September 2003 ISSUE No. 71

AUSGEO *news*

Major feat

topo map revision

Spatial aspects of *geoscience* work

PP 255003/00048

Also: Cool work in Antarctica, nature's course tracked, minerals atlas live...

AUSGEO News
September 2003 Issue no. 71

Editor Julie Wissmann

Graphic Designer Katharine Hagan

This publication is issued free of charge. It is published four times a year by Geoscience Australia.

ISSN 1035-9338

Printed in Canberra by
National Capital Printing

Geoscience Australia
GPO Box 378
Canberra ACT 2601 Australia

cnr Jerrabomberra Ave & Hindmarsh Dr
Symonston ACT 2609 Australia

Internet: www.ga.gov.au

Chief Executive Officer
Dr Neil Williams

Subscriptions

Phone +61 2 6249 9249
Fax +61 2 6249 9926
www.ga.gov.au/about/corporate/ausgeo_news.jsp

Sales Centre

Phone +61 2 6249 9519
Fax +61 2 6249 9982
E-mail sales@ga.gov.au

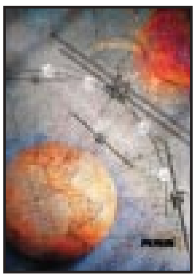
GPO Box 378
Canberra ACT 2601 Australia

Editorial enquiries

Julie Wissmann
Phone +61 2 6249 9249
Fax +61 2 6249 9926
E-mail julie.wissmann@ga.gov.au

***AusGeo News* is available on the web at www.ga.gov.au/about/corporate/ausgeo_news.jsp**

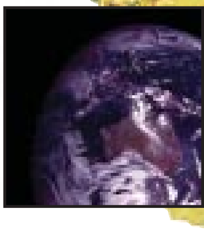
CONTENTS



For centuries man has looked to the stars to find his place in the universe. But in 1973 Australia turned to the Earth's artificial satellites for some answers and built its first Satellite Laser Ranging station. These stations and artificial satellites are critical to modern navigation systems and mapping, and for determining Earth's orientation.

Photo: © Australian Picture Library






This month, Geoscience Australia celebrates a major achievement in mapping Australia.

The 1:250 000 scale topographic maps and data (branded NATMAP and GEODATA) that were previously maintained as 513 separate maps are now held as a single 'continuous' mapping database.

The creation of this database is a huge step forward for map users around the country, and I would like to thank our defence and state/territory government partners, as well as our colleagues in private industry for helping us achieve this important milestone.

Another noteworthy event in Canberra this month is the inaugural Spatial Sciences Conference.

Readers may recall the announcement of the formation of the Spatial Sciences Institute in a recent issue of *AusGeo News*. This landmark decision creates a single umbrella organisation representing the interests of members of five professional associations.

The Institute's first conference promises to be a good one and Geoscience Australia will be involved in presentations and the technical exhibition.

On another positive note, Geoscience Australia is a partner in the new Cooperative Research Centre for Spatial Information.

The Australian Government has committed $13.3 million to establish the CRC-SI, demonstrating its clear and strong support for the spatial information industry.

The Government recognises that the industry is a vital link for decision making on a wide range of key economic, environmental and social issues.

The purpose of Cooperative Research Centres is to strengthen collaboration among industry, research organisations, educational institutions and government agencies to achieve practical outcomes of national economic and social significance.

The CRC-SI will have five core research programs:

1. Integrated positioning and mapping systems;
2. Metric imagery as a spatial information source;
3. Spatial information system design and spatial data infrastructures;
4. Earth observation for renewable natural resource management; and
5. Modelling and visualisation for spatial decision support.

Geoscience Australia's involvement will include research into GNSS networks, automated feature extraction from imagery, near real-time distribution of satellite data, and advanced visualisation techniques.

Geoscience Australia is teaming up with the Defence Imagery and Geospatial Organisation (DIGO) to form one Commonwealth core participant in the CRC-SI.

Computer-based visualisation of spatial data is an integral part of mineral and petroleum resource assessments in Geoscience Australia.

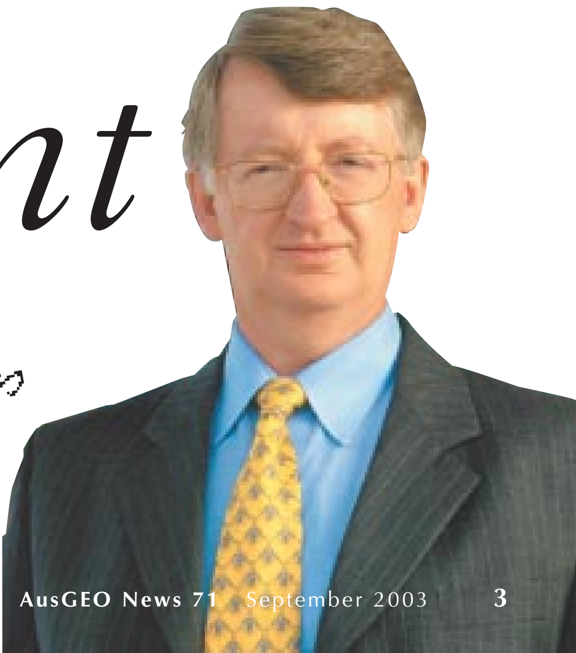
Three weeks ago we set up a 3D theatre for staff to view and analyse crustal models in true three-dimensional space. Already the pmd*CRC project team is reinterpreting complex relationships in their preliminary 3D model after time in the theatre.

Our theatre was a big hit with the public at our Open Day on August 24, where a few hundred people donned special glasses to view 3D models of Tasmania, and the Earth and its earthquake zones, as well as a 2.5D fly-through movie with surround sound.

These innovative, virtual-reality technologies are likely to be used far more in the future to deliver spatial data to you, our clients.

Enjoy reading our September issue of *AusGeo News* which, I'm sure you will understand why, focuses on some of our very important spatial information work.

Comment



NEIL WILLIAMS
CEO Geoscience Australia

Mount Stromlo *aims high* again

The $6 million Mount Stromlo Satellite Laser Ranging station razed by bushfires on January 18 is rising out of the ashes and will begin operating again early in 2004.

In July, Electro Optic Systems was contracted by the Australian Government to rebuild the SLR station, which was one of the world's best satellite tracking stations.

Because it is a new system, it will be more technically advanced.

Many SLR stations use a visible laser in conjunction with an aircraft detection system. A less powerful laser is shot into the sky along with the satellite laser. It 'senses' aircraft in the large laser's path and immediately shuts down the system until the way is clear.

Australia has a spotless record in its 30-year history of using SLR.

The laser proposed for Mount Stromlo's new system will be invisible to humans because it will use a different wave length. When the system is proven, it will be a world first.

Only a rapidly rotating dome on the observatory roof will tell passers-by that the satellite laser is busy.

Mount Stromlo will observe a minimum of 400 satellite passes a month when it starts up again.

SLR consists of a powerful laser, a telescope that is about a metre in diameter, and a very accurate timing system based on an atomic clock. The process for firing the system and recording data is automated, but the end products used by the International Laser Ranging Service and the International Earth Rotation Service require Geoscience Australia's technical and scientific expertise.

Mt Stromlo SLR is being rebuilt under insurance. EOS, a Queanbeyan based company, built the original facility and makes most of this sort of equipment for the world.

Light shed on *spatial* questions

For centuries man has looked to the stars to find his place in the universe. But in 1973 Australia turned to the Earth's artificial satellites for some answers.

Thirty years ago it built a powerful laser and large telescope near Canberra to bounce laser light off passing satellites so that it could measure their precise position at a particular time and check the coordinates on Earth.

This technique is called Satellite Laser Ranging (SLR). There are only six SLR stations in the Southern Hemisphere and Australia has two of them (see figure). Geoscience Australia manages both stations.

The stations are critical to modern navigation systems and mapping, and for determining Earth's orientation.

Australian stations

The first Australian SLR station was set up at Orroral, south of Canberra in 1973. It was replaced in 1998 by a more modern facility at Mount Stromlo to the west of Canberra.

Mount Stromlo was one of the world's top 10 SLR stations until bushfires destroyed it on January 18 this year.

Until it is re-built, Australia's other SLR station at Yarragadee in Western Australia is very important (see figure).

The National Aeronautical and Space Administration (NASA) established Yarragadee in 1979. Its observations—sometimes up to 1000 satellite passes a month—make it the world's best SLR station.

Satellite locations

Artificial satellites orbit Earth at altitudes that vary from a few hundred kilometres to 20 thousand kilometres. SLR can accurately determine the orbits of those with special reflectors (retro-reflectors).

Short pulses of laser light are fired at retro-reflectors on passing satellites and the light bounces back in the direction from which it came.

Measurements of the satellite's location are based on the speed of light, and the time taken for the light to travel from the SLR station to the satellite and back. The elapsed time can be calculated with an accuracy of picoseconds (10^{-12}) and the distance with a precision of a few millimetres.

SLR stations around the world take these measurements as the satellite traverses the sky (see figure). There are more than 40 stations, and their priorities about which satellite to fire at and when are coordinated through the International Laser Ranging Service.

Position error

Earth is a dynamic planet. It rotates, providing night and day, and its axis of rotation gradually changes. As well, Earth's surface comprises many tectonic plates that move slowly and relative to each other.

Star observations were used for many years to determine positions on Earth, the motion of the poles, and Earth's rotation. But celestial positioning is only accurate to a few hundred metres.

Geodetic techniques (SLR, GPS and a radio telescope technique called Very Long Baseline Interferometry) can measure tectonic motion. For Australia this is about seven centimetres a year in a north-easterly direction.

The coordinate systems traditionally used for mapping and all other positioning ignored this movement and were true only for a particular instant in time.

SLR was included in the design of satellites such as LAGEOS (LAser GEOdynamics) to accurately measure plate tectonic movement, polar motion and Earth's orientation.

This type of satellite technology contributes to a global coordinate system (the International Terrestrial Reference Frame) allowing positions anywhere in the world to be located to within a few centimetres.

Navigation satellites

Because of satellite navigation, harvesters and tractors can move between rows of crops and down identical wheel ruts to ensure minimal crop damage. Airborne crop dusters can fertilise fields without contaminating waterways and adjacent land.

As well, the response systems used in taxis and trucks, the navigation of ships and aircraft, and the precise location of evacuation routes and people in emergencies such as floods and fires, all depend on satellite positioning systems.

Two GPS satellites (USA's global positioning system) have retro-reflectors so that SLR can check their orbits. Satellites in the Russian positioning system (GLONASS) also have them, and they are likely to be included in a planned navigation system called GALILEO.

Environment role

Earth-sensing satellites such as ENVISAT and ICESAT acquire data about vegetation, ice volumes and sea level to monitor environmental changes. But these satellites tend to be large and irregular in shape and may be subject to unpredictable forces. SLR is important for monitoring their orbits.

Many also have altimeters (determine the height of the satellite above Earth) to measure changes in the ocean surface.

SLR is currently the most accurate method to measure altimeter height. This calibration is essential for measuring global sea-level and ice-volume changes.

Global importance

Australia is important to global SLR because of its expertise and location. Its service to science and spatial activities is expected to continue for many years, as there is no apparent replacement for the SLR technique.

