicators, Geomorphology & Geology, Environmental Management and Natural Resource Management (NRM) Reporting. These modules can be accessed from a global navigation bar on the home page.

The NRM Reporting module, which is the most recent addition to the website, provides online access to the key information and data that supports NRM. It includes the national Estuary Coastal and Marine (ECM) indicator protocols, and has data exploration tools for viewing information that relates to Habitat Extent, Distribution and Monitoring Reports and Estuary Report Card Reporting (see below). The NRM Reporting module, was developed in conjunction with the NLWRA to assist in delivering national-level assessments on the broad ecological integrity of estuaries based on the National Monitoring and Evaluation Framework.

Habitat extent and distribution reporting

The Habitat Extent, Distribution and Monitoring interface comprises high spatial resolution polygons as mapped by the state and territory agencies with thematic attributes based on the recently-agreed National Intertidal/Sub-tidal Benthic (NISB) Habitat Classification scheme (Mount, Bricher and Newton 2007). The NISB classification scheme was developed as part of a collaborative project between the Department of Climate Change and the NLWRA. It will contribute to an initial vulnerability assessment of the whole Australian coastline and will support the development of marine 'ecoregions' or bioregional subregions.

Prior to the NISB Habitat Classification scheme, there was no consistently-classified coastal habitat mapping of the entire Australian coastline, except at scales that were not detailed enough to be of practical use in a coastal vulnerability assessment.The habitat classes occur between the location of the outer limit of the photic benthic zone (usually at the 50 to 70 metre depth contour) and the approximate position of the highest astronomical tide mark. These habitat classes include: coral reef, rock dominated, sediment dominated, mangroves, saltmarsh, seagrass, macroalgae and filter feeders (such as sponges). An account of the development of the map series and the resulting scheme is included in Mount, Bricher and Newton (2007).

There are national, state and regional summaries that comprise vector polygon layers of 10 and 50 kilometre grid cells which include a colour code indicating whether a habitat is present, absent or unknown within a given grid cell (figure 2a, b: Mount and Bricher, 2008). The grid cells have 50 kilometre grid spacings at the national scale, and 10 kilometre spacings at state and regional levels. The summary maps are designed to help users visualise the occurrence of the different habitats around the continent. The summary maps also depict the nature of data availability around the continent. The national, state and regional summary maps will be made available through the Australian Resources Online website. The actual habitat maps from some states (Tasmania, South Australia, Western Australia and most of Queensland) as well as the Northern Territory are accessible to users at scales less than 50 square kilometres (figure 2b).

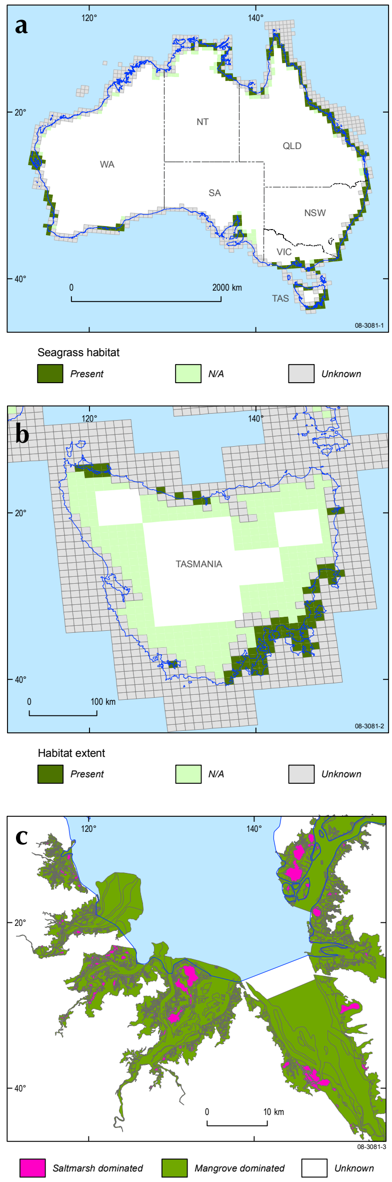
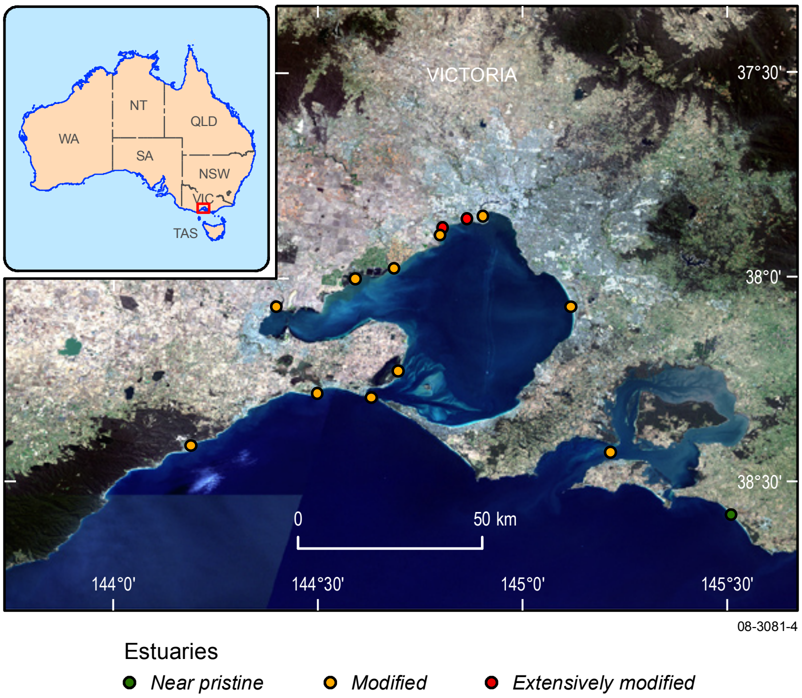


Figure 2. Output from the habitat mapping component of the NRM Reporting module illustrating the presence and absence of seagrass-dominated habitats: (a) at the national scale (50 kilometre grid cells) and (b) regional scale (10 kilometre grid cells). Users can also zoom to scales <50 square kilometres to obtain the actual habitat maps (c).

Report Card facility

The ECM Report Card Reporting tool allows users to view aggregated ('national') report scores and trends (if available) on an annual basis at a range of different spatial scales including national, state/territory, regional (Catchment Management Authorities, NRM zones and Local Government Areas) and bioregional (Interim Marine and Coastal Regionalisation for Australia and Marine Planning regions).

This tool also enables users to get a statistical breakdown of the scores for the area selected (figure 3). The map interface shows the reporting regions (estuaries) as dots with a colour coding that matches that of the condition assessment in an accompanying



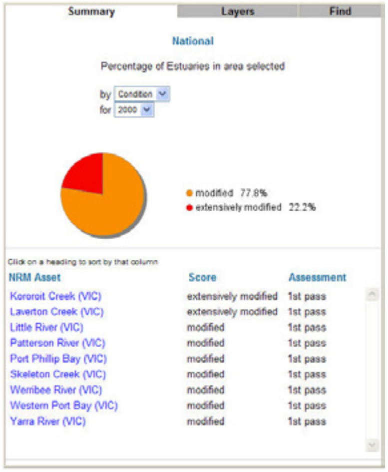


Figure 3. Sample of report card, showing the statistical break-down of the condition of scores of estuaries in the Southern Rivers NRM region in 2000.

pie chart. A dialogue box at the bottom of the screen provides hyperlinks to more detail on the report cards and other information behind the assessments.

Though the report cards for the NLWRA 2000 assessments are available in OzCoasts, those from future assessments may be found at state/territory or regional websites. The condition classification dataset from the first NLWRA (NLWRA 2002) comprises the first year of data in the website, and has been used for the proof of concept.

There are also interactive tools to capture the more individualistic approaches of the states/territory or regional groups to reporting and monitoring. For example, the Burnett Mary region (Queensland) reports against condition and risk using a range of different stressors (Scheltinga and Tilden 2008). The functionality in OzCoasts allows users to view the distribution and statistical breakdown of the scores for each of the different stressors listed in both the 'condition' and 'risk' fields. More detailed information about the indicator results behind these stressors will be made available through the Burnett Mary website constituting the second tier in the web-reporting process (Scheltinga and Tilden 2008).

