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Geoscience Australia

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CEO comment

Dr Chris Pigram – CEO Geoscience Australia

Geoscience Australia has recently been reviewed by the Department of Finance and Deregulation and the Department of Resources, Energy and Tourism (DRET). The Review found the agency to be a valuable whole-of-government capability that provided relevant and timely geoscience information to service the government's needs, and that there was no overlap or duplication between Geoscience Australia's work and other providers of geoscience information and research. The Review recognised the need for a sustainable funding base for Geoscience Australia and has recommended that Geoscience Australia and DRET bring forward a funding proposal for consideration in the context of the 2012–13 Budget. The full review report can be found at: www.finance.gov.au/publications/strategic-reviews/geoscience.html

The 2011 release of Offshore Acreage exploration areas for petroleum exploration was announced by the Minister for Resources and Energy, the Hon. Martin Ferguson AM MP, on 11 April 2011. This release is the largest since 2000 and our article includes details of the 29 release areas located in Commonwealth waters off the Northern Territory, Western Australia, Victoria and Tasmania. Underexplored regions are represented by areas in the Money Shoal, outer Browse, Roebuck, Northern Carnarvon, Southern Carnarvon and North Perth basins. There are smaller gazettal blocks in the producing hydrocarbon provinces of the Northern Carnarvon, Otway and Gippsland basins. Areas in the Caswell Sub-basin and on the Ashmore Platform are also close to known oil and gas discoveries.

The Broken Hill Block and the Eastern Succession of the Mount Isa Inlier are two of the most highly mineralised provinces in Australia. They are also among the most highly mineralised Proterozoic provinces in the world. Similarities in their geological histories have led many researchers to infer that they were contiguous during much of the Proterozoic. An article in this issue discusses the relative position and orientation of the provinces during this period using potential field datasets, including gravity and aeromagnetic datasets.

This issue also includes a report on Geoscience Australia's contribution to the emergency response and relief and recovery efforts following the flood emergencies across eastern Australia between November 2010 and early February 2011. This contribution demonstrated the critical role remote sensing services have in emergency management and took the utilisation of satellite imagery to a new level for Australia.

There are also brief updates on the Onshore Energy Security Program which is now focussing on the delivery of data and project outcomes. Phase 1 data from the Frome airborne electromagnetic survey has now been released. The survey, which covers about 10 per cent of South Australia's total area, was flown between May and November 2010. Analysis of the survey data from the Georgina—Arunta seismic survey, in the Northern Territory, has revealed major new geological structures which will assist energy and mineral resource exploration in the region.

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

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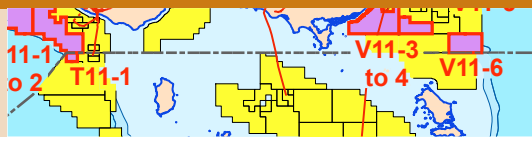
The 2011 Acreage Release for offshore petroleum exploration

Release includes large areas in frontier regions



Thomas Bernecker

The Australian Government formally released new offshore exploration areas at the annual Australian Petroleum Producers and Explorers Association Conference on 11 April 2011. The Minister for Resources and Energy, the Hon. Martin Ferguson AM MP, released twenty-nine areas in nine offshore basins for work program bidding. Closing dates for bid submissions are either six or twelve months after the release date, that is 13 October 2011 and 12 April 2012 respectively, depending on the exploration status of these areas and data availability.

"The 2011 Release is the largest since 2000… located in Commonwealth waters offshore Northern Territory, Western Australia, Victoria and Tasmania."

The 2011 Release is the largest since 2000, covering approximately 200 000 square kilometres with all 29 areas located in Commonwealth waters offshore Northern Territory, Western Australia, Victoria and Tasmania (figure 1). Underexplored regions off the Northern Territory and Western Australia are represented by 13 areas characterised by a large areal extent ranging from around 100 to 270 graticular blocks. These areas, located in the Money Shoal, outer Browse, Roebuck, Northern Carnarvon, Southern Carnarvon and North Perth basins, offer new opportunities for data-acquisition and regional exploration. The release of three large areas in the Southern Carnarvon and North Perth basins is supported by new data acquired and interpreted by Geoscience Australia as part of its Offshore Energy Security Program.

The producing hydrocarbon provinces of the Northern Carnarvon, Otway and Gippsland basins are represented by smaller gazettal blocks. These are located close to existing infrastructure and are supported by extensive open file data-sets. Other areas that are close to known oil and gas discoveries lie in the Caswell Sub-basin (eastern Browse Basin) and on the Ashmore Platform (northwestern Bonaparte Basin).

Money Shoal Basin

Two Release Areas (NT11-1 and NT11-2) are available for bidding in the Money Shoal Basin, offshore Northern Territory. These are located in shallow waters (10 to 110 metres) about 150 kilometres north of Darwin. The Money Shoal Basin is Mesozoic to Cenozoic in age and is underlain by the Goulburn Graben in the northeast which is part of the Neoproterozoic to Permian Arafura Basin (figure 2). The northeastern part of Area NT11-2 has access to the Goulburn Graben, which is known to host liquid hydrocarbons, while further west Area NT11-2 partly overlaps the Bonaparte Basin, a known gas producing province. Both Release Areas are located to the southeast of the Evans Shoal, Caldita and Barossa–Lynedoch gas accumulations in Australian waters and the Abadi gas accumulation in Indonesian waters. The Bayu–Undan to Darwin gas pipeline is located about 30 kilometres south of Release Area NT11-2.

No wells have been drilled in either of the Release Areas, but well control is provided by four wells to the north and northeast of NT11-1 and nine petroleum

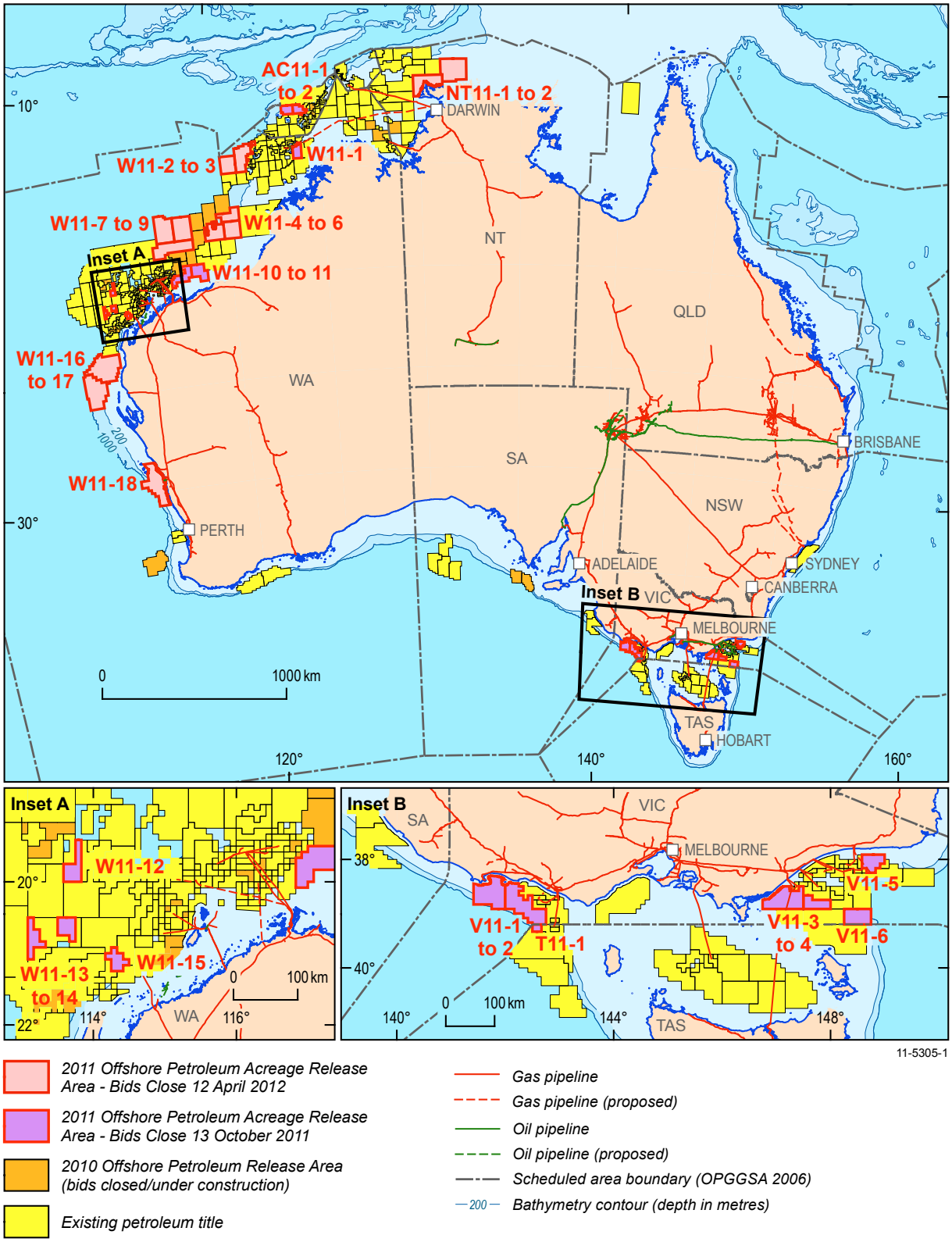


Figure 1. Location map showing the 2011 Offshore Petroleum Acreage Release Areas.

exploration wells in the Goulburn Graben area, northeast of NT11-2. Some of the most significant oil shows were intersected in Arafura-1, and pervasive oil indications occur in Goulburn-1. Tasman-1 encountered an oil show in an unnamed Carboniferous carbonate, and Kulka-1 discovered an oil show in the Kulshill Group. A review of available geological data together with the results

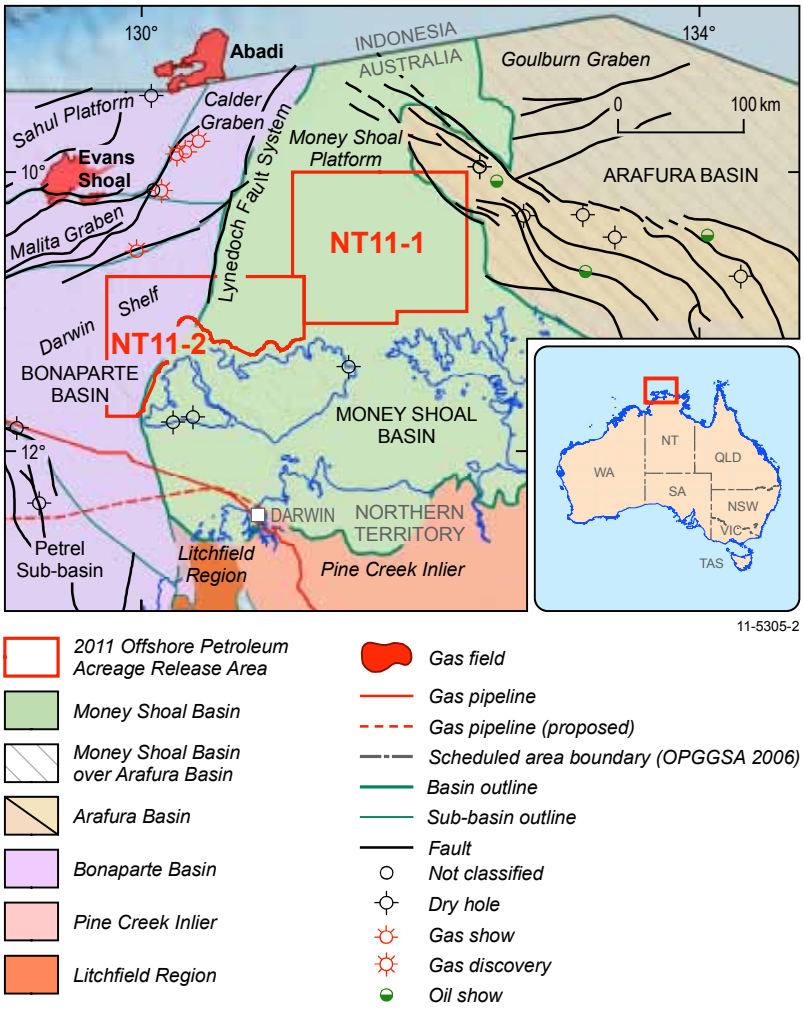


Figure 2. Tectonic elements map of the Money Shoal Basin showing location of the 2011 Release Areas and petroleum accumulations.

from a survey investigating potential hydrocarbon seepage in the Arafura Basin (Logan et al 2006) show that the region contains not only all the required petroleum systems elements to generate, expel and trap hydrocarbons, but also evidence that generation and expulsion has occurred.

Bonaparte Basin

In this year's acreage release, the Bonaparte Basin is represented by two areas on the Ashmore Platform (figure 3), an extensive, elevated and highly structured block that borders the Vulcan Sub-basin to the east, the northern Browse Basin to the south and deepens into the Timor Trough to the west. The Release Areas AC11-1 and AC11-2 are located in shallow water (less than 300 metres), adjacent to the Vulcan Sub-basin (figure 3), the host to several oil accumulations.

Drilling on the Ashmore Platform has focused on the Upper Cretaceous Puffin Formation sandstone fans and Triassic sandstones (Nome and Challis formations) that immediately underlie the prominent base-Cretaceous unconformity. Most of the drilling activity has been focused on the eastern margin of the platform, relying on Jurassic-sourced hydrocarbons migrating from the adjacent depocentres in the Vulcan Sub-basin. Top-Triassic targets have been tested by wells on the western, central and northern parts of the platform (Ashmore Reef-1, Sahul Shoals-1, Brown Gannet-1, North Hibernia-1 and Cartier-1). The main trap types for this exploration play are tilted fault blocks, unconformity pinchouts and broad anticlines that are all sealed by Lower Cretaceous claystones above the Jurassic–Lower Cretaceous unconformity.

