Areas AC04-1 & AC04-2
Vulcan Sub-basin, Bonaparte Basin,
Territory of Ashmore & Cartier Islands

Bids close 31st March 2005

Location

The vacant areas in the Territory of Ashmore and Cartier Islands are located some 700 to 1000 kilometres west or west southwest of Darwin in the Timor Sea (Figure 1). They are within 100 km of existing petroleum production facilities and provide significant opportunities for explorers to further evaluate acreage which previous exploration has found to be both oil and gas bearing (Preston and Edwards, 2000).

Areas AC04-1 and AC04-2 overlie the northern part of the Vulcan Sub-basin and the northwest margin of the Londonderry High in the offshore Bonaparte Basin (Figure 2). Area AC04-1 overlies the northern Vulcan Sub-basin and the younger overlying Cartier Trough. Area AC04-2 overlies the eastern margin of the Vulcan Sub-basin and the adjoining Sahul Syncline, and Laminaria High.

Area AC04-1 contains 55 graticular blocks, and covers an area of approximately 250 km^2. Area AC04-2 comprises 46 graticular blocks and covers approximately 220 km^2.

The Ashmore Cartier region contains producing and decommissioned oil fields as well as oil and gas discoveries that are presently undeveloped. A diverse range of undrilled structures is likely to be present in the available vacant areas. These features, and others that may be identified in the course of further exploration, are expected to provide additional exploration targets.

A diverse range of seabed features are evident in the Territory of Ashmore and Cartier Islands which appear to be associated with hydrocarbon seepage and nutrient utilisation. These include 'solution pockmarks' and large-scale carbonate bioherms which project up to several hundred meters above the seafloor. Some of the latter features has been mapped and charted for navigation and environmental management and evaluation purposes.

The Jabiru and Challis/Cassini oil production facilities are located immediately south of Area AC04-1 and other oil and/or gas accumulations are present in nearby parts of the Timor Sea (Figure 1). The Vulcan Sub-basin is a part of the broader Bonaparte Basin which in total has produced 11 GL of oil to end-2000 but only 0.11 BCM of gas, although gas production is expected to increase considerably in the future, with several major projects under consideration. Remaining known reserves are 33.4 GL of oil and 668.6 BCM of gas.

Water depths in Area AC04-1 range from less than 20 metres (isolated bioherm patch reef systems) to 100-300 metres over much of the vacant area (Figure 1). In Area AC04-2 the water depth are generally shallower (Figure 1). Here, with the margin of the Cartier Trough and an adjoining major shoals system is evident along the eastern margin of the Cartier Trough (Karmt Shoal, Dillon Shoal).

Regional Geology

Basin/Sub-basin evolution

The Vulcan Sub-basin and Sahul Platform developed as part of an upper plate rift margin (O'Brien, 1993). The rift margin consisted of a linked array of northwest trending accommodation zones and northeast trending normal faults (Etheridge and O'Brien, 1994; O'Brien et al., 1996, 1999). Pre-existing Proterozoic fracture systems controlled the geometry of the rifting. Thermal subsidence phase sedimentation continued until the late Tertiary resulting in 10 to 14 km of relatively unstructured sediments (Baxter et al., 1997). Three major reactivation events affected the Timor Sea region during the Mesozoic.

1. compression (Late Triassic – Early Jurassic)
2. extension (Late Callovian – Early Oxfordian)
3. compression (Tithonian/Berriasian).

The area has been subsequently affected by the Late Miocene/Early Pliocene (~5-6 Ma) convergence between the Australian and Eurasian Plates with fault reactivation being a critical element in trap breaching.

Regional north-south compression in the Late Triassic resulted in widespread uplift and erosion, and, together with salt tectonics, produced inversion structures and anticlines in parts of the Vulcan Sub-basin. Erosion and collapse of these uplifted areas led to the widespread deposition of Lower-Middle Jurassic 'redbeds' and fluvio-deltaic clastics. Late Jurassic extension resulted in a series of linked, northeast-trending (Vulcan Sub-basin and southeast-trending (Sahul Syncline) intercontinental grabens (Kraus and Parker, 1979).

The Jurassic depocentres, such as the Vulcan Sub-basin, contain thick marine mudstones flanked by fan delta sandstones (Mory, 1988, 1991). A thick post-rift Cretaceous-Tertiary succession is dominated by fine-grained clastic and carbonate facies. Late Miocene-Pliocene convergence of the Australian and Eurasian plates resulted in flexural downwarp of the Timor Trough and widespread reactivation of the previous extensional fault systems (Shuster et al., 1998; Woods, 1992).

Tectonic/structural elements

Vulcan Sub-basin

The Vulcan Sub-basin is a northeast-southwest trending Mesozoic extensional depocentre in the western Bonaparte Basin and comprises a complex series of horsts, grabens and terraces (Figure 2) (O'Brien et al., 1996, 1999). The Vulcan Sub-basin developed as an intra-continental graben in the late Callovian, and structuring continued through to the Tithonian.

