Release Areas W09-12, W09-13, W09-14, W09-15, W09-16, W09-17, W09-18 and W09-19 Dampier Sub-basin, Northern Carnarvon Basin, Western Australia

Location

The Release Areas are located in the Dampier Sub-basin of the Northern Carnarvon Basin in close proximity to major producing oil and gas accumulations. These include the Rankin Platform, the Angel gas field and the Wanaea, Cossack, Wandoo and Stag oil fields (**Figure 1**). The gas pipeline from the Rankin Platform fields to the export LNG processing plant onshore traverses some of the Release Areas and plans are well advanced to bring the Reindeer/Caribou gas accumulation into production to supply the domestic gas market. The Elk gas accumulation is within Release Area W09-16, a gas discovery was made in the Morrel 1 well within Release Area W09-17 and the Lynx 1A well in Release Area W09-12 intersected tight gas sands. The Release Areas are between 30 and 120 km offshore from the Western Australian coastline and are in 40-100 m water depth.

Release Areas W09-12, W09-13 and W09-14 are located in the central depocentre of the Dampier Sub-basin and Release Areas W09-15, W09-16, W09-17, W09-18 and W09-19 are on the Enderby Terrace, the eastern flank of the sub-basin adjacent to its border with the Lambert Shelf (**Figure 2**). The Release Areas range in size from W09-15 and W09-16 which are single graticular blocks of approximately 80 km^2 to Release Area W09-19, which is made up of 17 graticular blocks and is 1370 km^2 in size.

Release Area Geology

Local Tectonic Setting

The Dampier Sub-basin is an elongate northeast trending depocentre within the Northern Carnarvon Basin. It contains a relatively thick (>10000 m) sequence of Paleozoic to Cenozoic sediments (**Figure 3**). The sub-basin is bound to the southeast by the Lambert Shelf and to the northwest by the Rankin Platform, other major structural elements within the Northern Carnarvon Basin (Hocking et al, 1994). The southwestern boundary of the Dampier Sub-basin with the Barrow Sub-basin is arbitrarily placed at the southwestern limit of the Madeleine Trend and Lewis Trough, and the northeastern limit of the Montebello Trend (Hocking, 1990). The Barrow and Dampier sub-basins are also separated by a change in orientation of the major structures from north-northeast in the Barrow Sub-basin to northeast in the Dampier Sub-basin (Kopsen and McGann, 1985).

The Dampier Sub-basin was initiated in the Early Jurassic as part of a rift system associated with Gondwanan breakup. Major fault movements occurred in the Callovian and new ocean floor was emplaced to the northwest of the Exmouth Plateau. Tectonic activity was more subdued from the Early Cretaceous to the Miocene, though inversion and reactivation of the major fault systems occurred in the Cretaceous. By the Middle Cretaceous the Dampier Sub-basin ceased to exist as a separate entity and the offshore Northern Carnarvon Basin become unified as a passive continental margin shelf-slope system.

Five main structural elements are recognized within the Dampier Sub-basin. From northwest to southeast (**Figure 2**) they are: the Kendrew Trough, Madeleine Trend, Lewis Trough, Legendre Trend and Enderby Terrace (**Figure 2**). These structural features, along with the adjacent Rankin Platform and Lambert Shelf are described below.

The **Rankin Platform** is a structurally high area that flanks the western edge of the Dampier Sub-basin and the Exmouth Plateau. 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 (Vincent and Tilbury, 1988). Along the Rankin Platform, large, uplifted Early Jurassic/Triassic fault-blocks covered by thin Late Cretaceous shale and a thick Cenozoic section are juxtaposed with a graben preserving thick Early-Middle Jurassic sequence. A major late Early Cretaceous unconformity truncates the Late Triassic to Middle Jurassic sediments.

The **Kendrew Trough** lies between the Rankin Platform and the Madeleine Trend. It is broader to the southwest and narrows towards the De Grey Nose in the northeast where it may converge with the other main structural trends.

The **Madeleine Trend** is a basin-forming, fault controlled, southwest-oriented trend that separates the Kendrew Trough from the Lewis Trough. It is expressed as a narrow linear high that runs parallel to the Rankin Platform, and is within the sub-basin depocentre. Much of the Madeleine Trend is within an elongate anticline that parallels the Lewis Trough to the northwest. The northwestern closure of this anticline trend was most likely

formed after the Paleocene, with the depression of its outer flank under a seaward-thickening carbonate wedge. Both the Madeleine and Legendre trends are related to inversion or reactivation of major basin-forming fault systems during the Cretaceous (AGSO North West Shelf Study Group, 1994). The Angel gas field and the Wanaea and Cossack oil accumulations are located along the Madeleine Trend and the trend continues through Release Areas W09-12 and W09-13 (**Figure 2**, **Figure 4** and **Figure 5**).

The **Lewis Trough** is a narrow, deep, uncomplicated downwarp with a large volume of sedimentary fill (Jurassic is 4500 m thick) and no major faulting. The trough appears to have originated during the late Triassic to Early Jurassic in response to the final stages of Gondwanan break-up (Hocking, 1990). The axis of the Lewis Trough passes through Release Area W09-13 (**Figure 2** and **Figure 4**). Release Area W09-14 is located at the southern end of the Dampier Sub-basin within the main Jurassic depocentre (**Figure 2**, **Figure 4** and **Figure 6**).

The **Legendre Trend** is a complex fault controlled positive feature that lies immediately shoreward of the Lewis Trough. The Legendre Trend is a narrow, heavily faulted linear high that parallels the Rosemary Fault System which separates the Lewis Trough from the Enderby Terrace. It is also sometimes termed the Legendre-Rosemary Trend which emphasises its extent along the eastern Dampier Sub-basin. The Legendre Trend contains the Talisman oil field (Vincent and Tilbury, 1988) and the Amulet, Legendre, Sage and Saffron hydrocarbon accumulations are located this feature (**Figure 2** and **Figure 4**).

The **Enderby Terrace** is located between the Lambert Shelf and the Legendre Trend. It is a submerged offshore portion of the stable Pilbara Craton (Hocking et al, 1994) and is cut by a number of northeast-trending faults (**Figure 2** and **Figure 4**). The thick Jurassic section seen in the Lewis Trough and Legendre Trend progressively wedges out across the terrace. Release Areas W09-15, W09-16, W09-17, W09-18 and W09-19 along with the Wandoo, Stag Tusk and Elk hydrocarbon accumulations are located on the Enderby Terrace (**Figure 2**, **Figure 4** and **Figure 7**).

Landward of the Enderby Terrace is the **Lambert Shelf**, a shallow basement area along the southern margin of the Northern Carnarvon Basin which is overlain by a thin Cretaceous and younger section (**Figure 2**, **Figure 4** and **Figure 7**).

Structural and stratigraphic evolution of the sub-basin

The Early Triassic of the Northern 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 or Precambrian basement 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.

The Exmouth, Barrow, Dampier and Beagle sub-basins formed as a series of

northeast-trending en-echelon structural depressions during Pliensbachian to Oxfordian times (Tindale et al, 1998). These sub-basins are Jurassic depocentres representing a failed rift system that developed during the early syn-rift phase of break-up in the Northern Carnarvon Basin. They contain thick successions of Jurassic oil-prone sediments and are bound to the west by the subsided continental platform of the Exmouth Plateau which is dominated by a thick, faulted, Triassic sedimentary sequence.

The Exmouth, Barrow and Dampier sub-basins remained tectonically active throughout the Jurassic. The early syn-rift mega-sequence (mid-Pliensbachian to mid-Callovian) comprises restricted marine claystones of the Athol Formation and deltaic sandstones of the Legendre Formation. The Legendre Delta developed in the early Bathonian in the Dampier Sub-basin, but sedimentation ceased by the early Callovian. The mid-Callovian unconformity surface defines the boundary between the Early Syn-rift (mid-Pliensbachian to mid-Callovian) and Main Syn-rift (mid-Callovian to latest Tithonian) megasequences. This unconformity represents the onset of the continental breakup of the northwest Australian margin (Jablonski, 1997). Claystones of the transgressive Callovian Calypso Formation were deposited over the unconformity surface.

Following continental breakup, active faulting continued in the Late Jurassic. This resulted in uplift and erosion on the Lambert Shelf, Enderby Terrace and the Rankin Platform but further downwarp of the incipient Lewis Trough in the central Dampier depocentre. Reworked sediments were deposited from the adjoining uplifted areas but tectonic subsidence rates exceeded sedimentation rates and a thick succession of the deep-water Dingo Claystone gradually filled the graben depocentres of the Dampier, Barrow and Exmouth sub-basins. Although marine claystones dominate the Main syn-rift (mid-Callovian to latest Tithonian) megasequence, paradoxically this is also the time when reservoir-quality turbidite, submarine fan, shoreline and fluvial sandstones (Angel Formation) were deposited locally within the Dampier Sub-basin.

Rifting between Australia and Greater India at the end of the Jurassic produced uplift along the Cape Range Fracture Zone to the south of the Exmouth Sub-basin and provided the sediment source for the Barrow Delta. During the latest Tithonian to mid-Valanginian, the delta prograded from the southwest across the Exmouth Sub-basin, southern Exmouth Plateau and into the Barrow Sub-basin. In contrast, the Early Cretaceous of the Dampier Sub-basin is dominated by fine grained sediments because of its distal location, including the Forestier Claystone, a prodelta, fine grained equivalent of the Barrow Group, and the transgressive marine Muderong Shale. The deposition of claystones, marls and calcilutites continued in the depocentre throughout the Cretaceous and early Cenozoic.

The offshore shelf depositional environment persisted through to the early Eocene, when changes in sediment source and water temperature were coupled with a minor regressive phase. Collapse of the shelf in the early Oligocene resulted in the northwesterly tilting of the Dampier Sub-basin and the progradation of a carbonate wedge. This progradation was terminated by a eustatic sea-level rise, and in the late middle Miocene, a second phase of clastic/carbonate progradation began (Romine et al, 1997).

A phase of compressional tectonism occurred in the Miocene, effectively enhancing the

northwesterly tilt of the basin and causing movement along the Rosemary Fault System, which in some localities may have persisted until very recently. Another eustatic sea-level rise in the late Miocene was followed by the progradation of talus-slope carbonates, and the deposition of carbonate-rich sediments that continues today on the North West Shelf. Seismically resolved late Miocene prograding carbonate wedges are well developed in the northern Dampier and Beagle sub-basins. These wedges are up to several kilometres thick on the Rankin Platform and in the Dampier Sub-basin, where they have provided the overburden for thermal maturation (Romine et al, 1997).

Stratigraphy

Seismic data shows that the Dampier Sub-basin is a complex depositional basin with about 6000 m of sediment deposited from the Triassic to Recent. Permian sediments were encountered in Arabella 1, located to the south of the Release Areas (**Figure 1**) and on the Peedamullah Shelf (**Figure 2**) both Permian and Carboniferous sediments have been intersected (Bentley, 1988). However, in the Release Areas well data indicates that Permian and older sediments have not been preserved and Early Triassic sediments directly overlie basement at Hauy 1, Lawley 1, Kanji 1, Gimlet 1 and Hampton 1 (**Figure 1**).

The basement includes Precambrian igneous and metamorphic rocks that are truncated by a weathered and erosional unconformity. Hampton 1 encountered medium brown-grey to olive-green cherts that may be of volcanic origin. Lawley 1 reached total depth in altered granitic gneiss and Hauy 1 on the Lambert Shelf terminated in economic basement composed of highly metamorphosed Paleozoic or older rocks. Deposition may have commenced on the shelf in the latest Permian rather than earliest Triassic, as the palynomorph *P.microcorpus* was identified in Hauy 1. These microfossils could be reworked, implying that only a brief interval separates the Permian and Triassic successions that in the eastern Barrow Sub-basin are separated by a significant unconformity (Bentley, 1988).

Following a short period of erosion in the Lopingian, an Early Triassic marine transgression followed. On the Lambert Shelf and Enderby Terrace, a basal Triassic sandstone grades upwards into a thick (~100-150 m) sequence of claystones with minor interbedded siltstones, sandstones and limestones that represents the marine Locker Shale (**Figure 3**). In the Middle to Late Triassic, decreasing marine influence resulted in the deposition of a fluvio-deltaic medium grained sandstone with interbedded claystone (Mungaroo Formation) as intersected at Hampton 1 in Release Area W09-17, on the Enderby Terrace (**Figure 5**). In more inboard locations the Late Triassic Mungaroo Formation is not preserved and the Locker Shale is directly overlain by Cretaceous sediments as at Gimlet 1 in Release Area W09-19.

After a minor marine incursion at the end of the Triassic, fluvio-deltaic sands with interbedded clays (Brigadier and North Rankin formations) were deposited, followed by the finer-grained Murat Siltstone (**Figure 3**). These latest Triassic to Early Jurassic units have been intersected in the western Dampier Sub-basin in the Lynx 1A well (Woodside Offshore Petroleum Pty Ltd, 1997) located in Release Area W09-12. The Middle Jurassic

is dominated by siltstone (Athol Formation, sometimes called the Middle Dingo Claystone) with a restricted deltaic to delta-front unit (Legendre Formation). The Legendre Delta developed in the early Bathonian in the Dampier Sub-basin, but sedimentation ceased by the early Callovian.

