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AUSGEO news
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CEO *comment*

Neil Williams – CEO Geoscience Australia

In the September issue of *AusGeo News* I reported on the Prime Minister's Energy Security Initiative which included the injection of $134 million in new program funding into Geoscience Australia over the next five years. This includes $75 million to continue offshore frontier basin research to identify a new oil province as well as $59 million for the application of the latest geophysical imaging and mapping technologies to attract investment in exploration for onshore petroleum, geothermal and energy mineral sources.

This issue contains reports on progress to date in the implementation of the program. Meetings with national and international petroleum exploration companies to discuss potential frontier areas for inclusion in the new offshore program are currently being held. Consultations have been held with the state and Northern Territory geological surveys to develop a 'first pass' program for the onshore initiative detailing the national data acquisition work to be done, including where and in what order. Consultations with industry will follow.

New geoscience datasets developed during the Tanami-North Australia Project will provide a better understanding of the evolution and metallogenesis of this area and will greatly assist the exploration industry's search for gold and base metals. A major focus of the project was the refinement of geology, geochronology, geochemistry and controls on lode-gold mineralisation in the Tanami region. The six-year project was carried out in collaboration with the Northern Territory Geological Survey and the Geological Survey of Western Australia.

Geoscience Australia is making a major contribution to marine research which is helping to characterise and protect the valuable marine environment within Australia's marine jurisdiction. A major article outlines research to develop methodologies to predict marine biodiversity using geoscience information on the nature of the seabed. This article also places the research in an international context. Another article examines the use of physical parameters such as the morphology of the seabed, the water depth and the sediment properties to define and map distinct marine habitats.

There is also a report on the recently completed detailed spatial analysis of seabed environments in the Great Barrier Reef Marine Park which will provide baseline information that can be used to monitor potential changes to seabed habitats and biological communities.

Another article outlines how turbidity modelling in Torres Strait to explain seagrass dieback is contributing to a better understanding of biophysical processes in the strait. In related news Geoscience Australia is also contributing to a major international effort to define the biodiversity of Antarctic waters.

This issue includes a report on the preliminary investigations of Amplitude Versus Offset (AVO) anomalies in two proven gas areas which suggest the technique may have value in evaluating the exploration potential of the North West Shelf. Nickel explorers will be greatly assisted by a new map which summarises the major known Proterozoic mafic and ultramafic events and associated mineral deposits in Western Australia.

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

Neil Williams

Contents

ISSUE 84 Dec 2006

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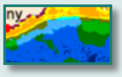
CEO comment **1**


Extra $75m for offshore oil work **3**
Energy Security Initiative boosts exploration


Onshore Energy Security Program underway **5**
New insights will encourage exploration


Tanami – North Australia Project wraps up **9**
New datasets reveal geological evolution and mineral systems of North Australian Craton


Classifying Australia's seascapes for marine conservation **13**
Geoscience data predicts seabed biodiversity


Mapping marine diversity **19**
Habitats are keys to conservation management


Great Barrier Reef Marine Park sedimentology revealed **25**
New research into inter-reefal environments will assist reef managers


Let there be light **31**
Turbidity modelling in Torres Strait explains seagrass dieback


Looking for life below the sea ice **34**
New project assesses biodiversity in Antarctic seas

In Brief **36**
More than a map 36
Landslide Database Interoperability Project 37
Geoscience Australia's new Cadetship scheme 38

Product News **39**
Reprocessing shows AVO potential for petroleum exploration 39
New Map for nickel explorers 40
Explore Australia's vast marine environment 41
New satellite imagery for Australia 41

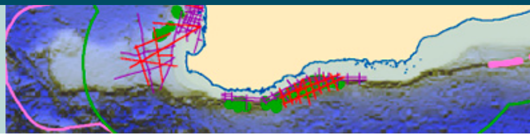
Events 2007 43
Citizen's Science celebrated 44

Australian Government
Geoscience Australia

AUSGEO news
ISSUE 84 Dec 2006

Extra $75m for offshore oil work

Energy Security Initiative boosts exploration



Clinton Foster

On 14 August 2006, the Prime Minister announced $134 million in additional funding for Geoscience Australia as part of the Australian Government's Energy Security Initiative. This new funding, which will extend from 2007 until 2011, includes $75 million to continue Geoscience Australia's offshore frontier basin program to identify a new oil province. The program will support the annual offshore acreage releases for the next five years by providing precompetitive information, acquiring new geophysical (such as 2D seismic) and geological data, and improving data access for the exploration industry.

> "Meetings with national and international companies will take place over the next few months."

The initiative builds on the $61 million 2003–07 Big New Oil Program, but at an accelerated pace. In contrast to the 2003–07 program, which included $10 million for remastering of existing seismic data and $15 million for new data acquisition, the new program allocates over $60 million for new data acquisition, reprocessing, interpretation and access. Staffing levels will increase so that project teams can run concurrently in an expanded program.

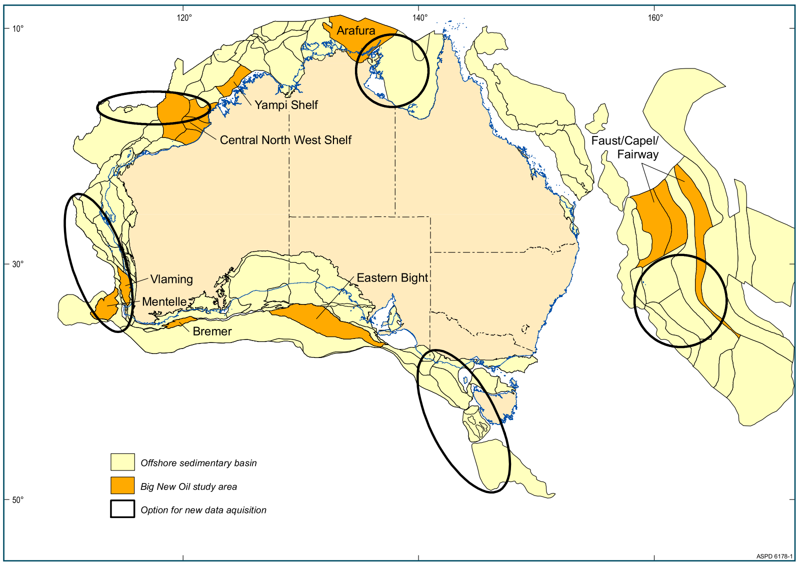


Figure 1. Areas studied in current Big New Oil program and options for new data acquisition.

Geoscience Australia has prepared a portfolio of potential offshore frontier areas for discussion with industry (figure 1). Likely areas for inclusion in the new program are deepwater frontier areas, such as the Mentelle Basin and offshore northern Perth Basin, off southwestern Australia; the Capel, Faust, Fairway, Gower and Moore Basins of the southern Coral Sea; and the Sorell Basin / South Tasman Rise region off western Tasmania. Options for data acquisition in older, more complex basins in shallow waters of western and northern Australia are also being considered.

Industry consultation began with a presentation of the proposed portfolio to the Australian Petroleum Production and Exploration Association (APPEA) Technical Committee in Perth on 10 November 2006. Meetings with national and international companies will take place over the next few months, and planning should be finalised by the end of March 2007.

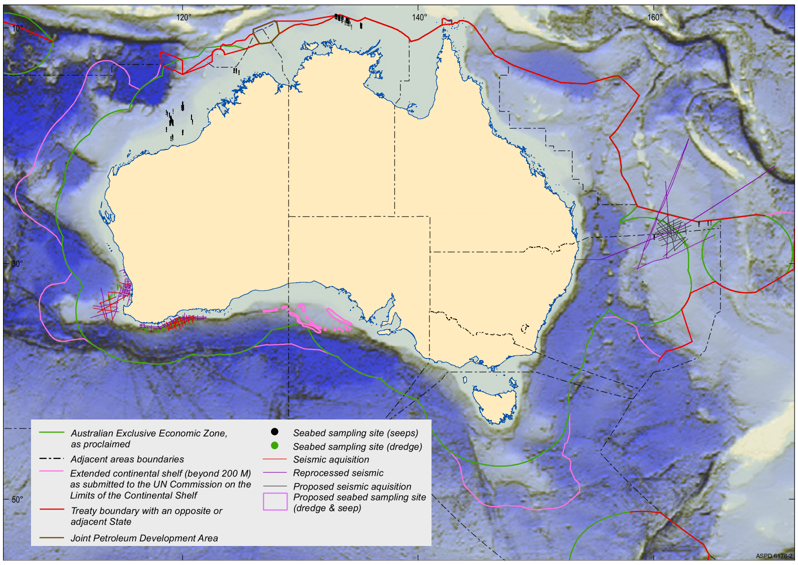


Figure 2. Data types collected in current Big New Oil program.

"The new 2007–11 program will use and expand this tool kit to elucidate the petroleum geology of frontier basins."

Acquisition of new regional 2D seismic data in frontier basins has been the cornerstone of the 2003–07 program, augmented by reprocessing of previously acquired seismic data, geological sampling and natural hydrocarbon seep detection. Technologies employed to sample and image the water column, seafloor and shallow subsurface, include coring and dredging, sub-bottom profiling, swath-mapping and side-scan sonar (figure 2). Remote sensing data—synthetic aperture radar, Landsat and hyperspectral—have been collected to detect evidence of seepage on the sea surface, while the deep subsurface has been imaged with reflection and refraction seismic and gravity and magnetic data.

The new 2007–11 program will use and expand this tool kit to elucidate the petroleum geology of frontier basins. Geoscience Australia will improve access to precompetitive information by providing workstation-ready seismic data packages covering new acreage release areas, and by developing online or near-online access to seismic data held by the organisation.

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www.ga.gov.au/ausgeonews/ausgeonews200503/bignewoil.jsp
link

Australian Government
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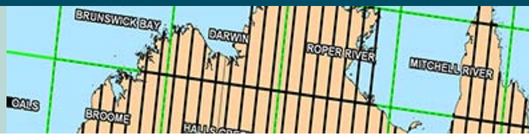
AUSGEO news
ISSUE 84 Dec 2006

Onshore *Energy Security Program underway*



New insights will encourage exploration

James Johnson

A program to acquire pre-competitive geoscience information for onshore energy prospects has begun following the Prime Minister's Energy Security Initiative.

The initiative provides $58.9 million over five years for the acquisition of new seismic, radiometric, magneto-telluric and airborne electromagnetic (EM) data to attract investment in exploration for onshore petroleum, geothermal, uranium and thorium energy sources. A further $75 million will fund data acquisition to encourage offshore petroleum exploration.

Many of Geoscience Australia's Minerals Division scientists have been scoping programs for the onshore initiative, which will run to June 2011. A 'first-pass' program detailing work to be done, where and in what order, is close to completion. The initial scope will be modified through several iterations in consultation with industry stakeholders.

> "The proposed radiometrics program will significantly increase the value of the National Gamma-ray Spectrometric and Magnetic databases."

Key criteria identified

All onshore elements of the program will be under the banner of the National Geoscience Agreement between the states, the Northern Territory and the Commonwealth Government, requiring a high degree of consultation between Geoscience Australia and state and territory geological surveys.

A set of principles has been circulated, listing the criteria that will be used to decide which programs will proceed. Key criteria are:

- Projects will produce outputs aimed at promoting investment in exploration for energy-related resources, especially in greenfields areas.
- Project outputs will be aimed at improving discovery rates for energy-related resources.
- Projects will be of national or strategic importance.

Consultation with the states and Northern Territory was completed in November. A draft plan for the program includes ~7000 line kilometres of new seismic data, around 190 000 kilometres of airborne EM data and 140 000 kilometres of new gamma-ray spectrometric (commonly referred to as radiometric) data.

Radiometrics to track geothermal energy sources

Radiometric data are useful in the detection of concentrations of uranium, thorium and potassium, all of which are indicators of high-heat-producing granites that are potential sources of geothermal energy.

The proposed radiometrics program will significantly increase the value of the National Gamma-ray Spectrometric and Magnetic databases. Existing airborne gamma-ray surveys contained in the National Radiometric Database are not consistent with a common datum. This severely limits their usefulness because surveys are not easily combined into regional-scale compilations and quantitative between-survey comparisons of radiometric signatures are difficult. The solution is to 'back-calibrate' all surveys in the database using a well-calibrated airborne spectrometer system. While Australia has a world-class airborne magnetic database, wavelengths in the 100 to 500 kilometre band are not accurately represented because of the nature of the original data acquisition. Long traverses at 75-kilometre spacing would allow these wavelengths to be accurately recovered for a variety of valuable scientific purposes.

The solution to both these problems is to fly an Australia-wide airborne geophysical tie-line survey (AWAGS 2). Acquisition will take place in 1:1 000 000 map sheet blocks with 400-kilometre line segments separated by 75-kilometre line spacing (figure 1). The AWAGS 2 data will be used to match all gamma-ray spectrometric data to the same common datum and to recover the wavelengths that are currently corrupt in the National Magnetic Database.

"The AWAGS 2 data will be used to match all gamma-ray spectrometric data to the same common datum"

The improved datasets will lead to an increased understanding of the geology, structure, geochemistry and geomorphology of the continent.

Levelled and calibrated datasets will directly assist uranium and thorium exploration by allowing quantitative comparisons of radiometric signatures from different surveys. Furthermore, in areas of solid rock outcrop, knowledge of the distribution of potassium, uranium and thorium in absolute concentrations is important in determining absolute heat production and modelling heat flow.

These data will also aid research in land-use modelling,

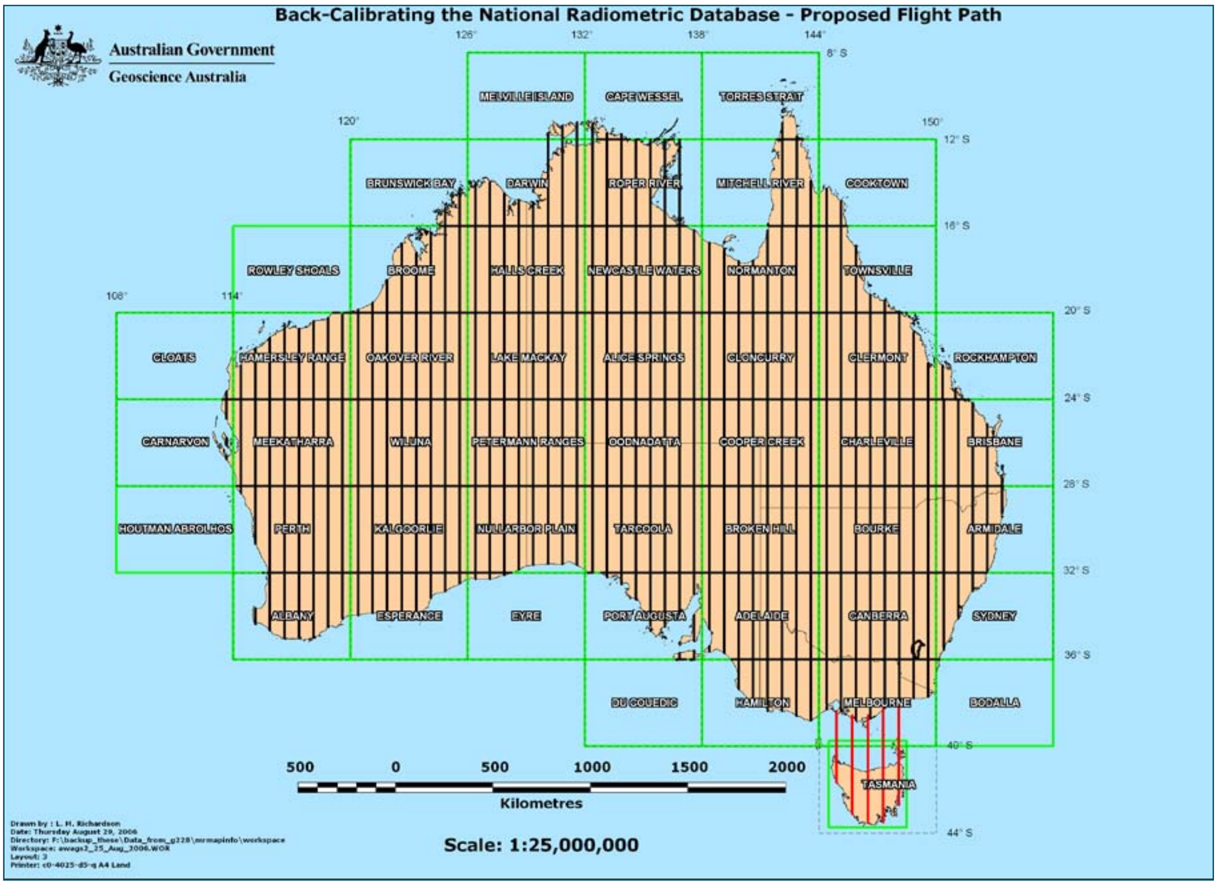


Figure 1. Proposed flight line pattern for the AWAGS 2 magnetics and radiometrics survey to back-calibrate the National Radiometric Database

sustainability, agricultural and forest productivity, radiation risk, mineral exploration, regional geology, regolith and soils.