A potential new play type on the Ashmore Platform comprises lower–middle Miocene reefs within the Oliver Formation. More than 30 patch reef structures have been identified on the southeastern and eastern margin of the Ashmore Platform, and confirmed by reefal facies intersected in the Lucas-1, Pascal-1 and Prion-1 wells.

Browse Basin

The Browse Basin is one of the richest hydrocarbon provinces in Australia. Areas in two different parts of the basin were released this year: Area W11-1 in the Caswell Sub-basin and Areas W11-2 and W11-3 on the Scott Plateau in the outer Browse Basin (figures 1 and 3).

The Caswell Sub-basin is the northernmost major depocentre of the Browse Basin and contains up to 15 kilometres of

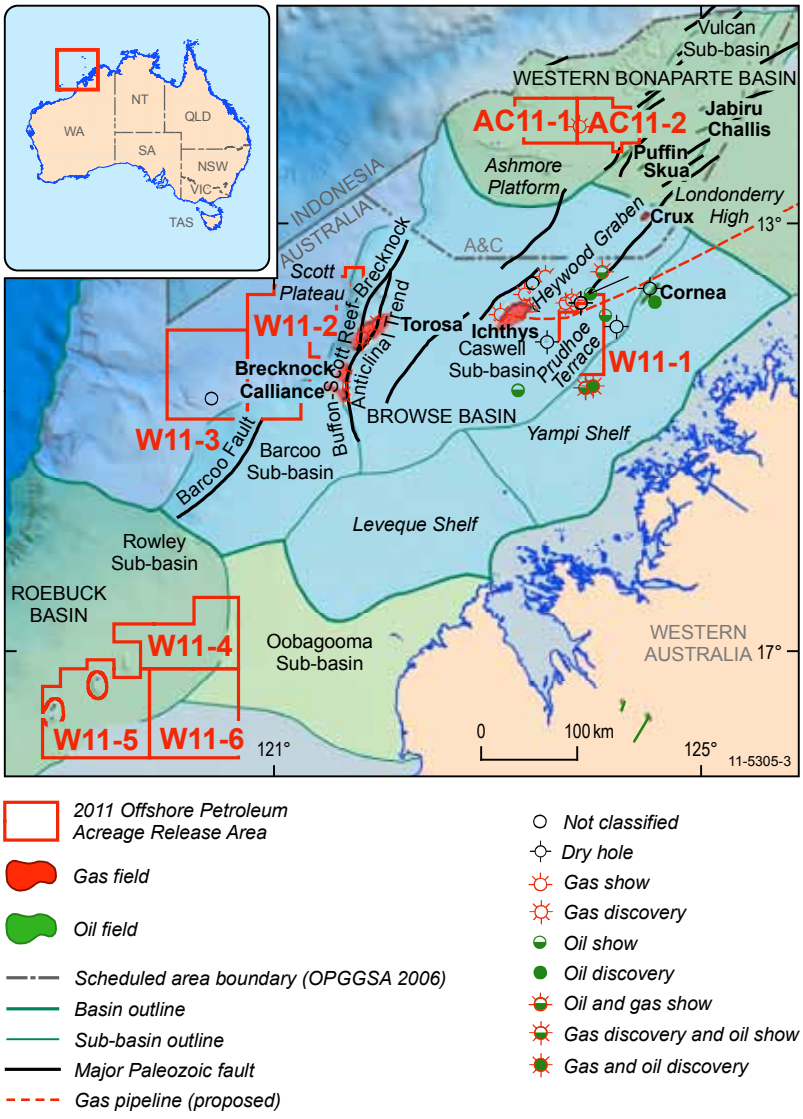


Figure 3. Tectonic elements map of the Browse Basin region showing location of the 2011 Release Areas and petroleum accumulations.

Paleozoic to Cenozoic sediments (Struckmeyer et al 1998). It is well explored and hosts significant discoveries of gas, condensate and to a lesser extent, oil. Five gas fields have been discovered in the Caswell Sub-basin, but remain undeveloped: Torosa, Brecknock, Calliance (Brecknock South), Ichthys (Brewster) and Crux. Release Area W11-1 is located on the Prudhoe Terrace which separates this sub-basin from the Yampi Shelf, an area that is characterised by an onlapping succession of Permian to Mesozoic sediments onto shallow basement. No wells have been drilled in the Caswell Release Area to date. However, hydrocarbon accumulations have been encountered near the Release Area in both structural and stratigraphic plays in the Caswell Sub-basin and on the Yampi Shelf.

Release Areas W11-2 and W11-3 are located in deep water (1000 to 3000 metres) on the largely unexplored Scott Plateau. The geological inventory is not well understood but believed to comprise up to four kilometres of ?Carboniferous to Cenozoic rocks overlying ?Paleozoic and older basement. Despite being well covered by modern 2D seismic data, insufficient data exists to confirm the presence of active petroleum systems in this part of the Browse Basin. Regional studies by Geoscience Australia, recent exploration activities and comparisons with the petroleum systems in the adjacent Caswell and Barcoo sub-basins, however, indicate the potential of this underexplored region.

Several models presented by Hoffman and Hill (2004) for the structural development of the Scott Plateau infer shallow-water source rocks (Plover Formation) may have developed during the pre- and early-rift stages, while thick syn-rift to immediately post-rift sequences (Vulcan Formation) may also have been deposited in the Late Jurassic restricted marine depocentres (or areas of thick sediment accumulation in a sedimentary basin). Regional subsidence and thermal history modelling by Kennard et al (2004) suggests that if source rocks are present, oil and gas were expelled from the Jurassic rift depocentres on the Scott Plateau during the late Cenozoic. The results of BHP Billiton's HBR 2002A Seabed Coring Survey (BHP Billiton Petroleum Pty Ltd 2002) imply Plover and Vulcan Formation source rocks are mature in this region.

Roebuck Basin

The Roebuck Basin covers approximately 93 000 square kilometres on the North West Shelf. It forms the central part of the Westralian Superbasin, which is a northeast-trending passive margin of late Paleozoic and Mesozoic age. Three Release Areas (W11-4, W11-5 and W11-6) are located in the Rowley Sub-basin (figure 3), a major Mesozoic depocentre situated on the outer continental shelf. The sub-basin contains about nine kilometres of Permo–Carboniferous or older strata and up to six kilometres of Mesozoic–Holocene sediments.

Well control is limited to nine wells in the entire Roebuck Basin, none of which was commercially successful. The only significant hydrocarbon shows were recorded by Phoenix-1 and Phoenix-2 in the adjacent Bedout Sub-basin. Because of the perceived absence of a prolific source rock, the petroleum potential of the Roebuck Basin is currently considered to be poor compared to other areas along the North West Shelf. However, recent research suggests that the Lower Permian and Lower Triassic strata possibly include marine shales as well as organic-rich coaly sediments which could be capable of expelling liquid hydrocarbons (Geoscience Australia and Geomark Research 2005). Widespread distribution of oil inclusions in the Roebuck Basin, including in East Mermaid 1, may be indicative of palaeo-oil columns and evidence of petroleum generation within the Rowley Sub-basin. The entire Triassic section within the sub-basin remains untested to date and it is therefore possible that the application of new concepts to these Release Areas may translate to exploration success.

Northern Carnarvon Basin

The Northern Carnarvon Basin is one of Australia's most explored and prospective hydrocarbon provinces and has ready access to established oil and gas exploration, production and support infrastructure. Large-scale development projects under way include the Gorgon, Pluto and Wheatstone LNG projects, Macedon–Pyrenees project (gas and oil) and Reindeer–Devils Creek Development (gas). New discoveries were made in 2010 and 2011, highlighting the large exploration potential of the region which is supported by established and expanding production infrastructure. The 2011 Release Areas (figure 1) are located on the northeastern Exmouth Plateau (three areas), in the Beagle and Dampier Sub-basins (two areas), Central Exmouth Plateau (three areas) and Exmouth Sub-basin (one area).

Northeastern Exmouth Plateau

The Exmouth Plateau is a broad, sunken continental block, which is underlain by 10 to 15 kilometres of a generally flat-lying or block-faulted and tilted, Lower Cretaceous, Jurassic, Triassic and Paleozoic section. These sediments were deposited during periods of extension that preceded the breakup of Australia and Argo Land in the Middle Jurassic and then Greater India in the Early Cretaceous. Release Areas W11-7 and W11-8 lie on the outer part of the plateau (figure 4) in water depths greater than 1000 metres, while Release Area W11-9 lies within the northern part of the Beagle Sub-basin on the outer shelf, where water depths range between 500 and 1000 metres.

The giant Scarborough and Io-Jansz gas fields, along with the gas discoveries at Jupiter-1, Chandon-1, Thebe-1 and -2, Martell-1, Larsen Deep-1 and Alaric-1, demonstrate that the deepwater Exmouth Plateau is prospective for large gas discoveries. The extension of this prospectivity further north, to the northern margin of the plateau, is yet to be demonstrated. However, several of the key elements that combine to produce successful petroleum systems further south also occur in the region of the Release Areas.

The prospectivity of the Beagle Sub-basin is demonstrated by the Nebo-1 oil discovery confirming the presence of an active petroleum system. It is unclear whether this system is locally restricted or whether it extends across major parts of the Release Areas. As with the Roebuck Basin, all exploration wells drilled in this part of the

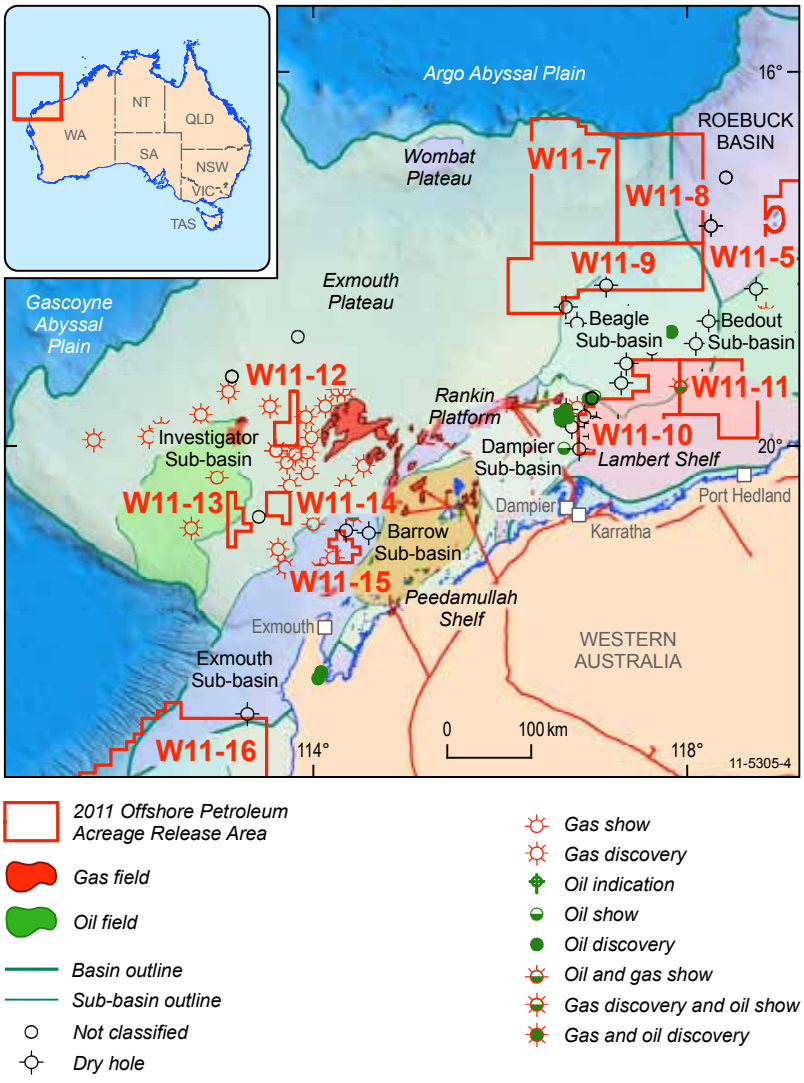


Figure 4. Tectonic elements of the Northern Carnarvon Basin and adjacent basins showing the 2011 Release Areas, oil and gas accumulations and selected wells.

Northern Carnarvon Basin have targeted Jurassic objectives while the thick Triassic strata have not been tested. Given the widespread hydrocarbon occurrence in Triassic sediments further west, the three large exploration blocks offer opportunities to test that stratigraphic section.

Dampier and Beagle Sub-basins/Lambert Shelf

The Beagle and Dampier sub-basins are bounded to the southeast by the Lambert Shelf, an offshore extension of the Precambrian Pilbara Block. The Release Areas W11-10 and W11-11 straddle the southern Beagle Sub-basin, northeastern Dampier Sub-basin and Lambert Shelf (figure 4) of the Northern Carnarvon Basin. The northeastern part of Release Area W11-11 extends into the Bedout Sub-basin of the Roebuck Basin. Release Area W11-10 is located immediately to the east of the Legendre, Amulet and Talisman oil accumulations in the Dampier Sub-basin, and is proximal to the gas pipelines connecting the Rankin Platform gas fields to the LNG processing plant at Karratha. Minor oil and gas occurrences have been recorded at Bruce-1 within Release Area W11-11, indicating that an active petroleum system is present in this part of the southern Beagle Sub-basin and the Lambert Shelf.

The Beagle and Dampier sub-basins contain a Paleozoic to Cenozoic sedimentary succession with a maximum thickness of 10 to12 kilometres. The sediments are predominantly Triassic to Middle Jurassic in the Beagle Sub-basin and Triassic to Lower Cretaceous in the Dampier Sub-basin. The Beagle Sub-basin is a frontier area of the Northern Carnarvon Basin, with only 25 wells drilled to date. Initial exploration drilling between 1971 and 1992 tested a variety of play types, but no hydrocarbon shows were recorded except at Bruce-1 (1979; minor oil and gas) on the boundary between the Beagle Sub-basin and the Lambert Shelf.