All SLR data are free via the internet to global analysis centres and researchers, including Geoscience Australia's Space Geodesy Analysis Centre in Canberra.

With this data, geodesists contribute to the reference frame for coordinates around the world and determine the Earth's changing orientation and its geocentre. This information is used to calculate the orbits of satellites needed in many scientific and commercial applications.

For more information phone Jim Steed on + 61 2 6249 9061 or e-mail jim.steed@ga.gov.au

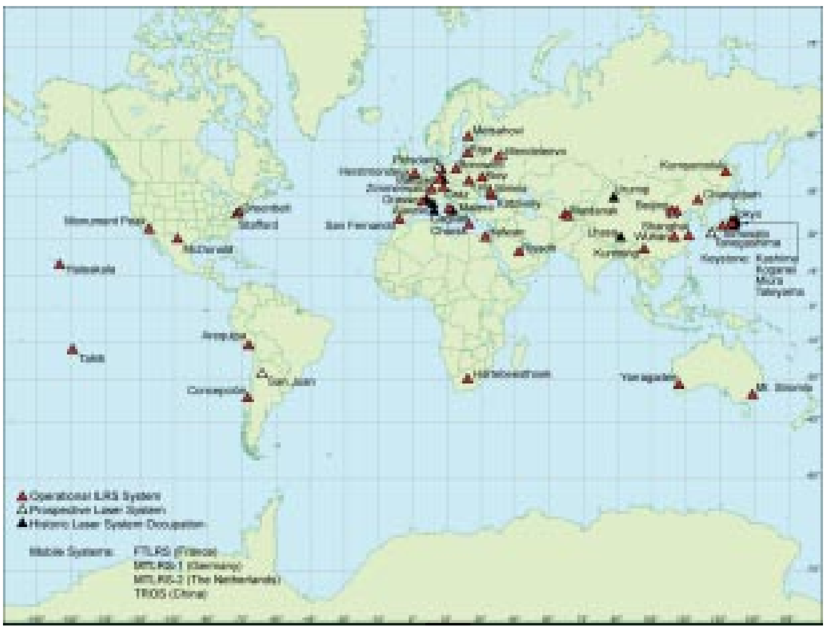
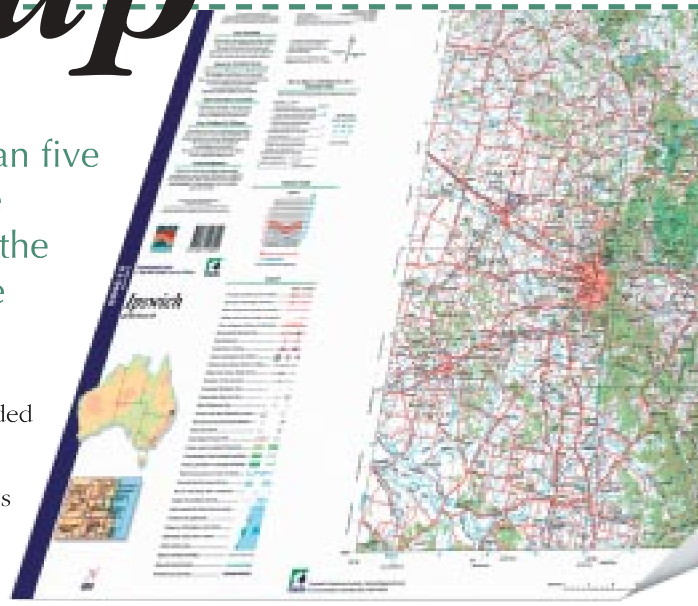


Figure 1. Location of SLR stations around the world

Topo map revision *stitched up*

Early next year you and I can access more than five decades of topographic mapping of the entire Australian continent at 1:250 000 scale from the web for free, and we will be unaware that we are looking at 513 separate maps.



It all started after World War II when the federal government decided to survey and map all of Australia.

The Department of Post-War Reconstruction began the huge project in the late 1940s with the 1:250 000 scale topographic maps of the populated areas. Full coverage of Australia at this scale was completed in 1968.

The printed 1:250 000 topographic maps are still heavily used by government, many industries and the public.

Onset of GIS

The rapid growth of geographic information systems (GIS) in the early 1990s highlighted a need for high-quality base data, including topographic map information. This sparked an ambitious initiative to design a GIS data specification known as GEODATA Series 1.

Once procedures were automated, the database developed quickly. The conversion and revision of the main features of the 1:250 000 scale mapping into GEODATA was completed in 1994.

Many government agencies started to rely on GEODATA for a broad range of applications—for example, web mapping applications like the National Land and Water Resources on-line atlas. Industry, too, used the data, and for commercial benefit.

GEODATA Series 1, however, needed many improvements.

New series

In Series 1 not all features in the topographic maps were included, the maps themselves could not be generated from the data, and their specifications varied. The data variation was obvious when the maps (called tiles) were scanned and joined into a mosaic or giant 'patchwork quilt'.

A revision of GEODATA and the printed maps began in May 1998. Private-sector mapping companies were contracted to revise data and produce the maps.

Major achievement

By the end of this month, all 513 of the 1:250 000 scale printed maps (NATMAPS) and GEODATA will have been revised.

For the first time the entire Australian continent, an area of 7 660 000 square kilometres, will be mapped to a consistent map and data specification. This is a major achievement in Australia's mapping history.

Seamless database

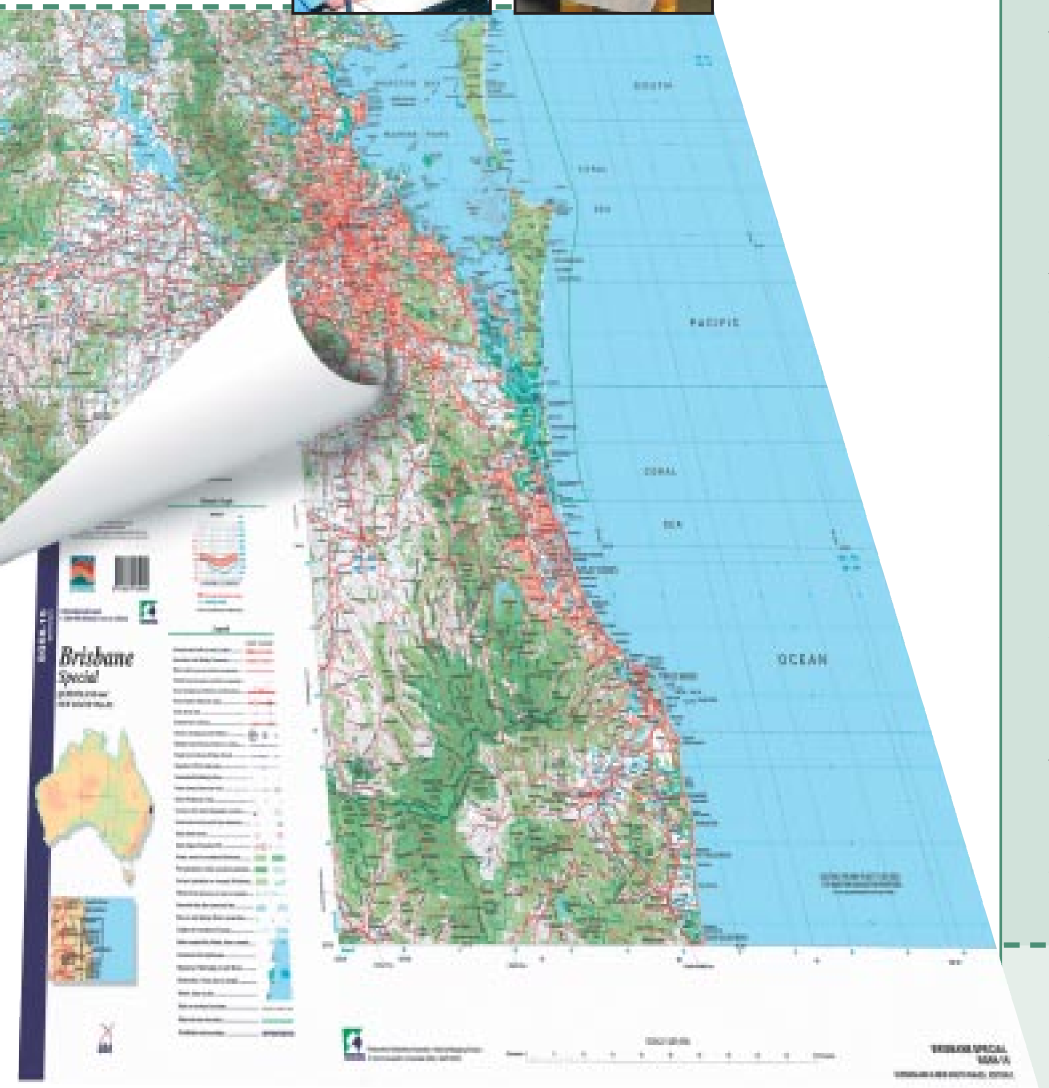
Mobile phones, GPS receivers and the internet have pushed the boundaries of mapping and with improvements in the quality and consistency of data, have ended the era of the map tile.

It is now possible to make a seamless digital map—one continuous database of mapping information that is not limited by individual map boundaries.

Early next year Geoscience Australia's 1:250 000 scale seamless topographic database goes live on the internet. Users will be able to specify combinations of themes and geographic extent, and roam map tiles unencumbered because the problem of an area of interest falling on the edges of neighbouring maps will be eliminated.

The database will be the cornerstone of a planned multi-scaled spatial data environment that will include data at 1:2.5 million and 1:10 million scales complemented with 1:100 000 and 1:1 million scale data.

Other data sets will be served from this environment, such as a continuous raster image (a national satellite image with a digital elevation model) at 1:250 000 scale.



Free access

Geoscience Australia is improving access to its data sets as part of the Australian Government's Spatial Data Access and Pricing Policy.

This policy was introduced in September 2001, in response to users demanding that all sectors of the community have a right to easily accessible and affordable spatial data generated by government.

The spatial data covered by the policy, termed 'fundamental data', are free over the internet (or for the marginal cost of transfer for packaged products and full cost of transfer for customised services). There are no restrictions on commercial value adding to the 'fundamental' spatial data sets, but each transaction is subject to a licence.

The data available for free download are listed at www.ga.gov.au/download.

For additional information about topographic map products (GEODATA Series 2, and the NATMAP raster products that include all new maps and a new seamless mosaic version) contact the Geoscience Australia Sales Centre.

For more details about Geoscience Australia's topographic mapping program phone Ian O'Donnell on +61 2 6249 9590 or e-mail ian.odonnell@ga.gov.au.

DATA COLLECTION STREAMLINED

Geoscience Australia isn't the only organisation generating topographic maps of Australia, and this has implications for map-scale consistency, and data management and delivery.

In June last year, Geoscience Australia and the Department of Defence decided to work more closely on the collection and management of geospatial information over Australia.

As much as possible, Geoscience Australia manages the capture, presentation and distribution of geospatial data while the Department of Defence funds specific defence priorities.

Geoscience Australia organises the production of unclassified onshore topographic mapping and air charts and distributes them to both Defence and civilian customers (including unclassified Defence maps such as the 1:50 000 topographic maps covering much of northern Australia).