Improvements in the airborne magnetics dataset will provide increased resolution of the magnetic structure in the lower crust and large geologic features, an accurate regional magnetic field for shallower crustal studies, and further refine our understanding of mechanical properties of the lithosphere. These benefits will help to identify favourable areas for energy, thermal and mineral resources, and aid in the mitigation of geological hazards.

Seismic acquisition for minerals and hydrocarbons

The seismic acquisition program will provide a whole-of-crust, structural understanding of regions with enhanced mineral and hydrocarbon energy potential. Seismic acquisition will be used in Palaeoproterozoic provinces with higher uranium potential and high-heat-producing granites as possible sources of geothermal energy. These include the Curnamona, Gawler, Pine Creek–Rum Jungle, Capricorn, Mt Isa and Georgetown regions. Seismic acquisition began in the Eastern Succession of the Mt Isa Block in November 2006, and will move to Georgetown in 2007.

The program will also target basins with perceived hydrocarbon potential where a seismic stimulus is required to encourage exploration. The Lander Trough in Central Australia, the Kidson and Gregory sub-basins of the Canning Basin, and the Arrowie Basin are currently high priorities.

"The work will reduce the technical risks of exploration, especially in terrains where the current level of information is poor due to old or substandard basic datasets."

Airborne EM for uranium

Airborne EM acquisition will target palaeochannels and seek to identify graphitic horizons in schists buried beneath unconformities, both of which have potential for uranium mineralisation. Regions of enhanced uranium prospectivity where airborne EM acquisition will be used include the Western Gawler, Curnamona–Mt Painter, Rum Jungle, Mt Isa–Georgetown, Paterson and Pine Creek regions. Acquisition parameters will vary, but the emphasis will include regional surveys with wide line spacing to provide a better regional framework for exploration.

Tenders called

Tenders for the Australia-wide radiometrics program closed on 1 November 2006. Geoscience Australia expects acquisition to begin in February–March 2007 and to be completed by May 2008. The request for tender document for the airborne EM and seismic programs will involve separate deeds of standing offer arrangements, similar to the current system for airborne magnetics, radiometrics and gravity acquisition.

We expect airborne EM acquisition to begin by March–April 2007. Seismic surveys in the 2006–07 financial year will involve acquisition under the current Australian National Seismic Imaging Resource arrangements, while the deeds of standing offer document will be used to arrange contracts in subsequent years. Over the coming months, tenders will be let for data acquisition programs to cover the first stage of the program, the locations of initial surveys will be finalised, and magneto-telluric programs will be scoped.

National benefit

This marks the start of an exciting period of national data acquisition to benefit the Australian energy and minerals sectors. The work will reduce the technical risks of exploration, especially in terrains where the current level of information is poor due to old or substandard basic datasets.

The new data will give explorers new insights into Australian's petroleum and mineral potential, and are expected to identify new exploration plays and encourage exploration in greenfields provinces.

The data will also provide a substantial input to new regional and continental-scale geological syntheses and research that will provide new insights into controls on Australia's mineral and petroleum systems and their potential.

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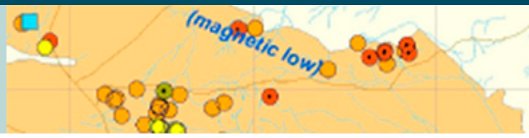
ISSUE 84 Dec 2006

Tanami – *North Australia Project wraps up*

New datasets reveal geological evolution and mineral systems of North Australian Craton



David Huston

A six-year collaborative study has produced major changes in our understanding of the geological make-up and mineral potential of the North Australian Craton. Now available on CD-ROM from Geoscience Australia, this new window into the evolution and metallogenesis of this important region is the result of the Tanami – North Australia National Geoscience Accord Project involving Geoscience Australia, the Northern Territory Geological Survey (NTGS) and the Geological Survey of Western Australia (GSWA).

Extensive collaboration

The North Australia Project began in July 2000, when NTGS geoscientists briefed Geoscience Australia geoscientists on the geology of the Arunta region during a 10-day field trip. The NTGS provided in-depth knowledge of the geology of the area gained from regional and more detailed mapping, while Geoscience Australia added specialist knowledge in geochronology, geochemistry and metallogenesis. In 2004, the GSWA joined the project to map the western Tanami region, making the North Australia Project one of the first National Geoscience Accord projects to cross state boundaries.

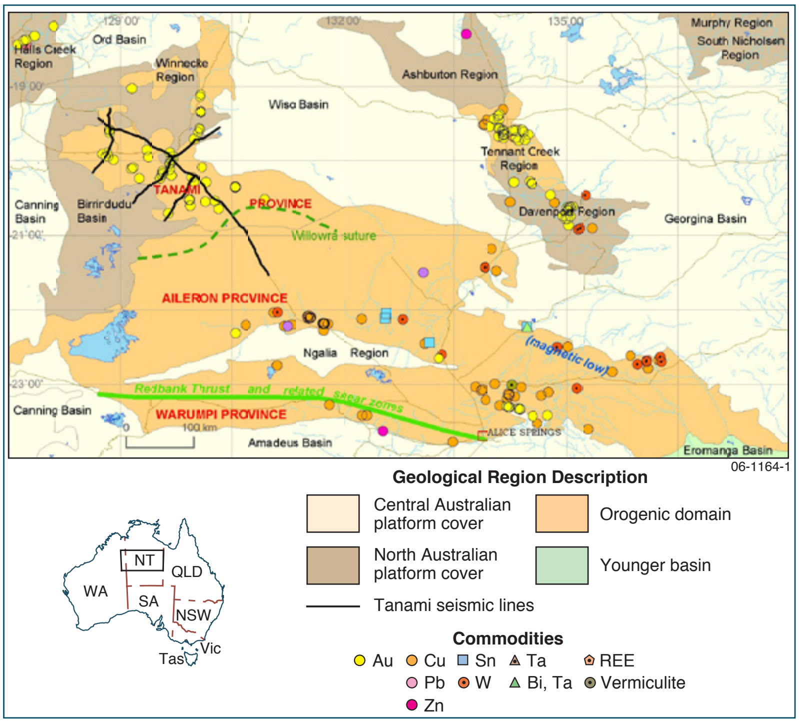


Figure 1. Map showing the North Australia-Tanami Project area.

For Geoscience Australia, a major focus in the project has been the collection of new geochronological data, including data to constrain the age and correlation of supracrustal volcanic and sedimentary units, felsic and mafic intrusive bodies, and mineral deposits. This program, which involved collaboration with the NTGS, the Australian National University and Curtin University, increased the geochronological database for the Arunta, Tanami and Tennant regions by over 300 dates. These regions now have well over 500 dates, making the North Australian Craton one of the best studied Proterozoic provinces in the world. These data will serve as a cornerstone for future synthesis studies and provide a basis for developing exploration models.

Another significant result was the correlation of the Lander 'package' of turbiditic sedimentary rocks with the Tanami Group, the major host for gold in the Tanami gold province. The correlation suggests that potential for lode-gold mineralisation extends south into the poorly exposed western and northern Arunta. This potential has been confirmed by Tanami Gold's recent success at the Tekapo prospect, which returned an intersection of 16 metres grading 3.4 g/t Au.

"major conclusions of this study, include the identification of a major suture between the Tanami and Aileron provinces"

New models for Tanami gold

A second major focus of the project has been the refinement of geology, geochronology, geochemistry and controls on lode-gold mineralisation in the Tanami region. This program, which involved close collaboration with the NTGS and GSWA, extended regional geological mapping to include studies on the fluid history, geochemistry, structure and ore controls of lode-gold deposits. This has led to descriptive models for deposits in The Granites, Dead Bullock Soak and Tanami goldfields and holistic models of structural, stratigraphic and geochemical controls on gold mineralisation. The results have been published in *NTGS Report 17* and in an upcoming *Mineralium Deposita* special issue on the Tanami gold province.

Our geological, geochronological and geochemical studies of the Tanami region have been followed up by the acquisition of 720 kilometres of land seismic data (figure 1) to establish the architecture of this major Proterozoic gold province. Two major conclusions of this study, to be described in more detail in the next issue of *AusGeo News*, include the identification of a major suture between the Tanami and Aileron provinces and the recognition that mineral deposits in the region are associated with major crust penetrating shear zones and/or anticlinal stacks (figure 2). The suture, which corresponds spatially to the Willowra gravity ridge, has a classic crocodile form and juxtaposes Aileron province crust with a characteristic north-dipping structural grain against Tanami crust to the north and west. As rocks of the correlated Tanami–Lander package blanket this suture, collision of the Tanami and Aileron crust is interpreted to have happened prior to ~1840 Ma.

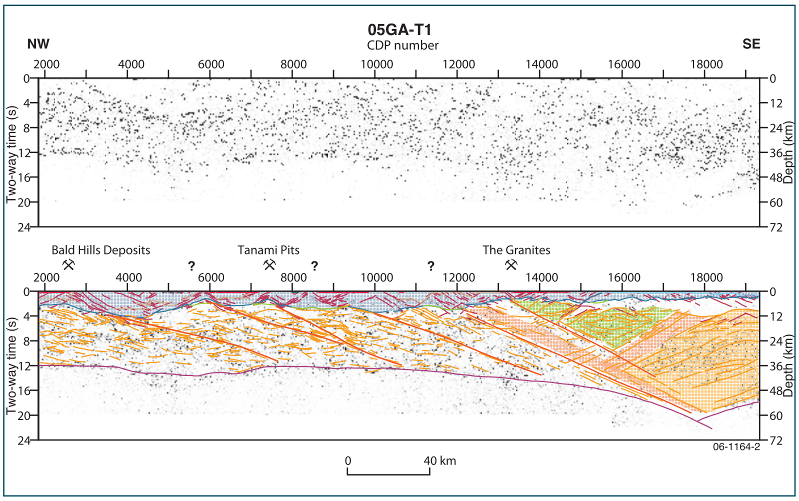


Figure 2. Seismic data and interpretation of line 05GA-T1, Tanami region, northwestern Australia.

Firmer dates for Tennant magmatism

Outside the Tanami region, the project undertook work in the Tennant and Arunta regions (figure 1). In the Tennant region, dating of felsic magmatic rocks, including granites and porphyries, has indicated that the Tennant magmatic event was restricted in time to between 1850 and 1845 Ma. This result, although consistent with previous results of Compston (1995), indicates a much tighter constraint on the age of granite emplacement.

Recalculation of Ar–Ar isotopic dating results for ore-related muscovite from Compston and McDougall (1994) to account for updates to standards and decay constants yielded ages between 1850 and 1845 Ma. This suggests that gold–copper–bismuth (Au–Cu–Bi) mineralisation at Tennant Creek coincided with felsic magmatism of the Tennant magmatic event (figure 3).

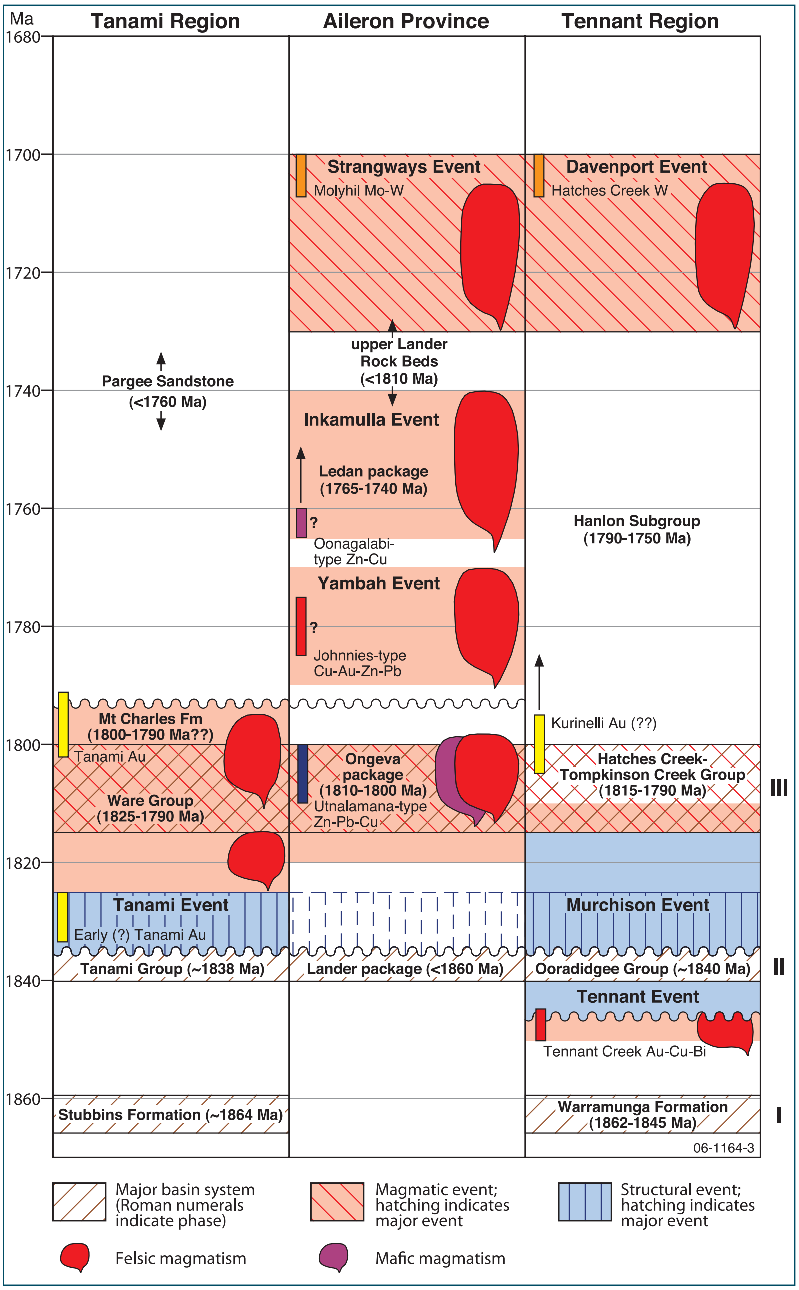


Figure 3. Space-time diagram showing basin forming, magnetic, structural and mineralising events in the Tanami, Arunta and Tennant regions between 1870 and 1680 Ma.

Arunta region potential

One of the first studies undertaken as part of the North Australia Project was an assessment of the Arunta region for mafic–ultramafic orthomagmatic nickel – copper – platinum group elements (Ni–Cu–PGE) mineralisation. Initial results suggested that the western Arunta has moderate potential for Voisey's Bay-type basal Ni–Cu segregations, whereas the eastern Arunta has moderate potential for Merensky Reef-type strataform PGE-bearing sulphide layers. Associated geochronological studies suggest that the mafic–ultramafic bodies were emplaced during three major periods: 1811–1803 Ma (during the Stafford Event), 1787–1774 Ma (during the Yambah Event) and 1639–1633 Ma (during the Liebig Event). Forward modelling of potential field data indicates that many of the ultramafic–mafic intrusions are under relatively shallow cover.

To establish the origin and potential of small base metal ± gold deposits in the Strangways Ranges of the eastern Arunta, NTGS and Geoscience Australia undertook a systematic program of mapping and sampling the deposits. Based on those studies, it was concluded that, as previously interpreted by Warren and Shaw (1985), many of the deposits were volcanic-hosted massive sulphide deposits that formed within 1810–1801 Ma volcaniclastic rocks that were deposited during the Stafford igneous event. However, several prospects associated with massive ironstone bodies, including Johnnie's Reward and possibly some of the Jervois deposits, were interpreted as iron oxide – Cu – Au deposits formed during the Yambah igneous event at 1795–1780 Ma. In addition, the Oonagalabi Cu–Zn prospect was interpreted as a carbonate-replacement deposit formed during an Inkamullah igneous event at 1760–1740 Ma.

Results synthesised for North Australia Craton

The final aspect of the project was to synthesise individual results into an overall understanding of the geologic and metallogenic development of the North Australia Craton. The results of this synthesis are presented in figure 3. Between ~1865 and ~1800 Ma, the Tanami–Tennant–Arunta region was characterised by the development of three basin systems at ~1865–1860 Ma, 1840–1835 Ma and 1815–1800 Ma. Although the earliest basin system appears to be restricted to the Tanami and Tennant regions, the two later basin phases are present in all regions. Sedimentary rocks deposited during the second phase are most widespread, making up large parts of all regions.

"These deposits produced over 5 million ounces of gold"

All thermotectonic events—with the possible exception of the Liebig event—in the Tanami, Tennant and Arunta regions are associated with significant mineralisation. Iron oxide – copper – gold deposits in the Tennant Creek and Rover goldfields are associated with the Tennant igneous event at 1850–1845 Ma. These deposits produced over 5 million ounces of gold in addition to significant copper, bismuth and selenium. Their high grade and polymetallic character make them attractive exploration targets, particularly in the Rover field, which until recently had not been actively explored for several decades.