Coastal vulnerability to climate change

The Department of Climate Change and the Department of Environment, Water, Heritage and the Arts (DEWHA) are working with the states and territories through the Intergovernmental Coastal Advisory Group to assess Australia's coastal vulnerability to climate change, including impacts on coastal habitats and infrastructure. The Department of Climate Change and Geoscience Australia have signed a collaborative agreement to contribute to the Coastal Vulnerability Assessment Project. It will provide fundamental datasets to support decision-makers in identifying those areas in Australia's coastal zone where potential climate change impacts may be rated as high, medium and low. To provide a foundation for the initial assessment, Geoscience Australia has contracted the University of Tasmania to conduct a National Shoreline Geomorphic and Stability Mapping Project.

The Project includes the preparation of a nationally-consistent geomorphic map of the entire Australian shoreline in a geographic information system (GIS)-based segmented line format (figure 4). Each line segment will include multiple attribute fields that describe important aspects of the shoreline geomorphology (or landforms). This format, which

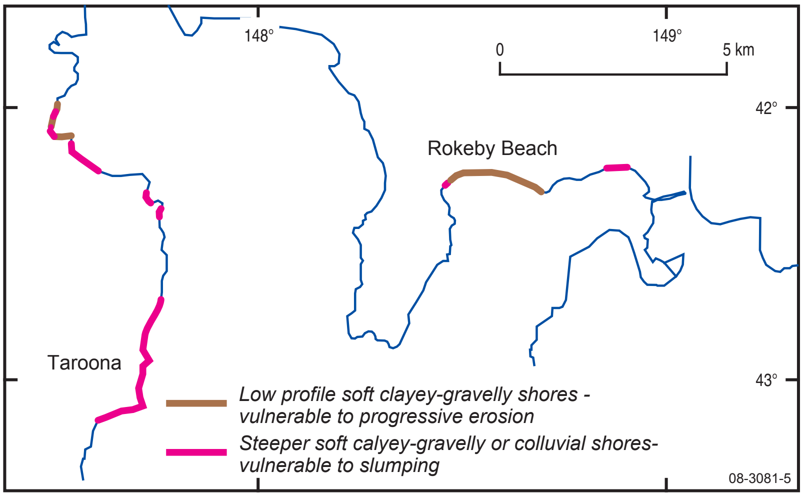


Figure 4. A 'smartline' geomorphology map. Each line segment includes multiple attribute fields that describe important aspects of the geomorphology of the coast as illustrated in figures 1 and 2 (from Sharples 2006).

has been termed a 'Smartline', is based on an approach that has been used in Tasmanian studies and expanded to incorporate the broader range of coastal landforms found around Australia (Sharples 2006). Interactive Smartline maps and query functions will be delivered through OzCoasts via a module dedicated to Coastal Stability. The three Smartline maps already scoped for development in 2008-2009 include: Geomorphology (simple), Geomorphology (advanced), and Stability.

The Smartline stability map will be based on an assessment of the geomorphology (or landform) data and includes potential impacts of climate change and sea level rise, including shoreline erosion. The stability map will also be made accessible through the NRM Reporting module so that it may be used in the context of NRM assessments.

Geoscience Australia is concurrently developing a national approach to coastal geomorphological mapping, especially the classification of Quaternary coastal depositional environments to overcome current inconsistencies in nomenclature. Once accepted, this classification scheme will be used in the development of a comprehensive, nationally-consistent GIS of Australia's coastal depositional features (geomorphological units). This GIS will provide one of the fundamental datasets for more detailed and rigorous coastal vulnerability assessments.

For more information

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Related websites

OzCoasts website

www.ozcoasts.org.au

Australian Government
Geoscience Australia

AUSGEO news
ISSUE 91 Sept 2008

AuScope Geospatial: Towards a high resolution four-dimensional reference frame

Upgrades usher in new era of precision geodesy

Gary Johnston, Nick Dando and Oleg Titov

AuScope is an initiative established under the National Collaboration Research Infrastructure Strategy (NCRIS) to characterise the structure and evolution of the Australian continent. AuScope includes a Geospatial component that will enhance the accuracy and resolution of the National Geospatial Reference System including its temporal variability. This will have a direct impact on the many fields of science and industry that require accurate positioning to improve effectiveness. Ultimately it will also significantly improve the way geospatial data sets can be integrated.

AuScope Geospatial will complement the other geoscience elements of AuScope by providing contemporary estimates of continental deformations including those resulting from plate tectonics stresses and anthropogenic (or human induced) causes. Knowledge of the deformation of the continent will lead to improved assessments of the state of stress of the continental crust and earthquake risk. This supports the development of improved risk mitigation procedures and updating of building codes. The improved understanding of the deformation of the continent will also assist studies of landscape evolution, research into soil types (agriculture) and salinity (land degradation). Geoscience Australia is working collaboratively with the Australian National University, University of Tasmania, Curtin University, and all of the state and territory governments to implement this program over four years to 2011.

AuScope Geospatial will upgrade the ground infrastructure in all four key geodetic areas through:

- Increasing the density of the network of Global Navigation Satellite System (GNSS) Continually Operating Reference Stations (CORS)
- Establishment of an array of radio telescopes for Very Long Baseline Interferometry (VLBI)
- Enhancement of the satellite laser ranging (SLR) capability at Mt Stromlo, in the Australian Capital Territory, to allow more efficient ranging to high-orbiting satellites
- Establishment of a National geodetic gravity monitoring program.

The refinement of the global geodetic frame of reference requires a multi-technique approach. Broadly speaking SLR provides the definition of the origin of the frame (that is, the geocentre). VLBI provides the orientation of the frame within the celestial reference system and the scale of the terrestrial frame. GNSS provides the density of stations within the frame to allow effective monitoring of the global tectonic processes as

Figure 1. Typical AuScope GNSS installation at Norfolk Island collocated with Australian Tsunami Warning Service (ATWS) seismograph station.

well as give users access to the frame. Gravity provides the linkage between the geometric frame and the gravimetric potential surfaces. Refinement of the International Terrestrial Reference Frame (ITRF) is a continual process, and updated versions of the frame are essentially the numerical realisation of the improved accuracy that is seen in each element of geodetic science.

GNSS Continually Operating Reference Stations

Global Navigation Satellite System (GNSS) is a generic term used to describe the US Global Positioning System (GPS) and other constellations such as the Russian Global Navigation Satellite System (GLONASS), that provide geospatial positioning across the Earth (see figure 1). Over the last two decades the GNSS has proved to be a very accurate and efficient method of measuring the tectonic motion of the continents.

By collecting geodetic data from GNSS Continually Operating Reference Stations (CORS), Geoscience Australia is able to measure the relative locations of points up to several thousand kilometres apart with an accuracy to several millimetres. As such, the Australian Regional GNSS Network (ARGN) operated by Geoscience Australia is the national foundation for all positioning applications in Australia. However this network is sparse and tells us little about intraplate deformation and the resultant neo-tectonic stresses. In addition, it does not provide good proximity for the many surveying applications that use the ARGN data.

Figure 2. AuScope Patriot 12 metre VLBI telescope dish to be installed at Katherine, Northern Territory and Mingenew, Western Australia.

The AuScope GNSS network which will be implemented by Geoscience Australia and the state and territory governments is designed to distribute GNSS stations along transects with a nominal spacing of 200 kilometres. Researchers will be able to monitor the deformation of the Australian continent in greater detail in near real-time, and the benefits of such a high-accuracy reference system will flow through to other areas of geoscientific research.

Australian Very Long Baseline Interferometry (VLBI) Array

The Very Long Baseline Interferometry (VLBI) technique was developed in the 1960s and has been used globally for geodetic purposes on a regular basis since 1979. It measures weak radio signals from remote radio sources (quasars) using radio telescopes, and records an interferometric signal from each telescope for processing and analysis. VLBI reveals information that helps to solve many scientific problems, and advances our knowledge of the dynamics of the Earth. It was the first technique that directly measured the motions of the tectonic plates, and since 1998 is the only technique used to fix the Earth's reference frame to celestial reference frames replacing the previous optical astronomy techniques.

