Australian Government
Geoscience Australia

10 Celebrating a decade of excellence in geoscience 2001–2011

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## In brief



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# CEO comment

Geoscience Australia has recently reorganised its structure to better reflect the government's major strategic foci: supporting the future energy and resource base of the economy; providing geoscience input to a range of environmental issues, such as climate change and its potential impact on the coastal zone, and groundwater; and contributing to community safety through research into natural hazards and their impact on society. Details of the agency's new structure can be found at: www.ga.gov.au/about-us/organisational-structure.html

This month marks one hundred years since the Australasian Antarctic Expedition 1911–14, led by Dr (later Sir) Douglas Mawson, left Hobart bound for Macquarie Island and East Antarctica. This expedition marked the start of Australia's long engagement with Antarctica and this issue includes several articles relating to Geoscience Australia's current research in Antarctica.

Cape Denison was selected by Mawson as the location for his main expedition base. Our article describes the area's landforms and geology and includes the most recent age determinations for the main rock types. The current reconstructions of the ancient supercontinent Gondwana place this area adjacent to the coast of South Australia prior to rifting and the dismemberment of Gondwana.

There is also an article on the investigation of the impact on marine ecosystems of the break-up of the Mertz Glacier ice shelf following a collision with a massive iceberg in February 2010. The region is one of the 'biological hotspots' of the Antarctic and Southern Ocean ecosystem and was the focus of a joint survey in collaboration with the Australian Antarctic Division. The survey will help answer some key questions relating to ocean acidification and change in marine ecosystems as well as the protection of marine biodiversity.

Virtual globes have increased in popularity since the first online offerings in 2004–05. Our article outlines the development of Geoscience Australia's 3D Data Viewer and its increasing use to provide stakeholders with access to a growing number of the agency's national and regional datasets.

This issue also includes brief reports on Geoscience Australia's contributions to a number of important projects including:

- the recently-completed northern Perth Basin seepage survey
- recent field tests to assess the storage capacity of supercritical carbon dioxide within a potential storage reservoir
- the international effort to establish a representative system of marine protected areas in the Southern Ocean around Antarctica
- monitoring recent earthquakes near Bowen in Queensland
- the rapid collection of information to support the investigation of the after-effects of natural disasters
- development of a database with basic location information for 1700 waste management facilities across Australia.

As always we welcome your feedback and encourage you to use the email address at the end of each article.

**Dr Chris Pigram**
CEO Geoscience Australia.

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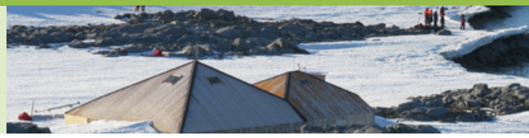
# Cape Denison, the birthplace of Australian Antarctic expeditions



## *New map and poster commemorates the Australasian Antarctic Expedition*

*Chris Carson*

This year marks the 100th anniversary of the Australasian Antarctic Expedition (AAE, 1911–1914) which was organised and led by the eminent geologist Dr (later Sir) Douglas Mawson. The objectives of the AAE were the exploration and scientific investigation of the then largely unknown coastline and hinterland in the vicinity of Adélie Land. This expedition marked the start of Australia's long engagement with Antarctica, a productive and active involvement that continues to this day.

The expedition departed Hobart on 2 December 1911 on the *Aurora*, under command of Captain John K Davis, and established a vital support base on Macquarie Island before continuing south to Antarctica and establishing the main base. Finding a suitable site for a base was difficult and Mawson finally located a small rocky ice-free cape, later named Cape Denison after Sir Hugh Denison, one of the major expedition supporters, located within Commonwealth Bay. The bay was named for the newly federated Australian Commonwealth and, according to Charles Laserson the expedition biologist, 'stretched in a great semicircle, bordered everywhere by high ice cliffs, with here and there a patch of black rock showing at the base'.

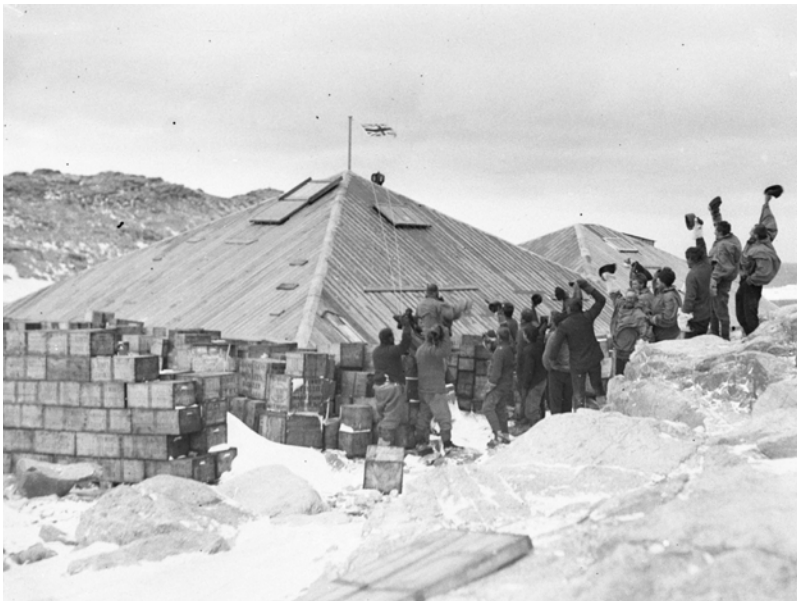


**Figure 1.** Members of the Australasian Antarctic Expedition (1911–14) celebrating the completion of the hut (Photograph by Frank Hurley).

Mawson decided that Cape Denison would be the location for the main expedition base (figure 1). During the initial landing at Cape Denison weather conditions were pleasant enough, with Mawson recording 'the day had been perfect'. However, the true character of Commonwealth Bay was soon to reveal itself with katabatic winds, that drain dense cold air from the polar plateau inland behind Commonwealth Bay, which are the most ferocious and persistent winds on the planet. Cecil Madigan, the AAE meteorologist, recorded a mean wind-speed of over 71 kilometres per hour over nearly two years of recording. Cape Denison is now acknowledged as the windiest place on Earth. Mawson's choice of title for his published account of the expedition, 'The Home of the Blizzard' was no idle appeal to poetic licence!

## Landforms of Cape Denison

Cape Denison is an ice-free rocky promontory covering less than one square kilometre which emerges from beneath the continental ice sheet (figure 2). The continental ice sheet rises steeply behind Cape Denison reaching an altitude of '1000 ft in three miles and 1500 ft in 5 and a half miles' (Stillwell 1918). Cape Denison is described as a 'miniature mountain area' with four parallel broad-bottomed shallow valleys, with intervening rocky ridges, 'steep rock faces and sharp ledges'. Understandably, the main action responsible for the geomorphological features (or landforms) at Cape Denison is the erosive effects of glaciation, with abundant evidence of polished and striated rock surfaces, *roche moutonnée* (elongate whale-backs of bedrock, sculptured by the movement of ice flow) and abundant exotic glacial erratics (Stillwell 1918). 'Freeze-thaw' processes were also considered active erosive agents at Cape Denison during the summer months whereas the actions of wind and running water were considered comparatively minor geomorphologic agents (Stillwell 1918).

## Geology of Cape Denison

In addition to Mawson, Frank Stillwell was a qualified geologist and made major contributions to the geology of the Commonwealth Bay region *('The metamorphic rocks of Adélie Land')*. Publications from the AAE on the geology, geomorphology, and other physical sciences appeared in a series of scientific reports published between 1918 and 1940. Geological studies did not resume at Cape Denison until Oliver et al (1983), Stüwe & Oliver (1989) and Sheraton (1989). French geologists (such as Heurtebize 1952; Bellair 1961a,b; Bellair and Delbos 1962) initially conducted investigations to the west in Adélie Land in the vicinity of the French Base Dumont D'Urville (Cape Jules, Port Martin and Point-Géologie) but recent French studies have examined outcrops both east and west of Cape Denison (Ménot et al 2007).

**Figure 2.** Cape Denison, facing northwest, overlooking Mawson's Hut from the 'Proclamation Plaque' site.

Ice-free bedrock along the George V Land coastline is limited to small rocky capes, islands and nunataks, and geological investigations focused on studies of material from moraine fields. Moraines are 'rubble piles' of rocks transported and concentrated as a result of glacial movement and may be transported many kilometres from their source region. The AAE also described the first meteorite found in the Antarctic (Bayly and Stillwell 1923) which was found in December 1912 on the ice plateau, 'about 20 miles from Cape Denison…'.

The bedrock geology of Cape Denison, as well as other locations along the Adélie Land and George V Coast, was described by Stillwell (1918). The geology of Cape Denison is relatively simple and can be divided into two dominant rock-types in order of abundance, the Cape Denison Orthogneiss, and amphibolitised mafic dykes (the Cape Denison Amphibolite) which are described below.

## Cape Denison rock types

The most abundant rock type at Cape Denison is the Cape Denison Orthogneiss, described by Stillwell (1918) as coarse-grained grey quartz-feldspar layered granitic gneiss. Stüwe and Oliver (1989) further described the Cape Denison Orthogneiss as a variably foliated, partially migmatised felsic orthogneiss, that is, metamorphosed granite (see figure 3). The Cape Denison Orthogneiss has been intruded by a number of now-amphibolitised mafic dykes (see also Sheraton et al 1989). Oliver et al (1983) noted, on geochemical grounds, that the Cape Denison Orthogneiss had 'S-type' characteristics, suggesting derivation from the melting of a predominantly sedimentary source rock. The Cape Denison Orthogneiss constitutes all of Cape Denison, the nearby offshore Mackellar Islands, and crops out around Point Alden and Port Martin about 50 to 70 kilometres to the west.

The other major rock type found at Cape Denison is amphibolitised mafic dykes (Stillwell 1918). These mafic dykes are between about 0.1 metre to 2 metres wide, dark green/grey in colour and generally planar in outcrop. The dykes are sub-parallel to the regional foliation, and are strongly foliated. Sheraton et al (1989) concluded, on the basis of geochemistry, that at least three distinct generations of mafic dykes are present but were recrystallised and deformed during the regional amphibolite-facies metamorphism.

**Figure 3.** The Cape Denison Orthogneiss, one of the two dominant rock types found at Cape Denison.

## Geochronology at Cape Denison

The first age determination of the Cape Denison Orthogneiss was conducted by Oliver et al (1983), who, reported the emplacement age of the Cape Denison Orthogneiss at 2366 ± 33 million years ago (Ma). Recent uranium-lead (U-Pb) zircon geochronology analysis has been conducted at Geoscience Australia's Sensitive High Resolution Ion Microprobe (SHRIMP2e) facility. The SHRIMP uses the natural radioactive decay of uranium to lead as a quantitative measure of time. A cluster of accepted analyses, all from oscillatory zoned domains, return a median $^{207}Pb/^{206}Pb$ age of 2445 +6.1/-5.2 Ma (95% confidence level) which is interpreted as a conservative estimate of emplacement age for the Cape Denison Orthogneiss. The youngest six analyses from dark recrystallised metamorphic rims return a median $^{207}Pb/^{206}Pb$ age of 2419 +11/-20 Ma, broadly correlating with the Sleaford Orogeny (about 2480 to 2420 Ma) reported in the Gawler Craton in South Australia (Kositcin et al 2010).

The emplacement age of the dykes has proven more problematic. Sheraton et al (1989) concluded that the mafic dykes correlate with similar mafic dykes identified in the Gawler Craton in South Australia (Kositcin et al 2010) and the likely minimum age of dyke emplacement was suggested at around 1600 Ma based on a possible relationship with dykes exposed at the Port Lincoln area in South Australia. However, a conclusive estimate of the emplacement age of the mafic dykes of Cape Denison has been elusive. Zircons from the Cape Denison Amphibolite yielded only three zircons. However, all three grains preserve oscillatory zoning and have elevated thorium/uranium (Th/U) values, characteristic of zircons crystallised from a mafic silicate melt. Seven analyses on these zircons returned a weighted mean $^{207}Pb/^{206}Pb$ age of 1809 ± 10 Ma (95% confidence level), which was interpreted as the emplacement age of the mafic dyke protolith.

