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CEO comment

This issue of *AusGeo News* features several articles on Geoscience Australia's research to assist energy resource explorers and reduce exploration risk in frontier areas. Other articles highlight some significant recent contributions to natural resource management.

The main feature article reports on the development of a basement architecture framework for a section of the continental margin off Australia's western coast referred to as the Southwest Margin. This area includes the Southern Carnarvon, Perth and Mentelle basins, as well as the Naturaliste and Wallaby plateaus. The methodologies used for this study may be applied to other regional geological and exploration activities in different geographic and tectonic settings.

Trap breach is a major exploration risk in the offshore northern Perth Basin. Our article outlines the trap integrity study which evaluated the potential of fault reactivation as a critical exploration risk for hydrocarbon preservation in the Abrolhos Sub-basin. The results from this work are a step towards the development of a regional predictive approach for assessing trap integrity in this area.

The Joseph Bonaparte Gulf and Timor Sea region, off northern Australia, is a focus for a range of stakeholders in both the energy industry and marine management agencies. Our article describes a recent environmental review, describing the physical characteristics of the seabed and associated biological communities, which drew on results from two recent mapping and sampling surveys in the area led by Geoscience Australia.

In 2010 the United Nations General Assembly appointed 25 experts representing all nations to carry out the first cycle of the Regular Process to review the ocean's condition every five years. The process and approaches to be used for the first global integrated marine assessment between 2010 and 2014 is summarised in our feature article. Dr Peter Harris of Geoscience Australia has been appointed to be Australia's member of the Group of Experts for the current phase of drafting the assessment.

This issue also includes reports on:

- The National Dynamic Land Cover Dataset which will assist sustainable farming practices as well as management of our water resources, soil and forests.
- The Gnangara geomagnetic observatory in the southwest of Western Australia which was recently commissioned.
- Preparations for the 34th International Geological Congress, to be held in Brisbane between 5 and 10 August 2012.

In the last issue of *AusGeo News* I outlined the new structure for Geoscience Australia to better reflect the government's major strategic foci. This issue includes brief profiles of the recently appointed Chiefs of our new scientific Divisions as well as our new General Manager Corporate Services.

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

Chris Pigram
CEO Geoscience Australia

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Understanding Australia's Southwest Margin

Basement architecture as a framework for predictive basin analysis

Lisa Hall, Ron Hackney, Stephen Johnston

The Southwest Margin is a section of the continental margin off Australia's western coast. It includes the Paleozoic to Mesozoic Southern Carnarvon, Perth and Mentelle basins, as well as the Naturaliste and Wallaby plateaus. While several smaller hydrocarbon discoveries have been made onshore, the offshore region remains underexplored. Recent studies, however, indicate there is potential for new petroleum discoveries in many of these frontier areas (Nicholson et al 2008; Borissova et al 2010; Jones et al 2011).

Despite the new geological insights gained from these studies, depth-to-basement and basement structure and composition beneath the Southwest Margin sedimentary basins remain poorly understood. The extent of exposed basement outcrop is limited, only a few wells intersect basement and, in many areas, the basement horizon cannot be resolved using seismic data. An understanding of basement is however important when conducting basin studies, as the basement of any basin provides the foundation onto which sediment fill is deposited. As tectonic stresses are applied to a region, the rheology and mechanical behaviour of the basement influences how the crust deforms. Hence, variations in basement strength, composition and structure significantly influence the resulting basin geometry, patterns of sediment deposition and basement derived heatflow. All of these factors fundamentally affect the generation and preservation of hydrocarbon resources.

Geoscience Australia is currently engaged in a study to improve our understanding of the basement in the Southwest Margin region, which will generate the following products:

- regional gravity and magnetic datasets
- a map of interpreted basement terrane distribution
- maps of interpreted basement composition and structure
- a depth-to-basement model.

This work develops alternative technical methodologies to define the basement architecture so it can be used as a framework for predictive basin analysis when other datasets are unavailable. Although this study will primarily complement offshore petroleum exploration studies along a rifted margin, the methodologies described here are applicable to other exploration activities in many different geographic and tectonic settings.

New data

Geoscience Australia has assessed the prospectivity of the frontier areas of the Southwest Margin basins as part of the Australian Government's Offshore Energy Security Program (Geoscience Australia 2011; *AusGeo News* 103). This work included the acquisition of 7300 kilometres of new 2D seismic reflection data in 2008–09 and re-processing of 11 700 kilometres of open-file industry seismic data (*AusGeo News* 94). Whilst regional-scale interpretation of these data provided important new insights into the structural framework of the basins along this margin, the lack of a clear basement reflector makes it very difficult to resolve basement geometry and structure.

In addition, 26 000 line kilometres of new potential-field data were acquired as part of the Offshore Energy Security Program. These new data were merged and levelled (Hackney and Morse 2011; Hackney et al 2012) and combined with an existing Australia-wide dataset of levelled marine data (Petkovic et al 2001). The data were subsequently combined with onshore data from the 5th Edition of the Magnetic Map of Australia (Milligan et al 2010) and the 2010 release of the Australian National Gravity Database. The final compilation (figure 1) provides a consistent onshore/offshore dataset that covers the entire Southwest Margin of Australia, and is the primary dataset used for this study where seismic data is unavailable or no basement reflector can be resolved.

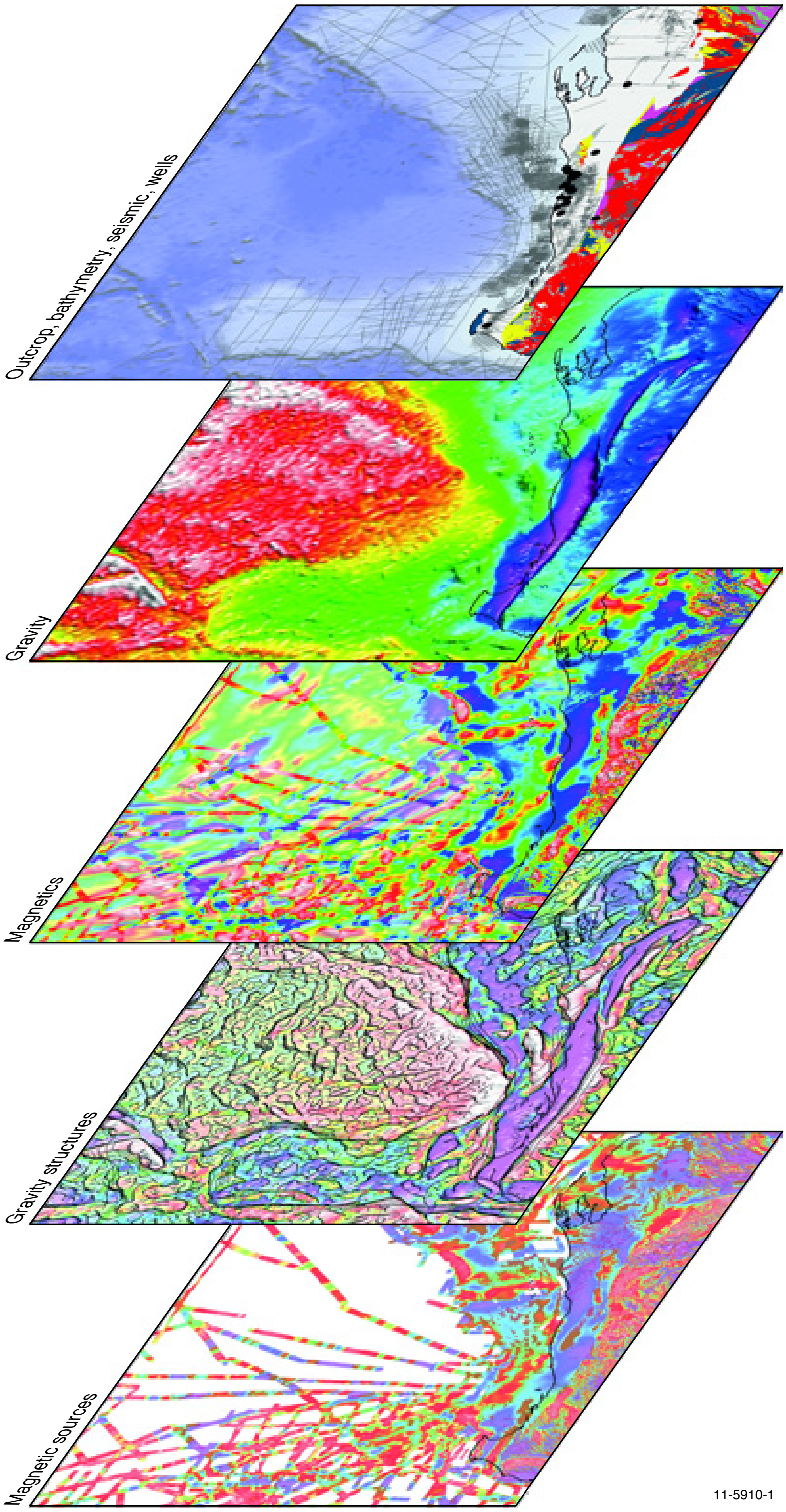

Figure 1. Datasets used for basement architecture interpretation of the Southwest Margin basins.

Insights into basement composition are provided from limited basement outcrop onshore, basement intersections in wells, and dredge samples (figure 1). Basement outcrop is restricted to the Northampton, Mullingarra and Leeuwin Complexes (figure 2), and approximately 30 basement penetrating wells have been identified across the Perth and Southern Carnarvon Basins which provide information on basement composition. In addition, sampling surveys conducted across the region over the last five years have obtained additional samples from basement rocks in the southern part of the study area (Halpin et al 2008; *AusGeo News* 94).

Basement terranes, structure and composition

New interpretive maps of basement terrane distribution, composition and structural fabric for the Southwest Margin will better characterise the nature of basement across the region. For this study, basement is defined as the economic basement for petroleum systems and represents all igneous and metamorphic rocks of Late Neoproterozoic/Early Cambrian age and older, as well as any younger plutonic intrusions and Mesozoic oceanic crust (Nicholson et al 2008; Borissova et al 2010; Jones et al 2011). The maps extend from the Naturaliste Plateau in the south to the Southern Carnarvon Basin and Wallaby Plateau in the north. In addition, they link the Archean Yilgarn Craton and surrounding Proterozoic mobile belts in the east through to the Early Cretaceous oceanic crust of the Indian Ocean to the west, and are therefore not constrained by the coast line or crustal type.

The basement terrane, structure and composition layers have been constructed through the integrated interpretation of all available geological and geophysical datasets, including outcrop, wells, geochronology, seismic, gravity, magnetic and bathymetry datasets (figure 1). The interpretation methodology is adapted from Shaw et al (1995, 1996) and FrOG Tech (2005). Direct geological observations (outcrop, wells or dredge samples) are compared with potential field characteristics to identify any relationships between observed basement composition and rock properties (density or magnetic susceptibility). There are also correlations between observed structural fabrics and equivalent trends in the potential field data. In addition, along the continent–ocean transition zone, a similar relationship is established between the observed seismic characteristics and potential field data.

The potential field data are then used to predict basement terrane distribution, basement composition and structural fabric in areas where no other datasets are currently available. In addition, the Proterozoic to Mesozoic geological history of each basement terrane is assessed using all available geochronological data from the literature. Continental basement evolution is reviewed in the context of regional Proterozoic plate reconstructions (Collins and Pisarevsky 2005).

The basement terrane map shows regions of similar geological history, and is useful as a predictive tool for determining the likely generic geological history, composition

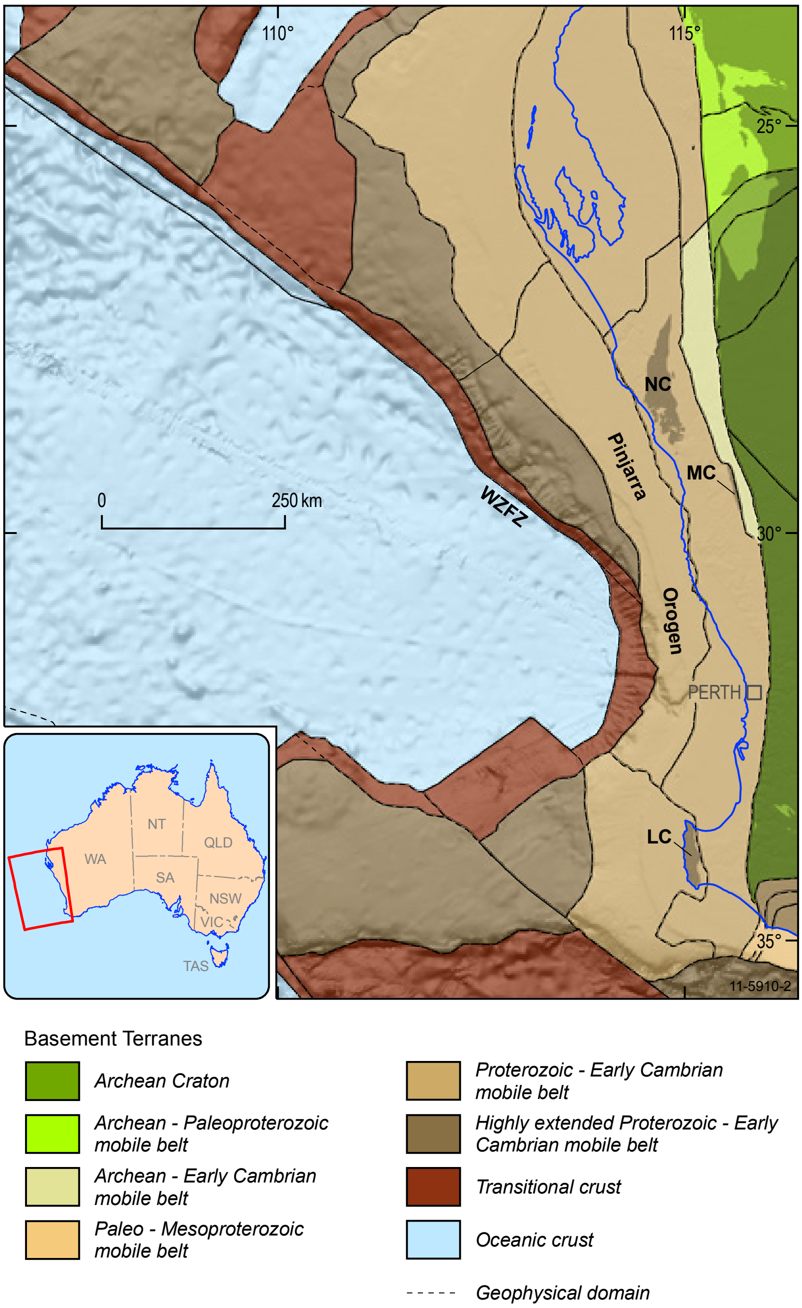

Figure 2. Basement terrane map showing terrane type (abbreviations: NH-Northampton Complex; LC-Leeuwin Complex; MC-Mullingarra Complex; WZFZ- Wallaby–Zenith Fracture Zone).

and structural fabric of basement (figure 2). The terrane map provides new insights into the nature and distribution of terranes within the Neoproterozoic–Early Cambrian Pinjarra Orogen, and suggests that rocks with a strong affinity to the Northampton complex terrane may extend much further south than previously mapped. This has implications for sediment provenance studies in the Perth Basin and on the North West Shelf. The terrane map also includes an update of the continent–ocean boundary and associated continent–ocean transition zone which developed during the Mesozoic separation of Australia from India and Antarctica. This boundary effectively marks the limit of any potential petroleum occurrence.

