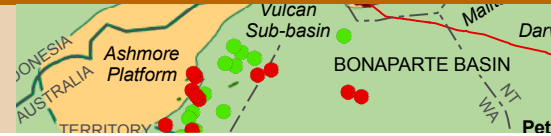


# New opportunities for offshore petroleum exploration

*2009 acreage release includes deep water frontiers*

Thomas Bernecker



The Australian Government formally releases new offshore exploration areas during the annual Australian Petroleum Production and Exploration Association (APPEA) conference. The 2009 release of offshore petroleum exploration areas was announced on 1 June in Darwin by the Hon Martin Ferguson AM MP, Minister for Resources and Energy.

This year, 31 areas plus two special areas in five offshore basins were released for work program bidding. Closing dates for bid

submissions are either six or twelve months after the release date, that is, 3 December 2009 or 29 April 2010 depending on the exploration status in these areas and on data availability. The 2009 Release Areas are

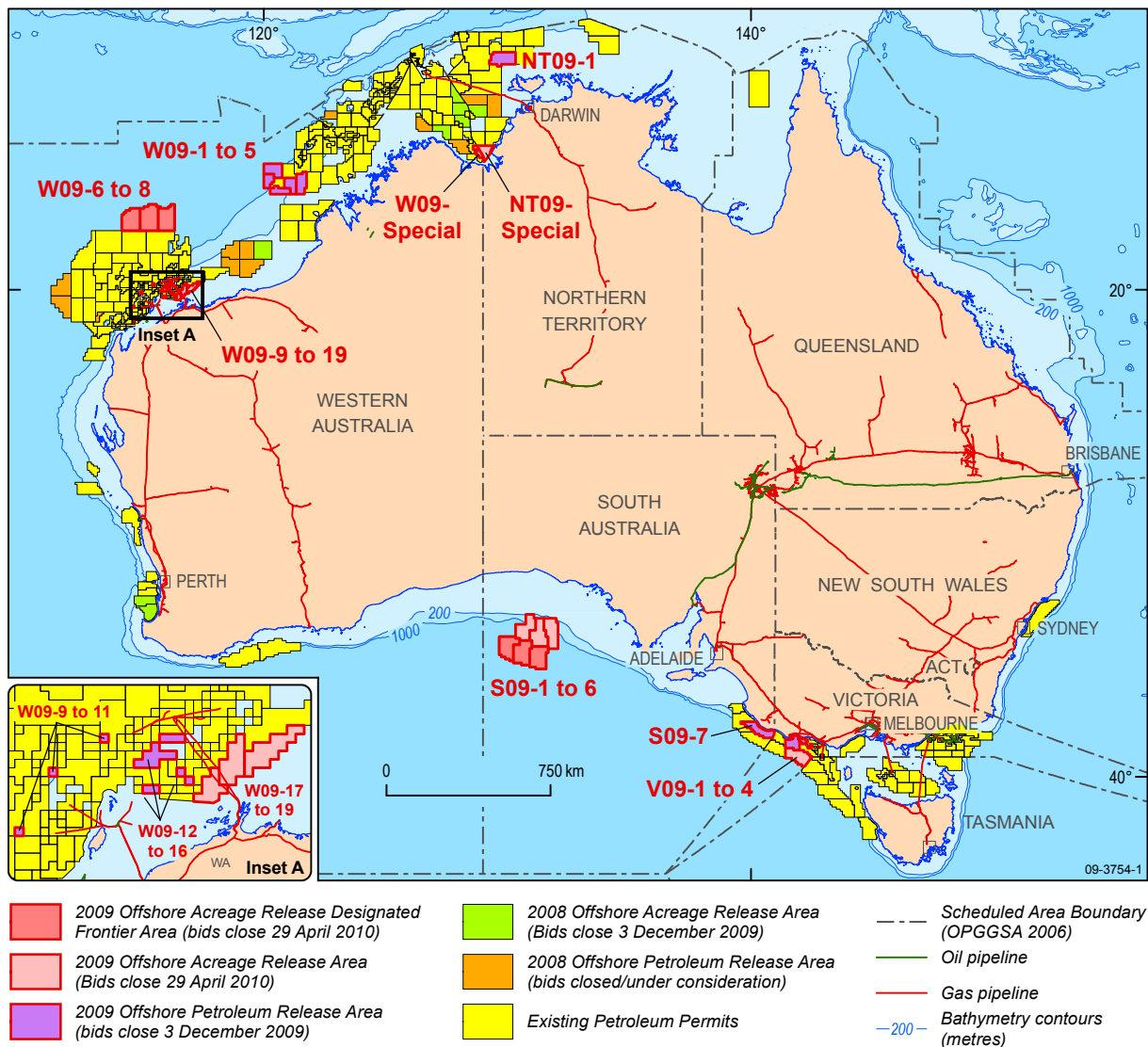


Figure 1. Location map of the 2009 Offshore Petroleum Acreage Release Areas.

located in Commonwealth waters off the Northern Territory, Western Australia, South Australia and Victoria, and comprise intensively explored areas close to existing production, as well as new frontiers (figure 1). The North West Shelf features very prominently with release areas in the Bonaparte, Browse and Carnarvon basins. These are complemented by new areas along the southern margin, including frontier exploration areas in the Ceduna Sub-basin (Bight Basin) and the Otway Basin.