Other geochronological studies (for example, Rb-Sr (rubidium to strontium) analysis of micas; Arriens 1975, Bellair 1961a,b) suggest that amphibolite-facies metamorphism affecting the Cape Denison region occurred around 1500 to 1700 Ma. The timing of retrograde amphibolite-facies metamorphism along George V Land coast to the east and west of Commonwealth Bay is somewhat better estimated to have occurred at around 1710 Ma. This correlates with a similar aged metamorphic event (Kimban Orogeny, 1740 to 1690 Ma) in the Gawler Craton in South Australia (Oliver & Fanning 2002, Ménot et al 2007) which is outlined below.

## Cape Denison in Gondwana

Current reconstructions of the supercontinent Gondwana place the coast of South Australia adjacent to the coastline of Adélie Land and George V Land prior to rifting and the dismemberment of Gondwana. One of the most conclusive lines of evidence which confidently links rocks in the Commonwealth Bay region with exposed rocks in South Australia is the correlation of the 'Cape Hunter Phyllite' with similar phyllitic rocks on the Eyre Peninsula.

The Cape Hunter Phyllite, west of Cape Denison, was described by Stillwell (1918). The rock is a low-grade fine-grained phyllite, unlike other high-grade metamorphic rocks in the region. Based on lithological chemical and isotopic constraints, Oliver and Fanning (1997) correlated the Cape Hunter Phyllite with phyllites exposed at Coffin Bay on the west coast of the Eyre Peninsula in South Australia. This study, as well as later more comprehensive studies (Fanning et al 1995, Oliver & Fanning 2002), and the geochronology results determined at Geoscience Australia, clearly place the Cape Denison region directly opposite the Gawler Craton in South Australia (Kositcin 2010). These studies led to the concept of a contiguous continental block termed the 'Mawson Block' after Sir Douglas Mawson (Fanning et al 1995, Oliver and Fanning 1997 2002). The Mawson Block includes the Gawler Craton and the rocks of the Commonwealth Bay region and formed part of the amalgamated supercontinent of Gondwana. The full extent of the Mawson Block is currently difficult to assess as the Antarctic component is largely covered by continental ice sheet, but geophysical evidence (Finn et al 2006) strongly suggests the Mawson Block extends well into the interior of the present day continent of Antarctica. While breakup of the supercontinent Gondwana commenced in the Jurassic Period (around 185 Ma), Antarctica began to rift from Australia much later, some 85 to 80 Ma in the late Cretaceous Period, a dynamic tectonic process that continues to this day (figure 4).


**Figure 4.** The separation of Australia from Antarctica, which began about 85 to 80 million years ago, was the last major geological event in the breakup of the supercontinent of Gondwana.

## Conclusions

The AAE (1911–1914) represented the first Australian managed and led expedition to the Antarctic and represents one of the last bold endeavours of what has become known as the 'Heroic Era" of Antarctic exploration. The expedition raised the profile of the Antarctic within the Australian consciousness, highlighted the geopolitical importance of the Antarctic and a formed a basis for future scientific research in the Antarctic. The expedition provided a solid foundation for ongoing interest and involvement and led directly to Mawson claiming, during subsequent expeditions, the Australian Antarctic Territory, an area of almost 6 million square kilometres, for the Australian Commonwealth.

## Cape Denison Historic Site poster

As part of the celebrations marking 100 years of Australian expeditions in the Antarctic, Geoscience Australia, in partnership with the Australian Antarctic Division, has released a new special edition geologically-themed poster of Cape Denison. The commemorative poster presents a summary of Mawson's Australasian Antarctic Expedition, a brief description of the geological features of the area, as well as new data on the geochronology of Cape Denison.

## Acknowledgements

The author wishes to thank the 2010–2011 Mawson's Hut Foundation expedition for collection of geological specimens from Cape Denison. Samples were collected under Australian Antarctic Science project no. 3289 and Australian Quarantine Inspection Service (AQIS) permit IP10022443. The analytical and sample preparation expertise and assistance of the staff of Geoscience Australia's SHRIMP facility are also acknowledged.

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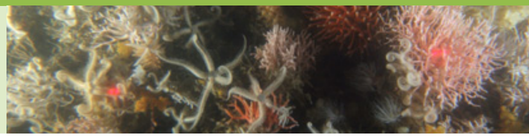
# Marine ecosystems in the Mertz Glacier region, Antarctica

## *Survey investigates impact of break-up of ice shelf*



*Jodie Smith*

In his account of the Australasian Antarctic Expedition of 1911–14, Sir Douglas Mawson (1915) described his encounter with large icebergs, resembling ice walls, during the voyage south to Adélie Land in January 1912: 'a south-south-east was blowing as we came abreast of the 'ice island', which, by the way, was discovered to have drifted several miles to the north, thus proving itself to be a free-floating berg'. They were to later learn that the ice formation was 'nothing more than a high iceberg measuring forty miles in length'.

The following day, Mawson wrote 'the *Aurora* was in calm water under another mighty ice face trending across our course. This wall was precisely similar in appearance to the one with which we have been in touch during the preceding days, and might well have been a continuation of it. We were afterwards to learn that this was not so'. It was then noted that this new shelf-ice formation was found to be a floating tongue sixty miles in length, the seaward extension of a large glacier which was named the Mertz Glacier, after Mawson's ill-fated colleague Dr Xavier Mertz (figure 1).

Almost 100 years later, in early 2011, the Mertz Glacier region was visited once again by Australian scientists, this time on board the *Aurora Australis*. Little has changed in this environment during the past 100 years, with 'the atmosphere foggy', 'the water merely littered with fragments of ice' and a 'mighty ice face' trending across the course, just as Mawson described it back in 1912.

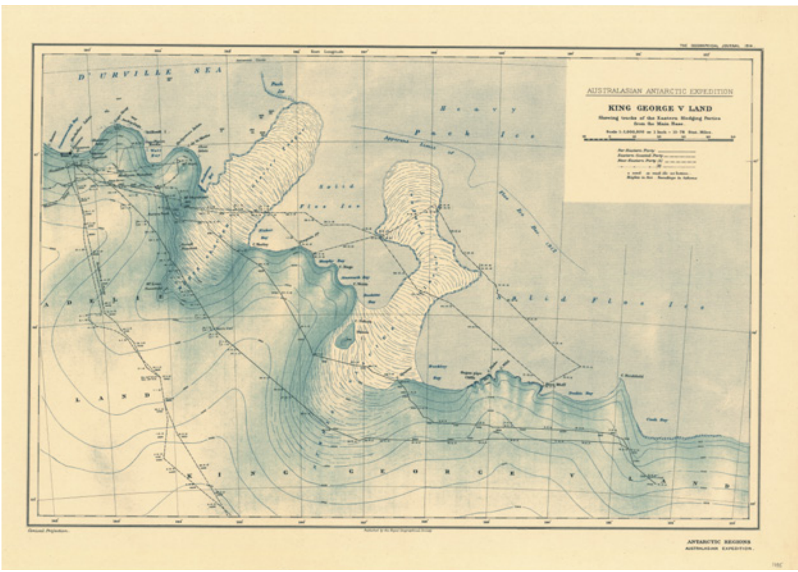



**Figure 1.** Historical map of King George V Land showing the Mertz Glacier from the Australasian Antarctic Expedition 1911–1914 (Map courtesy of the Australian Antarctic Division and reproduced from the Royal Geographic Society).

## The Mertz Glacier region

The Mertz Glacier region plays an important role in the global ocean over-turning circulation and is one of the few places in the ocean where dense, salty water forms at the surface and sinks to the deep ocean. Polynyas (areas of open-water or low sea ice concentration) in the region produce about 25 per cent of the Antarctic Bottom Water, and this sinking of dense water drives the deep over-turning circulation of the global ocean, carrying oxygen and nutrients to depth in all ocean basins (Young et al 2010).

The area around the glacier is one of the 'biological hotspots' of the Antarctic and Southern Ocean ecosystem (Gutt et al 2010). The ice-free waters of the polynya allow light to reach the ocean surface and stimulate primary production. The high biological productivity attracts whales, penguins and seals to feed on plankton in one of the few areas not covered by ice in the Antarctic winter. The region is also home to some unique marine communities such as deep water hydrocorals (Post et al 2010).

In February 2010, a massive iceberg designated B09B collided with the Mertz Glacier tongue—a section of the glacier that protruded about 100 kilometres from the Antarctic coastline. The collision precipitated the calving of the glacier tongue, producing a new massive iceberg, C28. This calving event removed about 80 per cent of the tongue, leaving only a 20 kilometre-long stub and exposed a large section of the sea floor, about 80 kilometres long and over 30 kilometres wide (figure 2). The calving event fundamentally changed the geography of the region, with, as yet, unknown consequences for ocean circulation patterns, sea ice production and biological productivity.

Less than a year after the spectacular calving event, scientists were collecting valuable data from this newly exposed area of the seafloor and the surrounding waters. The 2011 marine survey involved scientists from a number of research institutions, working collaboratively across a number of different projects. The overall aim of the survey was to conduct a coordinated and comprehensive study to measure and monitor the impact of the Mertz Glacier calving event on the local and regional environment (Pyper et al 2011). Collecting data as soon as possible after the calving event means that any physical, chemical and biological changes in response to the new conditions can be monitored over time.

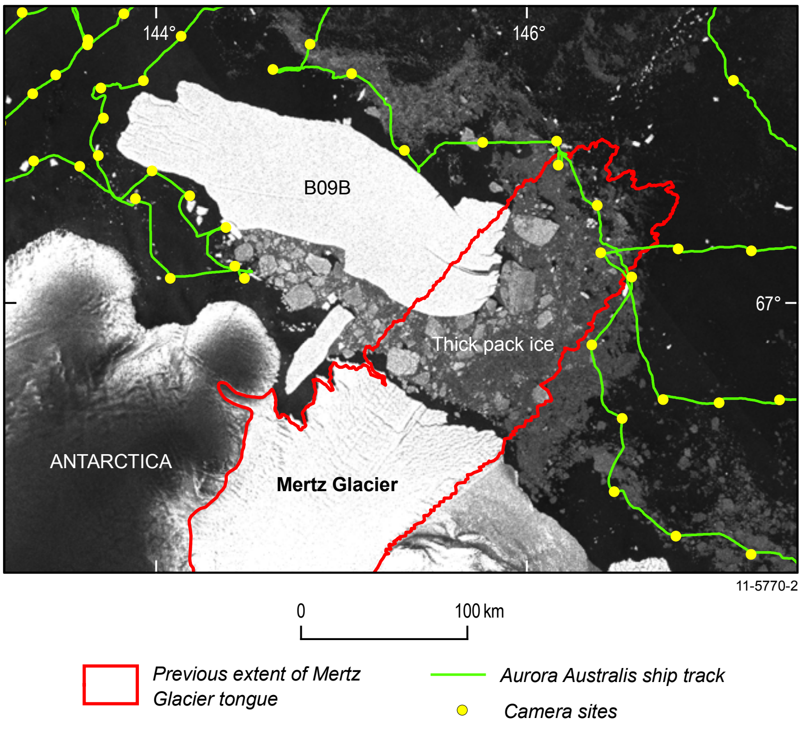



**Figure 2.** Ice conditions, ship track (green line) and camera stations (yellow dots) in the Mertz Glacier region during the Marine Science Voyage (VMS) in Janurary 2011. The satellite image (Envisat high-resolution radar image, 12 Janurary 2011) shows the position of iceberg B09B to the west of the Mertz Glacier tongue and the thick ice pack backed up behind it in the area previously covered by the glacier tongue (outlined in red).

A team of scientists and technicians from Geoscience Australia and the Australian Antarctic Division conducted a benthic (or seafloor) community survey during the voyage (Smith and Riddle 2011). The purpose of the survey was to collect high-resolution still images of the sea floor to investigate:

- benthic community composition in the area previously covered by the Mertz Glacier tongue and, to the east, an area previously covered by approximately 30 metres of fast ice
- benthic community composition (or lack thereof) in areas of known iceberg scours
- the lateral extent of dense hydrocoral communities along the shelf break.