This initiative offers a more strategic approach to national-scale topographic mapping. For example, Geoscience Australia's 1:250 000 topographic revision program is now linked to the Royal Australian Air Force's JOG (Air) map requirements. There are also efficiencies in collecting source material so that new information for revising one map scale can often be used for revisions at other scales.

MAP FEEDBACK

Geoscience Australia and state government mapping agencies exchange information about changes and errors on the topographic maps, but they also rely on the public to provide intelligence.

Individuals and local communities can lodge comments about the topographic features and names on Geoscience Australia's maps. This has proved useful, especially in remote areas of Australia, where details are often hard to come by or to verify.

All newly published topographic maps provide details about public feedback. Users can e-mail mapfeedback@ga.gov.au, or telephone Freecall 1800 800 173 in Australia.

Anyone who returns a map marked with corrections or changes receives a replacement map of his/her choice.

Satellite watch kept on NATURE'S COURSE

Every day Geoscience Australia acquires satellite data of the entire Australian continent via sensors known as MODIS on Terra (morning pass) and Aqua (afternoon pass) satellites, at its stations in Alice Springs and Hobart.

The images it generates from MODIS data are used for natural disaster management and in some crucial environmental work.

NASA designed MODIS (MODerate resolution Imaging Spectroradiometer) to monitor land, atmospheric, ocean and ice-forming processes on Earth at continental or global scales.

Because of its 2330 kilometre-wide swath, MODIS covers a large geographical area in each pass and the whole Earth at least twice a day.

Data are collected in 36 spectral bands with the ground resolution of each band in the range of 250 to 1000 metres.

Bushfire detection

CSIRO Land and Water in collaboration with Geoscience Australia and the Defence Imagery and Geospatial Organisation (DIGO) have added a 'hotspot detection' service to the web (see next article).

Immediately after Geoscience Australia acquires the MODIS data, a hotspot detection algorithm is applied to produce surface temperature imagery. The results are distributed to users via the Sentinel web server within an hour of acquisition.

More than 20 000 users accessed this site on one day in January this year during Australia's peak fire period.

The Department of Land Information in Western Australia also provides a hotspot detection service covering Western Australia and the Northern Territory.

MODIS data at 250 metres is ideal for mapping the fire history of an area. For example, the Department of Land Information provides fire scar maps on an operational basis using MODIS data.

Geoscience Australia also used MODIS data to map the extent of fire damage from the January bushfires in south-eastern Australia (figure 1). Such information is fundamental to a bushfire management system.

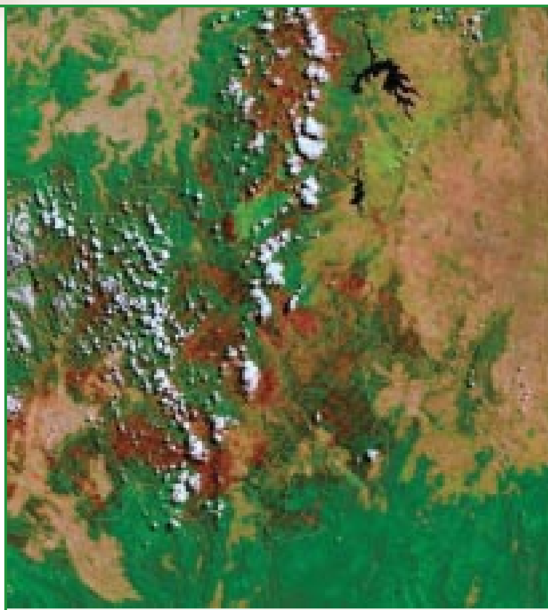
Environmental role

The path of the huge dust storm that blanketed eastern Australia on October 23 last year was captured in a series of MODIS images (figure 2 a–c). The MODIS data were later used to create a quantitative water chlorophyll image that shows what happened when the iron-rich dust was dumped at sea (figure 3).

The dust storm was 1500 kilometres long and 400 kilometres at its widest, and reached 2500 metres into the atmosphere. This huge volume of dust appears to have added extra nutrients to the water and created a bloom of suspended algae off the New South Wales coast.

Researchers at Flinders University in South Australia also use MODIS data to study coastal water, to examine the distribution of suspended particulate matter in the Gulf of Saint Vincent.

The most common application of MODIS data in Australia, however, is for monitoring changes in vegetation growth This is possible on a daily basis.



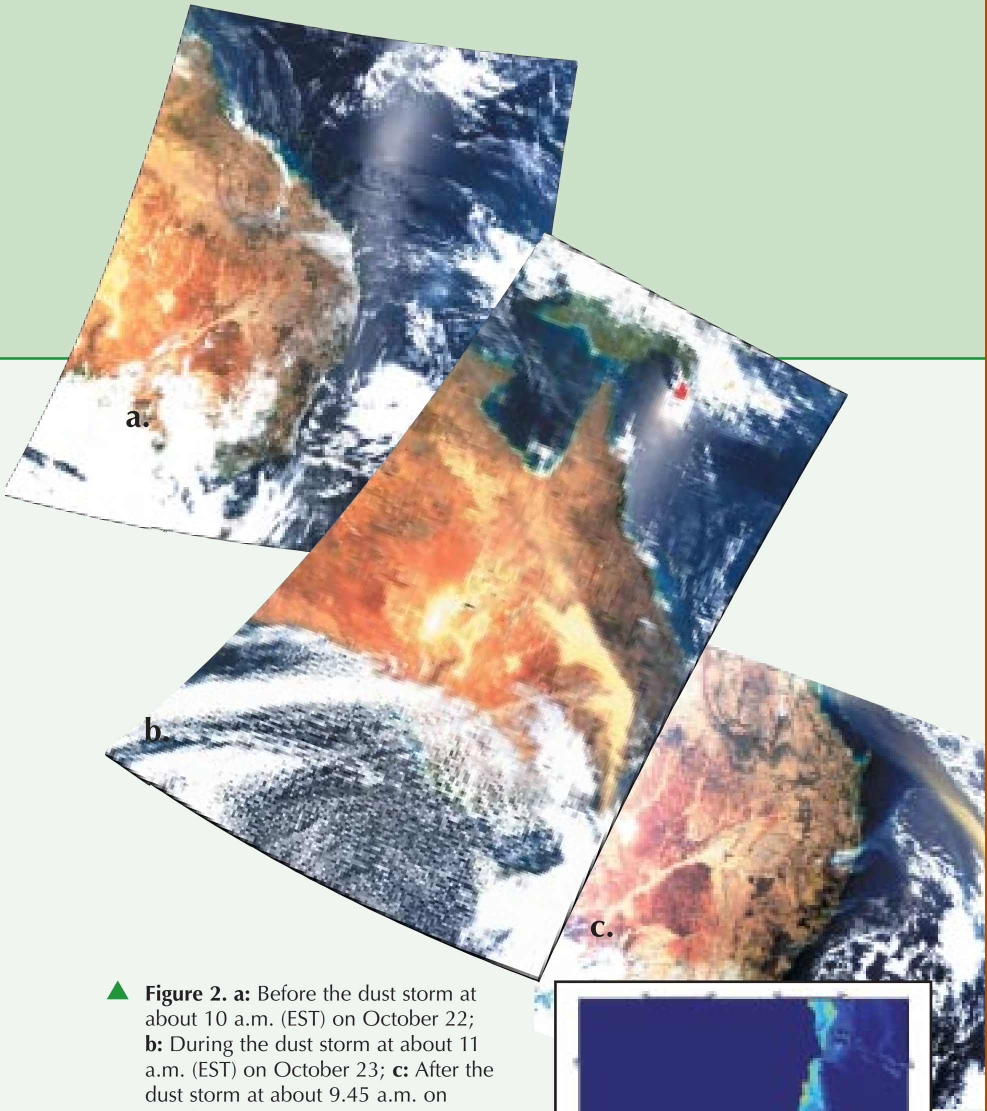
▲ **Figure 1.** Fire scar map of south-eastern Australia acquired in March this year

Table 1. Web addresses for MODIS images & activities

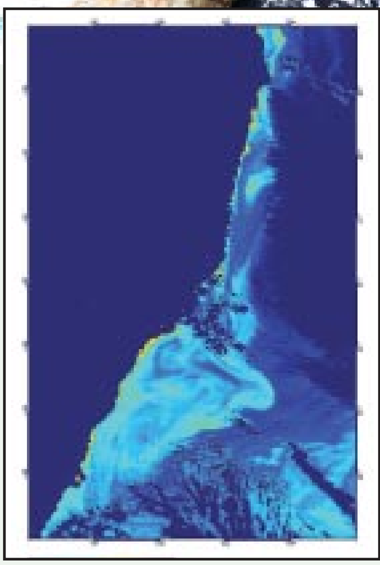
- Geoscience Australia — www.ga.gov.au/acres/
- Sentinel — www.sentinel.csiro.au
- Hotspot detection for Western Australia & Northern Territory — www.dola.wa.gov.au/corporate.nsf/web/satellite+imagery
- CSIRO Earth Observation Centre — www.eoc.csiro.au/modis/modis.htm
- Terra home page — www.eos-am.gsfc.nasa.gov/

MODIS information is used for crop monitoring and forecasting, and keeping a record of other vegetation such as grassland. Figure 4 shows an image of Australia's vegetation that can be generated from the coarse-resolution data acquired by MODIS.

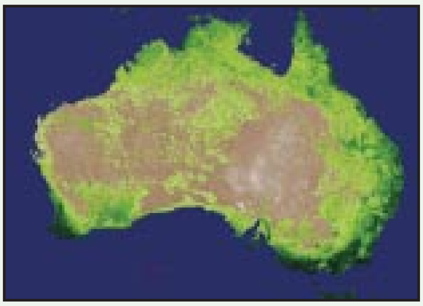
Wetlands, too, can be discerned in the images. Every month researchers at the Johnstone Centre, Charles Sturt University, obtain MODIS data to map wetlands for their three-year study of the movements of Grey Teal in arid inland Australia.



▲ **Figure 2. a:** Before the dust storm at about 10 a.m. (EST) on October 22; **b:** During the dust storm at about 11 a.m. (EST) on October 23; **c:** After the dust storm at about 9.45 a.m. on October 24



▲ **Figure 3.** Chlorophyll map of the eastern coast of Australia provided by Alex Held, CSIRO Land and Water. The MODIS image for this map was acquired on October 31 last year.



▲ **Figure 4.** A 16-day EVI composite of Australia showing vegetation cover in December 2002

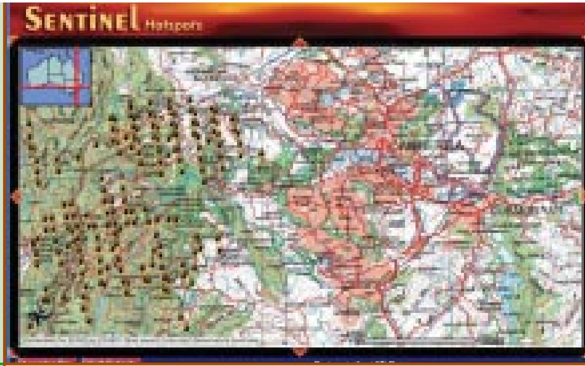
Data access

MODIS data are available to registered users within 24 hours of acquisition, and can be downloaded free from the internet. Geoscience Australia has about 1300 registered users who download about 100 gigabytes of data on average each month.

The data are provided in a simple band, sequential format.