The major mineralising event in the Tanami region occurred at the end of the Stafford event at 1803–1791 Ma. This lode-gold event produced a global gold resource of over 12 million troy ounces, and is currently interpreted to relate to the shift from convergence along the northwest margin of the North Australia Craton to convergence along the southern margin. It is likely that small discoveries in the north and west Arunta (Tekapo, Dodger and Falchion–Sabre) are associated with this event, and recent dating of deposits (Rasmussen et al 2006) in the Pine Creek region to the north indicates similar (within error) but slightly younger ages (~1780 Ma).

Results published

The North Australia and Tanami projects have generated extended datasets that provide a better understanding of the geological evolution and mineral systems of the North Australia Craton. A compilation of these new data and results has been published as Geoscience Australia Record 2006–17 (available on CD-ROM), while GIS datasets for the Tanami – north Arunta, Tennant and south Arunta regions are available on DVD. All products are available from the Geoscience Australia Sales Centre on Freecall 1800 800 173 (within Australia) or +61 2 6249 9966 (email mapsales@ga.gov.au).

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Evolution and metallogenesis of the North Australian Craton conference abstracts
North Australia Project results and products
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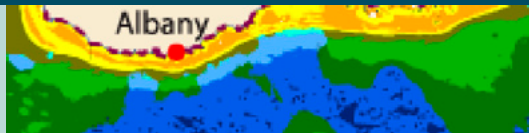
ISSUE 84 Dec 2006

CLASSIFYING *Australia's seascapes for marine conservation*

Geoscience data predicts seabed biodiversity



Andrew Heap

We know very little about the biodiversity of the seabed. Much of it, especially the deep seabed, is poorly known and unexplored. While evolutionary history and local conditions can be used to reliably predict the distribution of species on land to underpin landscape management, the same cannot be said for the seabed.

Geoscience Australia is leading research to develop methodologies to predict marine biodiversity using geoscience information. A crucial first step is to characterise seabed habitats accurately from geological and oceanographical data. The procedure adopted is inspired by the shelf classification applied in eastern Canada by Roff et al (2003), who used physical properties (sediment type, physiography, bed roughness, wave and current regime) to define ecologically meaningful habitats on the Scotian Shelf.

This approach is based on the premise that community types exploit the availability of any given habitat (Day & Roff 2000). Although the species occupying each habitat may be different because of environmental and biological factors (e.g. competition, predator–prey relationships), the overall community types are recognisable and can be predicted from physical properties.

Predicting marine biodiversity is confounded because many marine ecosystems have been altered by human activities, but the degree to which they have been altered is poorly known.

Australia's seascapes

The oceans cover 71% of the Earth's surface, or nearly 350 million square kilometres. Australia's marine region accounts for 4% of this area—about 14 million square kilometres, nearly twice Australia's land area. While land plants and animals can be observed directly, most of Australia's marine plants and animals are not easily accessible or observable. With current technologies, it is impossible to observe all of Australia's marine biodiversity, and it is impractical to classify and count every organism in the ocean.

To make informed decisions about the conservation and sustainable use of Australia's marine resources would require high-quality biological data across the nation's entire marine region, but such data do not exist. To make decisions now, managers must use what is available. Currently, only physical datasets such as those collected by Geoscience Australia are detailed enough to be extrapolated over Australia's entire marine region. Individually, physical data are not always informative, but when combined with other physical datasets to produce 'seascapes' they can effectively represent the spatial distribution of marine biodiversity.

The approach of developing seascapes from physical datasets leads to a series of universal research questions being addressed by Geoscience Australia and the international scientific community:

- What physical variables are the most useful for predicting marine diversity?
- How can the individual physical data layers be integrated into a single seascape?
- How can seascapes help design a national system of representative marine protected areas?

Table 1. Datasets used in the construction of the seascapes in Australia's marine region

Dataset		Data type	Product
Bathymetry (m)	»	Continuous interpolated data	Seascapes
Gravel (>2 mm) content (%)	»		
Mud (<0.63 μm) content (%)	»		
Seabed disturbance ((Nm–^{2})$^{1.5}$)	»		
Slope (°)	»		
Seabed temperature (°C)	»		
Primary productivity (g Carbon m^{-2} a^{-1})	»		
Geomorphology	»	Categorical data	Focal variety analysis

Physical surrogates

The assumption that physical properties can be used as surrogates to represent marine biodiversity is central to the seascapes approach. While linkages between the physical environment and biota seem intuitive, understanding how the biota relates to physical properties is only half the story. It is equally essential to identify which physical properties are relevant. To date, physical properties that show the strongest relationship with the biota (as defined by some measure of goodness of fit) are considered to be most relevant as surrogates for biodiversity.

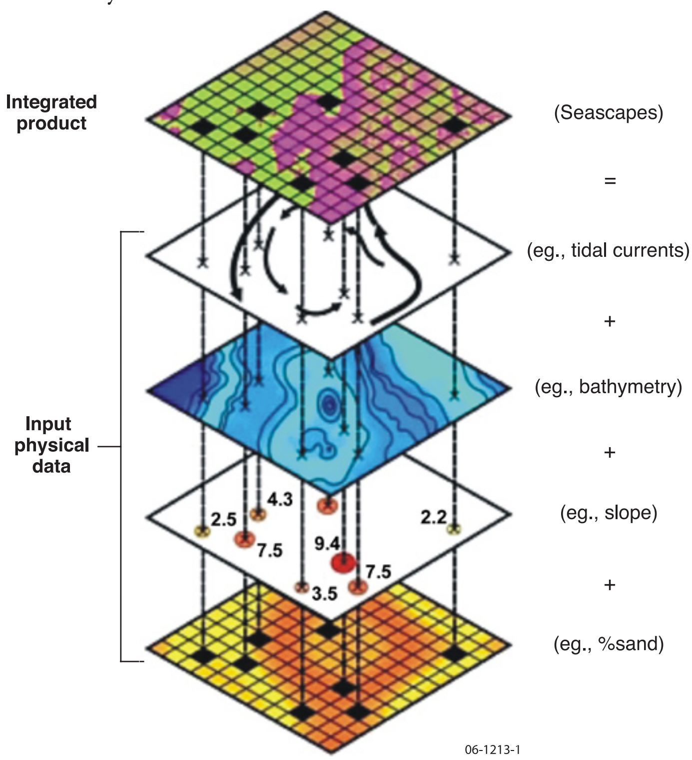


Figure 1. Seascapes represent a combination of different physical data that have an identifiable and consistent relationship with marine biota.

The influence of physical properties on seabed communities is clear and well documented. Relationships between physical properties and biota have been shown to exist in many studies of the marine environment (e.g. Thouzeau et al 1991, Snelgrove & Butman 1994, Williams & Bax 2001, Ramey & Snelgrove 2003). These studies show that, broadly, seabed biota have measurable and consistent relationships with many easily measured physical properties (table 1).

A Geoscience Australia study of associations between sediment properties and benthic biota in the southern Gulf of Carpentaria (Post et al 2006) shows that spatial changes in seabed biota are strongly related to mud and gravel content, seabed disturbance from waves and currents, water depth, and geomorphology.

Defining seascapes

While surrogacy studies provide important clues to how the biota are related to physical properties and which physical properties are most relevant, those studies are at a spatial scale that is too small to help managers make informed decisions about the conservation and sustainable use of Australia's entire marine region. We must take the results of these studies and extrapolate them over larger distances by creating seascapes.

Seascapes describe a layer of ecologically meaningful physical properties to spatially represent potential seabed habitats (figure 1). Each area of a seascape corresponds to an area of similar physical properties and, by association, habitats and communities. Geoscience Australia has used physical properties that have consistent relationships with the biota (table 1) and are known in sufficient detail across Australia's entire marine region (figure 2) to create seascapes for the region (figure 3).

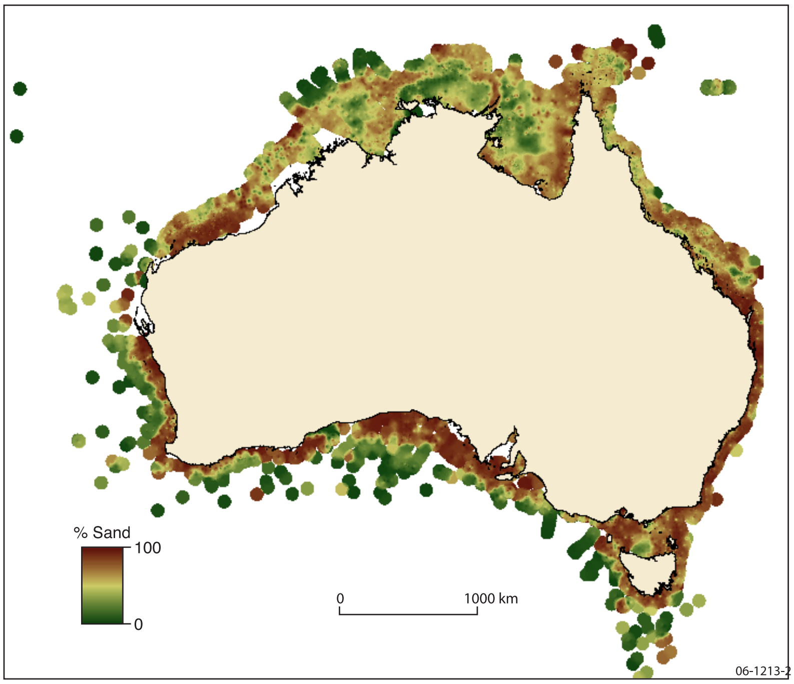


Figure 2. Physical data such as % sand can be extrapolated across vast areas of Australia's marine region.

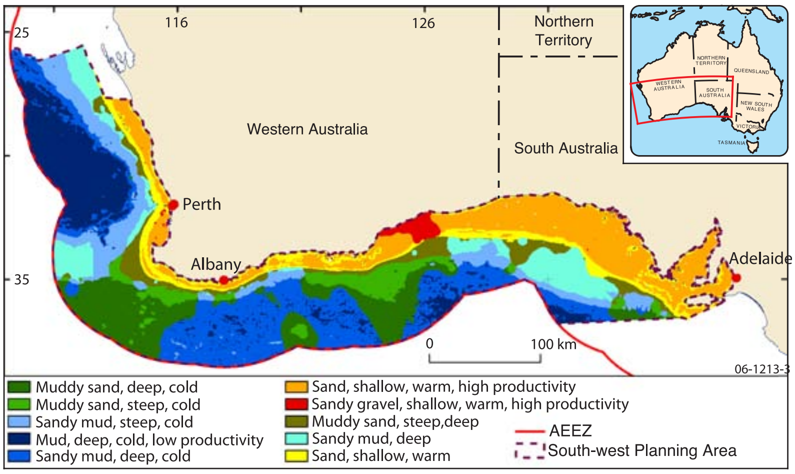


Figure 3. Each of the 10 seascapes derived for the South West Planning Region are defined by a diagnostic combination of physical properties.

The integration of these data to create seascape maps has been accomplished through an unsupervised classification, whereby all the data are combined with no prior assumptions about how each of the variables influences the biota. The process iteratively classifies the data into separate classes—based on statistical relationships—and continues until 100% of the classes are unchanged between iterations. The result is a number of mutually exclusive seascapes (figure 3).

Using this approach, the South West Planning Region contains a total of 10 separate seascapes, each defined by a diagnostic combination of physical properties. For example, the 'muddy sand steep deep' seascape is characterised by at least 50% sand and 20% mud, with relatively rugose and deep seabed topography. Interestingly, this seascape characterises those areas where numerous submarine canyons have incised the margin.

A major factor in defining seascapes is the method by which underlying physical property data are interpolated across Australia's marine region. Evaluation of two of the most diagnostic physical properties (gravel and mud percentage) using different interpolation techniques reveals that, while the overall fit of the interpolated surface across Australia's entire marine region is moderate (about 60%), the differences in

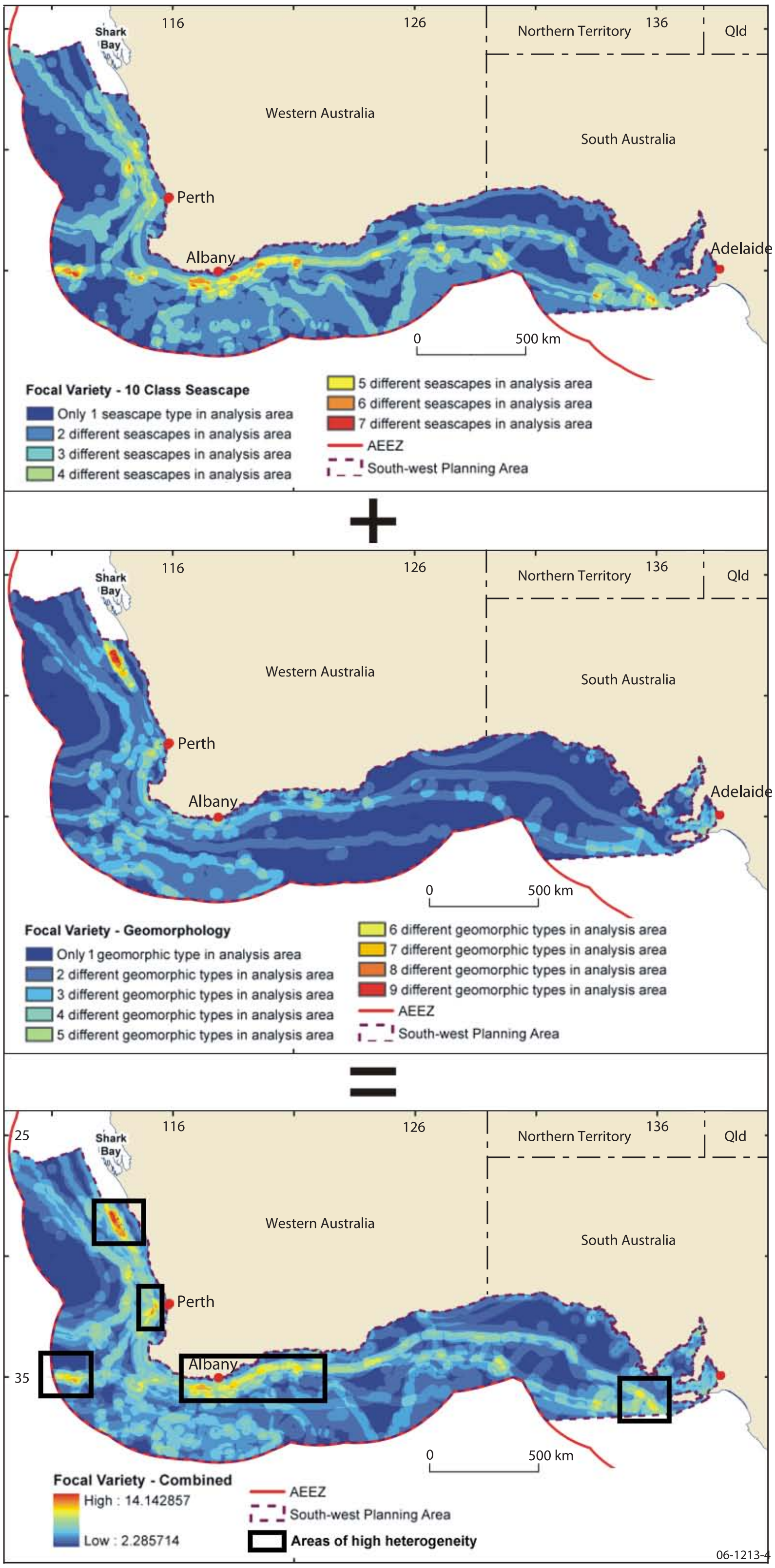


Figure 4. The selection of marine protected areas can be aided by a focal variety analysis of the seascapes and geomorphology to produce a map showing where the greatest seabed diversity occurs.

the underlying data produced by different interpolation methods are very small (less than 3%). Also, the effects of using different interpolation methods on the shape, distribution and area of the final seascapes are not significant. These results mean that the approach is relatively robust.

Geoscience Australia, together with Australia's marine biological research community, is currently working to correlate the seascapes with available biological information. The outcome will be ecologically meaningful seascapes that estimate the marine biodiversity over the scales required for marine management.

National system of marine protected areas

The seascapes can be used to help managers make decisions about where to place a system of representative marine protected areas. Ideally, such a system will maximise the biodiversity it protects while covering the smallest area. Maximum biodiversity is assumed to coincide with maximum habitat heterogeneity on the seabed, and thus with areas in which the most seascapes occur.

One way to define these regions using seascapes is to conduct a focal variety analysis in a geographic information system (GIS). This procedure counts seascape types within a specified distance (in this case 20 kilometres; figure 4). The focal variety analysis for the southern margin of Australia shows areas containing the most seascape boundaries (and thus highest seabed habitat diversity) in red, and areas of relative habitat homogeneity

" The seascapes can be used to help managers make decisions about where to place a system of representative marine protected areas"

in blue. Geomorphology is a categorical variable and so is treated separately, and a separate focal variety analysis is completed on this dataset. The red areas show where geomorphology is most heterogeneous and blue areas where it is most homogeneous. The results are combined to provide a map showing seabed habitat diversity and denoting regions where marine protected areas could maximise biodiversity coverage.

