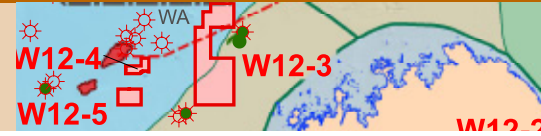


New opportunities for offshore petroleum exploration

2012 Acreage Release areas include Australia's southern margin

Thomas Bernecker and Jennifer Totterdell



The Australian Government formally released new offshore petroleum exploration areas at the annual APPEA conference on 14 May 2012. The Federal Minister for Resources and Energy, the Hon. Martin Ferguson AM MP, released 27 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, 8 November 2012 and 9 May 2013 respectively, depending on the exploration status of these areas and on data availability.

As was the case last year, the 2012 Release covers approximately 200 000 square kilometres including large areas in offshore frontiers. The 27 areas are located in Commonwealth waters offshore Northern Territory, Western Australia, South Australia, Victoria and Tasmania (figure 1). This year the usual strong representation of new release areas offshore Northern Territory and Western Australia is well balanced with nine areas along Australia's southern margin in the Bight, Otway, Sorell and Gippsland basins. Following the award of four permits in the Ceduna Sub-basin (Bight Basin) to BP in January 2011, additional exploration opportunities are on offer with three more areas being released this year. A mix of shallow water areas close to existing hydrocarbon production and deep water under-explored areas are available in the Otway, Sorell and Gippsland basins.

Multiple industry nominations for this Acreage Release were received, confirming the healthy status of petroleum exploration activity in Commonwealth waters. The Australian Government continues to support these activities by providing free access to a wealth of geological and geophysical data which are made available through Geoscience Australia.

Arafura Basin and Money Shoal Basin

Release Areas NT12-1 and NT12-2 are located about 240 kilometres northeast of Darwin on the continental shelf where depths range from 50 metres to 390 metres. Both areas cover part of the Mesozoic to Cenozoic Money Shoal Basin and the underlying Neoproterozoic to Permian Arafura Basin (figure 2). The western part of Release Area NT12-2 covers part of the Calder Graben of the Mesozoic to Cenozoic Bonaparte Basin. The Release Areas are located to the east of the Evans Shoal, Caldita and Barossa-Lynedoch gas accumulations in

Australian waters and the Abadi gas accumulation in Indonesian waters.

Although commercial discoveries have not been made in either the Money Shoal or Arafura basins, there are numerous hydrocarbon shows and indications in wells drilled in the Goulburn Graben (figure 2). A review of available geological data (Struckmeyer 2006), together with the results 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 elements for petroleum systems to generate, expel and trap hydrocarbons, but also evidence that generation and expulsion has occurred.

Petrel Sub-basin, Bonaparte Basin

Release Areas W12-1, W12-2 and NT12-3 are located in shallow water (10 to 125 metres) between 10 and 100 kilometres offshore northwestern Australia (figure 2). The Release Areas are located adjacent to current offshore petroleum exploration permits and overlie the offshore Petrel Sub-basin, a Paleozoic depocentre of the Bonaparte Basin. The