## Bonaparte Basin

The Bonaparte Basin lies on Australia's northwest continental margin and contains up to 15 000 metres of Phanerozoic marine and fluvial siliciclastics and marine carbonates. The basin is structurally subdivided into several Paleozoic and Mesozoic sub-basins and platform areas which host a number of proven petroleum systems for both oil and gas. This year, one Release Area is being offered within the Malita Graben.

Release Area NT09-1 is located on the northern margin of the Malita Graben, about 220 kilometres northwest of Darwin and 40 kilometres south of the Evans Shoal gas field (figure 2). It is close to the Darwin operations base and the Wickham Point LNG plant that is supplied by the Bayu–Undan gas pipeline. Water depths across the block range from 10 to 170 metres. The Malita Graben contains up to 10 000 metres of post-Paleozoic sediments as a result of high subsidence rates.

Release Area NT09-1 is highly prospective for gas as indicated by commercial accumulations immediately to the north and west of the block. It appears less likely that liquid hydrocarbons are present due to the dominant gas-prone source interval and the high geothermal gradients that have been recorded in the Malita Graben.



**Figure 2.** Structural elements map of the Bonaparte Basin showing location of the 2009 Release and Special Release Areas.

## Special Release, Petrel Sub-basin, Bonaparte Basin

The 2009 Special Offshore Acreage Release comprises two areas that are being offered to focus industry's attention on the former Turtle and Barnett Retention Leases which have oil accumulations. This Special Release complements the remainder of the 2009 release by making available areas with a full range of water

depths and prospectivity, from rank frontier to mature basins with known discoveries.