The main structural play types in the southeastern Dampier Sub-basin, southern Beagle Sub-basin and Lambert Shelf are Middle Jurassic to Lower Cretaceous horsts, tilted fault blocks and low-side rollovers, Triassic to Lower Cretaceous anticlines and faulted anticlines, and drapes and anticlines over Triassic to Jurassic fault blocks. The marginal location of Release Areas W11-10

and W11-11 relative to the main basin depocentres implies that the source rocks may be thin, immature and/or of low quality, and some of the areas may be outside the range of lateral hydrocarbon migration from the main source kitchens. Hydrocarbon accumulation in the area has been hampered by poor seal development due to erosion or high sand content, leakage via basin-bounding faults, lack of closure, and biodegradation. Since this part of the Northern Carnarvon Basin is underexplored, new data and new geological concepts have the potential to identify viable prospects.

Exmouth Plateau

The Exmouth Plateau is a deep-water marginal plateau that represents the westernmost structural element of the Northern Carnarvon Basin. Most of the plateau is underlain by 10 to 15 kilometres of generally flat-lying or block faulted, tilted Lower Cretaceous, Jurassic, Triassic and older sedimentary section. These sediments were deposited during the periods of extension that preceded the break-up of Australia and Argo Land in the Middle Jurassic, and then Greater India in the Early Cretaceous.

Release Areas W11-12, W11-13 and W11-14 are located in deep water (900 to 1400 metres) to the south and east of the giant ~8 trillion cubic feet (or Tcf) Scarborough gas field and to the west and southwest of the supergiant Io-Jansz field (figure 4). Gas production facilities are currently being developed for the Chevron-operated Gorgon and Io-Jansz fields and the Woodside-operated Pluto field. ExxonMobil and BHP Billiton are currently examining development options for the Scarborough and Thebe fields, as is Chevron for the Wheatstone field.

The thick Triassic and older sedimentary section on the Exmouth Plateau has the greatest potential for mature source facies, with possible organic-rich units in the Lower Triassic (marine Locker Shale equivalents) and Upper Triassic (deltaic Mungaroo Formation facies and marine equivalents). Recent exploration activities on the Exmouth Plateau are based on a model that invokes gas charge from the deeply buried coal and carbonaceous claystone of the Mungaroo Formation. Peak gas generation from these Triassic source rocks is interpreted to occur now at depths greater than five kilometres below sea level.

Given that a proven hydrocarbon system has already been established across the central Exmouth Plateau, continued success relies on the identification of additional valid traps with access to charge from the gas-prone Mungaroo source. Key exploration tools that are likely to lead to future discoveries on the deep-water Exmouth Plateau are 3D seismic and AVO technology.

Exmouth Sub-basin

The Exmouth Sub-basin is a Jurassic depocentre and has geological affinities with the Barrow, Dampier and Beagle sub-basins representing a failed rift system that developed during the early syn-rift phase of breakup of the northwestern Australian continental margin. Oil was first discovered in 1998 (Vincent-1) and was followed by several additional oil discoveries including Coniston, Laverda, Stybarrow, Ravensworth and Stickle, establishing the Exmouth Sub-basin as a new oil province with a reserve potential of 300 million barrels. Two new oil projects commenced production in 2010; the Van Gogh oilfield and the Pyrenees project, comprising the Crosby, Ravensworth and Stickle oilfields (Department of Mines and Petroleum 2010).

Release Area W11-15 is located in the northern part of Exmouth Sub-basin (figure 4) and has access to two petroleum systems. The extensive Locker/Mungaroo–Mungaroo/Barrow petroleum system, which has sourced some of the giant gas fields in the Northern Carnarvon Basin, was proven south of the Release Area with the discovery of gas in the Mungaroo Formation at Falcone-1A. The Upper Jurassic Dingo Claystone is the principal source for oil in the Exmouth Sub-basin (Tindale et al 1998) and it is relatively thick within the Release Area W11-15. The proven traditional Triassic

fault block play, which hosts most of the hydrocarbon reserves in the Northern Carnarvon Basin, is adjacent to the Release Area. Mungaroo Formation sandstones in fault block traps are sealed by either the Dingo Claystone or intraformational seals. Gas sands interpreted in the Mungaroo Formation equivalent from electric logs at Zeepaard-1, north of the Release Area W11-15, comprise an example of this play type. Partially confined channels have been proven to contain hydrocarbons within the Jurassic sandstones plays.

Southern Carnarvon Basin

The Southern Carnarvon Basin, a large (192 000 square kilometres), predominantly Paleozoic sedimentary basin to the south of the Mesozoic Northern Carnarvon Basin, is comprised of the Gascoyne, Merlinleigh and Byro sub-basins and the Bernier Platform. Of these, the Bernier Platform and western Gascoyne Sub-basin lie offshore (Figure 5).

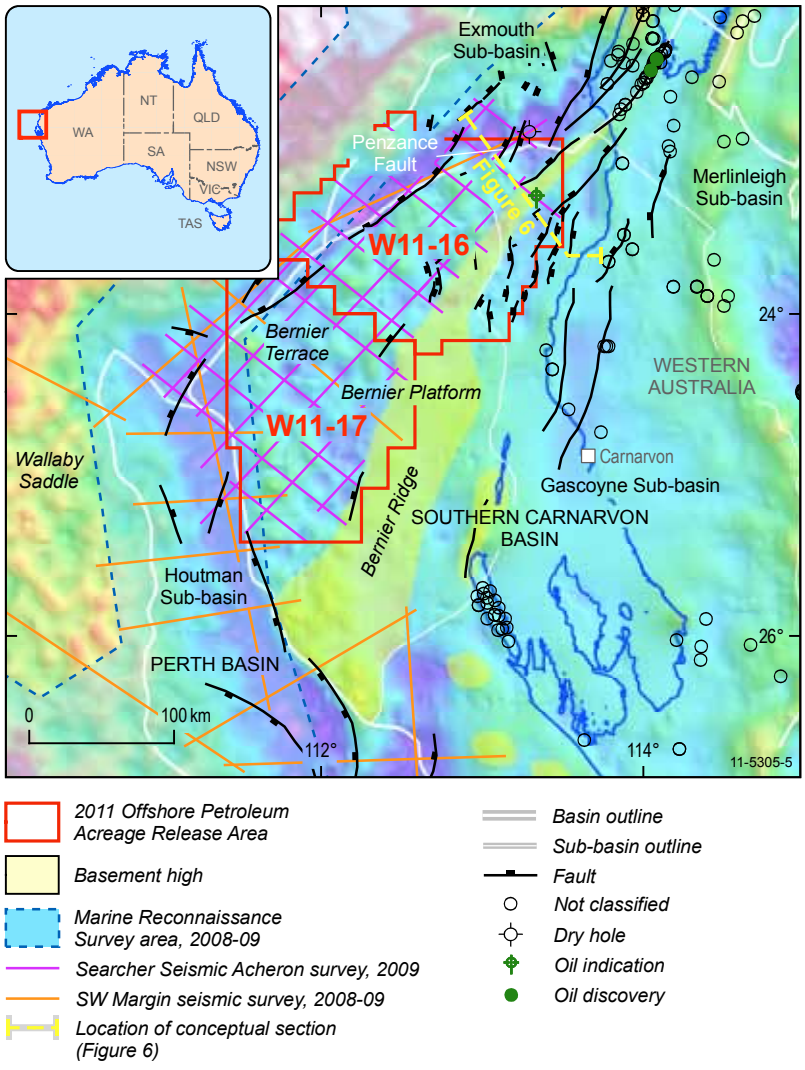


Figure 5. Tectonic elements map of the Southern Carnarvon Basin based on Geoscience Australia's interpretation of gravimetric data.

Release Areas W11-16 and W11-17 lie partly within the Paleozoic Bernier Platform and Gascoyne Sub-basin of the Southern Carnarvon Basin and partly on the southernmost Mesozoic Exmouth Sub-basin of the Northern Carnarvon Basin. Area W11-16 is the largest of this year's release featuring 264 graticular blocks covering an area of 20 735 square kilometres, while Area W11-17 comprises 230 graticular blocks covering an area of 17 925 square kilometres. Both Release Areas lie within the frontier part of the Carnarvon Basin. Pendock-1A was drilled over 40 years ago and during the last 20 years permits have covered only parts of Release Area W11-16.

Lack of exploration activity in the area could be partly attributed to the general focus on highly successful exploration in the adjacent Northern Carnarvon Basin. In recent years, new seismic data has been acquired to assess the basin architecture, tectonic styles and the hydrocarbon prospectivity of the Southern Carnarvon Basin. As part of its Offshore Energy Security Program, Geoscience Australia acquired regional seismic data sets along the Southwest Margin targeting potential depocentres that are delineated by gravity lows. This new data covers much of the northwestern, deep water parts of the Release Areas. Additional seismic data over both areas has been acquired by Searcher Seismic, but these were not interpreted prior to this year's acreage release.

The region has potentially two active petroleum systems: Paleozoic and Mesozoic. So far no commercial discoveries from Paleozoic petroleum systems have been made in the Southern Carnarvon Basin, however oil and gas shows have been encountered in a number of wells. Within the Paleozoic Gascoyne Sub-basin and Bernier Platform, source rocks are present in the Silurian and Upper Devonian. Effective reservoirs and seals are present both in the Paleozoic and the post-breakup Cretaceous succession (figure 6). The Mesozoic petroleum system of the southern Exmouth Sub-basin of the Northern Carnarvon Basin includes potential source rocks in the Triassic Mungaroo Formation and Jurassic Dingo Formation with multiple reservoir and seal units in the Triassic, Jurassic and Cretaceous. The potential of the Mesozoic petroleum system in the southernmost part of the Exmouth Sub-basin has not been proven. A test of a valid structure at Herdsman-1 suggests that the thickness of the Mesozoic succession is a critical factor for hydrocarbon generation in this part of the basin.

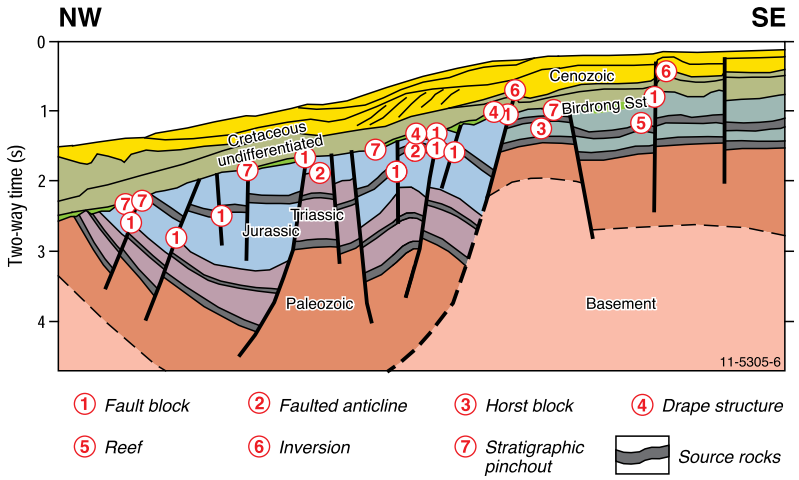


Figure 6. Conceptual cross-section across Southern Carnarvon Basin showing possible exploration plays.

North Perth Basin

The Perth Basin is a large (172 300 square kilometres), elongate, north to northwest-trending sedimentary basin extending about 1300 kilometres along the southwestern coast of Australia and encompassing both onshore and offshore areas. The maximum extent of the offshore part of the Perth Basin is placed at the limit of basin fill ranging in age from Cisuralian (Early Permian) to Early Cretaceous.

Release Area WA11-18 is situated in the offshore portion of the northern Perth Basin, around 200 kilometres northwest of Perth and directly offshore from Geraldton (figure 1). The Release Area comprises 260 graticular blocks, and covers an area of 17 475 kilometres and abuts Production License WA-31-L over the Cliff Head oil field.

New data have been acquired, interpreted and integrated with existing data-sets to assess the hydrocarbon prospectivity of this offshore frontier as part of Geoscience Australia's Offshore Energy Security Program. The results of this work will be published in a future issue of *AusGeo News*.

Otway Basin

The Otway Basin is a northwest-striking passive margin rift basin that extends from southeastern South Australia to the northwestern coast of Tasmania. The basin is filled with Upper Jurassic to Holocene sediments and covers an area of 150 000 square kilometres, 80 per cent of which lies offshore. The basin hosts several producing gas fields, most of which are located in the eastern offshore region, as well as onshore Victoria and South Australia. The 2011 Release Areas are located east of the South Australian border (figure 1) and cover much of the Voluta Trough and parts of the Mussel Platform.

Three petroleum systems, Austral 1, Austral 2 and Austral 3, are believed to exist in the Otway Basin (O'Brien et al 2009). Austral 1 is related to Upper Jurassic/Lower Cretaceous source rocks and dominantly Lower Cretaceous reservoirs in the onshore. Austral 2 is related to Aptian-Albian source rocks and dominantly Upper Cretaceous reservoirs both

onshore and offshore. The Austral 3 system relies on mature Turonian source rock intervals and is as yet unproven.

The shallow shelf regions of Release Areas V11-1 and V11-2 are known to have access to the prolific Austral 2 petroleum system, but the main discoveries seem to be concentrated around the Shipwreck Trough area. Maturity modelling suggests that the shelf region inboard of the Tartwaup–Mussel Fault Zone lies well within the area of mature Eumeralla source rocks and it will be a matter of carefully mapping appropriate structures on modern seismic, ideally in 3D-format. In these areas, it is also very important to understand lateral facies changes that range from fully terrestrial lower coastal plain to open shelf depositional environments. The most critical exploration uncertainty in the deeper water regions of the Release Areas is the presence of mature Turonian source rocks which would be a marine equivalent to the marginal marine to terrestrial Waarre Formation. The extent of Paleogene and Neogene overburden in the far offshore also impacts severely on the maturity levels of the Upper Cretaceous section. However, if it can be demonstrated that access to a mature Austral 3 petroleum system exists, these deep water parts of the Release Areas may indeed be more prospective than the lack of exploration success indicates.