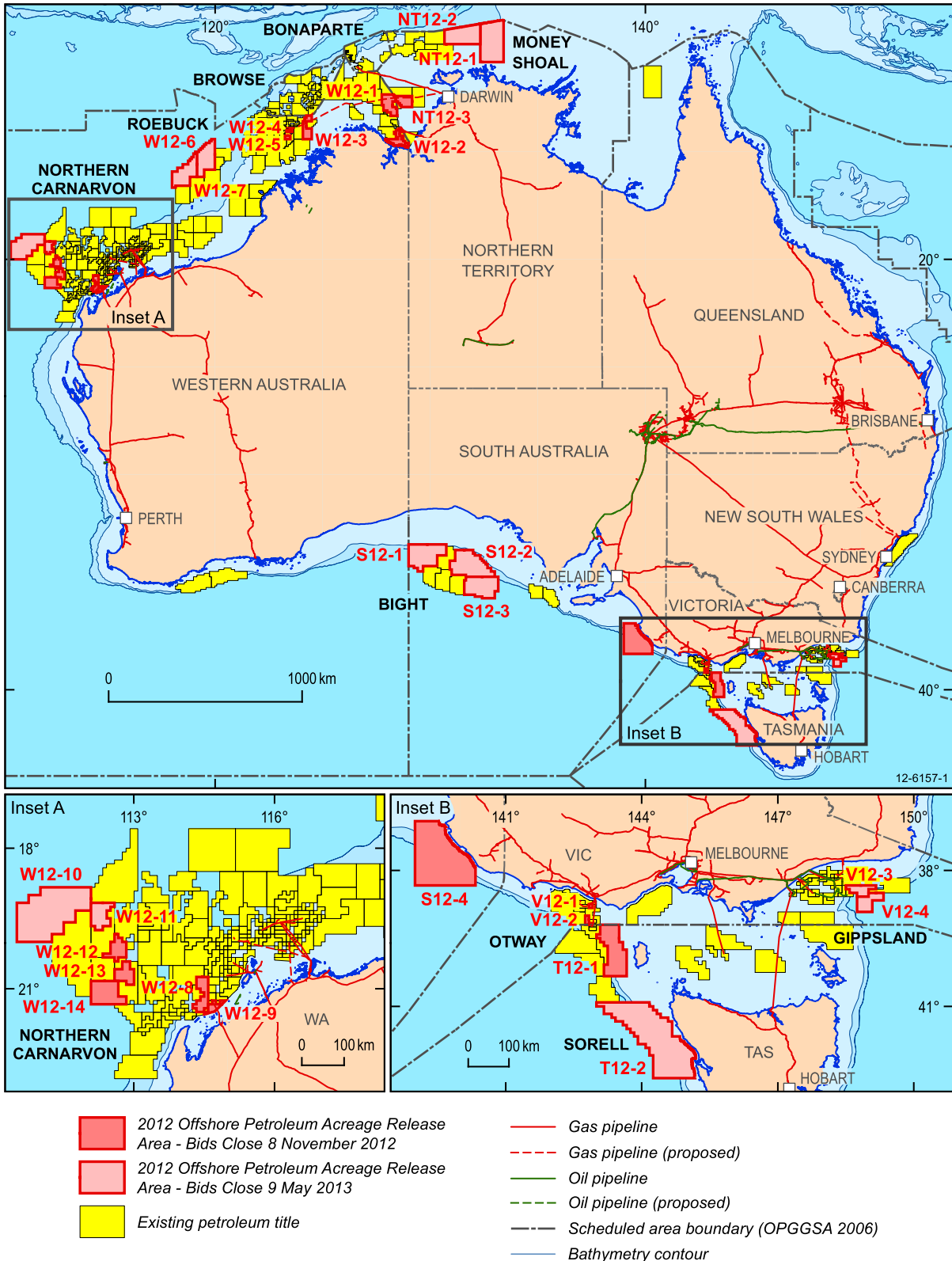


Figure 1. Location map showing the 2012 Offshore Petroleum Acreage Release Areas.

Release Areas are close to the Petrel, Tern, Frigate and Blacktip gas fields. Area W12-2 contains six exploration wells, while Release Areas W12-1 and NT12-3 do not contain any wells.

The most prospective reservoirs within the central Petrel Sub-basin, and Release

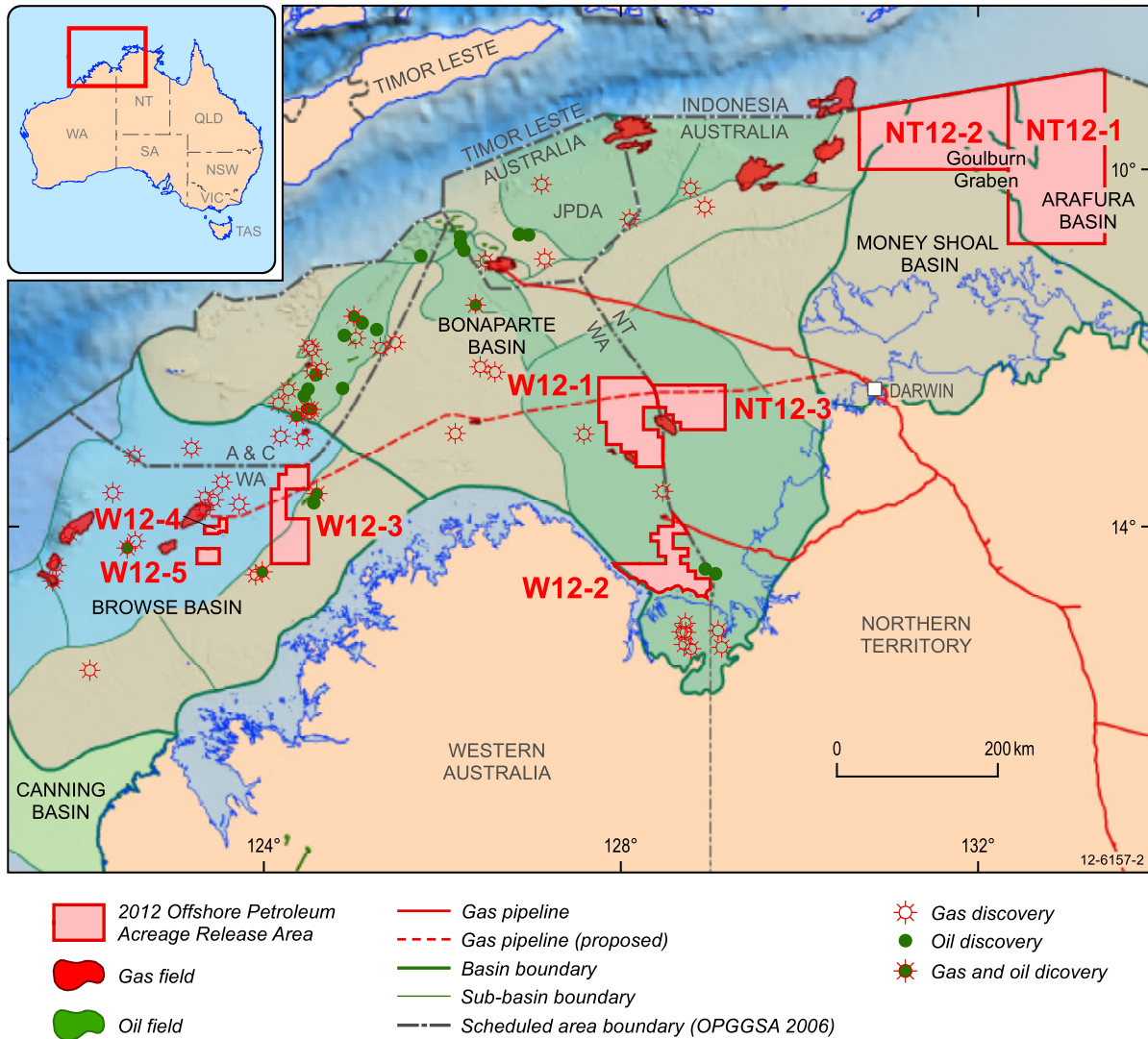


Figure 2. Tectonic elements map of the Browse Basin, Bonaparte Basin and Money Shoal Basin region showing location of the 2012 Release Areas and petroleum accumulations.

