Release Areas W09-6, W09-7 and W09-8, Northern Exmouth Plateau, Carnarvon Basin, Western Australia

Location

Release Areas W09-6, W09-7 and W09-8 are three large deepwater areas located on the northern Exmouth Plateau. The Exmouth Plateau is the deepwater frontier of the Carnarvon Basin, Australia's premier hydrocarbon province. Home to several giant gas accumulations (Jansz, Scarborough, Thebe), the Exmouth Plateau (**Figure 1**) is an area of active exploration with three (Briseis 1, Glencoe 1 and Nimblefoot 1) out of the six deepwater exploration wells (Bellatrix 1, Briseis 1, Glencoe 1, Ixion 1, Nimblefoot 1 and Warrior 1) drilled in 2008 being significant gas discoveries. At the time of writing another deepwater gas discovery, Martell 1 was made in WA-404-P.

Release Area W09-6 is the most westerly of the Release Areas and is located some 400 km from the Western Australian coastline. Water depths range between 2000 m and 3000 m shallowing to less than 2000 m in the northwest quadrant where the bathymetric high of the Wombat Plateau extends into the Release Area (**Figure 1**). No wells have been drilled in Release Area W09-6 which comprises 93 graticular blocks with a total area of approximately 7525 km^2.

Release Area W09-7 is the largest of the three Release Areas on offer on the northern Exmouth Plateau. It comprises 110 graticular blocks with a total area of approximately 9000 km^2. Water depths are in the range of 2000 m to 3500 m with shallower depths across its northern half and the Montebello Canyon occupying the southern half (**Figure 1**). Release Area W09-7 is located about 370 km from the Western Australian coastline. The Ocean Drilling Program (Haq et al, 1990) drilled 4 stratigraphic holes (ODP 759, 760, 761 and 764) in Release Area W09-7 in 1988 and intersected a Late Triassic carbonate reefal facies overlying Norian coal measures (**Figure 2**).

Release Area W09-8 is the more inboard of the three Release Areas but is in the deepest water. It is some 340 km to the north of the Western Australian coastline and 230 km from the Rankin Trend pipeline network that links the gas fields to the export LNG processing plant onshore (**Figure 1**). The Montebello Canyon occupies the northern half of Release Area W09-8 and water depths range from approximately 2500 m to 4000 m. No wells have been drilled in Release Area W09-8 which comprises 94 graticular blocks with total area of approximately 7690 km^2.

In 2008 Australia's submission for jurisdiction over an additional 2.5 million km^2 of seabed was confirmed by the United Nations Commission on the Limits of the Continental Shelf. The Commission confirmed the location of the outer limit of Australia's continental shelf in 9 distinct marine regions, including the Exmouth Plateau, offshore Western Australia (Geoscience Australia , 2008). Parts of Release Areas W09-6 and W09-7 are located

within this newly confirmed region of Australian marine jurisdiction.

Release Area Geology

Local Tectonic Setting

A flat-lying sedimentary section, dominated by a thick, faulted Triassic sequence, characterises the subsided continental platform of the Exmouth Plateau. The Release Areas are located along the northern margin of the Exmouth Plateau where it is bounded to the north by the Jurassic seafloor of the Argo Abyssal Plain (**Figure 3**). The orientation of the margin is oblique to the spreading direction in the Argo Abyssal Plain and has been described as "an oblique strike-slip margin" by Mihut and Müller (1998). This mixed rift/transform tectonic setting and the influence of underlying Early Paleozoic structures related to the onshore Canning Basin (Stagg et al, 2004) has produced a structurally complex margin characterised by a number of high standing planed blocks and intervening graben.

The Wombat Plateau is one of these high blocks which is bounded to the east and south by a down-faulted zone which has bathymetric expression as the Montebello Canyon (**Figure 1** and **Figure 4**). There are several kilometres of structural relief at the Triassic level between the Wombat Plateau and the graben, which has a thick Jurassic fill (Figure 4), and can be considered as a failed rift produced during the Australia and Greater India break-up.

The dominant fault trend on the Exmouth Plateau is north-south reflecting a pre-existing structural grain (Stagg et al, 2004) seen in the Paleozoic of the onshore Carnarvon Basin. However, the down-warp of the Montebello Canyon wraps around the Wombat Plateau to trend near to east-west, sub-parallel to northern Exmouth Plateau margin. This west-northwest-orientation of the northern margin of the Exmouth Plateau is on trend with the southern flank of Fitzroy Trough (Stagg et al, 2004) in the onshore Canning Basin.

Structural and stratigraphic evolution of the sub-basin

The Early Triassic of the Carnarvon Basin is marked by a regional marine transgression that represents the sag phase of a previous Paleozoic rift cycle. The marine Locker Shale unconformably overlies the Permian and grades upwards into the fluvio-deltaic Mungaroo Formation. The Mungaroo Formation was deposited in a broad, low relief, rapidly subsiding coastal plain that extended across the Release Areas and throughout the Exmouth Plateau. During marine transgression in the latest Triassic carbonate patch reefs developed on the Wombat Plateau (von Rad et al, 1992a; Williamson et al, 1989).

As rifting proceeded between Australia and Greater India, several faulting episodes occurred in the Jurassic. In the Pliensbachian, rifting inboard of the Exmouth Plateau formed the Exmouth, Barrow and Dampier sub-basins. Several kilometres of marine Jurassic sediments were deposited in these troughs that are the equivalent of condensed sections a few metres thick preserved in some locations on the central Exmouth Plateau. A significant thickness of Early to Middle Jurassic sediments are also interpreted to have been deposited in the graben underlying the Montebello Canyon as indicated on **Figure 4**

. However, the major movement on the rift-faults developed along the northern edge of the Exmouth Plateau occurred in the Callovian, while continuous oceanic crust in the Agro Abyssal Plain was not created until the Late Oxfordian (Norvick, 2002). The Wombat Plateau was uplifted and tilted to the north, resulting in erosion of the emergent high block and deposition of Late Jurassic sediments in the bounding graben. Evidence of the emergence of the Wombat Plateau includes its wave-planed form (Stagg et al, 2004) as well as moldic porosity and dedolomitization observed in the Triassic carbonates intersected in the ODP wells (von Rad et al, 1992a).

As the newly formed oceanic crust of the Argo Abyssal Plain rapidly subsided, the adjacent continental margin - the northern margin of the Exmouth Plateau, also foundered. By the Early Cretaceous the Wombat Plateau had been submerged and covered by pelagic sediments. Volcanic activity along the rift/transform margin at this time is recorded as thick bentonite layers interbedded with chalks (von Rad et al, 1992a). As the passive margin developed, deepwater calcareous sedimentation occurred throughout the remainder of the Cretaceous and Cenozoic on the northern Exmouth Plateau (**Figure 2**).