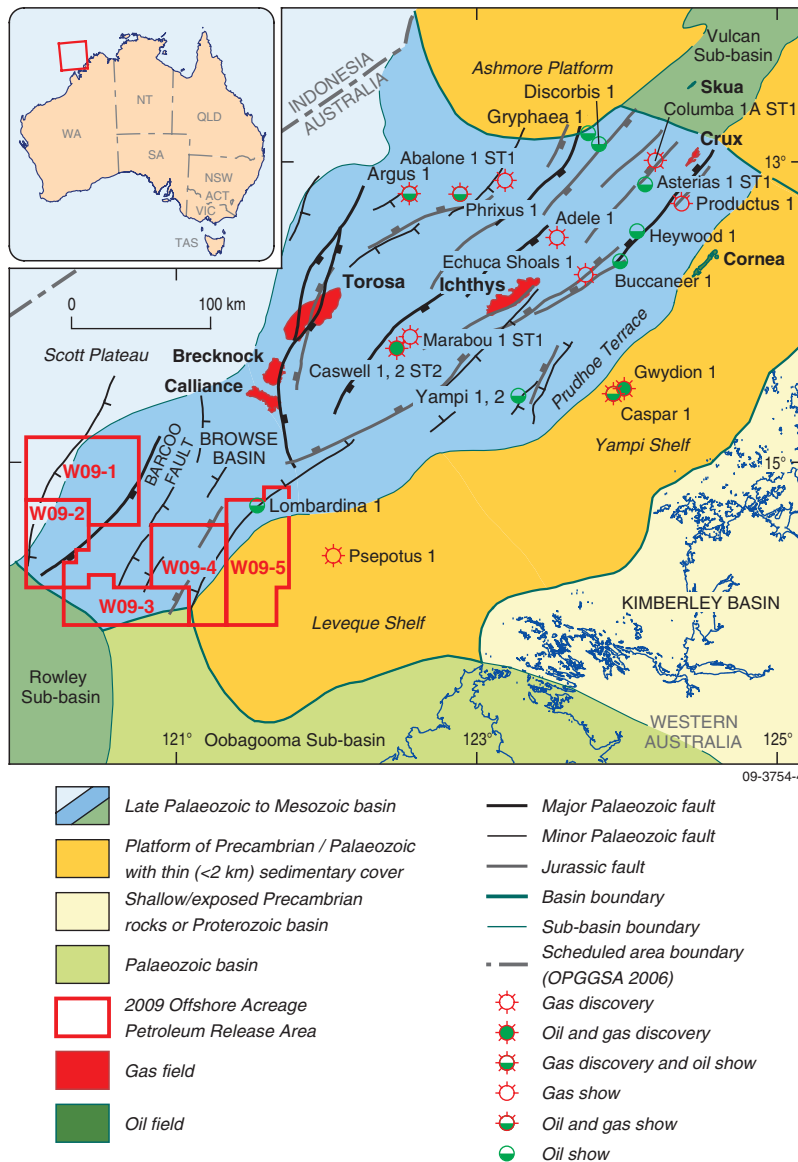
Release Areas NT09-Special and W09-Special are located in the Joseph Bonaparte Gulf, about 400 kilometres southwest of Darwin. The Release Areas are about 35 kilometres southeast of the Blacktip gas accumulation (figure 2). Following development drilling, gas will be piped to Darwin via the onshore gas plant near Wadeye and the Bonaparte trans-territory pipeline. This pipeline connects to the existing pipeline transporting gas from the Amadeus Basin to Darwin.

### Petrel Sub-Basin

The Petrel Sub-basin in the southern Bonaparte Basin is an asymmetric, northwest-trending Paleozoic rift that contains a succession of thick

Paleozoic and thinner Mesozoic sediments. The late Paleozoic–Mesozoic section exceeds 15 000 metres in thickness in the central and northern Petrel Sub-basin.

A variety of exploration plays exist in the southern Petrel Sub-basin, including structural and stratigraphic plays targeting both sandstone and carbonate reservoirs at numerous stratigraphic levels. The Middle-Late Triassic Fitzroy Movement is responsible for creating large-scale inversion anticlines (commonly associated with salt mobilisation), such as those drilled in the Petrel and Tern gas accumulations. Numerous potential structural and stratigraphic hydrocarbon traps were generated as the result of salt tectonics. Salt movement may have triggered petroleum migration and influenced migration pathways throughout the development of the Petrel Sub-basin.



**Figure 3.** Regional geological setting of the Browse Basin (after Struckmeyer et al, 1998), showing key discoveries.

### Browse Basin

The Browse Basin is a northeast-trending, Paleozoic to Cenozoic depocentre situated entirely offshore in the Timor Sea region of Australia's North West Shelf. The basin hosts vast commercial, but as yet undeveloped, reserves of gas and condensate, the majority of which are contained in six gas fields: Torosa, Brecknock, Brecknock South (Calliance), Ichthys, Crux and Argus. Five areas (W09-1 to

W09-5) are being released in the southern part of the basin. They overlie the Barcoo Sub-basin and adjacent portions of the Leveque Shelf and Scott Plateau (figure 3).