The Australian VLBI network constructed and operated by the University of Tasmania will include three 12-metre radio telescopes (see figure 2) located in Hobart (Tasmania), Yarragadee (Western Australia), and Katherine (Northern Territory). Together with other international telescopes they will form a series of baselines that can be used for measuring the deformations of the Australian Plate at a continental scale with an accuracy to a few millimetres. They will also be used in conjunction with the 64-metre dish at Parkes (New South Wales) to effectively form a large astronomical instrument with an aperture the size of the Australian continent to identify the positions of remote quasars.

The geodetic strength of the VLBI technique is its ability to accurately measure the Earth Orientation and Rotation Parameters (EOPs). These are fundamental to the accuracy of orbit predictions for a wide range of satellites including the GNSS constellations. EOPs are also important for studying the natural processes in the Earth's atmosphere, crust, mantle and core and their interaction. The new Australian geodetic VLBI network will improve the accuracy of the daily EOPs and nutation angle estimates to the accuracy of 10 to 30 micro arc seconds.

Beyond the immediate geodetic applications, the VLBI array will also be used for more fundamental science. The array can detect small systematic effects in the quasar apparent proper motion, which can be a sign of cosmologic effects, that is, rotation and anisotropic expansion of the Universe, and primordial gravitational waves.

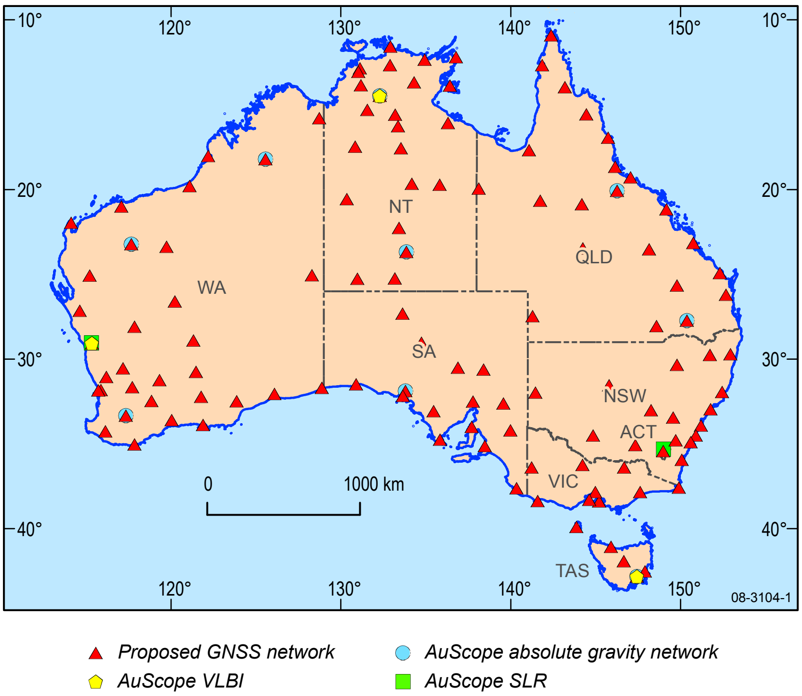

Figure 3. Spatial distribution of AuScope Geospatial infrastructure. The GNSS and absolute gravity stations are indicative only.

Einstein's theory of gravitation can also be tested by observing passages of close large planets such as Jupiter and Saturn in front of quasars to observe the gravitational lensing effect and to measure if the observed behaviour matches the predicted.

Satellite Laser Ranging

Satellite Laser Ranging (SLR) as its namesake suggests measures distances to earth orbiting satellites using a powerful laser to detect a satellite's variation from its predicted orbit. It is uniquely suited to accurately determine the variation of Earth's centre of mass, along with the orbit parameters of satellites orbiting Earth. Data from a global network of SLR stations are used to estimate the orbital parameters of satellites which revolve around the Earth's centre of mass. Therefore the position of Earth's Geocentre, which is the origin of the global reference frame, can be monitored through time.

The Satellite Laser Ranging component of AuScope Geospatial has two primary outputs. The first is the upgrade to the laser power at the Mt Stromlo SLR facility near Canberra, which will improve the efficiency with which the system can range to high Earth orbiting satellites, especially the GNSS satellites. The second is the completion of a mobile SLR campaign for altimeter calibration at Burnie, Tasmania. This campaign was undertaken primarily by the University of Tasmania using the French Mobile Laser Ranging System. It will allow a calibration of the satellite based altimeter systems that are currently used for measuring the surface heights of the world's oceans which are an indicator of sea level rise.

Gravity Program

Geoscience Australia and the Australian National University are jointly operating the geodetic gravity component of the Program, aiming to improve the understanding of the temporal gravity changes across the Australian continent. The geodetic gravity program has two separate outcomes. The first one is to use absolute gravimetry as an independent measure for vertical movements of the crust and/or other long-term gravity signals of interest. This objective is based on the principle that gravity changes as deformation occurs between the surface and the centre of the Earth. The second objective is to improve our understanding of temporal deformation of the Earth's surface induced by tidal changes on gravity caused by the movements of the sun and moon. These movements also cause ocean tides which deform the surface when large tidal masses of water are moved around the Earth. This deformation can be in the order of centimetres and can affect the other fundamental precision geodetic measurement systems of GNSS, VLBI & SLR.

The instrumentation and the observation programme is separated into two streams: absolute and relative. The absolute gravity program involves recording 24 to 48 hours of observations using an FG5 absolute gravimeter at around 10 geodetic sites across Australia which are co-located with continuous GNSS CORS (figure 3). The FG5 gravimeter can measure gravitational acceleration (*g*) to one part in 10^9 (8^{th} decimal place in m s^{-2}), or the equivalent of ~3 millimetres of height change. Therefore, monitoring small gravity changes over long time periods will allow changes in surface height to be accurately measured independently of other survey techniques.

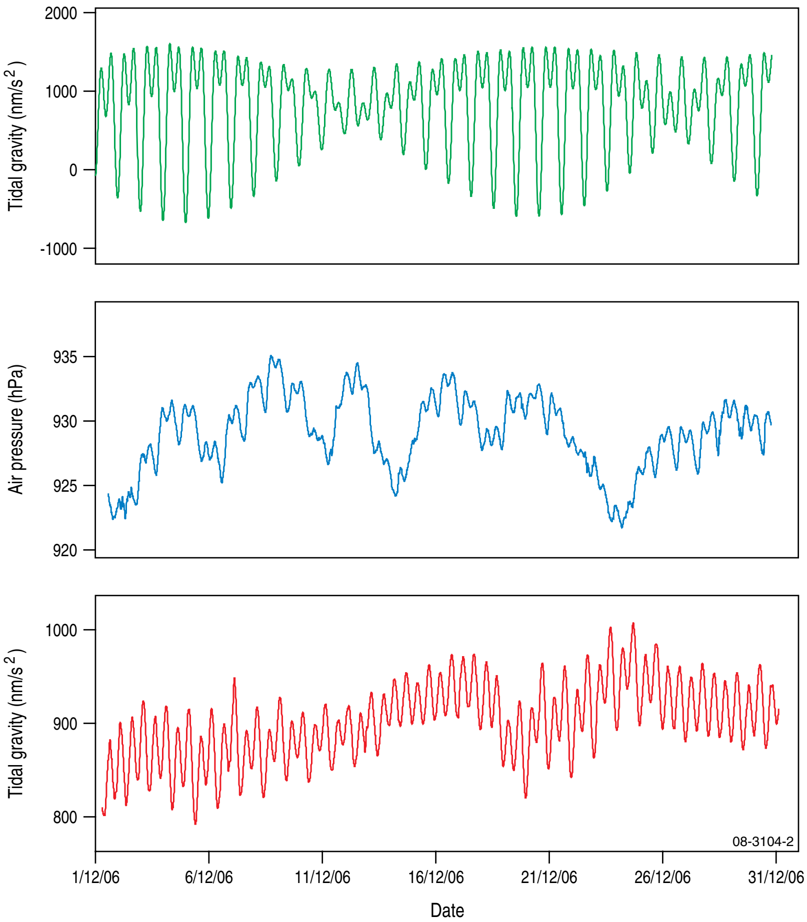

Figure 4. Figure shows tidal gravity recordings recorded over two weeks at Mount Stromlo, Canberra. Signal 1 is the tidal variation of gravitational acceleration in (nm.s^2 =10^{-9} m.s^2). Signal 2 is the atmospheric pressure variation (in hPa) which includes an atmospheric tide. The pressure reflects density changes which register small gravitational changes on the instrument and must be corrected. Signal 3 is the gravitational acceleration, which has been removed from the solid earth tide, leaving a residual with the Ocean Loading and attraction caused by deformation and attraction of large moving masses of tidal water.