Stratigraphy

The Exmouth Plateau is underlain by 10-15 km of generally flat-lying, faulted sedimentary section that was mainly deposited during extension related to the rifting and break-up of Australia's northwestern margin. The Permian section has not been intersected, but from deep seismic and regional geological evidence is believed to be about 2500 to 5000 m thick (1-2 seconds TWT) and includes a probable basal glacial facies overlain by a deltaic to marine succession of clastic and minor carbonates (AGSO North West Shelf Study Group, 1994; Stagg and Colwell, 1994). Similarly, the Early Triassic is only known from seismic records where its low amplitude character is consistent with its interpretation as marine shale, (equivalent to the Locker Shale intersected in the inboard parts of the Carnarvon Basin). The Locker Shale was deposited in shallow shelf environments during a regional Early Triassic marine transgression which is recognised along the western Australian margin from the Bonaparte to the Perth Basin.

The oldest rocks intersected on the Exmouth Plateau are the Middle Triassic (Ladinian) fluvio-deltaic siliciclastics in Jupiter 1. They represent the rarely intersected, lower part of the Mungaroo Formation, which is better known as a Late Triassic (Carnian-Norian) deltaic sequence that prograded northward across the Exmouth Plateau (Exon and von Rad, 1994). The Mungaroo Formation on the central Exmouth Plateau is composed of interbedded sandstones, siltstones and claystones with minor coal that was deposited during several cycles in environments that changed from marginal marine to lower delta plain.

The Mungaroo equivalent intersected in the ODP wells on the Wombat Plateau grades up from Carnian prodelta mudstone into lower delta plain siliclastics and minor coal to fluvio-delatic sediments of Norian age including medium grained quartz sandstones (von Rad et al, 1992a). The Norian deltaic sediments are overlain by Rhaetian carbonate reefs and intervening lagoonal facies as intersected in the fully cored wells drilled on ODP Leg

122 (Haq et al, 1990; von Rad et al, 1992a). Elsewhere, on the broader Exmouth Plateau, Rhaetian marl tops the Triassic succession. The total Triassic on the Exmouth Plateau is between 5000 to 6000 m (2-3 seconds TWT) thick.

The Jurassic section of the Exmouth Plateau occurs as a thin veneer over high-standing Triassic fault blocks, or as a few hundred metres of sediment in small half graben on the heavily faulted Triassic surface. A somewhat thicker section of Early and Middle Jurassic is interpreted in the deep graben bounding the Wombat Plateau. Over a thousand metres of Middle Jurassic coal measures were intersected in Delambre 1 and similar facies have been dredged from the Swan Canyon (von Rad et al, 1992a), another embayment in the northern margin of the Exmouth Plateau located to the east of the Release Areas. Late Jurassic marine claystones with reworked sediments eroded from the emergent Wombat Plateau are expected to overlie the Callovian horizon within the bounding graben (**Figure 4**).

On the Wombat Plateau the Jurassic is absent due to erosion and the Triassic is directly overlain by the Cretaceous. The ODP drilling (von Rad et al, 1992a) revealed that the Triassic unconformity surface is overlain by a 5 m interval of Berriasian shallow marine sandstones and sandy siltstones that rapidly grades up into hemipelagic chalk and bentonite layers of Berriasian to Valanginian age and then into condensed sequences of bathyal sediments (**Figure 2**).

Exploration History

Two major exploration campaigns have focussed on the deepwater Exmouth Plateau, the first in 1979 to 1980 for oil targets, and the second currently underway searching for gas. The initial exploration programs undertaken by Esso and Phillips (Barber, 1988) began when no proven technology existed to develop a deepwater oil field. Eleven deepwater (740-1375 m) wells were drilled by the early 1980s (Walker, 2007), with the anticipation of oil charge from the Jurassic Dingo Claystone.

A result of this campaign was the discovery of a giant gas accumulation in an Early Cretaceous Barrow Group basin floor fan by the Scarborough 1 well (**Figure 1**, **Figure 3** and **Figure 5**). The Scarborough domal anticline, which was generated by inversion tectonics in Campanian time, is low-relief but extensive, covering approximately 350 km^2 and containing reserves of 5.19 Tcf of gas. At the time of this dry gas discovery (1979), the available technology and the undeveloped LNG market made the remote, deepwater gas accumulation uneconomic to develop.

In the initial phase of exploration on the Exmouth Plateau, gas was also discovered in Late Triassic Mungaroo Formation sandstones by the Jupiter 1 well (**Figure 1**), in a tilted fault block trap (approximately 0.15 Tcf; Walker, 2007). Both the Jupiter 1 discovery and the Scarborough accumulation have strong flat spot DHIs on seismic coverage (Korn et al, 2003).

After the 1979-1980 drilling campaign no further exploration on the deepwater Exmouth Plateau was undertaken for over a decade. The second phase of activity commenced in the mid 1990s with a focus on the established Triassic fault block play along the eastern margin of the Exmouth Plateau, outboard of the Rankin Trend. Activity returned to the central Exmouth Plateau in 1996 with the appraisal drilling of the well Scarborough 2 in Retention Lease WA-1-R jointly held by ExxonMobil and BHP Billiton. Additional appraisal wells, Scarborough 3, 4 and 5, have been drilled and consideration is being given to plans for building an LNG processing plant near Onslow. The largest discovery yet made on the Exmouth Plateau is Jansz, a super-giant gas field in a new play type drilled in 2000 (Jenkins et al, 2003).

In 2003 BHP Billiton was awarded petroleum exploration permit WA-346-P adjoining the Scarborough retention lease to the north (**Figure 1**) and in 2004, it undertook a 3D seismic survey over both areas. Thebe 1, drilled in this permit in 2007, and is interpreted as a successful test of a Triassic fault block that may contain 2 to 3 Tcf of gas (Journal of Petroleum Technology, 2007). Thebe 2 was drilled in 2008 some 16 km to the north of the initial discovery and also found gas (Macdonald-Smith, 2008).

As an outcome of the 2004 offshore acreage release, Chevron and Shell were awarded four large, deepwater exploration permits on the central Exmouth Plateau (WA-364-P, WA-365-P, WA-366-P and WA-367-P). During 2006 the 4144 km^2 Bonaventure 3D marine seismic survey was acquired over petroleum exploration permits WA-364-P and WA-365-P.

Market conditions have changed markedly since the first phase of exploration on the

Exmouth Plateau in the 1970s, with major gas contracts secured to supply LNG to China , in addition to the established trade with Japan . An indication of the viability of the deepwater frontier plays on the Exmouth Plateau was the competitive bidding for the 2006 Release Areas and the entry of a number of new explorers including Hess and OMV. In 2007, Hess Corporation was awarded the deepwater petroleum exploration permit WA-390-P, located southwest of the super-giant Io/Jansz field, with an aggressive bid including a 16 exploration well drilling commitment. The first three wells have all been gas discoveries - Glencoe 1 intersected 28 m of net gas pay, Briseis 1, 46 m and Nimblefoot 1, 28 m (Hess Corporation, 2008a, b, c).