The mid-Callovian unconformity represents the onset of the continental breakup of the northwest Australian margin (Jablonski, 1997) and claystones of the transgressive Callovian Calypso Formation were deposited over the unconformity surface.

In the central depocentre of the Dampier Sub-basin, the shales and siltstones of the Dingo Claystone overly these sediments and although marine claystones dominate the Late Jurassic, there are also reservoir-quality turbidite, submarine fan, shoreline and fluvial sandstones (Angel Formation) that were deposited along the tectonically active margins of the sub-basin. Hydrocarbon-bearing Angel Formation sandstones are found along both the western (Angel, Wanaea, Cossack) and eastern (Saffron) sides of the Dampier Sub-basin (**Figure 2**, **Figure 4** and **Figure 8**).

The progradation of the Barrow Delta dominates the Early Cretaceous of the Exmouth and Barrow sub-basins, but in the Dampier Sub-basin the fine grained pro-delta sediments of the Forestier Claystone were deposited. Within the claystone and siltstones of the Early Cretaceous a number of sands occur, several of which are hydrocarbon bearing. These include the earliest Cretaceous Berriasian sandstone in the Legendre oil field.

Overlying the Forestier Claystone is the Muderong Shale (**Figure 3**), a dark grey to greenish-black claystone deposited in the Hauterivian to Aptian and containing a number of progradational cycles that deposited the *M. australis* Sandstone. The *M. australis* Sandstone is a significant reservoir in a number of fields on the Endreby Terrace including Wandoo, Stag, Tusk and Elk. The Elk accumulation is located within Release Area W09-16 (**Figure 4**).

The *M. australis* Sandstone is a very fine to fine-grained, moderate to well-sorted, glauconitic sandstone. It consists of 20-50 % quartz and 10-60 % glauconite. Low-angle, planar cross bedding is developed in the well-sorted fine-grained sandstones, which are typically 10-20 m thick. Crowley and Collins (1996) classified the *M. australis* Sandstone from the Wandoo and Stag accumulation wells as arkose to subarkose. It comprises greensands deposited in estuarine, shelf and shoreface environments (Dyson, 1998).

The *M. australis* Sandstone is overlain by the Muderong Shale, which in turn is overlain by the Aptian-Albian Windalia Radiolarite, which represents a maximum flooding surface. During the Albian to Turonian, regressive Gearle Siltstone was deposited on the Enderby Terrace and the Haycock Marl in the Lewis Trough and Rankin Platform.

In the Late Cretaceous marine conditions increased and coarse clastic sedimentation decreased. Deposition changed from clastic-dominated to carbonate-dominated (outer shelf to upper slope marine environment) with open ocean circulation in the latest Cretaceous. An open ramped-shelf developed with a large carbonate wedge (up to 4000 m thick) that continued into the Cenozoic.

Exploration History

The Dampier Sub-basin on Australia's north western margin has been subject to intensive exploration activity since the 1960s. The Legendre1 oil discovery was made in 1968 and by the end of 2001, the Dampier Sub-basin contained 55 field discoveries and more than 120 exploration wells had been drilled with an historical technical success rate of 41%; the success rate of fields greater than 20 MMboe is 22% (Longley et al, 2002).

The initial exploration was carried out by BOCAL (Burmah Oil Company of Australia Ltd-now Woodside Energy Limited) who conducted reconnaissance seismic surveys to establish the basic structural framework for the area. In 1964 Barrow Island oil field was discovered by West Australian Petroleum Pty Ltd (WAPET) in the Barrow Sub-basin (**Figure 8**) and in 1968 the successful drilling of Legendre 1 proved that the Dampier Sub-basin was also oil bearing.

In the early 1970s, numerous gas accumulations including Angel and Goodwyn and other smaller discoveries were made on the Rankin Platform. In 1970, drilling on the Enderby Terrace commenced with the drilling of Enderby 1 by BOCAL. The well, which had minor hydrocarbon shows, is located between the Wandoo field and the Wandoo South 1 well.

In the mid-late 1970s, exploration interest in the eastern Dampier Sub-basin dwindled and substantial areas of petroleum exploration permits were relinquished. In 1976, Withnell 1 was drilled in the Lewis Trough (in Release Area W09-13) by BOCAL Pty Ltd It reached a total depth of 4650 mRT in Middle Jurassic sediments and had gas shows in the Paleogene, Cretaceous and Jurassic sections.

During the early 1980s, exploration activity increased with the discovery of oil in Talisman 1 along the Legendre Trend, in the north-eastern Dampier Sub-basin (**Figure 1**, **Figure 2** and **Figure 4**). It was drilled by Marathon Petroleum Australia Ltd and flowed at a rate of 4778 bopd (780 m^3/d). Talisman was the first oil production project (discovered in 1984 with production from 1989 to 1992) in the Dampier Sub-basin. However, the oil potential of the sub-basin was not generally recognised until 1989 when the Wanaea and Cossack fields were discovered. The fields are located along the Madeleine Trend in the western Dampier Sub-basin (**Figure 1**). Wanaea (286.9 MMbbls) is the largest offshore oil field in the Northern Carnarvon Basin (Department of Mines and Petroleum, Western Australia, 2008).

Wandoo 1, drilled in 1991, was the first oil discovery on the Enderby Terrace and successfully proved a new reservoir objective, the Early Cretaceous *M. australis* Sandstone, in the Dampier sub-basin. A flow of 4560 bopd (19° API) from a depth of only 600 m heralded the discovery of a new hydrocarbon play along the eastern margin of the Dampier Sub-basin.

Throughout the 1990s, improvement in sub-surface imaging through 3D seismic acquisition and processing made a significant contribution to exploration success (Longley et al, 2002). The Stag oil field, another *M. australis* accumulation, was discovered in 1993, followed by Saffron in 1994, Elk and Antler in 1996, and Sage in 1999. Cherring 1 is an *M. australis* Sandstone gas discovery drilled in 1997 on the

Enderby Terrace, about 5 km north west of Nickol Bay 1.During 1997-1998**,** Caribou 1, Jaubert 1, Legendre South 1 and Reindeer 1 were drilled on the Legendre Trend to re-evaluate the earlier discoveries and test new play concepts (Ballesteros, 1998; Seggie et al, 2003). In 2000, discoveries were made at Corvus 1, Oryx 1, Tusk 1 and Chamois 1 located in the southeast Dampier Sub-basin, in the area between Release Areas W09-13 and W09-14, W09-15 and W09-16 (**Figure 1**).

In the northeast Dampier Sub-basin, oil accumulations were discovered at Pitcairn (1997), Mutineer (1998), Norfolk (2002) and Exeter (2002). These recent discoveries are significant in extending the Dampier Sub-basin oil province to the north of its previously known limits. In 2007, another oil discovery was made at Brocket in the southeast of the Dampier Sub-basin near the Oryx oil discovery.

Well Control

In excess of a 120 exploration and development wells have been drilled in the Dampier Sub-basin. Some of the key wells particularly relevant to the Release Areas are described below. Note that not all wells are shown on the location map (**Figure 1**). For more comprehensive maps please see the **Carnarvon Basin GeoPDF**.

Legendre 1 (1968)

The Legendre oil field was discovered by the first well to be drilled in the Dampier Sub-basin, Legendre 1 (1968), by Burmah Oil Company of Australia Ltd The well flowed oil at a maximum rate of 1014 bopd from a thin sandstone within the lower part of the Early Cretaceous (Berriasian, *B. reticulatum* biozone) (Seggie et al, 2003). Despite this early success, the field was not proven commercial until the late 1990s, when the appraisal wells Jaubert 1 and Legendre South 1 established reserves of some 48.9 MMbbls (Department of Mines and Petroleum, Western Australia, 2008). Production from the field commenced in May 2001.

Dampier 1 (1968)

Dampier1 is located immediately to the east of Release Area W09-13 in the Lewis Trough. The well, drilled by B.O.C. of Australia Ltd was programmed as a 4115 m stratigraphic test of the sedimentary section in a closed anticline. The well was drilled to a total depth (TD) of 4142 mRT and penetrated a sedimentary section ranging from Late Jurassic to Cenozoic. Moderate to high gas readings were recorded from several intervals in the Late Jurassic section. Drill stem tests (DSTs) of the intervals 2946-2988 m and 3048-3065 m recovered small amounts of gas but no fluids. An open hole DST of the interval 3652-4142 mRT flowed gas at a rate too small to measure, indicating a lack of significant porosity and permeability in the Late Jurassic. These results suggest that the tight, marine Late Jurassic sequence is essentially a source of hydrocarbons that have possibly not migrated very far from their site of generation because of the lack of adjacent reservoir rocks (Burmah Oil Company of Australia Ltd, 1969)

Enderby 1(1970)

Enderby 1, drilled by B.O.C. of Australia Ltd, was the first well drilled on the Enderby Terrace. It is located close to the western boundary of Release Area W09-17, and just to the south of the Wandoo oil field (**Figure 1**). Although thick porous sandstones were intersected in the Lower Cretaceous and Jurassic and thinner porous sandstones in the Triassic section, all were water wet and the well was plugged and abandoned at a TD 2941 mRT (Burmah Oil Company of Australia Ltd, 1980).

Hauy 1 (1972)

Hauy 1 located on the Lambert Shelf in Release Area W09-19, was drilled by B.O.C. of Australia Ltd to test for potential hydrocarbons trapped on the basin margin in Early Triassic to Albian sediments. Mesozoic sediments were identified in the well, with Cretaceous sediments unconformably overlying Middle Triassic sediments. The well reached a TD of 825 mRT in an igneous rock of indeterminate age. No hydrocarbon shows were recorded in the well and wireline log interpretation indicates that all porous sandstones are 100% water saturated.

Rosemary 1 (1973)

Rosemary 1 was drilled by B.O.C. of Australia to test the hydrocarbon potential of Lower Cretaceous/Jurassic and Triassic sediments in a large fault-block at the southwestern end of the Rosemary-Legendre Trend. The well reached a TD of 3909mRT in Early Jurassic sediments. Although good potential reservoir rocks were encountered and high gas readings were recorded in the Jurassic section, RFTs failed to recover hydrocarbons and the well was plugged and abandoned (**Figure 1** and **Figure 5**).

Hampton 1 (1974)

Hampton 1, located in Release Area W09-17, was drilled by B.O.C. of Australia Ltd to test an up-dip position on an east-northeast trending tilted-horst block on the Enderby Terrace (**Figure 5**). The well penetrated a Late Cretaceous to Early Triassic sedimentary section and terminated in chert of indeterminate age at a TD of 2584 mRT. Minor hydrocarbons were recorded whist drilling Early Cretaceous sandstones. Wireline log evaluation indicated a gross hydrocarbon column of 58 m with a water saturation of 65 %. Although thick porous sandstones were encountered in the Jurassic and Triassic, log interpretation indicated that they were water wet (Woodside/Burmah Oil NL, 1974).

Withnell 1 (1976)

Withnell 1, located within Release Area W09-13, was drilled by BOCAL Pty Ltd to test a structure along the Madeleine Trend (**Figure 1** and **Figure 2**). It reached a total depth of 4650 mRT in Middle Jurassic sediments and reported gas shows in the Cenozoic,

Cretaceous and Jurassic section.

Lewis 1A (1976)

Lewis 1A ,located some 10 km to the west of Release Area W09-18, was drilled by BOCAL Pty Ltd to test an anticlinal culmination on the Legendre Trend, on the opposite side of the Lewis Trough to Withnell 1 (**Figure 1** and **Figure 2**). Lewis 1A reached a TD of 3400 mRT in Middle Jurassic sediments. No significant hydrocarbon indications were detected. Fine-grained facies dominated the Early Cretaceous section and the hydrocarbon bearing sands intersected at Legendre 1 to the northeast were absent. (Burmah Oil Company of Australia Ltd, 1976).

Parker 1 (1980)

Parker 1, located some 30 km to the west of Release area W09-13, was drilled by Woodside Petroleum Development Pty Ltd to test a tilted fault-block on the Kendrew Terrace (**Figure 1** and **Figure 6**). The well reached a TD of 4737 mRT in Lower Jurassic sandstones. Gas shows were recorded during drilling but RFT testing was unsuccessful due to tool failure.

Lawley 1 (1981)

Lawley 1, located in Release Area W09-19, was drilled by Hudbay Oil (Australia) Ltd to test a horst block lying immediately adjacent to the northwest flank of the Lambert Shelf (**Figure 7**). The well penetrated a sedimentary section ranging from Cretaceous to Early Triassic overlying altered granitic gneiss basement. The Jurassic section was absent. The well reached a TD of 1120 mRT without encountering any significant hydrocarbon indications.. Traces of patchy, dull yellow fluorescence were noted on some quartz grains below 690 mRT. Interpretation of wireline logs indicates that no free or residual hydrocarbons were present in the well. The well contains a large proportion of unconsolidated, porous sands that are water wet (Hudbay Oil (Australia) Ltd, 1982a).