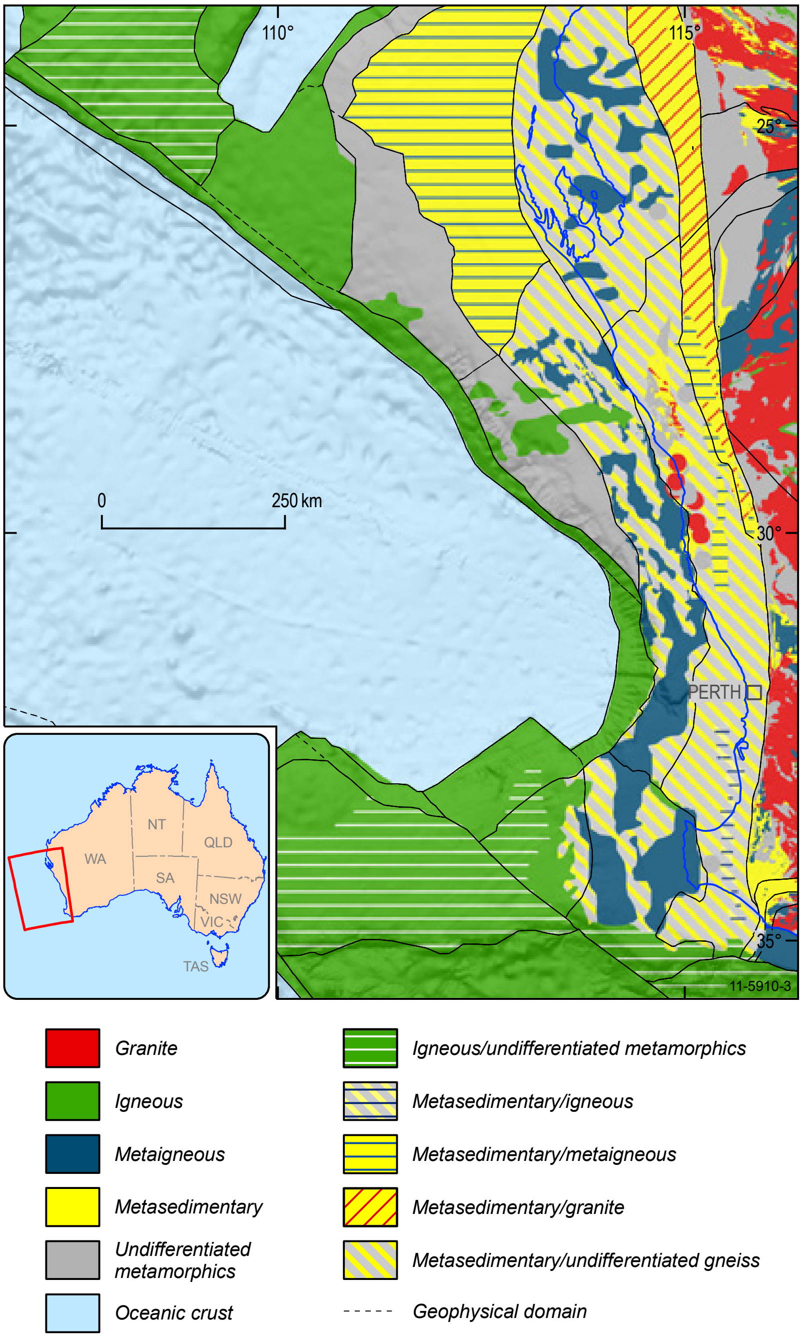

Figure 3. Basement composition map showing simplified primary rock type.

Major basement structures are mapped using basement outcrop, potential field and bathymetry data. The mapped structures include basement faults, dykes and general structural trends that can be identified in the potential field data. Basement trends associated with the Neoproterozoic Pinjarra Orogen appear to have had a profound affect on Late Jurassic–Early Cretaceous margin development. For example, the inception of the Wallaby–Zenith Fracture Zone correlates with a significant change in basement structural trend (figure 2). In addition, a linkage is evident between basement fabric orientation and basin geometry implying basement structures have significantly influenced basin evolution and hence patterns of sediment deposition through time.

The basement composition map (figure 3) is derived from all direct observations of basement composition, seismic basement characteristics and the potential field datasets. This map highlights potential variations in radiogenic basement-derived heatflow due to composition changes which may in turn influence the thermal evolution of the basin and hence petroleum source rock maturation.

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Depth-to-basement

Sediment thickness is a fundamental factor in assessing the architecture, evolution and petroleum prospectivity of a basin. While seismic reflection data is an important tool for investigating sedimentary basins, deep basin architecture may be difficult to resolve in some seismic datasets. Because parts of the northern Perth Basin are susceptible to this problem, this study used magnetic methods to estimate the depth to major magnetic susceptibility contrasts, such as the sediment-basement interface or magmatic bodies, to resolve depth-to-basement in areas of limited seismic resolution.

Depth to magnetic basement was estimated using the spectral method of Spector and Grant (1970), which relates the wavelength of the magnetic grids to magnetic source depths (Johnston and Petkovic 2012). While many magnetic methods estimate depth-to-basement (Gunn 1997), the spectral method allows additional geological and geophysical data (such as well information, surface outcrop, gravity and seismic interpretations) to be integrated into the workflow. This results in a more geologically plausible depth-to-basement model. As part of this project, software has been developed which has allowed rapid implementation of this workflow.

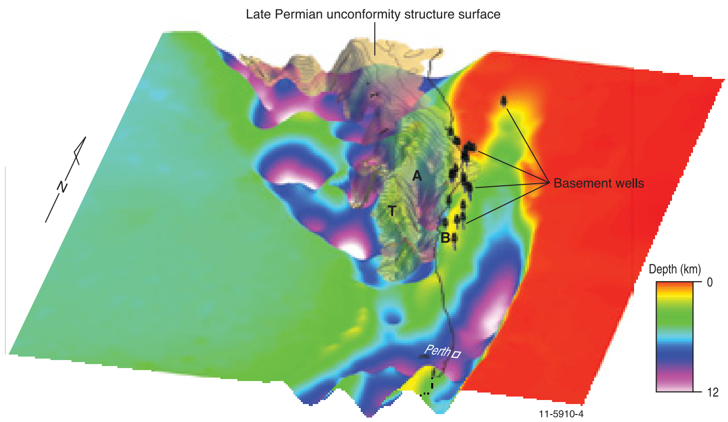

Figure 4. Perspective view of depth-to-magnetic basement map, derived from magnetic power-density spectrum, well depths and depth-converted seismic interpretation (abbreviations: A-Abrolhos Sub-basin; B-Beagle Ridge; T-Turtle Dove Ridge). Basement is overlain by the top Permian unconformity structure surface (Jones et al 2011).

The depth to Precambrian basement for the Perth Basin highlights the main sub-basins and structural highs and gives an indication of total sediment thickness (figure 4). For example, the Abrolhos Sub-basin is clearly delineated as a 32 kilometre-wide, elongate, north-northwest trending depocentre, located between the Beagle Ridge to the east and the Turtle Dove Ridge to the west. A comparison of the depth-to-basement map with the topography of the overlying Late Permian unconformity (see figure 7 in Jones et al 2011) gives further insight into the total thickness of early syn-rift/pre-rift sediments, beyond what may be resolved using seismic data alone.

Two-dimensional magnetic cross sections (forward models) were used to independently test the spectral depth-to-basement model and overall a good correlation was observed between the two methods (Johnston and Petkovic 2012). In addition, the modelled magnetic susceptibility variations across the Turtle Dove Ridge and Abrolhos Sub-basin are consistent with the interpreted basement composition variations described in the previous section.

Conclusions

This study provides a regional view of the simplified basement lithology, geometry and variation of basement across Australia's Southwest Margin based on the integration of numerous geophysical and geological datasets.

The spatial variation of basement terranes, composition and structural fabric is captured through a series of data products and interpreted maps, which can be used to predict regional-scale changes in basin geometry and patterns of sediment deposition over time. The depth-to-basement model integrates both geological and geophysical data to provide a new 3D view of total basin architecture, not obtainable from the seismic data alone, which better constrains the possible thickness of pre- and early syn-rift sediments. Future work will involve integration of new geochronological data and plate reconstructions to provide new insights into the timing and nature of the tectonic events controlling both the Proterozoic basement and the Mesozoic margin evolution.

The Southwest Margin basement architecture framework defined in this study demonstrates the application of basement studies for predictive basin analysis in the context of petroleum exploration in rifted margin settings. These workflows are equally applicable to studies on the adjacent Southern Margin and North West Shelf. In addition, the methodologies described here may be applied to other regional geological and exploration activities in many different geographic and tectonic settings.

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Seabed environments of the Joseph Bonaparte Gulf and Timor Sea

Seabed mapping reveals significant habitats and potential hazards

Rachel Przeslawski & Scott Nichol

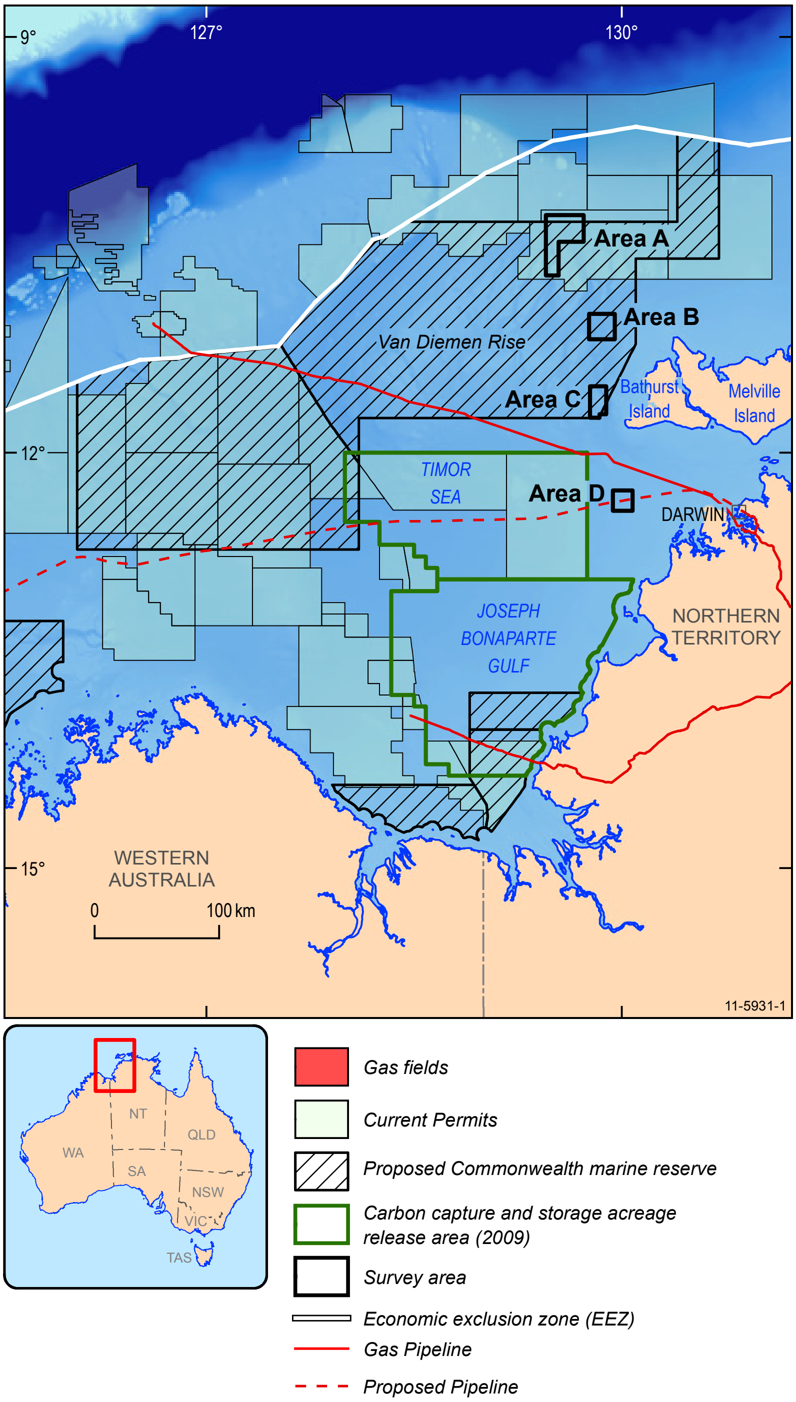

Figure 1. Map of the study area showing petroleum industry and marine research activity in the region. Geoscience Australia Survey areas are indicated by the letters (A, B, C, D).

Offshore northern Australia, is a focus for both the energy industry and marine management agencies (figure 1). In particular, the Joseph Bonaparte Gulf and adjacent Timor Sea is a region that supports active petroleum exploration and infrastructure development and includes one of Australia's first acreage releases for carbon storage in an offshore sedimentary basin. Parts of the region are also included in the proposed Commonwealth network of marine reserves due for finalisation in 2012. Consequently, the Joseph Bonaparte Gulf and Timor Sea region offers unique opportunities for marine researchers to provide fundamental environmental information to a range of stakeholders.