Other recent giant gas finds have been made at Wheatstone and Pluto to the east, and Chandon to the northwest of the Io/Jansz super-giant field (**Figure 1**). 3D seismic and AVO technology are key exploration tools and contribute to high success rates (Longley et al, 2002; Korn et al, 2003; Williamson and Kroh, 2007). Most of the Exmouth Plateau is now under permit, with indicative work program commitments since 2004 totalling approximately $1 billion, including 9 guaranteed deepwater wells to be drilled in WA-404-P held jointly by Hess Corporation and Woodside. The Martell 1 gas discovery recently made in this permit (Woodside Petroleum Ltd., 2009) is the closest discovery to the 2009 Release Areas.

Well Control

The only wells drilled within a hundred kilometres of the Release Areas are the stratigraphic wells drilled by the Ocean Drilling Program which lie within Release Area W09-7. To the south there are number of deepwater exploration wells and several gas discoveries drilled on the central Exmouth Plateau. Other relevant wells have been drilled in shallower water along the Brigadier Trend to the west of the Rankin Platform. Delambre 1, located in the Beagle Sub-basin some 115 km southeast of W09-8, is the closest exploration well to the Release Areas (Figure 1).

Brigadier 1 (1978)

Brigadier 1 was drilled by Woodside Petroleum Development Pty Ltd in 1978 in the early stages of exploration of the Carnarvon Basin. It was drilled to a total depth (TD) of 4292 mRT in 313 m of water on the inboard northern Exmouth Plateau. The objectives were the Late Triassic to earliest Jurassic and the Early to Middle Jurassic on a prominent horst trend. It was the first well drilled on the Brigadier Trend, a gently folded structure, dissected into a series of en echelon north-northeast trending horsts and graben by north-south faulting. Evolution of the middle Jurassic Brigadier Trend is thought to be similar to that of structures on the Rankin Trend, with less erosion (Woodside Offshore Petroleum Pty Ltd, 1978). No significant hydrocarbon shows were observed in the well. Subsequent drilling has also taken place along this trend (see below).

Gandara 1 (1979)

Gandara 1 was drilled by Hudbay Oil (Australia) Limited to a TD of 4361 mRT in 305 m of water. This well was also drilled on the Brigadier Trend. Some high gas readings were encountered in coal seams near to TD, but no significant hydrocarbon shows were observed (Hudbay Oil (Australia) Limited, 1979).

Delambre 1 (1980)

Delambre 1, drilled by Woodside Offshore Petroleum Pty Ltd, tested a Middle Jurassic-Triassic eroded tilted fault block on the Brigadier Trend at the outer-western margin of the Beagle Sub-basin. The well had two objectives, Middle Jurassic sandstones (Legendre Formation) beneath the Main Unconformity horizon and sealed by Early Cretaceous claystone, and Early Jurassic-Late Triassic sandstones sealed by Early Jurassic claystone. The well reached a TD of 5495 mKB and penetrated a thick section of Middle Jurassic (Bathonian to Bajocian) sandstones, siltstones and claystones beneath the Main Unconformity, grading downward to Early Jurassic (Aalenian) to Late Triassic (Carnian) marginal marine claystones, sandstones and siltstones. Minor fluorescence and gas shows were recorded within Middle Jurassic to Late Triassic sandstones and claystones. The well appears to be a valid test of dip and postulated fault closure at the Main Unconformity and base Jurassic levels; however, there is some evidence of minor late stage reactivation of faults bounding the structure (Woodside Offshore Petroleum Pty Ltd, 1981).

Scarborough 1 (1979)

Scarborough 1 was drilled in 912 m of water on the Exmouth Plateau Arch by Esso Australia Ltd. Scarborough is a giant gas discovery in an Early Cretaceous Barrow Group basin floor fan. The Scarborough domal anticline (Figures 1 and 3), which was created by inversion tectonism in the Campanian, is of low-relief but areally extensive.

Jupiter 1 (1979)

Jupiter 1 was drilled by Phillips Australian Oil Company in 959 m of water on the central Exmouth Plateau to test a Triassic horst block. Gas was discovered in Late Triassic Mungaroo sands in a tilted fault block trap (Phillips Australian Oil Company, 1979). Jupiter 1 penetrated over 3000 m of Mungaroo Formation and reached TD at 4946 mKB in interbedded grey-brown siltstones, claystones and white to grey sandstones, with minor coals and dolomites that are dated to the *S quadrifidus* spore/pollen zone ranging from Carnian to Anisian (Nicoll, 2002).

Mercury 1 (1980)

Mercury 1 was drilled in 1142 m of water by Phillips Australian Oil Company on the eastern flank of the Exmouth Plateau Arch. The target was Upper Triassic fluvio-deltaic reservoirs contained within a tilted fault block structure and sealed by a drape closure of

Neocomian claystones. High quality reservoirs were encountered in the Mungaroo Formation but only minor hydrocarbon indications were reported (Phillips Australian Oil Company, 1980).

Eendracht 1 (1980)

Eendracht 1 was drilled in 1354 m of water by Esso Australia Ltd to test a tilted fault block. Four gas-bearing sandstones in the Triassic Mungaroo Formation were intersected over the interval 2467-2652 mKB, with a total net gas pay section of 25.5 m.

Andromeda 1 (1997)

Andromeda 1 was drilled by Mobil Exploration and Producing Australia Pty Ltd to a TD of 4208 mRT in 343 m of water on the Brigadier Trend. The well had two objectives; a four-way drape closure in the Middle Jurassic Legendre Formation beneath the Base Cretaceous Unconformity, and a deeper fault-dependent closure in the Early Jurassic to Late Triassic North Rankin and Brigadier formations. All objectives proved to have good quality reservoirs, but were water wet. However, a limestone at the base of the Athol Formation resting on the top Triassic unconformity revealed trace hydrocarbons from a "clastic or marly source rock containing mixed marine/land plant matter deposited under relatively low oxygen conditions" (Mobil Exploration and Producing Australia Pty Ltd, 1999).

Banambu 1 (1998)

Banambu 1 was drilled by Woodside Offshore Petroleum Pty Ltd to a TD of 4001 mRT in 295 m of water. The primary objective was Early Jurassic to Triassic reservoirs in a large upthrown fault block on the Brigadier Trend. Good quality reservoirs were intersected in the North Rankin, Brigadier and Mungaroo formations, but no hydrocarbon shows were encountered. GOI™ studies gave results = 0.1 % (Woodside Offshore Petroleum Pty Ltd, 1998).