Areas W12-1 and NT12-3, are the upper Permian Cape Hay and Tern formations, as exemplified by the gas reservoirs at Petrel and Tern, and the Torrens Formation, which hosts the gas discovery at Penguin 1 (Polkadot 1). In addition, the Penguin Formation is an important reservoir for gas in Fishburn 1. The most prospective reservoirs within the offshore southern Petrel Sub-basin, and for Release Area W12-2, are the Permian Keyling and Treachery formations, the Permo-Carboniferous Kuriyippi Formation, and the Carboniferous Tanmurra Formation, Kingfisher Shale and Yow Creek Formation. These reservoirs host oil accumulations at Barnett and Turtle. Gas at Blacktip 1 is reservoired in sandstones of the Ascalon, Fossil Head, Keyling, Quoin and Treachery formations (Gorter et al 2008). Numerous hydrocarbon traps were created by salt tectonics and related features such as diapirism have been identified across most of the sub-basin.

Caswell Sub-basin, Browse Basin

The Browse Basin is one of Australia's richest offshore hydrocarbon provinces. The Caswell Sub-basin is the major depocentre of the Browse Basin (figure 3) and contains up to 15 kilometres of Paleozoic to Cenozoic sediments. Release Area W12-3 is located on the Prudhoe Terrace and Yampi Shelf, 90 to 120 kilometres off the northwest coast of Western Australia, and

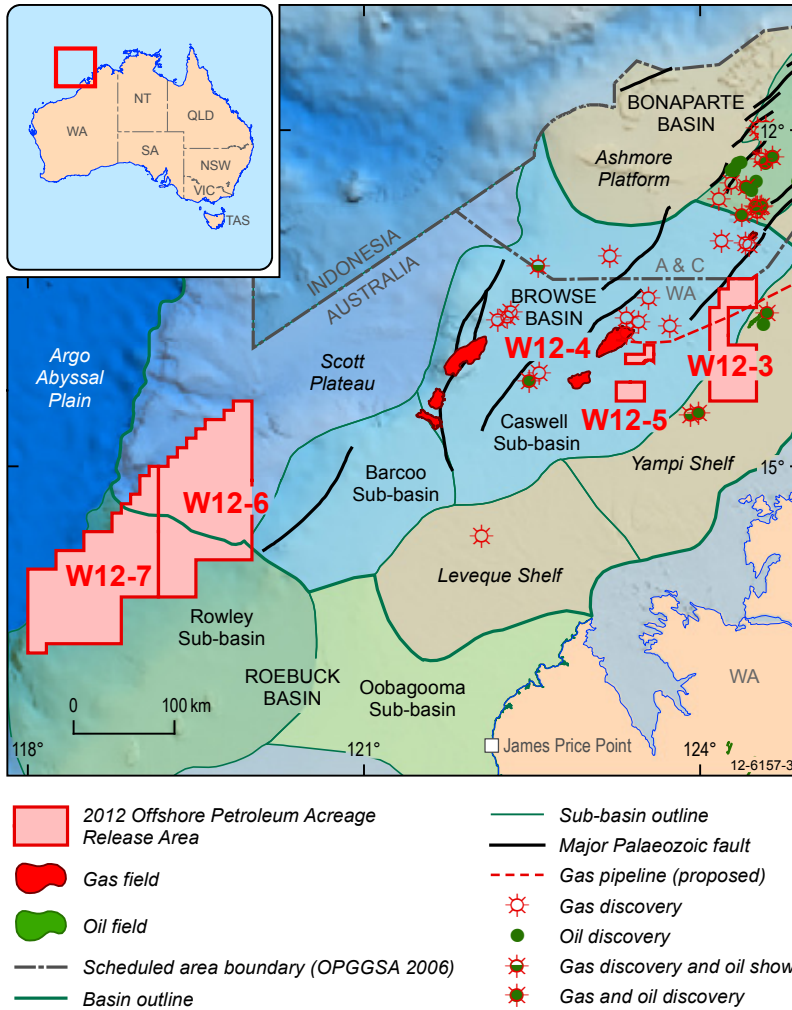


Figure 3. Tectonic elements map of the Browse Basin and Roebuck Basin region showing location of the 2012 Release Areas and petroleum accumulations.

water depths vary between 70 and 150 metres. Release Areas W12-4 and W12-5 are located on the Prudhoe Terrace in water depths ranging from 100 to 250 metres.

The Release Areas in the Caswell Sub-basin have access to oil- and gas-prone petroleum systems. Most of the oil-prone source potential is associated with transgressive marine shale sequences of the Upper Jurassic–Lower Cretaceous Vulcan and Echuca Shoals formations. The more gas-prone source potential is associated with fluvio-deltaic shales of the Lower–Middle Jurassic Plover Formation. Source rocks in and near Release Areas W12-3, W12-4 and W12-5 exist at multiple stratigraphic levels within the Plover Formation, the lower and upper Vulcan formations, the Echuca Shoals Formation and the lower and upper Jamieson formations (Blevin et al 1998a, 1998b; Kennard et al 2004).