Environmental review

Geoscience Australia has recently compiled an integrated description of the seabed environments within the Joseph Bonaparte Gulf. This will provide the offshore petroleum industry with all available information describing the physical characteristics of the seabed and associated biological communities. Particular attention was given to potential geohazards to infrastructure as well as the occurrence of unique and sensitive biota. The study area encompasses three geologically distinct structures: the Petrel Sub-basin, Darwin Shelf, and Malita Graben. The Petrel Sub-basin was included because it underlies most of the study area, while the Darwin Shelf and Malita Graben were chosen because they incorporate a range of geomorphic features (or undersea landforms) and habitats. These habitats were the focus of two collaborative marine surveys undertaken in 2009 and 2010 by Geoscience Australia and the Australian Institute of Marine Science (AIMS) on the RV Solander (surveys GA-322 and GA-325 respectively; Heap et al 2010, Anderson et al 2011).

During these surveys, the seafloor was mapped with high resolution multibeam sonar which provided the basis for designing a sampling program to collect a range of physical and biological material. The data collected during these surveys was then combined with publicly accessible information about the region to provide a comprehensive environmental review. This regional synthesis will assist industry in their pre and post-bid environmental assessments and emergency planning (Przeslawski et al 2011).

Seabed habitat types

The continental shelf in the Joseph Bonaparte Gulf and Timor Sea is the widest in Australia, extending up to 400 kilometres from the shore. Most of the inner shelf is characterised by relatively flat expanses of soft sediment seabed with localised rocky outcrops, gravel deposits and sand banks. The inner shelf section of the Gulf receives significant loads of sediment from several large rivers including the Daly and Victoria rivers. Circulation and mixing are driven by tidal and wind-generated currents that vary in intensity according to season. Across the mid and outer shelf, the seabed and associated habitats are more complex due to carbonate banks and terraces that flank a network of channels and deep valleys.

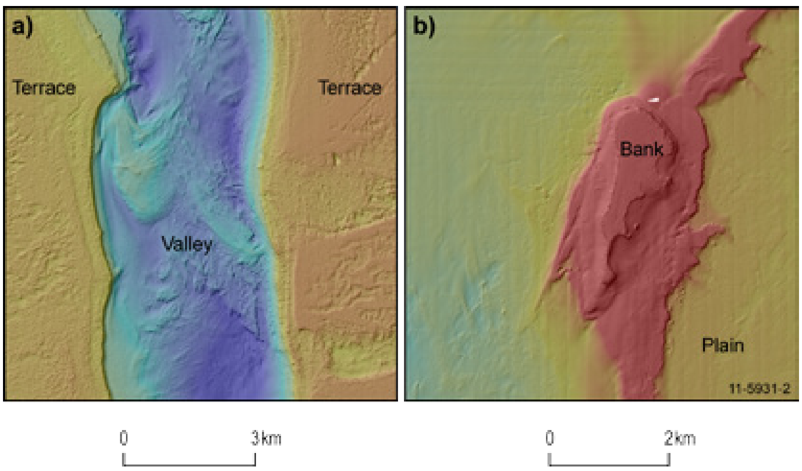

Figure 2. High-resolution false colour bathymetry showing: a) terraces and a valley in Survey Area A; b) a plain and bank (Moss Shoal) in Survey Area B.

Bathymetric grids produced at five metre resolution from the multibeam sonar data obtained during the 2009 and 2010 surveys allowed a new level of detail when the geomorphology of the shelf in representative areas was mapped (figure 2). Using a range of physical and biological datasets collected during the surveys, researchers characterised habitat type and biological communities at each of these geomorphic features:

- *Banks* are the shallowest features in the study area, sitting in water depths between 20 and 40 metres. They are characterised by hard carbonate substrate with localised deposits of carbonate gravel, but they also have sandy sediments with high organic matter content. All of the banks that were mapped and sampled support localised gardens of sponges and octocorals (a group that includes sea fans, sea whips and soft corals).
- *Terraces* are flat-topped features with a discontinuous cover of mixed carbonate sand and gravel. Locally, sand ripples occur interspersed by rocky outcrops. Terraces support moderate numbers of epifaunal species (living on the seafloor) but low numbers of infaunal species (living within loose sediment deposits). Sponge and octocoral gardens occur at some locations, but their distribution is generally patchy.

- *Ridges* are narrow elongate features that are generally flat-crested but have shallow channels incised to depths up to 10 metres. Sediments are sandy with local fields of bedforms (for example, sand waves) particularly in channels. Ridges have highly variable numbers of epifaunal species.
- *Plains* are the least complex geomorphic feature in terms of bedform and relief. Physical properties of the sediments are very uniform consisting mainly of very poorly sorted gravelly-muddy sands. Plains have the lowest number of epifaunal species but the highest number of infaunal species.
- *Valleys* are also dominated by flat expanses of soft sediments interspersed with exposed rock in debris-swept channels. Compared to other geomorphic features, they have the greatest variety in substratum types. Epifauna is sparse with the exception of patches of immobile animals fixed to local exposures of rock.

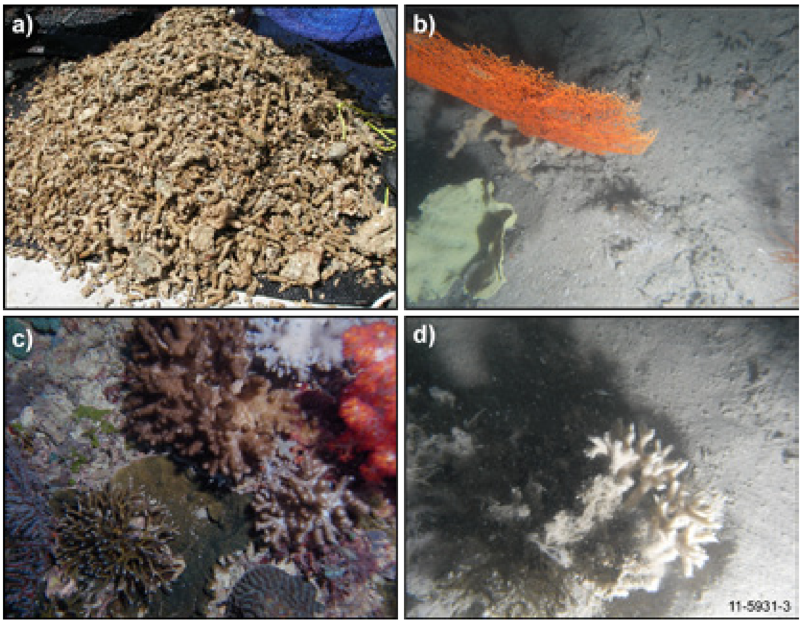

Figure 3. Significant biological communities identified from surveys GA-322 and GA-325: a) Coral rubble (Area A, 90 metres depth); b) sponge and octocoral gardens (Area C, 60 metres depth); c) hard coral communities (Area A, 13 metres depth); d) branching mesophotic coral (Area D, 53 metres depth).

Based on these biophysical characterisations and results from the surveys, researchers identified several significant communities from the Joseph Bonaparte Gulf and Timor Sea (figure 3). Sponges and octocorals are major habitat-forming animals on the seafloor, providing structure to otherwise flat environments and sheltering a range of animals (such as brittlestars, crabs, fish). Many of the observed sponge and octocoral gardens include large species that are long-lived and slow-growing, making them potentially vulnerable to anthropogenic and natural disturbance. Where sponges and octocorals occur in dense gardens, the number of other animals is often also high, and these gardens can thus be indicative of high biodiversity. In the Joseph Bonaparte Gulf and Timor Sea, sponge and octocoral gardens are commonly found on rocky outcrops, a habitat that is particularly common on banks.

Hard corals

For the first time, dense communities of reef-forming hard corals were observed in the offshore waters of Joseph Bonaparte Gulf. Hard corals provide a raised substrate that becomes an important habitat for a range of species, a function that is termed 'ecosystem engineering'. Reef-forming corals are also valued because of their association with high levels of biodiversity, including fish communities. The surveys found hard corals on the shallow banks of the Van Diemen Rise approximately 250 kilometres offshore in Survey Area A. In the same area, samples of dead coral (possibly *Acropora*) were collected at 90 metres depth and observed in underwater video as mounds of coral rubble, possibly reflecting coral reefs that grew here during the sea-level lowstand of the last glacial maximum (around 15 to 18 thousand years ago). Because of their conservation status, some of these hard coral species are included on the International Union for Conservation of Nature red list list as near threatened, vulnerable, or endangered (*Stylophora pistillata, Turbinaria reniformis, Turbinaria patula,* cf. *Caulastrea* sp., and *Cantharellus* cf. *noumeae*).

Surprisingly, small isolated specimens of hard corals (possibly *S. pistillata*) were observed growing at five stations on the muddy inner shelf in Survey Area D. These inner shelf waters are mostly soft-sediment and highly turbid, but it appears that even in these conditions limited coral growth is possible for mesophotic species (that is, species which adapted to low light levels).

Overall, the Joseph Bonaparte Gulf and Timor Sea region is characterised by habitats that are distinct at the regional scale when compared to neighbouring regions such as the Big Banks Shoals to the west. In particular, the carbonate banks of the study area seem to represent a regionally distinct habitat since they are dominated by sponges and octocorals. The atolls and banks to the west of the region are dominated by hard corals and *Halimeda* algae (Heyward et al 1997).

Potential geohazards

The development of infrastructure on the seafloor requires basic geomorphological and geological information including water depth, seabed slope, sediment properties and thickness, and sedimentation rates. After consideration of these and other parameters, the potential for hazardous processes such as erosion, faulting, and fluid expulsion can be evaluated. Survey data acquired from multibeam sonar and sub-bottom profiles were used to map the location of steep scarps and sites of possible mass movement on the seabed along the northeastern Joseph Bonaparte Gulf and Timor Sea. As anticipated, these features only occur along the flanks of deep valleys, particularly those on the carbonate banks of the outer shelf. Though there is geomorphic evidence for seabed instability, the age or rate of these potential mass movements remains unknown.

In order to assess the stability of the seabed over time, the Geoscience Australia survey in 2010 re-mapped an area of seabed on the outer shelf that had been mapped in 2009. This area included a complex terrace and valley network with local relief of up to 25 metres. The repeat mapping did not detect any change in the form or position of these features, with their stability over time likely to be attributable to the hard composition of the terraces.

Pockmarks are a pervasive feature of soft sediment areas across the plains and deeper valleys on the continental shelf of the Joseph Bonaparte Gulf and Timor Sea. These circular depressions have diameters of several metres and depths of two to three metres and several hundred occur in some places (figure 4). The origin of the pockmarks is unclear, however it is possible that they are evidence of gas or fluid expulsion from the shallow sub-surface. Despite the pockmarks and the potential for sediment mobility and slope failure (or landslides), the overall risk to industry presented by geohazards in the study area is relatively low.

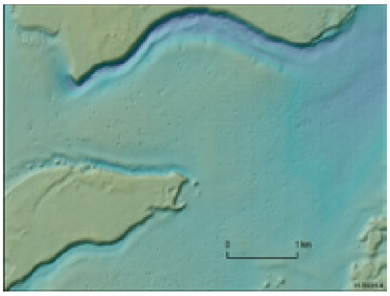

Figure 4. High resolution multibeam sonar image of the seafloor on the outer continental shelf of Joseph Bonaparte Gulf showing pockmarks formed in muddy sands across a valley floor.

Conclusions

The distribution of seabed habitats, communities and geohazards in the study area is regulated by complex interactions between oceanographic, geological, and biological processes. The suite of these processes operating at a given location is affected by distance from the coast and the geomorphic features present.

Many of the observations in this study relate to broad spatial patterns identified from regional-scale data (between ten and several hundred kilometres scale). This scale allows the offshore petroleum industry to put proposed development plans in a regional environment context. Similarly, management of marine reserves requires a regional context regarding the ecosystems found within them.

Both industry and marine management agencies, however, can also benefit from information at the local scale (one to ten kilometres scale). Results from the recent Geoscience Australia surveys indicate that significant habitats, communities, and potential hazards exist at a scale too small to be detected in regional-scale analysis. This point is illustrated by the discovery of reef-forming hard corals and sponge and octocoral gardens on the shallow banks of the Van Diemen Rise. These communities are unique on a regional scale but would not have been identified without sampling at a local scale. Similarly, potential geohazards such as seabed slumps and gas expulsions can only be identified using sub-bottom profiles collected across targeted sites. These results highlight the continued importance of acquiring high-resolution geophysical data and biophysical samples to allow the identification of significant habitats and communities that may otherwise remain undetected.

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AUSGEO news
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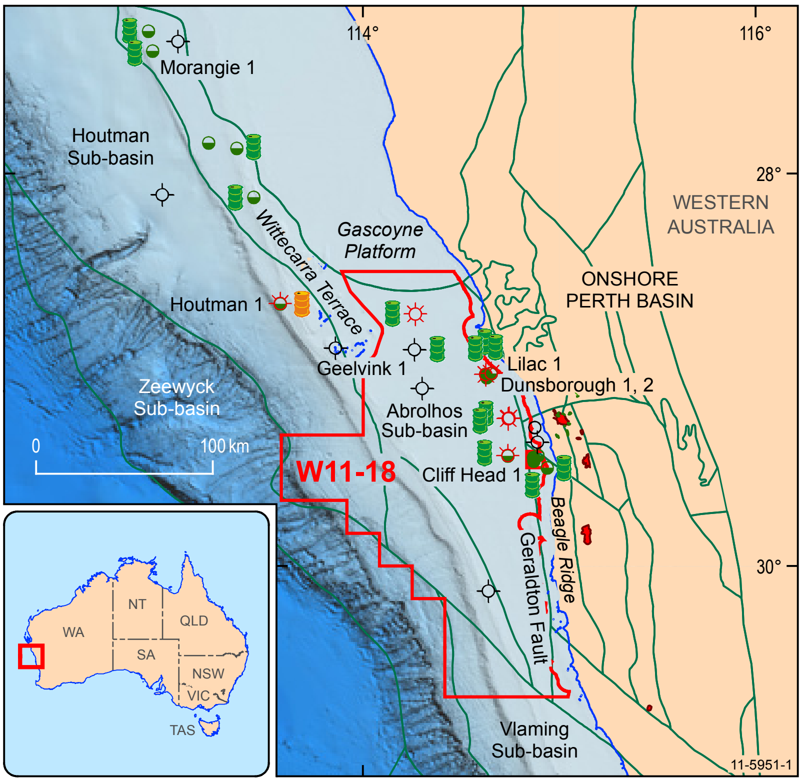
Reducing exploration risk in the offshore northern Perth Basin

Trap integrity study addresses a key exploration risk

Chris Nicholson[1], Laurent Langhi[2], Yanhua Zhang[2], Nadege Rollet[1], George Bernardel[1], Richard Kempton[2], John Kennard[1]

Geoscience Australia is currently reassessing the petroleum prospectivity of the offshore northern Perth Basin (see *AusGeo News* 103 and 104). Part of the reassessment was a trap integrity study, led by CSIRO in partnership with Geoscience Australia, which evaluated the potential of fault reactivation as a critical exploration risk for hydrocarbon preservation in the Abrolhos Sub-basin. This reassessment was initiated under the Australian Government's Offshore Energy Security Program, as part of Geoscience Australia's continuing efforts to identify a new offshore petroleum province.