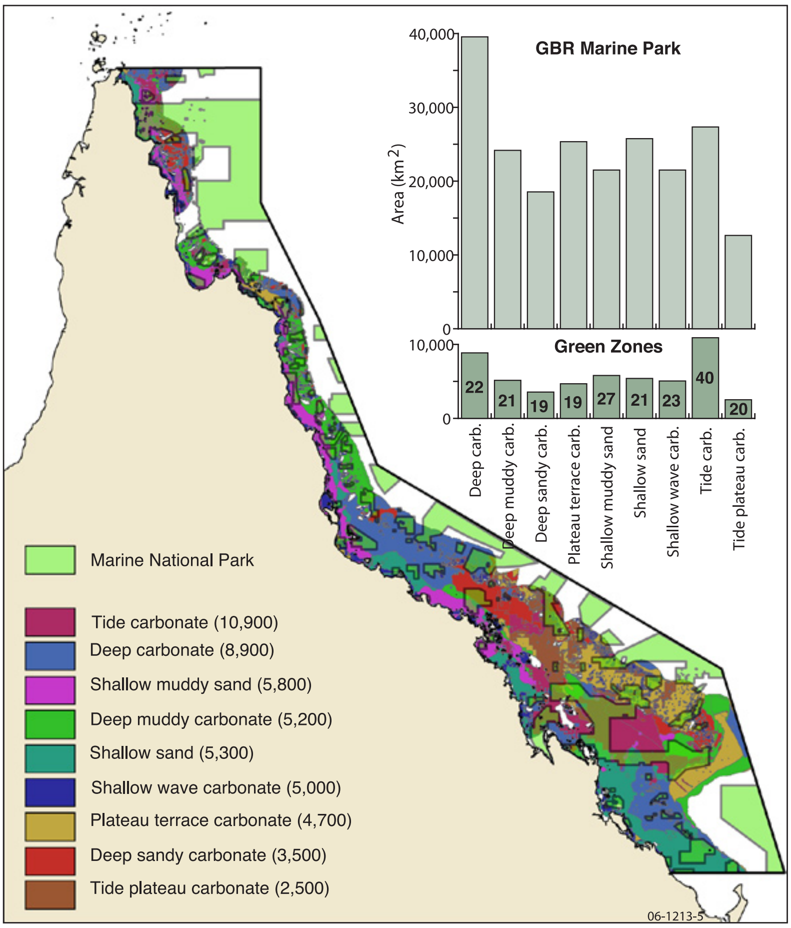


Figure 5. Simple spatial analysis provides an indication of whether the marine protected area system is comprehensive, adequate and representative. Numbers in blue are percentage of each seascape covered by Marine National Park zones (green zones).

Seascapes can also be used to test the efficacy of the marine protected area system using simple spatial analysis in a GIS. An effective system will be comprehensive, adequate and representative. In a comprehensive system, the habitats in the marine protected areas are proportional to their coverage across the entire planning area, for example the Great Barrier Reef (GBR) Marine Park. In an adequate system, enough of the habitat is protected to be self-sufficient (20% is considered appropriate). In a representative system, all the seascapes in the planning area are represented in the marine protected areas.

Geoscience Australia has analysed the seascapes contained in the green zones (Marine National Park zones) of the GBR Marine Park (figure 5). This analysis shows that the green zones are relatively comprehensive, with a slight over-representation of the tide carbonate seascape. The green zones are adequate, as only two of the nine seascapes have less than 20% of their total area covered, and they are representative because they contain all the seascapes that occur in the marine park.

Environmental significance

The mandate for undertaking this work comes directly from the United Nations Convention on Biological Diversity (CBD), which Australia ratified in 1994. The CBD requires each country to set up a system of marine protected areas for the conservation and sustainable use of threatened species, habitats and living marine resources and ecological processes (de Fontaubert et al 1996). To meet Australia's obligations under the CBD, the Australian Government and state governments are creating a national system of representative marine protected areas under the national oceans policy (ANZECC 1999) and the *Environment Protection and Biodiversity Conservation Act 1999*.

By creating seascapes from fundamental geoscience data on the nature of the seabed and by testing how far physical properties can be used as surrogates for biodiversity, Geoscience Australia is playing a crucial role in the development of the nation's system of marine protected areas.

Using seascapes for marine conservation is a new endeavour, and Australia is at the forefront of this work. We are among the first nations to tackle the problem of predicting marine biodiversity at the scales needed to manage our vast jurisdiction effectively. Geoscience Australia will continue to conduct marine environmental surveys to improve surrogacy and seascape research, providing scientific information to manage Australia's marine environment for conservation and sustainable resource use.

Geoscience data is the only spatially comprehensive data that is currently available to predict biodiversity over Australia's entire marine region. Geoscience Australia continues to work in collaboration with Australia's marine biologists and ecologists in the formation of seascapes for marine biodiversity prediction, including undertaking targeted marine surveys to collect further physical and biological data and building combined databases that permit direct correlation of data.

This research will improve the accuracy and precision with which we can predict Australia's marine biodiversity and thus strengthen confidence in decisions about the conservation and sustainable use of Australia's marine resources.

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Mapping *marine diversity*

Habitats are keys to conservation management

Alix Post, Ted Wassenberg (CSIRO Marine and Atmospheric Research), Vicki Passlow

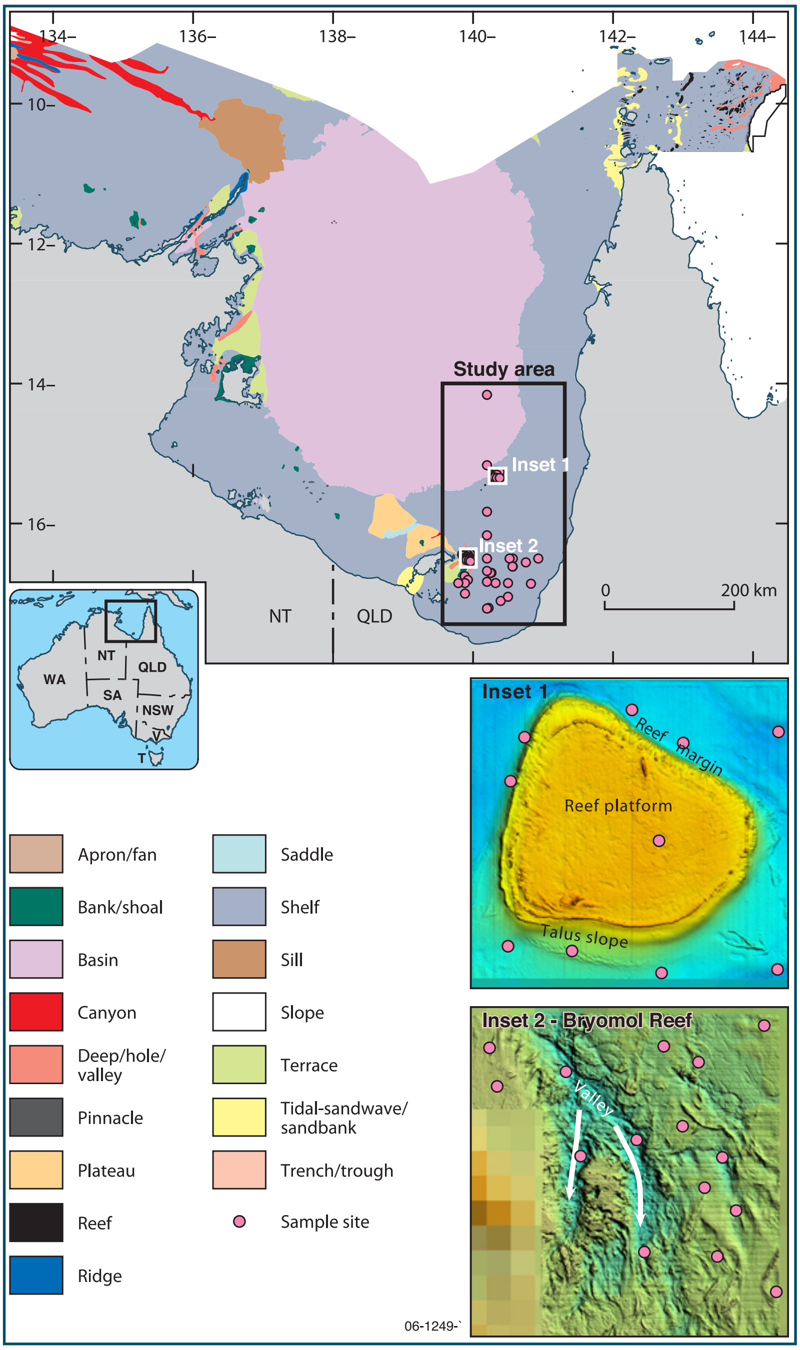

Figure 1. Geomorphic features across the Northern Planning Region, and within the study area, with sample areas shown by the pink dots. The insets show multibeam bathymetry images and detailed geomorphic features intersected by the sample sites.

Australia's Exclusive Economic Zone covers over ten million square kilometres, significantly more than the area of its land surface. The Australian Government has made a commitment to assign a proportion of this as marine protected areas (MPAs). The MPAs are to be designed to protect and preserve representative samples of marine biodiversity.

However, our knowledge of marine diversity and the distribution of marine biota is extremely patchy. Biological surveys are continually discovering species that are new to science. Recent expeditions in the deep ocean have found that, among samples collected at depths of more than 3000 metres, about half the specimens belong to new species (Schrope 2005).

Even within Australia's existing MPAs, our knowledge of the distribution, abundance and diversity of marine organisms remains sparse (e.g. southeast region MPAs; Harris, in press). The lack of biological data is a serious impediment to the aim of selecting for protection sites that are representative of the total marine biodiversity.

Defining habitats

An alternative to the species-based approach to conservation is the protection of marine habitats (e.g. Zacharias and Roff 2000). Marine habitats can be defined on the basis of physical datasets, such as the morphology of the seabed, the water depth and the sediment properties. This approach is similar to the way in which forest types (or biomes) on land are mapped based on knowledge of the slope, aspect, climate and soil types.

> "Physical parameters can be measured much more quickly... providing a rapid assessment of marine ecosystems"

Physical parameters can be measured much more quickly and across wider areas than biological information, providing a rapid assessment of marine ecosystems that can contribute significantly to the selection and ongoing monitoring of MPAs. This habitat approach is being increasingly employed in the management of marine areas in Canada, New Zealand, South Africa and the United States, as well as in Australia.

The successful use of physical parameters as a surrogate for species diversity and distributions depends on the selection of relevant physical datasets. Although an increasing number of studies test the relationships between biological and physical datasets, broader environmental associations are still poorly established. The

Table 1. Characteristics of different benthic habitats and associated faunas

Morphology	Average depth (m)	Seabed exposure	Grain Size	Dominant fauna
Shelf	14–35	Mod	Sandy	Prawns
				Sea Urchins
Valley	37–43	Max	Sandy gravel	Bryozoans
				Brittlestars
				Crinoids
Bryomol Reef	27–36	Max	Sandy gravel	Brittlestars
				Hydrozoans
				Bryozoans
Talus slope	38–43	Mod–High	Sandy	Anenomes
Reef platform	27	Mod–High	Sandy gravel	Ascidians
				Octocorals
Reef margin	48–49	Mod–High	Sandy mud	Crinoids
				Sponges
Basin	51–65	Low–Mod	Sandy mud	Polychaetes

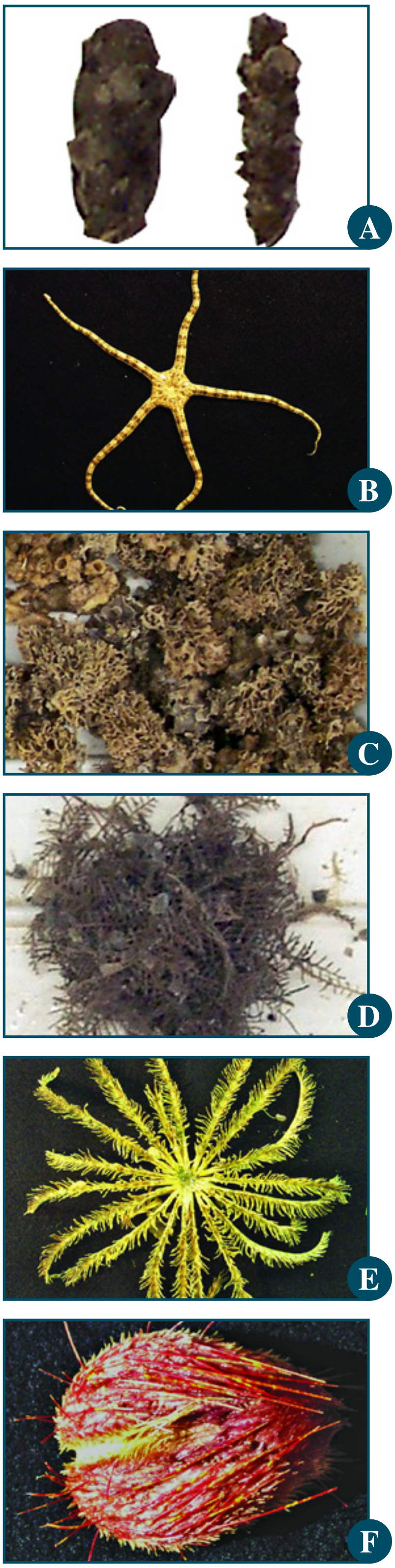

Figure 2. The six taxa with the highest abundance across the study area: A) polychaete tubes; B) brittlestars; C) a species of bryozoan; D) a species of hydroid; E) crinoids; and F) a species of heart urchin. Photos courtesy of T Wassenburg.

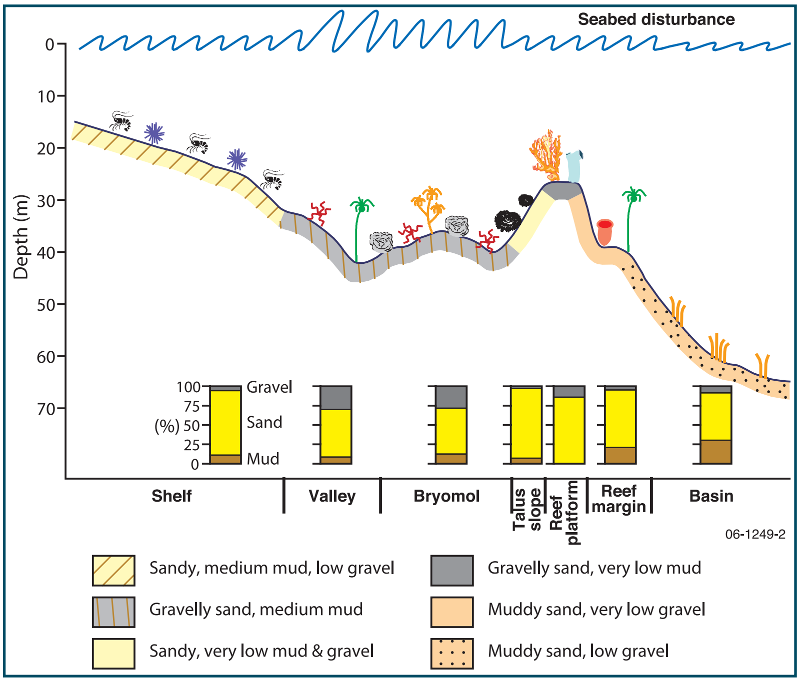

Figure 3. Relationship between physical properties and benthic biota in the southern Gulf of Carpentaria. For a full description of the key benthic biota and explanation of symbols, refer to table 1.

environmental associations studied to date vary greatly between regions, organisms, scales and approaches (e.g. Thouzeau et al 1991, Kostylev et al 2001, Ramey & Snelgrove 2003). Detailed testing within the Australian region is helping to reveal which physical datasets best describe the distribution of seabed biota in different settings around the Australian margin.

"Recent research in the Gulf of Carpentaria, northern Australia, has provided detailed physical and biological datasets"

Mapping biota in the Gulf of Carpentaria

Recent research in the Gulf of Carpentaria, northern Australia, has provided detailed physical and biological datasets, which we have used to test the relationships between physical habitats and the distribution of seabed communities. Sampling and detailed bathymetry mapping have revealed a range of physical habitat types, including reefs, plateaus, valleys and shelf environments (Heap et al 2006; figure 1 and table 1), along with distinctive seafloor biota associated with these different features.

A total of 569 species were collected on the research voyage. The six taxa with the highest abundance across the study area are polychaetes (tube worms), brittlestars, a species of bryozoan, a species of hydroid, crinoids, and a species of heart urchin (figure 2). Of these, the heart urchin species has the highest total abundance, while the species of bryozoan and hydroid have the broadest distributions.

A range of physical variables were tested against the species data to determine whether statistically meaningful relationships could be established, which could allow better prediction of species distributions (see Post et al 2006). This analysis revealed that the distribution of the seabed biota can be best predicted in this region based on a combination of physical variables, including the sediment composition (mud and gravel content), sediment disturbance, the seabed morphology and water depth. The relationship between these variables and the seabed biota is illustrated in figure 3 across the seven main geomorphic zones: shelf, a relict bryozoan–mollusc built reef (bryomol reef), valley, talus slope, reef platform, reef margin and basin.