Of the numerous gas fields discovered within the basin, four separate developments are currently proposed: the Prelude Floating

Liquefied Natural Gas (FLNG) Development, the Ichthys Project, the Browse Liquefied Natural Gas (LNG) Development (encompassing the Torosa, Brecknock and Calliance fields) and the Crux Liquids Project.

Scott Plateau, Browse Basin and Rowley Sub-Basin, Roebuck Basin

Release Areas W12-6 and W12-7 are located over the outer, deep-water Scott Plateau in the Browse Basin, and the Rowley Sub-basin in the Roebuck Basin (figure 3). This under-explored part of the North West Shelf lies to the southwest of the Torosa, Brecknock and Calliance gas fields in the Browse Basin, and northeast of the established oil and gas fields and production infrastructure of the Northern Carnarvon Basin. Release Area W12-6 is mostly located in water depths of 1400 to 2600 metres, deepening to 4000 metres along the northwestern edge of the Scott Plateau (figure 3). The southeastern part of Release Area W12-7 lies in water depths of 1600 to 3000 metres. The western part of this Release Area is located over the Argo Abyssal Plain in water depths exceeding 5000 metres (figure 3).

The presence of active petroleum systems within Release Areas W12-6 and W12-7 is difficult to confirm given the lack of well control. However, available knowledge about the adjoining Barcoo Sub-basin of the Browse Basin and the Rowley Sub-basin of

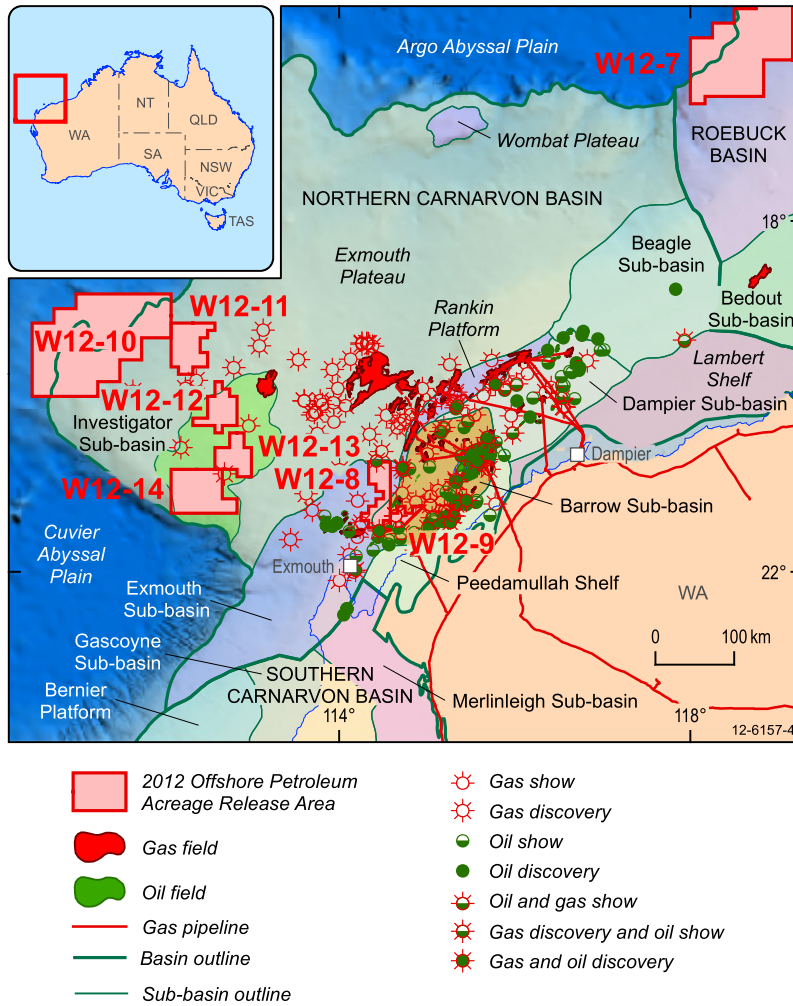


Figure 4. Tectonic elements of the Northern Carnarvon Basin and adjacent basins showing the 2012 Release Areas, oil and gas accumulations and selected wells.

the Roebuck Basin may provide some valuable information. Lower–Middle Jurassic source rocks are likely to occur within the Plover Formation and were deposited under syn-rift, paralic to shallow marine conditions (Hoffman and Hill 2004).

The Triassic and Jurassic successions are the most likely to contain reservoir-quality sandstones including the sandy shoreline, shelf and fluvio-deltaic facies of the Triassic Keraudren Formation and Locker Shale in the Rowley Sub-basin. Equivalents of these in the Browse Basin and the Roebuck Basin are the Lower–Middle Jurassic fluvio-deltaic Plover Formation and the Lower–Middle Jurassic Depuch Formation respectively.

Barrow and Exmouth Sub-basins, Northern Carnarvon Basin

The Northern Carnarvon Basin, Australia’s premier hydrocarbon province, is the southernmost of the late Paleozoic to Cenozoic basins

that underlie the northwestern continental margin of Australia. The sedimentary fill of the Northern Carnarvon Basin is up to 15 000 metres thick and dominated by deltaic to marine siliciclastics and shelfal carbonates of Mesozoic to Cenozoic age.

Release Area W12-8 is located predominantly in the northern Exmouth Sub-basin (figure 4), the southernmost sub-basin in a series of Jurassic depocentres that form the Northern Carnarvon Basin. The southeastern portion of this Release Area extends onto the Alpha Arch in the southwestern petroliferous Barrow Sub-basin. Release Area W12-9 in the Barrow Sub-basin is located approximately 45 to 60 kilometres offshore from production facilities at Onslow. Both Release Areas are located close to numerous oil and gas fields including the Vincent/ Van Gogh oil field, the Macedon gas accumulation (planned for domestic gas production from 2013), the Chinook/Scindian oil and gas field; and the Corowa and Griffin oil fields.