Well symbol information is sourced either from "open file" data from titleholders where this is publicly available as at 1 April 2011 or from other public sources. Field outlines are provided by Encom GPinfo, a Pitney Bowes Software (PBS) Pty Ltd product. Whilst all care is taken in the compilation of the field outlines by PBS, no warranty is provided re the accuracy or completeness of the information, and it is the responsibility of the Customer to ensure, by independent means, that those parts of the information used by it are correct before any reliance is placed on them.

2011 Offshore Petroleum Acreage Release Area
Gas field
Oil field
Sub-basin outline
Petroleum exploration well - Not classified
Petroleum exploration well - Dry hole
Petroleum exploration well - Gas discovery
Petroleum exploration well - Oil show
Petroleum exploration well - Oil and gas show
Petroleum exploration well - Gas and oil discovery
Palaeo-oil column - Permian
Palaeo-oil column - Post-Triassic

Figure 1. Location map showing palaeo-oil column distribution in the offshore northern Perth Basin (modified from Kempton et al 2011). The red outline shows 2011 Acreage Release Area W11-18.

Regional trap integrity study

A major exploration risk in the offshore northern Perth Basin is trap breach, where trapped oil or gas has been lost due to fault movements (Kempton et al 2011; Jones et al 2011a & 2011b). Evidence of lost oil accumulations, referred to as palaeo-oil columns, were detected in Permian reservoir sandstones below the Triassic Kockatea Shale regional seal in 14 of the 18 wells analysed from the Abrolhos Sub-basin (Kempton et al 2011, Kempton et al 2011b). Further outboard, a palaeo-oil column in Houtman 1 demonstrates an effective oil-charge system in Jurassic strata in the Houtman

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Sub-basin. Oil charge from the Hovea Member of the Kockatea Shale west of the Beagle Ridge has been modelled as having occurred in the Late Jurassic to Early Cretaceous, and breach of many palaeo-accumulations could be attributed to structural processes after this time. These include:

- fault reactivation and structuring associated with Jurassic–Early Cretaceous extension and continental breakup in the Valanginian
- tilting and thermal subsidence of the margin post-breakup
- inversion of faults associated with collision of the Australian and Eurasian plates during the Miocene.

This study focused on several drilled prospects which are covered by three-dimensional (3D) seismic data and contain both breached and preserved oil columns all sourced and sealed by the Triassic Kockatea Shale (figure 1). 3D deformation and fluid-flow numerical modelling has been applied to these prospects to simulate the response of trap-bounding faults to Jurassic–Early Cretaceous NW–SE extensional reactivation and, therefore, to investigate hydrocarbon preservation risk in the Abrolhos Sub-basin during this time. The detailed results of this regional trap integrity study will be made

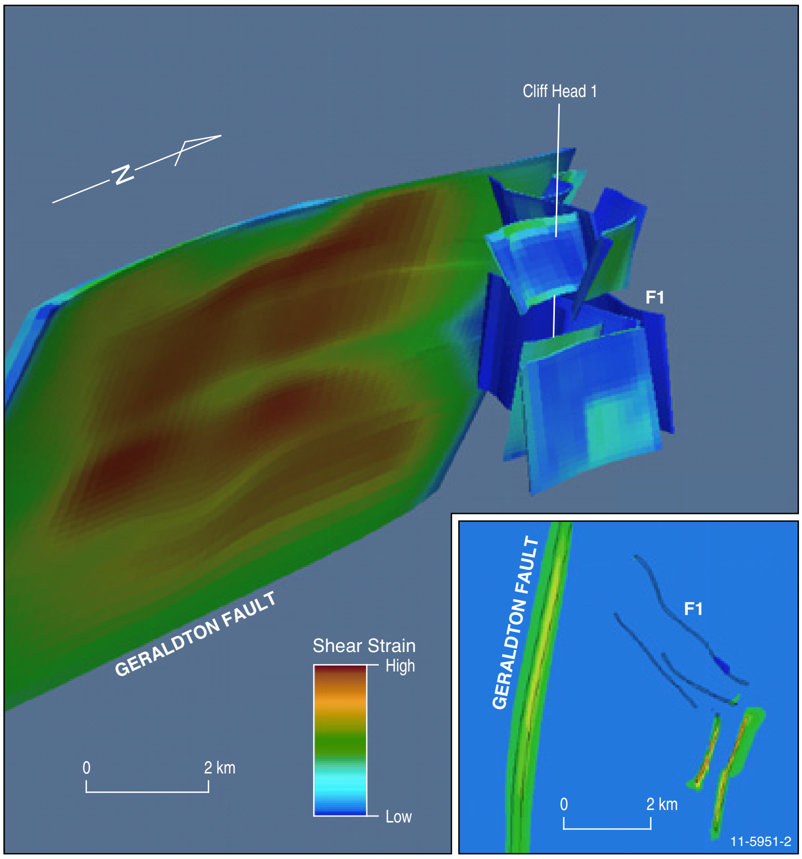


Figure 2. 3D and 2D strain distribution showing the shielding effect of the Geraldton Fault, for NW-SE extension, on the Cliff Head field. Cliff Head trap bounding fault is labelled F1. Inset shows Cliff Head-1 trajectory into structure. Note the low strain modelled on NW striking trap bounding faults.

available as a CSIRO open file report (Langhi et al 2012) which can be downloaded from either the CSIRO or Geoscience Australia websites, as well as the Western Australian Department of Mines and Petroleum WAPIMS database.

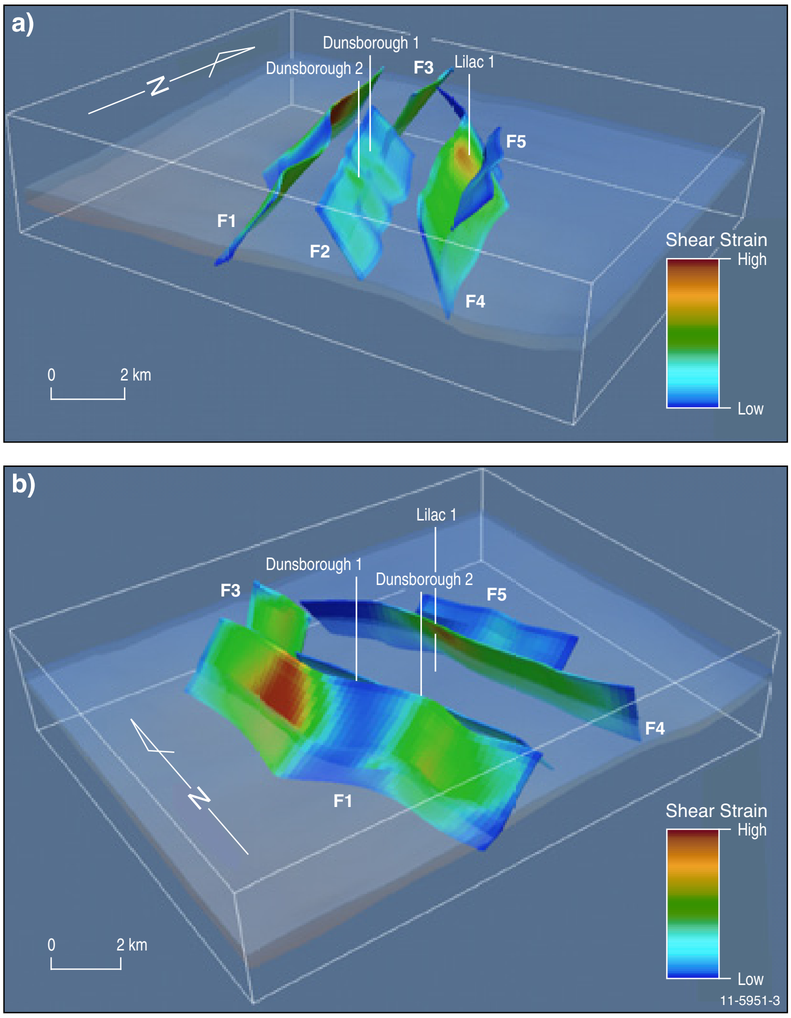
Geomechanical models

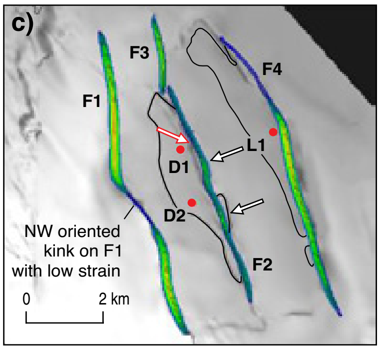
Geomechanical models, which describe the stresses and mechanical properties of a rock mass, were produced for the: (i) Cliff Head oilfield; (ii) Diana 3D survey covering the Dunsborough oil/gas discovery and the Lilac prospect; (iii) Macallan 3D survey, including the Morangie prospect. The 3D datasets were used to interpret major faults and key horizons (such as top reservoir and top seal) around these prospects, which were then used as modelling inputs. The 3D geomechanical models assist in understanding the first order factors controlling the distribution of reactivation stresses and strains, as well as the likelihood of shear failure occurring along fault planes and triggering up-fault leakage through the regional seal. The stress data were also used to compute increases in pore fluid pressure required to bring fault segments to a state of instability and, therefore, to a high risk of reactivation.

Preservation risk in the Abrolhos Sub-basin

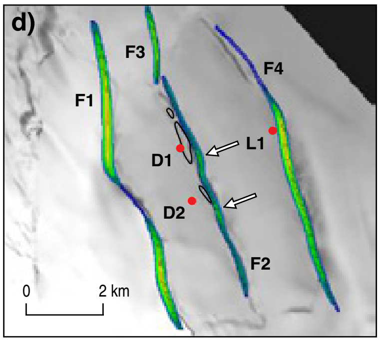
Cliff Head oil field

The Cliff Head oil field (figures 1 and 2) was discovered in 2001 on the Beagle Ridge in a large faulted anticline to the east of the Geraldton Fault. The oil accumulation in the Cliff Head field is trapped within Permian Irwin River Coal Measures in a NW-trending main horst. The Permian fault F1 (figure 2) is the most critical structure as it bounds the crest of the horst closure to the north-east. Modelling results show that this fault, and other similar NW-oriented faults around the structure, are consistently associated with low risk of reactivation. Their strike orientations are sub-parallel to the modelled NW–SE extension direction, which is probably the main factor preventing the reactivation of the trap bounding faults. It is likely that this has prevented the trap bounding faults from breaching the regional seal and allowing hydrocarbon leakage. The geomechanical deformation models also show that the large north-striking Geraldton Fault to the west was optimally oriented to accommodate reactivation strain, which helped to shield the Cliff Head horst structure from fault reactivation.

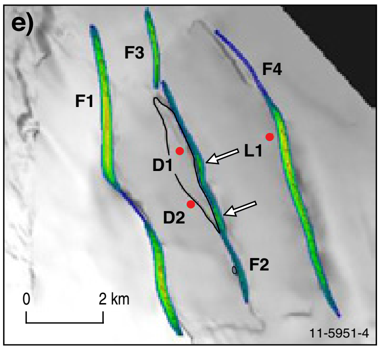




Possible palaeo-field prereactivation (OWC c 1525 mRT)



Possible post reactivation remaining accumulation



Present-day accumulation based on (OWC c 1490 mRT)
Shear strain loci
Crest closure
Petroleum exploration well location

Figure 3. Relationship between strain distribution and charge history for the Dunsborough and Lilac traps: A) 3D shear strain distribution south-east view; B) 3D shear strain distribution south-west view showing the lateral variation in shear strain distribution for fault F1; C) Limit of possible palaeo-oil column at Dunsborough and Lilac prior to fault reactivation; D) Extent of remaining accumulation if high shear strain loci acted as fluid pathways at Dunsborough and Lilac; E) Probable extent of present-day oil column for Dunsborough trap. Abbreviations: F1-4 show main fault trends; D1-2 indicates Dunsborough-1 and -2 wells; L1 indicates Lilac-1 well.

Dunsborough oil/gas discovery and Lilac breached trap

Dunsborough-1 (figures 1 and 3) was drilled in 2007 to test a N–S oriented, rotated fault block trap within Permian Dongara Sandstone and Irwin River Coal Measures, and was a successful oil and gas discovery. Dunsborough-2 was then drilled approximately 1.7 kilometres to the south to test the extent of this discovery, but failed to find hydrocarbons. Palaeo-oil columns were identified in both wells below the Kockatea Shale regional seal (Kempton et al 2011). Lilac-1 (figure 3) was then drilled 2.7 kilometres to the east of Dunsborough-1 in 2008 to test an equivalent fault block trap. This well failed to find hydrocarbons, but subsequent studies detected a palaeo-oil column in the same Permian Dongara Sandstone and Irwin River Coal Measures (Kempton et al 2011).

As with Cliff Head, the modelling results show that fault segments trending more to the north show higher levels of strain and, therefore, are more likely to reactivate than the segments trending to the northwest under the Jurassic–Early Cretaceous NW–SE stress field (figure 3). In the Dunsborough prospect this resulted in strain partitioning between the main trap forming faults F1 and F2. The concentration of strain on F2 (shear strain loci, figure 3), for example, may be related to the northwest kink on F1 to the west. The increased strain at these loci may have been sufficient to force the Permian faults up through the overlying Kockatea Shale, which would promote the development of high permeability zones and, therefore, fluid leakage. This is shown in figure 3D, which models the extent of the hydrocarbon accumulation remaining after up-fault leakage and indicates that both Dunsborough-1 and -2 would be dry. However, the present day oil-water contact shown on figure 3E suggests that these leaking fault segments closed up at some later point and allowed subsequent hydrocarbon charge to accumulate around Dunsborough-1 on the trap crest.