Glatton 1 (1999)

Glatton 1 was drilled by Woodside Energy Ltd. targeting closure, at the mid Jurassic (Legendre Formation) level, on the north-northeast- trending Banambu horst block on the Brigadier Trend in 360 m of water. The well reached a TD of 2985 mRT.. Although good quality reservoir sands were encountered in the Middle Jurassic, only minor fluorescence was observed. Evidence for hydrocarbon migration into the structure was provided by the presence of bitumen rings, fluid inclusion analysis and limited fluorescence all at the targeted stratigraphic level (Woodside Energy Limited, 1999). However, the well was plugged and abandoned as a dry hole. Failure was interpreted to be due to insufficient volumes of hydrocarbons migrating from the source areas to the north and northwest and the lack of feasible migration routes from the Victoria Syncline (Figure 3).

Titania 1 (2000)

Titania-1 was drilled by Woodside Energy Ltd on the Exmouth Plateau, outboard of the Brigadier Trend. This well was drilled in 1500 m of water and tested a new play type in Late Cretaceous bathyal turbidites (Bussell et al, 2001). In addition to the primary objective of the Campanian fan there was a deeper target of Late Jurassic turbidite sand. Titania 1 intersected good quality reservoir and seal facies but the well was dry. The absence of hydrocarbons in Titania 1 was attributed to the lack of a migration pathway through the regional Cretaceous seal. Oxfordian sands, although present, are likely to have a limited areal extent (Woodside, 2000).

Io 1 (2001), Jansz 1 (2001)

The super-giant Io/Jansz gas accumulation introduced a new play type to the Exmouth Plateau. Hydrocarbons are stratigraphically trapped in an Oxfordian shallow marine sandstone (**Figure 5**) on the western limb of the Kangaroo Syncline (Jenkins et al, 2003). The field covers an area of approximately 2000 km^2 and the discovery wells Jansz 1, drilled by Mobil Exploration & Producing Australia Pty Ltd, and Io 1, drilled by Chevron Australia Pty Ltd, are located 18 km apart. The Oxfordian (*W. spectabilis* zone) gas reservoir at Jansz 1 and Io 1 is in pressure communication with Tithonian and Triassic to Early Jurassic Brigadier Formation gas-bearing sandstones at Geryon 1 and Callirhoe 1 (Jenkins et al, 2003), a further 30 km away. Appraisal wells Jansz 2 (2002) and Jansz 3 (2003), plus a prominent AVO-response indicate that this discovery is the largest gas field yet found on the Exmouth Plateau.

Atlas 1 (2001)

Atlas 1 was drilled by Woodside Energy Ltd and targeted a Triassic Mungaroo fault block in 1397 m of water. This well proved to be dry, attributed to a lack of charge. Modelled gas migration routes from the Mungaroo Formation in the Kangaroo Syncline (**Figure 3**) are potentially blocked by a northwest-oriented structural high (Woodside, 2001).

Guilford 1 (2003)

Guilford 1 was drilled by Woodside Energy Ltd to test a Triassic tilted horst block on the Exmouth Plateau about 30 km to the west of the Rankin Platform. Guilford 1 also targeted an amplitude supported drape trap at the Campanian level overlying the Triassic fault block predicted to be fan sands as intersected at Titania 1. However, the Campanian sands were absent and a 27 m gas column was encountered in the Toolonga Calcilutite which is interpreted to be "tight" (Woodside, 2003). All the sandstones in the Triassic Mungaroo Formation were water wet.

Chandon 1 (2006)

Chandon 1 drilled by Chevron in 1200 m of water is located 31 km northwest of the Jansz 2 well. Unlike the Jansz accumulation, the objective was a Triassic fault block. A 196.9 m gross gas column was intersected in high quality Mungaroo Formation sandstones (Tinapple, 2007).

Thebe 1 (2007)

Thebe 1 is interpreted as a successful test of a Triassic fault block that may contain 2 to 3 Tcf of gas (Journal of Petroleum Technology, 2007). The well was drilled in 1173 m of water and confirmed a gas column of approximately 73 m (BHP Billiton, 2007). Thebe 2, drilled approximately 16 km to the north-northeast, was also successful (Macdonald-Smith, 2008).

Belicoso 1 (2007)

Belicoso 1 is the most northerly exploration well drilled on the Exmouth Plateau. It was drilled by Woodside Energy Ltd in over 1400 m of water in WA-347-P. The target was one of many north-northeast-trending Triassic horst blocks on the northern Exmouth Plateau (Woodside, 2007). Although Belicoso 1 did not encounter hydrocarbons, newspaper reports (Wilson, 2007) indicate that thick, high quality sands were intersected.

Table 1: Key wells listing

Well	Operator	Year	Total Depth	Hydrocarbons
Andromeda 1	Mobil Exploration and Producing Australia Pty Ltd	1997	4208 mRT	No tests
Atlas 1	Woodside Energy Ltd	2001	4211 mRT	No tests
Banambu 1	Woodside Offshore Petroleum Pty Ltd	1998	4001 mRT	No tests
Belicoso 1	Woodside Petroleum Ltd	2007	2573 mRT	No public data
Bellatrix 1	Woodside Energy Ltd	2008	3095 mRT	No public data

Brigadier 1	Woodside Petroleum Development Pty Ltd	1978	4292 mRT	No tests
Briseis 1	Hess Exploration Australia Pty Ltd	2008	3554 mRT	No public data
Briseis 1CH1	Hess Exploration Australia Pty Ltd	2008	n/a	No public data
Chandon 1	Chevron (TAPL) Pty Ltd	2006	3124 mRT	Gas
Delambre 1	Woodside Petroleum Development Pty Ltd	1980	5495 mRT	No tests
Eendracht 1	Esso Australia Ltd	1980	3410 mKB	Gas
Ermine 1	Woodside Energy Ltd	1999	2710 mRT	No tests
Gandara 1	Hudbay Oil (Australia) Limited	1979	4361 mRT	No tests
Glatton 1	Woodside Energy Ltd	1999	2985 mRT	No tests
Glencoe 1	Hess Exploration Australia Pty Ltd	2008	3410 mRT	No public data
Glencoe 1 CH1	Hess Exploration Australia Pty Ltd	2008	n/a	Gas
Guilford 1	Woodside Energy Ltd	2003	4272 mRT	Gas
Investigator 1	Esso Australia Limited	1979	3746 mKB	Minor gas
Jupiter 1	Phillips Australian Oil Company	1979	4946 mRT	Gas

Mercury 1	Phillips Australian Oil Company	1979	3812 mRT	No shows
Nimblefoot 1	Hess Exploration Australia Pty Ltd	2008	4344 mRT	Gas
ODP 759A				
ODP 759B				
ODP 760A				
ODP 760B				
ODP 761A				
ODP 761B				
ODP 761C				
ODP 762A				
ODP 762B				
ODP 762C				
ODP 763A				
ODP 763B				
ODP 763C				
ODP 764A				
ODP 764B				
Scarborough 1	Esso Australia Ltd	1979	2360 mKB	Gas
Thebe 1	BHP Billiton Petroleum (Australia) Pty Ltd	2007	2510 mRT	Gas
Thebe 1CH	BHP Billiton Petroleum (Australia) Pty Ltd	2007	2450 mRT	No public data
Thebe 2	BHP Billiton Petroleum (NWS) Pty Ltd	2008	2550 mRT	No public data

Titania 1	Woodside Energy Ltd	2000	3196 mRT	No tests
Vinck 1	Esso Australia Ltd	1980	4600 mKB	Gas

Rig Release Year shown. Shaded areas highlight those wells for which complete data sets are not yet available. Data accurate as at 31 March 2009

Seismic Coverage

The deepwater frontier of the northern Exmouth Plateau has limited seismic coverage. Deep seismic data was acquired by Geoscience Australia across the Exmouth Plateau on its former research vessel Rig Seismic between 1991 and 1995 (Stagg et al, 2004, Alcock et al, 2006). In 2008 a new multi-client survey PGS New Dawn was acquired across the Exmouth Plateau including several lines over the Release Areas (Petroleum Geo-Services, 2009).