Gippsland Basin

The Gippsland Basin, one of Australia's most prolific hydrocarbon provinces, is situated in southeastern Australia and is located about 200 kilometres east of the city of Melbourne. Most of the hydrocarbon discoveries which have been made are stored within the siliciclastics of the Upper Cretaceous to Paleogene Latrobe Group. Remaining reserves are estimated at 400 million barrels of liquids and 6 trillion cubic feet (Tcf) of gas.

"The 2011 Offshore Acreage Release offers a wide variety of geological settings in shallow as well as deep water."

Release Areas V11-3 to V11-6 are distributed across the basin (figure 1) providing explorers with the choice of several different tectonic settings, play types and petroleum systems. Release Areas V11-3 and V11-4 are in close proximity to the southern Gippsland coast. Water depths across both of these are typically shallow, with the maximum depth of around 70 metres reached in the eastern edge of V11-4. Release Area V11-5 lies in the northeastern part of the basin with water depths increasing from 50 to 150 metres towards the southeast. This area also includes the small Leatherjacket oil field and is close to the Kipper gas field. Release Area V11-6 is in the far southeastern part of the Gippsland Basin, and covers the majority of the area known as the Pisces Sub-Basin. This Release Area stretches over the southern margin of the Bass Canyon, where water depths range from 50 metres on the shallow shelf up to more than 1500 metres in the northeastern corner of the Release Area.

In terms of prospectivity, it must be pointed out that the Release Areas are relatively underexplored, particularly along the southern margin of the basin. An effective regional seal is likely to be present over the majority of the Release Areas, although the lithologies in the eastern offshore area and on the Southern Platform remain unknown. The quality of intraformational seals depends very much on the overall facies associations and their variations through time. Well control in the central part of the basin (Central Deep) and in the north (Northern Terrace) indicates that the Latrobe Group sediments tend to have more marine influence in the easternmost part of the basin.

Although the Gippsland Basin is a mature, well explored hydrocarbon province with a long production history, there are still many areas that deserve a fresh look. In addition, the deeper stratigraphic levels remain poorly understood with respect to hydrocarbon generation and

migration. The Release Areas offer access to a variety of structural and depositional settings in which known and new play concepts can be tested.

Summary

The 2011 Offshore Acreage Release offers a wide variety of geological settings in shallow as well as deep water. Area selection continues to be undertaken in consultation with industry, the states and the Northern Territory. As part of that consultation, large blocks were gazetted in the 2011 release round, totalling about 200 000 square kilometres in area, the largest release since 2000. The annual Acreage Release caters for the whole gamut of exploration companies since many areas are located within producing regions and close to existing infrastructure while others are located in offshore frontier regions with very little supportive data. New data, acquired in unexplored regions as part of Geoscience Australia's Offshore Energy Security Program, have yielded new insights into the hydrocarbon prospectivity of the North Perth and the Southern Carnarvon basins.

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For more information on data supporting the 2011 acreage release

Seismic data is available in GeoFrame™, Kingdom and Landmark™ formats

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Related websites/articles

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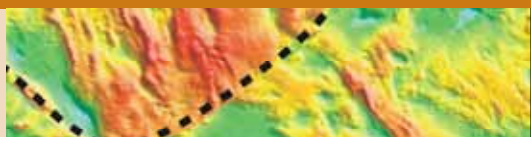
AUSGEO news
ISSUE 102 June 2011

Broken Hill and Mount Isa: linked but not rotated

Gravity datasets point to a link between the Mount Isa and Broken Hill mineral provinces



Paul Henson, Natalie Kositcin and David Huston

The Broken Hill Block and the Eastern Succession of the Mount Isa Inlier are two of the most highly mineralised provinces in Australia. They are also among the most highly mineralised Proterozoic provinces in the world.

Similarities between these provinces

Since the early ideas of Bill Laing, a consultant and academic (Laing and Beardsmore 1986; Laing 1996), for a 'Diamantina Orogen' connecting the Eastern Succession of the Mount Isa Inlier with the Broken Hill Block, similarities in the geological histories of these provinces have led many researchers (such as Betts et al 2002; Giles et al 2004; Betts and Giles 2006) to infer that they were contiguous through much of the Proterozoic. These similarities, which are detailed in Kositcin (2010) and illustrated in Figure 1, include:

1) Emplacement of voluminous ~1850 Ma (or million years) granites in north-south belts along the eastern margin of the Gawler Craton (Donington Suite) and the central part of the Mount Isa Province (Kalkadoon Supersuite).
2) Similar chemistry of around 1790 to 1780 Ma mafic and felsic volcanic rocks in the eastern Gawler and Mount Isa provinces.
3) Synchronous deposition of the Willyama Supergroup (Curnamona Province) and Eastern and Western Successions (Mt Isa Province) between around 1710 to 1600 Ma, including bimodal magmatism in both terranes at around 1710 to 1670 Ma.
4) Low-pressure upper amphibolite to granulite facies metamorphism at around 1600 to 1580 Ma during the Olarian Orogeny (Curnamona Province) and D_2 phase of Isan Orogeny (Mount Isa Province).
5) The coincidence of 1600 to 1580 Ma bimodal magmatism in the Gawler Province with high-temperature, low-pressure metamorphism at mid-crustal levels in the eastern Mount Isa Province.
6) Similar timing of the Kararan Orogeny (Gawler Province) to the D_3 and D_4 phases of the Isan Orogeny (Mount Isa Province) between 1580 and 1540 Ma.

Although there is a general consensus that these provinces were contiguous through much of the later Paleoproterozoic, the relative position and orientation of these provinces when they were contiguous is contentious.

The Broken Hill Block contains the world's largest single sediment-hosted zinc-lead-silver deposit (Broken Hill) plus a number of small iron-oxide-copper-gold (IOCG) deposits (for example, Portia, Kalkaroo). The Eastern Succession contains major IOCG deposits (such as Ernest Henry, Mount Dore, and Mount Elliott) as well as a number of significant sediment-hosted zinc-lead-silver deposits (for example, Cannington, Pegmont). The zinc-lead-silver deposits in both provinces formed at ~1690 to 1680 Ma, whereas the iron-oxide copper-gold deposits formed between ~1520 and 1500 Ma (King and Thomson 1953; Page and Laing 1992; Gibson and Nutman 2004; Huston 2009; Duncan et al 2011).

To account for similarities presented above, Betts et al (2002) and Giles et al (2002, 2004) proposed that the Kimban Orogeny (and the Strangways Orogeny in the Arunta Province) was a consequence of collision between the Gawler Craton (as part of the Mawson Continent) and the North Australian Craton

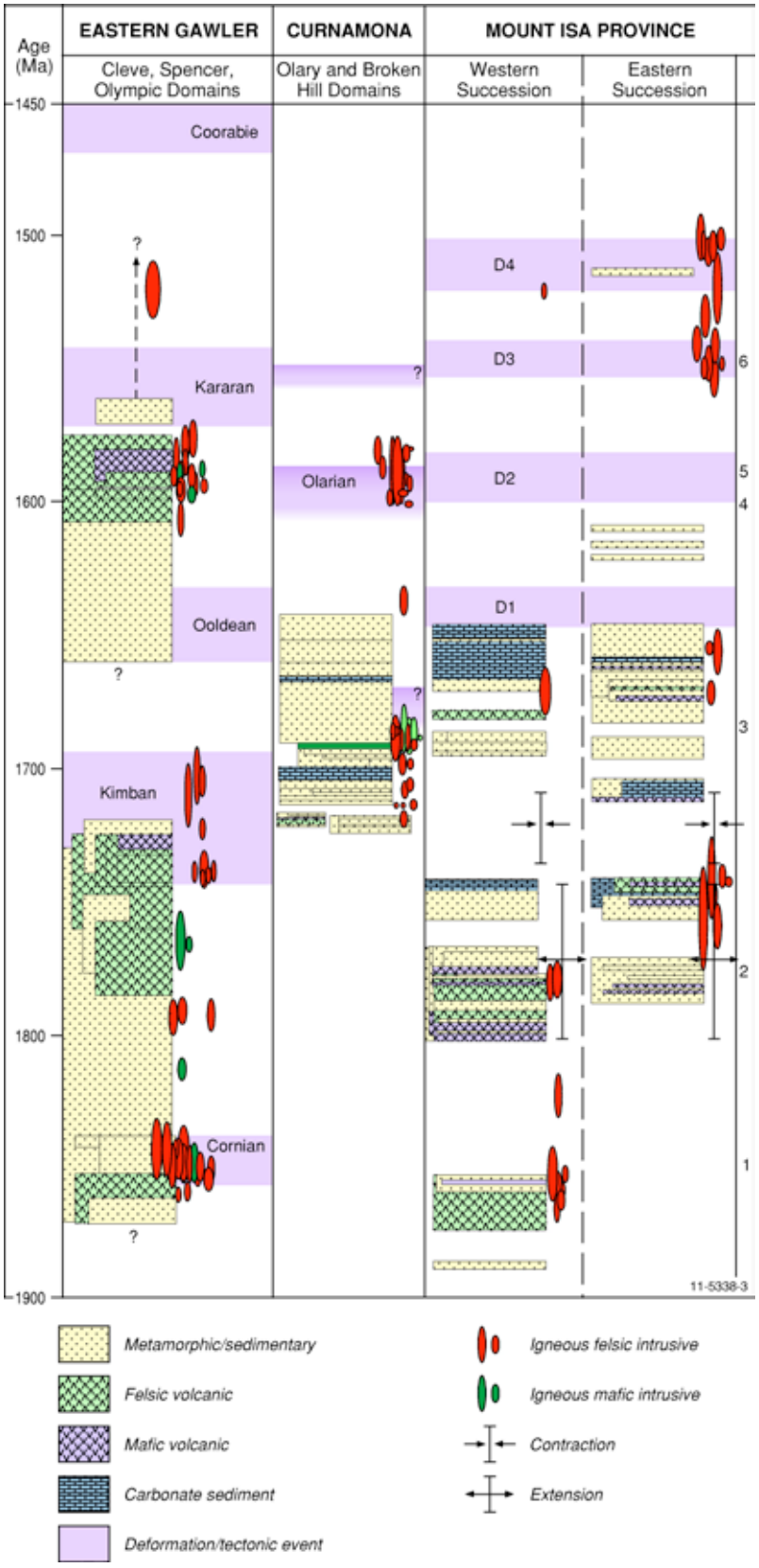


Figure 1. Simplified time-space-event plot for the Eastern Gawler, Curnamona Province and Mt Isa Province for the period 1900 Ma-1450 Ma, showing the similarities between them (see Kositcin, 2010 for details). The numbers on the right of the figure correlate with the similarities listed in the text.

(including the Arunta and Mount Isa provinces) between around 1740 Ma and 1690 Ma. Betts and Giles (2006) modified this model so that crust east of the Kalinjala Mylonite Zone in the Gawler Province was originally part of the North Australian Craton and the proto-Gawler Province to the west was the colliding terrane during the Kimban-Strangways Orogeny. In these models, the ~1720 Ma Kimban Orogeny is interpreted to connect with the Strangways Orogeny in the Arunta Province to form an approximately east–west trending collisional belt. This interpretation requires the South Australian Craton (including the Gawler and Curnamona provinces) to be rotated 52 degrees counterclockwise relative to its current position. This places the Curnamona Province adjacent to the current southern subsurface extent of the Mount Isa Province and Georgetown Region (Giles et al 2004) thus linking the Eastern Succession and Willyama Supergroup (Broken Hill Block) as part of the same stratigraphic package.

Alternatively, based on studies in the Mount Isa Province Gibson et al (2008) proposed a Basin-and-Range-style model in which crustal evolution was dominated by extension along the eastern margin of Proterozoic Australia. In this interpretation, the north-south relative positions of the North Australian and South Australian cratons did not change significantly through the Paleo- to Mesoproterozoic.

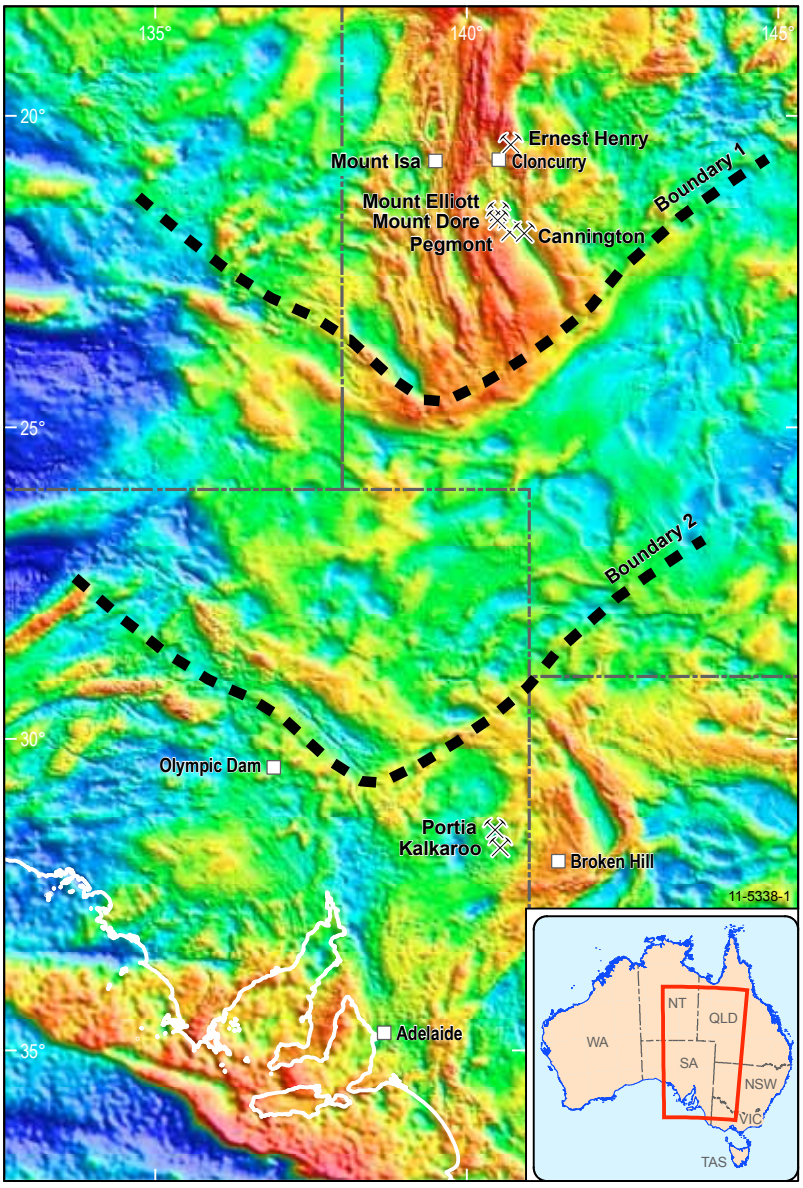


Figure 2a. Bouguer gravity image showing the proposed boundaries (broken black lines) between the Mt Isa province (Boundary 1) and the Broken Hill Block (Boundary 2), and the co-joined Curnamona Province and Gawler Craton. The locations of major towns are shown as white squares and the mine symbol denotes mines.