Strickland 1 (1982)

Strickland 1, located in Release Area W09-18, was drilled by Hudbay Oil (Australia) Ltd to a TD of 1050 m. The well was drilled to test a double plunging anticlinal structure at the inner edge of the Enderby Terrace (**Figure 5**) and penetrated a sedimentary sequence ranging in age from Early Cretaceous (Albian) to Middle Triassic (Anisian). Fluorescence and cut were observed in cuttings between 530 and 595 mRT which are postulated to be indicative of a trace of immovable, residual hydrocarbon indicating that liquid hydrocarbons have migrated through the structure. It is believed that the failure of the well was due to faulting resulting in juxtaposition of sand-to-sand at the critical levels (Hudbay Oil (Australia) Ltd, 1982b).

Rosemary North 1 (1982)

Rosemary North 1 is located adjacent to the Sage field between Release Areas W09-13 and W09-18 (**Figure 1**). The well was drilled by Woodside Offshore Petroleum Pty Ltd to a TD of 2263 mRT. The well was drilled on the Legendre Trend to test Late Jurassic sandstones at the crest of a faulted anticlinal structure. Secondary objectives consisted of sandstones immediately beneath the Albian/Aptian boundary and sandstones within the Early Cretaceous sequence. It penetrated a sedimentary sequence ranging in age from Eocene to Tithonian and recorded minor gas shows. Wireline log analysis indicates the Tithonian sandstones between 2195 and 2202.5 mRT have a porosity ranging from 18-25 % and a hydrocarbon saturation ranging from 10-29 %. These hydrocarbons correlate with minor shows in cuttings and SWCs and are presumed to be residual (Woodside Petroleum Ltd, 1983).

Arabella 1 (1983)

Arabella 1 is located to the south of the Release Areas on the basin margin. It was drilled Australian Occidental Petroleum Pty Ltd to test a fault bounded anticline and is considered a valid structural test of basal Triassic sands and Permian sandstones intersected below the Cretaceous section. The lack of hydrocarbons in the well is attributed to the thermal immaturity of the local prosect area (Australian Occidental Petroleum Pty Ltd, 1983).

Nickol Bay 1 (1988)

Nickol Bay 1 is located on the Enderby Terrace on the western edge of Release Area W09-18. It was drilled by Arco Australia Limited to test the Triassic Mungaroo Formation, sealed by Early Jurassic shale in a tilted Triassic fault-block. Horizontal seal across the faults was to be provided by Lower-Middle Jurassic shales. The Mungaroo Formation was expected to be in excess of 500 m thick. Secondary sandstone objectives were expected in the Middle Jurassic and base Triassic. The well was drilled to a TD of 2739 mKB without encountering any significant hydrocarbon shows. Geochemical analyses indicate low quality and immature source rocks for the drilled interval. In addition, the high sand content of the Early Jurassic sediments makes vertical seals and seals across the bounding faults suspect. This has been confirmed by post-drilling seismic analyses. Both factors are believed to have contributed to the failure of the well to encounter significant hydrocarbons (Arco Australia Ltd, 1988).

Cygnus 1 (1989)

Cygnus 1 is located on the Enderby Terrace some 10 km northeast of Release Areas W09-18 (**Figure 1**). It was drilled by Arco Australia Limited to test the Lower Jurassic North Rankin and the Upper Triassic Mungaroo formations on a northeast-trending faulted anticline. The well reached a total depth of 2470 mDF within Middle Triassic claystones without encountering any significant hydrocarbons. The basal part of the

Dingo Claystone, which overlies the North Rankin Formation, was found to be sandy. Potential source rocks in this well tend to be of poor quality for hydrocarbon generation and are immature (Arco Australia Ltd, 1989).

Wandoo 1 (1991)

The Wandoo oil field was discovered by Ampolex Limited adjacent to the western boundary of Release Area W09-17 (**Figure 1**). The discovery well, Wandoo 1 was drilled in June 1991 some 2.5 km northeast of Enderby 1 (drilled almost 20 years earlier) to a TD of 1570 mRT. Wandoo 1 intersected oil and gas in Early Cretaceous sands associated with the *M. australis* dinoflagellate zone (Barremian), and gas from Early Jurassic (Aalenian) sands. The main reservoir at Wandoo is the *M. australis* Sandstone Member of the Muderong Shale. The reservoir is unconsolidated primarily due to the shallow depth of burial at around 600 mSS. The accumulation occurs in a low-relief, roll-over structure on the up-thrown side of a regional fault (Delfos and Boardman, 1994).

Despite its biodegraded nature, the Wandoo oil flowed to surface at rates of up to 10000 bopd. The Wandoo oil field is characterised by having a shallow reservoir, high oil viscosity, thin oil column, unconsolidated sands and very high permeability. Porosity is greater than 35 % and is matched with tens of darcies of permeability. The glauconite in the Wandoo area is of a microcrystalline pelletal form, and thereby forms part of the rock framework, helping maintain excellent reservoir properties (Delfos and Boardman, 1994). The reserves are estimated at 97.4 MMbbl (Department of Mines and Petroleum, Western Australia, 2008) and production commenced from the field in October 1993.

Forrest 1, 1A and 1A ST1 (1992)

Forrest 1A ST1 is located to the south of the Release Areas in the central basin depocentre. It was drilled by Phillips Australian Oil Company to test a large anticline on the southern extension of the Madeleine Trend with stacked Late Jurassic to Early Cretaceous reservoir objectives. Reservoir development was dependent on the deposition of detached, basin floor submarine fan sands. Due to drilling problems the initial well, Forrest 1, was plugged and abandoned at 645 mRT, and following further difficulties the new hole, Forrest 1A ,was side-tracked at 3426 mRT with the Forrest 1A ST1 terminating in over-pressured Late Jurassic Dingo Claystone at 4300 mRT. Good gas shows were recorded in the Early Cretaceous (Phillips Australian Oil Company, 1992).

Stag 1 (1993)

The Stag oil field is located on the Enderby Terrace some 25 km southwest of the Wandoo oil field, adjacent to Release Areas W09-16 and W09-17. The Stag 1 discovery well, drilled by Hadson Dampier Pty Ltd, reached a TD of 933mRT and intersected a gross oil column of 15.5 m within the Early Cretaceous *M. australis* sandstone. Two of the appraisal wells were tested; Stag 2 flowed 1050 bopd from a 5 m vertical section and

Stag 6 flowed at 6300 bopd on pump from a 1030 m horizontal section. The reservoir quality of the *M. australis* sandstone at Stag oil field is excellent, but evaluation has been complicated by the high glauconite content which has affected log and other analyses (Crowley and Collins, 1996). The *M. australis* sandstone is interpreted by Crowley and Collins (1996) to have been deposited on a broad quiescent shelf with very low sedimentation rates. All the facies are dominated by glauconite and bioturbation, including *Rhizocorallium*, *Skolithos* and *Cruziana* ichnofacies which are characteristic of a moderate to relatively low energy environment. Abundance of small scale wavy bedding with shale laminae and small scale, low angle cross-bedding, indicates low but consistent current energy. Variations in the glauconite content and associated early formed carbonate cementation, record fluctuations of sea-level which terminated in the erosion of the top of the reservoir during a relative sea-level low. Subsequent deposition of transgressive and highstand systems tract sediments preserved the reservoir from further modification.

Kanji 1 (1994)

Kanji 1 was drilled by Ampolex Ltd on the Enderby Terrace in Release Area W09-19.. It was drilled to appraise the hydrocarbon potential of an interpreted four way dip closure of Early Cretaceous sediments unconformably draped over a Triassic tilted fault block. The primary objective of the well was the *M australis* sandstone. Triassic sandstones within an underlying horst block constituted a secondary objective. The well reached a TD of 1288 mRT in Middle Triassic sediments. Stratigraphic units encountered range from Holocene to Middle Triassic. The Early Cretaceous section was sandier than predicted and the Locker Shale was homogeneous rather than intercalated as predicted. All unit tops, except the main unconformity, were shallow to prognosis. An interpreted change in structural dip suggests the presence of an angular unconformity between the Locker Shale and Mungaroo Formation. Sandstones within the Early Cretaceous section are of excellent reservoir quality and have a log-derived average porosity of 25 %. The Triassic section also displays excellent reservoir qualities. No hydrocarbon shows were encountered during drilling. The absence of hydrocarbons is attributed to a lack of seal to the primary *M. australis* sandstone objective, an invalid structure at the *M. australis* sandstone level; and/or lack of effective migration pathways (Ampolex Ltd, 1994).

Saffron 1 (1994)

Saffron 1, located 2 km northeast of Rosemary 1 on the Legendre Trend is an oil and gas discovery. The well was drilled by Woodside Offshore Petroleum Pty Ltd to a TD of 2496 mRT in the Dingo Claystone. The well was designed to test the Tithonian Angel Formation in a low-relief faulted-anticlinal feature with Barremian sands within the Muderong Shale as a secondary objective. Stratigraphic units encountered range from Holocene to Oxfordian in age. Good quality reservoir sands were encountered and hydrocarbon pay was intersected in the Tithonian and Barremian sands. The depths of the oil-water-contacts and post-drill mapping suggest that the Tithonian and Barremian traps are full to the structural spill point. The presence of gas in the reservoir (80% by volume) suggests an overmature or gas-prone source rock. Results have increased the

gas risk for similar or deeper wells in the area. However, the presence of the oil leg could upgrade shallower prospects situated on the hydrocarbon migration route out of the basin (Woodside Offshore Petroleum Pty Ltd, 1996).

Tingle 1 (1993)

Tingle 1 is located immediately north of Release Area W09-17 and approximately 5 km southeast of the Wandoo oil field (**Figure 1**). It was drilled by Ampolex Ltd to test a three-way dip closure against a fault at the Lower Cretaceous level. The well reached total depth at 1050 mRT in Middle Jurassic sandstone. The *M. australis* sandstone was present and of excellent reservoir quality but no significant hydrocarbon shows were encountered. The lack of shows despite a valid structural trap is attributed to Tingle 1 being in the migration shadow of Wandoo structure or lack of seal along the fault component of the trap (Ampolex Ltd, 1996).

Hyperno 1 (1995)

Hyperno 1 is located in Release Area W09-17 on the Enderby Terrace some 6 km south of the Wandoo oil field. The well was drilled by Ampolex Ltd to a TD of 874 mRT in Bajocian sediments. The Hyperno prospect was prognosed as a stratigraphic pinch-out of the Wandoo reservoir sands. The prospect relied on base seal being provided by the pinch out of this sand to the south, cross-fault seal against the southeast down-thrown Tingle Fault to the southeast and dip closure to the northeast and northwest. Hyperno 1 intersected the *M. australis* sandstone 9.5 m below the oil-water contact of the Wandoo accumulation. No direct hydrocarbon fluorescence was observed in cuttings or sidewall cores (Ampolex Ltd, 1997).

Elk 1

Elk is a small gas accumulation located within Release Area W09-16, on the southern portion of the Enderby Terrace some 8km north of the Stag oil field. Elk 1 was drilled by Apache Energy Ltd to a TD of 1110 mRT. At depth the Elk structure is controlled by an underlying northeast-trending fault block. The primary objective was the *M. australis* sandstone within a small 4-way dip closure with potential for significant stratigraphic enhancement. Shelfal marine sands between the base Cretaceous and Bajocian unconformities within the upper Athol Formation provided the secondary objective. Petrophysical and pressure data indicate a 2.2 m dry gas column within the top *M. australis* sandstone (Apache Northwest Pty Ltd, 1997a).

Antler 1 (1996)

Antler is a small gas and oil accumulation located 9 km west of the Stag oil field and between Release Areas W09-14, W09-16 and W09-17 (**Figure 1**). Antler 1 was drilled by Apache Energy Ltd to a TD of 1037 mRT with the *M. australis* sandstone in a broad low

relief structure as its primary target. The top of the *M. australis* sandstone was intersected 1.5 m low to prognosis and contained a 2.4 m gas column overlying a 1.4 m oil leg (Apache Northwest Pty Ltd, 1996).

Greenshank 1 (1996)

Greenshank 1 is located on the southern Enderby Terrace between Release Areas W09-14 and W09-15 (**Figure 1**). It was drilled by Apache Northwest Pty Ltd to a total depth of 2500 mRT, terminating in Oxfordian sandstone. The well was designed to investigate a seismic amplitude anomaly associated with an interpreted lower *M. australis* basin floor fan sequence. The stratigraphic units intersected were close to prognosis, with differences due to internal velocity variations. The objective lower *M. australis* sandstone sequence was intersected at 2048 mRT, 23.6 m high to prognosis, but as expected in TWT proving the slope/basin floor fan reservoir model. Petrophysical analysis indicates good reservoir quality (log derived porosity of 16%) in the upper 3.2 m of the sandstone sequence. The remainder of this sequence is of fair to poor reservoir quality. The interpreted depositional environment suggests that the sandstones are likely to be laterally continuous and that net reservoir thickness is likely to improve towards the east-southeast. The slightly younger middle *M. australis* sandstone, which proved to have good reservoir properties in the Stag oil field 25 km to the south east, was not encountered in the well. Sandstone sequences with good reservoir potential were encountered both above and below the base Cretaceous unconformity. An approximately 50 m thick sequence of Valanginian sandstones was found to overlie an Oxfordian turbidite sequence. The Valanginian sands average up to 16.5% porosity, while log data indicates the Oxfordian sands have an average porosity of 15 %. All sandstones were found to be water saturated. The absence of significant hydrocarbons (minor gas) in the well is attributed to ineffective lateral seal (Apache Northwest Pty Ltd, 1997b).