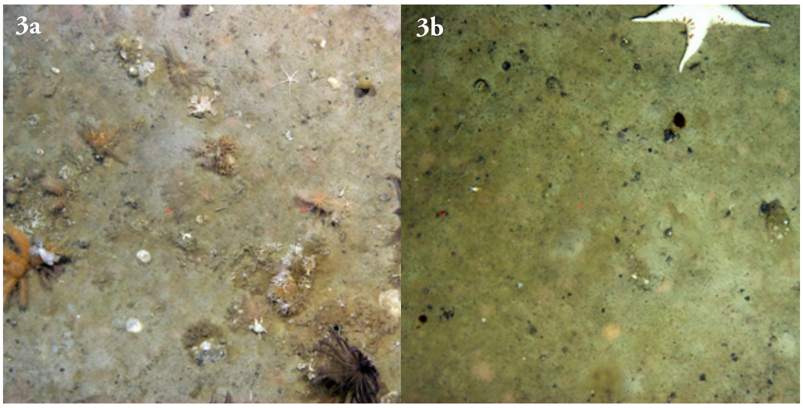
Using a digital camera inside a waterproof casing, over 1800 still images of the sea floor were collected at depths ranging from 170 to 2300 metres. Because there is little or no light reaching the sea floor at these depths, two strobe lights were used to illuminate the bottom. The position from the seafloor was monitored using an altimeter attached to the frame. The target depth was four to five metres from the seafloor. Parallel laser pointers set 50 centimetres apart were used to provide a scale for the images (figures 3a, 3b).

The benthic images from the voyage will be analysed in detail to identify the organisms and communities at each site. Bathymetric data, satellite images, substrate information and physical and chemical oceanographic datasets will be used to examine the relationship between the benthic communities and the physical and chemical environment.

## Sub-ice shelf communities

A widespread but unique habitat in Antarctic waters lies beneath floating ice shelves that cover one-third of Antarctica's continental shelf. This expansive marine setting remains largely unexplored because of general inaccessibility. It has long been recognised that benthic organisms exist under ice shelves, sometimes at substantial distances from the open water. However, any marine organisms living on the sea floor in these areas do not have the same opportunity for food as in the open ocean, where there is a regular supply of phytoplankton from the surface waters. These populations must be sustained by horizontal advection (or horizontal currents) of their primary food source. Because of the ice cover, there are few opportunities to study ecosystems that are able to exist in such situations. In addition, little is known about the potential biological impacts of ice shelf collapse.

The calving event has enabled access to an area where no information on benthic communities or seafloor substrate currently exists. Unfortunately, access during the 2011 voyage to areas previously under ice (that is, under the Mertz Glacier tongue and to the east) was limited by the ice conditions at the time of the voyage.




**Figures 3a, 3b.** Life under the Mertz Glacier tongue includes sea pens, bryozoans, gorgonians, brittle stars, anemones, holothurians, sponges, urchins, crinoids and sea stars. The seafloor is scattered with dropstones which have fallen from the glacier above. (Photo from Australian Antarctic Division underwater camera).

The large iceberg B09B was in a stationary position just to the west of the Mertz Glacier tongue. Because of the current and wind regime and the size of the iceberg, a large amount of pack ice built up behind the iceberg, restricting ship access to the region previously covered by the Mertz Glacier tongue (figure 2). As a result, the benthic camera could be deployed at only three stations in the area previously under the Mertz Glacier tongue.

Benthic life under the Mertz Glacier tongue was found to be similar to that in the adjacent areas, although more sparse. A diversity of marine animals was observed, including sea pens, bryozoans, anemones, gorgonians, holothurians, urchins, brittlestars, crinoids, sponges, and even a sea star that was more than half a metre across (figures 3a, 3b). These benthic communities must source their food from particles carried by currents that flow beneath the Mertz Glacier tongue. The sea floor under the glacier tongue is comprised mostly of mud with pebbles and cobbles ('dropstones' from the glacier above) scattered across the surface.

It should be noted that the three camera stations were located less than 20 kilometres from the edge of where the ice tongue extended prior to its calving (figure 2). Therefore, the benthic communities found at these stations may not resemble those further from the ice edge and closer to the grounding line of the glacier.

The area to the east of the Mertz Glacier tongue has been covered by annual or multi-year fast ice for varying periods of time. Historical satellite imagery will be used to determine the changes in ice conditions over the last few decades. The benthic photographs collected at stations east of the Mertz Glacier tongue will also be examined to determine if the different ice conditions have had any influence on benthic community composition. Initial observations of the photographs indicate low benthic cover in this area.

## Iceberg scouring

Seafloor disturbance due to iceberg scouring is a common form of disturbance of benthic communities on parts of the Antarctic shelf, typically less than 500 metres deep (Barnes and Lien 1988). Iceberg scours (both relict and recent) were identified on the continental shelf in this region at depths of at least 500 metres and benthic communities were found to vary in relation to the age of the scours (Post et al 2011). It has been suggested that it takes the benthic community hundreds of years to recover following disturbance from iceberg scours (Gutt 2000), however, because scours in the Mertz region have not been dated, it is not known how long recolonisation takes.

Following the calving of the Mertz Glacier tongue in February 2010, the newly-formed iceberg (C28) collided with the Adélie Bank (figure 4) and broke into several sections. This survey aimed to collect baseline information on benthic communities (or lack thereof) in areas of recent scouring, including the point where iceberg C28 collided with the Adélie Bank. This will determine which, if any, benthic organisms have started to recolonise the scoured areas. Understanding how and when recolonisation occurs may assist in better predicting the types of communities that will occur in different areas of the shelf.

The targeting of sites affected by iceberg scouring proved to be difficult given the nature of the camera system used, the resolution of the satellite and bathymetry data, and the manoeuvrability of the ship. As such, there was no evidence of iceberg scouring at these camera stations. However, there was evidence of iceberg scouring identified at some other stations. At two camera stations, located east of the glacier tongue, the photos show fracturing of compacted sediments which is consistent with mechanical stress. When disturbed by ice keels, irregular blocks and slabs of compact, overconsolidated mud are ripped loose with angular fracture faces. Other photos show a linear scrape across the surface,

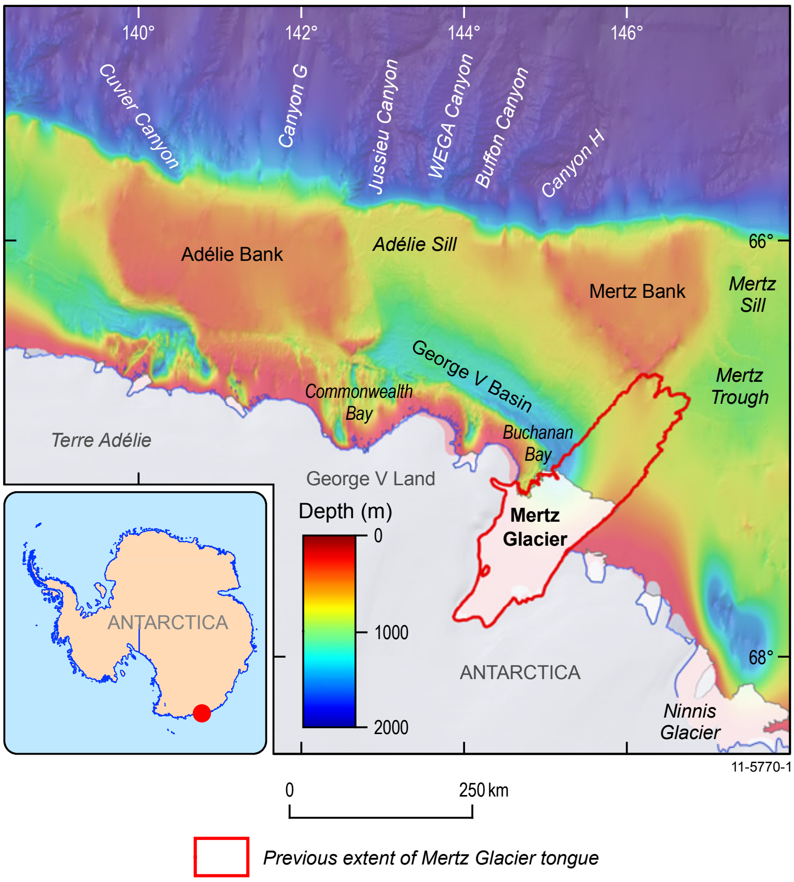



**Figure 4.** The location and seafloor morphology of George V Land and Terre Adélie shelves. The previous extent of the Mertz Glacier tongue, as of Janurary 2008, is also shown. The bathymetry is from the Beaman et al (2011) 250 metre grid.

a common iceberg scour feature. Water depths at these camera stations are approximately 500 to 550 metres which is considered too deep for modern iceberg scouring. However, relict scours have been found in the region to approximately 600 metres and these most likely date from the last glaciation when sea level was approximately 120 metres lower than present levels (Post et al 2011).

## Dense hydrocoral-sponge communities

Dense hydrocoral-sponge communities were identified on the upper continental slope off George V Land during a previous survey (Post et al 2010). In 2008 they were declared Vulnerable Marine Ecosystems (VMEs) by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and are closed to bottom fishing (CCAMLR 2009a, b). The richest hydrocoral communities were found below 500 metres and in canyons that cut the shelf break and receive Antarctic Bottom Water. Three main factors regarding the distribution of the hydrocoral communities were identified:

- their depth in relation to iceberg scouring
- the flow of organic-rich bottom waters
- their location at the head of shelf-cutting canyons (Post et al 2010).

This survey aimed to test these hypotheses by collecting data from several sites along the continental slope to identify the presence or absence of hydrocoral-sponge communities.

The sites were chosen within two broad areas; those thought to be receiving and not receiving Antarctic Bottom Water. Additionally, within these areas, sites were chosen to include canyons and interfluves. Oceanographic data collected during the voyage provides evidence of descending plumes of Antarctic Bottom Water down the continental slope. Dense and sparse hydrocoral-sponge communities were identified in areas receiving bottom water. The photos collected at these sites show a spectacular display of vulnerable marine life (figure 5). There were no hydrocorals identified in areas where there was no bottom water flow. The new data supports the hypotheses regarding the physical controls on hydrocoral-sponge community distribution (Smith et al 2011). This new information will be used to support the application to CCAMLR for a Marine Protected Area in the Mertz region (Weragoda and Bartley 2011).

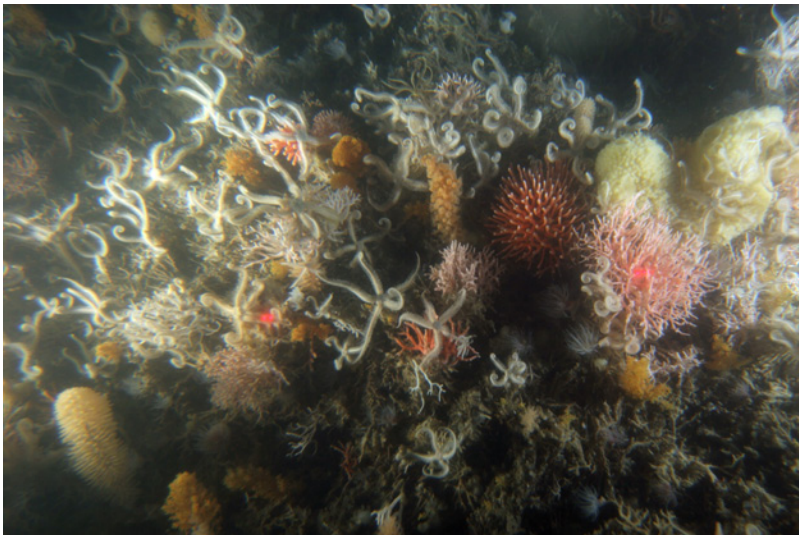


**Figure 5.** Dense hydrocoral communities inhabit areas along the continental shelf break. These fragile communities, first discovered in this region in 2008, have been declared a Vulnerable Marine Ecosystem by CCAMLR. (Photo from AAD underwater camera).

## Conclusions

The survey has provided a major new set of data which will greatly enhance the understanding of Antarctic marine biodiversity and the relationship between physical conditions and benthic communities. This information will be used to help answer some key research questions outlined in the Australian Antarctic Science Strategic Plan relating to ocean acidification and change in marine ecosystems, as well as protecting marine biodiversity. It will also provide a benchmark for tracking future changes in benthic communities in areas previously covered by ice.