The shelf zone within the southeastern part of the Gulf is characterised by shallow depths (15 to 30 metres) with moderate seabed disturbance and sandy low carbonate sediments (figure 3). The fauna in this shelf zone is dominated by mobile organisms with relatively low diversity, with prawns and sea

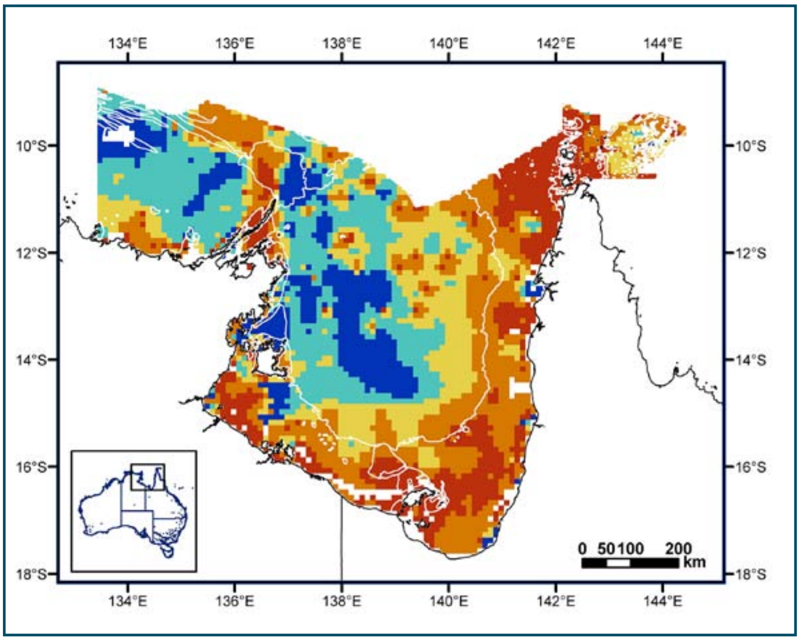

Figure 4. Distribution of five habitat clusters derived from the percentage of gravel and mud, the water depth and the seabed exposure for part of the Northern Planning Area, with geomorphic units shown by the grey outlines. The southeastern and eastern parts of the Gulf and Torres Strait are part of clusters 1, 2 and 3, while the central and western Gulf and the western Arafura Sea are characterised by clusters 4 and 5. Substrate clusters occur within different geomorphic features, illustrating the importance of combining these datasets.

urchins more abundant. The basin environment is also dominated by mobile fauna (predominantly polychaetes) with medium diversity and, because the water is deeper, has low to moderate seabed disturbance with muddy sand sediments. The bryomol reef and valley environments lie at depths intermediate between the shelf and basin zones (25 to 39 metres and 37 to 42 metres, respectively), with very high seabed disturbance (maximum values), particularly across the valley area, and a gravelly sand seafloor. The faunas associated with these two zones are composed of equal abundances of attaching and mobile organisms, with the bryomol reef dominated by brittlestars, hydrozoans and bryozoans, and the valley faunas by bryozoans, crinoids and brittlestars.

"The modern reef environment is divided into three distinct zones, each with a moderate to high seabed disturbance"

The modern reef environment is divided into three distinct zones, each with a moderate to high seabed disturbance (figure 3). The talus slope is sandy with high carbonate content, and the presence of ripples indicates strong bottom currents. These characteristics are associated with low faunal diversity dominated by solitary anemones.

The reef margin, by contrast, is composed of muddy sand sediments, reflecting the lower energy of this area. These features have produced high faunal diversity, with crinoids and sponges dominating the community. The reef platform is distinct from these other two zones in its higher energy and harder substrates, with relatively high gravel content. Faunas on the reef platform show high diversity, with an abundance of ascidians and octocorals.

How are species related to physical factors?

By various mechanisms, the physical factors identified in this study can be associated with the types of organisms present. The seafloor properties are clearly associated with the habitat modes of the organisms. The areas with a sandy seafloor, such as the shelf and basin areas, are dominated by mobile deposit feeders and infauna, since those organisms require a soft seafloor in which they can burrow and forage for food (Jumars 1993). Gravelly areas, such as on the reef and bryomol reef areas, contain high proportions of suspension feeders, which attach to the strong anchor points available in these environments.

Seabed disturbance is a measure of the stability of the seabed environment. In areas with a low frequency and magnitude of disturbance, competition between organisms is greater, which tends to suppress diversity (Connell 1978). The relatively low seabed disturbance of the shelf and basin environments (low to moderate) in this study is most likely associated with the lower overall species diversity in those environments. In areas of very high frequency and magnitude of disturbance, diversity is also suppressed due to the high variability of the environment, which reduces reproductive success and the ability of the community to mature or be recolonised before the next disturbance event (Connell 1978).

An area of very high disturbance in this study occurs on the talus slope adjacent to the main patch reef. The species diversity on the slope, which is characterised by active sedimentation, is substantially lower than at the surrounding reef sites, where sediment input is much lower. This comparison suggests that areas of lower sediment input and lower disturbance (such as on the reefs) support a larger variety of faunas compared to highly variable areas (such as the talus slope) where species diversity is suppressed. Some degree of disturbance also reflects current flows; these can bring in nutrients and other food sources, which are particularly important for suspension feeders.

"This study demonstrates that selected physical datasets are well correlated to the distribution of the seabed biota in this region "

In summary, this study reveals an association between the sediment composition and the types of macroorganisms present, and particularly their habitat modes. Mobile and infaunal species are more prevalent on softer substrates, while suspension feeders dominate areas with higher gravel content and harder substrates. The seabed disturbance may reflect the supply of food via currents to suspension feeders in areas of moderate disturbance, while low disturbance leads to reduced diversity, which could be due to higher levels of competition. The high seabed disturbance on the sandy substrate of the talus slope is also associated with a low diversity of mobile organisms, reflecting the stress to organisms in high-energy environments where anchor points are not available (e.g. Connell 1978). The water depth primarily reflects changes in light intensity, temperature, oxygen, salinity and energy (Murray 1991), and is associated with the distinct communities that occur between the shelf and basin environments in this study.

Applying physical relationships for marine planning

The biophysical relationships established from this study can be used to predict the diversity and distribution of marine benthic organisms across the broader region of the Northern Planning Area. The four physical parameters that show the strongest relationship to the seabed biota (mud content, gravel content, seabed disturbance and water depth) were combined using existing datasets across the broader region with an unsupervised classification. Five classes are formed from this classification, and their distribution can be used to interpret the distribution of potential seabed habitats (figure 4). We obtain further information about habitat variability by overlaying the geomorphic features. Through the production of habitat maps such as these, marine managers can take a more rigorous approach in the selection of marine reserves.

Conclusions

Determining representative areas within the Northern Planning Area for protection as part of a network of MPAs is not currently possible based on the sparsely distributed biological data currently available for this region. Physical datasets, however, can provide information about the variations in the physical environment, and hence the variations in the seabed habitats. This study demonstrates that selected physical datasets are well correlated to the distribution of the seabed biota in this region. By combining these broadly distributed physical datasets, we can produce maps that show the distribution of distinct marine habitats in the region and provide marine managers with information about the predicted distribution of seabed communities.

This information will provide a more rigorous basis for the selection of representative areas for protection within a network of MPAs. At Geoscience Australia, continuing research ensures that habitat maps will be based on rigorously tested parameters. Those parameters will need to be good predictors of seabed biota for the regions that they are applied to. Current research is focusing on a number of regions in Australia's marine jurisdiction, including the northwest and southwest regions.

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Great *Barrier Reef Marine Park sedimentology revealed*

New research into inter-reefal environments will assist reef managers

Emma Mathews and Andrew Heap

Geoscience Australia has completed a detailed spatial analysis of seabed environments in the Great Barrier Reef (GBR) Marine Park. The analysis was based on a new dataset of more than 3000 samples, which is accessible online from Geoscience Australia's marine samples database.

The results, to be published later this year (Mathews & Heap 2006), represent the first regional assessment of postglacial sediments across the entire GBR since Maxwell's pioneering work in 1968, and provide the first quantified comparisons in a spatial framework. The information can be used by managers and planners to make better decisions in Australia's highest profile World Heritage Area.

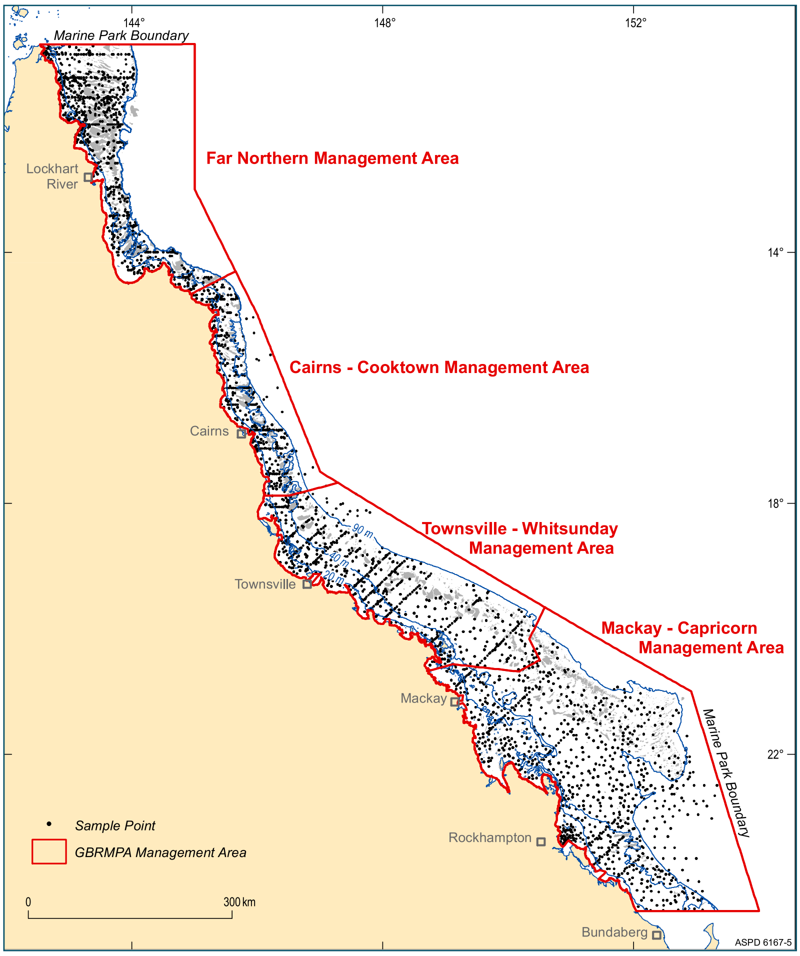

Figure 1. Location of samples collected within the Great Barrier Reef Marine Park.

Spatial study

A quantitative spatial study of the seabed sediments comprising inter-reefal environments gives important clues about the sources of sediment, their relative influence on GBR ecosystems, and sediment distribution by hydrological processes.

The study also contributes to our understanding of the evolution during the past 18 000 years of the northeast Australian margin, the largest tropical mixed siliciclastic–carbonate margin on Earth and the modern type case used to compare ancient rocks from similar environments elsewhere on the Earth.

Inter-reefal environments cover 327 950 square kilometres or 95% of the total area of the GBR Marine Park but are much less studied than the reefs. They form a connected network of habitats that support a wide range of biological communities in addition to the reefs (Chin 2003). Spatial changes in the composition and texture of seabed sediments help to characterise the benthic environments covered by the existing GBR Marine Park planning scheme.

Table 1 Calculated area of % sediment concentrations in the Great Barrier Reef Marine Park

Sediment attribute	km²	Per cent
Gravel %		
0–20	196,050	56.8
20–40	23,100	6.7
40–60	8,400	2.4
60–80	3,000	0.9
80–100	2,500	0.7
Sum:	**233,000**	**67.5**
No data:	**112,150**	**32.5**
Sand %		
0–20	10,140	2.9
20–40	24,940	7.2
40–60	57,010	16.5
60–80	81,370	23.6
80–100	59,560	17.3
Sum:	**233,010**	**67.5**
No data:	**112,170**	**32.5**
Mud %		
0–20	120,190	34.8
20–40	59,050	17.1
40–60	33,640	9.8
60–80	14,400	4.17
80–100	5,730	1.7
Sum:	**233,020**	**67.5**
No data:	**112,160**	**32.5**
Bulk carbonate %		
0–20	14,580	4.2
20–40	28,680	8.3
40–60	43,310	12.6
60–80	66,170	19.2
80–100	86,560	25.9
Sum:	**239,300**	**69.3**
No data:	**105,880**	**30.7**
Carbonate sand %		
0–20	15,720	4.6
20–40	20,960	6.1
40–60	29,160	8.5
60–80	41,230	11.9
80–100	99,880	29.0
Sum:	**206,960**	**60.0**
No data:	**138,220**	**40.0**
Carbonate mud %		
0–20	16,800	4.9
20–40	34,870	10.1
40–60	36,130	10.5
60–80	39,400	11.4
80–100	50,660	14.7
Sum:	**177,870**	**51.5**
No data:	**167,310**	**48.5**
Marine Park total	**345,180**	**100.0**

* Calculations were made using Albers Equal Area Projection.

Largest sediment database

The study is based on more than 3000 surface sediment samples collected in the GBR Marine Park since 1984 and represents the largest sediment database assembled for any part of the shallow tropical Australian shelf (figure 1). Nearly half of the samples were collected between 2003 and 2005 by six regional surveys conducted by the Australian Institute of Marine Science and CSIRO for the GBR Seabed Biodiversity Project, a program run by the Reef CRC in Townsville. Geoscience Australia's contribution to this program was to produce a quantitative regional synthesis of the seabed sedimentology from a systematic analysis of the texture and composition of the samples. The new data are part of a fundamental national marine dataset maintained by Geoscience Australia.

Regional sedimentology

Previous work from the GBR shows that postglacial sediments are essentially made up of a mixture of calcium carbonate from the skeletal remains of marine organisms (molluscs, foraminifers, corals and algae) and siliciclastic sediments mainly derived from sources on land (Maxwell 1968, 1969; Maxwell & Swinchatt 1970; Flood & Orme 1988).

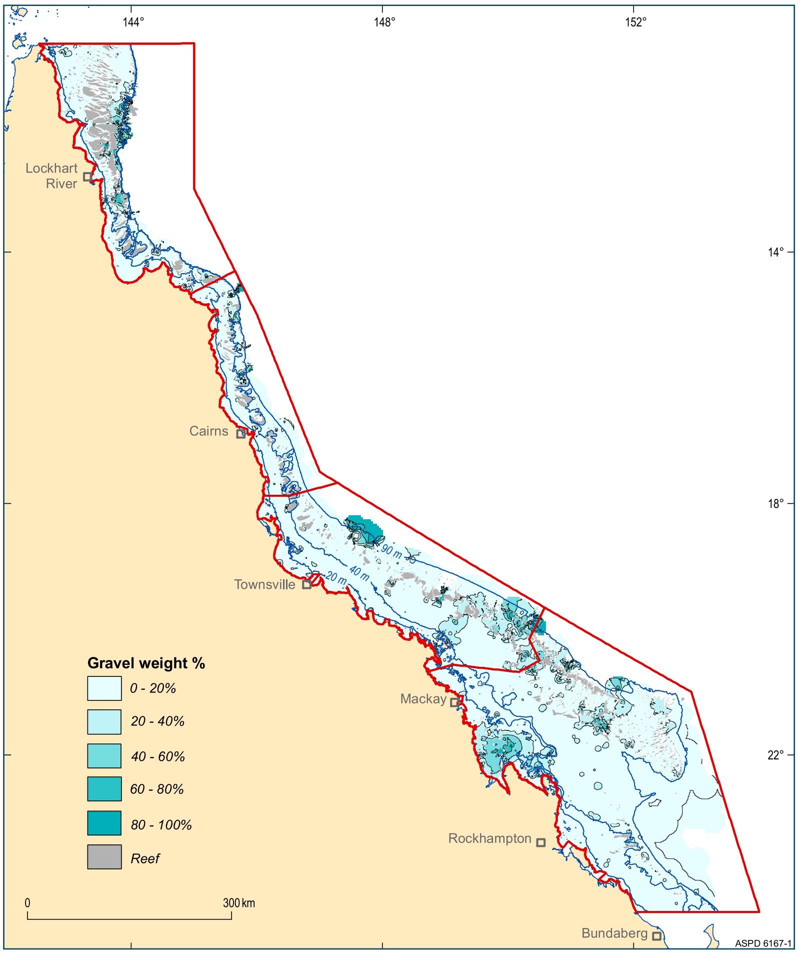

Figure 2. Map of the % gravel weight concentration in sediment.

The distribution of these two major components shows a cross-shelf variation wherein the siliciclastic sediments are restricted to the inner shelf regions close to the coast, and the carbonate sediments are dominant on the middle and outer shelves (Belperio, 1983).