Cognac 1B (1996)

Cognac 1B, located in Release Area W09-13, was drilled by M.I.M. Petroleum Exploration Pty Ltd to test the hydrocarbon potential of the Tithonian Angel Formation in a faulted anticline along the Madeleine Trend. The well reached a total depth of 3690 mRT in Upper Jurassic (Tithonian) sediments. Minor oil and gas shows were recorded.

Lynx 1A (1996)

Lynx 1A, located in Release Area W09-12, was drilled by Woodside Offshore Petroleum Development Pty Ltd to test the Middle Jurassic and Early Jurassic to Triassic levels in a large structure along the Madeleine Trend (**Figure 1** and **Figure 2**). The complexity of the Lynx structure made 3D seismic critical to locating the well (Kingsley and Tilbury, 1999).Three main tight gas intervals were encountered within the Legendre, North Rankin and Brigadier formations (Woodside Offshore Petroleum Pty Ltd, 1997). The well was plugged and abandoned at a TD of 5190 mRT after encountering hydrocarbons in these tight, non-productive reservoirs.

Bugle 1 (1997)

Bugle 1 is located on the Enderby Terrace to the northwest of Release Area W09-18 and to the north of Release Area W09-19 (**Figure 1**). It was drilled by Apache Northwest Pty Ltd to test the North Rankin and Legendre formations and early Cretaceous sands in a titled fault-block. The well reached a TD of 1833 mRT and encountered reservoir quality sandstones at all three objective levels but no hydrocarbon shows were recorded. The lack of hydrocarbons is interpreted to be due to a lack of cross-fault seal at the North Rankin Formation and base Cretaceous levels (Apache Energy Ltd, 1999a).

Buck 1 (1997)

Buck 1 is located on the Enderby Terrace to the northwest of Release Area W09-18 and to the north of Release Area W09-19 (**Figure 1**). It was drilled by Apache Northwest Pty Ltd to test the *M. australis* sandstone on a low relief anticline. The well reached a TD of 1050 mRT. Reservoir quality sands were encountered but no hydrocarbon shows were recorded. Re-interpreted mapping places the Buck 1 well location on the edge of the mapped structure and it may be outside closure due to lateral velocity variations (Apache Energy Ltd, 1999b).

Reindeer 1 (1997)

Reindeer is a gas field located on the Enderby Terrace some 6 km north of Release Area W09-15 (**Figure 1**). Reindeer 1, the discovery well, was drilled by Apache Energy Ltd to test a northeast-trending, four way dip closure on an anticline mapped at the top of the Jurassic Legendre Formation (Apache Energy Ltd, 2005a). Secondary targets were predicted in the Calypso Formation and in the Early Cretaceous *M. australis* sandstone. No movable hydrocarbons were found in the secondary targets but an 87.5 m gas column was found in the Legendre Formation sands. The well reached a TD of 2905 mRT in the Legendre Formation (Apache Energy Ltd, 2005a).

There are advanced plans for the development of Reindeer with the neighbouring Caribou gas accumulation for the local domestic market including mineral processing. The proposed pipeline will run south from the accumulations to a new gas plant being built onshore at Devil Creek (Devil Creek Development Project, 2009).

Wandoo South 1 (1997)

The Wandoo oil field is located on the western edge of Release Area W09-17, approximately 7 km southwest of the North Rankin Gas Condensate pipeline. Wandoo South 1 was drilled by Mobil Exploration and Producing Australia Pty Ltd to evaluate the *M. australis* sandstone. The well was drilled to a TD of 802 m, terminating in Bathonian sediments beneath the base Cretaceous unconformity. The reservoir is not as clean as the Unit 'B' Sandstone in the main Wandoo oil field. Reservoir quality improves in the lower portion of the *M. australis* Sandstone where pelletal and argillaceous/glauconitic

matrix is reduced to less than 10 %. The major stratigraphic variation from prognosis was the increased thickness of the Muderong Shale. No gas anomalies or shows were observed during the intersection of the *M. australis* sandstone. Petrophysical analysis confirmed all reservoirs intersected in this well are water saturated. Wandoo South 1 intersected the *M. australis* sandstone (top porosity) 6 m above the OWC of the Wandoo field. The sandstone is an excellent quality, dominantly medium grained, glauconitic quartz sandstone, but no hydrocarbons were present. The reservoir sands are in communication with the Wandoo field reservoir (Mobil Exploration and Producing Australia Pty Ltd, 1998).

Caribou 1 (1998)

The Caribou gas accumulation is located on the Enderby Terrace between Release Areas W09-13, W09-15, W09-16, W09-17 and W09-18 (**Figure 1**). Caribou 1, the discovery well, was drilled by Apache Energy Ltd to test a large north-trending titled fault-bock and horst complex at the top Mungaroo Formation level. The northern part of the structure is mapped as partially underlying the Reindeer gas accumulation in the Jurassic Legendre Formation. The well was drilled to a TD of 3710 mRT and intersected a 21.6 m gross gas column in the Legendre Formation which is interpreted to be in pressure communication with the Legendre gas accumulation at Reindeer 1 some 3 km to the north. Other gas sands were also intersected in the North Rankin and Mungaroo formations and pressure data indicates that the Legendre, North Rankin and Mungaroo reservoirs in Caribou 1 are not in pressure communication (Apache Energy Ltd, 2001).

Gimlet 1 (1998)

Gimlet 1 is located in Release Area W09-19, some 40 km east of the Wandoo B production facility and 5 km south of Kanji 1. The well was drilled by Mobil Exploration and Production Australia Pty Ltd to a total depth of 684 mRT. Gimlet 1 tested a three-way dip closure of the southeasterly pinch-out of the *M. australis* sandstone between the Muderong Shale and igneous basement rocks along the Lambert Fault escarpment. The *M. australis* sandstone was the primary objective with other sands in the Lower Cretaceous and Triassic being secondary targets. In Gimlet 1 the Albian Gearle Siltstone was absent due to erosion by an Eocene channel. The *M. australis* sandstone was present but of lower reservoir quality than expected due to a high glauconite content. The lack of significant hydrocarbon indications is attributed to lack of an effective Muderong Shale top seal due to breach by the Eocene channel, by small scale faulting, or because of an invalid trap due to failure of the pinchout closure at the Muderong Shale/ basement interface (Mobil Exploration and Producing Australia Pty Ltd, 2000).

Morrel 1 (1998)

Morrel 1 is located in Release Area W09-17 only 1.5 km southeast of Hampton 1. The well was drilled by Mobil Exploration and Production Australia Pty Ltd to a TD of 800 mRT. Primary objectives were the *M. australis* sandstone and the Windalia Sandstone.

Small non-commercial gas accumulations were identified in the *M. australis* sandstone, as well as in the overlying Windalia Sandstone equivalent. The gas accumulations within the Windalia Sandstone equivalent and *M. australis* sandstone are both predominantly methane (>97%) and contain an estimated 8bcf and 3bcf of dry gas in place respectively (Mobil Exploration and Production Australia Pty Ltd, 1998). In the absence of a commercial accumulation of hydrocarbons, Morrel 1 was plugged and abandoned as a minor gas discovery.

Webley 1A (1999)

Webley 1A , located some 10 km west of Release Area W09-13, was drilled by Woodside Energy Ltd to test Lower Jurassic and Triassic reservoirs in a fault block. Due to well control problems the well was terminated in the Cretaceous Windalia Radiolarite at a TD of 3108 mRT. High gas readings were encountered in the Cretaceous seal section.

Corvus 1 (2000)

The Corvus gas accumulation is located in the central Dampier Sub-basin between Release Areas W09-13 and W09-15 (**Figure 1**). Corvus 1, the discovery well, was drilled by Apache Northwest Pty Ltd to test multiple reservoir targets in Early Cretaceous, Jurassic and Triassic formations within a complex faulted, four-way dip closed structure on the up-thrown side of the Legendre Trend. Corvus 1 was successful in discovering a 427 m gross and 62.8 m net pay gas column in the North Rankin and Mungaroo formations. Flows of 15 MMcfd with 20 bbl/d of condensate were recorded (Apache Energy Ltd, 2003a)

Oryx 1 (2000)

Oryx 1 is located on the southern portion of the Enderby Terrace some 6 km west of Release Area W09-14 (**Figure 1**). It was drilled by Apache Energy Ltd to a TD of 1853 mRT to test Early Jurassic and Triassic sandstones (North Rankin, Brigadier and Mungaroo formations) in a tilted fault-block trap that had been mapped on good quality multi-client 3D data acquired in 1999. The North Rankin and Brigadier formations were absent due to erosion but oil pay was found in sandstone interbeds within the shale-prone Athol Formation and a residual oil column was recognised in the underlying Mungaroo Formation (Apache Northwest Pty Ltd, 2004). Reserves of 3.2 MMbbls of oil are listed for the Oryx accumulation (Department of Mines and Petroleum Western Australia , 2008).

Tusk 1 (2000)

Tusk 1 is located approximately 5 km northeast of the Oryx 1 oil discovery and 20 km west of the Stag oil field between Release Areas W09-14 and W09-16 (**Figure 1**). Tusk 1 was drilled by Apache Northwest Pty Ltd to a TD of 2020 mRT as a deviated exploration

well with multiple reservoir targets through the Early Jurassic and Triassic sandstones of the Athol and Mungaroo formations on the southern portion of the Enderby Terrace. The Tusk structure is a tilted fault-block that was mapped on good quality 1999 multi-client 3D seismic data with closure present at the Jurassic Athol Formation and Middle Triassic Mungaroo Formation levels. Closure is formed by dip to the north, west and south and by fault dependent closure to the southeast. Minor oil shows were seen in the *M. australis* sandstone and the underlying Berriasian sandstone, but log analysis indicated these were not economic. The Jurassic Athol Formation sands intersected in Tusk 1 were found to be oil saturated with the oil column extending into the top of the Triassic Mungaroo Formation. Log analysis indicates a total net hydrocarbon pay column of 31.8 m with an average porosity of 21% and water saturation of 48%.

Chamois 1 (2000)

Chamois 1 is located 9 km southwest of Oryx 1 oil discovery and to the south of Release Area W09-14 (**Figure 1**). The well was operated by Apache Northwest Pty Ltd and drilled to a total depth of 1356 m. The primary objective was the Mungaroo Formation and secondary objectives were the Athol Formation and the *M*. *australis* sandstone. The *M. australis* sandstone was intersected at 771.0 mRT and a gas sand occurs from 771.0 to 780.0 mRT. This 9.0 m thick unit has a net to gross of 72.5% with 25.3% net pay, an average porosity of 29% and permeabilities ranging from 86.2 to 1337.7 mD. An oil sand (residual oil) occurs from 780.1 to 810.0 mRT. This 29.8 m thick unit has a net to gross of 58.3% with no net pay, an average porosity of 25% and permeabilities ranging from 31.3 to 1435.5 mD. Sandstone interbeds within the shale-prone Athol Formation, overlying the Bajocian seismic marker exhibit 'hot' gamma-ray and low resistivity values and range in thickness from 5.0 to 11.0 m. Porosity ranges from 23% to 29% and permeabilities range from 0.3 to 4440.6 mD. Intervals of residual oil were identified in a sample taken from the *C. halosa* sand member and a live oil column was identified in this member. The Bajocian unconformity was intersected at 978.0 mRT. Below this unconformity lies the basal Bajocian sand member, which is 16.7 m thick, has an average porosity of 23% and permeabilities ranging from 0.1 to 5621.8 mD. The basal Bajocian sand member was devoid of significant hydrocarbons although intervals of residual oil were identified. The Athol Formation disconformably overlies the Mungaroo Formation (Apache Energy Ltd, 2003b).

Kudu 1 (2000)

Kudu 1 is located close to the southwestern corner of Release Area W09-14, approximately 25 km west southwest of the Stag oil field on the southern edge of the Enderby Terrace (**Figure 1**). The well was drilled by Apache Energy to test Early Jurassic and Triassic sandstones of the Athol and Mungaroo formations (Apache Energy Ltd, 2004a). It was drilled to a total depth of 1940 mRT in the Triassic (Anisian to Carnian). The Kudu structural feature is a tilted fault-block that trends northeast parallel to the faults that control the Chamois, Oryx and Tusk oil accumulations (**Figure 1**). Kudu 1 was designed to be approximately 200 m from the fault plane at the primary objective level, on the up-thrown side of the fault. This fault ceased movement in the Early Cretaceous.

Sandstone interbeds within the shale-prone Athol Formation, overlying the Bajocian seismic marker, formed the first objective of the well. The second primary objective was the fluvio-deltaic sandstones lying below the Pliensbachian unconformity within the Mungaroo Formation. Weak hydrocarbon shows were observed in cuttings samples above the primary targets in the Upper Muderong Shale. A gas peak of 440 units was recorded from this interval, from 908.0 mRT. Minor fluorescence was observed intermittently in cuttings samples in the Athol Formation. The average background gas was 282 units. Sidewall cores recovered from the Athol Formation displayed oil staining: gas peaks were associated with these shows. Sidewall cores recovered from the near the top of the Mungaroo Formation displayed weak fluorescence. (Apache Energy Ltd, 2004a).