## Acknowledgements

The author wishes to thank Alix Post and Phil O'Brien (Geoscience Australia) and Martin Riddle (Australian Antarctic Division) for providing advice throughout the project. Thanks are also due to Miguel de Salas, Michael Field, Kim Briggs, Penny Purdie and Gerrit Klomp (Australian Antarctic Division), Captain Murray Doyle and the crew of the RSV *Aurora Australis* (P & O), the voyage leader Steve Rintoul (CSIRO) and the CTD team (CSIRO and ACE CRC) for assistance in collecting the data.

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### For more information

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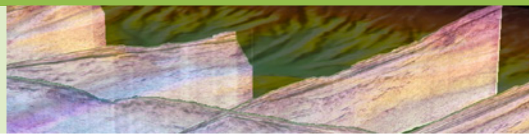
ISSUE 104 Dec 2011

# Presenting geoscience using virtual globes

## *Communicating geoscience data in a variety of contexts*



*James Navin and Michael de Hoog*

Virtual globes have increased in popularity since the first online offerings appeared in 2004–05. Since its release in mid-2005, Google Earth has been downloaded over one billion times (Official Google Blog 2011), and there are now numerous virtual globe software applications available that cater to different audiences and industries.

As a platform for communicating and visualising geoscience data, virtual globes have a number of key benefits. These include:

- visualisation of data at a range of scales, from local to global
- three-dimensional representation of terrain, helping to locate and contextualise data
- overlay and visualisation of different datasets simultaneously
- interactivity, allowing users to freely explore the data
- the easy incorporation of large datasets associated with the geosciences.

Like many other organisations, Geoscience Australia is using virtual globes as an important visualisation tool. In a 'right tool for the job' approach, different virtual globe applications are used to meet different needs; these include NASA's World Wind, Google Earth and ESRI ArcGIS Explorer. This article focuses on the development of Geoscience Australia's 3D Data Viewer and its use within the agency to share information with external stakeholders.

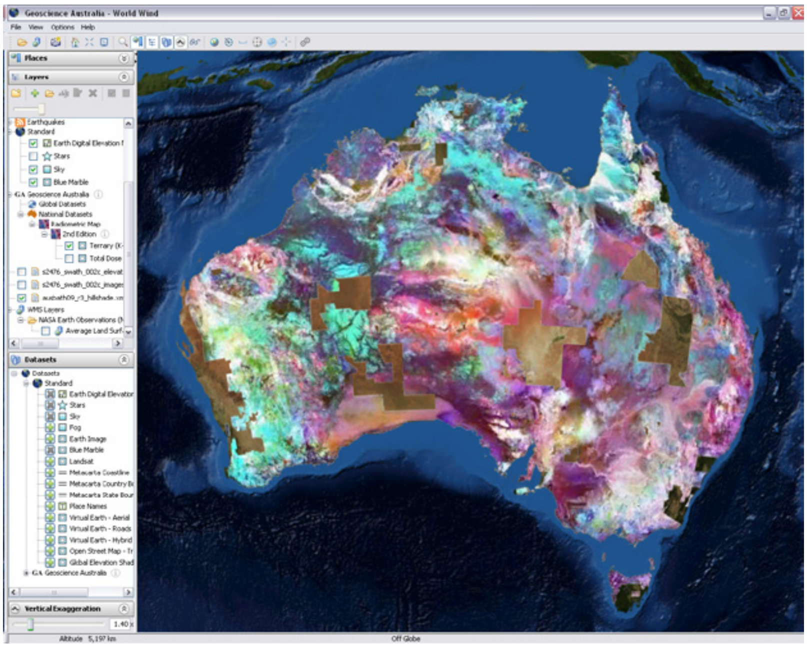



**Figure 1.** A screenshot of Geoscience Australia's 3D Data Viewer showing the Ternary layer of the 2nd Edition Radiometric Map of Australia.

## Geoscience Australia's Virtual Globe

In February 2009, Geoscience Australia released the national Radiometric Map of Australia as eight data grids totalling 55 gigabytes. In the lead-up to the public release, the agency looked for an application that would provide external stakeholders with easy and intuitive access to images of the data at full resolution without the need for specialist software. The application also needed to allow users to compare each of the eight data grids with each other as well as with other national datasets, such as the national Gravity and Magnetic Anomaly maps. The application that best met the agency's requirements was the NASA World Wind Java Software Development Kit (SDK) which enabled the development of an agency-specific application built on the base World Wind components (figure 1).

Development on the 3D Data Viewer has continued since its release and it now supports a range of data types including:

- Raster images
- shapefiles (point, line and polygon)
- digital elevation models (DEMs) and digital surface models (DSMs), including high-resolution LiDAR-derived data
- earthquake data (recent and historic)
- seismic and airborne electromagnetic (AEM) survey data
- web map service (WMS) data layers.

A growing collection of Geoscience Australia's national and regional datasets are now available through the public version of the 3D Data Viewer (see below), which has been used by agency staff at a number of international conferences to present data and findings.

## Uniform data presentation

A key advantage of using virtual globes for the visualisation of geoscience data is that they provide a uniform and familiar interface for interacting with data from a wide range of sources and disciplines. For example, topographic data can be viewed alongside geophysical survey data and remote sensing data, all of which can then be overlayed on a digital terrain model, and navigated and controlled in a uniform manner. This immediately makes data more accessible, which is important for communicating scientific data to a broad audience.

Through the use of open data standards, such as Web Map Service (WMS), Web Feature Service (WFS) and GeoSciML, this uniform data presentation can be taken a step further: virtual globe applications become further decoupled from the data they are displaying and become data agnostic. This is uniform data presentation from a producer's perspective. Rather than preparing data specifically for use in Software Package A and then separately for use in Software Package B, data can be prepared once and then delivered over a standard interface to any number of consuming software packages.

Most of the popular virtual globe applications on the market today support open data standards to some extent. The 3D Data Viewers support for WMS includes a WMS Browser tool that allows users to browse for and select data layers from WMS servers around the world. It also includes a WMS Server Search tool that allows users to discover WMS servers that contain data layers of interest. Once added to the 3D Data Viewer, WMS layers are treated in the same way as any other layer: they can be turned on and off, opacity can be altered, and vertical 'draw order' can be changed. This consistency of the user experience ensures that WMS data can be added and used seamlessly alongside data and imagery from other sources.

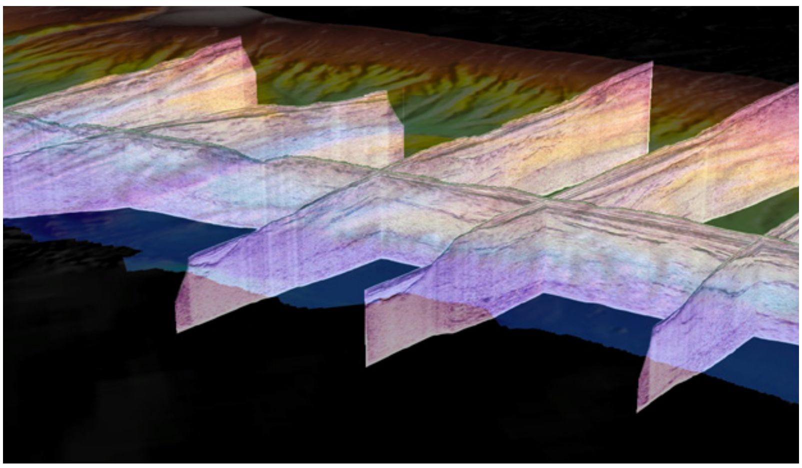


**Figure 2.** The 'curtain image' layer showing offshore seismic survey slices from Geoscience Australia's Southwest Margin project.

## Subsurface in a virtual world

Much of geoscience is concerned with gathering, analysing and interpreting data about processes and structures that occur beneath the surface of the earth. This data can come from a range of sources and often requires specialised and expensive software to view. Communicating this data in a way that is intuitive and accessible can be challenging.

A number of techniques for visualising subsurface data in virtual globes have developed recently. One technique is to generate a two-dimensional representation of the data as viewed 'top-down' and to project this data onto the surface of the globe. This has the advantage that the data can be manipulated in the same way as other image-based data, but it can be difficult to convey the three-dimensional nature of the data. A second approach is to display the data in some way above the globe's surface. This approach has the benefit that the three-dimensional nature of the data can be conveyed, but suffers from a disconnect between where the data is displayed in the digital world and the real-world location of the features.

A more compelling representation of subsurface data can be obtained by visualising it in the correct location beneath the surface of the virtual globe (figure 2). Geoscience Australia has been working to add features to the 3D Data Viewer to support the visualisation of subsurface data.

## Recent innovations

A recent addition to the 3D Data Viewer is support for the display of survey data collected as two-dimensional slices into the Earth's surface. Examples of this type of data include 2D seismic and airborne electromagnetic (AEM) survey data. These data are displayed using a 'curtain image' layer type that defines survey paths as a series of latitude and longitude coordinates with a top and bottom slice depth. From this information a simple mesh is generated that represents the data slice. The actual survey data is projected onto the mesh from a pre-computed image tile cache, with appropriate resolution image tiles selected based on the distance of the user from the survey slice.

This approach is similar to quad-tree tiling or 'pyramiding' techniques used to display high resolution surface imagery in many virtual globe and 2D web mapping applications. The use of a pre-computed tile cache rather than the source data has a number of benefits for the display of this type of data:

- The size of the tile cache is often smaller than the source data, due to the use of compressed formats such as JPEG and ZIP. This makes the transmission of the data faster and less network intensive.
- Tiles are pre-computed, so selecting an appropriate tile to use is very fast and requires minimal processing. This aids in delivering an engaging interaction for the user.
- Tiles are stored in common image formats, so specialised software is not required by the user to load the data.

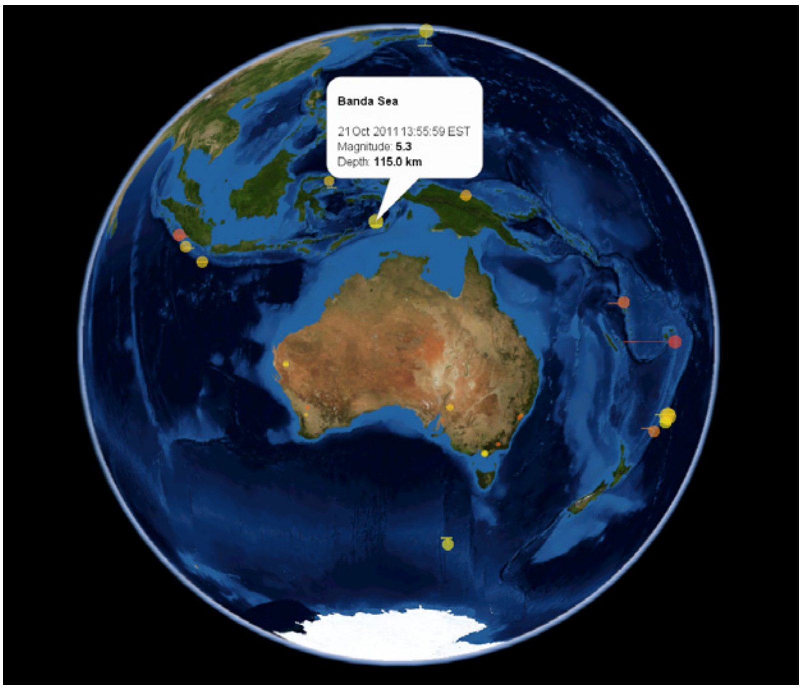



**Figure 3.** Recent earthquake activity as shown within Geoscience Australia's 3D Data Viewer.

Another feature that has been added to the 3D Data Viewer is a recent earthquakes layer (figure 3). This layer connects to an RSS feed of recent earthquake activity published by Geoscience Australia. The RSS feed contains the location, depth, magnitude and timestamp of earthquakes that have occurred within the last seven days. The 3D Data Viewer connects to this feed and visualises earthquakes as a sphere located on the Earth's surface at the earthquake epicentre, scaled by magnitude and coloured by age. In addition, a 'tail' is added that extends subsurface data down to the earthquake hypocentre. This visualisation gives a clear overview of recent earthquake activity so users can immediately differentiate deep, recent, high-magnitude quakes from older less significant ones. Users can access more information by hovering the mouse over specific earthquakes and clicking to link to detailed earthquake information pages.