Given the under-explored status of the southern Browse Basin, potential plays remain untested. These include Carboniferous to Permian extensional half-graben, Late Triassic tilted fault blocks and associated anticlines, stratigraphic traps related to Early Cretaceous onlap and erosional truncation, as well as traps generated during Miocene fault re-activation. The main exploration risk is access to unproven oil-mature source rocks. The oil accumulations that have been discovered in the Browse Basin are sourced from the Early Cretaceous Echuca Shoals Formation in the Caswell Sub-basin, but this succession is immature to marginally mature in the Barcoo Sub-basin. Evidence of gas at Arquebus-1ST1 and Psepotus-1, however, suggests that source, maturity and relative migration/trap timing are not critical risks for gas prospectivity in the Barcoo Sub-basin and the adjacent Leveque Shelf.

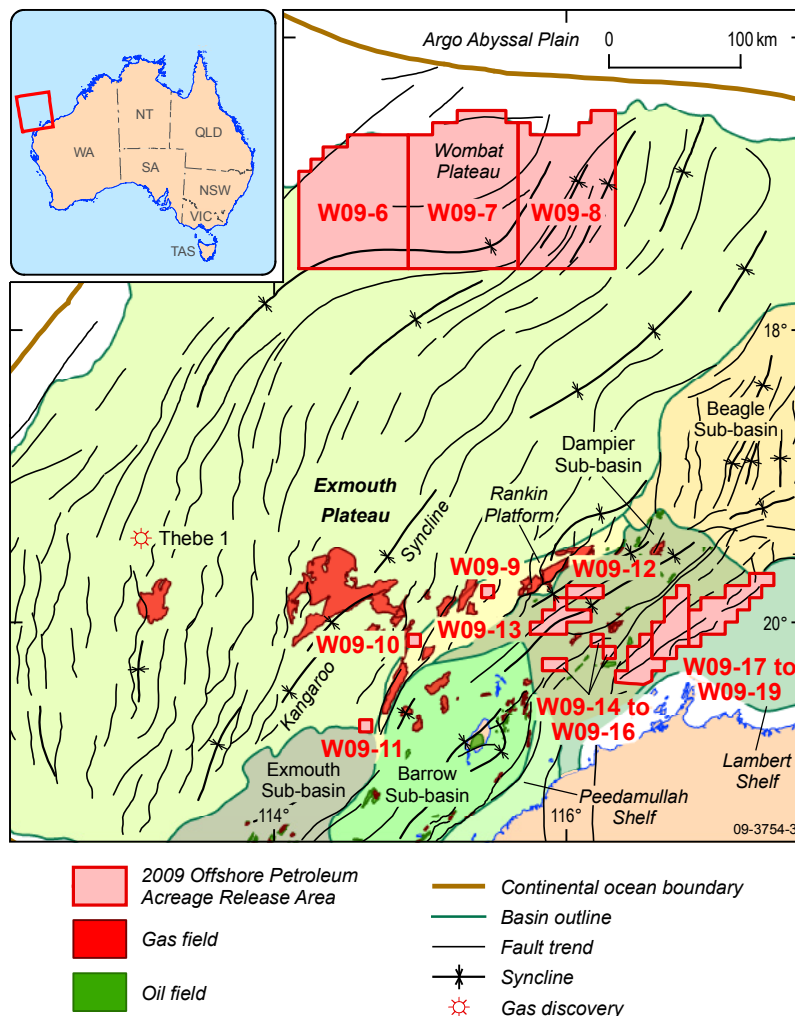
## Carnarvon Basin

The Carnarvon Basin is the southernmost province of the Late Paleozoic to Cenozoic Westralian Superbasin that underlies the northwestern continental margin of Australia from the Exmouth Plateau in the south to the Arafura Sea in the north. The northern offshore Carnarvon Basin contains about 15 000 metres of mainly Mesozoic sediments that host a world class gas and oil province and is Australia's premier hydrocarbon province. The 2009 Acreage Release Areas (figure 4) are located on the Northern Exmouth Plateau (three areas), on the Rankin Platform (three areas) and in the Dampier Sub-basin (eight areas).