A full listing of the seismic is available in the **Northern Exmouth Plateau Data Listing**.

Other data

In addition to commercial petroleum exploration efforts on the Exmouth Plateau, there have also been scientific investigations. In 1988, the Ocean Drilling Program, ODP Leg 122 (Haq et al, 1990; von Rad et al, 1992b) drilled in four locations on the Wombat Plateau (**Figure 1**). Detailed descriptions of the fully cored holes and the interpretation of the results are given by von Rad et al (1992b).

Hydrocarbon Potential

The super-giant Io/Jansz gas field, the giant Scarborough gas field, 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 prospectivity to the northern margin of the Exmouth 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. ODP drilling on the Wombat Plateau has intersected a similar sedimentary section to the petroliferous central Exmouth Plateau. In addition to Triassic deltaic sandstones and coals (stratigraphic equivalents of the reservoir and source facies of the proven deepwater giant gas play), there are Triassic carbonate reefs providing another play type. Potentially prospective areas occur in water depths of around 2000 m and new commercial multi-client seismic data is available (Petroleum Geo-Services, 2009).

Source Rocks

The thick Permian to Triassic sedimentary section on the Exmouth Plateau has the greatest potential for mature source facies, with possible organic-rich units in the Early Triassic (marine Locker Shale equivalents) and Late 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 coals and carbonaceous claystones of the Mungaroo Formation. Peak gas generation from these Triassic source rocks is interpreted to occur now at depths greater than 5 km subsea (Bussell et al, 2001).

Gas-prone potential source rocks with total organic carbon content up to 2.5% have been described from the Carnian prodelta sediments intersected on the Wombat Plateau (von Rad et al, 1992a). On the high block of the Wombat Plateau, these rocks are currently thermally immature (<0.5% vitrinite reflectivity) but may reach maturity within the bounding graben where buried by Jurassic sediments and perhaps subject to higher heat flow during the formation of adjacent oceanic crust in the Argo Abyssal Plain. Organic rich sediments may also be present within the Jurassic graben fill but these are unlikely to be mature.

Expulsion and Migration

Though the Triassic section on the Wombat Plateau is currently immature where drilled, the Mungaroo Formation delta that extended across northern Exmouth Plateau may have provided sufficient burial to bring the underlying Early Triassic or Permian sequences to maturity perhaps sometime in the Late Triassic. A later phase of generation may have occurred in the bounding graben due to the additional load of Jurassic fill. Hydrocarbons that may have generated within the failed rift underlying the Montebello Trough could migrate into the adjacent fault bounded high blocks of the Wombat Plateau in Release Areas W09-6 and W09-7 or up-dip towards the southeast into the fault blocks of the

northern Exmouth Plateau in Release Area W09-8.

Reservoirs

Norian fluvio-deltaic sandstones and secondary porosity developed in Rhaetian carbonates as intersected in the ODP drilling are reservoir targets on the Wombat Plateau in Release Areas W09-6 and W09-7. On the deepwater northern Exmouth Plateau in Release Area W09-8, sandstones ranging in age from Middle Jurassic to Late Triassic are potential reservoir targets. In Delambre 1 porosities of up to 20% were reported from sandstones ranging in age from Bathonian to Carnian (Woodside Offshore Petroleum,1981) and the recent Belicoso 1 well is reported (Wilson, 2007) to have intersected good reservoir facies.

Seals

Fine grained deepwater Cretaceous sediments provide a regional seal across the Exmouth Plateau and the Wombat Plateau. There are also intra-formational seals within the deltaic sequences of Middle Jurassic to Late Triassic age. The Rhaetian marl, where it is preserved, provides a top seal to Triassic reservoirs, though at the crest of the Wombat Plateau it is absent and Norian deltaic sediments directly underlie Cenozoic pelagic sediments (Exon and von Rad, 1994).

Play Types

High relief fault block traps together with associated drape features provide numerous potential structural traps in the Release Areas. On the available seismic data, this faulting does not appear to penetrate the Cretaceous regional seal. Reefal stratigraphic traps, such as porous patch reefs laterally sealed by fine grained lagoonal facies, provide another family of play types on the Wombat Plateau as described by Williamson et al (1989).

Critical Risks

Access to a viable mature hydrocarbon source is the key risk in the Release Areas. Drilling locations will be in water depths exceeding 1500 m.

Figures

Figure 1:	Location map of Release Areas W09-6, W09-7 and W09-8, showing existing petroleum permits, oil and gas accumulations and discoveries, and gas pipelines.
Figure 2:	Preliminary generalised stratigraphy of the Exmouth and Wombat plateaux (Gradstein et al, 2004 Time Scale).
Figure 3:	Structural elements of the Northern Exmouth Plateau showing 2009 Release Areas and the location of the seismic line shown in Figure 4.
Figure 4:	Geoscience Australia seismic line GA 95r/19 across the Wombat Plateau, Montebello Canyon and Exmouth Plateau.
Figure 5:	Major oil and gas accumulations of the Northern Carnarvon Basin indicating age of main reservoir.