## Making the world go around

A feature that is becoming more common in virtual globe applications is the ability to record 'fly-throughs' and output them in a video format for later playback and distribution. The 'pre-recorded' nature of these animations has a number of attractive features:

- a visually compelling method to illustrate spatial data
- presentation of data in a choreographed way to communicate specific information or ideas
- movies can be embedded in presentations and combined with other content in longer movies
- easy distribution on the internet.

Geoscience Australia has developed high quality animation capabilities for its virtual globe application in a standalone tool that is maintained alongside the 3D Data Viewer. This tool (the 'Animator') bridges the gap between GIS/scientific visualisation tools and traditional 3D animation software. It has the same core functionality as the 3D Data Viewer (such as support for large geoscience datasets, data layering and global to local navigation) and adds features such as key framing, motion graphs and composition guides that are common in professional 3D animation tools. The agency has used this tool to produce high quality animations of geoscience data for use at conferences, in communications with the public and for its education program (figure 4). Examples of movie outputs are available from the multimedia section of the Geoscience Australia website.


**Figure 4.** A still taken from a recent animation produced with the 'Animator' tool. This animation featured high-resolution LiDAR digital surface model and 25 centimetre aerial photography.

## Conclusion

Virtual globes are powerful tools for communicating geoscience data to a varied and potentially non-technical audience. The increasing popularity of these tools ensures that many users are already familiar with this type of global interaction, enabling easy interaction with the data.

Geoscience Australia has developed a virtual globe application targeted for use with geoscience data. The 3D Data Viewer is being used to provide access to a growing number of the agency's national and regional datasets. It provides support for the display of a range of data, including subsurface data such as seismic and AEM survey data. Its companion tool, the Animator, provides support for creating high quality animated fly-throughs of geoscience data. These animations are used to communicate geoscience information in a variety of contexts. Development on both the 3D Data Viewer and Animator is ongoing, with the focus being on adding features to support the visualisation of geoscience data in all its forms.

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## For more information

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## Related articles/websites

World Wind 3D Data Viewer (Geoscience Australia website)

www.ga.gov.au/products-services/maps/interactive-3d-models/world-wind-3d-data-viewer.html

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in brief

## Early results from Northern Perth Basin seepage survey

A marine survey was recently completed by a team of scientists and technicians from Geoscience Australia who were searching for evidence of natural hydrocarbon seepage sites in the offshore northern Perth Basin. The survey, undertaken between 20 September and 18 October 2011 on the Australian Government's Marine National Facility, the RV *Southern Surveyor*, studied nearly 3500 square kilometres of the continental margin off Geraldton, Western Australia.

The first leg of the survey acquired 4000 line kilometres of multibeam bathymetry and sub-bottom profiler data plus 1500 line kilometres of sidescan sonar data. These data were used to map the morphology (or shape) of the seabed and the structure of the sub-surface sediments within 100 metres of the seabed. Researchers from CSIRO Petroleum and Geothermal Research in Perth, who joined Geoscience Australia staff during the first leg of the survey, deployed hydrocarbon sensing equipment capable of detecting oil in seawater.

The second leg was equipped with a remotely operated vehicle (ROV) supplied by research collaborators from the Royal Netherlands Institute for Sea Research and the University of Ghent in Belgium who also joined this leg of the survey. It is the first time this type of equipment has been deployed for such research purposes in Australian waters (figure 1). The ROV was deployed nine times within the study area, providing many hours of excellent underwater video footage from multiple camera angles. Nearly 100 sediment samples were also collected.

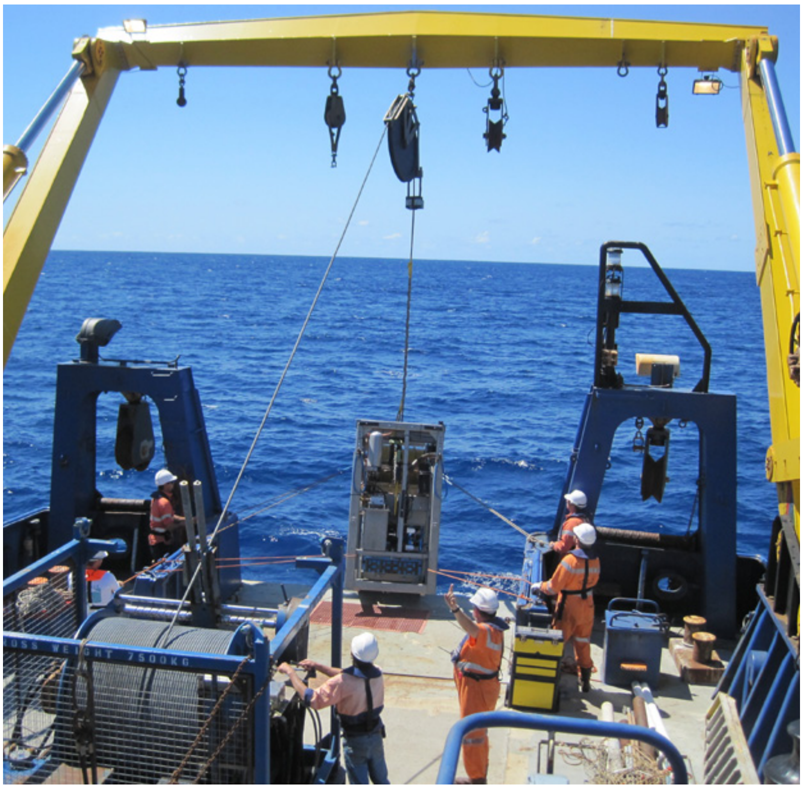

**Figure 1.** The remotely operated vehicle being deployed from the Australian Government's Marine National Facility the RV *Southern Surveyor* during the marine survey searching for evidence of natural hydrocarbon seepage sites in the offshore northern Perth Basin. The RV *Southern Surveyor* is owned and managed by CSIRO.

Acoustic data acquired in this region revealed pockmarks on the seabed and numerous 'flares' in the water column. Carbonate blocks and other interesting features were also observed in this area with the ROV. These acoustic and seabed features are located over a major fault system with evidence of recent tectonic movement, in a zone of palaeo-oil generation and migration.

These features in the northernmost part of the survey area, in approximately 500 metres water depth, are analogous with known hydrocarbon seepage sites in the Timor Sea. Sediment and biological samples from this area are currently being analysed, and further reports will be provided as results become available.

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### Related articles/websites

*AusGeo News* 103: Hydrocarbon potential of the offshore northern Perth Basin

www.ga.gov.au/ausgeonews/ausgeonews201109/hydrocarbon.jsp

*in brief*

## Field test on $CO_2$ storage capacity a world first

Geoscience Australia is a partner in the Collaborative Research Centre for Greenhouse Gas Technologies, (CO2CRC) and has recently made a significant contribution to a complex field test at their demonstration site in the Otway Basin, Victoria. It was the world's first test comparing five different approaches to assess the storage capacity of supercritical carbon dioxide ($CO_2$), also known as residual gas saturation, within a sandstone potential storage reservoir. Supercritical carbon dioxide behaves similarly to a fluid when injected. A comparison of test results and the overall performance of the different methods will guide industry in the development of common practice standards to assess residual gas saturation.

After injection of the $CO_2$ into a well some of the supercritical $CO_2$ becomes permanently trapped in capillaries between sand grains, a condition also known as residual trapping. The extent of this residual trapping is an important property which contributes to the total $CO_2$ storage capacity of a geologic reservoir. To date, only a few attempts have been made to quantify residual trapping within the demonstration storage reservoir.

Drilling of the 1565 metre deep CRC-2 well at the Otway Basin site was completed in March 2010. This was followed by the extensive downhole and surface installations to allow for: the injection and production of large quantities of fluids, the *in situ* measurement of reservoir properties, and the sampling of fluids under reservoir pressure. A test sequence detailing each operational step over a three-month period including engineering requirements, modelling of reservoir properties, staffing and risks was also developed.

### *Residual Gas Saturation Test*

The Residual Gas Saturation Test commenced in mid-June 2011 with an initial production of 510 tonnes of water over 15 days followed by a range of tests and operations including the injection of 150 tonnes of supercritical $CO_2$. The Residual Gas Saturation Test involved five independent tests:

1. A thermal conductivity test—heating and cooling cycles along the well casing are imposed and the derived thermal conductivity can be related to the residual gas saturation.
2. A hydraulic test—the pressure response during water injection and subsequent return to the baseline (when pumping ceases) are recorded and utilized to infer the amount of gas trapped in the formation. The residual gas changes the permeability of the pore spaces and the associated hydraulic pressure build-up during the injection phase.
3. A noble gas tracer test—the inert gases krypton and xenon plus water are injected into the formation where the residual $CO_2$ saturation had been artificially produced. During the latter state, these tracers partly diffuse into the supercritical $CO_2$ phase and remain locked in the reservoir. The difference in tracer concentrations in the back-produced water (or water pumped to the surface) before and after the supercritical $CO_2$ was formed can be used to estimate residual gas saturation.
4. An organic tracer test—dissolved organic compounds


**Figure 1.** The test team gather around the head of the injection well at the CO2CRC Otway Project during the dissolution test in September 2011.

plus water are injected into the formation. The organic tracers partially react with the supercritical $CO_2$ for 10 days forming daughter products. The concentration of these daughter products relates to the degree of residual gas saturation.

5. A dissolution test—water with a low $CO_2$ concentration is injected into the formation and this leads to the dissolution of supercritical $CO_2$ within the formation. The $CO_2$ concentration in the back-produced water increases over time and this increase can be measured and used to infer the initial residual gas saturation.

These tests were successfully completed by mid-September 2011. Geoscience Australia's contribution during the Residual Gas Saturation Test included:

- leading the field teams for the continuous noble gas (test 3)and dissolution tests (test 5)
- providing technical support staff for the continuous sampling and analysis on site
- building and deploying a field laboratory for the on-site analysis of gas and fluid composition
- providing training for field teams in all aspects of sample collection and analysis.

### For more information

**email** ausgeomail@ga.gov.au

### Related articles/websites

CRC for Greenhouse Gas Technologies (CO2CRC)
www.co2crc.com.au

## Protecting marine communities in eastern Antarctica

An international effort is currently underway to establish a representative system of marine protected areas (MPAs) in the Southern Ocean around Antarctica. These MPAs will contribute to the long-term conservation of marine biodiversity in the region. In eastern Antarctica, seven broad areas have been identified as potential MPAs based on characteristics such as biodiversity patterns, ecosystem processes, physical environmental features and human activities (figure 1). The boundaries of these broad regions will be refined or confirmed over the next 12 months as more detailed information becomes available.

Scientists from Geoscience Australia are collaborating with researchers from the Australian Antarctic Division to improve our understanding of the habitat characteristics within each of the regions. This includes providing information about the seafloor environments within and adjacent to each of the proposed MPAs based on new bathymetry compilations, an analysis of all available sediment data, and the interpretation of seismic sections. The new bathymetry grids, together with the seismic analysis, provide a much clearer picture of the seabed morphology and geology, and the sediment data help to delineate different substrate types. By identifying features such as submarine canyons, rocky substrate, seamounts and sediment drifts, we can build a better picture of the distribution of distinct benthic communities. This fundamental environmental information will also improve our understanding of the physical processes that shape the seabed environment and inform the development of representative marine protected areas.

The November 2011 meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) reached an historic agreement which means that specific MPA proposals will be considered by the Commission from 2012. This follows from their declaration of the first MPA, within the convention Area, south of the South Orkney Islands in 2009. Australia already manages two Southern Ocean MPAs around Heard and Macdonald Islands and Macquarie Island.