Rhebok 1 (2000)

Rhebok 1 is located some 11 km from the eastern edge of Release Area W09-17 (**Figure 1**). It was drilled by Apache Northwest Pty Ltd to test an east-trending stratigraphic pinch-out of the *M. australis* Sandstone (Apache Northwest Pty Ltd, 2003a). However no reservoir quality sands were intersected at this level and no significant hydrocarbon occurrences were recorded before the well reached TD in the Triassic Mungaroo Formation at 1082.0 mRT. Rhebok 1 is one of several wells drilled on the shallow inboard Enderby Terrace between Release Areas W09-14 and W09-17, including Kudu 1, Chamois 1, Ceres 1, Oyrx 1, Antler 1, Springbok 1 and Longhorn 1. For a detailed map of the area please refer to the **Carnarvon Basin GeoPDF**.

Bloodwood 1 (2002)

Bloodwood 1, located in Release Area W09-18, was drilled by Mobil (Legendre) Pty Ltd to test the Barremian *M. australis* sandstone within the crest of a northeast- trending tilted fault block on the Enderby Terrace. Minor oil indications were recorded in the *M. australis* sandstone but no significant hydrocarbon accumulation was encountered, probably due to leakage across the bounding fault (Apache Northwest Pty Ltd, 2003b). However, the presence of these shows suggests that Bloodwood 1 lies on a migration pathway. The well terminated in the Middle Jurassic Athol Formation at a TD of 834mRT.

Cerberus 1 (2003)

Cerberus 1 is located in Release Area W09-18 on the Enderby Terrace. It was drilled by Apache Northwest Pty Ltd to test sands in the North Rankin and Legendre formations in a three-way dip and fault bounded structure. The well was drilled to a total depth of 2182 mRT and no hydrocarbon shows were encountered (Apache Energy Ltd, 2005b).

Chiru 1 (2003)

Chiru 1 is located in Release Area W09-16 and was drilled in exploration permit

WA-209-P R2 by Apache Oil Australia Pty Ltd Chiru 1 was designed to test Athol and Mungaroo formations in a buttress trap formed by the intersection of north-south and east-west trending fault sets. It was drilled to a TD of 1779 mRT without encountering any hydrocarbons (Apache Energy Ltd, 2004b).

Kilauea 1 (2003)

Kilauea 1 is located in the central Dampier Sub-basin, immediately to the north of Release Area W09-14 (**Figure 1**). The well was drilled by Apache Northwest Pty Ltd to test a buttress trap located in the same fault block as the Corvus gas discovery. Elevated gas readings were encountered in sands in the North Rankin and Mungaroo formations. However the North Rankin Formation reservoirs were both poorly developed and thinner than at the Corvus accumulation, 12 km to the northeast (Lilienthal, 2003).

Bandera 1 (2003)

Bandera 1 is located to the immediate south of Release Area W09-14. It was drilled by Apache Northwest Pty Ltd and plugged and abandoned with no hydrocarbon shows.

Muggles 1 (2004)

Muggles 1, located on the northwestern boundary of Release Area W09-18, was drilled by Apache Northwest Pty Ltd The well was drilled to a total depth of 1600 m and was plugged and abandoned with no hydrocarbon shows.

Libris 1 ST1 (2006)

Libris 1 well is located in the Lewis Trough about I km from the eastern boundary of Release Area W09-13. It has been reported by Blevin (2007) as a sub-economic oil discovery made by Apache Energy in the Late Jurassic Angel Formation.

Brocket 1 (2007)

Brocket 1 is located about 1 km to the northwest of the Oyrx oil accumulation and some 10 km to the east of Release Area W09-14. It has been reported as having oil shows (Krassay et al, 2008).

Table 1: Key wells listing

Well	Operator	Year	Total Depth	Hydrocarbons
Amulet 2	Tap Oil limited	2006	2052 mRT	Oil

Arabella 1	Australian Occidental Pty Ltd	1983	2209 mRT	No tests
Bloodwood 1 (Apache)	Mobil (Legendre) Pty Ltd	2002	834 mRT	minor gas
Brocket 1	Apache Northwest Pty Ltd	2007	1944 mRT	minor oil
Buck 1	Apache Northwest Pty Ltd	1997	1050 mRT	no tests
Bugle 1	Apache Energy Ltd	1997	1833 mRT	no tests
Cerberus 1	Apache Northwest Pty Ltd	2003	2182 mRT	no tests
Chamois 1	Apache Northwest Pty Ltd	2000	1356 mRT	Oil and Gas
Chiru 1	Apache Northwest Pty Ltd	2003	1779 mRT	no tests
Cognac 1	Santos Asia Pacific Pty Ltd	1996	1213 mRT	no tests
Cognac 1 ST1	Santos Asia Pacific Pty Ltd	1996	628 mRT	no tests
Cognac 1A	Santos Asia Pacific Pty Ltd	1996	1383 mRT	no tests
Cognac 1B	Santos Asia Pacific Pty Ltd	1996	3690 mRT	minor oil and minor gas
Cygnus 1	Arco Australia Limited	1989	2470 mRT	no tests
Dampier 1	B.O.C. of Australia Limited	1969	4142 mRT	minor oil and minor gas

Elk 1	Apache Energy Limited	1996	1110 mRT	Gas
Forrest 1	Phillips Australian Oil Company	1992	645 mRT	No tests
Forrest 1A	Phillips Australia Oil Company	1992	3426 mRT	No tests
Forrest 1A ST1	Phillips Australia Oil Company	1992	4300 mRT	Minor gas
Gimlet 1	Mobil Exploration and Producing Australia Pty Ltd	1998	684 mRT	No tests
Greenshank 1	Apache Northwest Pty Ltd	1996	2500 mRT	no tests
Hampton 1	B.O.C. of Australia Ltd	1974	2584 mRT	Gas
Hauy 1	B.O.C. of Australia Limited	1972	825 mRT	no tests
Hyperno 1	Ampolex Limited	1995	874 mRT	no tests
Kanji 1	Ampolex Limited	1994	1288 mRT	no tests
Lawley 1	Hudbay Oil (Australia) Ltd	1981	1120 mRT	no tests
Lewis 1	BOCAL Pty. Ltd.	1976	265 mRT	no tests
Lewis 1A	BOCAL Pty. Ltd.	1976	3400 mRT	no tests
Libris 1	Apache Northwest Pty Ltd	2006	2940 mRT	no public data
Lynx 1	Woodside Offshore Petroleum Pty. Ltd.	1996	2090 mRT	No tests

Lynx 1A	Woodside Offshore Petroleum Pty. Ltd	1996	5190 mRT	Minor gas
Mermaid 1	West Australian Petroleum Pty Ltd	1978	1271 mRT	No tests
Morrel 1	Mobil Exploration and Producing Australia Pty Ltd	1998	800 mRT	Gas
Muggles 1	Apache Northwest Pty Ltd	2004	1600 mRT	no public data
Nickol Bay 1	ARCO Australia Limited	1988	2739 mRT	no tests
Oryx 1	Apache Energy Limited	2000	1853 mRT	minor oil
Rosemary 1	B.O.C. of Australia Ltd.	1973	3909 mRT	Gas
Rosemary North 1	Woodside Petroleum Development Pty Ltd	1982	2263 mRT	minor gas
Saffron 1	Woodside Offshore Petroleum Pty. Ltd.	1994	2496 mRT	Oil and Gas
Sage 1	Apache Northwest Pty Ltd	1999	2271 mRT	Oil
Stag 1	Hadson Dampier Pty Ltd	1993	933 mRT	Oil and Gas

Strickland 1	Hudbay Oil (Australia) Ltd.	1982	1050 mRT	no tests
Tingle 1	Ampolex Limited	1993	1050 mRT	no tests
Tusk 1	Apache Northwest Pty Ltd	2000	2020 mRT	Oil
Tusk 1 CH1	Apache Northwest Pty Ltd	2000	1214.5 mRT	no tests
Tusk 2	Apache Northwest Pty Ltd	2001	1377 mRT	Oil
Wanaea 1	Woodside Offshore Petroleum Pty Ltd	1989	4154 mRT	Oil
Wanaea 1 ST1	Woodside Offshore Petroleum	1989	3011 mRT	Oil
Wandoo 1	Ampol Exploration Limited	1991	1570 mRT	Oil and Gas
Wandoo South 1	Mobil Exploration and Producing Australia Pty Ltd	1997	802 mRT	no tests
Webley 1A	Woodside Energy Ltd	1999	3108 mRT	Minor gas
Withnell 1	Woodside Energy Ltd	1976	4650 mRT	No tests

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

There is a dense grid of 2D seismic of various vintages across the Release Areas, as well as good 3D seismic coverage, especially across Release Areas W09-12, W09-14, W09-15 and W09-16. There is also partial 3D coverage of the other Release Areas, while the eastern sectors of W09-17, W09-18 and W09-19 have only a 2D grid. Some of the 3D data sets are now open file and a full listing of the seismic that is available from Geoscience Australia is in the **Dampier Sub-basin Data Listing**.

Hydrocarbon Potential

The Dampier Sub-basin has producing oil and gas fields with hydrocarbon accumulations at multiple stratigraphic levels from the Cretaceous to the Triassic and stacked pay sections in a number of fields. The 2009 Release Areas are on structured flanks either side of proven hydrocarbon kitchen of the Lewis Trough and on the Enderby Terrace near the producing Wandoo and Stag oil fields.

Petroleum Systems

Two proven petroleum systems are recognised in the Release Areas. Geochemical studies (Boreham et al, 2001; Edwards and Zumberge, 2005; Edwards et al, 2007) indicate that the giant gas accumulations lying along the western margin of the sub-basin on the Rankin Platform were sourced from deltaic Triassic to Middle Jurassic source rocks. The oil fields of the Dampier Sub-basin are sourced from the marine Jurassic Dingo Claystone, particularly the organic rich Oxfordian interval (van Aarssen et al, 1996).

Hydrocarbon Families

Multiple source rocks and a complex charge history is reflected in the recognition of a number of distinct hydrocarbon families in the Dampier Sub-basin (Longley et al, 2002; Thomas et al, 2004; Edwards and Zumberge, 2005). These include gas and condensate in the giant fields on the Rankin Platform considered to be predominantly sourced from Triassic to Middle Jurassic deltaic sediments (Mungaroo, Murat and Athol formations); and the contrasting oils (Wanaea, Legendre, Lambert and Mutineer) that have been typed to the Late Jurassic marine sediments (Dingo Claystone) in the Lewis and Kendrew troughs. The biodegraded oils at Wandoo and Stag also belong to this family (Summons et al, 1998).

Source Rocks

Source rock intervals are well represented in the Triassic and Jurassic of the Dampier Sub-basin. The central Dampier Sub-basin is underlain by deeply buried Mungaroo Formation coals and carbonaceous claystones and the marginal marine facies of the Brigadier Formation. These Late Triassic units constitute a deep gas source.

Fine grained deltaic to marine sediments (Murat Siltstone, Athol and Legendre formations) with the potential to source both oil and gas accumulated preferentially in the developing central Dampier depocentre through the Early and Middle Jurassic. The Bathonian-Callovian Legendre Formation is considered a major source for gas, but could also have contributed minor oil in the northeast of the Dampier Sub-basin. The gas in the Angel field is thought to have been sourced largely from the Legendre Formation (Thomas et al, 2004).

The Late Jurassic Dingo Claystone is the principal oil source rock for the Northern

Carnarvon Basin. It was deposited in deep water, low energy, anoxic environments in the Exmouth, Barrow and Dampier sub-basins. Thomas et al (2004) identify two discrete source intervals in the Late Jurassic of the Dampier Sub-basin. These are a Kimmeridgian (*D. swanense* biozone) source interval in the western Dampier Sub-basin and an Oxfordian (*W. spectabilis* biozone) source in the eastern part of the sub-basin.

Expulsion and Migration

Hydrocarbon generation from Triassic source rocks in the central Dampier Sub-basin commenced in the Jurassic. Presently, most of the Lewis Trough is in the gas window or overmature for units older than Late Jurassic (Thomas et al, 2004). For the currently generative Oxfordian oil kitchen in the Lewis Trough, maturity increases to the southwest. This is reflected as a maturation gradient in the fluids with the Saffron and Sage accumulations having the most mature oils and Legendre and Talisman accumulations the least mature oils (Thomas et al, 2004). Early expelled oil from the southwestern Lewis Trough migrated up onto the Enderby Terrace into the Wandoo and Stag structures and has since undergone biodegradation. In the more basinward location at Corvus the earlier oil charge from the Oxfordian has been displaced by later gas charge from Middle Jurassic and older sediments (Thomas et al, 2004). Thick Jurassic shales of the Athol and Calypso formations are considered to have shielded the oil accumulations at Wanaea, Legendre, Wandoo and Stag from this late gas charge (Longley et al, 2002).