In Australia MODIS-related research activities are coordinated through an informal working group from several organisations that ensure MODIS products are validated for Australian conditions. CSIRO Earth Observation Centre has set up a web site listing these activities.

For more information phone Shanti Reddy on +61 2 6249 9647 or e-mail shanti.reddy@ga.gov.au



Hot site *for fire crews*

Sentinel Hotspots is a prototype internet-based satellite mapping system for fighting bushfires in Australia. It provides on-line bushfire maps within an hour of satellites detecting the hotspots, which is proving useful for monitoring fire progress.

With Sentinel, emergency services managers can zoom in from a continental-scale view and detect the bushfire location to an accuracy of about 1.5 kilometres.

They can overlay important information such as access roads, airports, towns, and nearby water supplies on the maps.

Sentinel Hotspots had a major impact when it was launched on January 15 this year as much of south-eastern Australia was threatened by bushfires.

Government agencies responsible for managing remote public lands used the system to spot fires in southern New South Wales and western Victoria.

The Victorian Country Fire Authority relied on Sentinel for morning briefings, as they combined Sentinel Hotspots data with ground fire-crew observations to produce interpreted maps.

It was particularly useful when smoke prevented spotter aircraft from taking off.

Two NASA satellites with MODIS on board provide the Sentinel Hotspots data. These satellites scan Australia nearly four times every 24 hours.

Surface temperature imagery is generated as soon as data are received. Fast computer processing systems and internet delivery allow the images to be customised and provided in near real-time.

Sentinel Hotspots was developed by scientists from CSIRO Land and Water with funding from the Defence Imagery and Geospatial Organisation (DIGO) in collaboration with Geoscience Australia, NASA and the United States Geological Survey.

Fire impact mappable from satellite

Forest fires are inevitable during Australia's hot summers. They cannot be prevented but with a little help from the spatial information industry prior to bushfire season, Australia can mitigate the worst consequences.

Tony Sparks and James Moody from Natural Resource Intelligence (NRI) explain how satellite imagery can be used to assess the impact of fire and minimise future burns.

Fire scars can be mapped from a single satellite image obtained after a bushfire. But more information can be gleaned when images of the same area immediately before and after the fire are compared.

This is possible because satellite images are geometrically stable, and their high spectral sensitivity allows even small changes to be detected.

Canberra fires

The bushfires in summer 2002 were a minor event compared to those in December last year, the effects of which are still being measured. Nevertheless, the 2002 bushfires provided an opportunity for NRI to examine the potential of satellite imagery for accurately evaluating the impact of fire.

Satellite imagery and ground observations were used in the study. Geoscience Australia (ACRES) provided Landsat 7 ETM imagery, and the Australian Capital Territory government provided information about fire locations. NRI organised training and facilities for Australian National University forestry student, Michele Gilbert to conduct the study.

The study evaluated fire occurrence and the magnitude of change it caused by referring to antecedent conditions such as the type and condition of vegetation. The costs of developing the information, its reliability, and ease of understanding were key considerations in the approach used.

Wet, bare & green

Indices were computed for wetness (level of moisture), bareness (bare ground) and greenness (green vegetation) from the six Landsat 7 bands over the visible and infrared, using pre- and post-fire images. The measures were independent—for example, wetness did not depend on the amount of green vegetation.

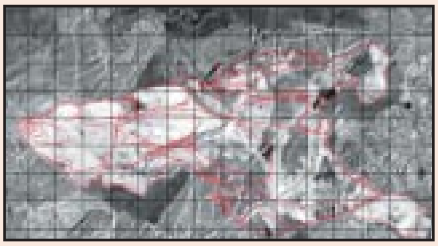


Figure 1. Post-fire bareness index with an overlay of fire boundaries. The fire boundaries show the progress of the fire.

The indices were easy to compute and interpret and could be compared over time.

Figure 1, which is a bareness index overlaid by red lines, shows the progress and extent of fires from field observations by the ACT government. The fire started in the west of Canberra and spread to the east. The bareness and field boundaries generally correspond but there are discrepancies, mainly in grasslands. There is also a cleared patch of pine plantation.

When the three indices are applied to the post-fire image (figure 2), unburnt grasslands and burnt areas are bare (red) and pine plantations are green and moist.

The change in greenness is reliable for distinguishing the extent of forest fires but not grassland. The change in bareness, however, clearly differentiates burnt grasslands from burnt forests and unburnt grasslands. This allows the separate mapping of burnt forests and grassland (figure 3).

images

The indices are also useful for detecting the severity of change. For example, figure 4 shows the variation in post-fire bareness for the large block of grassland in the centre of figure 3B.

When all indices pre- and post-fire are compared, there are details that require field examination to understand. For example, the strong fence-line effect in the large grassland block in figure 3B is not apparent in the post-fire bareness (figure 4).

Subsequent analysis should indicate whether the differences in pre- and post-fire images were related to such factors as topography, or antecedent moisture which would be highlighted by the pre-fire wetness index.

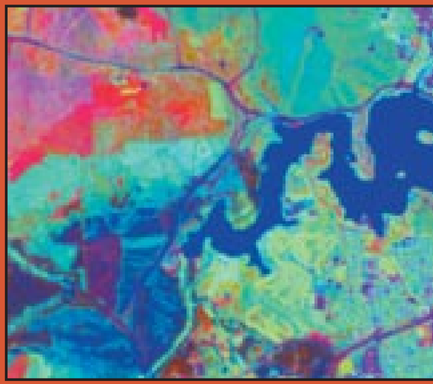
Fire management

For fire management of the natural environment, it is important to know the type, amount and condition of the fuel, and the associated fire characteristics.

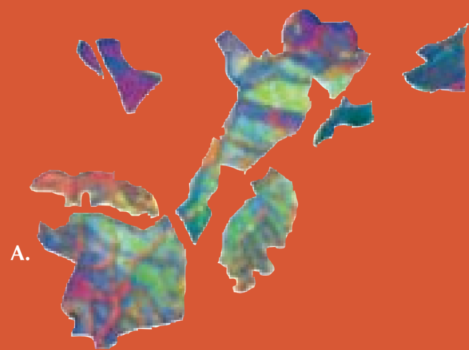
Fuel loads are the manageable component of Australia's bushfires and they can be estimated by using satellite imagery to map the different types and amount of vegetation in an area.

The time since burning also influences the amount of fuel. Here satellite imagery has an important role because it can be used to map fire scars, to determine the condition of the fuel, and the fire characteristics by showing the severity of the burn.

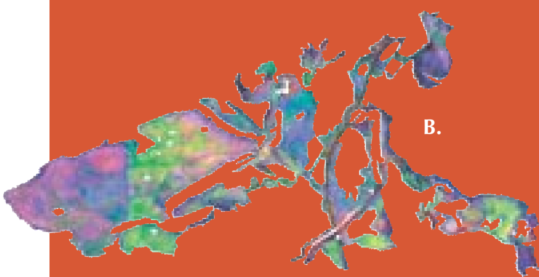
For more information phone Tony Sparks or James Moody, Natural Resource Intelligence, on +61 2 6285 9966 or e-mail info@resourceintelligence.net

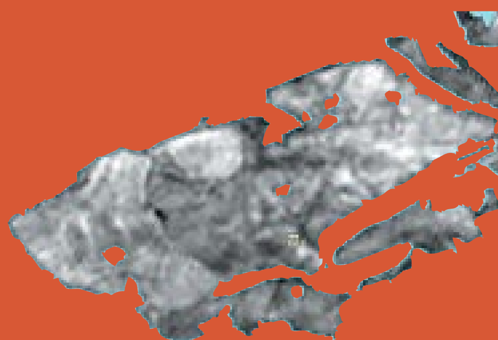


▲ **Figure 2.** The indices of wetness (blue), greenness (green) and bareness (red) are applied to this post-fire image of the Canberra region. Lake Burley Griffin is bright blue, grassland is red, and forests blue-green. The burnt areas (dark blue) are mainly grassland.



▲ **Figure. 3** Post-fire wetness (blue), greenness (green) and bareness (red) image for grasslands (A) and forests (B)





▲ **Figure 4.** Post-fire bareness for part of the burnt grassland

Cool work to trace continent movement

Antarctica, that perfect place for scientific research, has its faults. These interest geologists and geodetic surveyors because Antarctica is on the move and this can be traced along faults.

Last summer two geodetic surveyors from Geoscience Australia joined a party of 32 researchers from Australia, Germany and Russia in the Southern Prince Charles Mountains in eastern Antarctica. Their main targets were the Lambert Graben—a large depressed valley bounded by faults—and the Lambert Glacier.

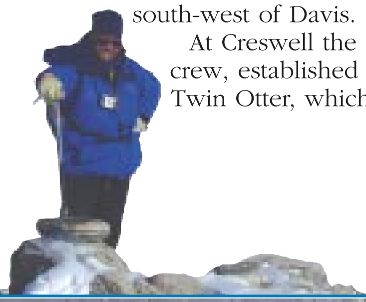
The Australian Antarctic Division and the BGR, which is Germany's Geological Survey organisation, ran the expedition (called the Prince Charles Mountains Expedition of Germany and Australia, or PCMEGA).

Getting there

In late November, the expedition sailed from Hobart to Antarctica aboard the *Aurora Australis*.

After 16 days the ship berthed in pack ice at Davis, one of Australia's three, continental Antarctic research stations. The expedition and its freight were unloaded onto sea ice, and from there transported to field camps by a Twin Otter aircraft.

By the time the ship arrived at Davis, a land team had transported fuel and supplies approximately 570 kilometres from Mawson Station to Mount Creswell by tractor train. Mount Creswell is approximately 680 kilometres south-west of Davis.



At Creswell the land team set up camp for the airborne survey crew, established a fuel depot, and built a snow runway for the Twin Otter, which is a fixed-wing twin-engine aircraft with skis.

Air support

After the field teams were unloaded at seven camps in the Southern Prince Charles Mountains (Mount Stinear, Cumpston Massif, Roefe Glacier, Mount Rucker, Tingey Glacier, Mount Creswell and Wilsons Bluff), the aircraft returned to Davis and was fitted with airborne geophysics measuring equipment.

The geodetic surveyors camped at Mount Creswell and Wilsons Bluff and moved from site to site by Squirrel helicopter. The two Squirrel helicopters also transported the geologists between camps. These helicopters can place people and several hundred kilograms of freight onto otherwise inaccessible areas, depending on visibility and wind speed.

Generally it was blue-sky weather, and aircraft flew most days.

The geodetic surveyors mainly worked at an altitude of 1100 to 2000 metres in a temperature of about -8° C and five to 10 knots of wind. Some of the peaks were a little more extreme, at -20° C and 30 to 40 knots of wind. There was light snow on a couple of days.

Of a night it was -20° C and drifting snow regularly covered Creswell camp, which was in an open area.

Geodetic program

Geoscience Australia's ongoing Antarctic Geodesy project contributes to what is known about the vertical and horizontal motion of the Antarctic continent. It provides spatial data for scientific research in the Australian Antarctic Territory, and also supports the Australian Antarctic Division's mapping program.

Last summer its activities were rolled into the PCMEGA campaign.

In addition to Geoscience Australia's two geodetic surveyors there was one from Dresden University of Technology. His major task was taking ground measurements for the satellite mission, ICESAT.