### Northern Exmouth Plateau

The Exmouth Plateau is the deepwater frontier of the Carnarvon Basin, and is home to several giant gas accumulations (such as Jansz, Scarborough, Thebe). It is an area of active exploration with several recent significant gas discoveries including Martell-1, drilled earlier this year.

The three Release Areas (W09-6 to W09-8) are considered deep-water frontiers (figure 4) and were nominated for the status of Designated Frontier Area (DFA). Parts of Release Areas W09-6 and W09-7 are located within the



**Figure 4.** Structural elements of the Northern Carnarvon Basin showing the 2009 Release Areas (after Stagget et al, 2004).

newly defined outer limit of Australia's continental shelf, confirmed by the United Nations Commission on the Limits of the Continental Shelf (Geoscience Australia 2008). Water depths range from 2000 metres to over 4000 metres in the Montebello Canyon. Well control in this part of the basin is limited to four stratigraphic holes (ODP 759, 760, 761 and 764) drilled in 1988 on the Wombat Plateau which intersected Late Triassic carbonates of possible reef facies and underlying Norian coal measures.

The super-giant Io/Jansz gas field, the giant Scarborough gas field and the gas discovery in the Jupiter-1 well, along with the recent gas discoveries in the Chandon-1, Thebe-1,-2 and Martell-1 wells, demonstrate that the deepwater Exmouth Plateau is prospective for large gas discoveries. The extension of this gas potential to the northern margin of the Exmouth Plateau is yet to be demonstrated. However, several of the key elements, such as source and reservoir facies, that combine to produce successful petroleum systems further south probably also occur in the region of the three Release Areas.

These three deep water frontier areas offer opportunities for innovative exploration as well as access to DFA conditions. The key unknown aspect in this frontier is the presence of mature source rocks; but, if appropriate source rock intervals can be identified, all areas would be capable of hosting hydrocarbon accumulations.

## “The 2009 Release Areas ... comprise intensively explored areas close to existing production as well as new frontiers.”

### ***Rankin Platform***

The Rankin Platform is a structurally high area that flanks the western edge of the Dampier Sub-basin and the Exmouth Plateau (figure 4). It consists of tilted Triassic fault-blocks that contain the supergiant Goodwyn and North Rankin gas/condensate accumulations, as well as many other smaller fields. The Release Areas (W09-9 to W09-11) are three separate, individual graticular blocks located along the Rankin Platform. Although no wells have been drilled in any of these areas, they are considered highly prospective because of their close proximity to existing fields and successful exploration wells.

Proven exploration plays on the Rankin Platform include Triassic, Jurassic and Early Cretaceous targets. Two proven petroleum systems are recognised in the Release Areas. Areas W09-9 and W09-10 are

located within the heart of the Rankin Platform, where giant gas fields in Triassic and Early Jurassic sandstones are charged from deltaic Triassic to Middle Jurassic source rocks and sealed by Early Cretaceous shales. Release Area W09-11 is located at the southern end of the Rankin Platform and, in addition to the Triassic-dominated system, also has access to the Late Jurassic oil-prone system in the Barrow and Exmouth sub-basins. Early Cretaceous Barrow Group sandstones, as well as the Late Triassic Mungaroo Formation and the Early Jurassic Brigadier Formation, represent viable reservoirs.