The relative gravity program consists of a series of relative gravimeters suited to tidal gravimetry that will be used to improve the understanding of temporal gravity variations caused by tidal forces. Currently researchers rely on predictive models that have yet to be tested over most of the Australian continent. Currently there is some doubt about the accuracy of the models, particularly in the northern part of the continent. The greatest improvement to the understanding of the tidal models will come from observing the dominant tidal frequencies (which are in the diurnal and semi-diurnal tidal bands, around one and two periods/cycles per day respectively).

"A coordinate reference frame with the proposed degree of accuracy will be used by many fields of scientific research including the measurement of the deformation of the Australian continent"

Up to six months of data are required from each site to obtain sufficient precision in the local tidal parameters. Data from many years of observations from sites around the continent are necessary for an improved understanding of the Ocean Loading models that are applied across Australia (figure 4). Although uncertainties in these models provide the most pressing need for Earth tide measurements across the country, building a tidal catalogue across the country will also provide other benefits, potentially including additional knowledge of the Earth's sub-surface structure used for geodynamics research.

Conclusion

The AuScope Geospatial initiative offers an exciting period of research infrastructure development for Australia. The resulting research will herald a new era of precision geodesy previously unseen in Australia. The improved accuracies achieved across these geodetic techniques will be integrated to improve the accuracy and precision of the coordinate reference frame.

A coordinate reference frame with the proposed degree of accuracy will be used by many fields of scientific research including the measurement of the deformation of the Australian continent. For the first time achievable accuracies will allow the detection and subsequent interpretation of geophysical signals that were not previously measurable.

Ultimately, the GNSS network will provide the backbone of a new National Datum and the potential for a series of national and regional real-time positioning services. These will have a direct benefit to road transport safety systems, large scale precision mining, driverless vehicles, precision fertilizer distribution in agriculture, engineering projects and many unforeseen applications that will evolve as the degree of accuracy increases.

Importantly Australia has taken up the challenge of being one of the global leaders in the refinement of the global reference frame, in order to keep Australia competitive in the spatial industry, and all of the related fields of science and industry that rely on accurate positioning.

For more information

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Related websites

The Very Long Baseline Interferometry (VLBI) technique
www.ga.gov.au/geodesy/sgc/vlbi/vlbitech.jsp

Satellite Laser Ranging
www.ga.gov.au/geodesy/slr/

in brief

New satellite imagery for Australia

Geoscience Australia has been acquiring and archiving satellite imagery from the Indian Remote Sensing Satellite P6 (IRS-P6, or Resourcesat-1) since 14 February 2008. The IRS-P6 development is the key component in Geoscience Australia's contingency plan for the possible failure of Landsat-5. That possibility has increased with a major reduction in the performance of Landsat-5 batteries. During Australia's winter, Landsat-5 can only image in the far north of the country before the batteries are too low for safe operation.

In June 2008 engineers from the Indian Space Research Organisation (ISRO) installed software at Geoscience Australia to allow images to be produced from IRS-P6 raw image data. Imagery will be available through commercial distributors this calendar year. Although initially the P6 images will not be ortho-rectified, eventually Geoscience Australia expects to produce all P6 data as ortho-rectified imagery.

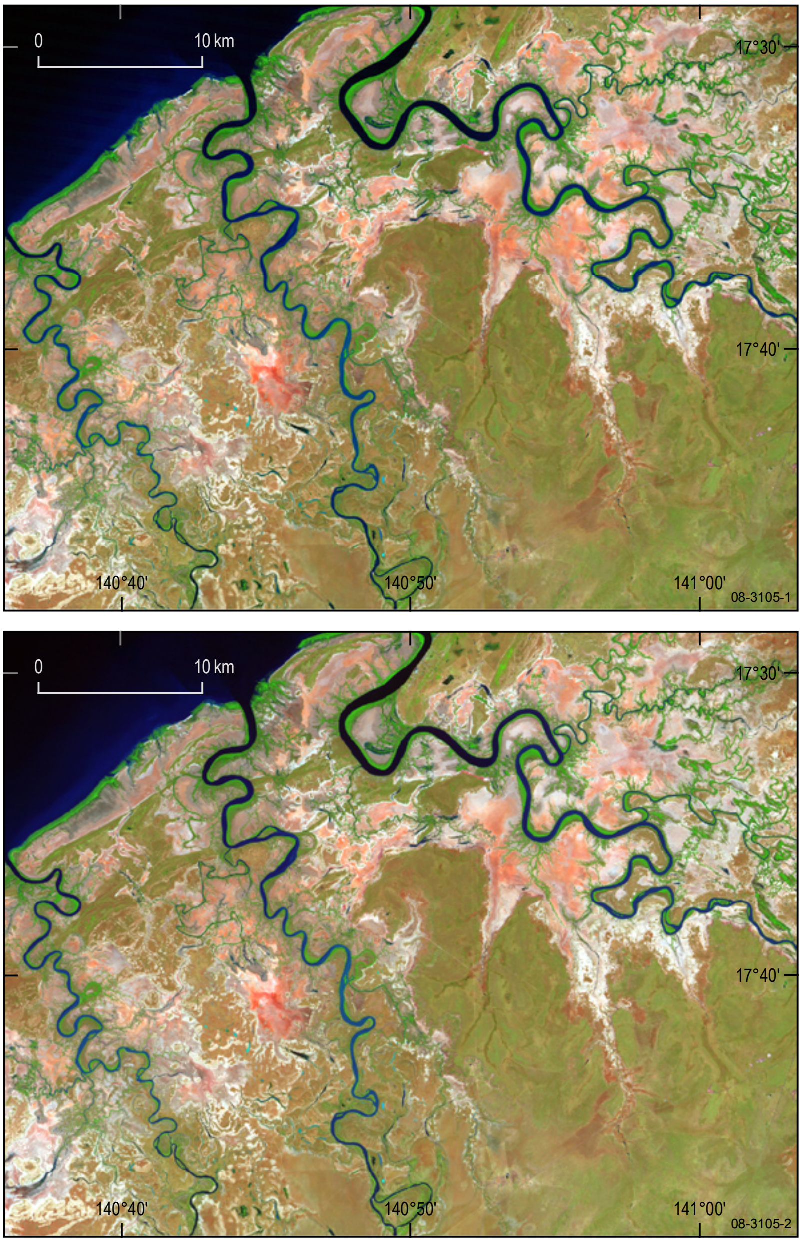

Figure 1. Comparative images from Landsat-5 and IRS-P6 with the Landsat image at the top and IRS-P6 below.

IRS-P6, launched in 2003, has several similarities to historical Landsat data and for many applications is a valid substitute for Landsat (Chander, Coan & Scaramuzza 2008). However, there are also significant differences including a 141 kilometre swath width (compared to 185 kilometres for Landsat), 24 days between overpasses (compared with 16 days) and fewer radiometric bands (see table 1). Geoscience Australia is receiving data from the Linear Imaging Self Scanner (LISS-III), which has a spatial resolution of 23.5 metres (compared to 30 metres for Landsat) but also from the Advanced Wide Field Sensor (AWiFS).

AWiFS creates new opportunities in land imaging for Australia. The instrument has a large (740 kilometre) swath width, allowing a 5-day revisit time, with a pixel size between 56 and 70 metres.