At Lilac-1 shear strain distribution and modelled deformation on the trap bounding fault F4 was significantly greater than at the Dunsborough prospect, and was sufficient to allow migration pathways to develop through the Kockatea Shale seal (figure 3F) resulting in the total loss of hydrocarbon accumulation.

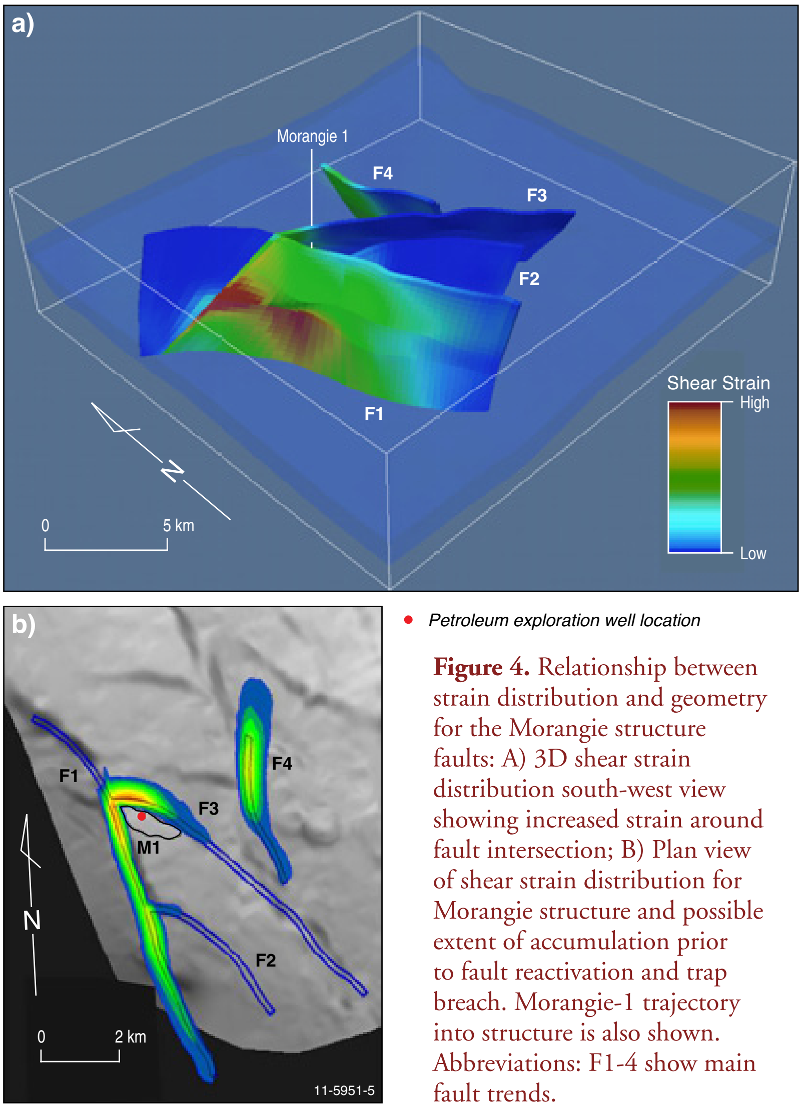


Figure 4. Relationship between strain distribution and geometry for the Morangie structure faults: A) 3D shear strain distribution south-west view showing increased strain around fault intersection; B) Plan view of shear strain distribution for Morangie structure and possible extent of accumulation prior to fault reactivation and trap breach. Morangie-1 trajectory into structure is also shown. Abbreviations: F1-4 show main fault trends.

Morangie breached trap

Morangie-1 was drilled in 2002 on the Wittecarra Terrace in the Abrolhos Sub-basin (figures 1 and 4). The well tested a tilted horst trap within Permian Dongara Sandstone that had dip closure to the south and was fault bounded in all other directions. However, despite good oil shows the well failed to find recoverable hydrocarbons. Subsequent palaeo-charge studies identified a minimum 52 metre palaeo-oil column (Kempton et al 2011) indicating that the trap had once been filled, but was subsequently breached.

A schematic palaeo-field reconstruction indicates that while the crest of the trap is fault-bound to the east by fault F3 (figure 4B) the palaeo-oil column would have also been partially fault bound to the west by fault F1. Modelling results show an increase in strain at the triple junction between these two faults. It is likely that this would result in the development of a high permeability zone, which may explain the total loss of hydrocarbons from the Morangie structure.

Reducing exploration risk

This study addresses a key exploration risk in the offshore northern Perth Basin–hydrocarbon leakage caused by trap breach. Despite the general lack of exploration success offshore, apart from the Cliff Head oil field, the identification of palaeo-oil columns in many offshore wells indicates that an active petroleum system has been widespread in this part of the Perth Basin. Trap integrity modelling provides the opportunity to investigate the likely cause of trap breach and develop a framework for assessing the risk of leakage for individual structural trap styles.

3D geomechanical modelling simulated the response of trap-bounding faults and fluid flow to Jurassic–Early Cretaceous NW–SE extension. Calibration of the modelling results with current and palaeo oil columns demonstrates that fluid flow along faults correlate with areas of local high shear and volumetric strains. The concentration of this deformation leads to: (i) an increase in structural permeability promoting fluid flow; (ii) the development of hard-linkage between reactivated Permian reservoir faults and Jurassic faults producing top seal bypass. The modelling found that several key structural factors controlled the distribution of these permeable fault segments during reactivation: (i) faults oriented between NNW and ESE were found to be at high risk of failure during the extension; (ii) fault intersections were also found to generate high permeability zones prone to leakage. In addition, large faults optimally oriented for reactivation preferentially accommodate strain and help shield nearby structures, as is the case with the Geraldton Fault immediately to the west of the Cliff Head field.

Results from this work are a step towards the development of a regional predictive approach for assessing trap integrity in the offshore northern Perth Basin. The predictive approach of this technique could be applied to newly identified, and yet to be drilled, prospects to help reduce risk for future exploration. The technique could equally be applied using modern day stress fields in the assessment of areas suitable for carbon capture and storage on other parts of the Australian Margin.

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For more information

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Related articles/websites

Full details and results of the trap integrity study (CSIRO Open File Report EP12425) are available through:
www.csiro.au (keywords: Perth Basin, trap integrity)

Geoscience Australia
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Western Australian Department of Mines and Petroleum WAPIMS database
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AUSGEO news ISSUE 105 Mar 2012

United Nations Global Ocean Assessment

First global assessment of the state of the oceans

Peter Harris

Is the wealth generated by marine industries increasing or decreasing? Is the condition of global marine ecosystems improving or declining? What is the overall state of the global marine environment? How can we measure the state of the oceans at a global scale in a meaningful way? These questions were posed in 2002, when Heads of State gathered in Johannesburg, South Africa, for the World Summit on Sustainable Development. They decided to commence a Regular Process to review the ocean's condition every five years. It was noted that a large number of marine environmental assessments are already carried out by countries, regional authorities and international organisations. Consequently, it was decided that the best approach was to take advantage of these as much as possible. A key decision was to include social and economic aspects within the scope of the Regular Process, which has the full title 'Global Reporting and Assessment of the State of the Marine Environment including Socio-economic Aspects'.

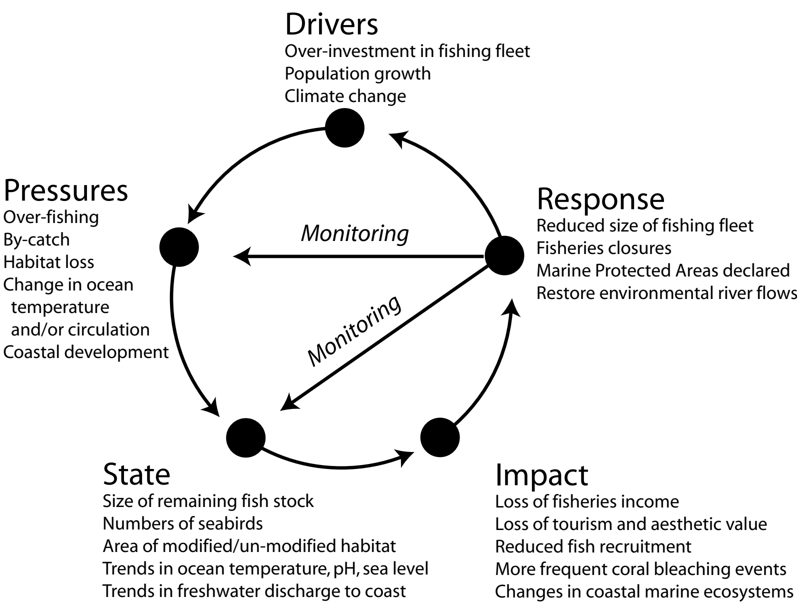

Figure 1. Drivers-Pressures-State-Impact-Response (DPSIR) Framework as used by the Regular Process in relation to the ocean environment (UNEP 2009). Drivers result in Pressures that have an effect on the State of the environment. Measuring the State of marine ecosystems also allows the Impact of pressures to be assessed and guides government policy Responses. Monitoring is required to gauge the effectiveness of the policy Responses.

The progress of the Regular Process within the United Nations (UN) has been managed by an Ad Hoc Working Group of the Whole, which is a subset of the General Assembly. The Working Group has determined that the Regular Process should be an integrated assessment of the oceans, including the cross-cutting thematic issue of food security, and that it should provide a baseline for future global assessments. The Working Group is a subset of the General Assembly and is open to all member countries.

In 2006 a start-up phase commenced to review over 500 existing marine environmental assessments from around the world (UNEP, IOC-UNESCO 2009). In 2010 the UN General Assembly appointed 25 experts representing all nations to carry out the first cycle of the Regular Process between 2010 and 2014. The immediate tasks for the Group of Experts include preparing a draft outline for the First Global Integrated Marine Assessment (the Assessment) and to design a process for drafting and reviewing it. Producing the Assessment will be a major undertaking that will have to involve many marine experts from around the world in order to succeed. The Australian Government has supported the development of the Regular Process by providing experts to participate in the start-up phase (2006–2009). For the current phase of drafting the Assessment Dr Peter Harris of Geoscience Australia has been appointed as Australia's member of the Group of Experts.

Rationale for the structure of the Assessment

The Drivers-Pressures-State-Impacts-Response (DPSIR) framework shown in figure 1 suggests at least three possible approaches for structuring the Assessment:

- Pressures
- Habitats
- Ecosystem Services.

Using Pressures as chapters in the Assessment report has the advantage that the associated human activities are commonly linked with data collection and reporting structures for regulatory compliance purposes. For instance, permits that are issued for offshore oil and gas development require that specific monitoring and reporting obligations be met by operators.

> "Successfully drafting the First Global Integrated Marine Assessment is a major undertaking that will require the full cooperation and participation of the world's community of marine experts."

Using marine habitats as chapters has the advantage that Habitat is the property that inherently integrates many ecosystem features, including higher and lower trophic level species, water quality, oceanographic conditions and many types of anthropogenic pressures (UNEP, IOC-UNESCO 2009). The cumulative aspect of multiple pressures affecting the same habitat, that is often lost in sector-based environmental reporting (Halpern et al 2008), is captured by using Habitats as reporting units.

Using Ecosystem Services as chapters follows the approach of the Millennium Ecosystem Assessment which has the advantage of broad acceptance in environmental reporting (Millenium Ecosystem Assessment 2005). It includes provisioning services (food, construction materials, renewable energy, coastal protection) while highlighting regulatory services and quality-of-life services that would not be captured using a pressures or habitats approach to structuring the Assessment.

Given that each approach has their own particular advantages, the Group of Experts proposed that all three approaches be included in the Assessment which would be structured into seven broad sections:

I. Summary for decision-makers
II. The Context of the Assessment
III. Ecosystem Services
IV. Cross-cutting issue—food security
V. Other human activities
VI. Biodiversity and habitats
VII. Overall evaluations

It should be noted that this structure has not yet been adopted by the Working Group.

The coverage of the Assessment

A summary for decision-makers comprises Part 1 of the Assessment. This is followed by a broad, introductory survey of the role played by the oceans and seas in the life of the planet, the way in which they function, and human relationships to them in Part 2. This section will also explain the mandate from the United Nations to carry out the Assessment and how it was carried out.

Part 3 of the Assessment will describe the ecosystem services provided by the oceans. Provisioning services will not be addressed in detail in this Part because they are covered in the pressures and habitat sections of the Assessment. Chapters on the earth's hydrological cycle, air/sea interactions and primary production will draw heavily on the work of the Intergovernmental Panel on Climate Change–the aim would be to use the work of the Panel, not to duplicate it or challenge it.

The cross-cutting issue of the oceans and seas as a source of food will be addressed in Part 4. This part of the Assessment will draw substantially on information collected by the Food and Agriculture Organisation of the United Nations. The economic significance of employment in fisheries and aquaculture and the relationship these industries have with coastal communities, including capacity-building needs of developing countries, will also be addressed.

All human activities that relate to the oceans (other than fisheries) will be covered in Part 5. Each chapter will outline the location and scale of activity, the economic benefits, employment and social role, environmental consequences, links to other activities and capacity-building needs. The inclusion of chapters on offshore oil and gas, the renewable energy (wind, wave and tidal power) sector, and seabed mining will be of particular significance for Geoscience Australia.

The aim of Part 6 is to:

a) give an overview of marine biological diversity and what is known about it, drawing heavily upon the Census of Marine Life (Ausubel 2010)
b) review the status and trends of, and threats to, marine ecosystems, species and habitats that have been identified by competent authorities at the global, regional or national level as threatened, declining or otherwise in need of protection (FAO 2008)
c) review the regulatory and management approaches to conservation, the range of their application and results
d) identify capacity-building needs.

Drafting the Assessment

The First Global Integrated Marine Assessment will be carried out by the Group of Experts (under the supervision of the Ad Hoc Working Group of the Whole) and will be assisted in drafting the report by a Pool of Experts who will be nominated by member states. The types of expertise required by different members of the Pool of Experts will include all aspects of marine industry and scientific research.

Successfully drafting the First Global Integrated Marine Assessment is a major undertaking that will require the full cooperation and participation of the world's community of marine experts. If the types of experts required are multiplied by the number of different geographic regions covering the Earth, plus the number of chapters (including the different roles required for producing each chapter), it is likely that the Pool of Experts will require the contributions of about 1000 individuals.