The main objective of the Australian pair was to establish a network of highly accurate geodetic points around the Prince Charles Mountains to quantify the tectonic activity of the Lambert Graben.

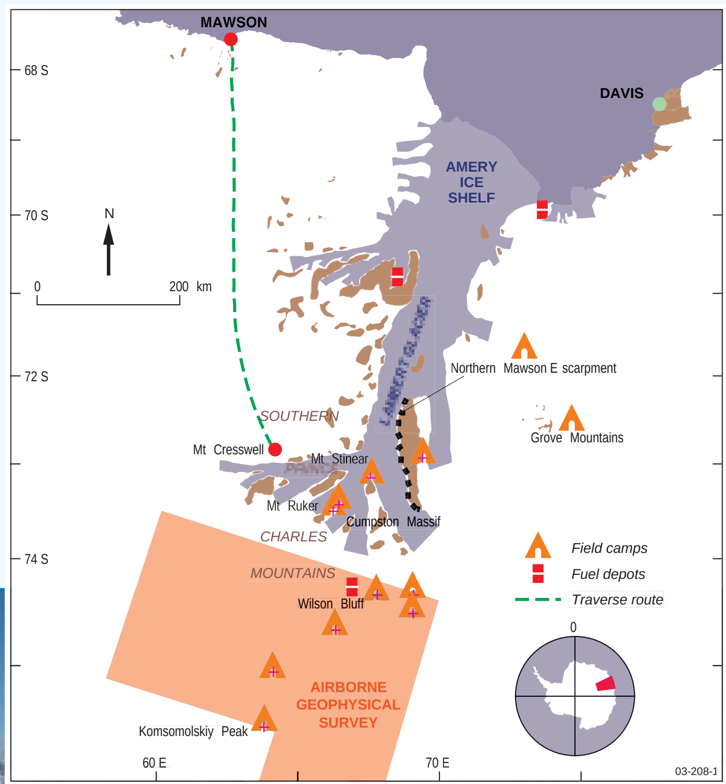
By installing survey marks on either side of the Lambert Glacier, their observations over time should help determine whether the graben is active.

ICESAT ground calibration

ICESAT was launched late last year primarily to generate a digital elevation model of Earth's ice surface.

Most artificial satellites orbiting Earth only travel to about 70 degrees south so they do not pass over the polar caps. ICESAT goes over the bottom of the planet, and its orbit (particularly its height systems) needed to be calibrated with points on the Antarctic continent.

The Australians helped survey a grid of ice that ICESAT would fly over and correlated grid measurements with Geoscience Australia's GPS stations on the coast. When the satellite mission produces an image of the ice surface it can be compared with this grid.



AAGN extension

In the late 60s and early 70s, National Mapping (now Geoscience Australia) surveyors extended the Australian Antarctic Geodetic Network (AAGN) into the Prince Charles Mountains. The network was based on measurements of angles and distances, supplemented with astronomical observations for position.

The accuracy of data from the original 15 survey marks was only good to 30 metres in places. Detecting Antarctica's tectonic motion was impossible with this amount of error. The network needed an upgrade.

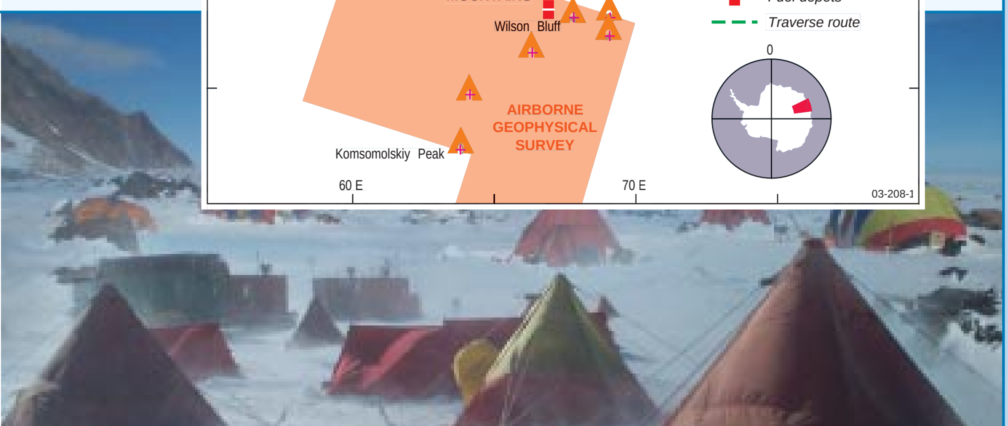
Most old survey marks were re-observed. The geodetic surveyors also set their sites on other major nunataks scattered across the Southern Prince Charles Mountains (hills and ridges completely surrounded by glacier ice). They established a network of 21 control points that are accurate to about two millimetres.

With this level of coordinate accuracy, detecting site motion across the network should be possible with the next observations. This could take three visits over six years.

Relative gravity

Gravity observations were also taken. The results are being used as ground calibration for the airborne gravity survey and to improve the gravity network, which was very sparse over this part of Antarctica.

The Australian continent has AusGeoid 98 as a reference for surveys. It describes the offset between ellipsoidal heights from GPS and mean sea-level heights from the Australian Height Datum.



In Antarctica there haven't been enough gravity observations to produce such a reference, and most satellites that generate this type of information don't go far enough south. The PCMEGA provided an opportunity to extend the gravity network inland.

Gravity observations had been taken on some hills in the early 70s. This time, when the old stations were occupied, they were linked to Geoscience Australia's GPS sites at Mawson and Davis to get accurate coordinates, accurate ellipsoidal heights, and gravity values.

Extra observations were taken on hills not previously occupied to 'densify' the gravity network.

Testing DORIS

Doppler Orbitography and Ranging System (DORIS) is a French positioning system that has facilities at Geoscience Australia's Mount Stromlo and Yaragadee stations. While in the Prince Charles Mountains, the geodetic surveyors elected to proof this positioning technique on a glacier.

The benefit of using DORIS on a mobile platform like a glacier is that nobody has to retrieve data. With DORIS, there are no ground receivers. The satellite is the receiver, and data are retrieved any time one of the four satellites with DORIS capability passes overhead. When over France, the satellites download to a data centre in Toulouse that disseminates the information.

The position of the ground antenna is derived when a satellite is overhead. When another satellite passes an hour later, the antenna is in a different position because the ice has moved down the glacier. By tracking antenna positions, the motion of the ice is recorded.

DORIS was tested about 600 kilometres inland on the Lambert Glacier, where ice movement was about a metre a day. The ice moves significantly faster as the Lambert Glacier approaches the sea.

There were configuration problems that have since been rectified. Plans are to test DORIS again this summer, but on the Sorsdal Glacier near Davis.

Airborne geophysics

The airborne geophysics work involved the observation of gravity, magnetics and ice radar from the Twin Otter. All three instrumentation packages were integrated into a single platform inside the aircraft.

Geoscience Australia's geodetic surveyors coordinated the GPS base station operation to support the aircraft positioning system.

For four weeks the Twin Otter was based at Creswell camp and flew either one or two six-hour flights per day undertaking the geophysics survey. This was about 32 000 line-kilometres of flights that resulted in a grid spacing of approximately 10 kilometres.

The gravity and magnetics should reveal a wealth of information about the structure of the rock formations, which are several kilometres below the ice surface in places. The ice radar is used to determine the ice thickness which, when coupled with the aircraft positioning system, gives a highly detailed profile of the rock–ice boundary.

Fugro Australia and the BGR are currently processing this data.

Geology

Geologists specialising in geochronology, geochemistry and geomorphology concentrated on the Mawson escarpment, Mount Stinear, Mount Ruker and Cumpston Massif, although they visited most other outcrops in the region at least once.

Only a small part of the total area has rocks protruding above the current ice levels. But these outcrops provide much information about the underlying structures, their formation and subsequent erosion.

Rocks taken as samples are in Australia and Germany for analysis.

Pack up

When the airborne survey was finished, the Twin Otter returned to Mawson to remove the geophysics equipment. It then ferried teams and equipment from the field camps to Mawson and Davis.

Once all were removed, the land team packed up the Creswell camp and drove back to Mawson with a cargo of empty fuel drums, equipment and the geologists' rock samples.

The return voyage to Australia was aboard the *Polar Bird.* Unusually smooth seas allowed everybody to catch up on sleep and start analysing the information collected, before reaching Hobart on February 20.

For more information phone Gary Johnston on +61 2 6249 9049 or e-mail gary.johnston@ga.gov.au

Border checks
COMPLEX BUT ROUTINE FOR GA

When Governor Arthur Phillip proclaimed the western territorial boundary of the New South Wales colony at the meridian of 135° East of Greenwich in February 1788, he started a complex process of determining Australia's borders that continues today at Geoscience Australia.

The former New South Wales colony is now part of Australia—an area of more than 7.5 million square kilometres, and that is just the land area.

The seafaring Phillip would no doubt be interested that his western border has moved and is determined at sea.

Establishing borders

Australia's borders are all off shore because it is an island continent. Its borders are defined in two ways: by agreement between neighbouring countries, and by the distance from the low-water line around the mainland and its islands.

Australia has border treaties with Indonesia, Papua New Guinea, Solomon Islands and France (involving New Caledonia and Kerguelen). It is currently negotiating borders with East Timor and New Zealand.

Defining Australia's low-water line can be quite complicated.

▲ **Figure 1.** The various sea borders are shown in this map of Australia's maritime zones.

Australia has more than 8000 islands and nearly 60 000 kilometres of coastline to consider—and that is without its external territories. It also has numerous reefs that can extend sea borders if any part is within the first 12 nautical miles (approximately 22 kilometres) of an island.

Information about the low-water line, reefs and other features used to determine Australian sea borders are compiled by Geoscience Australia in a geographic information system (GIS) called the Australian Maritime Boundaries Information System.

Details in AMBIS are continually checked and updated.

Border lines

There are a number of demarcation lines around Australia because international law provides for more than one sort of sea border (figure 1).

The first boundary is the limit of the territorial sea. This is a belt of water extending 22 kilometres seaward from the low-water line.

Australia has sovereignty over this zone of sea, seabed and sub-soil and the airspace above it. This boundary is important to Australia and the government departments that deal with customs, defence, immigration and environment.

The second demarcation is a zone contiguous to the territorial sea. Under international law, Australia can use this zone to prevent and punish infringements of customs, fiscal, immigration or sanitary laws and regulations that can affect its territory or territorial sea.

The third boundary is the exclusive economic zone. This area extends from the territorial sea up to 200 nautical miles (about 370 kilometres) from the low-water line.

Here Australia has sovereign rights to explore, exploit, conserve and manage the natural resources of the sea and seabed and carry out other activities such as energy production from water, currents and wind.

In most cases this boundary is the outer limit of Australia's fishing zone. It is critical to the Australian Fisheries Management Authority (AFMA) which is responsible for helping to prevent illegal fishing.

But this is not the limit of Australia's jurisdictions.

Australia also has rights to seabed where the continental shelf extends beyond the exclusive economic zone. The United Nations needs to approve this claim and Australia is preparing a submission that may be lodged as soon as next year.

Geoscience Australia locates the sea borders in consultation with such agencies as the Attorney General's Department, the Department of Foreign Affairs and Trade, and the Australian Hydrographic Office. State and territory mapping agencies also contribute up-to-date coastal mapping data.