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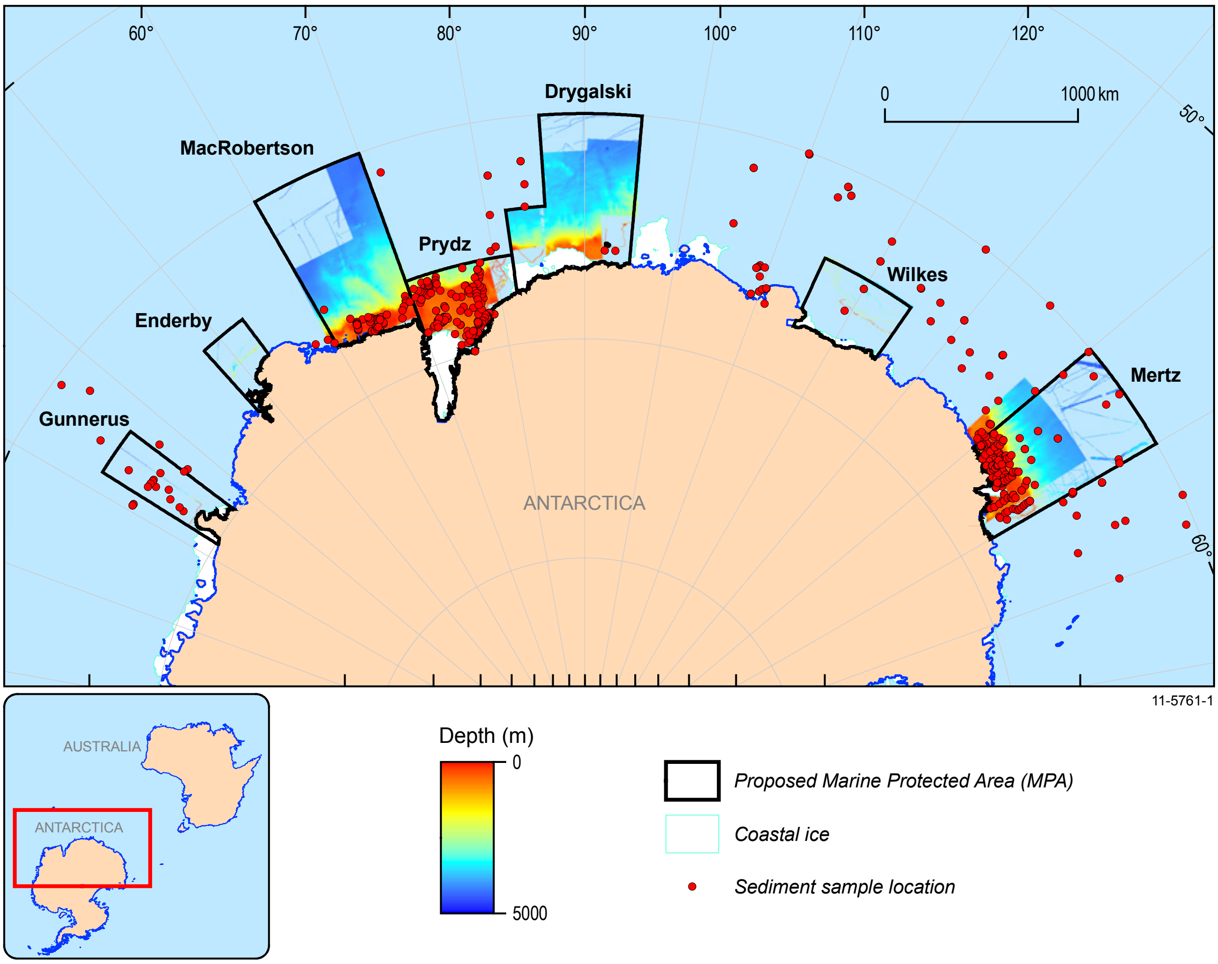


**Figure 1.** The seven regions identified as potential marine protected areas (MPAs) showing new bathymetry grids and the location of sediment samples within and adjacent to them.

### Related articles/websites

Geoscience Australia's Antarctic Geoscience Project
www.ga.gov.au/marine/projects/antarctic-geoscience.html

Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
www.ccamlr.org

## Bowen shaken after recent earthquakes

After what was a relatively stable year in 2010 (Glanville 2010) earthquake activity in Queensland substantially increased in 2011. There have generally been fewer major earthquakes in Queensland than in other parts of Australia such as New South Wales (Newcastle 1989), Northern Territory (Tennant Creek 1988), and Western Australia (Meckering 1968). Only 12 earthquakes with a magnitude greater than 5.0 have been recorded in Queensland between 1900 and 2010. One of the largest earthquakes, which occurred in 1913 near Ravenswood, was a magnitude 5.7 earthquake.

This all changed on Saturday 16 April when residents of central Queensland were shaken by a magnitude 5.3 earthquake at 3.31 pm in the afternoon. The epicentre was located 50 kilometres west of Bowen in a sparsely populated area south of Cape Upstart (figure 1). The shake shocked and surprised residents from Townsville, Ayr,

*in brief*

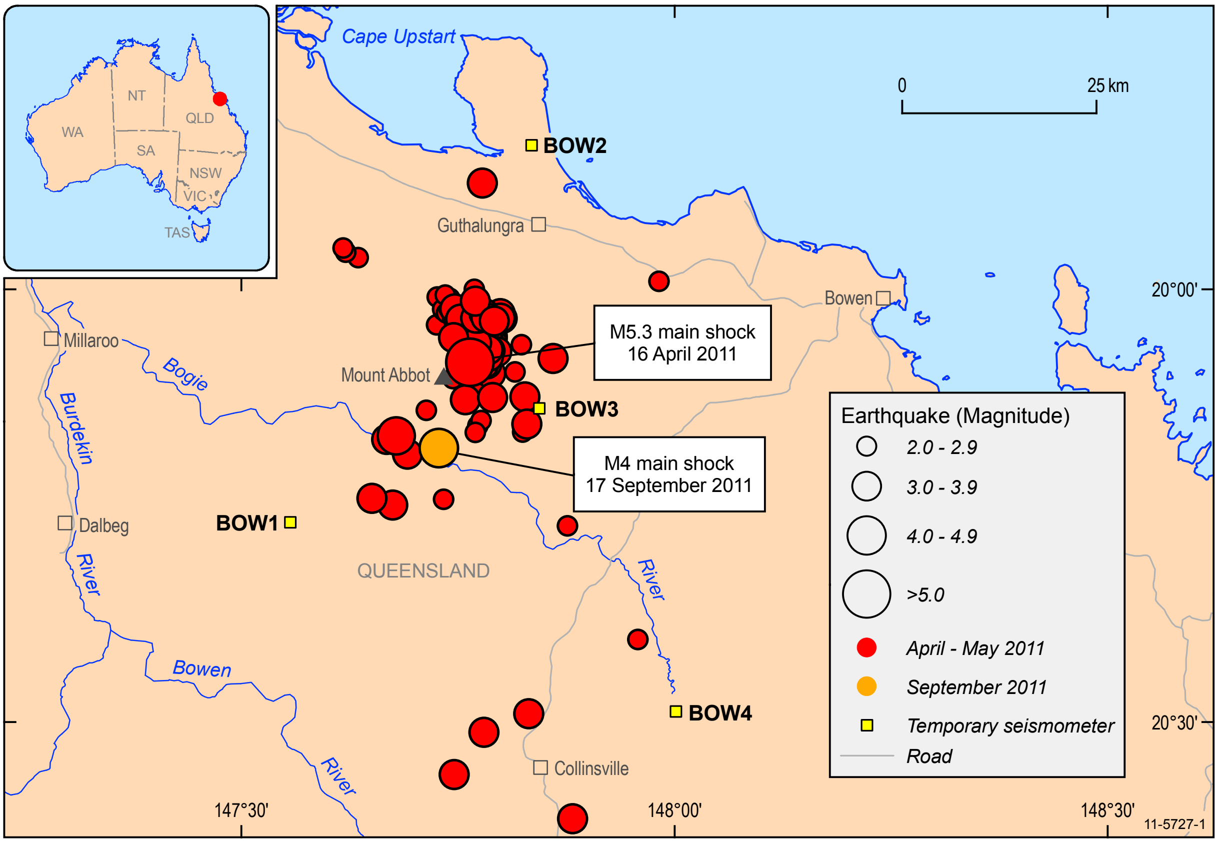


**Figure 1.** The April 2011 (magnitude 5.3) and September 2011 (magnitude 4.0) earthquakes both occurred near Mount Abbot, west of Bowen. This diagram also shows the location of aftershocks that followed the main shock on 16 April as recorded on temporary seismometers. These temporary recording sites (BOW1-BOW4) are shown in yellow.

Bowen, Airlie Beach, Mackay and Rockhampton, who reported the event to Geoscience Australia's Earthquake Hotline. More than 500 felt reports were submitted from residents of the central Queensland region.

The unexpected earth movement produced by the main shock was followed by several smaller aftershocks, and there was an immediate response by Geoscience Australia to record the aftershock activity. Scientific and technical staff quickly mobilised to install temporary seismometers in the Bowen region. Once in the area, staff travelled to the four pre-selected sites around the epicentre of the 16 April main shock. Local farmers allowed access to their land so that the equipment could be installed at suitable locations. The equipment consisted of a portable seismometer connected to a recording device which was recharged daily by a solar panel to ensure continuous operation. The recorders were left in place for a period of six weeks (between 19 April and 2 June) with a site maintenance trip to download data after three weeks of operation.

Aftershocks were recorded as soon as the equipment was installed. A review of the data revealed that multiple aftershocks occurred daily over the six weeks following the main shock with a gradual decrease in activity over time. Over 550 small aftershocks were recorded during this period, with the maximum number of aftershocks in a single day reaching 56 events on 21 April, soon after the recorders were installed. Following the earthquake activity in April and May, the same area was shaken by a magnitude 4.0 earthquake on 18 September at 2.28 am (figure 1).

Geoscience Australia seismologists will continue to monitor earth movements in the Bowen area through continuous earthquake monitoring carried out at the agency's headquarters in Canberra. The recent cluster of earth movements near Bowen resulted in many aftershocks, which is a typical sequence of events, as the continental crust readjusts after the initial release of

*in brief*

stress following the main shock. This activity, like earthquake activity across the continent, is related to the build up of stresses within the Australian tectonic plate as it moves northward.

### References

Glanville DH. 2010. Australian Seismological Report 2010. Geoscience Australia Record 2011/16. Available at: https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71806

### For more information

**email** ausgeomail@ga.gov.au

### Related articles/websites

Earthquake Basics (information on earthquakes):
www.ga.gov.au/hazards/earthquakes/earthquake-basics.html

Earthquakes@Geoscience Australia
If you have felt an earthquake, you can find earthquake information and fill in an online felt report at:
www.ga.gov.au/earthquakes/ or you can contact the Earthquake Hotline on 1800 655 739.

## Inventory system assists disaster research

Emergency managers, researchers and urban and environmental planners will have improved opportunities to investigate the after-effects of natural disasters more quickly following the development of a new information collection system. Known as the Rapid Inventory Collection System, the vehicle-mounted equipment and associated computer programs have been developed by Geoscience Australia as part of its Earth monitoring and hazards program. These programs evaluate the aftermath of earthquakes, floods, and cyclones.

The Rapid Inventory Collection System operates with up to four cameras mounted on a vehicle and connected to a user-friendly, consistent and intuitive computer-based interface. It uses open source software and displays the images obtained with relevant GPS data as well as incorporating a notepad for including comments.

**Figure 1.** The Rapid Inventory Collection System vehicle gathering data in north Queensland in the aftermath of Cyclone Yasi.

The equipment has been used to gather images in the aftermath of the Brisbane floods (January 2011) and tropical cyclone Yasi in Queensland (February–March 2011), the earthquakes in Kalgoorlie, Western Australia (April 2010) and Christchurch, New Zealand ( September 2010). The system has also captured imagery of the Darling River in New South Wales for ecological research.

Following a magnitude five event below the Kalgoorlie suburb of Boulder in 2010 scientists from Geoscience Australia, The University of Adelaide and The University of Melbourne used the Rapid Inventory Collection System to obtain 230 000 street view images and conducted a detailed assessment of the effects of the earthquake on more than 400 buildings of various ages.

That research revealed that older unreinforced masonry buildings were particularly vulnerable to the nature of the ground motion experienced during the event. While buildings

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of more contemporary cavity brick construction experienced less damage than older buildings they suffered greater damage than wooden-framed buildings of equivalent age.

The data obtained with the Rapid Inventory Collection System will help government planners to minimise risk of damage by developing a better understanding of the vulnerability and retrofit options for buildings and other infrastructure.