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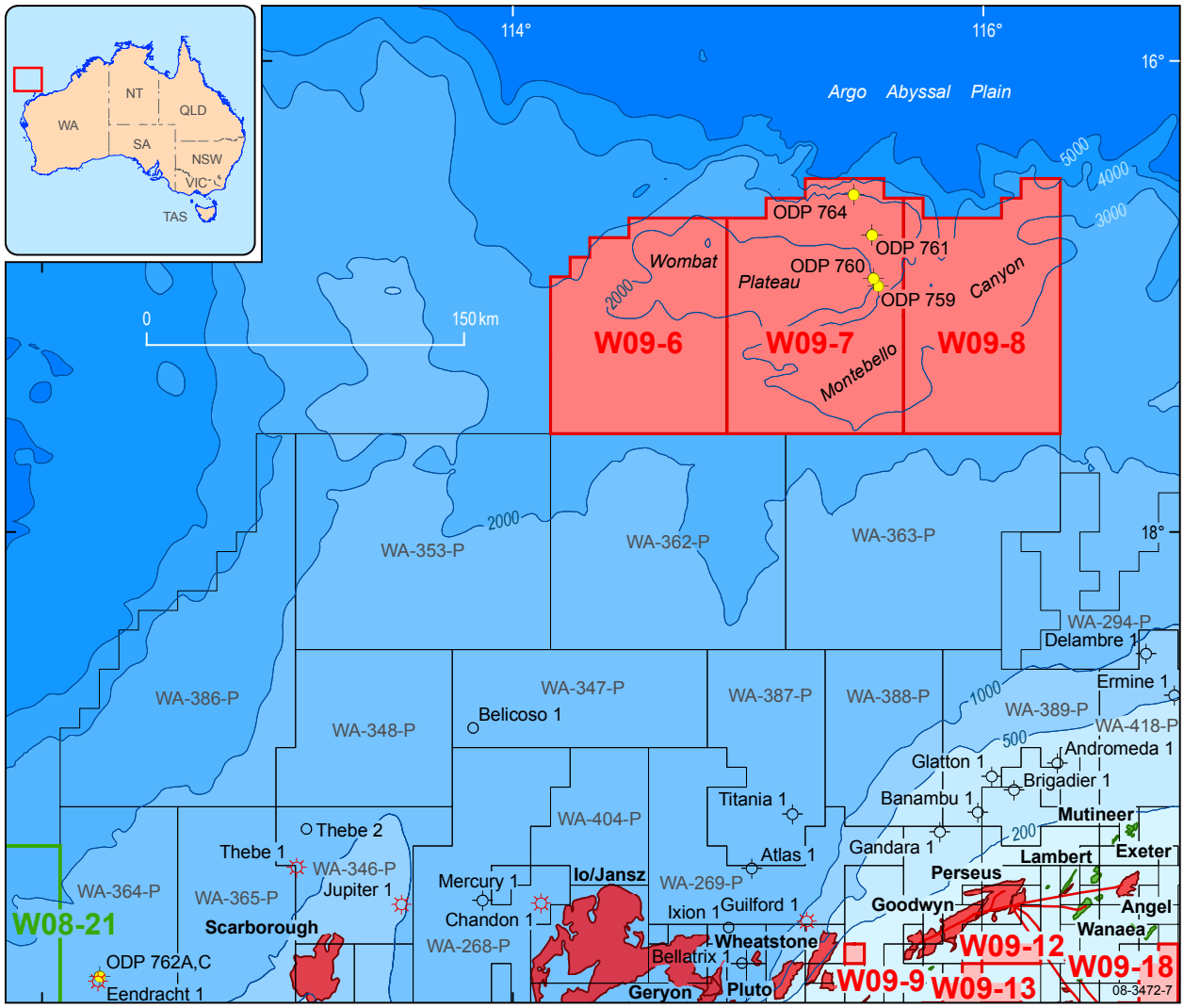


Where well symbol information is sourced from publicly available "open file" data, it has been provided by Geoscience Australia from Well Completion Reports. These symbols were generated from open file data as at 31 March 2009. Where well symbol information is not publicly available from titleholders' data, the information has been extracted from other public sources. Field outlines are provided by GPinfo, an Encom Petroleum Information Pty Ltd product. Field outlines in GPinfo are sourced, where possible, from the operators of the fields only. Outlines are updated at irregular intervals but with at least one major update per year.

- *2009 Designated Frontier Area*
- *2009 Offshore Petroleum Acreage Release Area*
- *2008 Offshore Petroleum Aceage Release Area*
- *Existing petroleum title*
- *Gas field*
- *Oil field*
- *Gas pipeline*
- *200 Bathymetry contour (depth in metres)*
- *Ocean Drilling Program Stratigraphic Well*
- *Petroleum exploration well - Not classified*
- *Petroleum exploration well - Dry hole*
- *Petroleum exploration well - Gas discovery*

Figure 1. Location map of Release Areas W09-6, W09-7 and W09-8, showing existing petroleum permits, oil and gas accumulations and discoveries, and gas pipelines.