Exmouth Plateau, Northern Carnarvon Basin

Release Areas W12-10 to W12-14 are located on the Exmouth Plateau, a deep-water marginal plateau of the Northern Carnarvon Basin (figure 4). The plateau hosts numerous giant to supergiant gas fields, and has recently become Australia’s premier deep-water gas exploration province.

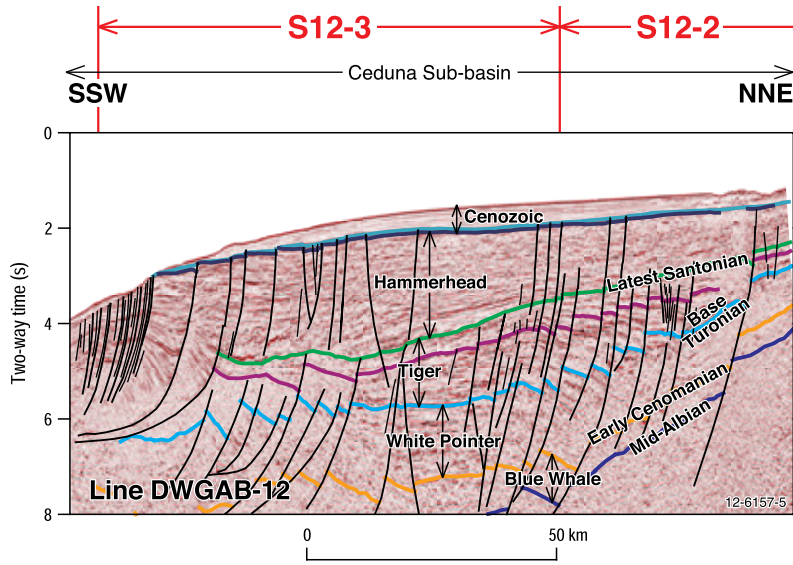


Figure 5. Seismic section across Ceduna Sub-basin showing the main depositional sequences.

The supergiant Io/Jansz gas field, giant Scarborough gas field, and the Jupiter 1 and Eendracht 1 gas discoveries, together with the recent gas discoveries in the Chandon 1, Thebe 1 and 2, Martin 1, Kentish Knock 1/Guardian 1, Brederode 1 and Alaric 1 wells, demonstrate that the deep-water Exmouth Plateau is prospective for large gas discoveries. All these discoveries are attributed to a widespread regional gas system sourced from the Triassic succession. 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 be occurring now at depths greater than five kilometres subsea (Bussell et al 2001).

A proven hydrocarbon system has been established across the Exmouth Plateau although the full extent of the system, particularly in the north and west, is yet to be determined. Continued exploration success on the Exmouth Plateau relies on the identification of additional valid traps with access to charge from the gas-prone Mungaroo source.

Ceduna Sub-basin, Bight Basin

Release Areas S12-1 to S12-3 (figure 1) are situated in the central Great Australian Bight, off southern Australia. The areas are located mostly within the frontier Ceduna Sub-basin, in the eastern part of the Bight Basin. The Release Areas are located adjacent to petroleum exploration permits EPP37–40 which were awarded to BP Exploration in January 2011.

The Ceduna Sub-basin contains a sedimentary section in excess of 15 kilometres thick. The key to the petroleum prospectivity of

the sub-basin is the distribution of the Upper Cretaceous marine and deltaic facies. Dredging of upper Cenomanian–Turonian organic-rich marine rocks has confirmed the presence of high quality potential source rocks in this section. These rocks are mature in the central part of the Ceduna Sub-basin and are likely to have generated and expelled hydrocarbons since the Campanian. Mature source rocks are also interpreted to be present within older Albian–Cenomanian marine deltaic sediments in the Sub-basin.