Sahul Syncline

The Sahul Syncline is a prominent Palaeozoic to mid Mesozoic trough in the Northern Bonaparte Basin (Whittam et al., 1996). The syncline trends northwest separating the Londonderry High from the Sahul Platform. It is a sag basin overlying the extension of northwest margin of the Bonaparte Basin. The syncline lies beneath a thick Cretaceous and Tertiary sedimentary section. Late Carboniferous to Early Permian northeast trending continental extension/rifting may have reactivated pre-existing orthogonal, northwest trending fault zones (the Sahul Syncline) as transfer faults. Late Permian to Late Triassic subsidence followed producing a thick sedimentary section with little fault related growth. Late Jurassic to Early Cretaceous rifting led to extensional and trans-tensional reactivation of the northeast trending Permo-Carboniferous faults throughout the area (O'Brien, 1993; Etheridge and O'Brien, 1994). The Sahul Syncline underlies the northern part of Area AC04-1.

Ashmore Platform

The Ashmore Platform is a large elevated block that lies west of the Vulcan Sub-basin and north of the Browse Basin. On the platform, flat-lying Cretaceous strata overlie up to 4500 m of Triassic sediments that were faulted during the Middle Jurassic to form an extensive terrain of tilted blocks prior to peneplanation. The Ashmore Platform underlies the northwest part of Area AC04-2.

Londonderry High

The Londonderry High comprises Palaeozoic and Triassic sediments that are overlain unconformably by relatively unfaulted Late Jurassic and younger sediments (although some faults show evidence of Miocene age reactivation; Woods, 1992). On the higher parts of the Londonderry High the Triassic section is deeply eroded. Uplift and erosion are less pronounced on the eastern and northern flanks of the high where the unconformity is progressively sub-cropped by younger sediments.

Structural trends on the Londonderry High are oblique to the adjacent Vulcan Sub-basin. During the Mesozoic, the region was subjected to three significant tectonic events that reactivated Palaeozoic structures. Reactivation was concentrated along the pre-existing major fault sets (Woods, 1992). Significant uplift occurred along the Vulcan sub-basin/Londonderry High Boundary zone in the Late Triassic-Early Jurassic and the Late Jurassic-Early Cretaceous structuring events. The Londonderry High underlies the southeast margin of Area AC04-1.

Stratigraphy

The Permian Hyland Bay Formation conformably overlies the Fossil Head Formation and consists of sandstones, shales, coal and limestone (Figure 3). It is Late Permian in age (Kazanian and Tartarian) and contains three major lithological elements:

- a basal sequence of dense limestone and shales,
- a middle tidal clastic sequence and,

- an upper sequence of mudstones and sandstones, deposited as a coarsening-upwards deltaic sequence.

Upper Permian sediments on the Sahul Platform, Ashmore Platform and Londonderry High consist mainly of shelfal limestones with minor interbeds of fluvio-deltaic sandstone. The Port Keats Group comprises largely non-marine sediments deposited proximal to the eastern basin margin.

The Mount Goodwin Formation, a transgressive marine sequence of shales and siltstones, conformably overlies the Hyland Bay Formation. The Mount Goodwin Formation thickens towards the centre of the Petrel Sub-basin and is Early Triassic in age. It is conformably overlain by the Sahul Group, a Middle Triassic regressive sequence of fluvial sandstones. Late Triassic uplift and erosion is reflected in some instances by an unconformity. The overlying Malita Formation is Late Triassic to Early Jurassic in age.

The overlying Early Jurassic to Early Cretaceous sequence consists of the Plover Formation and Flamingo Group which are separated by a Late Jurassic unconformity (Figure 4). The Plover Formation comprises deltaic sandstones, siltstones and some coal. In the Northern Bonaparte Basin the synrift Middle Jurassic Plover Formation is divisible into three major sandstone sequences:

- a lower sandstone sequence of Pliensbachian to early Bajocian age which consists of braided stream and floodplain deposits,
- a middle sandstone sequence from Bajocian to Callovian age which consists of marginal marine and deltaic sediments including distributary channels and mouth bars,
- an upper sequence of Late Callovian age consisting of shallow marine sediments.

The top of the Plover Formation sandstone facies intersected in wells in the Northern Bonaparte Basin represents a widespread transgressive surface. This surface marks the termination of deltaic sedimentation and the onset of shallow marine shelf deposition and is interpreted to correspond to accelerated subsidence and increased rifting. This section is often referred to as the 'marine Plover' in the older literature and is referred to as the Elang or Laminaria Formation or 'Montara Beds' in many of the 'Northern Bonaparte Basin' wells.