The Landsat program commenced in 1971 with the launch of Landsat-1. Geoscience Australia has a comprehensive archive of Landsat data from 1979 onwards. The latest satellite in the program, Landsat-7, developed an anomaly in its Enhanced Thematic Mapper (ETM+) sensor in 2003 causing the value of data to degrade. A replacement satellite, the Landsat Data Continuity Mission, is planned for launch in 2011.

in brief

Table 1. Comparison of Landsat-5 TM, Landsat-7 ETM+ and IRS-P6 spectral bands.

Spectral Range (µm)			
Band	**Landsat-5 TM**	**Landsat-7 ETM+**	**P6 AWiFS/LISS-III**
1	0.450 - 0.520	0.450 - 0.515	
2	0.520 - 0.600	0.525 - 0.605	0.520 - 0.590
3	0.630 - 0.690	0.630 - 0.690	0.620 - 0.680
4	0.760 - 0.900	0.775 - 0.900	0.770 - 0.860
5	1.550 - 1.750	1.550 - 1.750	1.550 - 1.700
6	10.40 - 12.50	10.40 - 12.50	
7	2.080 - 2.350	2.080 - 2.350	
Pan		0.520 - 0.900	

References

Chander G, Coan MJ & Scaramuzza PL. 2008. Evaluation and Comparison of the IRS-P6 and the Landsat Sensors. Institute of Electrical and Electronic Engineers. IEEE Trans on Geoscience and Remote Sensing. 46:209–221.

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Geothermal data collection heats up

An important part of Geoscience Australia's Onshore Energy Security Program is the Geothermal Energy Project. The Project aims to shed light on the type and location of geothermal resources on a national scale, and is designed to encourage exploration and investment in this renewable energy sector.

The Project will be integrating existing data and acquiring new data to map temperature in the continent's upper crust. Heat flow measurements are the primary data for quantifying the amount of thermal energy available at a geographic location. Currently there are less than 150 heat flow measurements publicly available across the entire continent resulting in a limited understanding of the distribution of heat in the Australian crust.

To produce a new heat flow measurement, both the temperature gradient and corresponding thermal conductivity of a rock sample need to be measured. The temperature gradient is measured in boreholes using borehole logging equipment. The Geothermal Energy Project has established a borehole logging capability through the purchase of a trailer mounted logging system which is currently undergoing testing and calibration, with the first measurements anticipated soon (figure 1). Thermal conductivity is measured in a laboratory using samples collected from drill cores and the Project is currently awaiting installation of a thermal conductivity meter at Geoscience Australia.

In collaboration with state and Northern Territory government agencies, Geoscience Australia will be measuring temperature gradient in selected drillholes across the continent and taking new thermal conductivity measurements of samples from state and territory core libraries.

Geoscience Australia is currently seeking available drillholes suitable for temperature logging as well as access to cores for sampling.

Figure 1. The new geothermal borehole logging equipment during a field test.

The Project welcomes enquiries from companies who might have holes available in the near future and are agreeable to allowing access to these holes for sampling.

For more information

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Related websites/articles

AusGeo News 87: In search of the next hotspot

www.ga.gov.au/ausgeonews/ausgeonews200709/geothermal.jsp product news

New surface geology dataset for South Australia

Seamless digital surface geology of South Australia at 1:1 million scale is now available from Geoscience Australia. The dataset was primarily compiled from 1:250 000 scale digital geology maps covering the state and recent mapping by the Department of Primary Industries and Resources, South Australia. It is edge-matched to previously released datasets of the geology of the eastern states and the Northern Territory and includes a consistent nation-wide classification of regolith materials.

The surface geology of South Australia is dominated by regolith including sand plains, dunes, lake sediments, and colluvium around prominent topography. Exposed bedrock is intermittently and widely distributed with the intervening regions often covered with only a thin regolith veneer. This bedrock is of diverse age, ranging from recent Cainozoic sediments, to Archaean gneiss and greenstone in the Gawler Craton.

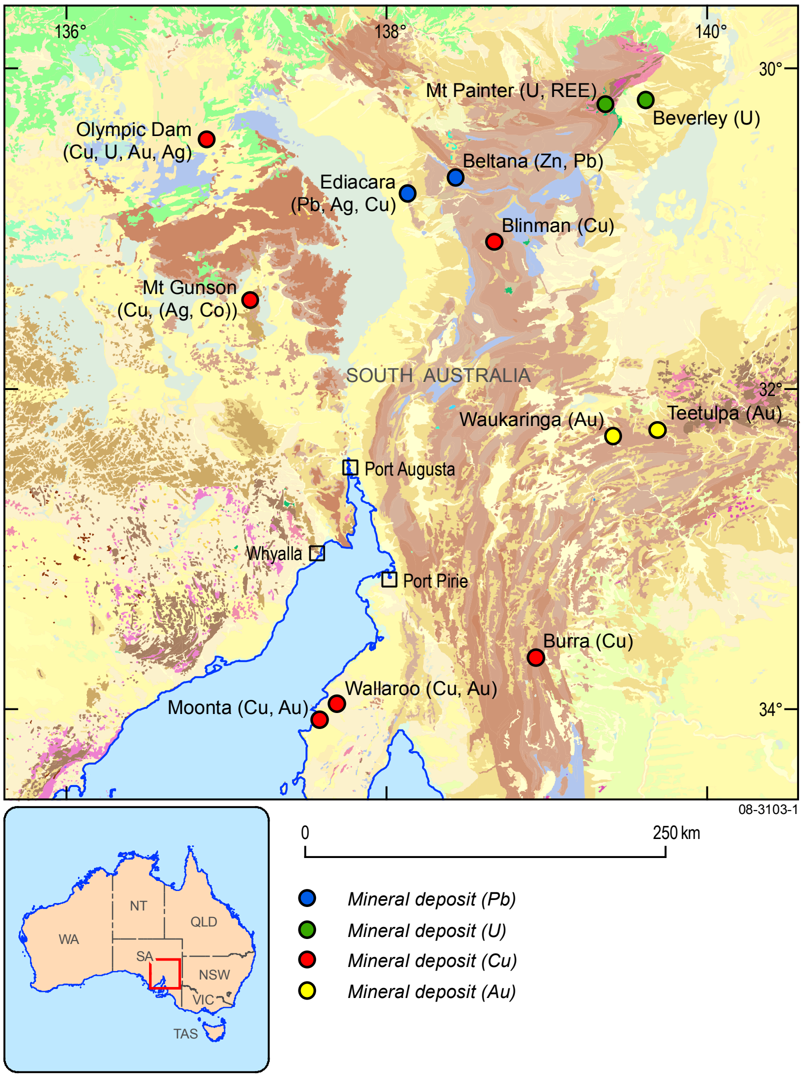

Figure 1. Geology of the Flinders Ranges region, north of Adelaide.

The Gawler Craton is located in the central part of the state and hosts several important mineral deposits including iron oxide-copper-gold deposits at Olympic Dam and Prominent Hill, historic copper production from Moonta –Wallaroo, gold at Challenger, and iron deposits in the Middleback Ranges west of Whyalla. The world's largest uranium deposit occurs at Olympic Dam in the eastern Gawler Craton. Uranium was also mined at Radium Hill and Mount Painter in the Palaeo- to Mesoproterozoic Curnamona Craton located in the central eastern part of the state, and is currently extracted from Cainozoic sediments at the nearby Beverley Deposit. There has been historic production of copper and other base metals from many deposits throughout the Neoproterozoic to Cambrian Adelaide Fold Belt and adjacent Cambrian Kanmantoo Fold Belt.

The new digital data puts these mineral deposits and many others in their regional geological context. It also supports the development of regional exploration models which are necessary to effectively explore regions under cover. The digital geology data are intended for use at 1:1 million scale and have a spatial accuracy of approximately one kilometre. Geological unit attributes include the stratigraphic name, the Australian Stratigraphic Unit Database number, lithological description, and maximum and minimum ages. Summary attributes including lithology group and lithology type provide additional flexibility for analysing the geological polygon data. Outcropping and selected buried faults are also represented in the dataset.

The data are available as a free download, or on CD which can be purchased through the Geoscience Australia website for $99.00.