Linked but not rotated

Hence, there is significant controversy as to the relative position, rotated or not, of the Gawler and Mount Isa provinces. Potential field datasets, including gravity and aeromagnetic datasets, have the potential to resolve this controversy as large-scale geophysical trends should be less susceptible to re-orientation and have fewer complexities of interpretation than geological datasets. However, the age of geophysical trends, in many cases, cannot be established conclusively. Figure 2a illustrates the variations in the Bouger gravity field for the eastern margin of Proterozoic Australia. This dataset and the aeromagnetic dataset are characterised by a major (under cover) boundary along the southern margin of the Mount Isa Province that truncates a broadly north–south geophysical grain.

Although less certain, the geophysical data in the Curnamona Province are also characterised by a north–south grain and a northern boundary (Boundary 2 on figure 2b) sub-parallel to the boundary that defines the southern margin of the Mount Isa Province (Boundary 1). To further assess this north–south trend, Figure 2b juxtaposes the Curnamona Province with the Mount Isa Province using the sub-parallel boundaries discussed above. This fit is remarkable: not only are the trends continuous, but individual linear anomalies in the gravity dataset can be traced across the province boundaries. If the Curnamona Province was rotated 52 degrees counterclockwise relative to the Mount Isa Province, the trends should not be traceable across the now separated province boundaries. This relationship is considered to favour a simple geological link without rotation, which is more consistent with models such as Gibson et al (2008) and the original interpretations of Bill Laing.

The white band in Figure 2b is intended to indicate that the Broken Hill Block and the Mount Isa Eastern Succession were not juxtaposed directly. Rather, they would have been

separated by attenuated crust. The zone between the two boundaries in Figure 2a is characterised by crust that is significantly thinner than crust in either the Broken Hill Block or the Mount Isa Eastern Succession (30 to 35 kilometres, including ~5 kilometres of Paleozoic basins, compared to 40 to 45 kilometres, or more: Collins 1991; Meixner and Holgate 2009). It is possible that the attenuation of the crust was accompanied by granite emplacement (Meixner and Holgate 2009), as indicated by the large gravity lows in Figure 2a.

Implications for mineral potential

This reconstruction has important implications for the mineral potential of Proterozoic Australia, particularly its eastern margin. The Curnamona and Mount Isa Provinces are some of the most highly mineralised provinces in the world, and large parts of these provinces are under cover. The reconstruction discussed above suggests that the southern extension of the Mount Isa Province under cover has high potential for both sediment-hosted zinc-lead-silver and iron oxide copper-gold deposits. This potential will extend into the inferred attenuated crust between the two boundaries. In addition, younger parts of the Curnamona Province, particularly the Paragon and Sundown Groups, may have potential for sediment-hosted zinc-lead-silver deposits akin to the Mount Isa and Hilton-George Fisher deposits.

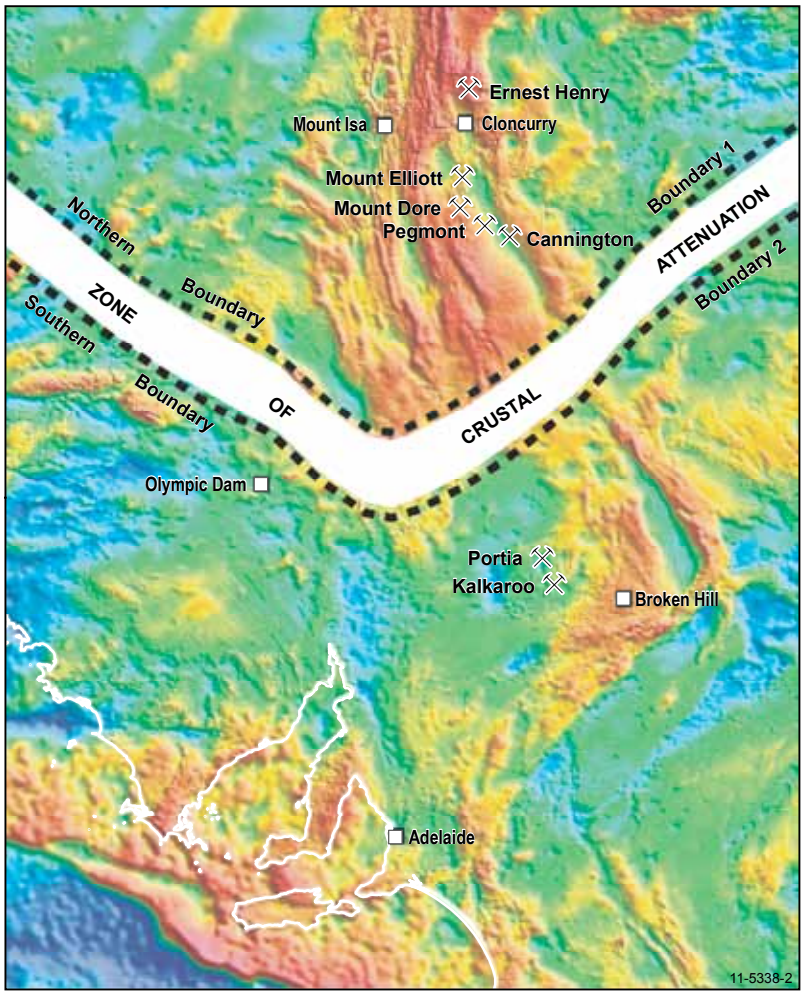


Figure 2b. Reconstruction using the gravity image of the Mt Isa Province and the Broken Hill Block, and the co-joined Curnamona Province and Gawler Craton. Boundary 1 and Boundary 2 have been repositioned (with no rotation) to show a proposed reconstruction of the architecture during the Mesoproterozoic (the white area between Boundary 1 and Boundary 2 represents crust that was attenuated). The locations of major towns are shown as white squares and the mine symbol denotes mines.

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AUSGEO news
ISSUE 102 June 2011

Satellite imagery assists flood emergency response and recovery

International support for Geoscience Australia's contribution

David Hudson and Norman Mueller

Heavy rainfall occurred across most of Australia between November 2010 and early February 2011 causing extreme flooding across eastern Australia, particularly in Queensland and Victoria. During the flood emergencies, Geoscience Australia provided satellite imagery and derived mapping information to support the emergency response and recovery efforts. These images came from more than twenty different satellites operated by governments and companies from the United States, United Kingdom, Germany, Japan, Italy, France, Canada, Taiwan and the European Commission.

Between December 2010 and February 2011, Geoscience Australia acquired more than 600

Table 1. Detailed breakdown of each of the acquired datasets and their source.

Satellite sensor	Type	Acquisition window	Scene acquired	Resolution (m)	Acquisition method	Country of origin
Cosmo-SkyMed	RADAR	12.01.2011–13.01.2011	2	3	OGRE	Italy
RADARSAT-2	RADAR	06.01.2011–12.01.2011	4	10	Charter	Canada
TerraSAR-X	RADAR	04.01.2011–18.01.2011	9	10	Charter	Germany
ALOS, PALSAR	RADAR	04.01.2011–16.01.2011	6	10–30	Charter	Japan
ENVISAT, ASAR	RADAR	05.01.2011–17.01.2011	2	150	Charter	European Commission
Formosat 2, RSI	Optical	06.01.2011–10.01.2011	2	2–8	Charter	Taiwan
Spot4/5	Optical	07.01.2011–09.01.2011	11	20–10	Charter	France
ASTER	Optical	05.01.2011–17.01.2011	12	15	Charter	Japan
DMCii	Optical	09.01.2011–20.01.2011	6	22	Charter	UK
Quickbird	Optical	19.12.2003–22.11.2006	23	2.4	Charter	US
Worldview 1	Optical	13.01.2008–16.01.2011	331	0.5	Charter	US
Avnir2	Optical	16.01.2011	4	10	Charter	Japan
Terra, MODIS	Optical	05.12.2011–19.01.2011	10	250	GA ground station	US
Aqua, MODIS	Optical	12.12.2010–18.01.2011	6	250	GA ground station	US
MODIS Composite	Optical	19.10.2010–14.01.2011	103	500	GA ground station	US
Landsat 5, TM	Optical	05.12.2010–20.01.2011	53	25	GA ground station	US
Landsat 7, ETM+	Optical	13.12.2010–19.01.2011	25	25	GA ground station	US
			Total			
			609			

Figure 1. Landsat 5 true-colour images of Brisbane before and after the January floods. The image on the left was acquired on 19 October 2010 and shows the typical conditions around Brisbane before the floods. Urban areas appear light grey while vegetation appears green and dry areas such as farmlands appear brownish. The image on the right was acquired on 17 January 2011 and shows the conditions as flood waters receded. The flood waters appear as dirty brown while clear water is dark blue. Sediment plumes from the flooding rivers can be seen streaming out into Morton Bay from the Brisbane River. Many of the areas that appear dry (brownish) in the pre-flood image are now showing green as grasses react to the wet conditions. The cloud in this image appears grey to white.

satellite images covering flood-affected areas from satellite imagery archives around the world, satellite downlink stations in Australia, international space agencies and overseas commercial imaging satellite operators (Table 1). The three key sources of these satellite images were:

1) Day-to-day satellite imagery acquisition from downlink stations in Alice Springs and Hobart.
2) Activation of the International Charter for Space and Major Disasters. The International Charter is an agreement involving 39 countries to provide satellite data during a major disaster.
3) The cooperative panel for Optical Geospatial Radar and Elevation (OGRE) data and services. This panel is a government procurement mechanism for accessing imagery-related data and services. The panel was established in 2010 in a joint project by Geoscience Australia and the Defence Imagery and Geospatial Organisation (DIGO).

The emergency support included the provision of satellite imagery, flood extent data and flood maps showing flood-affected areas and their surrounds. These images allowed emergency managers to carefully monitor the extent of the flooding and receding waters. Imaging satellites capture a specific point in time and so it is extremely difficult to capture the peak of a flood. In addition, many of the images are obstructed by clouds as the majority of satellites are optical satellites and cannot see through the clouds which are highly likely over a flooding area (figure 1).

Utilisation of the satellite imagery

During the flood crises, Geoscience Australia was able to provide over 75 maps and 25 flood extent products based on the data received by emergency service agencies across Australia (figure 2). These products were used for many applications including emergency response deployment, early impact assessment, guiding Natural Disaster Relief and Recovery Arrangements (NDRRA) payments, assisting the Bureau of Meteorology with data used for flood warnings where ground instruments had been damaged, briefings and redeployment of government services such as child care facilities.

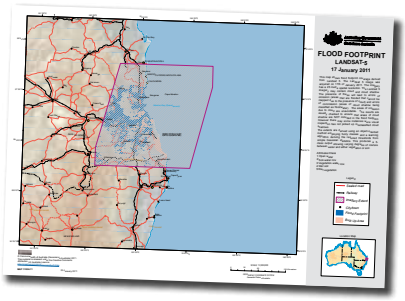

Figure 2. Map showing flood footprint coverage in southeast Queensland derived from the Landsat 5 satellite.

The response to the Queensland floods took the utilisation of satellite imagery to a new level for Australia and demonstrated the critical role remote sensing services have in emergency management.

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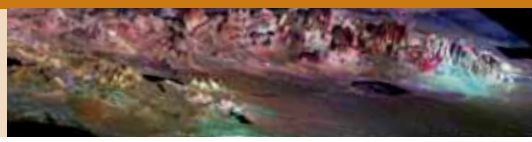
AUSGEO news
ISSUE 102 June 2011

Onshore Energy Security Program update

Delivering data and improved scientific understanding



Frome airborne electromagnetic data release

Geoscience Australia has recently released the Phase 1 (contractor-delivered) data from the Frome airborne electromagnetic (AEM) survey. The Frome AEM survey was flown between May and November 2010 and was the most extensive survey of its kind in Australia. The survey was a collaborative project involving Geoscience Australia, the Department of Primary Industries and Resources South Australia (PIRSA) and a consortium of exploration industry representatives. The data will assist in highlighting potential areas for mineral exploration as well as improving the understanding of groundwater resources in the area.