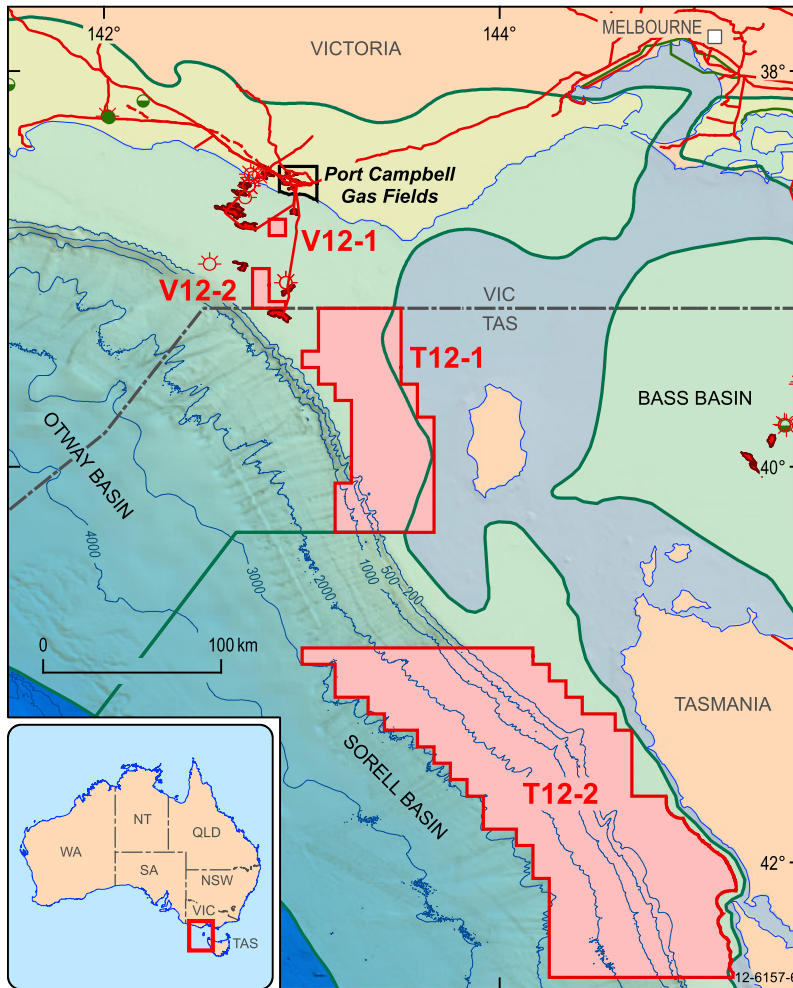
The primary reservoir units in the Ceduna Sub-basin are the deltaic and shallow marine sandstones of the upper Santonian to Maastrichtian Hammerhead Supersequence delta. Seismic facies studies of the Hammerhead Supersequence delta (Krassay and Totterdell 2003; King and Mee 2004) indicate that alluvial and coastal plain facies occur in the inner to central part of the sub-basin (figure 5), while shelf deposits and turbiditic slope and basin floor sands are likely to occur in the central to outer part of the sub-basin.

One of the key risks identified prior to the most recent exploration phase was the possible lack of an effective source rock and thus adequate hydrocarbon charge (Somerville 2001). This risk has been significantly reduced by the sampling and identification of a high quality marine source rock of Cenomanian to Turonian age (Totterdell et al 2008; Totterdell and Mitchell 2009).

Otway Basin

The Otway Basin is a northwest-striking passive margin rift basin that extends from southeastern South Australia to its boundary with the Sorell Basin west of King Island. It belongs to a series of basins, including the Bight, Otway, Sorell, Bass and Gippsland basins, that were formed during the break-up of Gondwana and Antarctic-Australian separation. Four areas are included in this year's release: S12-4 in the western part of the Otway Basin offshore South Australia (figure 1), V12-1 and V12-2 in the eastern Otway Basin offshore Victoria, and T12-1 offshore western Tasmania (figure 6).

Release Area S12-4 extends from the shallow shelf into deeper water reaching water depths of around 3000 metres (figure 1).



- | | |
|--|---------------------------------------|
| 2012 Offshore Petroleum Acreage Release Area | Scheduled area boundary (OPGGSA 2006) |
| Gas field | Bathymetry contour (depth in metres) |
| Gas pipeline | Gas discovery |
| Gas pipeline (proposed) | Gas show |
| Oil pipeline | Oil show |
| | Oil discovery and gas show |

Figure 6. Simplified tectonic elements map of the eastern Otway and Sorell basins.

Previous sporadic exploration in the shallow water parts of the Release Area resulted in the discovery of an uneconomic gas accumulation at Troas 1 ST1, and the identification of numerous gas shows and one oil show, confirming the presence of at least two working petroleum systems. Release Area S12-4 contains nine wells but little exploration has been carried out in the outboard areas beyond the continental shelf; Morum 1, drilled in 277 metres of water, is the only well to have been drilled seaward of the continental shelf. Release Area S12-4 offers numerous opportunities to test existing and new play concepts, within both shelfal and deepwater areas.

Release Area V12-1 is located in the eastern Shipwreck Trough, southwest of the Minerva accumulation and east of Casino 1 (figure 6). Release Area V12-2 lies further to the southwest and overlies the western Shipwreck Trough and eastern Voluta Trough. Release Area T12-1 is located on the southern extension of the Prawn Platform to the southeast of the Shipwreck Trough, west of the King Island High.

Recent geochemical studies suggest two petroleum systems are accessible within the Release Areas. The Early Cretaceous Austral 2 petroleum system is a known gas producer in the eastern Otway Basin, while the Late Cretaceous Austral 3 petroleum system, based on potentially mature Turonian source rocks in the deeper water area, remains untested.