Related articles/websites

Surface geology of South Australia, 1:1 million scale (free download)
www.ga.gov.au/products/

Geoscience Australia Sales Centre (for purchase on CD)
www.ga.gov.au/oracle/agsocat/

For more information

phone Alan Whitaker on +61 2 6249 9702
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email sales@ga.gov.au

Revealing Proterozoic mafic-ultramafic magmatism in Australia

Geoscience Australia in collaboration with the State and Territory geological surveys has recently released a detailed web-based map that shows the location, age, and correlations of Proterozoic mafic-ultramafic igneous rocks across the Australian continent. The new colour map *Australian Proterozoic mafic-ultramafic magmatic events* consists of two sheets which are available in pdf and jpeg formats through the Geoscience Australia website.

A 1:5 000 000 scale map showing the continental distribution of 30 magmatic events that range from the Early Palaeoproterozoic (~2455 million years (Ma), ME 1) to the Early Cambrian (~520 Ma, ME 30) is the main feature of Sheet 1. The newly-defined magmatic event series (ME 1–ME 30) is based on several hundred age measurements, over 90 per cent of which are derived from recent Uranium-Lead (U-Pb) dating of zircon and baddeleyite.

Solid geology digital maps with state/territory and regional coverages were synthesised to produce a national presentation of mafic-ultramafic rock units, and regional rock packages that include coeval mafic-ultramafic igneous rock components. Colour-coding of rock units by their age of magmatism provides a visual cue to the spatial and temporal correlations of magmatic units at both province and continental scale. Their relationship to the evolution of the continent is shown with an overlay of the Australian Crustal Elements dataset. The detail in the new map extends to isolated occurrences of dated magmatic units and a commentary describing relevant rock relationships.

The second sheet includes a large format Time–Space–Event Chart which shows the presence and correlation of the 30 magmatic events across 28 Australian crustal provinces. Those events known to be mineralised in Australia are highlighted, and six of the magmatic events are shown to be coeval with major nickel-copper ± platinum-group element deposits in other continents, such as ~2440 Ma Penikat in Finland, ~1918 Ma Raglan, ~1880 Ma Thompson, and ~1850 Ma Sudbury in Canada, ~1403 Ma Kabanga in Tanzania, and ~827 Ma Jinchuan in China.

Sheet 2 also includes two maps at 1:10 000 000 scale. The first map shows the locations of Australian nickel-copper-chromium-vanadium-titanium and platinum-group element mineral deposits and occurrences overlain on a composite of Proterozoic and Archaean mafic-ultramafic rock units. The second map shows the geographic extent of five magmatic events which are designated Large Igneous Provinces which are characterised by exceptionally large volumes of mafic-dominated magma emplaced over short geological periods of a few million years or less.

The new national map is the final component of the Proterozoic magmatic event map series. It revises and supersedes the earlier maps of Western Australia and Northern Territory–South Australia. The geological and geochronological basis of the map series is summarised in an accompanying Geoscience Australia Record 2008/15 *Guide to using the 1:5 000 000 map of Australian Proterozoic mafic-ultramafic magmatic events by DM Hoatson, JC Claoué-Long, & S Jaireth*. The Record includes individual time-slice maps of Australia for each of the 30 Proterozoic magmatic events.

The new national map focuses attention on the extent and volume of certain magmatic systems, and associations with mineralisation. The locations of mafic-ultramafic rock units, correlations across the continent, and the relationship of magmatism to the evolving crustal structure of the continent, are all prominent. The new map and Record will be of interest to explorers searching for nickel, platinum-group elements, chromium, titanium, and vanadium, as well as providing fundamental resources for understanding the dynamic evolution of the Australian continent.

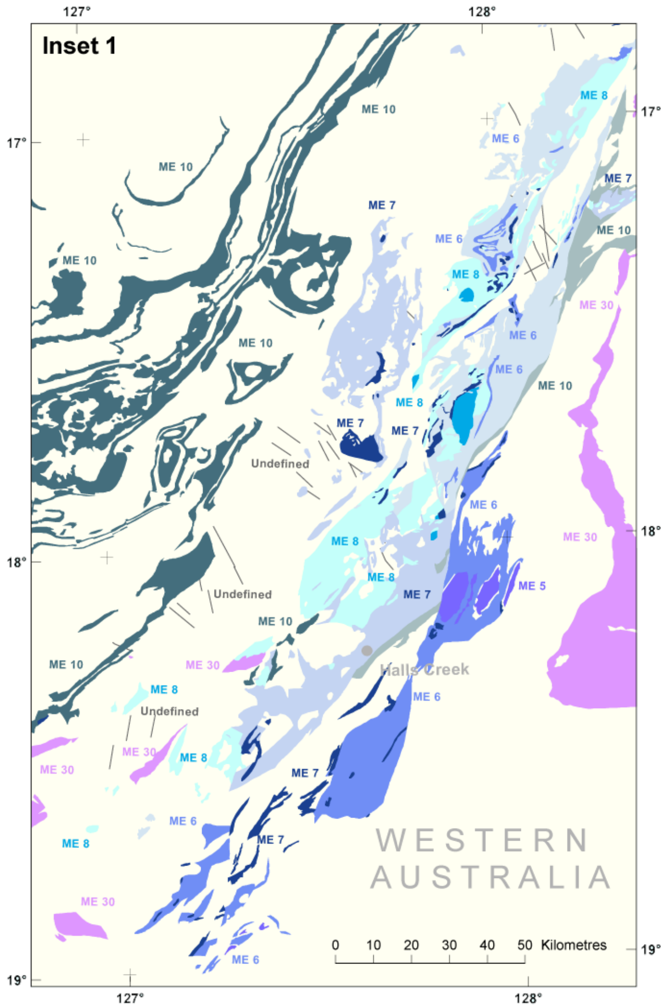

Figure 1. Part of the new 1:5 000 000 scale Australian Proterozoic mafic-ultramafic magmatic events map.

For more information

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Related websites/articles

Australian Proterozoic Mafic-Ultramafic Magmatic Events Map (Sheet 1 of 2)

www.ga.gov.au/image_cache/GA11507.pdf

www.ga.gov.au/image_cache/GA11511.jpg

Australian Proterozoic Mafic-Ultramafic Magmatic Events Map (Sheet 2 of 2)

www.ga.gov.au/image_cache/GA11506.pdf

www.ga.gov.au/image_cache/GA11510.jpg

Part 1. Proterozoic Mafic-Ultramafic Magmatic Events Map: Western Australia

www.ga.gov.au/image_cache/GA8798.pdf

www.ga.gov.au/image_cache/GA8797.jpg

Part 2. Proterozoic Mafic-Ultramafic Magmatic Events Map: Northern Territory and South Australia

www.ga.gov.au/image_cache/GA10636.pdf

www.ga.gov.au/image_cache/GA10645.jpg

AusGeo News 84: New map for nickel explorers

www.ga.gov.au/ausgeonews/ausgeonews200612/productnews.jsp#product2

AusGeo News 87: New map for nickel and platinum explorers

www.ga.gov.au/ausgeonews/ausgeonews200709/productnews.jsp#product1

Australian Government
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product news

Review of Australia's thorium resources

This review provides an enhanced understanding of geochemical processes controlling the distribution of thorium in the Earth's crust and the status and distribution of Australia's thorium resources. It is an output from Geoscience Australia's Onshore Energy Security Program (OESP) and can be downloaded through Geoscience Australia's website. The OESP is delivering pre-competitive data packages and scientifically-based assessments to attract investment in exploration for onshore energy resources such as oil, gas, uranium, thorium and geothermal energy.

Thorium can be used as a nuclear fuel, through breeding to uranium (^{233}U). Several reactor concepts based on thorium fuel cycles are under consideration, but much development work would be required before the thorium fuel cycles can be commercialised. At present thorium fuels are used to varying degrees in some research reactors in India and Russia. Tests are being undertaken in Russia on the use of thorium fuel in conventional nuclear reactors and India is currently developing a thorium-fuelled Advanced Heavy Water Reactor.