Invisible lines

Sea boundaries lack fences, gates and border guards to warn seafarers that they are about to enter another country's territory. The boundaries therefore need to be shown on nautical or hydrographic charts.

When seafarers plot their course, they can consult the Annual Notices to Mariners Handbook for a description of the sea borders. But unlike Phillip's day, most ships rely on electronic navigation equipment and use GPS to obtain their position.

Their position is displayed on a screen with the relevant hydrographic chart as background. When a border is crossed, the navigator can obtain information about the sea border via a pop-up menu.

AMBIS data can be represented on maps or charts and integrated into electronic navigation systems. The Royal Australian Navy's Hydrographic Office is currently adding Australia's sea borders to their 1:150 000 and 1:300 000 hydrographic charts as they are revised.

AMBIS data can also be downloaded free from the Geoscience Australia web site.

Fishing maps

Fishing boats from neighbouring countries have been crossing Australia's borders. Many on board do not have high literacy skills and may not be able to read English. They need to know where they can and can't fish.

Geoscience Australia has helped the AFMA by producing special maps for Indonesian fishing boats (figure 2). Words on the maps are in Indonesian and they have large icons that show where the crew can fish and for what they can fish.

A new version of this map is currently in production in conjunction with Papua New Guinea and Indonesian fishing authorities.

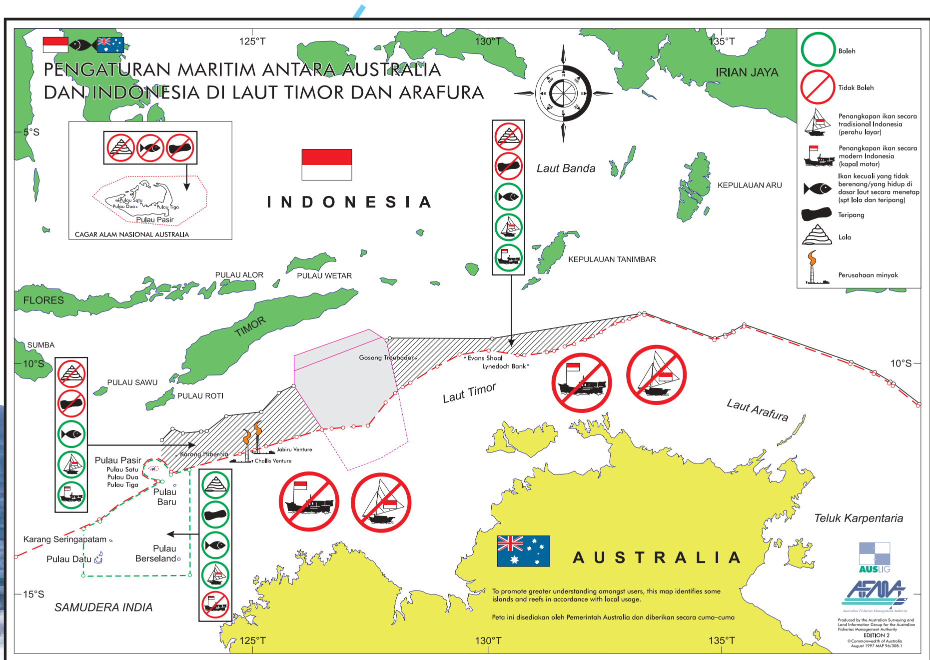
Commonwealth Fisheries boundaries can be downloaded free from the Geoscience Australia web site.

Vital role

Australia has various rights over a vast area of ocean, and the fishery, mineral and petroleum resources found in that area. These resources are worth billions of dollars to Australia.

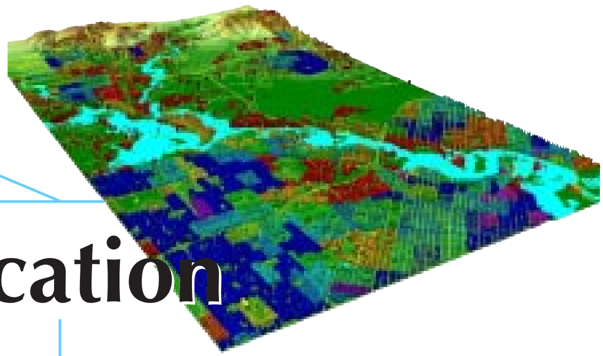
Geoscience Australia plays an important part in helping the Australian Government to define and locate its borders according to international law.

For more information phone Bill Hirst on +61 2 6249 9741 or e-mail bill.hirst@ga.gov.au



▲ **Figure 2.** A map with fishing zones printed in Indonesian helps the Australian Fisheries Management Authority.

GIS tools have *broad* application



Geographic information systems (GIS) are powerful computer-based tools for mapping and analysing spatial data.

Geoscience Australia had been using GIS for more than a decade primarily to produce geological maps and data. From geological applications it expanded its GIS capabilities to analysis and visualisation tasks related to research as diverse as community safety and determining Australia's sea boundaries.

Seamless geological map

The largest scale at which Australia has complete national coverage of geological information is at 1:250 000. But only 45 per cent of the 540+ maps in this series are digital, and some are up to 50 years old.

It would take many years to create a complete, consistent and seamless geological data set covering the whole Australian continent at this scale.

A less ambitious project has Geoscience Australia using GIS to construct a surface geology data set of Australia at 1:1 million scale, with the help of state and territory geological surveys.

This seamless data set will supersede the very generalised 1:2.5 million scale geology of Australia produced in 1998. It will include stratigraphic and other geological attribute information not previously captured in national compilations.

A bedrock geology (solid geology) compilation is also planned.

Meanwhile all the printed 1:250 000 geological maps have been scanned and are available in raster format from Geoscience Australia and state surveys. The challenge is to produce a fully attributed, seamless data set in vector format that can be queried and visualised using standard GIS software.

Geological provinces

Geoscience Australia is also creating a digital map, database and on-line GIS of Australian geological provinces.

The geological provinces of the Australian continent and surrounding marine jurisdiction are being mapped at a scale of 1:1 million. Detailed descriptive attributes are being added to the new 'Provinces' database. These include age limits, parent and constituent units, relations to surrounding provinces, and igneous, sedimentary and resources data.

The data will be presented in an on-line GIS accessible via the web and will be integrated with other national coverages like geophysics and satellite imagery, and analytical data sets such as geochemistry and geochronology.

Sea boundaries

Under the United Nations Convention on the Law of the Sea (UNCLOS), Australia has jurisdiction over large tracts of ocean and seabed surrounding the Australian continent, its islands and territories.

Its marine jurisdiction may include areas of continental margin beyond the exclusive economic zone that are still being worked out for a submission next year to the UN Commission on the Limits of the Continental Shelf.

Defining the outer limits of Australia's seabed jurisdiction is a very complex process. Deliberations include the shape of the continental margin, sediment thicknesses, the foot of slopes, abyssal plains, 200 and 350 nautical mile limits, 60 nautical mile arcs, and the application of 'rules' set out in Article 76 of UNCLOS.

GIS suits these deliberations. It allows large volumes of data to be integrated and handled, and retains the linkages between the raw data/metadata and the outputs derived from them.

Geoscience Australia has modified ArcView software to extract, query and present data collected to 'map' the outer limit. ArcView 'extensions' were written for various computations and to organise the maps, sections, graphs and images, and the point, line, polygon and attribute data needed for Australia's submission.

If the UN Commission wants to know how a segment of boundary was calculated, the GIS can be used to quickly extract all data, track the processing, and show all computations.

Risk GIS

Geoscience Australia has been acquiring information about the risks of earthquakes, floods, severe winds, landslides and coastal erosion in such cities as Cairns, Mackay, Wollongong, Newcastle, Perth and the greater Brisbane area to assess community vulnerability.

Most of this information has a spatial element so GIS technologies have been applied to analyse, model and map the huge data sets involved.

The resultant 'Risk GISs' are decision support tools that can significantly improve the capacity of Australian communities to make informed decisions about natural hazard risks and community safety and sustainability. For example, a Risk GIS can be used to:

- Improve planning (e.g. siting critical infrastructure such as water and power);
- Increase public awareness through its extensive visualisation capabilities;
- Make emergency response training more effective through better estimates of the likely impact of hazards and by creating realistic impact scenarios;
- Help in real-time emergencies by providing demographic information and possible evacuation routes;
- Demonstrate the interrelationship of physical and social systems and the need for inter-agency coordination.

Even though it is some way off, the GIS databases eventually will be closely integrated with web applications so that data can be accessed and queried in 'real time'. Until then, Geoscience Australia will continue to provide high-quality maps and GIS data sets.

For further information phone Jon Stirzaker on +61 2 6249 9135 or e-mail jon.stirzaker@ga.gov.au

Geoscience visuals enter *new realm*

If one picture is worth a thousand words, imagine the potential of one interactive '3D visualisation' of Australia's provinces or basins in resource assessments.

Computers, the web, and 3D applications and tools have opened up how geological and topographic data are viewed and interpreted.

Keeping pace

Geoscience Australia continually develops data required by government and industry for resource assessments, exploration, and locating critical infrastructure. Generally it involves obtaining increasingly detailed digital elevation and bathymetric data, and constructing regional-scale models of the continent's sub-surface.

Software to generate visuals from these data is plentiful. But it is often limited to simple image captures or snapshots.

This was acceptable a decade ago when most geoscience data such as maps or geological cross-sections were presented in two dimensions.

Technological advances, fast computers and the explosion of information on the web have changed that and are pushing Geoscience Australia to explore new ways of presenting its data.

Visualisation of Geoscience Australia data has headed in two directions: producing movies or 'fly-throughs' and creating VRML (virtual reality modelling language) products.

Movies

Movies or fly-throughs are not new to the geosciences. The know-how, tools and data have been around for years.

Geoscience Australia used movies sporadically because of costs, limited production experience, and the perception that a movie was a one-off product.

In the past two years these inhibiting factors have been resolved so that movies are now a regular and cost-effective method for presenting research results from Geoscience Australia (figure 1).

Movies can be viewed as an independent product or they can be combined with other applications such as slide shows, html, GIS projects, and pdf reports. They are very portable and the Mpeg-1 format is viewable on all systems.

The content can be a mix of images, text, audio, video footage, production music, narration and sound effects.

A three-minute movie used for promotion at a geoscience conference is usually about 120 megabytes. The settings are altered to a smaller file size for CD-ROMs, the web and slide shows.

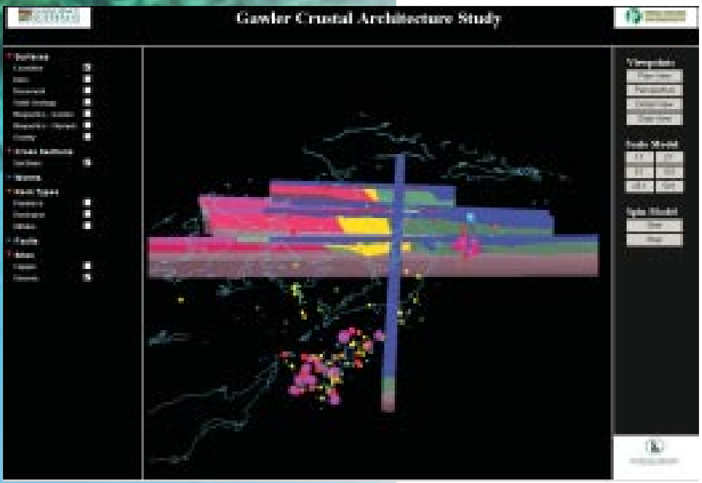


Figure 2. Gawler Craton model

VRML products

Virtual Reality Modelling Language (VRML) is a simple language for describing 3D objects and scenes and is used to publish 3D models on the web.