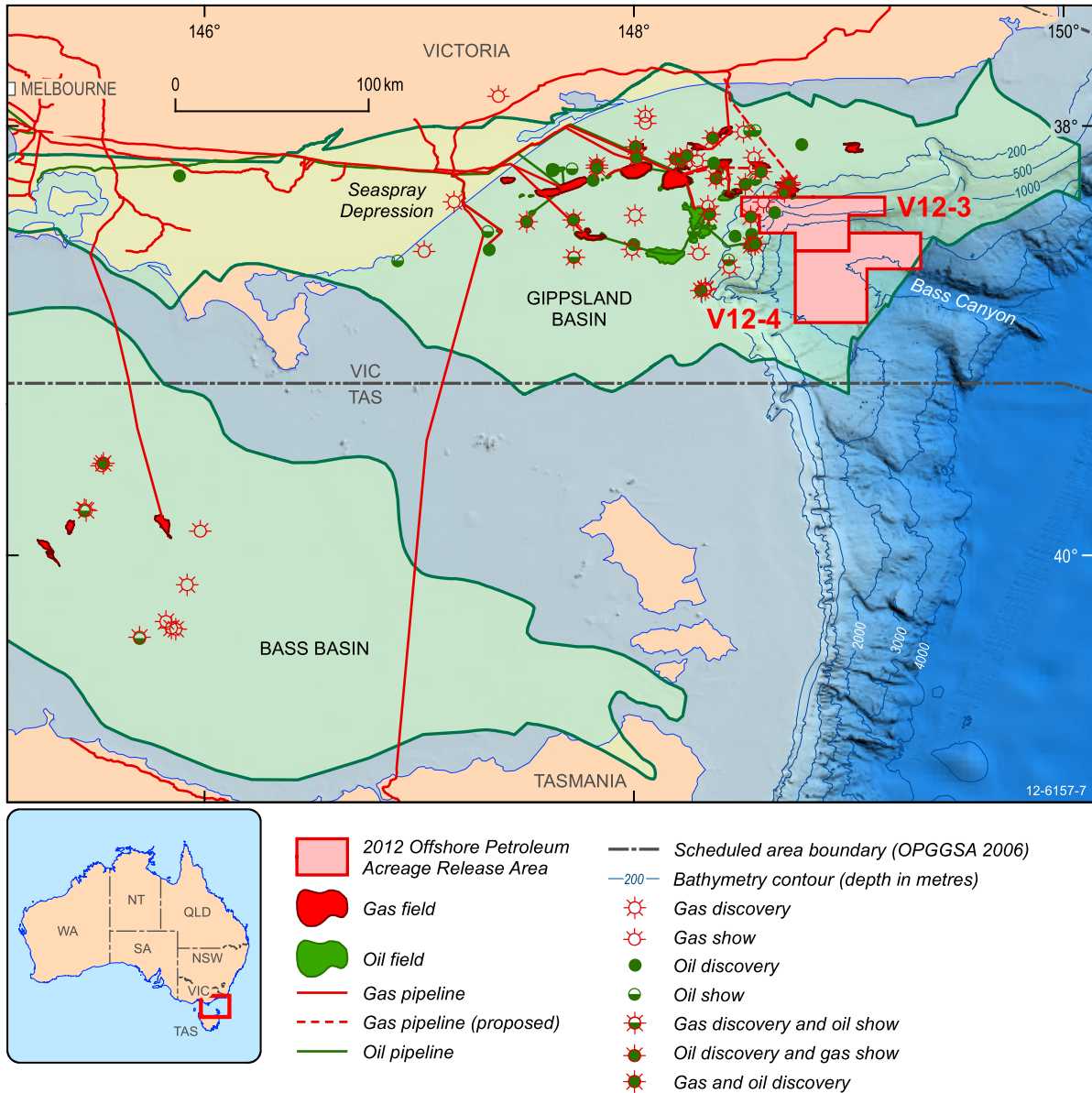


Figure 7. Simplified tectonic elements map of the Gippsland Basin.

Sorell Basin

The Sorell Basin is one of the easternmost elements of Australia's southern rift system. Release Area T12-2 is located over the Sandy Cape and Strahan sub-basins of the Sorell Basin, offshore western Tasmania (figure 6), in water depths ranging from 50 to 3000 metres. The Sorell Basin is one of the least explored of the major southeast Australian offshore sedimentary basins. The focus of exploration has been on the northern sub-basins, where three petroleum exploration wells have been drilled.

The Sorell Basin is contiguous with the Otway Basin, with which it shares a common stratigraphy. The depositional sequences that host active Austral 2 and 3 petroleum systems in the producing areas of the Otway Basin are interpreted to be present in the Sorell Basin.

Lower Cretaceous (Otway Group) and Upper Cretaceous (Sherbrook Group) successions have been mapped throughout the Sorell Basin. While limited well control prevents a thorough understanding of potential reservoir and seal facies in the basin, the few wells that have been drilled provide some encouragement. Cape Sorell 1 intersected a thick, sandy Maastrichtian–Eocene succession;



however, the well was drilled close to the half-graben bounding faults so lateral facies changes are likely. In Jarver 1, the basal Waarre Formation is overlain by a thick mudstone succession, which suggests sealing facies are present in more distal parts of the basin. However, no hydrocarbon discoveries have been made and the basin remains an exploration frontier.

Gippsland Basin

The Gippsland Basin is one of Australia's most prolific hydrocarbon provinces. Despite its relatively small area, the basin contains abundant economic hydrocarbon accumulations, including giant oil and gas fields. Release Area V12-3 is adjacent to producing oil and gas fields (Flounder, Blackback and Basker–Manta–Gummy), and is in water depths ranging from around 200 metres in the northwest to more than 2000 metres in the southeast (figure 7). Release Area V12-4 lies in water depths between 2000 metres and 3000 metres and includes the head of the Bass Canyon (figure 7).

The Release Areas in the Gippsland Basin are both relatively under-explored, especially Release Area V12-4. Only four wells—including discovery wells Bignose 1 and Culverin 1—are located within Release Area V12-3, although seismic coverage is reasonable, especially over the northern area. The 2012 Release Areas were formerly parts of VIC/P49, operated by Nexus Energy Australia, in joint venture with Roc Oil Pty Ltd. In 2007 Nexus acquired about 1700 kilometres of 2D seismic over the area now covering a large part of V12-3 and the northern half of V12-4.

Much of the oil and gas in the Gippsland Basin has been sourced from the lower delta plain shales and coals of the Latrobe Group. However, absence of a thick Cenozoic section in deeper water areas, especially in V12-4, means that the upper Latrobe Group is unlikely to be mature in much of this area. Therefore, the prospectivity of the Release Areas is likely to depend on the presence of older, deeper source rocks. Recent work (O'Brien et al 2008) indicates an older petroleum system may be operating in the Lower Cretaceous Strzelecki Group, generating significant quantities of dry gas. This applies especially along the northern margin of the Gippsland Basin (for example the Sole field) and in the Seaspray Depression onshore (Wombat, North Seaspray and Gangell fields).