The timeline for the production of the Assessment calls for the establishment of the Pool of Experts by April 2012 and for the final report to be submitted to the Ad Hoc Working Group by the end of 2014. Establishment of the Pool of Experts requires that individuals be nominated by their country. The Australian Government is calling on Australian marine experts interested in participating and supporting the Assessment to volunteer to become members of the Pool of Experts to ensure that the First Global Integrated Marine Assessment is as thorough and accurate as possible.

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Travis Bover
Australian Department of Sustainability, Environment, Water, Population and Communities

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The National Dynamic Land Cover Dataset

Geoscience Australia, with support from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), has recently completed the first comprehensive national dataset and map of Australia's land cover (figure 1). This will give land and resource managers and researchers the opportunity to analyse changing trends in Australia's vegetation cover.

Land cover is the observed biophysical cover on the Earth's surface including trees, shrubs, grasses, soils, exposed rocks and water bodies, as well as anthropogenic elements such as plantations, crops and built environments.

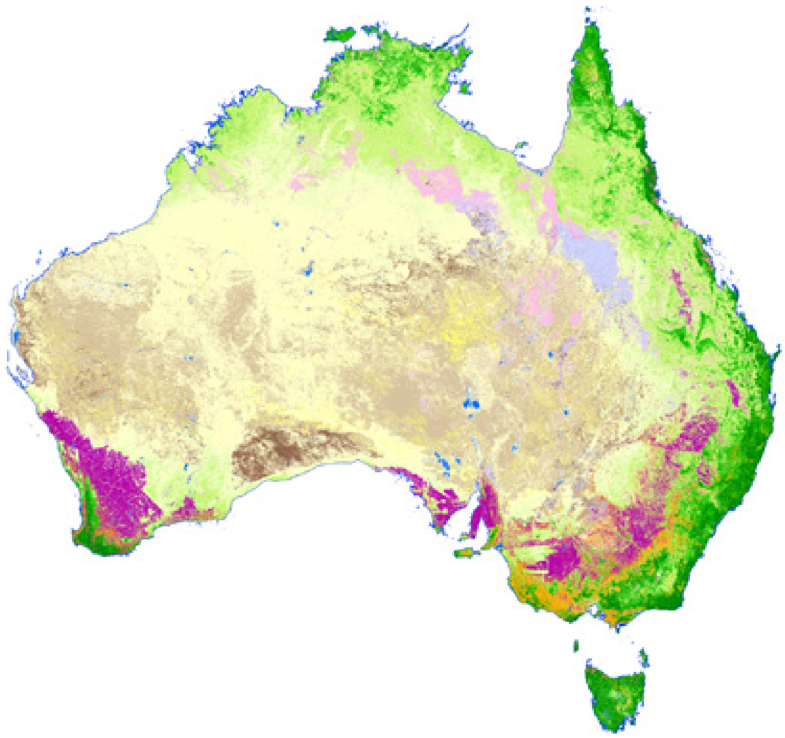

Figure 1. The Dynamic Land Cover Dataset of Australia is the first nationally consistent and thematically comprehensive land cover reference for Australia.

Australia's land cover changes constantly due to weather, seasonal changes and land use, so nationally consistent land cover information is essential to understanding and addressing a range of natural resource challenges. These include sustainable farming practices, management of our water resources, air quality, soil erosion, and our forests.

The Minister for Resources and Energy, Martin Ferguson AM MP, released the new map and dataset on 16 November 2011. The Minister pointed out that '…the land cover map and dataset will allow users to compare vegetation over time, at a national and local level, to monitor trends associated with short term changes brought on by cyclones, long term drought and bushfires, as well as cropping and broadacre agriculture'.

The map and datasets were produced in partnership with ABARES, who have also developed an information hub to assist land managers, planners and others, who need to know more about land use and land management practices, to use in conjunction with the new national land cover data.

Future updated versions of the map will identify actual changes in the land cover which could provide evidence of a need for action in areas such as water management and soil erosion, or that patterns of land use are changing due to economic, climatic or other factors.

Both datasets are now available free online via the Geoscience Australia website, or on CD ROM at cost of transfer from the Geoscience Australia Sales Centre. Hard copies of the land cover map are also available from the Geoscience Australia Sales Centre.

For more information visit

web www.ga.gov.au/earth-observation/landcover.html

Related websites/articles

The National Dynamic Land Cover Dataset
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71071

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) website
www.daff.gov.au/abares

Land Use and Management Information for Australia
http://adl.brs.gov.au/landuse/index.cfm?fa=main.welcome

in brief

New geomagnetic observatory in Western Australia

Geoscience Australia has established a new geomagnetic observatory near the country town of Gingin in southwestern Western Australia. The observatory, located about 90 kilometres north of Perth, will replace the Gnangara observatory. The Gnangara site has been increasingly disturbed, and occasionally vandalised, as the outer Perth suburbs have expanded in its direction over the last 10 years. It is also located on a large sand mining lease and mining operations are moving closer to the observatory site. Neither of these developments is compatible with the quiet conditions necessary for the operation of a geomagnetic observatory.

The new Gingin observatory will operate in parallel with the Gnangara observatory for a period of 12 months so that good station differences can be established between the two sites. After this period has elapsed the Gnangara observatory will cease operation.

Gingin is the third geomagnetic observatory to operate in the southwestern corner of Western Australia. The first was established near the small country centre of Watheroo in 1919 by the Carnegie Institution of Washington. In those days, and partly because of Watheroo's remoteness from Perth, the observatory was a relatively self-contained community consisting of tradespeople, domestics, and the families of the scientists and engineers who operated the observatory. The logistical challenges associated with this remote area eventually led to the relocation of observatory operations to Gnangara, closer to Perth, in 1957 and the closure of Watheroo in 1958, following a year of parallel operation.

> "Gingin is part of Geoscience Australia's network of geomagnetic observatories... "

Gingin is part of Geoscience Australia's network of 10 geomagnetic observatories in Australia and Antarctica (figure 1). They provide a wealth of information for a variety of purposes, ranging from natural resource exploration to navigation and space weather forecasting. The new observatory is expected to operate for at least 50 years considerably extending the 93 years of magnetic field monitoring that has taken place in southwestern Western Australia to date.

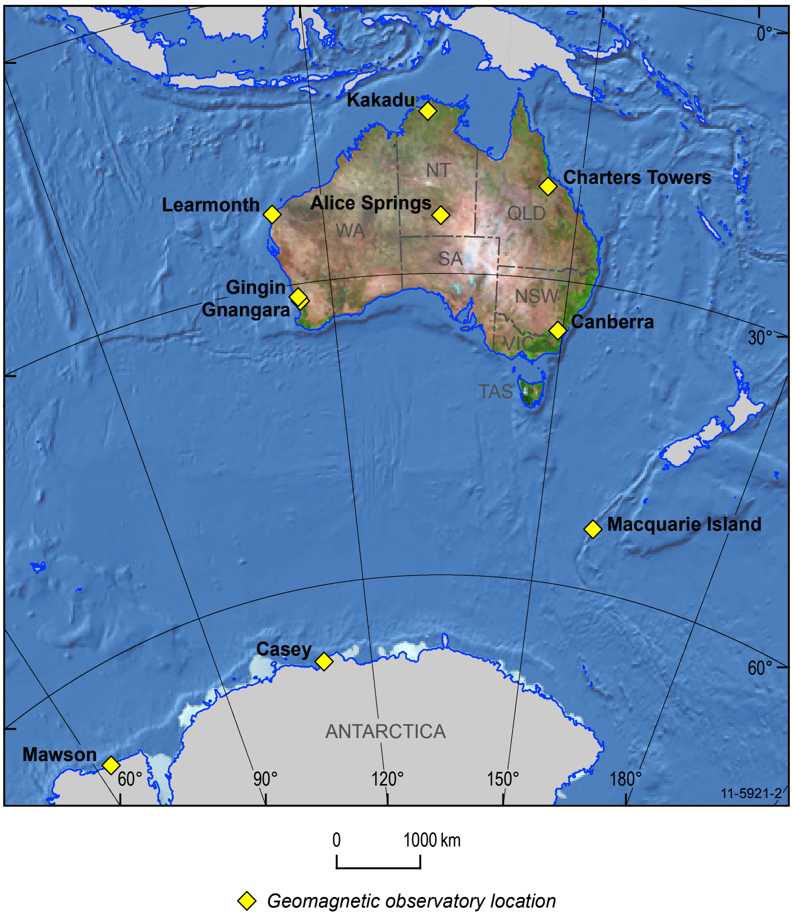

Figure 1. The new Gingin observatory is part of Geoscience Australia's network of 10 observatories on the Australian mainland and external territories.

For more information

email ausgeomail@ga.gov.au

Update on 34th International Geological Congress–AUSTRALIA 2012

Australia will be hosting the 34th International Geological Congress (IGC) at the Brisbane Convention and Exhibition Centre between 5 and 10 August 2012, on behalf of the Oceania region. The Congress will encompass the interests of geoscientists from industry, academia and governments and promises to be the largest geoscience meeting ever held in Australia.

The Congress will also be the venue for the 2012 meetings of the International Union of Geological Sciences' Commissions, Task Groups and Joint Programs and incorporate the second Young Earth Scientists (YES) Roundtable and has the benefit of UNESCO patronage. The scientific sponsor is the International Union of Geological Sciences, and Vale, the world's second largest mining company, is the major commercial sponsor. The Australian Agency for International Development (AusAID) will also be providing support for the GeoHost program.

The 34th IGC will feature a wide-ranging scientific program as well as field trips, a large GeoExpo featuring commercial, government and academic exhibitors, training workshops and an education and outreach program.

Figure 1. The Brisbane Exhibition and Convention Centre is the venue for the 34th International Geological Congress.

Fourth Circular now available

The Fourth Circular includes details of the:

- fee structure for the Congress and accommodation details
- fee structure and the logistics of the IGC Field Trips across Australia and Oceania
- Plenary 'hot topics' and speakers
- Symposia and Keynote Speakers
- Professional Development Workshops and Short Courses

Field trips

The 34th ICG is planning 50 pre- and post-Congress field trips which will offer diverse opportunities to experience the fascinating geology of the region. These field visits will include all Australian states and the Northern Territory. In addition, there will be field trips to New Zealand, Malaysia, New Caledonia and Papua New Guinea. There will also be a range of one-day tours available during the conference.

Plenary sessions

The Plenary sessions are:

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

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

Symposia and Keynote Speakers

The overall theme for the Congress is 'Unearthing our Past and Future—Resourcing Tomorrow' which recognises the crucial contributions of the geosciences in meeting societal needs and sustaining planet Earth. There will be more than 220 Symposia under 37 Themes covering all facets of the geosciences.

The program, which emphasises future mineral and energy supplies, is underpinned by Australia's experience in developing a strong and sustainable mineral and energy resources sector. Other major themes include climate change and its impacts on natural resource management and communities, and understanding and mitigating geohazards.

"The most advanced element of the program will cover a range of topics from the online worldwide geological map to data information/standards."

The most advanced element of the program will cover a range of topics from the online worldwide geological map to data information/standards.

A highlight of the Congress will be the release of information from major geological and geophysical surveys conducted over a vast region of central and eastern Asia with high mineral and energy resources potential. The maps and datasets are the result of collaboration between China, Russia, Kazakhstan, Mongolia and South Korea which was undertaken to provide new insights into the resource potential of this large under-explored region.

Professional Development Workshops

Twenty nine Professional Development Workshops are scheduled and include topics such as: sustainable mining, carbon sequestration, geohazards and groundwater. The Workshops, held in conjunction with the IGC, will be of two types: Professional fee-based workshops and training which will reflect Australian and New Zealand international assistance objectives and training workshops designed for participants from developing countries. Geoscience Australia is playing a key role in securing funding for and organising these workshops as well as contributing to them.

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

For more information or to register or receive regular updates please visit

email info@34igc.org
web www.34igc.org

Australian Government
Geoscience Australia

in brief

New appointments

Dr James Johnson–Energy Division

Figure 1. Dr James Johnson, Deputy CEO and the new Chief of Energy Division.

Dr James Johnson has been appointed as Chief of Geoscience Australia's new Energy Division which has responsibility for all of the agency's energy-related activities, including offshore and onshore petroleum work as well as geothermal energy. The work of the Division overlaps with the government's priority on Australia's Clean Energy Future through a major program on Carbon Capture and Storage. Dr Johnson will also be responsible for the new International Group which is coordinating and developing our growing relationship with AusAID (Australia's Agency for International Development).

Dr Johnson was appointed Deputy CEO of Geoscience Australia following the promotion of Dr Chris Pigram to CEO in June 2010. As Chief of the former Onshore Energy and Minerals Division, his main focus was ensuring the Division's programs were relevant and applicable to exploration in Australia, particularly undercover exploration, and the promotion of Australia as an investment destination. He was responsible for implementation of the Onshore Energy Security Program (2006–11) which focussed on stimulating exploration for energy resources, including non renewable resources such as hydrocarbons, uranium and thorium as well as renewable geothermal energy resources.

When Dr Johnson joined Geoscience Australia in March 2006 he brought a wealth of experience in mineral exploration, mine geology, research management and leadership to the agency. He had also been a member of the Executive Research Committee of the Predictive Mineral Discovery Cooperative Research Centre (pmd*crc).

After graduating with First Class Honours from Sydney University in the mid-1980s, Dr Johnson joined Western Mining Corporation (WMC) at their nickel mines in Kambalda before moving to Olympic Dam as a Mine Geologist. He then undertook a PhD at the Australian National University on Olympic Dam focussed on identifying metal sources followed by two years of post-doctoral studies at the University of Ottawa in Canada studying Australian and Canadian deposits similar to Olympic Dam (iron oxide, copper-gold).

Dr Andrew Barnicoat–Minerals and Natural Hazards Division

Figure 2. Dr Andrew Barnicoat, the new Chief of the Minerals and Natural Hazards Division.

Dr Barnicoat was appointed as Chief of Geoscience Australia's Minerals and Natural Hazards Division in late November 2011. Prior to Geoscience Australia's recent restructure he was Acting Chief of the former Geospatial and Earth Monitoring Division.

Dr Barnicoat graduated with a Bachelor of Science with Honours from the University of Leeds in 1977. He completed his PhD at the University of Edinburgh on the 'Thermal History of Parts of the Lewisian Gneiss Complex, NW Scotland'.