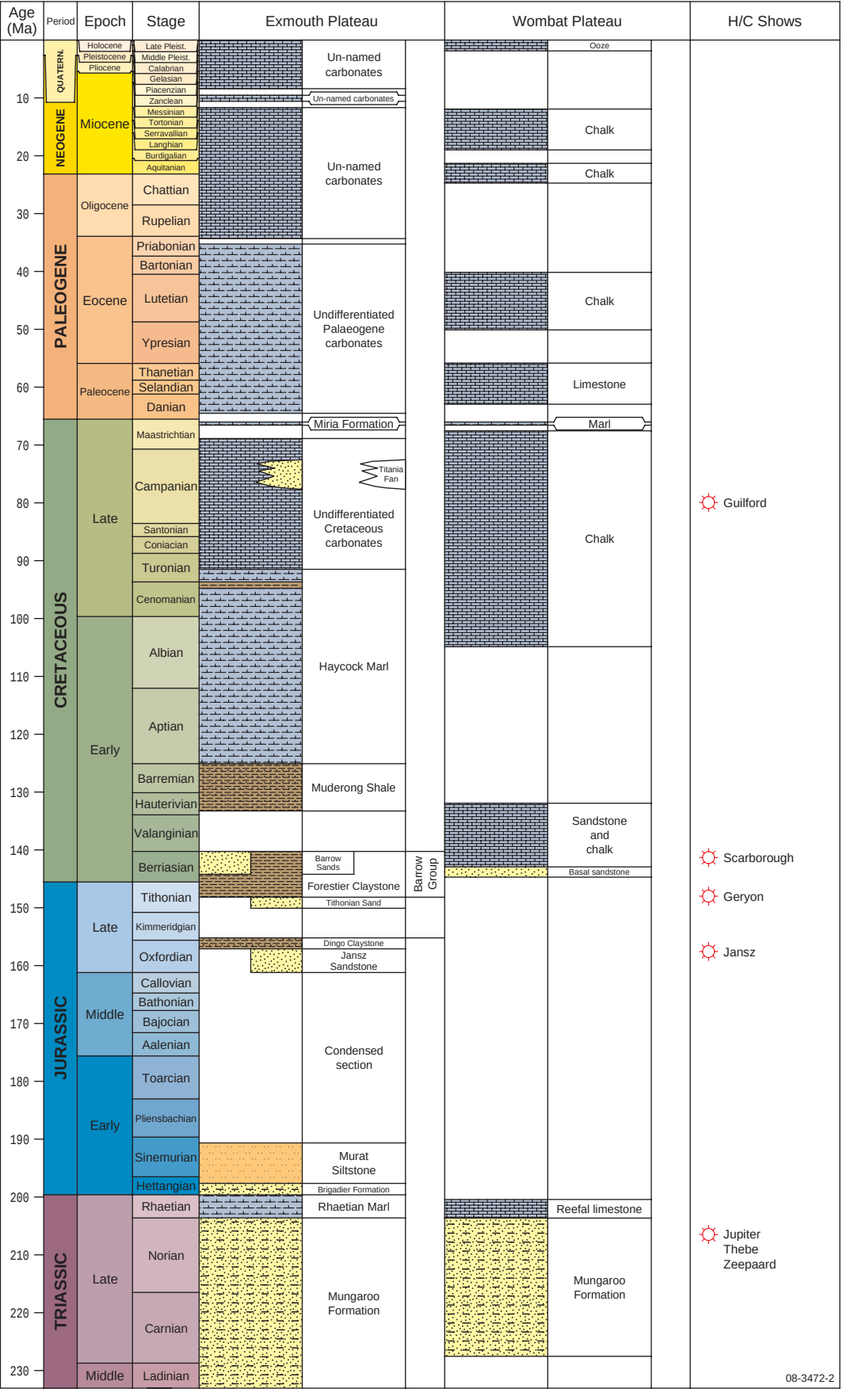
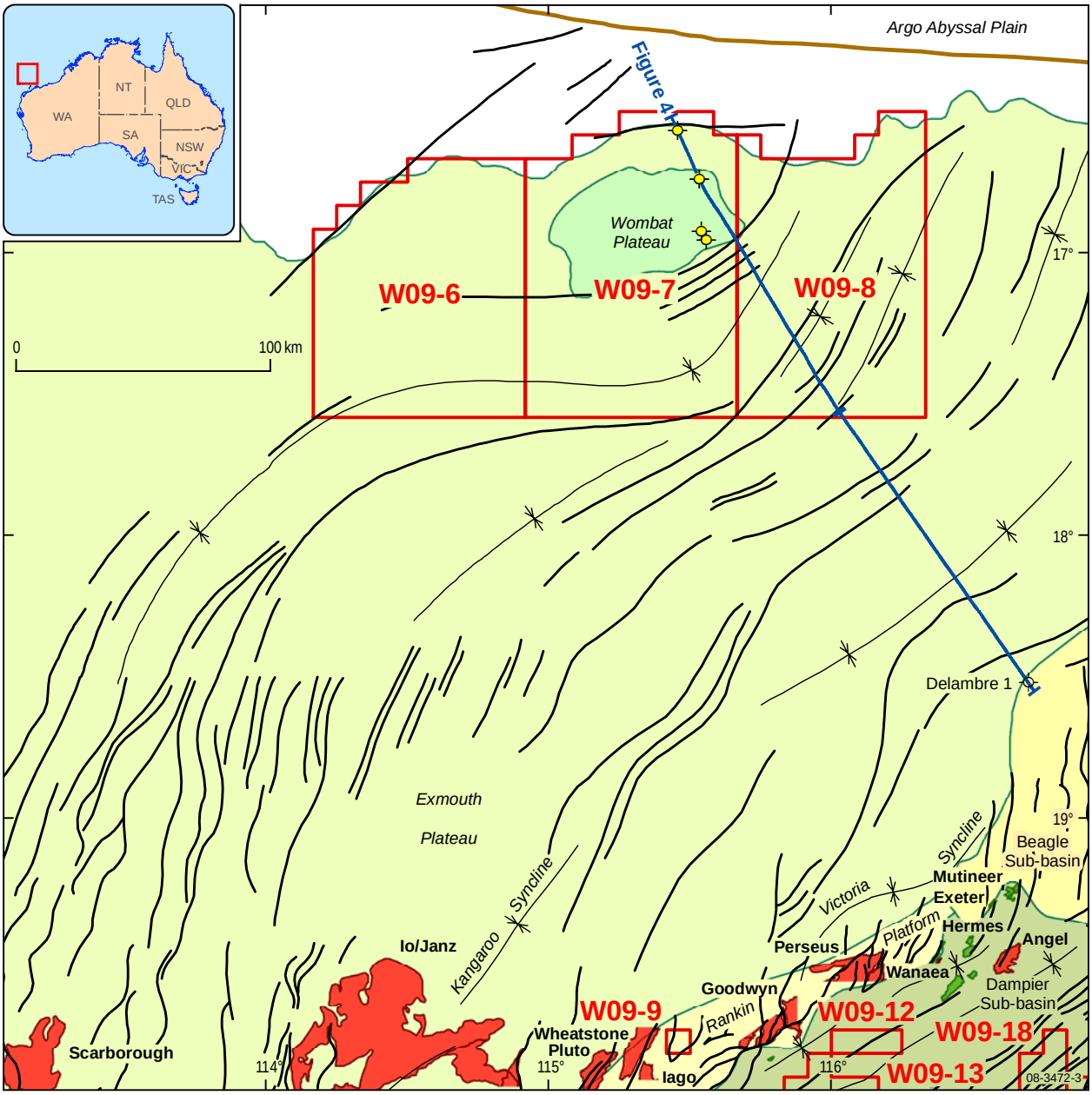


Figure 2. Preliminary generalised stratigraphy of the Exmouth and Wombat Plateaux (Gradstein et al, 2004 Time Scale).



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2009 Offshore Petroleum Acreage Release Area
Gas field
Oil field
Seismic line
Continental ocean boundary
Basin outline
Fault trend
Syncline
Offshore Drilling Program Stratigraphic Well

Figure 3. Structural elements of the northern Exmouth Plateau showing the 2009 Release Areas and the location of the seismic line shown in Figure 4.