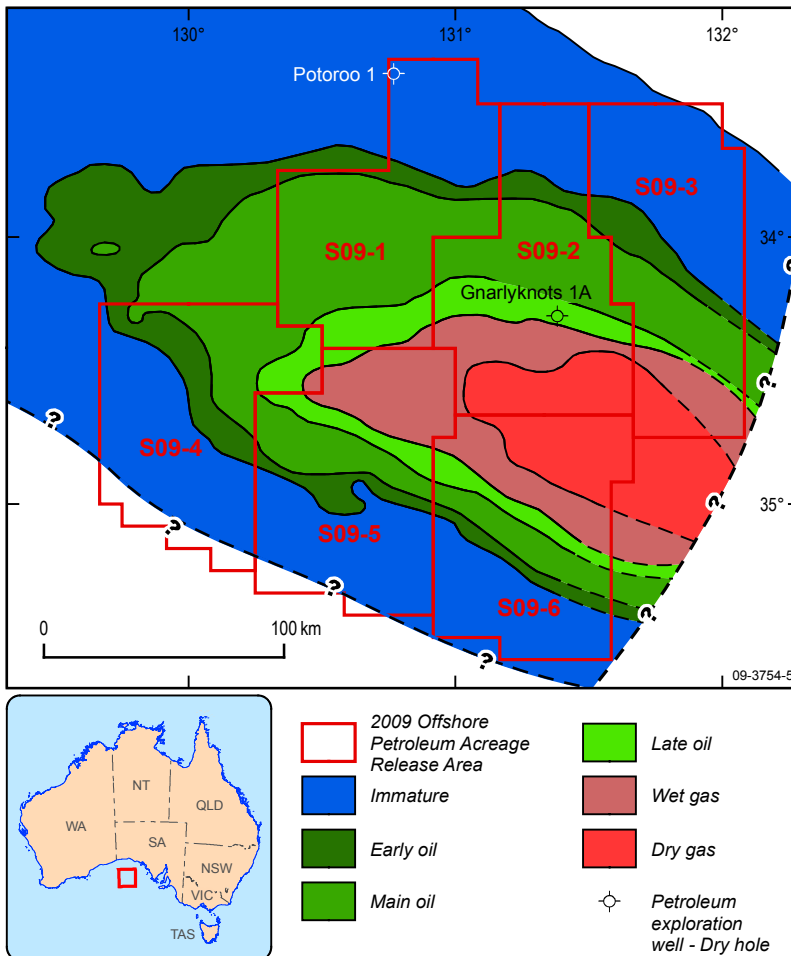
The proven traditional Triassic fault block play, which hosts most of the hydrocarbon reserves in the Carnarvon Basin, has the potential to extend onto the Rankin Platform. Gas charge in Triassic, Early Cretaceous and Paleocene reservoirs has a seismic expression which has been successfully used to guide exploration and development in the region surrounding the Release Areas. It appears that gas charge is pervasive throughout the region of the three Release Areas; in addition, there is some evidence of an oil charge. Exploration risks include trap geometries, reservoir facies distribution and relative location to migration pathways.

### Dampier Sub-Basin

The Dampier Sub-basin is an elongate northeast trending depocentre within the Northern Carnarvon Basin and contains over 10 000 metres of Paleozoic to Cenozoic sediments. The sub-basin is bound to the southeast by the Lambert Shelf and to the northwest by the Rankin Platform (figure 4) and hosts commercial oil and gas fields with hydrocarbon accumulations at multiple stratigraphic levels from the Triassic to the Cretaceous. The eight Release Areas are on structured flanks either side of the proven hydrocarbon kitchen to the west of the producing Wandoo and Stag oil fields.

Hydrocarbon plays in the central Dampier Sub-basin are related to Late Jurassic low-relief, oil-filled, drape structures that overlie gas-bearing horsts generated during Late Triassic to Early Jurassic rifting (such as Wanaea, Cossack, Mutineer, Egret). Seismic data suggests that this play may extend to Release Areas W09-12 and W09-13. The eastern flank of the Dampier Sub-basin contains a variety of play types along the Legendre Trend, with the principal types being Angel Formation sands sealed by Forestier Claystone, and Legendre

Formation overlain by Calypso Formation mudstones. Trap styles include Early Cretaceous low-side rollovers (Legendre) and faulted horsts (Talisman) and Middle Jurassic faulted anticlines (Reindeer gas field). These play types are relevant to Release Areas W09-14, W09-15 and W09-16. Fields on the Enderby Terrace are Early Cretaceous drape anticlines (Wandoo) and combination drape and onlap traps (Stag). Similar plays can be expected in Release Areas W09-17, W09-18 and W09-19, though in these basin margin locations, risks increase with longer migration pathways and thinning seal-units.