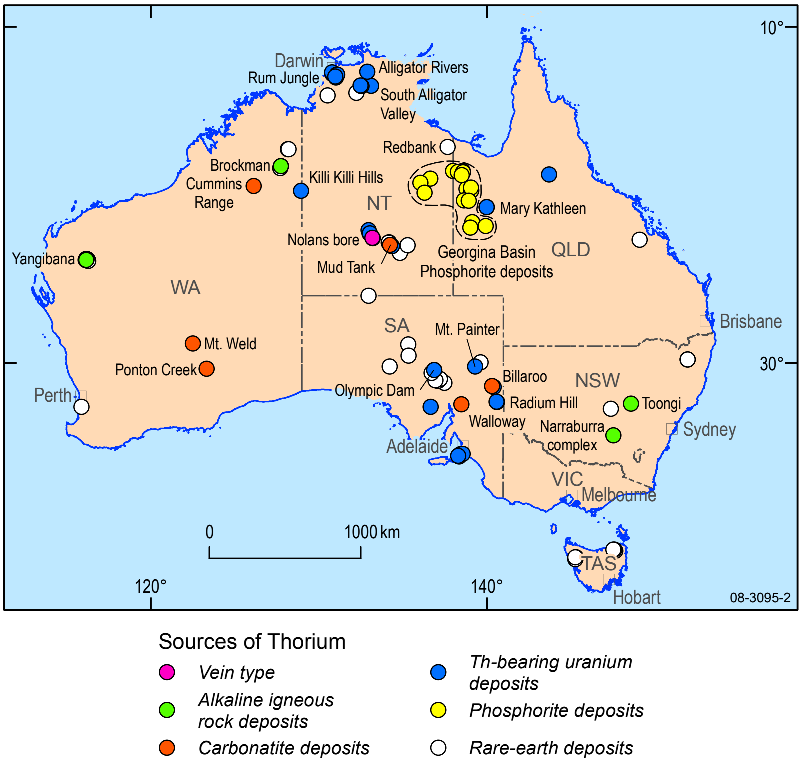

Figure 1. Location of Australia's thorium-bearing mineral deposits and occurrences excluding those related to heavy mineral sand deposits (Data is from the Australian Mines Atlas).

There has been no widespread exploration for thorium in Australia. However, thorium is known to be widely distributed across Australia in a number of different geological settings (figure 1). Australia contains about 19 per cent of the world's identified thorium resources. Most of them are held in the monazite component of heavy mineral sand deposits that are mined for their ilmenite, rutile, leucoxene and zircon content (figure 2). Australia's thorium resources in heavy mineral sand deposits could amount to about 364 000 tonnes. Other significant sources of thorium include the Nolans Bore deposit (with about 53 300 tonnes of thorium) in the Northern Territory and the Toongi zirconia project (with about 35 000 tonnes of thorium) in New South Wales.

Thorium occurs in nature either within minerals or as a tetravalent ion. The large, highly charged Th^{4+} ion has a marked tendency to form complexes with other ions in solution. The major ones of interest are with chloride, fluoride, nitrate, sulphate and carbonate ions.

product news

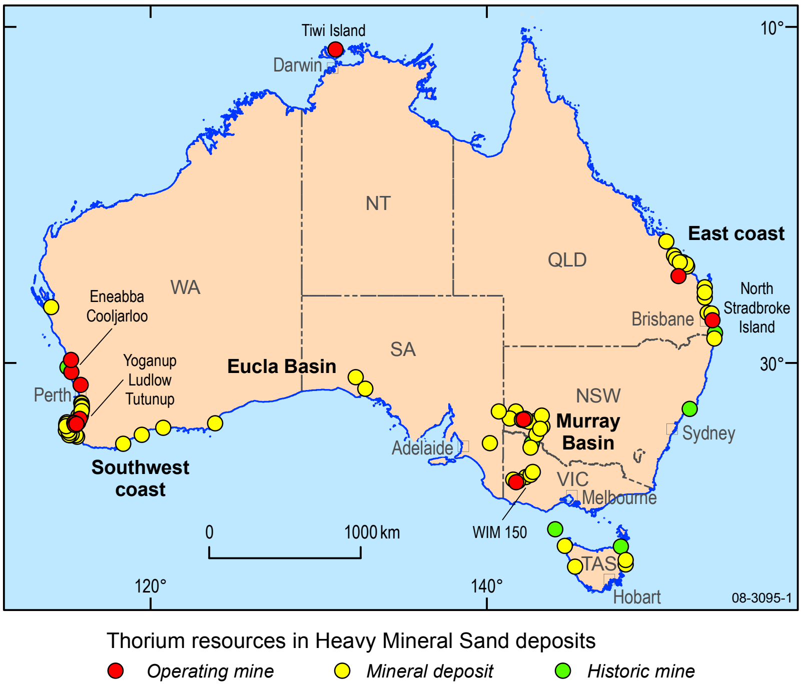

Figure 2. Location of Australia's mineral sand deposits including names of operating mines and selected historical mines. (Data is from the Australian Mines Atlas).

The average abundance of thorium in the Earth's crust is about 5.6 parts per million (ppm). The upper crust is enriched with an average concentration of 10.5 ppm thorium, while the middle crust has an average of 6.5 ppm, and the lower crust an average of 1.2 ppm. The most important thorium-bearing minerals are monazite, thorianite, thorite, and thorogummite. Other minerals that contain lesser amounts of thorium are allanite, bastnäsite, pyrochlore, xenotime, fluorapatite and zircon. Many of the thorium-bearing minerals are remarkably resistant to oxidation and tend to become enriched in the oxidised zones of mineral deposits.

Geophysical surveys involving radiometric, magnetic, and gravimetric techniques can all be applied to the search for thorium-bearing deposits. However, the lack of penetration of radiometric surveys limits the usefulness of this method in those areas of thick cover which are typical of many parts of Australia. In many places, the deep weathering of the Australian continent has destroyed primary rock lithologies, making recognition of mineralised areas exceptionally difficult. Consequently, stream sediment and other geochemical surveys may also be used to help identify target areas at both regional and local scales.

Australia has a wide variety of deposits that contain thorium but the geochemical processes that lead to thorium-enrichment are poorly understood at present. More work is required to better understand the role of thorium in the different styles of mineral deposits and to more comprehensively evaluate Australia's total identified thorium resources.

For more information

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Related websites/articles

Onshore Energy Security Program

www.ga.gov.au/minerals/research/oesp/index.jsp

A Review of the Geochemical Processes Controlling the Distribution of Thorium in the Earth's Crust and Australia's Thorium Resources by Terrence P Mernagh and Yanis Miezitis

www.ga.gov.au/image_cache/GA11421.pdf

Thorium Project

www.ga.gov.au/minerals/research/national/thorium/index.jsp *product news*

New geophysical datasets released

Datasets from five new geophysical surveys, which will be a valuable tool in assessing the mineral potential of the respective survey areas, have been released since June 2008.

These include data from four new airborne magnetic and radiometric surveys which cover Bass Strait and the offshore area off northwest and southwest Tasmania and the Westmoreland region of Queensland. New gravity data covering the West Musgrave area of Western Australia have also been released.

The data for all surveys were acquired in surveys during 2007 and 2008, conducted and managed by Geoscience Australia on behalf of Mineral Resources Tasmania, the Geological Survey of Queensland and the Geological Survey of Western Australia. The northwest Tasmania offshore airborne magnetic survey was funded by Geoscience Australia.

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

For more information

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Related websites

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

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

Mineral Resources Tasmania
www.mrt.tas.gov.au

Table 1. Details of the gravity survey.

Survey	Survey type	Date of aquisition	1:250 000 map sheets	Station spacing, orientation	Stations	Contractor
West Musgrave (WA)	Gravity	May – June 2008	Bentley (pt), Scott (pt), Talbot (pt), Cooper (pt)	2.5 x 2.5 km east – west	4001	Daishsat Geodetic Surveyors

Table 2. Details of the airborne surveys.