The Flamingo Group comprises glauconitic shale overlain in places by coastal to barrier-bar sandstone (Messent et al., 1994). Unconformably overlying the Flamingo Group, or older units, is the Early to Late Cretaceous marine shelf sequence of the Bathurst Island Group. This group comprises a sandstone and shale sequence which is Neocomian in age and is overlain by Aptian to Cenomanian claystone, siltstone and sandstone. The Late Cretaceous sequence comprises a younger part of the Bathurst Island Group and consists of marl and claystone.

The Early Tertiary Hibernia Formation comprises open marine siltstones, shales and mudstones. It is overlain by a Late Tertiary carbonate shelf sequence of marls, shales and sandstones. An unconformity at base Miocene level is related to basin-wide uplift and erosion in response to regional tectonism. Calcareous sandstone overlying the unconformity is succeeded by a major Pleistocene barrier-reef complex that rimmed the northern flanks of the Ashmore Block and Sahul Platform.

Exploration History

Exploration in the Vulcan Sub-basin commenced in the 1960s and the first notable oil discovery was made at Puffin-2 in 1974. The first commercial oil accumulation was discovered at Jabiru-1A in 1983, and since then additional commercial oil discoveries and have been made at Challis, Skua and Cassini, and significant oil and/or gas discoveries at Talbot, Oliver, Montara, Bilyara, Tahbilk, Crux, Audacious and Tenacious. Oil production from the Jabiru, Challis-Cassini and Skua fields is via FPSOs, although production ceased at Skua in January 1997.

Area AC04-1 was formerly the western portion of exploration permits AC/P15 and 16. It was previously held as such since the acreage release round of 1995. Prior to that it was held largely under the title AC/P4. In the 1980s it was covered by title NT/P26. Several wells have been drilled in the area and while no discoveries there have been several wells which have recorded traces of live or residual hydrocarbons.

Area AC04-2 has been covered by several permit titles since the early 1970s. Most recently it was covered by titles AC/P5 and 6. Prior to that it was held under title NT/P26. Several wells have been drilled in the northern part of the vacant area The number of wells drilled in the two vacant areas is limited given their relatively large geographic area.

The results of wells indicate that in some locations valid petroleum (largely oil) traps have been breached with the loss of accumulated hydrocarbons, and that trap integrity is a critical risk to the east of Area AC04-1 (Kennard et al., 1999, 2000, 2002; Ruble et al., 2000). That has not necessarily been a major issue in parts of the Vulcan Sub-basin occupied by the two available vacant areas. The recent oil (Tenacious-1, Audacious-1) and gas (Crux-1) discoveries in the Vulcan Sub-basin, and the scheduled 2004 gas/condensate production from the Bayu/Undan Field to the east of these vacant areas, highlight the continuing hydrocarbon potential and prospectivity of this part of the offshore Bonaparte Basin.

Previous Exploration

The first commercial oil accumulation in the Vulcan Sub-basin was discovered at Jabiru-1A in 1983, and since then additional commercial oil fields have been discovered at Challis (1984), Skua (1985) and Cassini (1988).

Other significant oil and gas accumulations include; Bilyara (1988), Eclipse 2 (1986), Montara (1988), Oliver (1988) and Talbot (1989); gas accumulations occur at Delamere 1 (1990), East Swan 1 (1978), Eider 1 (1972), Leeuwin 1 (1991), Lorikeet 1 (1988), Maple 1 (1990), Maret 1 (1992), Pengana 1 (1988), Swan 1 (1973) and Tahbilk 1 (1990) and an oil accumulation at Birch 1 (1990) (Figure 4). Recent exploration drilling has resulted in the discovery of oil and gas at Tenacious 1 (1997), oil at Audacious 1 (2001) and gas at Padthaway 1 (2000) and at Crux 1 (2000) in the most southern part of the Vulcan Sub-basin.

Crux 1 was drilled to test a large faulted anticline in the southern Vulcan Sub-basin in April 2000. The well encountered a single 244 m gas column in good quality Upper Triassic to Lower Jurassic stacked fluvial channel sandstones, tentatively identified as the Nome Formation. DST 2 (3642-3660 mRT) recorded a maximum flow rate of 34.0 MMSCFD with a condensate to gas ratio of 22 STB/MMSCF.

Geochemical and fluid inclusion analyses indicate that the structure has had a multiple hydrocarbon charge history, not an unusual interpretation if other results are applicable (Kennard et al., 1999, 2000, 2002). An initial hydrocarbon charge comprising oil and gas is interpreted to have occurred during the Paleocene, and subsequently lost during the Miocene. A second hydrocarbon charge comprising gas and oil is interpreted to have begun filling the Crux structure in the Pliocene to Pleistocene, with oil subsequently being spilt up-dip.

Results from Crux 1 provided further encouragement for the discovery of additional significant petroleum resources in the Vulcan Sub-basin and adjoining features.