This 'model' provided a useful regional framework for the current study, which adds essential detail by characterising the grain size of the bulk sediment and quantifying the areas of shelf comprising different proportions of gravel (>2 mm), sand (63 µm–2 mm), and mud (<63 µm) in both the bulk and carbonate fractions. The result is our most up-to-date representation of postglacial sediments for this margin.

Key findings

The GBR Marine Park is generally gravel-poor, with sediments comprising less than 20% gravel covering 196 050 square kilometres or more than 56% of the total marine park area (figure 2; table 1). Relatively high gravel concentrations (more than 40%) cover an area of 13 900 square kilometres (4% of total area), and are restricted to a few areas next to the outer-shelf reefs and in Broad Sound on the inner shelf.

Most of the sediment in the GBR Marine Park is composed of sand, with concentrations of more than 60% covering 140 900 square kilometres of the marine park, or more than 40% of the total area (figure 3; table 1). Sand concentrations show very high spatial variability across the marine park (much higher than previously reported) and are generally higher on the outer shelf and in the south. This high degree of spatial variability is also a feature of the carbonate concentrations and principally reflects the in situ production of carbonate by marine organisms.

Across the entire GBR Marine Park, mud concentrations above 60% cover 20 150 square kilometres (6%) of the marine park (figure 4; table 1). North of Townsville, mud comprises a relatively small amount of the middle and outer shelf sediments, with highest concentrations reaching 40% on the inner shelf. South of Townsville, similar mud concentrations occur only on the middle shelf, and extend into the Capricorn Channel.

Carbonate is the dominant sediment type, with concentrations above 60% covering 152 700 square kilometres (45%) of the marine park (figure 5; table 1). Concentrations increase from more than 20% near the coast to more than 80% on the middle and outer shelves. Concentrations of less than 20% occur in embayments north of the Burdekin, Pioneer, and Fitzroy rivers, which currently deliver the highest quantities of siliciclastic sediment to the inner shelf, and on the southern border of the marine park where siliciclastic sands are transported north into the park from Fraser Island and Hervey Bay.

> "This new study adds considerably more detail to the model of postglacial sedimentology for the northeast Australian margin"

A classification of sediment types has revealed that the Marine Park is dominated by gravelly, muddy sand, which covers 53 350 square kilometres or 16% of the marine park. Other common sediment types include gravelly sand and slightly gravelly, muddy sands, which cover 48 830 square kilometres (15%) and 46 650 square kilometres (14%), respectively. The most scarce sediment types include the gravels and muds, with muddy gravel covering 600 square kilometres and slightly gravelly mud covering 1100 square kilometres; both make up less than 1% of the total marine park area.

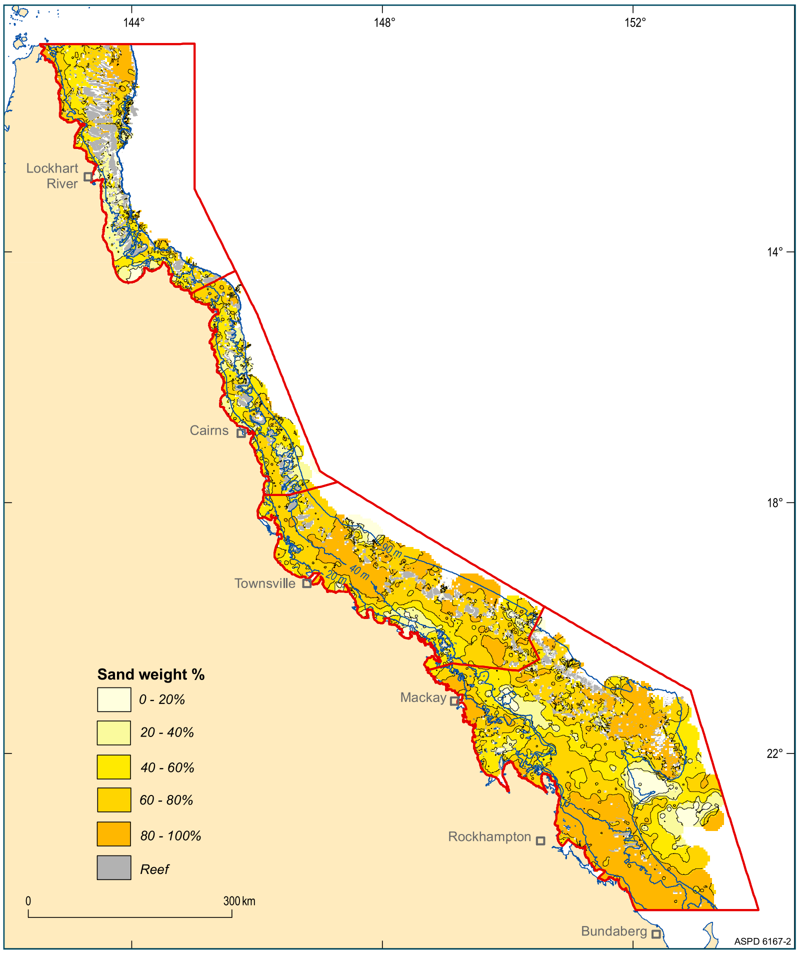

Figure 3. Map of the % sand concentration in sediment.

This new study adds considerably more detail to the model of postglacial sedimentology for the northeast Australian margin, specifically about spatial variability in the distributions of the sediment fractions. While there is a general increase in the carbonate content and a decrease in siliciclastic content across the shelf, as shown by previous studies, our results show that these across-shelf distributions are complex and do not hold for all parts of the margin. Overall, the texture and composition of postglacial sediments show strong correlations with the dominant sediment sources, with overprinting by hydrodynamic processes.

Applications for management

The spatial analysis of seabed sediment in the GBR reveals information about the texture and composition of inter-reefal seabed habitats and their variability. The GBR Marine Park is a unique natural environment of national and international significance, and its managers require detailed mapping to fully understand the nature of the seabed and its habitats. Our quantitative spatial analysis of the seabed sediment texture and composition, and the associated distribution

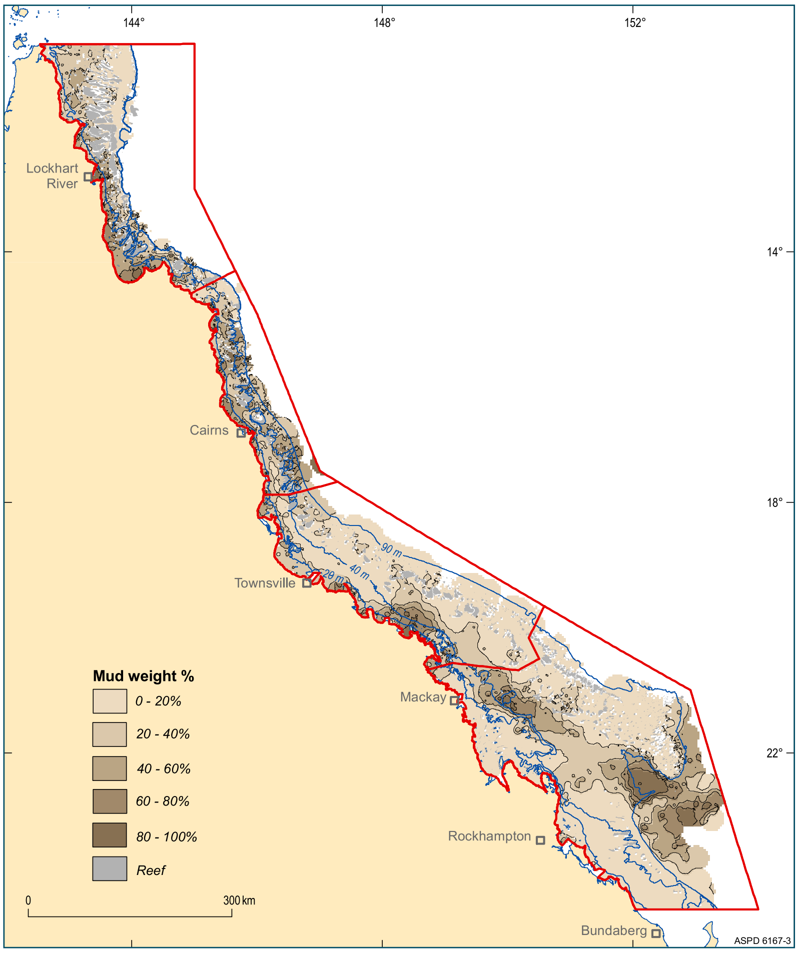

Figure 4. Map of the % mud concentration in sediment.

patterns, gives a systematic seabed classification. These data provide the best possible spatial information for marine park managers to make informed decisions and quantitative comparisons between areas of different habitat types in Australia's highest profile World Heritage Area.

"Our quantitative spatial information about seabed sediments provides a planning and management framework from which to assess new planning proposals in the GBR Marine Park, and to monitor habitats"

Assembled seabed sediment information provides a consistent and robust dataset that can be used to help characterise the different management zones making up the GBR Marine Park. Overall, seabed sediments range from gravel-poor with localised high gravel concentrations, to sediments with high sand and carbonate concentrations, and high mud with low carbonate concentrations. Together, this variability in surface sediments shows the potential range of inter-reefal seabed habitats and their physical characteristics. Seagrass meadows, mud and sand flats, and gravel and shoal bottoms are just some of the inter-reef habitats already identified.

The collection and mapping of seabed sediment samples has been undertaken as part of the GBR Seabed Biodiversity Project, which aims to form an inventory of the seabed's characteristics, such as sediment types and fish and invertebrate assemblages (Pitcher et al 2002). Seabed sediment data will be added to existing regional maps of the GBR Marine Park and will provide more detail to help managers conserve significant habitats and biological communities. In areas where biological information is not available, 'proxies' such as seabed sediments can help determine the relationship between physical environments and biology to predict biodiversity.

The main advantage of using sediment data is that they can be determined across broad regions, even in areas that lack biological data. Our quantitative spatial information about seabed sediments provides a planning and management framework from which to assess new planning proposals in the GBR Marine Park, and to monitor

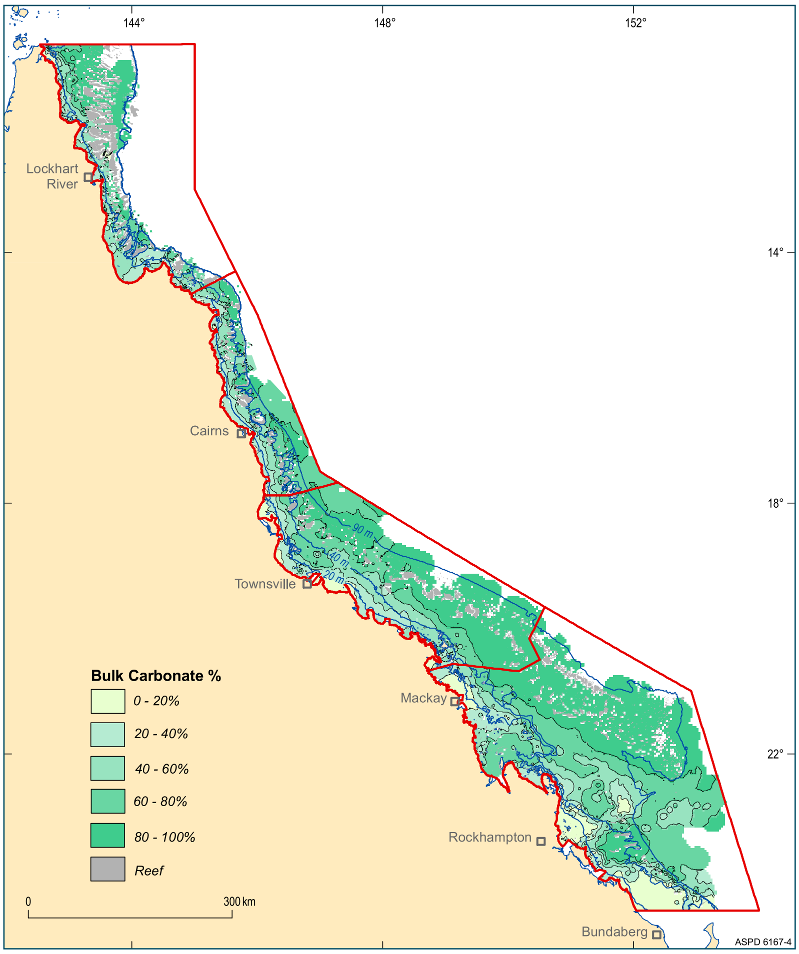

Figure 5. Map of the % bulk carbonate concentration in sediment.

habitats. This approach will improve marine park management and decision making. Further work, investigating the links between sediments, habitats and marine biota in general, is necessary for the conservation and appropriate future management of inter-reefal areas in the park.

The next stage of Geoscience Australia's work will be to characterise and quantify the spatial variability of sediments within the framework of the current GBR planning scheme. By revealing the texture and composition of different management zones, we provide vital baseline information that can be used to monitor potential changes to seabed habitats and biological communities.

Related website

Geoscience Australia's marine samples database
www.ga.gov.au/oracle/mars
link

For more information

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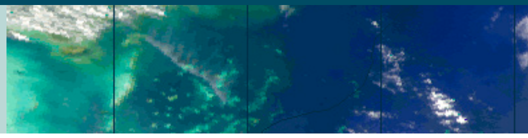
ISSUE 84 Dec 2006

Let *there be light*



Turbidity modelling in Torres Strait explains seagrass dieback

Frederic Saint-Cast

More than 1400 square kilometres (equivalent to 175 000 football fields) of seagrass was lost between 1989 and 1993 in Torres Strait, where around one quarter of Australia's seagrass resources is situated.

Local islanders are concerned about widespread seagrass dieback because they believe it is causing declines in populations of dugong and turtles, which feed on the seagrasses. Seagrass beds also provide shelter for small fish and act as nurseries for fish and crustaceans such as crabs, lobsters and prawns, including many commercially important species.

Geoscience Australia scientists, working as part of the Torres Strait Cooperative, believe seagrass dieback is largely a response to low light levels, which have resulted from extended periods of elevated turbidity. Local communities in Torres Strait are concerned that seagrass die back has have been caused by increased sediment load from the Fly River in the Gulf of Papua since the opening of the giant Ok Tedi gold and copper mine in 1984 (figure 1).

Satellite images show that high turbidity is restricted to the south coast of Papua New Guinea (PNG) during the season of southeasterly trade-winds, and only extends into the northern Torres Strait during the northwesterly monsoon season.

Simultaneous measurements of turbidity and bottom light levels in Geoscience Australia Survey 266 and six months later in Survey 273 indicate that the seagrass resilience threshold was reached at the end of the monsoon but not at the end of the trade-wind season (figures 2a, b and c).

> "Computer simulations show that sediment transport and turbidity in Torres Strait are controlled mainly by wind-driven currents"

Although we recognised the importance of seasonal changes in turbidity in seagrass dieback, our basic understanding of the sediment transport processes was hampered by the lack of information on water and sediment movements at the regional scale in Torres Strait and adjacent seas and gulfs.

For the first time, a computer simulation was developed to reveal sediment pathways throughout the complex shallow shelf

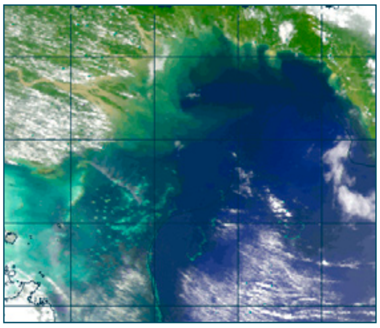


Figure 1. Satellite image of elevated turbidity in the Gulf of Papua.

Figure 2a. Bottom sediment grab – Geoscience Australia Survey 273.

Figure 2b. Water sample collection – Geoscience Australia Survey 273.

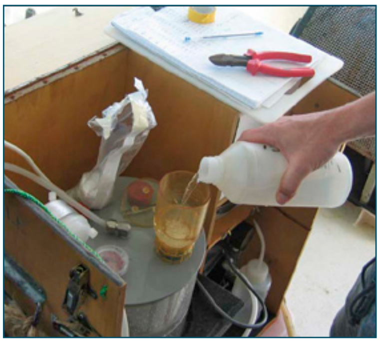


Figure 2c. Water sample analysis from Geoscience Australia Survey 273.

environment of Torres Strait, including the Gulf of Papua, the northern Great Barrier Reef and the northeastern Gulf of Carpentaria. A sediment dynamic model was embedded into a circulation model that incorporated realistic atmospheric and oceanographic forcing, including winds, waves, tides and large-scale ocean circulation. Calibrated simulations covered a hindcast period of eight years, allowing the tidal, seasonal and interannual flow characteristics to be investigated.

"Seagrasses are able to recover from a few weeks of reduced light caused by elevated turbidity"

Computer simulations show that patterns of net sediment transport and turbidity in Torres Strait are controlled mainly by wind-driven currents associated with the trade-wind and monsoon seasons, even though instantaneous water movements are strongly dominated by the tide and its spring–neap cycle.