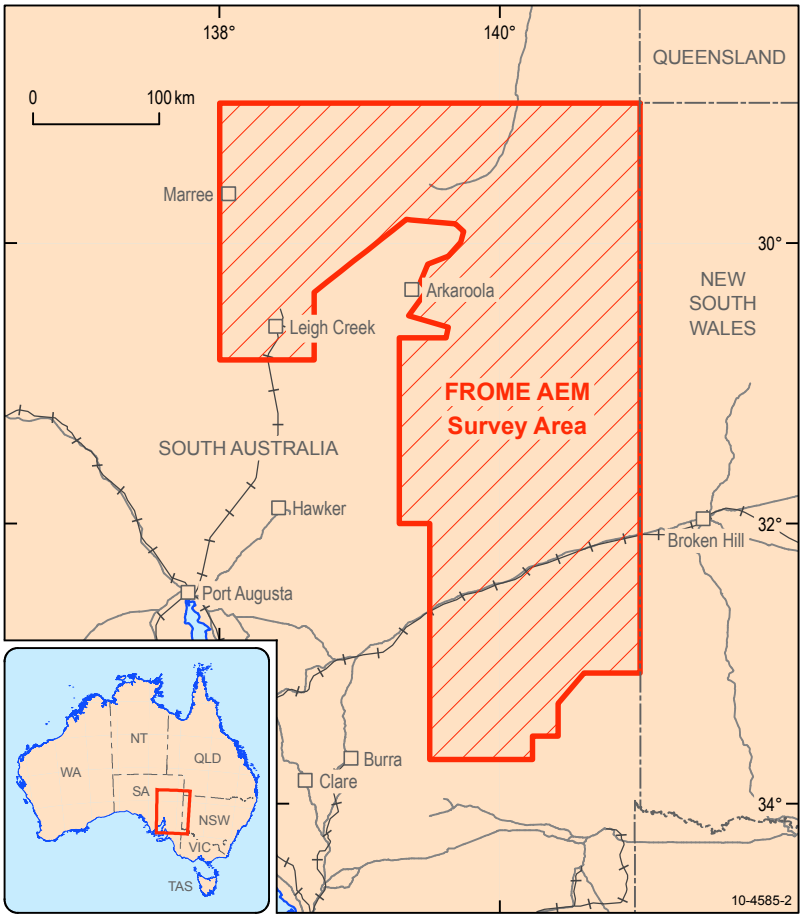


Figure 1. The survey area over the Frome Embayment and northern Murray Basin in South Australia.

The survey was the last of three regional AEM surveys conducted as part of Geoscience Australia's Onshore Energy Security Program (OESP). The program was designed to reduce risk in exploration and support the development of Australia's onshore energy resources. Data from the first two surveys, Paterson in Western Australia and Pine Creek in the Northern Territory, have already been released and are available through Geoscience Australia's website together with supporting information.

The Frome AEM survey covers 95 450 square kilometres in South Australia's outback (figure 1). The survey aircraft acquired 32 317 line kilometres of data using Fugro Airborne Surveys' TEMPEST™ system. The aircraft flew along east-west lines spaced 2.5 kilometres and 5 kilometres apart at a nominal height of 100 metres above ground level, resulting in data with an enhanced signal-to-noise ratio compared to previous surveys. The survey also included a global positioning system (GPS) unit fitted to the aircraft's receiver bird to enhance the accuracy of the received data for the first time.

The survey primarily targeted potential uranium-bearing mineral systems in the Callabonna Sub-basin of the Frome Embayment and the Lake Eyre Basin on the flanks of the northern Flinders Ranges as well as the area around Marree and Camerons Corner. It also included:

- The northwest Murray Basin including the South Australian Delamerian Orogen which is prospective for uranium, heavy mineral sands, gold and base metal deposits.

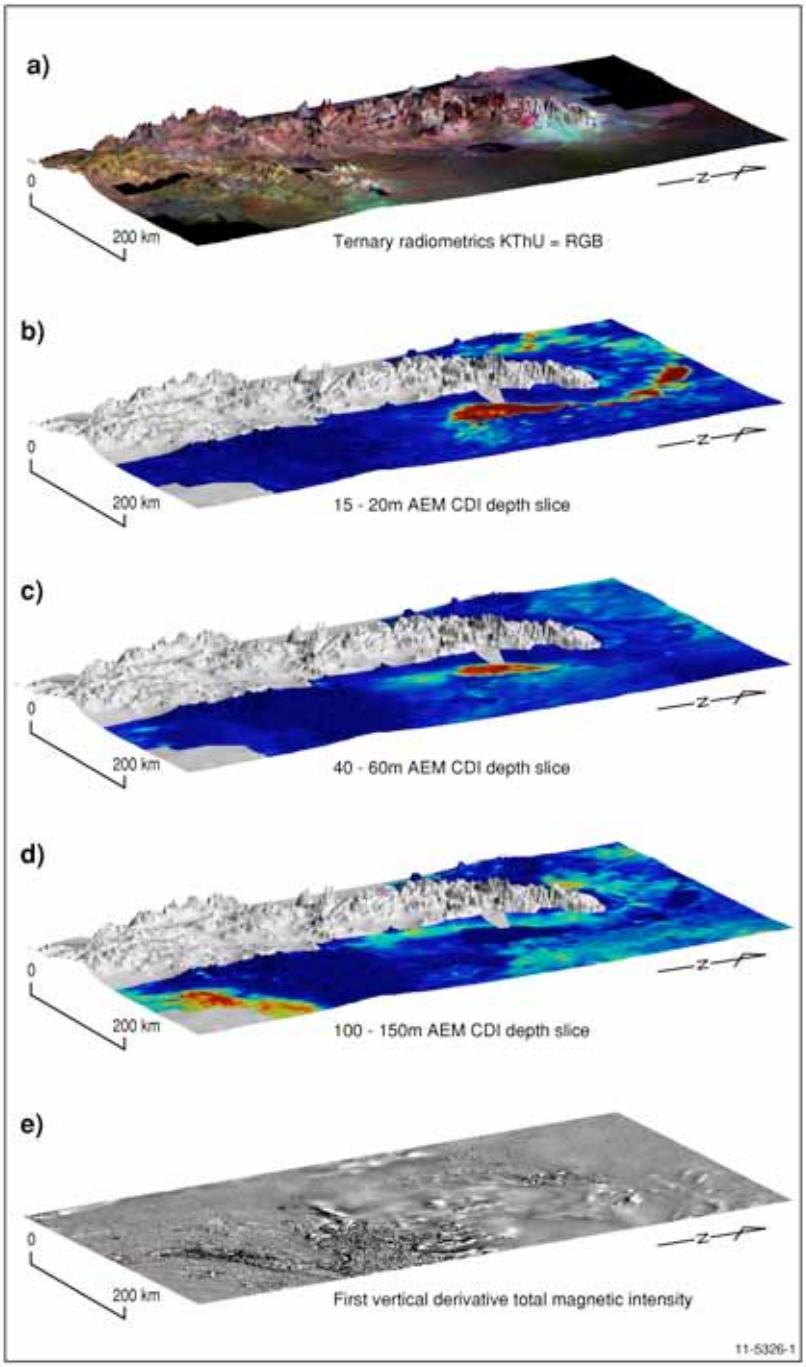


Figure 2. Radiometric data, AEM depth slices, and first vertical derivative total magnetic intensity for the Frome survey area superimposed on digital elevation data.

- The Benagerie Ridge which is prospective for uranium, gold, copper and Broken Hill-style lead-zinc-silver deposits.
- The Olary Range (Nackara Arc) which is prospective for uranium, gold, copper, Broken Hill-style lead-zinc-silver deposits and sedimentary iron ore deposits.
- The Leigh Creek–Beltana area which is prospective for coal, copper, zinc and magnesite.

Overall the survey will provide new geological insights into the distribution of prospective rocks within the Benagerie Ridge, the depth to highly-prospective rocks of the Delamerian Orogen under the Murray Basin, and the three-dimensional structure of Neoproterozoic rocks within the Nackara Arc. It will also map Cenozoic paleovalleys or paleochannels, neotectonic activity surrounding the Flinders Ranges and the depth of cover within the survey area (figure 2).

The Phase 1 release data include point-located ASCII data, EM Flow™ conductivity-depth interval (CDI) grids and EM Flow™ CDI multiplots. It is available for free download through the Geoscience Australia website or on DVD ROM for $99.00 from the Geoscience Australia Sales Centre.

The data will be further enhanced at Geoscience Australia using the agency's layered earth inversion (GA-LEI) algorithm (Brodie and Sambridge 2006) to produce point-located ASCII

data and geolocated grids and sections. These enhanced data will be released as Phase 2 of the Frome AEM data release in mid-2011.

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Related websites/articles

Airborne Electromagnetics Project downloadable data
www.ga.gov.au/energy/projects/airborne-electromagnetics.html

Phase 1 data on DVD-ROM from Geoscience Australia Sales Centre
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71624

New structures revealed in Northern Territory seismic survey

A deep seismic survey undertaken as part of Geoscience Australia's Onshore Energy Security Program has revealed major new geological structures in the Northern Territory which will assist energy and mineral resource exploration in the region.

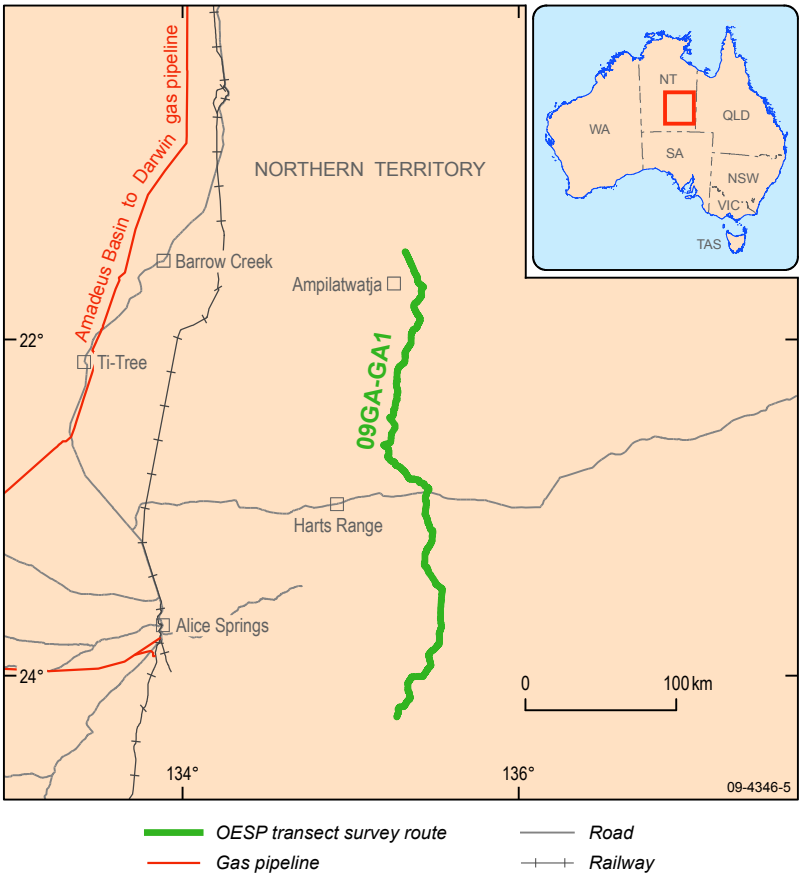

Figure 3. Location map for the Georgina–Arunta Seismic Line in central Australia which extends for 373 kilometres.

The Georgina–Arunta Seismic Line extended over 373 kilometres from near the Todd River 150 kilometres east of Alice Springs to just north of Amaroo. The survey was a cooperative program carried out by Geoscience Australia in collaboration with the Northern Territory Geological Survey (figure 3).

Analysis of the survey data has identified a series of previously unknown fault systems, and provided 3D constraints on the geometry and origin of the Irindina Province, an enigmatic late Neoproterozoic to early Paleozoic basin that has recently yielded significant copper-cobalt, nickel-copper and gold discoveries. These results will help to develop a better understanding of the geological architecture of the Northern Territory and improve the appreciation of how the Australian continent was formed.

> "These results will help to develop a better understanding of the geological architecture …"

The datasets will also help in developing a greater knowledge of the potential for future mineral and energy discoveries, particularly through the relationship between the newly-discovered features and other geological features supporting

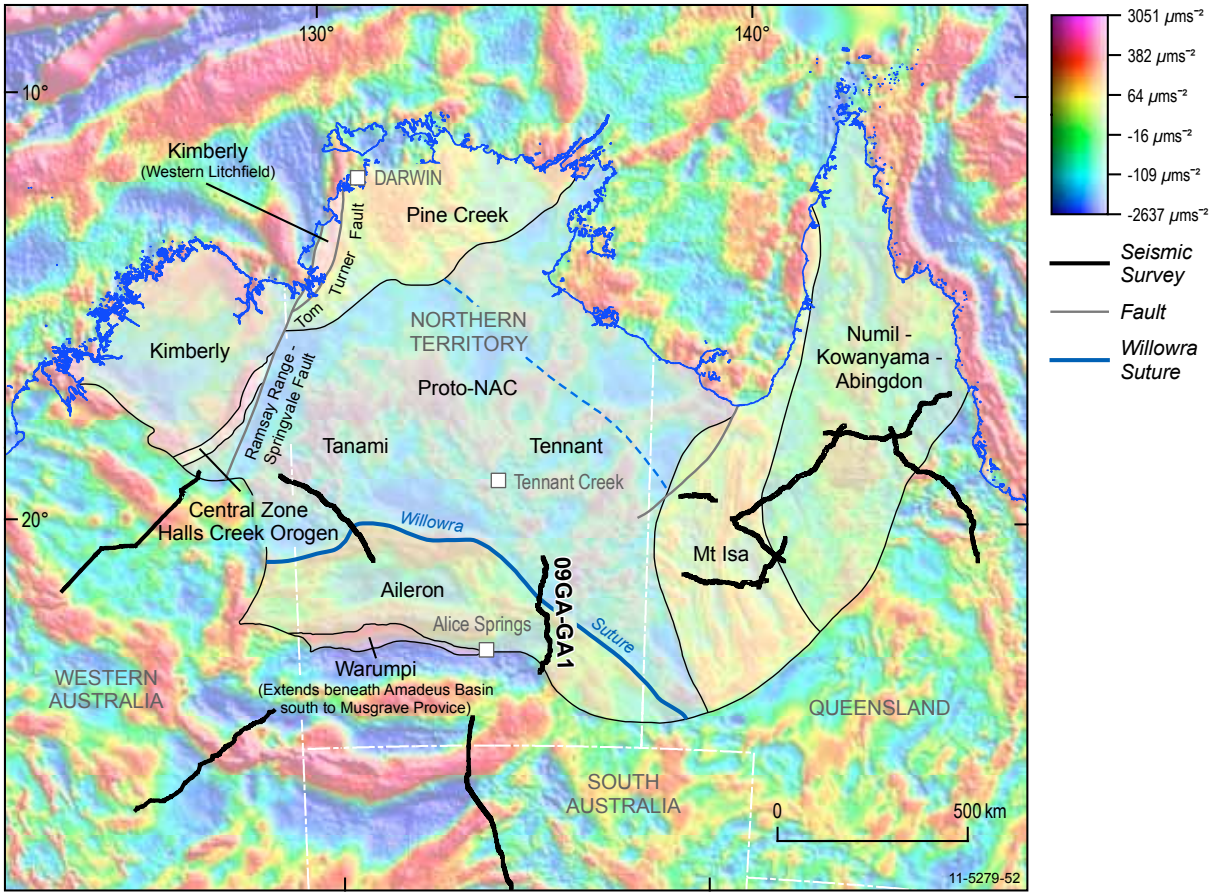

Figure 4. Gravity image showing the location of the Georgina-Arunta survey (09GA-GA1) and Tanami survey (05GA-T1) and the interpreted location of the Willowra Suture.

known mineral occurrences in the Northern Territory and elsewhere in Australia. The data from this survey and a survey carried out in the Tanami region in 2005 (*AusGeo News* 85), along with magnetic and gravity data, create a strong possibility that the feature known as the Willowra suture extends over a much more significant distance than previously inferred (figure 4). The suture has similar features to those associated with the Olympic Dam mineral system in South Australia and at Cloncurry in Queensland and may be related to the Tennant Creek gold–copper district and/or possible iron-oxide copper-gold discoveries in the southern Aileron Province.