Between 1979 and 2003, Dr Barnicoat was Reader in Petrology and Lecturer at the University of Leeds and also a Lecturer at the University of Wales. In 1992 he founded the Minerals Group of *in brief*

Rock Deformation Research (a university-owned consultancy company). The company worked with the minerals industry applying leading-edge research to practical problems. This work involved the synthesis and application of ideas and techniques from a wide range of geological disciplines for a range of large and small companies. These included developing new models for the formation of the world's largest gold deposits in South Africa, and developing new methodologies for use in exploration as well as the mining environment.

Dr Barnicoat joined Geoscience Australia in 2003 as a Principal Research Scientist, Research Integration for the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRC). This role involved scientific leadership and management of the research program. He was promoted to Group Leader, Energy Mineral Systems in 2006 and was responsible for leading the regional and commodity-based work which drew on the new data acquired as part of the Onshore Energy Security Program.

Dr Barnicoat has undertaken research on a wide variety of topics across the geosciences, including mineral systems and mineral deposits, petrology, structural geology and geochronology. His research has covered the UK, Sweden, France, Spain, Switzerland, Italy, Austria, Canada, USA, Saudi Arabia, South Africa, Malawi, India (Himalayas), Pakistan (Karakorum Mountains), Papua New Guinea and Australia.

Dr Stuart Minchin–Environmental Geoscience Division

Dr Stuart Minchin joined Geoscience Australia in January as the Chief of the new Environmental Geoscience Division. Dr Minchin has broad experience in water and environmental information sciences, particularly in the area of Earth observation and water resource management.

Dr Minchin has a Bachelor of Science with First Class Honours from the Water Studies Centre and Cooperative Research Centre for Freshwater Ecology at Monash University in Melbourne. He also successfully completed a PhD at the same university on 'The role of extracellular enzymes in the bio-availability of nutrients in natural and waste waters'.

His career has been focused on the development and delivery of improved natural resource information and knowledge to stakeholders and the public. Dr Minchin has previously held executive positions such as Research Director (Environmental Observation and Landscape Science) with CSIRO Land and Water and Principal Scientist (Water Assessment and Research) with the Victorian Department of Sustainability and Environment. These positions involved the direction of research priorities and the specification and management of large-scale natural resource observation and information management programs conducted by both the private and public sector.

Dr Minchin has a strong background in the management and computer modelling of water and environmental data and the online management, interoperability, and delivery of data, modelling and reporting tools for improved natural resource management. He conceived of and developed the Victorian Water Resources Data Warehouse, the first online database of water information in Australia, and later oversaw its expansion to include groundwater and community monitoring information. While at CSIRO, he led the development of a shared vision for a comprehensive Great Barrier Reef Information System

Figure 3. Dr Stuart Minchin, the new Chief of Environmental Geoscience Division.

in brief

(eReefs), which will incorporate in-situ and space-based monitoring and cutting-edge modelling to provide accounting and forecasting of water quality across the Great Barrier Reef region. He also led the delivery of a successful pilot project to showcase technology possibilities around the eReefs concept.

Tony Marks–Corporate Services

Tony Marks has recently joined Geoscience Australia as the new General Manager Corporate Services, delivering financial and human capital leadership, information and communication management and delivery of Geoscience Australia's extensive data and products and its major business transformation change program.

Tony is an experienced corporate executive with sophisticated financial, corporate strategy and leadership skills. He has initiated and led major organisation-wide strategic reforms, combining financial, human capital and technology reforms across diverse workforces, delivering a wide range of successful business outcomes. His strength lies in identifying business improvement opportunities and tailoring communication to staff, executive or stakeholder audiences to achieve support. He has a passion for building customer-focussed, technically competent and efficient teams and supporting resources which are clearly aligned and identifiable as serving the key objectives of the organisation.

Prior to joining Geoscience Australia Mr Marks had been Deputy CEO (Corporate) at the Australian Institute of Criminology. In this role and an extended period acting as CEO he delivered two years of record revenue and research output during a period which included two external reviews of the organisation and setting a new strategic agenda for the agency in response to new government and portfolio policy agendas.

Earlier he held senior financial roles with Defence Housing Authority and ActewAGL where he was responsible for financial management of multi-billion dollar asset bases, commercial contract management and business transformation through multiple integrated financial and operational systems and processes.

Figure 4. Mr Tony Marks, the new General Manager Corporate Services.

Tony holds a Bachelor of Commerce (Accounting) and a Graduate Diploma in Applied Finance. He is a fellow of CPA Australia, the Financial Services Institute of Australia and Taxation Institute of Australia. He is currently the Deputy President of CPA Australia's ACT Division and Chair of its Management Accounting Committee.

For more information

email ausgeomail@ga.gov.au

product news

The Australian Geographic Reference Image

Earth Observations from Space (EOS) are a vital source of information for Australia (Geoscience Australia 2010), enabling a wide range of essential services contributing billions of dollars to Gross Domestic Product annually. There is a diverse range of Australian Government programs which rely on EOS, such as the National Carbon Accounting System, which represent hundreds of millions of dollars of government outlays. State and territory government agencies are equally reliant on EOS data sources. Satellite images therefore play an essential and increasing role in mapping and monitoring of Australia's land and water, including the topography, natural and modified environments and infrastructure.

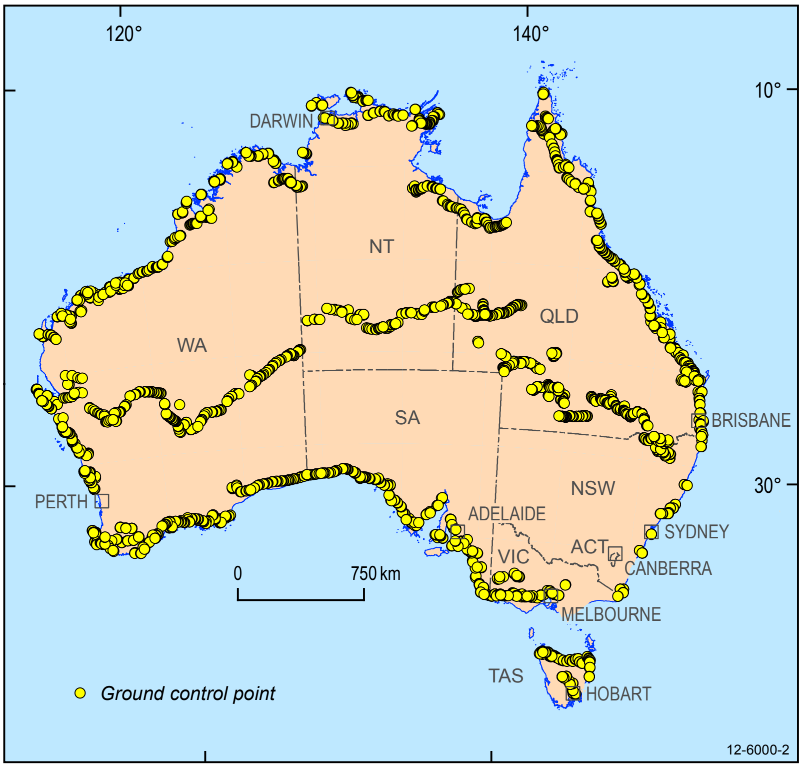

Figure 1. The locations of surveyed Ground Control Points for the Australian Geographic Image. A total of 2885 features were surveyed at 737 sites.

A problem common to all remote sensing is the need to accurately locate observations to the ground, a process called 'geo-referencing', 'image rectification' (since satellite observations are often in the form of images), and in some cases 'orthorectification'. Accurate and consistent geo-referencing is essential to ensure that observations taken at different times and from different satellites and instruments can be compared.

The most reliable approach to orthorectification is to register all images to a single controlled image base – a reference image. Geoscience Australia has used this approach since 2002, rectifying images from the Landsat satellites to the national Landsat panchromatic mosaic. However this mosaic has an accuracy of no more than fifteen metres, and cannot meet the need to rectify higher resolution imagery available from more recent, and proposed, Earth observation satellites.

The *Australian Geographic Reference Image* (AGRI) is a consistent and accurate reference image for rectification of imagery from multiple sources at resolutions of 2.5 metres or less. The AGRI is needed because the emerging new satellites and other sources of imagery will generate increasing amounts of data. AGRI can ensure that images from these sources are consistently and accurately registered to allow the maximum extraction of information.

During compilation more than 9560 satellite scenes, totalling over 6 terabytes, were used to produce eight mosaics, covering each of Australia's Universal Transverse Mercator map zones. These mosaics were then combined to produce a single mosaic covering the Australian continent. Intensity and contrast balancing were used to ensure visual consistency across the mosaic while maintaining the dynamic range of the image.

AGRI was made possible by new scientific and technical capabilities, international collaboration, the Australian spatial information industry, and the leadership and capabilities of Geoscience Australia.

Japan's Advanced Land Observing Satellite (ALOS) made possible the complete coverage of high quality imagery, which forms the foundation of the AGRI, as well as accurate data on the satellite orbit. Geoscience Australia was an international collaborator on the ALOS; handling data for the Oceania region. The *Barista* software, developed by the Cooperative Research Centre for Spatial Information, made the project feasible in terms of time, logistics, and cost. *Barista* reduced the image registration problem from correction of almost 10 000 scenes to correction of just 105 orbit segments.

The expertise and capability of the Australian spatial information industry was used in the design of GIS databases to manage the survey data and to conduct the many field surveys to remote areas of Australia (figure 1). The expertise and capabilities of Geoscience Australia staff in both Earth observation and geodesy were also essential inputs to the project.

Subject to future funding and data access, the AGRI could be progressively improved through:

- replacement of cloud-affected scenes with cloud-free scenes from the ALOS archive
- re-processing of problematic orbit paths with new satellite imagery
- additional or new ground control data sourced from new field surveys or through collaboration with state and territory agencies
- addressing other matters raised in user feedback.

The *Australian Geographic Reference Image* (AGRI) provides a consistent base image which will be an important foundation for future mapping and monitoring across Australia. It is a resource for both users and providers of satellite imagery covering Australia in government agencies, research institutions and academia, the spatial information industry, and international satellite operators. The AGRI mosaic and associated datasets are available to the public under the Creative Commons—Attribution licensing terms at cost of transfer from Geoscience Australia.

References

Geoscience Australia. 2010. A National Space Policy: views from the Earth Observation Community. Geoscience Australia, Canberra.

For more information

email ausgeomail@ga.gov.au
web https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=72657

Related articles/websites

AGRI: The Australian Geographic Reference Image-A technical report
www.ga.gov.au/image_cache/GA20164.pdf

Capricorn Survey processed seismic data

Interpreted processed seismic data for the Capricorn Deep Crustal Seismic Survey in Western Australia was released on 23 November 2011 during a Public Presentation Workshop in Perth which was hosted by the Geological Survey of Western Australia.

The Capricorn deep crustal seismic survey was conducted during 2010 and extends from the Pilbara Craton, across the Capricorn Orogen, to the Yilgarn Craton. The survey consisted of three traverses with a total length of 581 kilometres (figure 1). The objective of the survey was to image the extent of the Archean crust beneath the Capricorn Orogeny and identify the relationship between the Pilbara Craton and the Yilgarn Craton.

The survey was a collaborative project involving AuScope (funded by the National Collaborative Research Infrastructure Strategy: NCRIS), the Geological Survey of Western Australia and Geoscience Australia. Funding was provided by AuScope Earth Imaging, Western Australia's Exploration Incentive Scheme, funded under the Royalties for Regions program, and Geoscience Australia's Onshore Energy Security Program.

product news

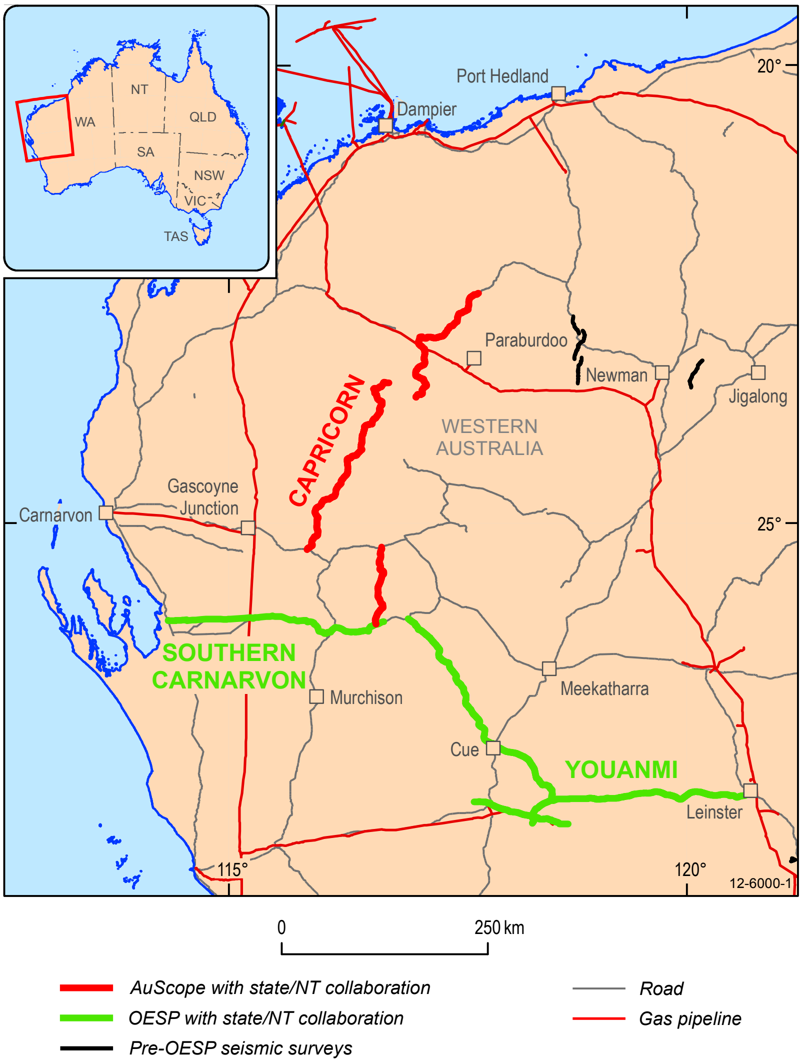

Figure 1. Location map showing the Capricorn Seismic Survey (in red) and the Youanmi Seismic Survey (in green) which were acquired in 2010. The Southern Carnarvon Basin Seismic Survey (in blue) was acquired in May 2011.