### *For more information*

**email** ausgeomail@ga.gov.au

### *Related articles/websites*

Geoscience Australia's Rapid Inventory Collection System (RICS)
www-approval.ga.gov.au/hazards/our-techniques/data-collection/data-acquisition/rapid-inventory-collection-system.html

The University of Adelaide
www.adelaide.edu.au

The University of Melbourne
www.unimelb.edu.au

## National Waste Management Sites Spatial Database

Geoscience Australia's new National Waste Management Sites Spatial Database contains basic location information for approximately 1700 waste management facilities across the Australian continent and external territories. This data coordination and capture has been a cooperative effort involving all state and territory governments, local councils, Australian Government departments and agencies and industry bodies.

The database has been developed as an authoritative geographic information source on landfill sites, waste reprocessing facilities and waste transfer stations. Data sources used to identify and verify waste management sites included Geoscience Australia's satellite imagery and information from a number of waste-related industry and government databases as well as consultation with state and local government agencies which provided the source information.


**Figure 1.** Sample output from the new National Waste Management Sites Spatial Database showing landfill sites, waste reprocessing facilities and waste transfer stations in the area around Hobart, Tasmania.

A unique site identification number links the Database to data maintained by state and local government agencies and industry bodies. This enables Geoscience Australia to both maintain the database and provide the other agencies with a link to cross-reference and access waste facility information through Geoscience Australia's database.

This 'first of a kind' public database is a valuable national asset that will have significant importance for Australia's waste management industries, community interest groups and all levels of government (figure 1). Clients of the agency, including Australian Government agencies and industry bodies, are already using the database to assist in evidence-based scientific studies as well as inform government policy development and decision-making. Current applications include:

*in brief*

- Spatially verifying waste management information underpinning departmental publications on *National Waste Policy* and *Australian Waste Classifications* for the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC)
- Undertaking assessments on the proximity of waste and recycling facilities to communities. These assessments will potentially guide policy decisions on the expected influx of analogue television sets and radios into the waste cycle as Australia moves to digital broadcasting
- Assisting the assessment and analysis of emissions from solid waste disposal sites in Australia's National Greenhouse Accounts, as part of Australia's reporting obligations under the United Nations Convention on Climate Change and Kyoto Protocol
- Informing government policy decisions regarding the centralisation of waste sites (landfills to waste transfer stations)
- Assisting with the identification and management of hazardous waste sites
- Spatially analysing results for future Australian Bureau of Statistics Environmental-Economic Account reports (Waste Account)
- Improving the assessment of waste catchment areas
- Spatially assessing facility longevity
- Assisting studies of sites that may be suitable for methane power generation.

Geoscience Australia is currently in the final phase of completing the second release of the National Waste Management Sites spatial database. Scheduled for release in mid-December 2011, the updated version will include updated site information, improved spatial location accuracy for sites previously assigned a low spatial accuracy confidence, and an additional 300 facilities identified following stakeholder consultation. Future updates will be available through Geoscience Australia's website.

## *For more information*

**email** ausgeomail@ga.gov.au

## *Related articles/websites*

National Waste Management Database
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=72592

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# Major new interpretation report on the Pine Creek airborne electromagnetic survey, Northern Territory

Geoscience Australia has recently released a comprehensive interpretation report on the Pine Creek airborne electromagnetic (AEM) survey which, combined with the survey data, is expected to provide a major boost to the efforts of explorers in this highly prospective mineral province. The survey was part of Geoscience Australia's Onshore Energy Security Program (OESP) and was the agency's second major electromagnetic survey. It was designed to deliver reliable, pre-competitive AEM data to promote exploration for uranium, copper-gold, base metals, tin and nickel in both brownfield and greenfield regions. The area covered hosts several major uranium deposits, including the Ranger Uranium Mine, Rum Jungle and Nabarlek.

The report demonstrates that the Pine Creek Province is prospective for unconformity-related uranium deposits, particularly where the Kombolgie Sandstone (latest Paleoproterozoic) of the McArthur Basin unconformably overlies early Paleoproterozoic metasediments of the Pine Creek Orogen. There is also potential for sandstone-hosted and Westmoreland-type deposits associated with mafic rocks (such as Oenpelli Dolerite) within the sandstone south of Rum Jungle, and further to the southeast lies an area with potential for buried Cenozoic paleochannel-hosted uranium deposits.

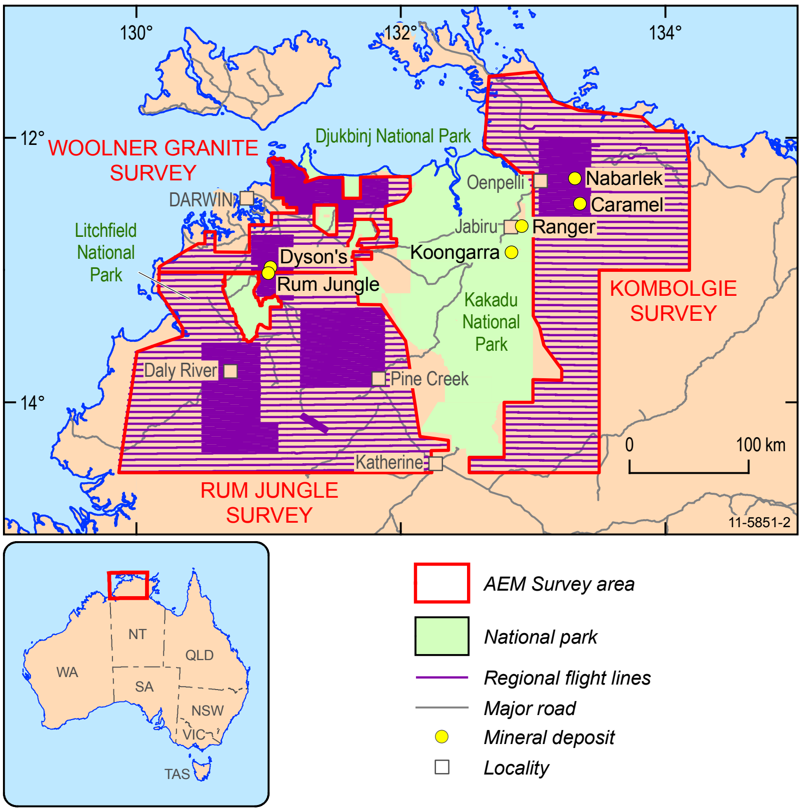


**Figure 1.** Pine Creek Survey boundary locations.

The survey was flown over the Pine Creek Orogen and parts of the McArthur Basin, Victoria River Basin and Daly Basin in the Northern Territory between August 2008 and May 2009. The survey collected 29 900 line-kilometres of new data at various line spacings (555 m, 1666 m and 5000 m) over an area of approximately 74 000 square kilometres. The survey area, shown in figure 1, covers three main areas: Kombolgie (east of Kakadu National Park), Woolner Granite (near Darwin), and Rum Jungle (west of Kakadu National Park). The Woolner Granite and Rum Jungle survey areas were flown by Fugro Airborne Surveys using the TEMPEST™ AEM system. The Kombolgie survey area was flown by Geotech Airborne using the VTEM™ AEM system.

Interpretation of AEM data for the Pine Creek region demonstrates that AEM data can be used to successfully map critical elements of highly prospective unconformity-related uranium systems. The report includes supporting diagrams and images to illustrate this. The critical elements include the:

- unconformity at the base of the Katherine River and Tolmer groups
- thickness of the Katherine River and Tolmer groups above the unconformity

- the metasedimentary rocks below the unconformity (especially rocks containing reductants)
- faults in the metasedimentary rocks.

The interpretation of these data has demonstrated that a regional-scale AEM survey in combination with drill-hole data can help to create a 3D model of basin architecture. The report includes examples from the Daly and Birrindudu basins in the Pine Creek area (figure 2). This architecture can provide information on the direction of fluid flow during diagenesis of basin sediments, thereby defining areas prospective for unconformity-related uranium systems.

AEM provides a unique dataset which gives depth information

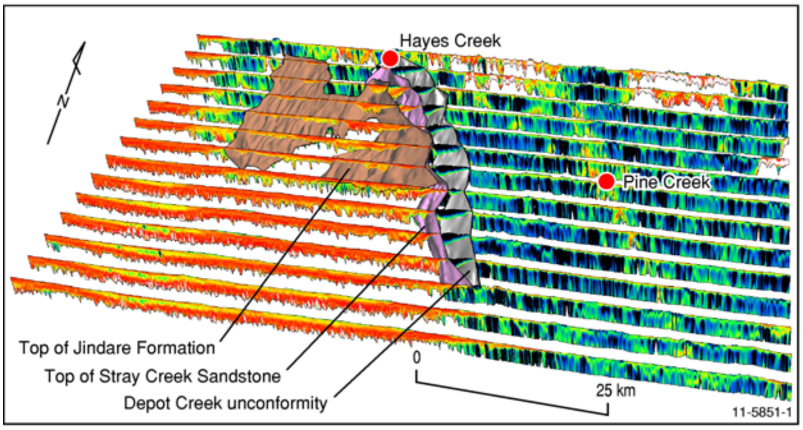


**Figure 2.** Conductivity-depth sections of the Pine Creek area in 3D plus a 3D model of part of the Daly and Birrindudu basins.

about geological features in the shallow crust at a regional scale. The Pine Creek regional AEM data are very useful in assisting mineral exploration (including uranium) in the top few hundred metres below the surface. The survey also indicates areas where exploration companies would gain maximum benefit from more detailed airborne and ground surveys.

The report includes tables, diagrams and a large number of high-resolution images which highlight methodologies developed to reveal the maximum amount of geological information from the AEM data. The report has been issued as Geoscience Australia Record 2011/18 (GeoCat # 71854). A pdf version is now available for download through the Airborne Electromagnetics Project page on Geoscience Australia's website.

### For more information

**email** ausgeomail@ga.gov.au

### Related articles/websites

Geological and energy implications of the Pine Creek region airborne electromagnetic (AEM) survey, Northern Territory, Australia (Geoscience Australia Record 2011/18)

https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71854

Geoscience Australia's Airborne Electromagnetics Project downloadable data

www.ga.gov.au/energy/projects/airborne-electromagnetics.html

*AusGeo News* 101: Onshore Energy Security Program update

www.ga.gov.au/ausgeonews/ausgeonews201103/onshore.jsp

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product news

## New maps define offshore jurisdiction

Oceanographers, scientific researchers, resource exploration companies, tourism operators and the public will now have a greater understanding of Australia's maritime jurisdiction following the recent release of 28 digital (PDF) maps of Australia's maritime jurisdiction by Geoscience Australia.

The maps detail the jurisdictional zones around the Australian mainland and those of Australia's remote offshore territories, including the Australian Antarctic Territory, Ashmore and Cartier Islands, Christmas Island, Cocos (Keeling) Islands, Coral Sea Islands, Heard and McDonald Islands and Norfolk Island (figure 1).

**Figure 1.** One of the wall maps showing Australia's maritime jurisdiction.

They also include the internal waters of Australia, the territorial sea, the contiguous zone, the Exclusive Economic Zone and the continental shelf which was confirmed in April 2008 by the United Nations Commission on the Limits of the Continental Shelf.

When launching the maps, the Minister for Resources, Energy and Tourism, the Hon. Martin Ferguson, AM MP, pointed out that in addition to providing details on Australia's maritime jurisdiction the maps show significant features such as bathymetry and reefs. This feature will be particularly beneficial for tourism operators in areas such as Queensland's Great Barrier Reef and Ningaloo Reef off Western Australia.

The series of maps, which was developed in consultation with the Attorney-General's Department and the Department of Foreign Affairs and Trade, can be downloaded from Geoscience Australia's website.

### *For more information*

**email** ausgeomail@ga.gov.au

### *Related articles/websites*

Australia's marine jurisdiction map series (Geoscience Australia webpage)
www.ga.gov.au/marine/jurisdiction/map-series.html

*AusGeo News 93*: Setting Australia's limits
www.ga.gov.au/ausgeonews/ausgeonews200903/limits.jsp

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## Update on 34th International Geological Congress—AUSTRALIA 2012

Australia will be hosting the 34th International Geological Congress (IGC) at the Brisbane Convention and Exhibition Centre, between 5 and 10 August 2012, on behalf of the Oceania region. The IGC, which is held every four years and attracts thousands of delegates from over a hundred countries is, the pre-eminent global geoscience event.

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

The scientific sponsor is the International Union of Geological Sciences and Vale, the world's second largest mining company, is a major sponsor. The Australian Agency for International Development (AusAID) and Events Queensland will also be providing support.