Release Areas W09-12, W09-13, W09-14, W09-15 and W09-16 are well located with respect to migration from the main hydrocarbon kitchen of the central Dampier Sub-basin. They either overlie mature source rocks with access to vertical migration or are within the well established range of horizontal migration as shown by the distribution of oil and gas fields and shows within and surrounding these Release Areas (**Figure 1**). The Release Areas on the inner Enderby Terrace (W09-17, W09-18 and W09-19) rely on horizontal migration from the source kitchen. Evidence of this migration includes the small gas accumulations at Hampton 1 and Morrel 1 in Release Area W09-17 and the gas show at Bloodwood 1 in Release Area W09-18. The significance of the minor oil indications at Strickland 1 and Lawley 1 is uncertain and oil inclusion studies (CSIRO, 2008) may determine whether a hydrocarbon charge has extended this far onto the Enderby Terrace.

Reservoirs

Proven hydrocarbon reservoirs occur at stratigraphic levels from the Triassic to the Early Cretaceous in the Dampier Sub-basin. Fluvial to marginal marine sandstones of Late Triassic through to Middle Jurassic age (Mungaroo, Brigadier, North Rankin and Athol formations) are the major reservoirs in the giant gas fields on the Rankin Platform (Seggie et al, 2007). Where these units have been intersected off the Rankin Platform, along the Madeleine Trend, they are at greater depth and can have poorer reservoir characteristics. At Lynx 1A in Release Area W09-12, tight gas sands in the Brigadier (9.5% porosity) and North Rankin (12.4% porosity, 0.1-3 mD permeability) formations are reported (Woodside Offshore Petroleum Pty Ltd, 1997). However, the Late Triassic to Middle Jurassic

sandstones are viable and proven hydrocarbon reservoirs on the eastern side of the Dampier Sub-basin at Caribou (North Rankin and Mungaroo formation gas sands), Corvus (North Rankin Formation), Tusk (oil column in Jurassic Athol Formation extending into top of the underlying Triassic Mungaroo Formation) and at Chamois 1 (live oil column in the *C. halosa* biozone sand, Athol Formation).

The Legendre Delta developed in the northern and eastern Dampier Sub-basin in the Bathonian to early Callovian. The Bathonian Legendre Formation is a proven gas reservoir in the Reindeer/Caribou field. The reservoir sands in Reindeer 1 are described as comprising fluvio-deltaic, predominantly clean, highly permeable quartz arenites, with porosities between 16% and 22% and permeabilities ranging from 1000 to 5000 mD (Apache Energy Ltd, 2005a). In contrast, on the western side of the Dampier Sub-basin, an extensively dolomite cemented, tight gas sand (5.1% porosity) was intersected in the Legendre Formation at Lynx 1A (Woodside Offshore Petroleum Development, 1997; Kingsley and Tilbury, 1999).

Thomas et al (2004) recognised four prospective, sand rich gravity flow intervals within the early Oxfordian of the Lewis Trough which are potential reservoir targets within the Late Jurassic Dingo Claystone. An associated slope apron depositional environment is mapped in the region of Release Areas W09-15 and W09-16 (Thomas et al, 2004).

Tithonian Angel Formation hydrocarbon reservoirs are best known from the northwestern Dampier Sub-basin, at the Wanaea and Angel fields. However, the Angel Formation is also a proven hydrocarbon reservoir in the central Dampier Sub-basin in the Saffron accumulation (**Figure 1**) where it is interpreted as having been deposited in a basin floor environment (Woodside Offshore Petroleum Pty Ltd, 1996).

Sands developed within the shale-prone Early Cretaceous section (Forestier Claystone and Muderong Shale) are major oil reservoirs along the eastern margin of the Dampier Sub-basin. In the Legendre field the earliest Cretaceous Berriasian (*B. reticulatum* biozone*)* sand is the oil reservoir (Seggie et al, 2003). These sands are thought to represent high density turbidites and sandy debris flows in a marine, sand-rich fan system (Woodside Offshore Petroleum Pty Ltd, 1998).

On the Enderby Terrace, it is the slightly younger Barremian *M. australis* Sandstone that is the main of reservoir with the initial find at Wandoo 1 followed by a whole herd of discoveries including Stag, Elk, Oyrx, Antler and Chamois. The greensands of the *M. australis* sandstone that were deposited in estuarine, barrier bar and shore face environments are very well-sorted and have excellent reservoir potential. These sands pass updip into lagoonal clay and are overlain by transgressive marine muds that provide impermeable barriers for stratigraphic traps.

Dyson (1998) and Crowley (1999) recognise three depositional sequences within the *M. australis* biozone. At Wandoo, incised valley fills of *M. australis* sandstone are considered to represent three transgressive-regressive cycles arranged in a progradational set; while at Saffron in the Lewis Trough the *M. australis* sands represent a basin-floor fan (Dyson, 1998). Thomas et al (2004) provide gross depositional environment maps of the three *M. australis* sandstone sequences showing the distribution of potential reservoir facies

across Release Areas W09-15, W09-16, W0-17 and W09-18.

An unproven potential reservoir unit present on the inboard parts of the Enderby Terrace is the basal transgressive sand recognised in the Early Triassic underlying the Locker Shale. Weathered and fractured basement is another possible reservoir type.

Seals

The occurrence of stacked hydrocarbon reservoirs within a number of wells (Caribou 1, Saffron 1, Lynx 1A) indicates that sealing facies are well developed within the stratigraphic section, especially in the central Dampier Sub-basin. The Early Cretaceous Muderong Shale is the regional seal across the entire sub-basin. It acts as top seal for reservoirs ranging in age from the Triassic Mungaroo Formation on the Rankin Platform, through to the Early Cretaceous *M. australis* Sandstone on the Enderby Terrace.

In more basinal locations the Early Cretaceous Forestier Claystone is the seal for Berriasian sands and the Tithonian Angel Formation. Fine-grained facies in the Middle to Early Jurassic (Athol Formation and Murat Siltstone) are seals for reservoirs of Middle Jurassic through to Triassic age (Legendre, North Rankin and Mungaroo formations).

On the inboard parts of the Enderby Terrace, seal facies in the Cretaceous and Jurassic become sandier or are absent due to erosion. However, the Albian Gearle Siltstone remains a potential top seal at the basin edge, as at Hauy 1 on the Lambert Shelf. Lower in the succession the Early Triassic Locker Shale is a potential seal for the underlying basal transgressive sand along the basin margin.

Play Types

Hydrocarbon occurrences and fields in the Dampier Sub-basin are summarised by Longley et al (2002). Within the central sub-basin area, Late Jurassic low relief oil-filled drape traps overlie deeper, rift related gas-filled Late Triassic-Early Jurassic horst traps (e.g. Wanaea, Cossack, Lambert/Hermes, Mutineer/ Norfolk and Egret). The results of Lynx 1A and seismic data (**Figure 5** and **Figure 6**) suggest that this play type may occur in 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 (Thomas et al, 2004). 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 the Release Areas W09-14, W09-15 and W09-16 (**Figure 6**). Fields on the Enderby Terrace are Early Cretaceous drape anticlines (Wandoo) and combination drape and onlap traps (Stag). These play types are relevant to Release Areas W09-17, W09-18 and W09-19.

The potential for stratigraphic traps has long been recognised within the Dampier

Sub-basin (Barber, 1994) and the advent of 3D seismic coverage linked with third order sequence stratigraphic analysis (Thomas et al, 2004) is now providing the tool kit to successfully pursue these play types. The Hurricane oil discovery by Santos in the Lewis Trough to the north of Release Areas W09-18 is reported by Mosaic Oil (2008) as being a successful example of a Late Jurassic submarine fan stratigraphic trap. Potential stratigraphic traps within the Release Areas include Late Jurassic or Early Cretaceous submarine fans in the central part of the sub-basin, and on the Enderby Terrace, barrier bar or estuarine mouth-bar reservoirs developed in the *M. australis* sandstone.

Critical Risks

Risks to the entrapment and preservation of hydrocarbon accumulations vary across the Dampier Sub-basin. In the western sub-basin in the region of the Release Areas W09-12 and W09-13, the reservoir characteristics of Early to Middle Jurassic sandstones can be expected to be adversely affected by digenesis as seen in Lynx 1A. Sandstone distribution is a risk for the Late Jurassic and younger plays which rely on anomalous sandstones within fine grained deepwater deposits. Gas flushing is a risk to preservation of any early oil charge both here and in region of Release Areas W09-15 and W09-16.

Hydrocarbon migration is a critical risk on the Enderby Terrace, as well as the biodegradation of oil accumulations in shallow reservoirs as seen at Wandoo and Stag. The lack of effective seals at the basin edge is another risk, particularly in the eastern sectors of the Release Areas W09-17, W09-18 and W09-19.

Figures

Figure 7:	Cross-section across the northern Dampier Sub-basin to the Rankin Platform, line drawing from Geoscience Australia seismic line 101/10. See Figure 4 for location of cross-section.
Figure 8:	Major oil and gas accumulations of the Northern Carnarvon Basin indicating age of main reservoir.

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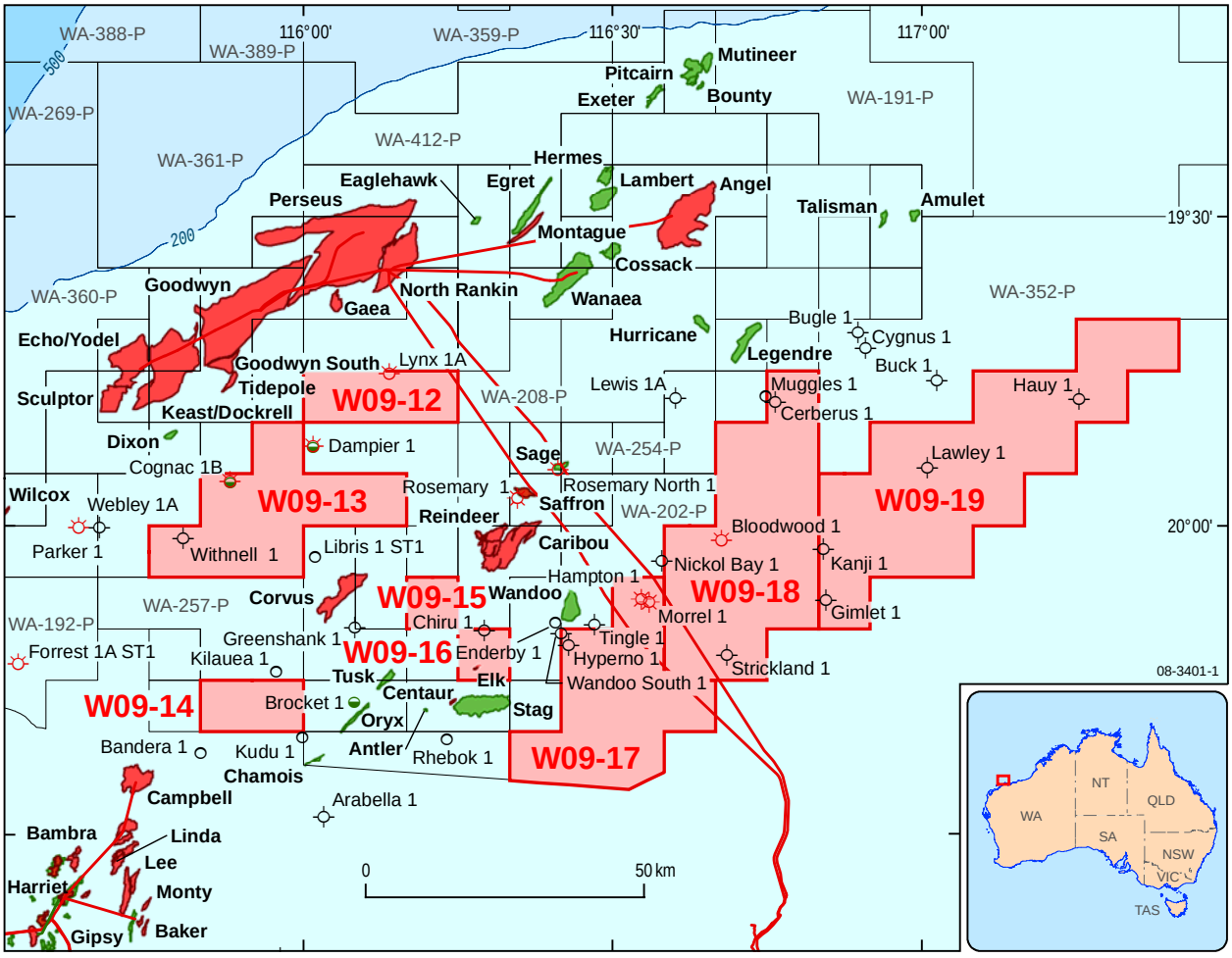


Where well symbol information is sourced from publicly available "open file" data, it has been provided by Geoscience Australia from Well Completion Reports. These symbols were generated from open file data as at 31 March 2009. Where well symbol information is not publicly available from titleholders' 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 Offshore Petroleum Acreage Release Area*
- *Existing petroleum title*
- *Gas field*
- *Oil field*
- *Gas pipeline*
- *Oil pipeline*
- *200 Bathymetry contour (depth in metres)*
- *Petroleum exploration well - Not classified*
- *Petroleum exploration well - Dry hole*
- *Petroleum exploration well - Gas show*
- *Petroleum exploration well - Gas discovery*
- *Petroleum exploration well - Oil show*
- *Petroleum exploration well - Oil and gas show*

Figure 1. Location map of Release Areas W09-12, W09-13, W09-14, W09-15, W09-16, W09-17, W09-18 and W09-19, showing existing petroleum permits, oil and gas accumulations, and gas and oil pipelines.