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Geoscience Australia's Onshore Energy Security Program

www.ga.gov.au/energy/energy-security-program/onshore-energy-security.html

Geoscience Australia's Seismic Acquisition and Processing Project

www.ga.gov.au/energy/projects/seismic-acquisition-processing.html

Northern Territory Geological Survey

www.nt.gov.au/d/Minerals_Energy/Geoscience/

in brief

Seabed mapping in Antarctica

Many of Geoscience Australia's offshore surveys have demonstrated the value of integrated data sets in understanding the marine environment. This approach was applied to a survey in Antarctic waters which carried out multibeam bathymetry, video and sampling programs in the coastal waters of the Vestfold Hills, near the Australian station of Davis. The survey, which was a joint project with the Australian Antarctic Division and the Royal Australian Navy, was carried out during the summer of 2009–10.

The Vestfold Hills are an ice-free area of about 400 square kilometres on the coast of East Antarctica. They are composed of low hills of Precambrian basement up to 160 metres high separated by valleys, with a coastline of numerous small islands and shallow bays and fjords extending inland. The area is home to many penguin breeding colonies and its beaches are favoured as summer moulting sites by elephant seals. The shallow coastal waters support a seabed community different to those on the open Antarctic continental shelf. The lakes, fjords and landforms of the Vestfold Hills have also been studied to understand the interaction of sea level change and changes in the adjacent ice sheet.

The survey area also includes the Australian station at Davis. To date, only the area immediately off Davis, used by ships resupplying the station, has been charted. Therefore, the joint project aimed to provide a picture of seafloor topography and character to support studies of the sea floor habitats and develop an understanding of the history of sedimentation and erosion in the area. These studies are also contributing to an assessment of any possible impact of the station at Davis; in particular whether effluent discharge from the station is having a measurable effect.

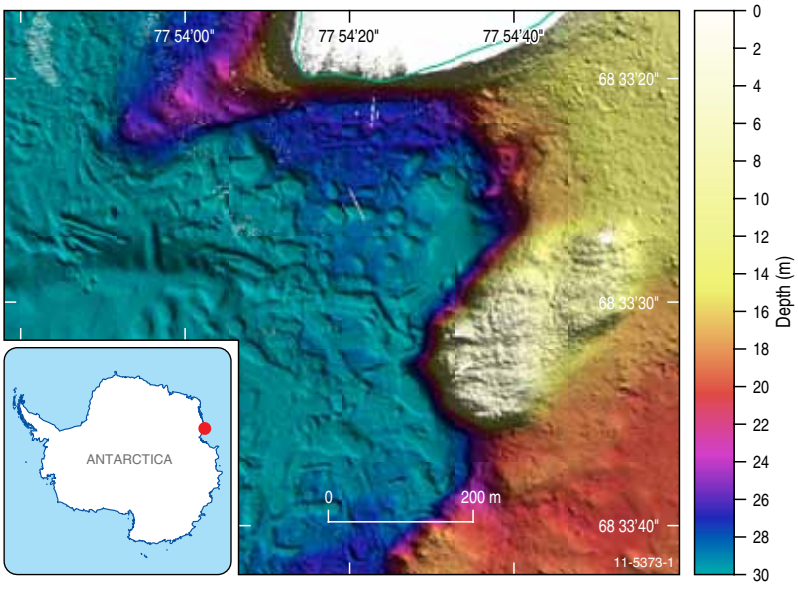

Figure 1. Selected multibeam imagery of the sea floor in Davis Harbour. In the east is a relatively shallow sediment-covered plain (about 10 to 20 metres water depth), with a bedrock high (rising to one to two metres depth). The plain is strewn with boulders, probably representing moraine debris. To the west is a steep drop-off (about 25 to 30 metres depth) to a sediment-covered plain characterised by large irregular scours and gouges probably caused by iceberg movements. Bluff Island is the white at the top of the image.

Geoscience Australia provided its Simrad EM 3002 multibeam echo sounder and underwater video camera which were mounted on the AAD's 8 metre long workboat *Howard Burton*. The bathymetric data were processed for sea floor character by Geoscience Australia and for hydrographic purposes by the Royal Australian Navy's Deployable Geospatial Survey Team. The Australian Antarctic Division conducted an extensive diving program, visiting 30 sites in the area where sediment and biological samples were collected and still photos of the sea floor taken to provide detailed point samples of the seabed environment.

Geoscience Australia's multibeam survey covered an area of 45 square kilometres and provides a picture of the sea floor based on at least one depth measurement every 40 centimetres. These data reveal a submarine landscape similar to that on shore but with basin areas accumulating sediment and abundant iceberg scours (figure 1). The data are of such high resolution that typical features of bedrock outcrops such as joints and resistant dykes can be seen. Some land areas of the Vestfold Hills are strewn with boulders. Adjacent areas offshore

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also show a speckled appearance indicating the boulder fields continue beyond the shore. Ice keel scours are abundant ranging from enclosed, rounded wallow marks 20 metres across through to meandering tracks. The predominant direction of larger scours is north to south and NNW to SSE, probably reflecting oceanic circulation in Prydz Bay which drives the icebergs.

Initial comparisons of the biological samples with the multibeam data shows the potential to predict the dominant biological communities across an area. Hard substrates are dominated by algae (*Himanthothalus* and *Iredea*) whereas sediment-covered areas are mostly inhabited by invertebrates such as sea pens and burrowing bivalves (*Laternula sp*). Patches of algae are present in sediment covered areas but it is less widespread and may be displaced. Mobile invertebrates such as holthurians, echinoderms and numertians are common in sediment areas.

For more information

email ausgeomail@ga.gov.au

New National Elevation Data Framework Portal

Digital elevation data which describes Australia's landforms and seabed is crucial for addressing the impacts of climate change, supporting emergency management and ensuring water security as well as environmental management, urban planning and infrastructure design.

The National Elevation Data Framework Portal (NEDF Portal) is a new online facility which provides users with access to existing elevation data holdings and metadata. The Portal has been developed to serve as a 'Virtual Data Repository' and is progressively being populated with data and links to national, state, local and commercial data custodians. It will also significantly improve the management and maintenance of elevation and related data within Geoscience Australia and across all levels of government.

The National Elevation Data Framework vision is to ensure that decision makers and the community have access to the best available elevation data. The mission of the NEDF is to optimise investment and access to existing and future data collections and ensure this investment supports policy and operational needs at national, state/territory and local levels.

The NEDF is hosted by Geoscience Australia. The development of the NEDF was coordinated by ANZLIC—the Spatial Information Council, the Australian Government Department of Climate Change and Energy Efficiency, the Cooperative Research Centre for Spatial Information and Geoscience Australia in partnership with federal state/territory and local government agencies and industry.

The NEDF will benefit the public sector at federal, state and local level as well as the private sector by:

- enhancing access to information across all levels of government, industry, academia and the community
- minimising duplication of effort
- increasing the utility of data by developing and promoting flexible standards that meet the needs of users and providers and 'future proof' the investment in data
- promoting industry development through the coordination of acquisition programs, adoption of standards, partnerships and development of appropriate licensing arrangements
- influencing the development of national and international capacity to mitigate and adapt to the impacts of climate change.

For more information

email elevation@ga.gov.au

Related websites/articles

National Elevation Data Framework
www.ga.gov.au/topographic-mapping/digital-elevation-data.html

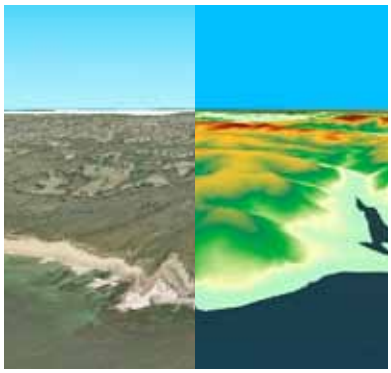

Figure 1. An example of digital elevation model data representation of elevation points, streamlines, cliff lines and water bodies.

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Stratigraphic units database update

The Australian Stratigraphic Units Database (ASUD) has been the authoritative repository of all stratigraphic unit descriptions in Australia since 1949. The ASUD contains the names plus summary descriptions of almost 15 000 geological units which are currently approved for use in Australia. The database also includes a record of another 30 000 unit names which are obsolete, superseded, or have been erroneously published in the geological literature. Users of the database can track the history of a particular geologic unit name as well as find references to geological units in the geological literature and maps.

The database is available online and is free of charge. Users can browse the database and retrieve descriptive reports of geological units by using the Stratigraphic Search tool at the ASUD website. Following a recent upgrade, the reports now graphically display the location of a unit within a stratigraphic hierarchy (such as group, subgroup, formation) or chemical hierarchy (such as supersuite, suite), and its relationship to surrounding units. The online reports also contain hyperlinks to any available descriptions of geological provinces in which the unit occurs and/or formal unit definition data.

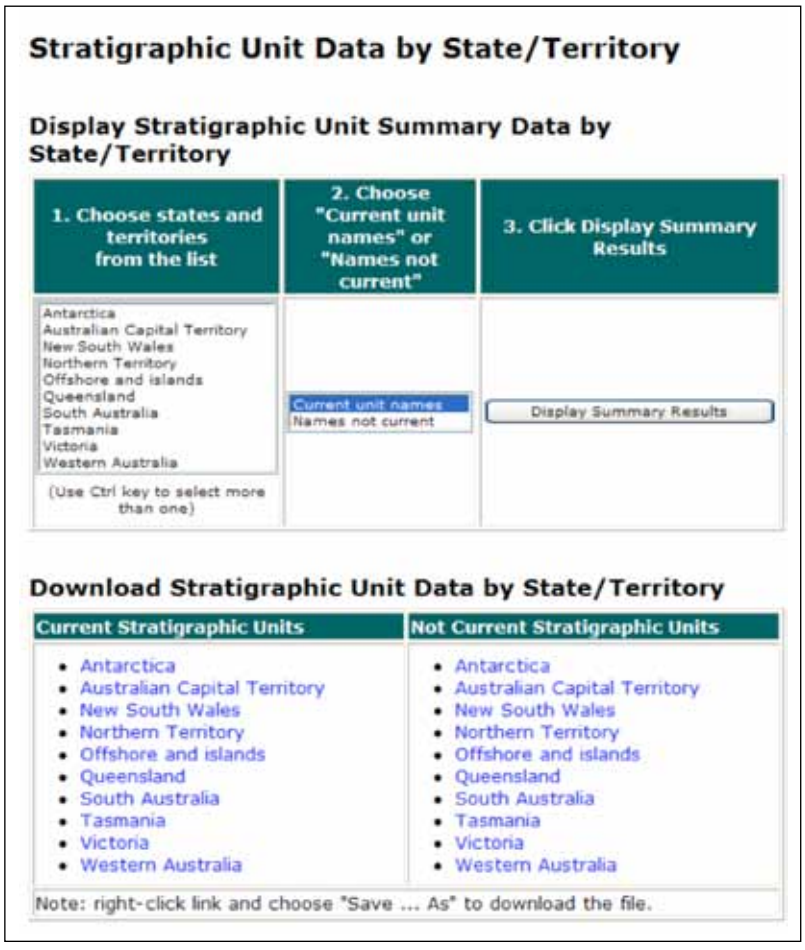

Figure 1. Users can now download geological units for a whole state or territory.

New feature

The ASUD website now includes a facility to download lists of all geological units within a particular state or territory (figure 1). The new lists comprise both current and non-current (that is, superseded or obsolete) geological units. The state/territory lists come in packages of several spreadsheets containing information about age and lithological description, published references and maps, related units, and formal definition data where available. These new state/territory lists are updated daily.

New website URLs

Users of the ASUD may need to update their bookmarks for some ASUD web pages as the URLs may have changed as a result of a recent website redevelopment at Geoscience Australia. The ASUD homepage includes links to the Whole State Lists and the online search tool, as well as the Australian Stratigraphy Commission and other useful stratigraphic links (see below).