The fine sediments (<63 µm) responsible for the turbidity move back and forth through Torres Strait according to the strong seasonal conditions. These sediments tend to accumulate to the west of Torres Strait over the nine-month trade-wind season (March–November) while they are swept back to the east over the three-month monsoon period (December–February). Over the course of a year, the relatively stronger currents during the trade-wind season result in the predominantly westward transport of sediment (figure 3).

Seabed samples collected during our surveys confirm that sediment in Torres Strait is finer and more easily picked up by near-bed currents after the monsoon, while at the end of the trade-wind season the bed sediment is coarser and requires more energy to be resuspended (figure 4).

Although significant amounts of terrigenous sediment are delivered by the Fly River to the Gulf of Papua and the southern PNG coast, our computer simulations and field data indicate that there is no

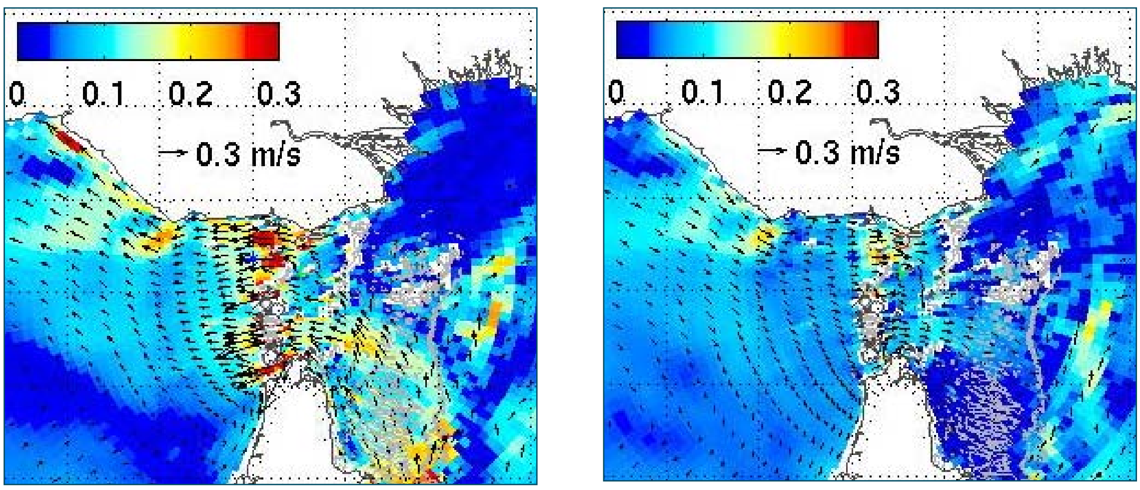


Figure 3. Computer simulation showing the regional flow pattern over the trade-wind season (left) and monsoon season (right). The simulation demonstrates that the flow through Torres Strait is strongly connected with the northern Great Barrier Reef.

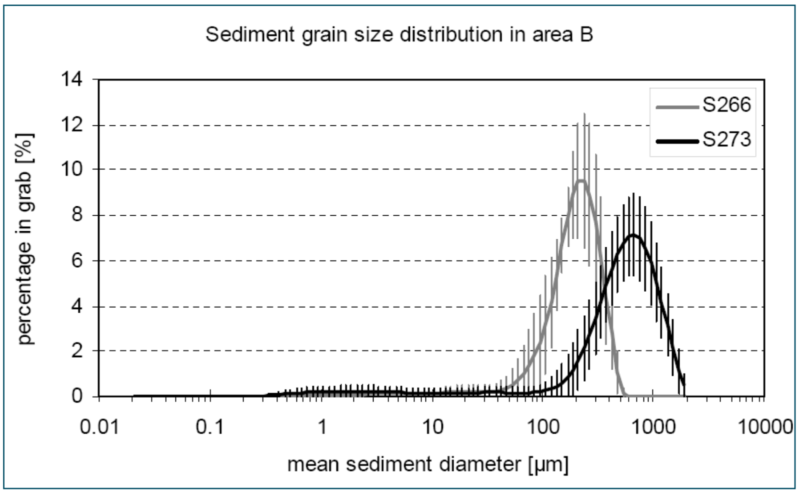


Figure 4. Comparison of sediment grain size distribution in Torres Strait following the monsoon season (Survey 266) and at the end of the trade-wind season (Survey 273).

significant connectivity between those regions and central Torres Strait. Instead, the model reveals that the flow in central Torres Strait strongly connects with the northern Great Barrier Reef.

Rather than increased sediment loads from PNG causing elevated turbidity in the strait, our results indicate that the turbidity is caused by the constant action of waves and tidal currents, which resuspend the bottom sediment in two major depocentres on either side of the strait.

During the trade-wind season, turbidity levels in Torres Strait decrease to a minimum because the relatively clear waters of the northern Great Barrier Reef gradually flush fine sediments to the west of the strait, where they settle in the northeast Gulf of Carpentaria. During the monsoon season, turbidity levels in central Torres Strait increase to a maximum, as fine sediment in the northeastern Gulf of Carpentaria is resuspended and transported eastwards into the strait.

Seagrasses are able to recover from a few weeks of reduced light caused by elevated turbidity, but beyond this resilience threshold they suffer irreversible damage. Over a number of trade-wind seasons, the amount of fine sediment that settles in the northeast Gulf of Carpentaria has certainly increased to such a level that elevated turbidity events during the following monsoons were longer and more severe, which might explain the seagrass dieback in Torres Strait.

This innovative modelling solution to a complex marine environmental problem has been provided as part of Geoscience Australia's contribution to the Torres Strait Cooperative Research Centre to better understand biophysical processes in the strait. We have gained new scientific understanding of underwater habitat disturbance and stability, reinforcing Geoscience Australia's ability to characterise and protect our valuable marine environment.

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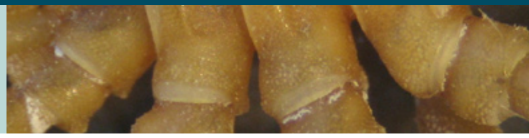
ISSUE 84 Dec 2006

Looking *for life below the sea ice*



New project assesses biodiversity in Antarctic seas

Philip E O'Brien, Alix Post and Victoria Wadley (Australian Government Antarctic Division)

Geoscience Australia's Marine and Coastal Group is contributing expertise in sea floor mapping to a major international effort to research the biodiversity of Antarctic waters.

The Census of Antarctic Marine Life (CAML) is a multinational project to improve our knowledge of Antarctic marine life through a series of coordinated research surveys during the International Polar Year of 2007/2008. Coordinated by the Australian Government Antarctic Division, CAML is sponsored by the Sloan Foundation under its Census of Marine Life project. So far, 13 countries are involved and eight marine surveys are planned.

CAML has five major goals:

- Develop an inventory of species of the Antarctic slopes and abyssal plains.
- Develop an inventory of benthic fauna under disintegrating ice shelves.
- Develop an inventory of plankton, nekton and sea-ice associated biota at all levels of biological organisation, from viruses to vertebrates.
- Assess critical habitats of the Antarctic's top predators.
- Develop a coordinated network of interoperable databases for all Antarctic biodiversity data.

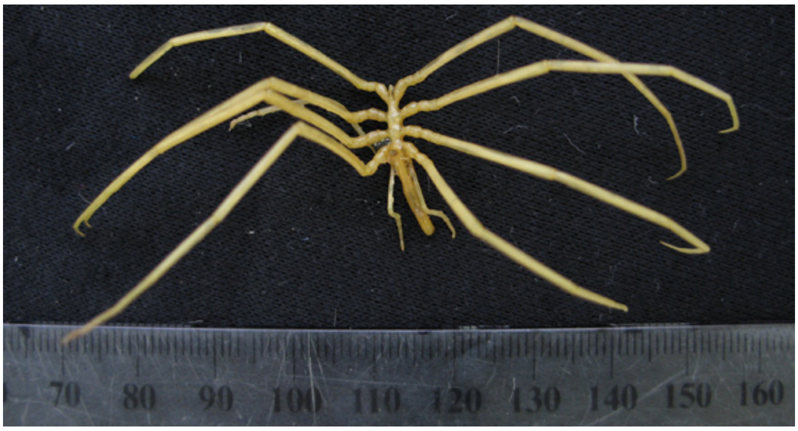


Figure 1. Sea spiders (pycnogonids) from the Southern Ocean near Heard Island. Pycnogonids are one of the more fascinating but poorly known groups of animals that will be studied during the Census of Antarctic Marine Life. In shallow tropical waters they grow up to five millimetres across, but in the Antarctic they reach 50 centimetres.

Geoscience Australia is contributing to themes 1 and 2 by applying methods developed over the past 10 years for mapping benthic habitats and understanding marine processing to help plan sampling regimes for surveys of benthic biota and demersal fish. An Australian–French survey to George V Land will use habitat maps of the shelf near the Mertz Glacier, developed by Robin Beaman (now of James Cook University) and Peter Harris as part of the Antarctic CRC program. Continental slope sampling will use benthic mapping based on multibeam data collected by the Italian vessel OGS *Explora* in 2006 and processed by Michele Spinoccia of Geoscience Australia and Laura De Santis of Italy's National Institute of Oceanography and Applied Geophysics (OGS).

The George V shelf study (Beaman & Harris 2005) was the first systematic attempt to understand the habitat of Antarctic benthos using multibeam bathymetry, sub-bottom profiler data, and sedimentological and oceanographic data. The CAML survey will use the habitat map produced by that study

Figure 2. Sea spiders (pycnogonids) from the Southern Ocean near Heard Island.

to inform its sampling design. This will enable the widest sampling of biodiversity in the area and provide some control on the physical parameters that affect the benthic ecology. This approach is important because the Antarctic shelf is one of the most variable marine environments, mainly because icebergs commonly plough the sea floor, causing major disruption of the benthos.

"Geoscience Australia will also contribute to CAML Theme 2 with studies of a remarkable set of cores collected from beneath the Amery Ice Shelf"

Geoscience Australia will also contribute to CAML Theme 2 with studies of a remarkable set of cores collected from beneath the Amery Ice Shelf. The Australian Government Antarctic Division is collecting oceanographic data, video footage and sediment cores through hot-water drill holes in the Amery Ice Shelf. The sediment cores are collected using a corer designed and built by Geoscience Australia. This project has now produced four cores.

The only other core ever obtained from beneath an extant ice shelf—from under the Ross Ice Shelf in the early 1970s—showed no signs of life. However, several Amery cores contain diatom-rich sediments, and one contains a succession of benthic faunas that indicate progressive colonisation of the sub-ice sea floor as ice retreated and currents began to seep nutrients and plankton into the sub-ice shelf cavity.

This work has helped oceanographic modelling studies in the Antarctic Climate and Ecosystems CRC, by indicating the extent and strength of current activity beneath the Amery Ice Shelf.

CAML research will contribute to the long-term conservation of the Antarctic environment by helping us understand some of the lesser known animal groups that inhabit the sea floor and water column. While less fashionable than penguins and seals, these organisms form an integral part of Antarctic ecosystems and some, like Antarctic sea spiders (figures 1 and 2), have their own fascination.

For more information

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Related websites

Census of Antarctic Marine Life
http://www.caml.aq/
link

In brief

More than a map

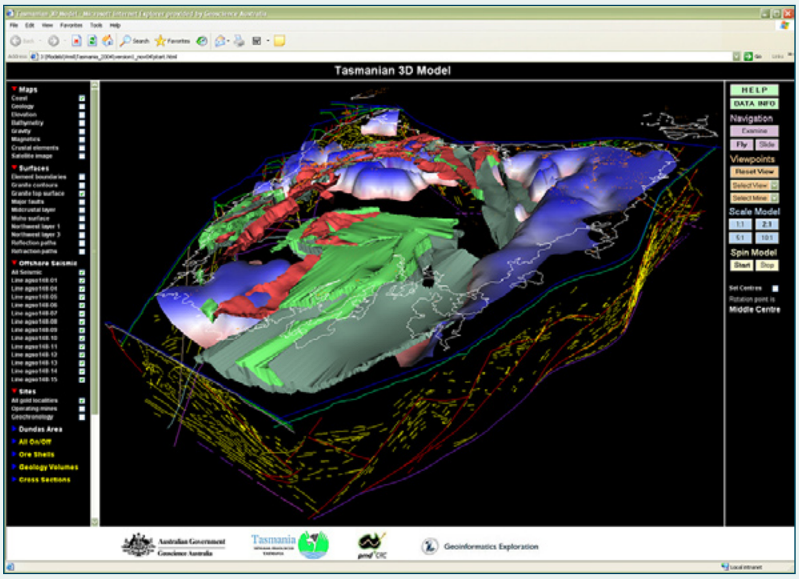
Geoscience Australia's 3D Visualisation Laboratory (3D VizLab) is the latest research tool to assist geoscientists explore underground Australia. The VizLab was designed to help Geoscience Australia's scientists interpret three dimensional geoscience data, by providing a venue for collaborative viewing and interpretation.

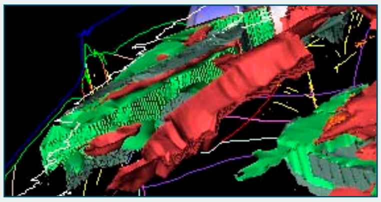
Scientists can view and discuss data presented on a large 7 metre by 2.5 metre rear-projection screen. Two active stereo projectors synchronise with special glasses to provide users with a 'true-3D' view of data.

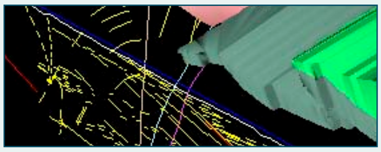
The facility was opened on 26 October by the Hon. Bob Baldwin MP, Parliamentary Secretary to the Minister for Industry, Tourism and Resources. He pointed out that it would not only prove to be a valuable tool in the continuing search for ways to identify and unlock Australia's vast resources wealth but it will also allow us to increase our understanding of our continent's subsurface structures and systems.

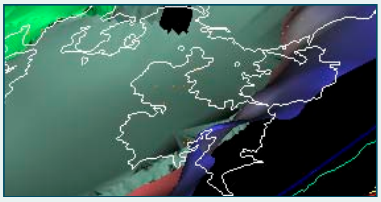
'Unlike viewing a geological model on a flat computer screen, using the models in 3D creates the perception that you are underground, exploring the subsurface structures and systems of Australia. This tool will be invaluable for identifying new exploration opportunities, and for encouraging international interest' Mr Baldwin said.

The lab will help scientists to better understand geological structures in areas critical to Australia's mineral and petroleum exploration and to better understand Australia's geological hazards.









James Johnson, Chief of Geoscience Australia's Minerals Division, highlighted the importance of the facility as a visualisation tool which allows geoscientists 'to produce models, turn them on their head, look from all angles at a geological problem… in effect, place ourselves inside the data and look at it that way.'

Some of the 3D models viewed in the 3D VizLab can also be viewed across the Web on the Geoscience Australia website.

For more information

www.ga.gov.au/map/web3d/

link

In brief

Landslide Database Interoperability Project

Landslide inventories are fundamental to the development of rigorous hazard and risk assessments. However, at present, an agreed, systematic way of developing these inventories is not available.

There are a number of different landslide inventories within Australia, and each database addresses a specific purpose. Although there are some similarities and a number of common themes between databases, the method in which information is organised and described varies considerably. As a result information cannot be readily compared or aggregated with other sources.

These inventories are also generally only accessible to a small number of individuals and consequently there is the possibility that there is significant duplication of effort between landslide researchers working independently. These limitations are being addressed by a collaborative project currently underway between Geoscience Australia, Mineral Resources Tasmania and the University of Wollongong.

The Landslide Database Interoperability Project (LDIP) was established as part of a continued endeavour between these agencies to improve the historic record of landslide events in Australia and to ensure that information is useful, relevant and easily accessible.

The project demonstrates how three diverse landslide inventory databases being maintained independently by different organisations at different scales, can be integrated via a web interface into one 'virtual' database using interoperability. Interoperability is like an information portal. It creates a series of 'live links' from separate databases into a common interface via the internet. The interface is where data is organised into a consistent format before allowing the user to view the information (figure 1).

The interoperable approach allows the virtual database to be tailored to meet the needs of various users and decision makers. This will ensure that the database is useful to all levels of government, geotechnical professionals, emergency managers, land use planners, academics and the general public. It will provide direct access to spatial data and allow users to simultaneously search and query different landslide databases for the most up-to-date information available. The combined search results can be displayed as reports, graphs, maps, statistics or tables, and data can be queried against background datasets, such as topography, geology and geomorphology.

The project also highlights the advantages in developing an 'overarching database structure' that adopts and promotes the use of agreed standards, classification systems and terminology to describe landslide events. This is currently in development as part of the LDIP and will provide the basis for incorporating other landslide inventories into the interoperable interface. It is envisaged that this overarching database structure could become a template for the 'best practice' capture of landslide information.

If the proposed landslide database structure is adopted for developing inventories, and the community assists by contributing relevant information to database custodians, it is possible that there could eventually be one virtual landslide database with national coverage. More importantly, it will ensure that the most up-to-date information on landslide events is accessible to those who need it.