### *Third Circular now available*

The Third Circular includes:

- Early Bird Registration Fee offer and detailed fee structure for the Congress
- a renewed call for abstracts, which should be submitted via the on-line system
- details of the Plenary 'hot topics' and speakers
- a list of Symposia and Keynote Speakers.

The Plenary sessions are:

- The Earth and Man: Living with a Restless Earth
- What does the geological record tell us about past climates in relation to projected climate change?
- Energy in a carbon-constrained world
- Resourcing Tomorrow: meeting the needs of a growing population
- Digital Earth—The information explosion.

Plenary Speakers confirmed to date include: Professor Iain Stewart (the BBC's *How Earth Made Us* series), former Shell chairman Lord Ron Oxburgh and Vale's Executive Director for Exploration, Energy and Projects Management, Eduardo Ledsham.

The Congress represents a once-in-a generation opportunity to showcase Australia's geosciences and to network with high profile international geoscientists. Interest from overseas is strong. There will be delegations from China and Russia and they will be presenting the results of their recent cooperative deep geophysical probing transects in central and eastern Asia. They were undertaken to provide new insights into the resource potential of this large under-explored region.

### *Congress program*

The 34th IGC will feature a wide-ranging scientific program under the overall theme 'Unearthing our Past and Future—Resourcing Tomorrow' which recognises the crucial contributions of the geosciences in meeting societal needs and sustaining planet Earth. Consistent with Australia's resource-based economy, roughly 40 percent of the scientific program will be of direct interest to the resources and energy sectors. Consequently each day's program will include several symposia on minerals, petroleum and energy.

Other features include field trips across Australia and the region, a large GeoExpo featuring commercial, government and academic exhibitors (over 40 percent of the premium booths have already been sold), training and professional development workshops, and an education and outreach program.

The 34th IGC is being organised by the Australian Geoscience Council (AGC) the peak body for Australia's major professional and learned societies. These societies are all investing in the IGC which will take the place of a number of their regular meetings in 2012.

### *Congress registration*

Readers are urged to review the Third Circular and take advantage of the 'Early Bird' Registration offer. Readers who wish to register for the Congress or wish to receive regular updates by email can do so through the Congress website.

### *For more information*

**visit** www.34igc.org
**email** ausgeomail@ga.gov.au

## Geoscience Australia continues to 'wow' its visitors

Raising awareness of the geosciences and their benefits for the community is a key priority for Geoscience Australia. Through activities and programs generated by the Events and Education Team, the agency is working toward raising awareness and opening people's minds to the world of Earth science by providing them with an unforgettable experience when they visit Geoscience Australia and its Education Centre.

These events, programs and activities help to showcase the amazing work the agency undertakes. The aim of these activities and programs is to create the interest that is needed to encourage a new generation of Australians to understand the Earth sciences and become involved in geoscience. This year's activities focused around two main events; National Science Week (13 to 21 August) and Earth Science Week (9 to 15 October).

### *National Science Week and Open Day 2011*

Geoscience Australia celebrated National Science Week 2011 by holding its annual Open Day on the final day of National Science Week. The agency also participated in other National Science Week activities in the Australian Capital Territory including the Science Trail, The Great Canberra Science Scramble and hosting our own virtual dinosaur (figure 1).

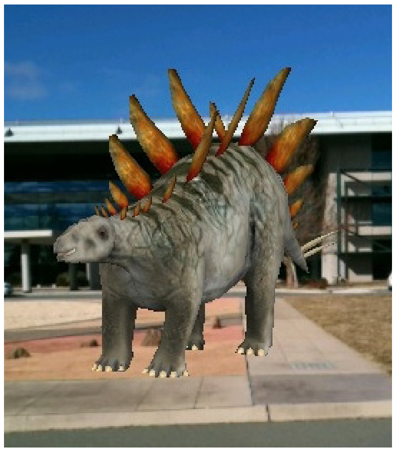

**Figure 1.** The virtual dinosaur hosted by Geoscience Australia as part of National Science Week.

The 2011 Open Day has been quoted as being our 'best ever' as well as setting a new record with over 3500 visitors during the day. Visitors included the Minister for Resources, Energy and Tourism, the Hon Martin Ferguson AM MP, who acknowledged that Open Day provided a great opportunity for the wider community to gain a better insight into the important work of Geoscience Australia.

The most popular activity for children (and adults) was the gold panning and sapphire sieving (figure 2) followed by the erupting model volcanoes, pet rock making, the Antarctic experience, rock identification and the 3-D Earth presentation. Tours of the SHRIMP (which provides data on the age of Australian rocks), the Joint Australian Tsunami Warning Centre, the laboratories and the Geological Timewalk also proved to be very popular on the day with additional tours being scheduled.

This year's Open Day not only set a record for visitors but also for the number of staff volunteers. The success of Open Day would not have been possible without the efforts and contribution of these Geoscience Australia staff.

**Figure 2.** The sapphire sieving demonstration proved popular with visitors to Open Day.

### *Earth Science Week 2011*

Earth Science Week 2011 was held between 9 and 15 October. This year's activities revolved around the *Geologi* Short Film Competition, the Top Geoshot Photographic Competition and a special Foyer display highlighting Geoscience Australia's research in Antarctica and commemorating 100 years since Mawson's expedition to Antarctica. To mark the launch of the anniversary celebrations, renowned Mawson historian Alasdair McGregor presented a public seminar on Douglas Mawson and the Australasian Antarctic Expedition 1911–14.

This year's Earth Science Week was officially launched by the Minister for Resources, Energy and Tourism, the Hon Martin Ferguson AM MP, at a presentation for the winners of the 2011 *Geologi* Short Film Competition in Canberra.

This year's *Geologi* Competition was themed around 'Geology and you' highlighting the role Earth sciences play in our everyday lives. Entries were received from Western Australia, Tasmania, New South Wales, Queensland and the ACT. The winner for the Junior Division (Year 7-10) was *Red Dirt* by St Joseph's Regional College, Port Macquarie NSW, who also wrote some catchy lyrics to accompany their brief geological history of Port Macquarie (figure 3). The Primary Division winner was *Wynyard: Created from Chaos* by Table Cape Primary School, Table Cape, Tasmania, a previous winner of the competition.

The Top Geoshots Photographic Competition received over 180 entries from all over Australia plus one from St Louis in the United States. The Overall Winner, a 'People's Choice' winner plus 10 additional winning entries will feature in a 2012 desktop calendar. All the entries received for this year's competition are on display in the Foyer of Geoscience Australia's building.

Geoscience Australia's Foyer also includes a display to acknowledge the 100th anniversary of the commencement of Mawson's expedition to Antarctica and the research the agency conducts in the region. The South Australian Museum kindly loaned some artefacts for this display, including clothing and a replica half sledge used by Tim Jarvis in 2007 in his re-enactment of Mawson's journey. The Earth monitoring and geoscience research that Geoscience Australia undertakes in Antarctica contributes toward a greater understanding of the region and its relationship to the world around us.

### *The Education Centre*

The Education Centre is increasingly popular as an excursion venue and has hosted more than 60 000 visitors since it opened in 1999. This year saw a record number of visitors (over 8000) to the Centre, an increase of at least 22 per cent from the previous busiest year (2009).

The Centre is staffed by trained educators, science communicators and geologists and offers structured hands-on activities with a science and


**Figure 3.** Bryden Sloan-Harris and Samantha Bayly, representing St Joseph's Regional College at Port Macquarie, received the Junior Division *Geologi* Award from the Minister for Resources, Energy and Tourism, the Hon Martin Ferguson AM MP (right), and Dr Chris Pigram, CEO of Geoscience Australia on 11 October.

geography curriculum focus for visiting school groups and special interest groups.

This year the Centre has hosted a number of special programs including the National Youth Science Forum, a Teachers Summer School, a Teacher Earth Science Education Program (TESEP) workshop, an Australian Catholic University Pre-service Teacher visit, U3A Group from Sydney University (environmental applications of GIS) and The Science Experience (ACT)—Year 9/10 special activities visit as well as hosting several international visitors.

Feedback to date has been extremely positive and often teachers comment that they had not been to Geoscience Australia before but will certainly ensure that the Centre is included on their itinerary for future visits. The Centre is continually looking for new ways to present programs and recently acquired a SMART Board which will allow the use of new technologies and greater interaction during school visits.

The Education Centre also hosted its first Geoscience Australia Graduate Program participant in 2011. Tegan Kelly spent four weeks assisting the Education Centre with school visits and creating a new booklet that highlights the significant rock and fossil specimens around the Geological Timewalk in the grounds of Geoscience Australia.

### *Classroom Resources*

This year the Program commenced the review and updating of the series of Teacher Education Resource Booklets. These booklets are a valuable teaching resource and will be aligned to suit the new national science curriculum and the draft geography curriculum. Current topics include Tsunami, Earthquakes, Volcanoes, Landslides and the Australian Coast. All of these booklets will soon be freely available to download from the Education website.

### *Future directions*

There is wide recognition of the need to develop a culture where the sciences are recognised as relevant to everyday life. Consequently, governments, business, academia and public institutions need to work together with science organisations and agencies to provide a coherent approach to communicating science and its benefits.

Geoscience Australia is contributing to Australian Government initiatives, such as Inspiring Australia, and closely working with other science organisations, such as Questacon and CSIRO Discovery. Geoscience Australia is working to ensure that its education programs and resources reach the widest possible audience.

### *For more information*

**email** ausgeomail@ga.gov.au

# events calendar

| NAPE Expo 2012 | 22 to 24 February 2012 |
|---|---|
| American Association of Professional Landmen<br>GBR Convention Center, Houston, Texas, USA<br>Contact: NAPE, 4100 Fossil Creek Boulevard, Fort Worth, Texas 76137 USA | p +1 817 306 7171<br>f +1 817 847 7703<br>e info@napeexpo.com<br>www.napeexpo.com |
| **22nd International Geophysical Conference and Exhibition** | **26 to 29 February 2012** |
| Australian Society of Exploration Geophysicists<br>Brisbane Convention & Exhibition Centre, Brisbane, Queensland<br>Contact: arinex pty limited, Level 5, 79 Adelaide Street Brisbane, QLD 4000 | p +61 7 3226 2800<br>f +61 2 9267 5443<br>e aseg2012@arinex.com.au<br>www.aseg2012.com.au/ |
| **PDAC 2012 International Convention, Trade Show and Investors Exchange** | **4 to 7 March 2012** |
| Prospectors and Developers Association of Canada<br>Metro Toronto Convention Centre, Toronto, Canada<br>Contact: PDAC, 135 King Street East, Toronto, Ontario M5C IG6 | p +1 416 362 1969<br>f +1 416 362 0101<br>e info@pdac.ca<br>www.pdac.ca/ |
| **Tasman Frontier Petroleum Industry Workshop and Data Release** | **8 and 9 March 2012** |
| Geoscience Australia, GNS Science (New Zealand) and Geological Survey of New Caledonia<br>Geoscience Australia, Canberra, ACT<br>Contact: Riko Hashimoto, Geoscience Australia, GPO Box 378, Canberra ACT 2601 | p +61 2 6249 9141<br>e riko.hashimoto@ga.gov.au<br>www.ga.gov.au/energy/projects/eastern-frontiers.html |
| **AGES—Annual Geoscience Exploration Seminar** | **26 to 28 March 2012** |
| Northern Territory Geological Survey<br>Alice Springs Convention Centre<br>Contact: Northern Territory Geological Survey, GPO Box 3000, Darwin NT 0800 | p +61 8 8999 5313<br>f +61 8 8999 6824<br>e ages@nt.gov.au<br>www.nt.gov.au/d/Minerals_Energy/Geoscience/ |
| **Disaster and Emergency Management Conference** | **16 to 18 April 2012** |
| Brisbane Convention & Exhibition Centre, Brisbane, Queensland<br>Contact: Tracey Toovey, Association Secretariat, Australian & New Zealand Disaster and Emergency Management Conference | p +61 7 5502 2068<br>e conference@anzdmc.com.au<br>www.anzdmc.com.au<br>http://bit.ly/oExEnZ |

***For more information*** on Geoscience Australia's involvement in the above events email: ausgeomail@ga.gov.au

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