**Figure 5.** Present-day maturity map for Cenomanian-Turonian marine shale at the base of the Tiger Supersequence.

### Bight Basin

The Jurassic–Cretaceous Bight Basin is a large, mainly offshore basin situated along the western and central parts of the continental margin of southern Australia in water depths of less than 200 metres to over 4000 metres. The basin contains five main depocentres—the Ceduna, Duntroon, Eyre, Bremer and Recherche sub-basins.

### Ceduna Sub-Basin

The Ceduna Sub-basin is in the eastern part of the Bight Basin and contains up to 15 kilometres of Middle Jurassic to latest Cretaceous rocks. The Ceduna Sub-basin has been the focus of the most recent exploration effort which, for a number of reasons, has not met with success.

The six new Release Areas being offered in 2009 are located in the northern central part of the sub-basin (figure 1). The six blocks range in size from 6000 to 6400 square kilometres. The three inboard blocks (Release Areas S09-1 to 3) are in water depths of 130 to 1600 metres. The three outer blocks (Release Areas S09-4 to 6) are in water depths from 1200 to 4600 metres and are nominated for DFA status. Geoscience Australia has recently acquired new biostratigraphic and geochemical data for the Ceduna Sub-basin which have been interpreted and integrated with existing datasets to reassess the hydrocarbon prospectivity of this large offshore frontier (Totterdell et al 2008).

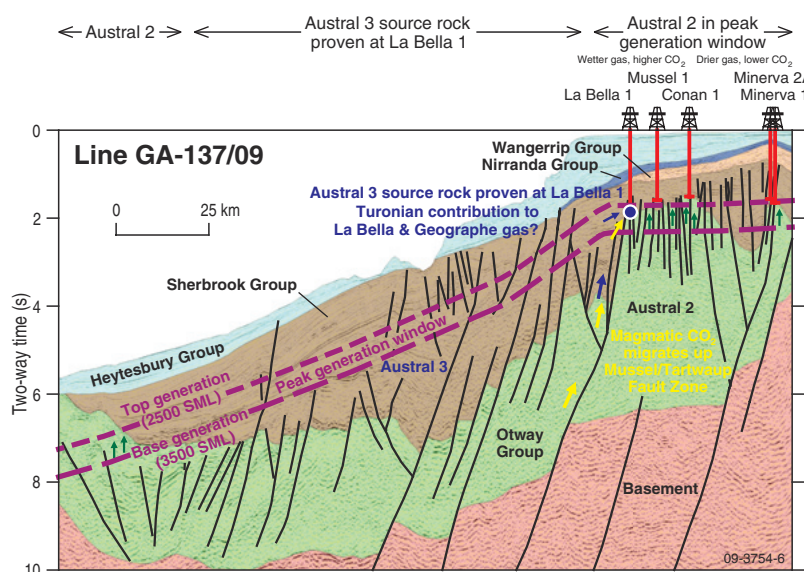
One of the key uncertainties identified prior to the most recent exploration phase was the possible lack of an effective source rock and thus adequate hydrocarbon charge. This uncertainty has been significantly reduced by the sampling and identification of a high quality marine source rock of Cenomanian to Turonian age as part of the southern offshore frontier study. The results of that work demonstrate the presence of a world-class hydrocarbon source rock of Turonian age which, according to petroleum systems modelling, is mature for oil and gas generation across much of the Ceduna Sub-basin (figure 5) and is capable of generating commercial quantities of liquid hydrocarbons.

Another concern is the presence of an effective seal, as evidenced by the high net to gross ratio encountered in the unsuccessful well Gnarlyknots-1A. However, seismic facies mapping suggests that pro-deltaic shales are likely to exist at various levels within

the Cenomanian–Turonian section. The majority of plays are structural and, as such, are dependent on cross fault seal. In the outboard basin this is probably less of a risk, because of the very likely presence of thick basinal shales in the Turonian-Santonian Tiger Supersequence, and outer shelf to slope fine-grained sediments within the lower part of the Santonian-Maastrichtian Hammerhead Supersequence.