VRML was conceived in 1994 at the first World Wide Web conference. Developers are working on an XML version called X3D.

Geoscience Australia uses software applications such as ArcGIS, Gocad, EVS, and ERDAS Imagine Virtual GIS for visualisation purposes. These are normally operated on high-end computers that some clients cannot access.

Exporting visualisations to VRML enables them to be viewed by anyone with a basic computer running a browser and free VRML plug-in. Most 3D modelling, CAD, and GIS applications have the ability to export to VRML.

Unlike a movie, a VRML product is interactive. The user explores the product or model using navigation tools (e.g. explore, pan, slide, and go to) provided by the plug-in. The user can examine relationships, for example among geological structures in a model of the Gawler Craton, from any aspect they choose (figure 2).

VRML displays text, 2D images, sound and movie files in a 3D environment. It can combine visualisations from different packages and objects in one model can be hyperlinked to another model.

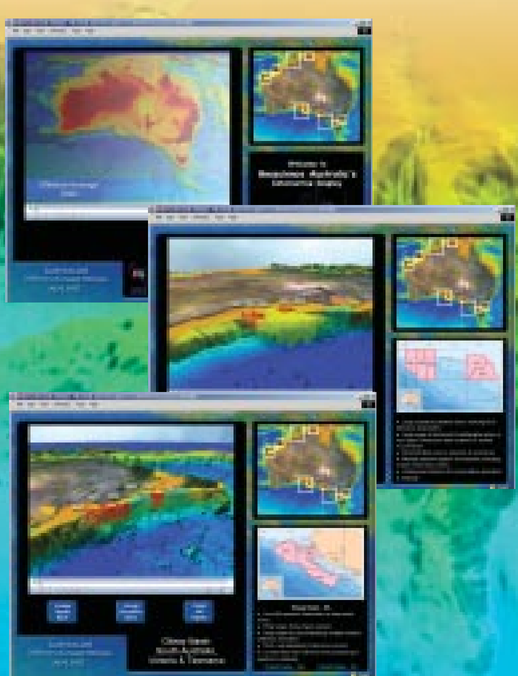


Figure 3. Kiosk-style presentation of acreage release data

Combined impact

Movies and VRML models combined via a web interface can be quite effective.

A fly-through provides an excellent overview or introduction to a geographic region, especially for a user unfamiliar with the territory. Once the user has been introduced to the geographic region he/she can examine various parts in more detail via the VRML models.

Geoscience Australia uses this combination and others at overseas conferences.

For example, Geoscience Australia used a 'kiosk-style' presentation earlier this year in a booth to showcase new offshore acreage for petroleum exploration. One major movie depicting all release areas around Australia was combined with a number of small movies detailing each area. A web interface linked these movies, text and other images to a large map. The map put the release areas in context and was the starting point for finding out about a region (figure 3).

Built correctly, 3D visualisation products are powerful tools for the interpretation, presentation, and exploration of geoscience concepts and information.

For more information phone Russell Hay on +61 2 6249 9158 or e-mail russell.hay@ga.gov.au

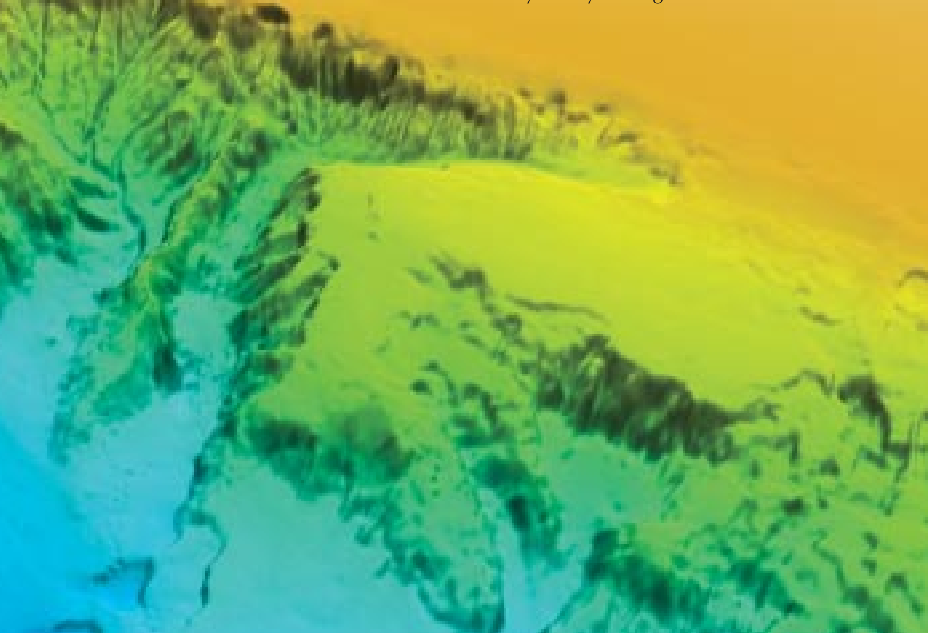


Figure 1. Image from the Murray Canyons fly-through

Great lengths for *deeper* view of SA MINERAL REGIONS

Four 30-tonne vibroseis trucks hit the road at the end of July, the start of a month-long project to record images of the crust in two of South Australia's most prospective mineral regions, the Gawler Craton and Curnamona Province.

The survey was a joint project of Geoscience Australia and Primary Industries and Resources South Australia, and collected data from approximately 250 kilometres of seismic lines in the Gawler.

Only 40 kilometres of the planned 120 kilometres of seismic line in the Curnamona were completed because of rain.

The lines followed existing roads and station tracks to minimise any disturbance of the environment.

▲ **Figure 1.** Location of seismic surveys carried out in the Gawler and Curnamona regions, South Australia, in July and August this year.

There were two lines in the Gawler. The north–south line ran from below Lake Eyre South to Woomera and was crossed by another running near Olympic Dam mine.

The Curnamona line was to run westwards from the New South Wales border, but stopped at Honeymoon Mine site (figure 1).

The vibroseis trucks thump the road surface with large, hydraulic-driven metal plates that send vibrations (seismic waves) through the crust. The waves bounce off the sub-surface geology and are picked up by sensitive microphones (geophones) on the surface, spread at 40-metre intervals over about eight kilometres (figure 2).

The signals are recorded on magnetic tape and later processed into images or cross-sections of the sub-surface down to about 50-kilometres depth.

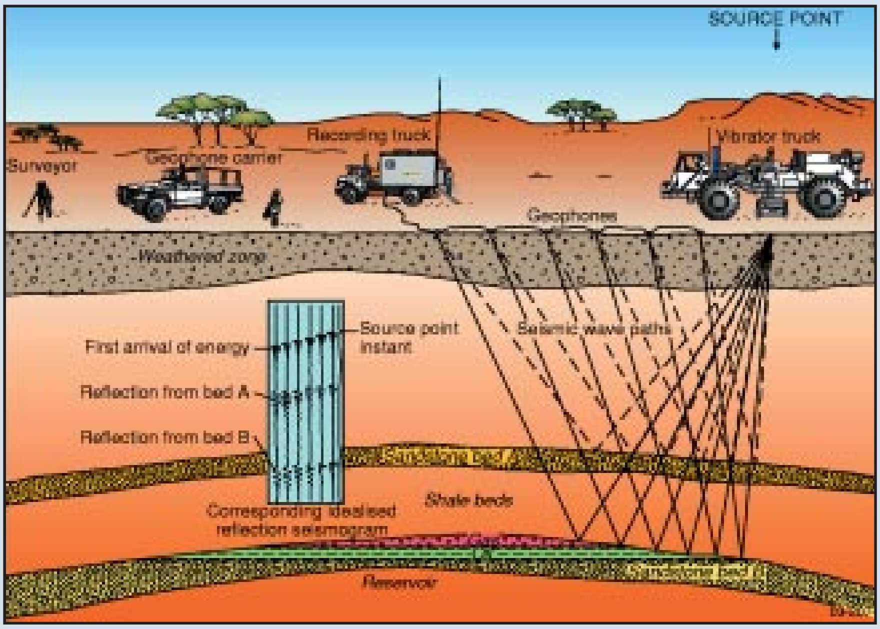
No other technique provides such a clear picture of the Earth's interior.

The Gawler has one of the world's largest copper mines at Olympic Dam and it is a real prize because gold is in the same deposit.

The Gawler also has a new copper-gold discovery at Prominent Hill and some historic mines around Moonta–Wallaroo. There could be others.

It is difficult to explore for minerals, however, because there is very little outcrop and much of the Gawler is buried by up to 300 metres of sediment.

The Curnamona shares many of the Gawler's features. Both formed about 1590–1600 million years ago and may share plumbing systems along which mineral-rich fluids travelled and pooled.



▲ **Figure 2.** Diagram shows the reflection seismic technique used in South Australia's mineral regions.

The Curnamona also has some significant copper-gold deposits, even though it is best known for the Broken Hill lodes of silver-lead-zinc.

But repeated movement of geological structures in the Curnamona over millions of years makes it difficult to interpret from the surface which faults created pathways or blocked the hot, mineral-rich fluids.

The seismic surveys will provide insights into the geometry, depth and significance of major structures in the crust. They will help geologists understand why structures are placed as they are and whether there is potential for more mineralisation.

With seismic recordings of the Olympic Dam site, exploration company WMC should know more about the size of their ore bodies and how deep they have to mine.

The Australian National Seismic Imaging Resource (ANSIR) and Trace Energy Services acquired the seismic data.

Final interpretations and seismic data for the Gawler survey will be released in August 2004.

The Curnamona line will be completed when an opportunity arises.

For more details phone Bruce Goleby on +61 2 6249 9404 or e-mail bruce.goleby@ga.gov.au

Common specs at last for vector data

The recent revision of all 513 topographic maps covering Australia at 1:250 000 scale is terrific news for digital data users because, for the first time, Geoscience Australia has vector GIS data for the entire continent in a common specification.

GEODATA TOPO 250K Series 2 is a vector representation of the major topographic features appearing on the 1:250 000 scale NATMAP topographic maps and is designed for use in commercial Geographic Information Systems (GIS).

The features are grouped into classes (e.g. road), with the characteristics of each class described by attributes (e.g. road surface type). Layers with common characteristics are grouped into themes.

Each tile therefore may include information on up to 27 different layers, arranged within five main themes: hydrographic, infrastructure, relief, reserved areas, and vegetation.