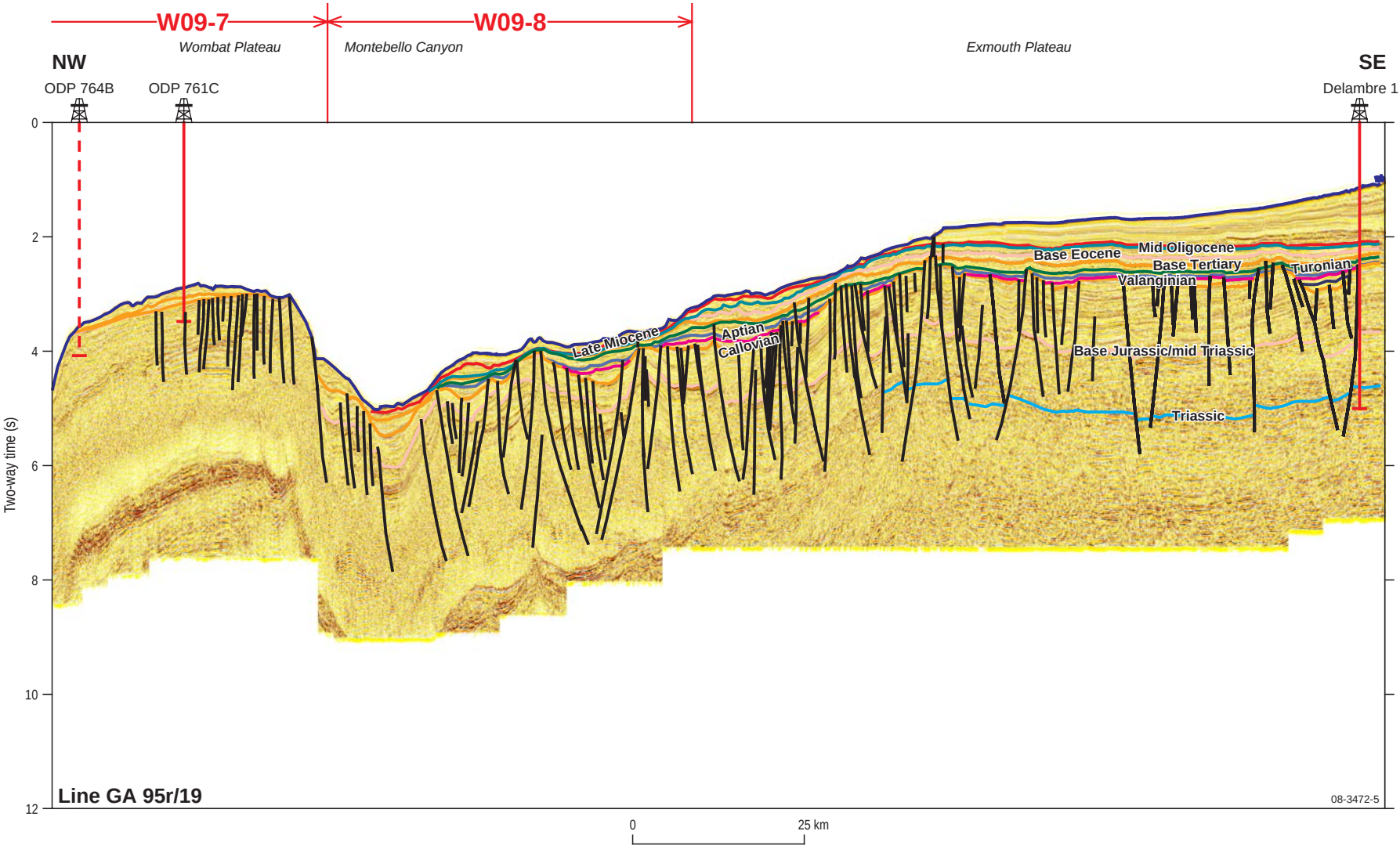
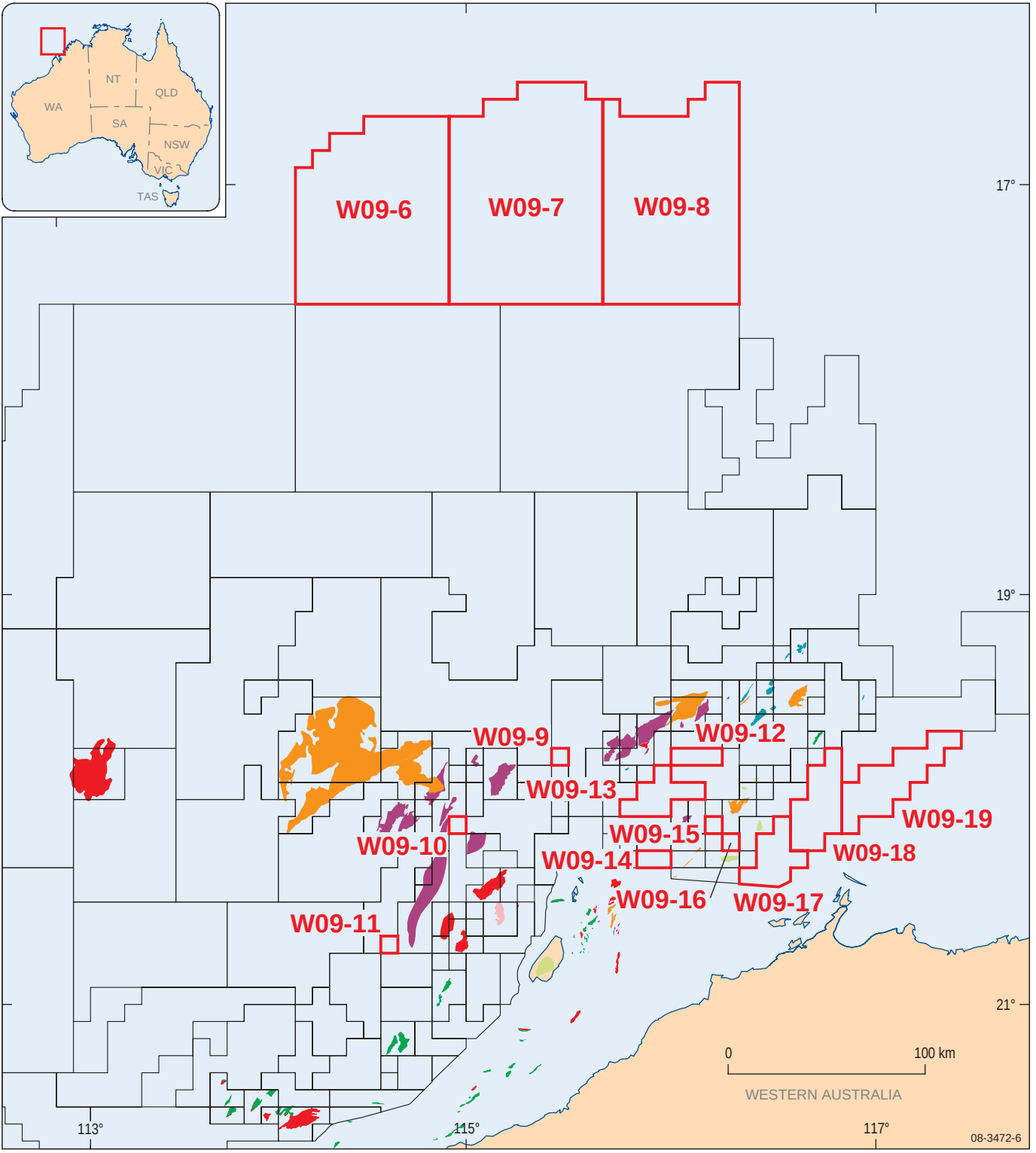


Figure 4. Geoscience Australia seismic line 95r/19 across the Wombat Plateau, Montebello Canyon and Exmouth Plateau.



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2009 Offshore Petroleum Acreage Release Area

Existing petroleum title

Period (Formation)	Oil accumulation	Gas accumulation
Paleocene		
Barremian		
Valanginian & Berriasian		
Tithonian, Oxfordian and Middle Jurassic		
Upper Triassic (Brigadier and Mungaroo Formations)		

Figure 5. Major oil and gas accumulations of the Northern Carnarvon Basin indicating age of main reservoir.