## 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. It belongs to a series of depocentres, including the Bight, Poldia, Otway, Sorell, Bass and Gippsland basins, which were formed during Gondwana break-up and the Antarctic-Australian separation. The Otway Basin is filled with Late Jurassic to recent 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 2009 Release Areas are located in the Western Otway Basin, offshore South Australia (S09-7) and in the Central Otway Basin, offshore Victoria



**Figure 6.** Hydrocarbon migration model for Austral 2 and Austral 3 petroleum systems (after O'Brien et al, 2009).



(V09-1 to V09-4). Of these five areas, four lie within shallow waters on the continental shelf, while area V09-4 is located in deep water over the continental slope (figure 1). All areas are proximal to existing infrastructure and growing energy markets.

Previous studies by Geoscience Australia (Edwards et al 1999) have identified three petroleum systems (Austral 1, 2 and 3) in the Otway Basin, of which Austral 1 is known to have produced hydrocarbons, including liquids, in the onshore part of the basin, while Austral 2 has produced most of the commercial gas accumulations. To date, the Austral 3 petroleum system is only recognised in a few onshore wells that have recorded gas shows in Late Cretaceous and Paleocene reservoir sandstones, but a source rock of that system has been identified in the offshore La Bella gas discovery (figure 6).

Although only a few exploration wells have been drilled in S09-7, the prospectivity of this area is largely similar to the three inboard blocks off Victoria (V09-1 to V09-3), where the Austral 2 petroleum system is accessible and known to be mature (figure 6). However, fault seal integrity and variable reservoir quality are the main uncertainties. In the deep-water area (V09-4), Early Cretaceous source rocks of the Austral 2 petroleum system are likely to be overmature. Therefore, source intervals within the Late Cretaceous section (Austral 3 petroleum system) are expected to occur within the maturity window and would have potential for hydrocarbon generation. Very little is known about the reservoir qualities of Late Cretaceous and Early Paleogene in the deep-water areas, and therefore require the testing of such exploration plays.

## Summary

In summary, the 2009 Offshore Acreage Release offers a wide variety of block sizes in shallow as well as deep water environments. Area selection has been undertaken in consultation with industry, the states and the Northern Territory. This year's Acreage Release caters for the whole gamut of exploration companies given that many areas are close to existing infrastructure while others are located in frontier offshore regions.

### For more information

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**To book into the 2009 Acreage Release Data Room**

**visit** [www.ga.gov.au/about-us/facilities/acreage-release-data-room.jsp](http://www.ga.gov.au/about-us/facilities/acreage-release-data-room.jsp)

## References

Edwards DS, Struckmeyer HIM, Bradshaw MT & Skinner JE. 1999. Geochemical characteristics of Australia's Southern Margin petroleum systems. *The APPEA Journal* 39: 297–321.

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O'Brien GW, Boreham CJ, Thomas HJ and Tingate P. In press 2009. Understanding the critical success factors determining prospectivity, Otway Basin, Victoria. *The APPEA Journal*, 49.

Totterdell JM, Struckmeyer HIM, Boreham CJ, Mitchell CH, Monteil E and Bradshaw BE. 2008. Mid–Late Cretaceous organic-rich rocks from the eastern Bight Basin: implications for prospectivity. In: Blevin JE, Bradshaw BE and Uruski C (eds). *Eastern Australasian Basins Symposium III*, Petroleum Exploration Society of Australia, Special Publication, 137–158.

## Related websites/links

2009 offshore petroleum exploration areas (Department of Resources, Energy and Tourism)

[www.ret.gov.au/resources/upstream\\_petroleum/offshore\\_petroleum\\_exploration\\_in\\_australia/Pages/offshorePetroleumExplorationinAustralia.aspx](http://www.ret.gov.au/resources/upstream_petroleum/offshore_petroleum_exploration_in_australia/Pages/offshorePetroleumExplorationinAustralia.aspx)

Data supporting the 2009 acreage release (Seismic data is available in GeoFrame™, Kingdom and Landmark™ formats)

[ausgeodata@ga.gov.au](mailto:ausgeodata@ga.gov.au)