For more information

email stratnames@ga.gov.au

Related websites/articles

Australian Stratigraphic Units Database home page
www.ga.gov.au/products-services/data-applications/reference-databases/stratigraphic-units.html

Stratigraphic Unit Definition forms
www.ga.gov.au/products-services/data-applications/reference-databases/stratigraphic-units/unit-definition-form.html

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Update on 34th International Geological Congress—AUSTRALIA 2012

Australia, on behalf of the Oceania region, is hosting the 34th International Geological Congress (IGC) in Brisbane from 5 to 10 August 2012. The Congress is being held at the Brisbane Convention and Exhibition Centre.

The 34th IGC will feature a wide-ranging scientific program as well as field trips, a large exhibition, training workshops and an education and outreach program. The Congress will also be the venue for the 2012 meetings of the International Union of Geological Sciences' Commissions, Task Groups and Joint Programs. The 34th IGC will also incorporate the 2nd Young Earth Scientists (YES) Roundtable and has the benefit of UNESCO patronage.

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

Scientific Program

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 approximately 210 Symposia under 36 Themes covering all facets of the geosciences. Details are included in the Second Circular, which was recently released, and can be accessed through the Congress website.

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 be a geoscience information 'supersession' covering a range of topics from OneGeology (the online world geological map) to data standards.

Summaries of each Symposium are included on the Congress website and Communicating Convenors and most co-Convenors have now been appointed. Abstracts for the oral and poster presentations are now invited. Although full papers will not be published by the Congress, the symposium convenors may elect to arrange publication of papers presented during their symposia.

Field trips

The 34th ICG is planning more than 30 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, field trips to New Zealand, Malaysia, and New Caledonia and Papua New Guinea are being planned. There will also be a range of one-day tours available during the conference. Details of proposed field trips are also available through the Congress website.

Workshops

Workshop topics include 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.

Congress registration

A Super Early Bird registration, aimed particularly at international delegates, will be available until the end of August 2011. A bulk rate of $A850.00 per head applies to a minimum purchase of three registrations;

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names of delegates can be confirmed until May 2012. Super Early Bird registration is also available to individuals at $895.00. Readers who wish to register for the Congress or wish to receive regular updates by email can do so through the Congress website.

For more information

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

product news

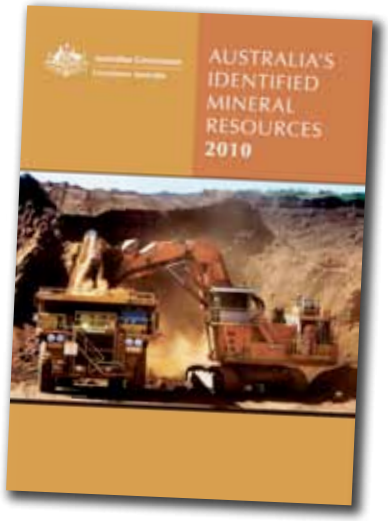
Australia's mineral resources maintain world status

A recent assessment by Geoscience Australia concludes that Australia's mining sector continues to hold the potential to remain the most important export earning sector of the Australian economy for the foreseeable future. This trend is based on the latest annual assessment of Australia's minerals inventory—*Australia's Identified Mineral Resources 2010*.

Australia's Identified Mineral Resources 2010 includes estimates of Australia's mineral resources at the end of December 2009 for all major and several minor mineral commodities based on published and unpublished data available to Geoscience Australia. These resource estimates give a long term view of what is likely to be mined. They are compared with national totals of ore reserves for each commodity, which provides the industry view of what is likely to be mined in the short to medium term. Mine production data are based on figures from the Australian Bureau of Agricultural and Resource Economics and Sciences.

The assessment provides information on and analysis of mineral exploration expenditures in Australia in recent years and shows that Australia's Economic Demonstrated Resources (EDR)* for a number of mineral commodities increased during 2009. These include:

- Recoverable EDR of **black coal** in 2009 increased by 11.5 per cent to 43.8 gigatonnes which represents seven per cent of the world's economic recoverable black coal resources and ranks Australia as having the world's fifth largest resources. The Bowen Basin in Queensland contains 35 per cent of Australia's recoverable EDR of black coal and the Sydney Basin in New South Wales contains 31 per cent.
- Australia's EDR of **copper** rose by 2.5 million tonnes in 2009 to 80.4 million tonnes, an increase of three per cent, with most of the increase in New South Wales. South Australia has the largest EDR at 56.5 million tonnes, mainly in the Olympic Dam deposit, which is 70 per cent of the national total.
- **Gold** mining and exploration occurs in all states and the Northern Territory. Australia's EDR of gold rose by 18 per cent to 7399 tonnes in 2009, while production increased 3.5 per cent to 223 tonnes. Western Australia has 40 per cent of Australia's EDR, while South Australia has 31 per cent and New South Wales 20 per cent.



Collectively these three account for more than 90 per cent of national gold EDR.

- Approximately one third of Australia's gold EDR are in gold-only deposits often referred to as 'lode gold' deposits (such as the Super Pit, and Sunrise Dam deposits) whereas two thirds of gold EDR are in polymetallic deposits. These polymetallic resources are mainly copper-gold deposits (such as Cadia, Cadia East, Boddington and Telfer) and iron oxide-copper-gold deposits (such as Olympic Dam and Prominent Hill). Increases in Australia's gold EDR in 2009 was due largely to increases at eight of the larger producing deposits. This follows the trend of recent years for growth in Australian EDR being driven by new resources delineated at these deposits. Growth in EDR at all other Australian deposits has only just covered EDR lost to production. Four major polymetallic deposits have more than 50 per cent of Australia gold resources—Olympic Dam, Cadia, Boddington and Telfer.

* Companies listed on the Australian Securities Exchange are required to report publicly on Ore Reserves and Mineral Resources under their control, using the Joint Ore Reserves Committee (JORC) Code. Data reported for individual deposits are compiled by Geoscience Australia and used in the preparation of national assessments of Australia's mineral resources. EDR are estimated by the addition of JORC Code figures for Proven and Probable Ore Reserves plus that part of the JORC Measured and/or Indicated Mineral Resources that are considered likely to be economic.

product news

- The EDR of **iron ore** increased by 16.7 per cent to 28 gigatonnes which is about 17 per cent of world economic resources and the world's second largest EDR. Western Australia has 98 per cent of Australia's EDR with about 81 per cent occurring in the Pilbara region.

A free download of *Australia's Identified Mineral Resources 2010* is available through the Geoscience Australia website and other fundamental data on the minerals sector can be accessed through the *Atlas of Australia's Mineral Resources, Mines and Processing Centres.*

For more information

email ausgeomail@ga.gov.au

Related articles/websites

Australia's Identified Mineral Resources 2010

https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71584

Atlas of Australia's Mineral Resources, Mines and Processing Centres.

www.australianminesatlas.gov.au/

New Gazetteer of Australia online!

The Gazetteer of Australia is the authoritative source for the location and spelling of approved place names for Australia and its territories. The recently released 10th edition—*Gazetteer of Australia 2010*—contains more than 332 000 official and unofficial place names, with data supplied by the Australian, state and territory government agencies responsible for administering place names.

The production and distribution of the *Gazetteer of Australia 2010* was overseen by Geoscience Australia on behalf of the Intergovernmental Committee on Surveying & Mapping (ICSM). The committee, which includes representatives from each jurisdiction, has been custodian of the Gazetteer dataset for some time and provided the specifications for compilation of the data.

The *Gazetteer of Australia 2010* is the first version to be available under the *Creative Commons Attribution 3.0 Australia* licence. This licence allows the user to copy, distribute, transmit and adapt the data for their own purposes with the only condition being that users must attribute the source of the original data.

Another feature of this version is that the data can be downloaded for free through the Geoscience Australia website, in MS Access and ASCII format. This will make the gazetteer a more convenient reference for users requiring authoritative place names across Australia.

For more information

visit https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71110

Related articles/websites

Geoscience Australia's Place Name Search facility

www.ga.govau/place-name/

events

Spreading the word about geoscience

Geoscience Australia continues to offer extensive education and outreach programs to promote awareness and knowledge of the Earth sciences, and the contribution geoscience makes to the Australian economy, resource management and environmental protection.

Outreach programs, such as Open Day, and participation in activities to celebrate National Science Week and Earth Science Week, aim to raise awareness and promote the work that Geoscience Australia undertakes.

Figure 1. 'Man and penguin, Antarctica' by Chris Carson was one of the winning entries in the 2010 Top GeoShot competition.

Geoscience Australia's Open Day will be held on Sunday 21 August 2011. It is an opportunity for interested members of the public to visit the agency's headquarters at Symonston, ACT, and will coincide with National Science Week celebrations. A range of displays, tours and activities will showcase how the agency's research is being applied to some of the major challenges facing Australia today. Building and laboratory tours, an Antarctic experience, a walk back in time, water sample taste testing, rock identification, gold panning and exploding volcanoes are some of the activities planned for the day.

Earth Science Week is an international initiative to promote the Earth sciences and raise awareness of the contribution geoscience makes to the community. This year's theme is 'Our ever-changing Earth' and celebrations will be held from 9 to15 October 2011. Geoscience Australia has participated in Earth Science Week activities for 13 years and has hosted Australia's Earth Science Week website and coordinated celebrations across Australia. Geoscience Australia will celebrate this year's event by acknowledging the 100th anniversary of Mawson's expedition to Antarctica.

In the lead up to Earth Science Week, Geoscience Australia also hosts two competitions: the *Geologi* short film competition and the *Top GeoShot* photographic competition.

The *Geologi* short film competition is in its fifth year and is hosted by Geoscience Australia and the Australian Science Teachers Association. The theme for this year's competition is 'Geology and you'. It is open for individuals, groups or classes from any Australian primary or secondary school to submit a short film that explores the affect on the individual or community of natural hazards, rocks and minerals, geological history, local geology or recent geoscience research.

The *Top GeoShot* photographic competition is open to members of the public. It aims to produce a collection of images that capture the essence of Earth science in Australia and amateur photographers are invited to submit their photographs (figure 1). This year's winning entries (or '*TopShots*') will be announced during Earth Science Week and will be on display in the foyer of the Geoscience Australia building.

For more information on Open Day, Earth Science Week or either of the competitions

email education@ga.gov.au
web www.ga.gov.au/education/public-events

events calendar

AMEC Convention 2011	28 to 30 June
Association of Mining and Exploration Companies Inc Burswood Entertainment Complex, Perth, WA Contact: AMEC, PO Box 6337, East Perth WA 6892	P +61 8 9225 4399 or 1300 738 184 (Within Australia) f +61 8 9221 9377 or 1300 738 185 (Within Australia) e events@amec.org.au www.amecconvention.com.au
XXV International Union of Geodesy and Geophysics General Assembly	**28 June to 7 July**
Earth on the Edge: Science for a Sustainable Planet Melbourne Convention & Exhibition Centre, Melbourne, Victoria Contact: arinex pty limited, IUGG General Assembly Managers, 91-97 Islington Street, Collingwood VIC 3066	P +61 3 9417 0888 f +61 3 9417 0899 e iugg2011@arinex.com.au www.iugg2011.com
AMSA 2011 Conference	**3 to 7 July**
Australian Marine Sciences Association Esplanade Hotel, Fremantle, WA Contact: EECW Pty Ltd, PO Box 749, Wembley WA 6913	P +61 8 9389 1488 f +61 8 9389 1499 e emma@eecw.com.au www.amsa2011.com.au
7th International Symposium on Digital Earth (ISDE7)	**23 to 25 August**
Perth Convention and Exhibition Centre, Perth, WA Contact: International Conferences and Events, Suite 4, Level 2, 73 Hay Street, Subiaco, WA 6008	p +61 8 9381 9281 f +61 8 9381 9560 e isde7@iceaustralia.com www.isde7.net/
Fire,Weather and Risk Workshop	**2 to 4 September**
Craigieburn Hotel, Bowral, New South Wales Contact: Bob Cechet, Geoscience Australia, GPO Box 378, Canberra ACT 2601	P +61 2 6249 9246 e bob.cechet@ga.gov.au www.highfirerisk.com.au/fwrw2011/fwrw_home.htm
Mining 2011 Resources Convention	**26 to 28 October**
Brisbane Convention and Exhibition Centre, Brisbane, Queensland Contact: Vertical Events, PO Box 1153, Subiaco WA 6904	P +61 8 9388 2222 f +61 8 9381 9222 e info@verticalevents.com.au www.verticalevents.com.au/
China Mining Congress and Expo	**6 to 8 November**
Ministry of Land and Resources, China Tianjin Meijiang Convention and Exhibition Centre, Tianjin, China Contact: China Mining Organising Committee	P +86 10 6446 6855 f +86 10 5885 7006 e info@china-mining.org www.china-mining.org/en/

events calendar

IMTA (Asia Pacific) Global Conference and Trade Show 2011	10 and 11 November
International Map Trade Association Bangkok, Thailand Contact: Noleen Zander, IMTA (Asia Pacific), PO Box 1112, Unley SA 5061	P +61 8 8357 1777 f +61 8 8357 3001 e imtaaspac@chariot.net.au www.imtamaps.org/events/displayevent.php?id=117
spatial@gov 2011 Conference & Exhibition	**15 to 17 November**
National Convention Centre, Canberra, ACT Contact: CeBIT Global Conferences, 80 Buckingham Street, Surry Hills NSW 2010	P +61 2 9280 3400 f +61 2 9280 1977 e cebit@hannoverfairs.com.au www.cebit.com.au/spatial
Australian Geothermal Energy Conference	**16 to 18 November**
Australian Geothermal Energy Association and Australian Geothermal Energy Group Sebel Albert Park, Melbourne, Victoria Contact: Rob Bulfield, Sapro Conference Management	P +61 8 8274 6063 e agec2011@sapmea.asn.au www.ausgeothermal.com/
Surveying and Spatial Sciences Conference 2011	**21 to 25 November**
New Zealand Institute of Surveyors and Surveying and Spatial Sciences Institute Wellington Conference Centre, Wellington, New Zealand Contact: Conference Works Ltd, PO Box 1449, Wellington, New Zealand	P +64 4 479 8616 f +64 4 479 4341 e convenor@sssc2011.org www.sssc2011.org

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