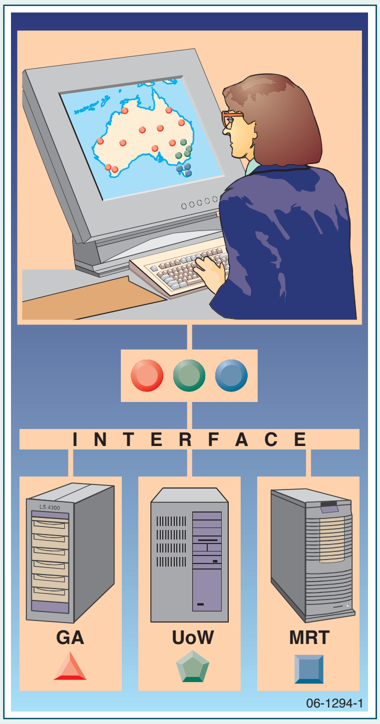


Figure 1. How interoperability works.

This project aligns well with recommendations made by the Council of Australian Governments (COAG) in the Report: *Natural Disasters in Australia: reforming mitigation, relief and recovery arrangements*. It is particularly relevant to Reform Commitment 2 and the establishment of a nationally consistent system of data collection, research and analysis to ensure a sound knowledge base on natural disasters and disaster mitigation.

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In brief

Geoscience Australia's new Cadetship scheme

Next year Geoscience Australia will be offering a unique cadetship scheme for Canberra-based students who are embarking on their first year of university science studies. It is hoped that the program will effectively boost the number of students pursuing careers in geoscience.

"We are looking for bright, enthusiastic young people who wish to pursue careers in science"

'We are looking for bright, enthusiastic young people who wish to pursue careers in science. In collaboration with the Australian National University, we will be offering a tailored cadetship program which will offer professional work experience placements and on-going support from academic mentors' said Dr. Neil Williams, Chief Executive Officer of Geoscience Australia, when announcing the scheme.

'Geoscience is just such a diverse scientific discipline that there are so many rewarding and exciting careers to choose from. The students who obtain a cadetship will have the opportunity to work in a range of professional working environments allowing them to make informed decisions about their futures' said Dr Williams.

The career path of Geoscience Australia's Trevor Dhu (pictured) demonstrates the rationale for the scheme. Trevor studied maths and physics at University because he enjoyed it at high school. As he continued with his university studies he discovered that there was a great opportunity to apply these skills to questions and problems relating to the Earth. This drove him towards geophysics and he is currently leading the development of earthquake risk and ground motion models for Australia.

The cadetship scheme is open to students in Canberra, who have performed well in science and maths for their Year 12 Certificate and are about to apply for a science-related degree at the Australian National University. The cadetships will be offered to students commencing science degrees including the newly offered Bachelor of Global and Ocean Sciences (Honours), or to students completing science degrees with interests in geoscience-related subjects.

For more information

phone Tony Robinson, on +61 2 6249 9411
web www.ga.gov.au/jobs/

Australian Government
Geoscience Australia

AUSGEO news
ISSUE 84 Dec 2006

Product News

Reprocessing shows AVO potential for petroleum exploration

product news

Geoscience Australia has been conducting preliminary Amplitude Versus Offset (AVO) compliant processing on long cable seismic data to identify anomalies that may potentially indicate gas and sometimes oil accumulations under some geological conditions. Geoscience Australia has reprocessed parts of four lines from the 2006 Offshore Acreage Release (areas W06-7 and W06-11) to determine if the AVO method could be useful in investigating petroleum prospectivity in those areas.

Digital seismic field data and the reprocessed seismic data containing near, middle and far angle PreSTM stacks and PreSTM CMP gathers across the AVO anomalies are available from Geoscience Australia at the cost of transfer.

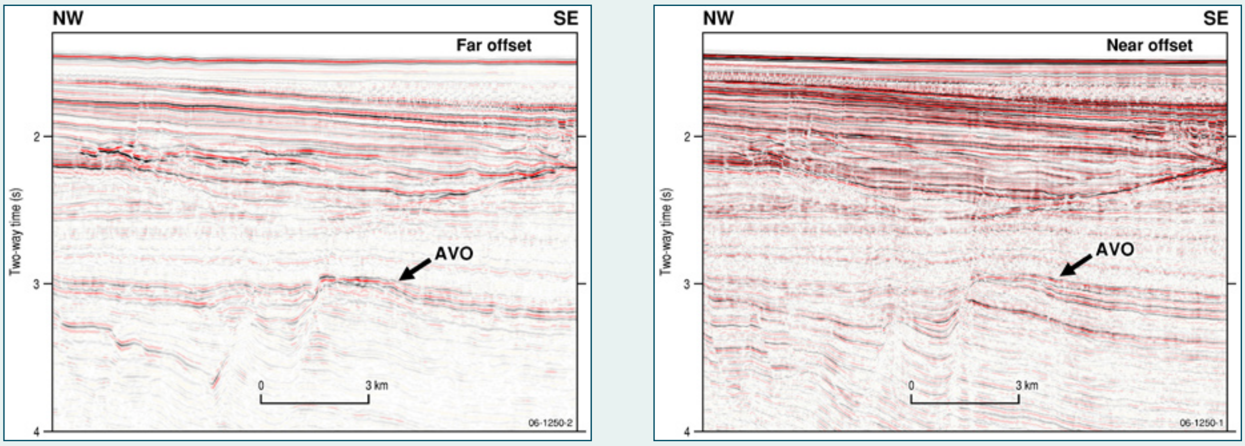


Figure 1. Near offset processing and far-offset processing for seismic line B97-27M showing a high amplitude AVO anomaly on the far-offset processed seismic data.

Data from Block W06-11 (2D Zeus Seismic Survey line B97-27M) over the Exmouth Plateau (shot in 1997), shows AVO anomalies including one that appears to be at the Jurassic level of the reservoir in the Jansz/Io supergiant gas field in the adjacent acreage to the north. There is also an AVO anomaly in Block W06-7 in the Caswell Sub-basin (seismic line P98-035) at or near the stratigraphic zone of the Brecknock South 1 gas discovery 20 kilometres to the north. All the AVO anomalies are kilometres in length along the lines. The preliminary results from this reprocessing have been published and were presented at the Australian Earth Sciences Convention in Melbourne in July 2006.

The success in these preliminary investigations of AVO anomalies in two proven gas areas in the 2006 Offshore Acreage Release suggests that the AVO technique may also have value in further evaluating the exploration potential of the North West Shelf.

However further processing, more detailed AVO evaluation, structural and stratigraphic evaluations, and AVO modelling will be required to establish greater confidence in the validity of our published AVO anomalies as indicating exploration targets. Initially, Geoscience Australia intends to extend its program of AVO investigation to areas in the 2007 Acreage Release.

For more information

phone Fred Kroh on +61 2 6249 9183
or Paul Williamson on +61 2 6249 9440
email fred.kroh@ga.gov.au;
or paul.williamson@ga.gov.au

Related websites

www.ga.gov.au/image_cache/GA8481.pdf

link

www.ga.gov.au/image_cache/GA8480.pdf

link

product news

New Map for nickel explorers

A new 1:3 500 000 scale colour map *A Synthesis of Australian Proterozoic Mafic-Ultramafic Magmatic Events. Part 1: Western Australia*, was released by Geoscience Australia at the recent Australian Nickel Conference in Perth. The map for the first time summarises the major known Proterozoic mafic and ultramafic magmatic events and associated mineral deposits in Western Australia.

The map includes details of fifteen major magmatic events with tholeiitic mafic systems dominating most Proterozoic provinces. Diagrams show the distribution of large igneous provinces (LIPS: large volumes of coeval mafic magmatism), different generations of dolerite dyke and sill complexes, gravity and magnetic anomalies. The geochronological data which underpins the main event map are summarised in Time–Space–Event charts. These charts also identify the major mineralised magmatic events throughout Western Australia.

The spatial and temporal correlations of mafic±ultramafic magmatic systems at province and continental scales are clearly indicated on the map. It also highlights the potential for nickel and platinum-group element mineralisation in relatively unexplored environments, such as the LIPS, which collectively covered more than 60% of Western Australia during five major regional magmatic events throughout the Proterozoic.

The new map should be of interest to nickel exploration companies, and those interested in the metallogeny of mafic-ultramafic rocks or the geological evolution of Proterozoic provinces. It can be downloaded online free in pdf and jpeg formats from Geoscience Australia's website (see *Related websites/articles*).

Figure 1. (left) Panton layered mafic-ultramafic intrusion, East Kimberleys (photograph by Ian Oswald-Jacobs).

For more information

phone Dean Hoatson on +61 2 6249 9593
email dean.hoatson@ga.gov.au

Related websites/articles

A Synthesis of Australian Proterozoic Mafic-Ultramafic Magmatic Events. Part 1: Western Australia
www.ga.gov.au/map/images.jsp#mum
link

AusGeo News 83
Catching the nickel boom: New synthesis will aid nickel explorers
www.ga.gov.au/ausgeonews/ausgeonews200609/nickel.jsp
link

AusGeo News 79
Nickel sulphide metallogenic provinces: resources & potential
www.ga.gov.au/ausgeonews/ausgeonews200509/nickel.jsp
link

Ore Geology Reviews 29
Nickel sulfide deposits in Australia: characteristics, resources and potential

Ore Geology Reviews 29, Nos 3-4, 177–241
www.sciencedirect.com
link

Explore Australia's vast marine environment

For the first time users can access an interactive online mapping program to explore and map Australia's marine environment. The program incorporates environmental, resource, boundary and legal information sourced from a diverse array of Australian government agencies and private organisations.

The individual user can create personalised marine maps by determining the scale, region and information to be displayed whether a small area of specific interest or the extent of Australia's marine jurisdiction.

The Australian Marine Spatial Information System (AMSIS) is an easy-to-use management and information tool bringing together over 120 layers of Australian marine information. It contains a wealth of marine data including state and federal jurisdictional boundaries, the underlying bathymetry, shipping routes, protected world heritage area, petroleum leases, known offshore minerals, submarine cables, Commonwealth fisheries and offshore infrastructure.

It has been designed for a wide audience including offshore industry organisations, marine planners and researchers, environmental managers, policy development officers, as well as members of the public.

Since being launched in June this year by the Hon Bob Baldwin MP, Parliamentary Secretary to the Minister of Industry, Tourism & Resources, the program has received wide acclaim and is currently used by more than 400 users from over 35 countries per month.

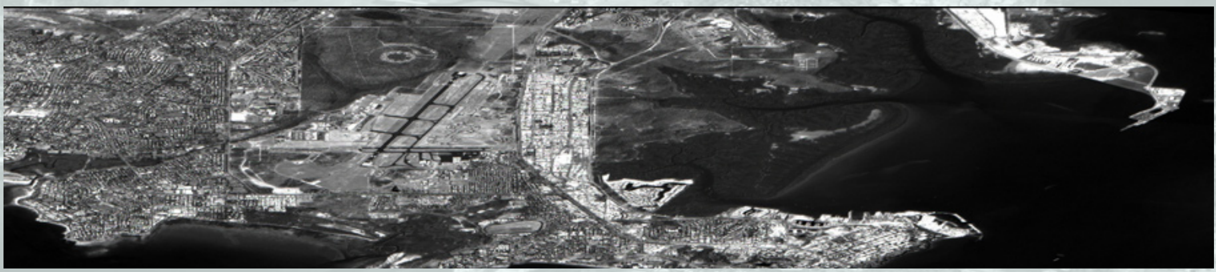
For more information

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

link

New satellite imagery for Australia

A new type of satellite imagery from Geoscience Australia will provide high quality Earth observation data for topographic mapping, disaster and environmental monitoring and climate change studies. The images are being acquired by the Japanese Advanced Land Observing Satellite (ALOS) which was launched in January 2006. Since launch the satellite has undergone extensive calibration and validation to ensure its images are of the highest quality.



The ALOS satellite carries three imaging sensors:

- PRISM (Panchromatic Instrument for Stereo Mapping) simultaneously views the earth in a single spectral band with 2.5 metre spatial resolution at three different viewing angles over a 35 kilometre wide swath. This 'stereo imaging' capability enables generation of high resolution digital elevation models.
- AVNIR-2 (Advanced Visible and Near Infrared Radiometer Type 2) is a multi-spectral sensor with 10 metre spatial resolution, 4 spectral bands and a 70 kilometre wide swath.
- PALSAR (Phased Array type L-band Synthetic Aperture Radar) is a sensor which allows day and night observation using a variety of imaging modes regardless of cloud cover.

Under an arrangement with the Japan Aerospace Exploration Agency (JAXA), Geoscience Australia's Australian Centre for Remote Sensing (ACRES) is one of only four worldwide nodes to download, process and distribute ALOS satellite data products. The others are JAXA in Japan, the National Oceanic and Atmospheric Administration (NOAA) in the United States and the European Space Agency (ESA).

Geoscience Australia is licensed to distribute ALOS data for non-commercial purposes within Australia, New Zealand, Papua New Guinea and many Pacific islands. Customers must register their proposed usage with Geoscience Australia prior to placing any orders. Customers requiring ALOS data for commercial purposes will be able to access ALOS data through local commercial distributors appointed by the Remote Sensing Technology Centre of Japan (RESTEC).

The availability of ALOS products from Geoscience Australia comes after extensive preparation and represents a significant achievement in the supply of quality public-good satellite imagery for Australia.

For more information

www.ga.gov.au/acres/prod_ser/ALOS/

link

Related websites

Japan Aerospace Exploration Agency (JAXA)
www.jaxa.jp/index_e.html

link

National Oceanic and Atmospheric Administration, United States (NOAA)
www.noaa.gov/

link

European Space Agency (ESA)
www.esa.int/esaCP/index.html

link

Events

Citizen's Science celebrated

Figure 1. Competition winners from Canberra region primary and high schools with the Hon Gary Nairn MP, Special Minister of State, Dr Neil Williams, CEO Geoscience Australia and Education Manager Dr. Kate List.

Earth Science Week 2006 promoted the theme of 'Citizen's Science' to encourage everyone to learn about the contribution that earth sciences make to the wellbeing of our society and environment.

This year Geoscience Australia offered two competitions for primary and secondary schools in the Canberra region to encourage children to find out more about earth science and the work of geoscientists.

Primary school students exhibited their creative talents in an art competition 'When I grow up I want to be a geoscientist' whilst secondary school students were asked to discuss Sir Douglas Mawson's geoscientific contributions to Australia.

The winning students were presented with a gold or silver medallion and other prizes by Special Minister of State, the Hon. Gary Nairn MP, during a visit to Geoscience Australia's Canberra headquarters headquarters on 13 October. Each participating school also received a book on earth science for their library as a commemorative gift.

Earth Science Week is an international event held in October each year which provides an opportunity for everyone involved in the earth sciences to share the significance of their work with the broader community.

Geoscience Australia has been the national coordinator of Earth Science Week events in Australia since 1999. It continues to promote the week, encourage participation and raise awareness about the diversity of careers within the earth sciences.

For more information

phone Jeanette Holland on +61 2 6249 9731
email jeanette.holland@ga.gov.au
web www.ga.gov.au/about/event/index.jsp

Events calendar

Events 2007

NAPE Expo 2006 –North American Prospects Exhibition — 1 & 2 February

1

American Association of Professional Landmen
Houston, Texas, USA
Contact: AAPL, 4100 Fossil Creek Boulevard, Fort Worth, Texas 76137 USA
phone +1 817 847 7700
fax +1 817 847 7703
e-mail nape@landman.org
www.napeonline.com

Australian Map Circle 35 Annual Conference — 11 to 14 February

2

Australian Map Circle Inc
Canberra ACT
Contact: Australian Map Circle, PO Box 4206, University of Melbourne, Vic. 3052
phone +61 3 8344 3550
fax +61 3 9347 0974
email j.cain@unimelb.edu.au
www.australianmapcircle.org.au

PDAC International Convention & Trade Show — 4 to 7 March

3

Prospectors and Developers Association of Canada
Metro Toronto Convention Centre, Toronto, Canada
Contact: PDAC, 34 King Street East Suite 900, Toronto, Ontario M5C 2X8
phone +1 416 362 1969
fax +1 416 362 0101
e-mail info@pdac.ca
www.pdac.ca/

APPEA Conference and Exhibition — 15 to 18 April

4

Australian Petroleum Production and Exploration Association
Adelaide Convention Centre
Contact: Vicki O'Gorman, APPEA Limited, GPO Box 2201, Canberra ACT 2601
phone +61 2 6247 0906
fax +61 2 6247 0548
e-mail vogorman@appea.com.au
www.appea.com.au

SSC2007-Biennial International Conference — 14 to 18 May

5

Spatial Sciences Institute
Hotel Grand Chancellor, Hobart
Contact: ICMS Pty Ltd, 84 Queensbridge Street, Southbank, Vic. 3006
phone +61 3 9682 0244
fax +61 3 9682 0288
email sponsorship@icms.com.au
www.spatialsciences.org.au/events/