The interpreted processed data can be downloaded free of charge via the Geoscience Australia website (see below). A preliminary edition of the workshop proceedings is also available through the Geological Survey of Western Australia website.

For more information

email ausgeomail@ga.gov.au
web https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=72863

Related articles/websites

Capricorn Orogen deep seismic public release workshop-Extended abstracts and accompanying material (Geological Survey of Western Australia)
www.dmp.wa.gov.au/11804.aspx

Geoscience Australia Seismic Acquisition & Processing.
www.ga.gov.au/minerals/projects/current-projects/seismic-acquisition-processing.html

New geophysical datasets released

Data from four airborne magnetic/radiometric and gravity surveys covering onshore Australia have been released since September 2010. These datasets can be interpreted to reveal the sub-surface geology of the survey areas and will be a valuable tool in assessing their mineral potential.

The new levelled magnetic and gravity data from the Southwest Margin will add to pre-existing data and enhance opportunities for improving the understanding of basin provinces off the southwest margin of Australia. In late 2008 and early 2009, two marine surveys (GA-310 and GA-2476) acquired new seismic reflection, swath bathymetry and potential-field (gravity and magnetic) data over the Mentelle, Perth and Southern Carnarvon basins, as well as the Wallaby Plateau. These surveys were major outputs of Geoscience Australia's Offshore Energy Security Program (2006–2011).

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

Survey	Date	1:250 000 map sheets	Line spacing/ terrain clearance/ orientation	Line km	Contractor
North Canning 4 WA	September 2010–June 2011	Lagrange (pt), Munro, Mandora (pt)	400 m/ 60 m/ north–south	103 792	Aeroquest Airborne Pty Ltd
Wolfe Creek Crater WA	July 2002	Billiluna (pt)	50 m/ 40 m/ north–south	500	UTS Geophysics Pty Ltd

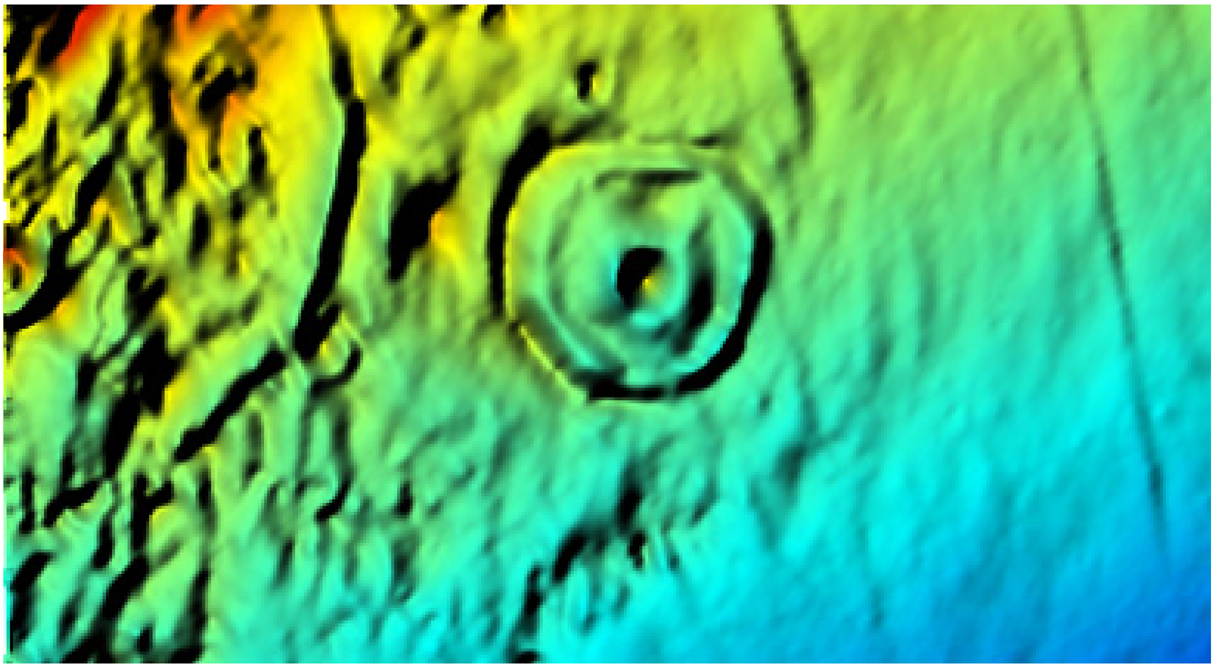

Figure 1. Magnetic image of the area around Wolfe Creek Crator WA.

Table 2. Details of the gravity surveys

Survey	Date	1:250 000 map sheets	Station spacing/ orientation	Stations	Contractor
Galilee	May–September 2011	Hughenden (pt), Tangorin (pt), Buchanan (pt), Winton (pt), Muttaburra, Galilee (pt), Clermont (pt), Longreach (pt), Jericho, Emerald (pt), Blackall (pt)	2.5 km/ north–south, east–west grid	6 464	Integrated Mapping Technologies Pty Ltd

Thomson	April–September 2011	Augathella (pt), Eddystone (pt), Quilpie (pt), Charleville (pt), Mitchell (pt), Toompine (pt), Wyandra, Homeboin (pt), Eulo (pt), Cunnamulla, Dirranbandi (pt),	2.5 km/ north–south, east–west grid	7 619	Daishsat Pty Ltd

Table 3. Details of the marine magnetic and gravity surveys

Survey	Date	1:250 000 map sheets	Station spacing/ orientation	Kilometres	Contractor
Southwest Margin	2008–09	Not applicable	Ship track	7 300	Various

For more information

email ausgeomail@ga.gov.au

Related articles/websites

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

High resolution bathymetry grids for Western Australian Margins and Bremer Sub-basin

Geoscience Australia has recently released Gridded XYZ bathymetric datasets for the Western Australian (WA) Margins and the Bremer Sub-basin off southwestern Australia. These XYZ bathymetric grids, which are an important tool in understanding the petroleum prospectivity of these areas, have been created using all of the most recent publicly available multibeam survey datasets.

The WA Margins bathymetric survey (GA-2476) covers part of the Exmouth Basin, the Houtman and Perth sub-basins and the Wallaby Plateau. This survey was conducted as part of Geoscience Australia's Offshore Energy Security Program. The Bremer Sub-basin dataset is a compilation of all the processed multibeam data Geoscience Australia holds in its database that are publicly available. The bathymetric grids are in ASCII, Arc Info grid and geotif formats and can be obtained free online through Geoscience Australia's website.

The release of these data are crucial in the promotion of these frontier basins for petroleum exploration and understanding the marine environment.

A compilation of all the single and multibeam grids, currently held by Geoscience Australia, covering the WA Margins and the multibeam grid for Macquarie Ridge in the Southern Ocean as well as the North Perth Sub-basin, will be released soon through Geoscience Australia's website.

Table 1. Details of the bathymetric datasets for the Western Australian Margins and the Bremer Sub-basin.

Survey	Date	Vessel	Coverage	Line km	Soundings
Southwest Margin	October 2008–January 2009	RV Sonne	200 967.83 square kilometres	28 126.7	167 270 211
Bremer Sub-basin	Multiple surveys	Multiple	23 523.94 square kilometres	11 128.5	163 620 444

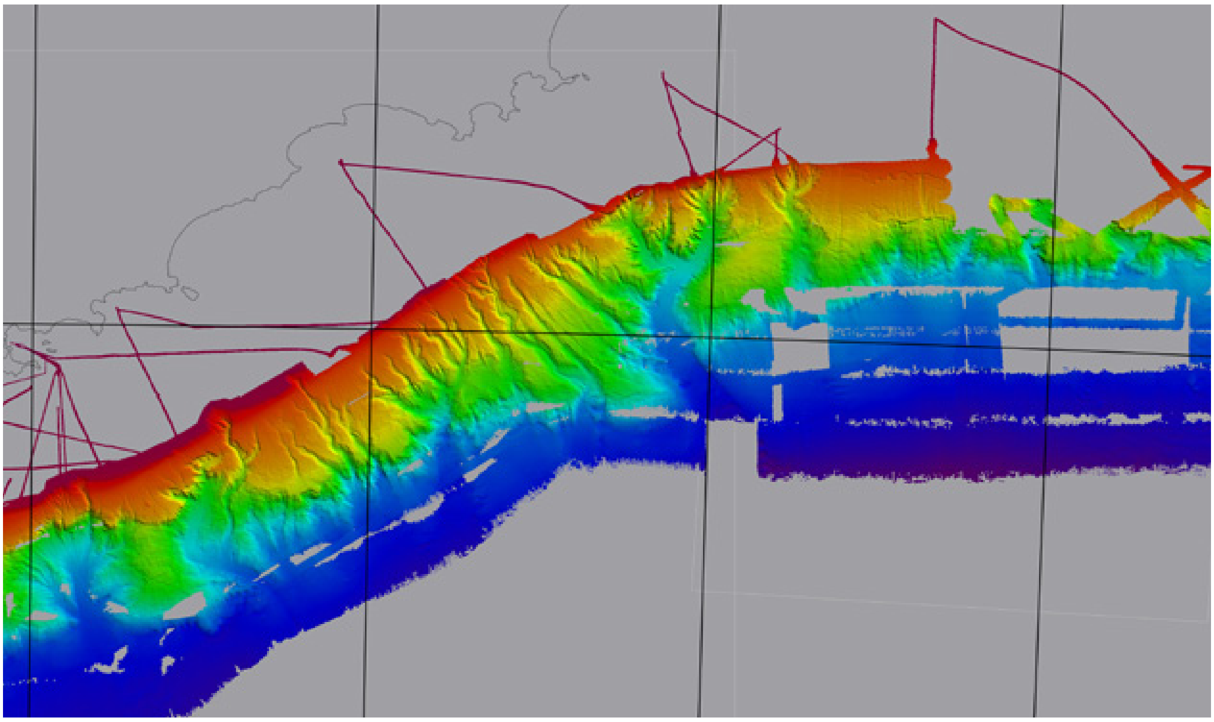

Figure 1. Multibeam Bathymetry from the Bremer Sub-basin.

For more information

email ausgeomail@ga.gov.au

Western Australian Margins datasets
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=72719

Bremer Sub-basin datasets
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=72768

Related articles/websites

XYZ marine bathymetric grids of survey GA-2476 WA Margins onboard the RV *Sonne*

https://www.ga.gov.au/products/servlet/controller?event=FILE_SELECTION&catno=72719

XYZ multibeam bathymetric grids of the Bremer Sub-basin

https://www.ga.gov.au/products/servlet/controller?event=FILE_SELECTION&catno=72768

events

National Youth Science Forum

More than 60 of Australia's top Year 11 science students visited Geoscience Australia in January as part of the 2012 National Youth Science Forum. During the visits the students attended half-day workshops and participated in a series of activities simulating some of the latest technology and techniques used for the geological storage of carbon dioxide.

The students undertook four key investigations to determine the suitability of proposed sites for geological storage under the guidance of Geoscience Australia scientists. The investigations involved techniques which are critical to make a sound, scientific decision based on the available data. They included: seismic interpretation, well-log interpretation, core analysis, and monitoring using a geographic information system (GIS). The students then gave a short presentation outlining the science and processes used by their chosen group, their use of geoscientific methods and equipment, and their conclusions.

The visit introduced students to the geosciences and was intended to encourage an interest in future study and careers in the geosciences. The students also had an opportunity to talk to staff involved in Geoscience Australia's cadetship and graduate programs as well as some of the young scientists in the organisation about various career opportunities.

The National Youth Science Forum is a two-week program held in Canberra in January each year. The program is designed for students moving into Year 12 who wish to follow careers in science, engineering and technology. It offers them an introduction to research and researchers in government and industry organisations.

Figure 1. Students checking the properties of core samples, assisted by Anna Paull of Geoscience Australia, during the National Youth Science Forum workshop in January 2012.

For more information

email ausgeomail@ga.gov.au

events calendar

AGES—Annual Geoscience Exploration Seminar	**26 to 28 March 2012**
Northern Territory Geological Survey Alice Springs Convention Centre Contact: Northern Territory Geological Survey, GPO Box 3000, Darwin NT 0800	p +61 8 8999 5313 f +61 8 8999 6824 e ages@nt.gov.au www.nt.gov.au/d/Minerals_Energy/Geoscience/
Australian and New Zealand Disaster and Emergency Management Conference	**16 to 18 April 2012**
Brisbane Convention & Exhibition Centre, Brisbane, Queensland Contact: Tracey Toovey, Joint Association Committee	p +61 7 5502 2068 f +61 7 5527 3298 e conference@anzdmc.com.au www.anzdmc.com.au http://bit.ly/oExEnZ
2012 APPEA Conference and Exhibition	**13 to 16 May 2012**
Australian Petroleum Production and Exploration Association Adelaide Convention & Exhibition Centre, Adelaide, SA Contact: Moira Lawler, APPEA Limited, GPO Box 2201, Canberra ACT 2601	p +61 2 6267 0960 e mlawler@appea.com.au www.appeaconference.com.au
6th International Sensitive High Resolution Ion MicroProbe (SHRIMP) Workshop	**1 to 4 August 2012**
Geoscience Australia and Australian Scientific Instruments Pty Ltd Lamington National Park via Brisbane, Queensland Contact: Geoscience Australia	p +61 2 6249 9543 or p +61 2 6249 9044 e SHRIMP2012@ga.gov.au www.ga.gov.au/minerals/projects/current-projects/geochronology-laboratory/geochronology-workshop.html
34th International Geological Congress	**6 to 10 August 2012**
Australian Geoscience Council Brisbane Convention Centre, Brisbane, Queensland Contact: Carillon Conference Management Pty Limited, PO Box 177, Red Hill QLD 4059	p +61 7 3368 2644 f +61 7 3369 3731 e info@34igc.org www.34igc.org
AMEC Convention 2012	**4 to 5 September 2012**
Association of Mining and Exploration Companies Burswood Convention Centre, Perth, WA Contact: AMEC, PO Box 948, West Perth WA 6892	p +61 8 9320 5150 or p 1300 738 184 (Within Australia) f +61 8 9322 3625 or f 1300 738 185 (Within Australia) e events@amec.org.au www.ameconvention.com.au

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