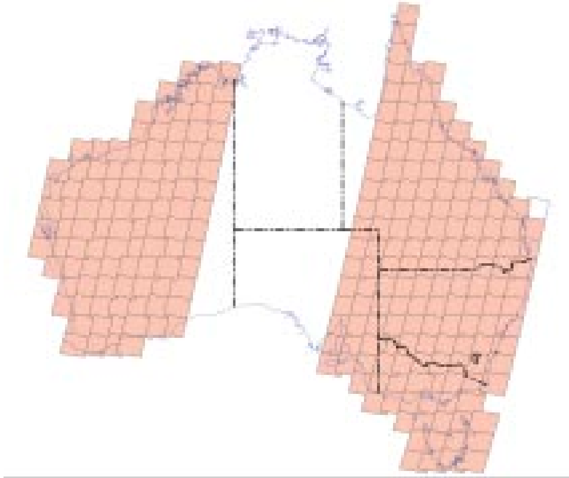
Series 2 is available either as individual tiles that can be downloaded for free from the Geoscience Australia web site, or as state-based packages on CD-ROM.

These separate packages cover New South Wales–Australian Capital Territory, Northern Territory, Queensland, South Australia, Victoria–Tasmania, and Western Australia.

Each package costs $99.00 (including GST). The complete set of GEODATA tiles comprising all packages costs $594.00.

For copies of GEODATA TOPO 250K Series 2 phone +61 2 6249 9966 or Freecall 1800 800 173 (in Australia), or visit the web at www.ga.gov.au/download/

Extra points score greater accuracy in *satellite images*



▲ **Figure 1.** Areas where SCPs are currently used for producing orthocorrected products.

Satellite image data in raw form need to be corrected because they contain location errors from such sources as the rotation of the Earth during image acquisition and the curvature of the Earth.

Geoscience Australia's 'Ortho' products have a high level of location accuracy because they are produced using a digital elevation model to remove terrain relief distortions and ground control points (GCPs) to refine models from spacecraft.

Traditionally, GCPs have been identified from the largest scale topographic maps available. For most of Australia, the maps are 1:250 000 and 1:100 000 in scale with some coverage at 1:25 000 and 1:50 000 in more populated areas.

Ortho products generated using these GCPs are accurate to about $^{+/-}$ 50 metres (1σ), which is sometimes inadequate.

Geoscience Australia has significantly improved the accuracy of Ortho products by using control points derived from GPS measurements. These GPS-controlled points (~25 per Landsat pass) are used to generate a dense network of supplemental points (SCPs) with an associated image chip of 64 x 64 pixels.

Geoscience Australia uses an Optical Data Processing System (ODPS) to automatically correlate the SCPs with the raw data to be corrected, and has significantly improved the positional accuracy of its orthocorrected products and the speed of product generation. The areas where SCPs are currently used are shown in figure 1.

There have been a number of assessments of the location accuracy of orthocorrected products, which show that sub-pixel registration is achievable with the use of SCPs.

This capability is useful for detecting landscape change and any other application that requires comparision of multi-date imagery.

Registration assessment

Eight Landsat ETM^{+} scenes of the Quilpie region in Queensland, acquired between August 1999 and January 2002, were examined to determine the multi-temporal consistency of SCP orthocorrected products.

An intensity-based, image matching technique was used to determine the sub-pixel difference between the scenes. Grided points were randomly selected as candidate matching points (figure 2).

The results show that the mean difference among the eight products is smaller than 0.15 pixel throughout the 28 comparison pairs, and the difference in standard deviation is 0.24–0.47 pixel.

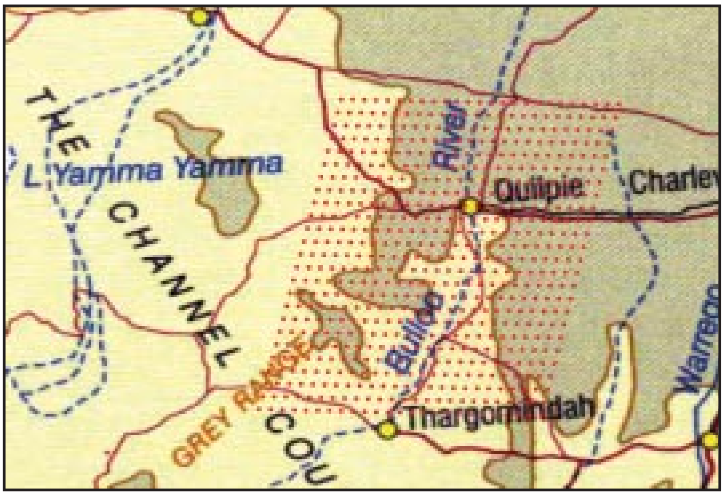
Accuracy assessment

The Department of Land Information, Western Australia conducted an absolute accuracy assessment on orthocorrected imagery in the Kimberley region (figure 3).

Three Landsat 7 scenes were examined (path 109 row 71 acquired in 2001 on May 17, September 6 and October 24). Eighteen evenly distributed checkpoints were identified in each scene, and their locations were estimated to the nearest half pixel (6.25 metres) along the east–west and north–south image axes. The image and ground coordinates of all checkpoints were compared.

The greatest difference measured was 14 metres, with the smallest residuals associated with checkpoints near the centre of the image.

For more information phone Craig Smith on +61 2 6249 9248 or e-mail craigj.smith@ga.gov.au



▲ **Figure 2.** Distribution of the check points around Quilpie in Queensland

▲ **Figure 3.** Distribution of the check points in the Kimberley region assessment

e-atlas an extensive view of minerals industry

The *National Atlas of Mineral Resources, Mines and Processing Centres* brings Australia's most important export industry onto your desk if you can access the internet. With a few mouse clicks, you can locate mines and mineral deposits, and make you own maps.

The electronic atlas is the first of its kind and allows you to take an in-depth look at the minerals industry—its sustainability, performance and contribution to Australia's economic growth.

It has three main sections: history of the minerals industry, information about all major and several minor mineral commodities, and map creation.

Commodity information

The commodity information is presented at three levels: for school students, the general community, and the industry.

'Rockfiles' are designed for school students up to Years 8 or 9. They provide descriptions and 'amazing facts' on 15 metals and minerals. For example, did you know "it was 1751 before nickel was first isolated by a Swedish chemist" or that "During the Middle Ages, lead was among the main exports of England, bartered for spices from the East"?

Mineral Fact Sheets are aimed at the general community and go into more detail about the occurrence, mining and processing of minerals, and provide suggestions for further reading.

Geoscience Australia's annual assessment of Australia's ore and mineral reserves provides industry-level information, which includes international rankings, summaries of significant exploration results, reviews of industry developments and an analysis of mineral exploration expenditure.

The on-line publication, *Australia's Identified Mineral Resources* (AIMR), is integral to the atlas and provides real-time links to mines and company information stored in Geoscience Australia's OZMin database.

The Mineral Fact Sheets and AIMR allow the user to access other web sites or view the location of a mine or deposit and other layers without leaving the atlas.

Making maps

The atlas allows users to search for mines and deposits and create maps with customised layers. The layers include topographic information (e.g. roads, rivers, airports and population centres), geoscience data (e.g. geology, gravity, terrain and magnetics), mineral processing centres, ports, major planned infrastructure projects, power stations, and satellite imagery covering most mines.

Satellite imagery for the entire continent has been processed and should be available in Stage 2.

Next stage

In Stage 2 the on-line performance and design of the atlas will be reviewed. More sophisticated data filtering is to be added to enhance map making, and high-resolution imagery is being considered for major mining centres and other important areas.

New features being considered include a mineral potential layer, the capability to download selected data sets, 3D visualisations of mines and ore bodies, and links to sites dealing with mining and processing methods.

Further information on major discoveries, growth in production, technology milestones, and innovations that characterise so much of the industry's success will also be added.

A long-term objective is to link the atlas to web-based atlases and on-line databases that cover other land uses including agriculture, and themes such as water, soils, climate and vegetation.

Atlas development

In 2001 Geoscience Australia, in consultation with the Minerals Council of Australia, decided that the *Atlas of Australian Resources—Geology and Minerals* published in 1988 needed revision.

The atlas had to be more easily updated and able to deliver authoritative data on known mineral and energy (solid fuel) resources, mines, processing centres and ports in real-time. The data also had to be intuitively laid out and accessible to users with responsibilities in the areas of planning, decision making, education, investment and environmental management.

The project won financial support through the Department of Industry, Tourism and Resources' Regional Mineral Program.

Stage 1 was a collaborative venture of Geoscience Australia, the Minerals Council of Australia, and the department through the Regional Minerals Program. The atlas web site was launched in June this year. Stage 2 should be completed in 2004.

Feedback about the atlas is important for Stage 2. A feedback form is accessible from any screen of the atlas web site.

For more information phone Bill McKay on +61 2 6249 9003, e-mail bill.mckay@ga.gov.au or visit www.nationalminesatlas.gov.au

New option for NATMAP product

You are now offered two choices with the latest NATMAP Raster 250K products: unjoined map sheets, or maps joined as a mosaic.

Both products consist of two CDs that include all 513 topographic map sheets covering the whole of Australia at 1:250 000 scale.

The individual maps in NATMAP Raster 250K Mapsheets have accompanying map information, and can be used for measuring distances and areas.

NATMAP Raster 250K Mosaic, however, is not suitable for measuring distances or areas because all coordinates are in latitude/longitude.

The products are compatible with most GIS and can be easily exported to a number of widely supported image formats. They are also compatible with GPS software such as OziExplorer or TrackRanger.

Both products include all published paper maps up to August 30 of which more than 400 maps were released since October 2000. The Mosaic also includes a single map image of all 1:1 million scale NATMAPs and a Landsat satellite image of Australia.

The maps were created by converting digital data into images rather than by scanning, to ensure positional accuracy. The images are in 24-bit colour and have a resolution of 200 dpi (equivalent to 32 m).

Most map images cover a grid of one degree of latitude by 1.5 degrees of longitude (approximately 110 km x 130 km). Some extended sheets cover larger areas. Map insets are stored as separately georeferenced images.

Both products come with map viewing software called RASTER VIEWER that allows the user to zoom and pan over the maps and indicates the location of the area on display relative to the surrounding region and the rest of Australia.

A major feature of the NATMAP Raster 250K Mapsheets is the map roamer, which allows the user to follow a feature across map sheets by loading the neighbouring map at the map view scale and correct location. The whole map or the currently displayed area can be printed with the coordinates and a scale bar.

Coordinates can be displayed in MGA, AMG and latitude/longitude, on either the Geocentric Datum of Australia (GDA94) or older Australian Geodetic Datum (AGD66).

Each product costs $99.00 (including GST) from Geoscience Australia or its map retailers.

PULL-OUT IN THIS ISSUE

Unique view of Australia

This view of Australian land cover at 1:5 million scale shows Australia in pseudo-natural colour. In general, forests are dark green, healthy crops and pastures are light green, bare earth and dry vegetation are red-brown-yellow tones, and water is blue.

The image was compiled from 369 Landsat 7 scenes acquired by Geoscience Australia (ACRES) between July 1999 and September 2000 for the Australian Greenhouse Office's National Carbon Accounting System.

Geoimage joined the scenes together to create a mosaic, which Geoscience Australia published as a large glossy poster (approximately 93 cm x 84 cm).

The National Carbon Accounting System is the reference for reports on Australia's greenhouse gas emissions for the National Greenhouse Gas Inventory and the Kyoto Protocol. It is also used for emissions trading discussions and for emissions projections.

The large version of this poster is available from the Geoscience Australia Sales Centre, ACRES distributors and Geoscience Australia map retailers for $16.