Summary

The 2012 Offshore Acreage Release offers a wide variety of geological settings in shallow and deep-water. Area selection continues to be undertaken in consultation with industry and the state and Northern Territory governments. The annual Acreage Release caters for the

whole gamut of exploration companies given that 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. As has been customary in recent years, Geoscience Australia supports the 2012 Acreage Release with an extensive data set, including open file seismic data, well completion reports and well-log data. These open file data are free of charge and made available at the cost of transfer.

References

- Blevin JE, Boreham, CJ, Summons, RE, Struckmeyer HIM & Loutit TS. 1998a. An effective Lower Cretaceous petroleum system on the North West Shelf: evidence from the Browse Basin. In: Purcell PG & Purcell RR (eds). *The Sedimentary Basins of Western Australia 2: Proceedings of the Petroleum Exploration Society of Australia Symposium*, Perth, 1998.
- Blevin JE, Struckmeyer HIM, Cathro DL, Totterdell JM, Boreham CJ, Romine KK, Loutit TS & Sayers J. 1998b. Tectonostratigraphic framework and petroleum systems of the Browse Basin, North West Shelf. In: Purcell PG & Purcell RR (eds). *The Sedimentary Basins of Western Australia 2: Proceedings of the Petroleum Exploration Society of Australia Symposium*, Perth, 1998.
- Bussell MR, Jablonski D, Enman T, Wilson MJ & Bint AN. 2001. Deepwater exploration: northern Western Australia compared with Gulf of Mexico and Mauritania. *The APPEA Journal*, 41:1.
- Gorter JD, Poynter SE, Bayford SW & Caudullo A. 2008. Glacially influenced petroleum plays in the Kulshill Group (Late Carboniferous Early Permian) of the southeastern



- Bonaparte Basin, Western Australia. *The APPEA Journal*, 48:1.
- Hoffman N & Hill KC. 2004. Structural-stratigraphic evolution and hydrocarbon prospectivity of the deep-water Browse Basin, North West Shelf, Australia. In: Ellis GK, Baillie PW & Munson TJ (eds). *Timor Sea Petroleum Geoscience. Proceedings of the Timor Sea Symposium, Darwin, 19–20 June 2003*. Northern Territory Geological Survey Special Publication 1.
- Kennard JM, Deighton I, Ryan D, Edwards DS & Boreham CJ. 2004. Subsidence and thermal history modelling: new insights into hydrocarbon expulsion from multiple petroleum systems in the Browse Basin. In: Ellis GK, Baillie PW & Munson TJ (eds). *Timor Sea Petroleum Geoscience. Proceedings of the Timor Sea Symposium, Darwin, 19–20 June 2003*. Northern Territory Geological Survey Special Publication 1.
- King SJ & Mee BC. 2004. The seismic stratigraphy and petroleum potential of the Upper Cretaceous Ceduna Delta, Ceduna Sub-basin, Great Australian Bight. In: Boulton PJ, Johns DR & Lang SC (eds). *Eastern Australasian Basins Symposium II*. Petroleum Exploration Society of Australia Special Publication.
- Krassay AA & Totterdell JM. 2003. Seismic stratigraphy of a large, Cretaceous shelf-margin delta complex, offshore southern Australia. *AAPG Bulletin*, 87: 6.
- Logan GA, Ryan GJ, Glenn K, Rollet N, Hemer M, Twyford L & Shipboard Party. 2006. Shallow Gas and Benthic Habitat Mapping, Arafura Sea. *RV Southern Surveyor May–June 2005, Post Cruise Report*. Geoscience Australia Record 2006/19.
- O'Brien GW, Tingate PR, Goldie Divko LM, Harrison ML, Boreham CJ, Liu K, Arian N & Skladzien P. 2008. First order sealing and hydrocarbon migration processes, Gippsland Basin, Australia: implications for CO₂ geosequestration. In: Blevin JE, Bradshaw BE & Uruski C (eds). *Eastern Australasian Basins Symposium III*. Petroleum Exploration Society of Australia. Special Publication.
- Somerville R. 2001. The Ceduna Sub-basin – a snapshot of prospectivity. *The APPEA Journal*, 41: 1.
- Struckmeyer HIM (compiler). 2006. New Datasets for the Arafura Basin. *Geoscience Australia Record 2006/06*.
- Totterdell JM, Struckmeyer HIM, Boreham CJ, Mitchell CH, Monteil E & Bradshaw BE. 2008. Mid–Late Cretaceous organic-rich rocks from the eastern Bight Basin: implications for prospectivity. In: Blevin JE, Bradshaw BE & Uruski C (eds). *Eastern Australasian Basins Symposium III*. Petroleum Exploration Society of Australia Special Publication.
- Totterdell JM & Mitchell C (eds). 2009. Bight Basin geological sampling and seepage survey, R/V *Southern Surveyor* Survey SS01/2007: post-survey report. *Geoscience Australia Record 2009/24*.

For more information

email ausgeomail@ga.gov.au

Related articles/websites

2012 Acreage Release:

www.petroleum-acreage.gov.au

Geoscience Australia:

www.ga.gov.au

Data supporting the 2012 acreage release (Seismic data is available in GeoFrame™ and Kingdom formats)

ausgeodata@ga.gov.au



© Commonwealth of Australia 2012.