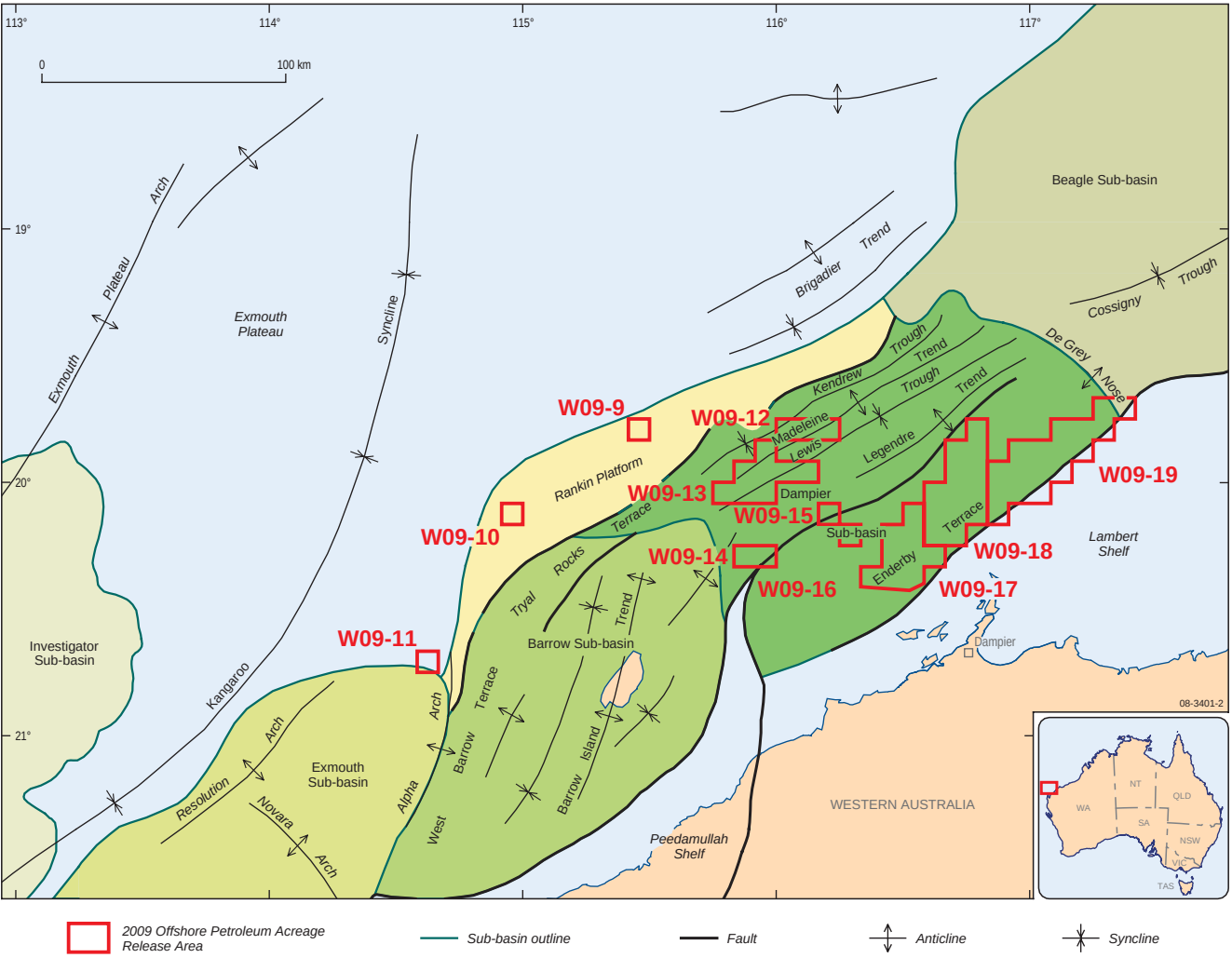


Figure 2. Structural elements of the Exmouth, Barrow, Dampier and Beagle sub-basins, Carnarvon Basin showing the 2009 Release Areas.

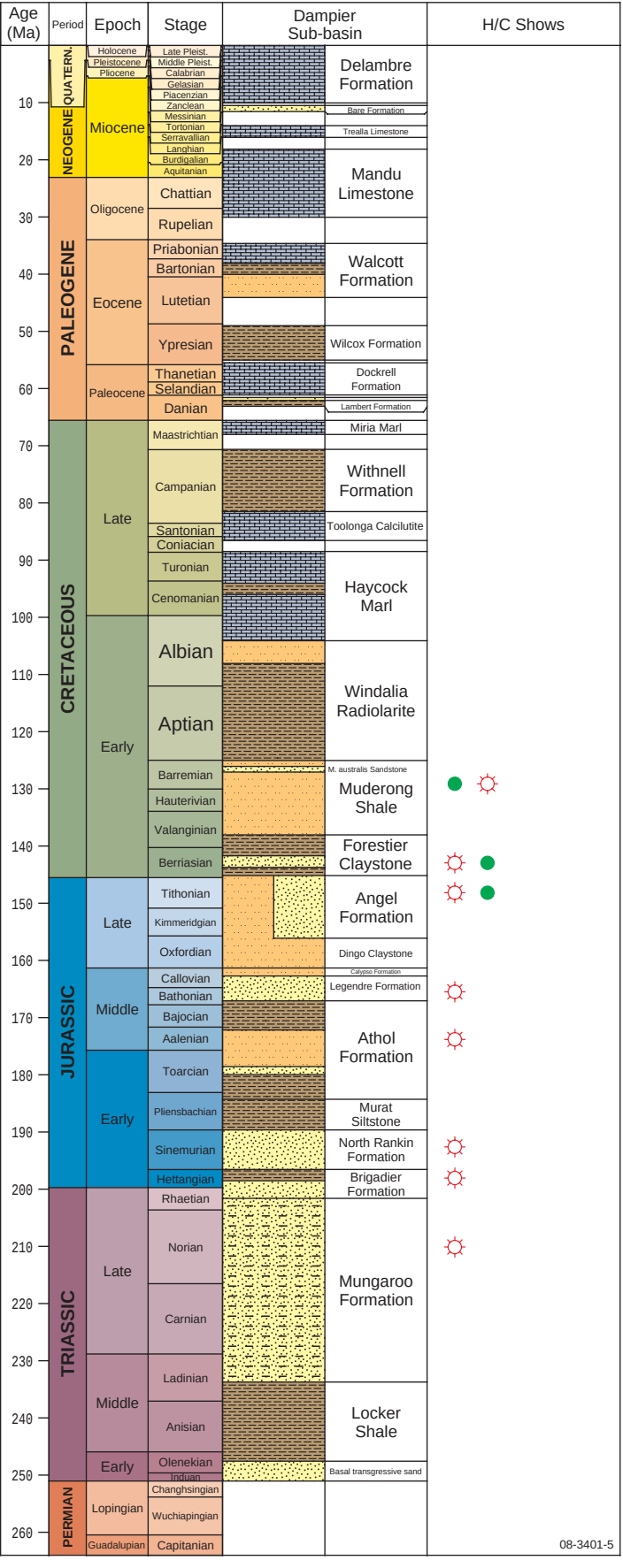
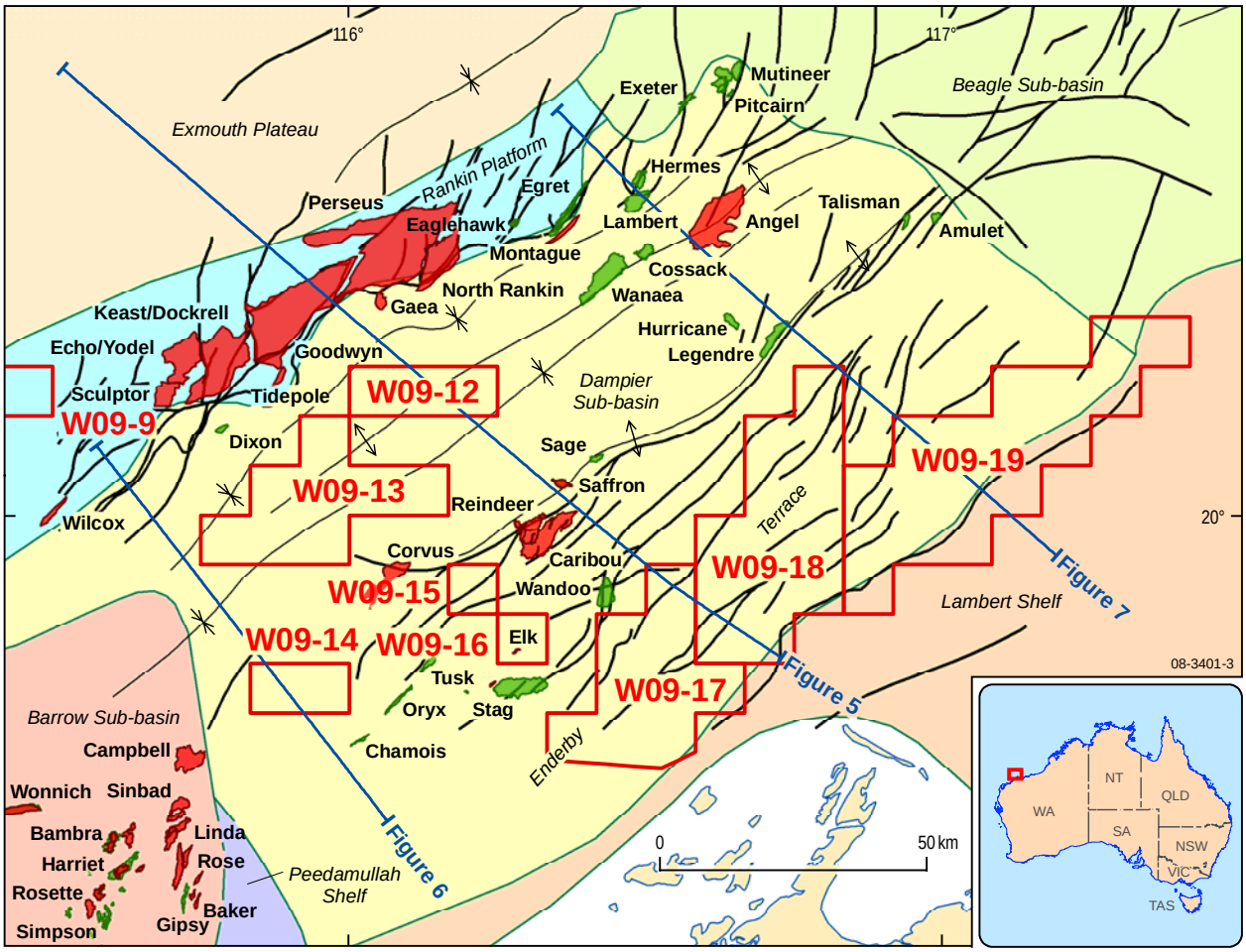


Figure 3. Preliminary generalised stratigraphy of the Dampier Sub-basin (after Gradstein et al, 2004 Time Scale).



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 Offshore Petroleum Acreage Release Area

Gas field

Oil field

Seismic line

Basin outline

Fault trend

Syncline

Anticline

Figure 4. Structural elements and fault trends, Dampier Sub-basin, showing the 2009 Release Areas and the location of cross-sections and seismic lines shown in Figures 5, 6, and 7 (modified after Liu et al, 2001).