Survey	Survey type	Date	1:250 000 map sheets	Line spacing/ terrain clearance/ orientation	Line km	Contractor
Bass Strait (Tas)	Magnetic	Jan – Mar 2008	NA	800 m 90 m east – west	70 856	Thomson Aviation
NW Tasmania Offshore	Magnetic	Jan – Apr 2008	NA	800 m 90 m east – west	43 824	Fugro Airborne Surveys
SW Tasmania Offshore	Magnetic	Jan – Apr 2008	NA	800 m 90 m east – west	26 554	Fugro Airborne Surveys
Westmoreland (Qld)	Magnetic, Radiometric, Elevation	Sep – Dec 2007	Mornington (pt), Cape Van Dieman (pt), Westmoreland (pt), Burketown (pt)	400 m 60 m north – south	60 547	Fugro Airborne Surveys

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New NATMAP Digital Maps widen appeal

Geoscience Australia has recently released *NATMAP Digital Maps 2008* featuring a seamless map which covers the whole of Australia at 1:250 000 scale. This new version of the flagship digital mapping product includes a number of updated maps and a new satellite image of Australia.

The operating software has been revised to improve its utility. Users can now compare a map with a satellite image of the same area using a new split window tool, or place one map over another with a transparency slide tool. The placename search facility, which is based on the Gazetteer of Australia, has also been updated.

NATMAP Digital Maps 2008 has a wide variety of professional, emergency management and recreational uses including:

- real-time navigation with global positioning systems (GPS)
- route and adventure planning
- providing backdrops for geographic information systems (GIS), where information is overlaid and analysed (such as emergency response planning)
- map-based presentations
- a convenient and compact storage of maps.

Since the 1:250 000 scale topographic Raster data was included in the Office of Spatial Data Management's Spatial Data Schedule in late 2005, the conditions for commercialisation of the product have been relaxed. Consequently, the licence conditions for *NATMAP Digital Maps 2008* have been clarified to remove any confusion regarding the increased commercialisation potential of the data. However, some of the other data sets included as well as the Viewing software remain proprietary and are not for commercial exploitation.

Though the previous edition of the NATMAP Raster 1:250 000 scale digital maps was available in two versions, the new version is equivalent in resolution quality to the previous 'Premium' version and the price has been reduced to $99.00. *NATMAP Digital Maps 2008* is supplied on two DVDs and contains all the software needed to use the maps.

For more information

phone Geoscience Australia Sales Centre on Freecall 1800 800 173 (in Australia) or +61 2 6249 9966

email mapsales@ga.gov.au

events

Earth Science Week 2008 celebrations

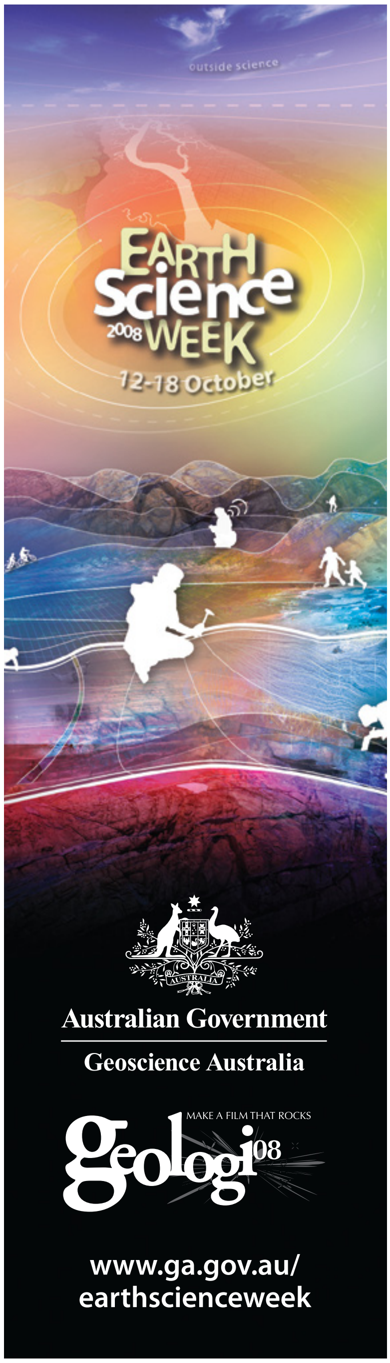
The 2008 Earth Science Week theme 'No child left inside' was announced by the American Geological Institute to encourage young people to get away from the television, off the computer and explore the world outside. Earth Science Week 2008 will be celebrated between 12 and 18 October.

In Australia, celebrations will focus on encouraging 'outside science', inspiring students, teachers and members of the community to step outside and discover the earth sciences. In addition, this 'outside science' theme aligns Australia's Earth Science Week celebrations with the United Nations endorsed International Year of Planet Earth 2008.

To celebrate Earth Science Week 2008 Geoscience Australia is again hosting the national *Geologi* short film competition. *Geologi08* invites all budding geoscientists from around Australia to submit a short film celebrating one of three nominated International Year of Planet Earth themes: Natural Hazards, Earth Resources, and Deep Earth.

The presentation of awards and official screening of the winning entries will take place at Geoscience Australia's headquarters in Canberra during Earth Science Week. The winning entries will also be screened on Australia's Earth Science Week website, and will be a significant contribution to Australia's International Year of Planet Earth outreach program ('bringing earth sciences to everyone').

Earth Science Week celebrations are taking place around Australia, and any individual, school or organisation hosting an event or activity is encouraged to register on Australia's Earth Science Notice Board. All registered events will be sent an Earth Science Week promotional kit, including posters and bookmarks to assist in raising awareness about this significant international celebration.



For more information

International Year of Planet Earth
www.ga.gov.au/about/event/IYPEhome.jsp

Short film competition (*Geologi08*)
www.ga.gov.au/about/event/geologi.jsp

Earth Science Week
www.ga.gov.au/about/event/eswhome.jsp

Earth Science Notice board
www.ga.gov.au/about/event/esw_online.jsp

events calendar

14 ARSPC–14th Australasian Remote Sensing and Photogrammetry Conference	**29 September to 3 October**
Darwin Convention Centre Contact: Spatial Sciences Institute, Conference Action, PO Box 576, Crows Nest NSW 1585	p +61 2 6282 2282 f +61 2 6282 2576 e info@spatialsciences.org.au
Celebrating the International Year of Planet Earth Geological Society of America Joint Annual Meeting	**5 to 9 October**
George R Brown Convention Center, Houston, Texas Contact: Geological Society of America Sales & Service 3300 Penrose Place, Boulder, CO 80301	p +1 303 357 1000 f +1 303 357 1070 e gsaservice@geosociety.org www.geosociety.org/meetings/
Mining 2008	**29 to 31 October**
Hilton Brisbane Contact: Vertical Events, PO Box 1153 Subiaco WA 6904	p +61 8 9388 2222 f +61 8 9381 9222 e info@verticalevents.com.au www.verticalevents.com.au
China Mining Congress	**11 to 13 November**
Beijing International Convention Center, Beijing Contact: Vertical Events, PO Box 1153 Subiaco WA 6904	p +61 8 9388 2222 f +61 8 9381 9222 e info@verticalevents.com.au www.china-mining.com/
NAPE Expo 2009 **American Association of Professional Landmen**	**5 & 6 February**
Houston, Texas, USA Contact: NAPE, 4100 Fossil Creek Boulevard Fort Worth, Texas 76137 USA	p +1 817 847 7700 f +1 817 847 7703 e info@napeexpo.com www.napeonline.com
ASEG 09–20th International Geophysical Conference & Exhibition	**22 to 25 February**
Adelaide Convention Centre Contact: SAPRO Conference Management, PO Box 187, Torrensville, SA 5031	p +61 8 8352 7099 f +61 8 8352 7088 e aseg09@sapro.com.au www.aseg.org.au
PDAC 2009 International Convention & Trade Show Prospectors and Developers Association of Canada	**1 to 4 March**
Metro Toronto Convention Centre, Toronto, Canada Contact: PDAC, 34 King Street East, Suite 900, Toronto, Ontario M5C 2X8	p +1 416 362 1969 f +1 416 362 0101 e info@pdac.ca www.pdac.ca/
2009 APPEA Conference and Exhibition–Australian Petroleum Production and Exploration Association	**31 May to 3 June**
Darwin Convention Centre Contact: Julie Hood, APPEA Limited GPO Box 2201, Canberra ACT 2601	p +61 7 3802 2208 e jhood@appea.com.au www.appea.com.au