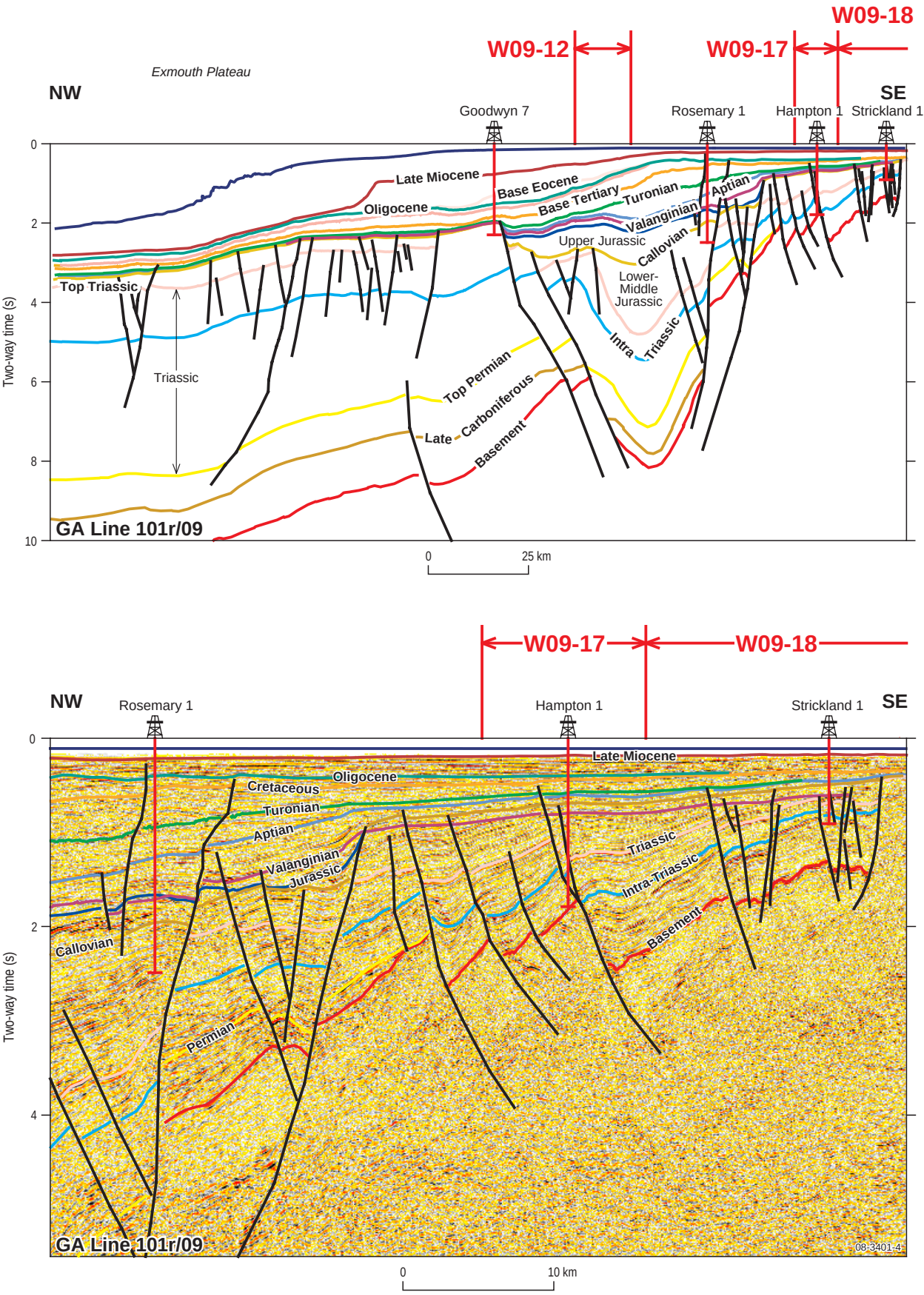


Figure 5. Cross-section across the central Dampier Sub-basin, Rankin Platform and onto the Exmouth Plateau, line drawing from Geoscience Australia seismic line 101r/09 with expanded seismic panel across the Enderby Terrace. See Figure 4 for location of cross-section.

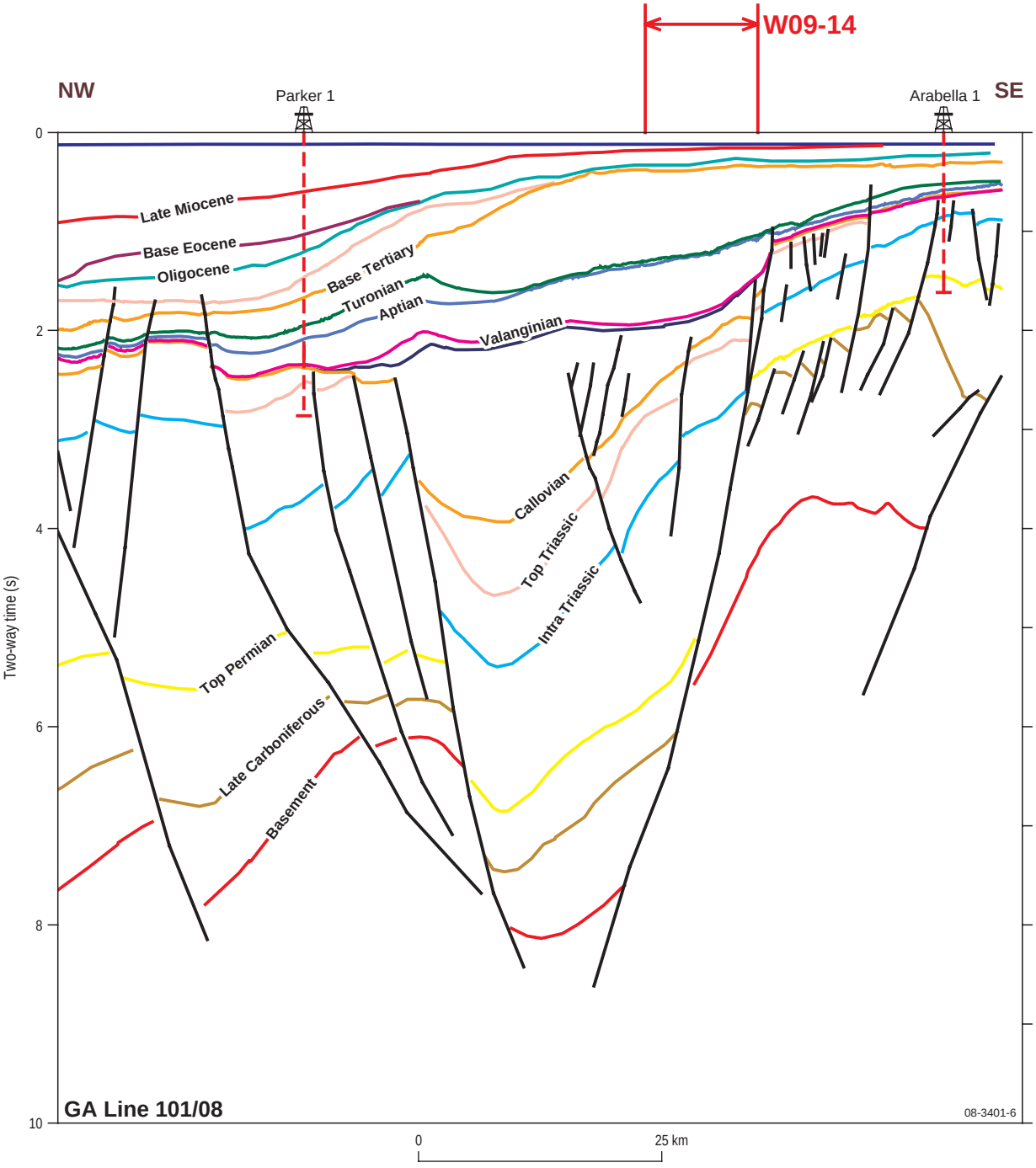


Figure 6. Cross-section across the southern Dampier Sub-basin to the Rankin Platform, line drawing from Geoscience Australia seismic line 101/08. See Figure 4 for location of cross-section.

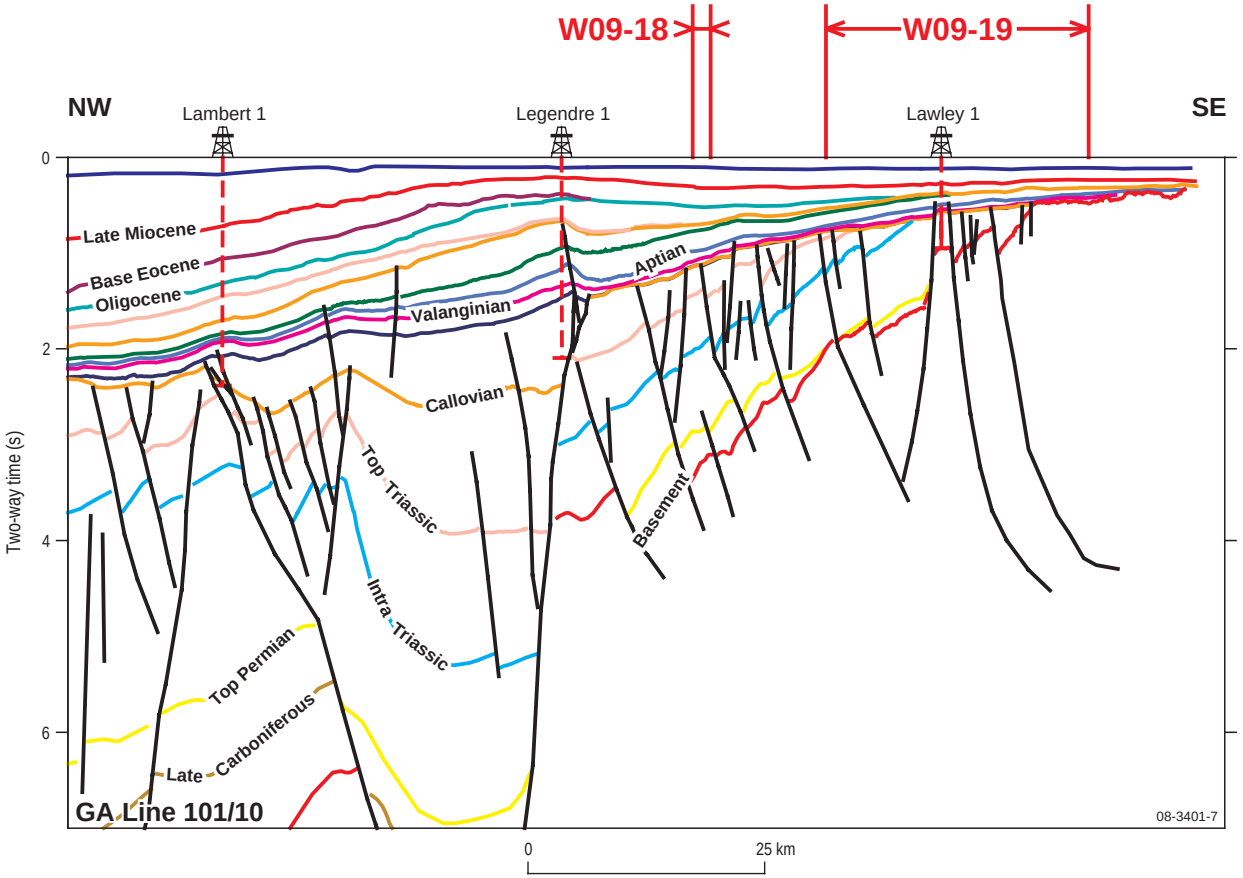
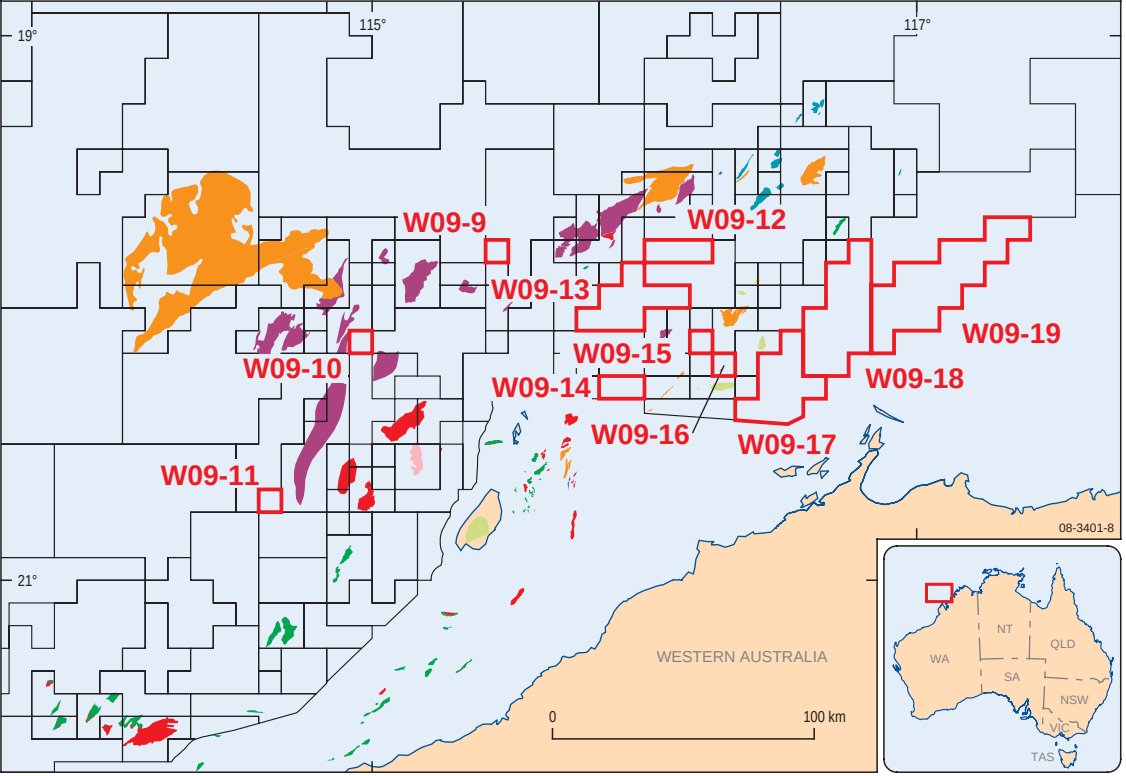


Figure 7. Cross-section across the northern Dampier Sub-basin to the Rankin Platform, line drawing from Geoscience Australia seismic line 101/10. See Figure 4 for location of cross-section.



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