Petroleum Potential

Areas AC04 -1 and 2 overlie the northern part of the Vulcan Sub-basin, Londonderry High and Nancar Trough, the latter being present between the Londonderry High and Laminaria High. The Vulcan Sub-basin has been the source of hydrocarbons for the Jabiru and Challis/Cassini oil accumulations and is thus a demonstrated potential source feature, although maturity and hydrocarbon type may vary compared to the southern Vulcan. The main exploration targets in Areas AC04-1 and 2 are likely to be Triassic and Jurassic sequences that are sealed by the overlying finer-grained Cretaceous-Tertiary sequences.

The Vulcan Sub-basin and the Nancar Trough could contain sequences which are in part oil prone sources, either in the Lower Vulcan Formation or the Lower to Middle Jurassic Plover Formation. Good quality reservoirs are likely to be present in the Triassic or Jurassic sequences.

The margins of the Londonderry High and prominent structural highs within and along the margin of the Vulcan Sub-basin and Nancar Trough have been the focus of previous exploration. Additional features of this type could yet prove a successful play. Upper Jurassic turbidites of the Nancar Sandstone Member may have additional potential along the southern extent of the Nancar Trough; to the north they pinch out into basinal clay sequences.

Early Cretaceous transgressive fan-delta sands (*M. australis*) and Late Cretaceous lowstand basin floor sands (Puffin Formation) provide additional significant diversity in exploration in the two vacant areas. The Upper Cretaceous Bathurst Island Group radiolarite is a major potential seal but it also has the potential to host reservoir sequences. Porosity has been demonstrated in this stratigraphic unit over many parts of the Ashmore Cartier region but permeability has, as yet, been a limiting factor which additional exploration may successfully resolve.

Most of the wells drilled to date have targeted fault-related traps. Fault-seal failure has been interpreted for most structures which have been found to contain residual oil columns. The timing of any fault movement varies regionally; hence there is considerable opportunity for some traps to have avoided fault movement which may have followed oil entrapment. As such considerable potential exists for the resolution of such issues with wide scope for the development of new and as yet untested traps types and play concepts.

Petroleum Systems

The oldest system is the Middle Triassic to Middle Jurassic Petroleum System with the oil in the Jabiru Field being the analogue. Fluvial sands in the Late Triassic/Early Jurassic Malita Formation and fluvial to paralic sands in the Middle Jurassic Plover Formation are the main reservoirs, with intra-formational shales and the overlying Late Jurassic Flamingo Group providing seals. The most probable source is the Frigate Shale of the Flamingo Group located down-dip in depocentres in the northern part of the Bonaparte Basin (Figures 5 and 6).

The second system is the Late Jurassic to Neocomian Petroleum System. The oil in the Skua Oil Field belongs to this group. Reservoirs include the Sandpiper Sandstone of the Late Jurassic Flamingo Group and the basal sands of the Bathurst Island Group. The Bathurst Island Group also acts as a regional seal, although it can sometimes act as a 'thief' zone (especially on the Londonderry High). Intra-formational marls and shales also provide seals in the area. The marine shales of the Frigate Shale are the most probable source of hydrocarbons in the area, with the Bathurst Island Group also having some source potential.

The youngest system is the Late Cretaceous Petroleum System, with oil in the Puffin Oil Field providing the analogue. The reservoir is the offshore bar sands at the top of the Bathurst Island Group with intra-formational marls and shales providing local seals; there is no regional seal. The Bathurst Island Group also provides the most probable source rocks for this system.

Data Availability

Open-file reports, data and down-hole samples (wells, geophysical surveys and other petroleum exploration and production data submitted by the petroleum industry) are available from both the Northern Territory Department of Business, Industry and Resource Development (DBIRD), Darwin and Geoscience Australia (GA), Canberra.

Digital wireline logs from wells drilled within the release areas and in adjacent acreage are available from Crocker Data Processing, Perth, and Wiltshire Geological Services, Adelaide.

Table 1. Relevant Wells

Well	Operator	Year	Total Depth (m)	Hydrocarbons
Avocet 1A	Bond Corp Holdings Ltd	1986	2217	Oil accumulation with gas indications
Banka Banka 1	Santos Ltd	1998	2775	
Barita 1	Bond Corp Holdings Ltd	1986	2500	Oil and gas indications
Cromwell 1A	OMV Australia Pty Ltd	2001	2032	
Dillon Shoals 1	Woodside/Burmah Oil NL	1974	3970	Gas and oil indications
Eider 1	Arco Australia Ltd	1972	2835	Gas show
Fagin 1	BHP Petroleum	1990	3262	Oil show and gas indications
Fannie Bay 1	Woodside Petroleum Ltd	1998	4190	Oil and gas indications
Fish River 1 ST1	Santos Ltd	1998	3037	
Fulica 1	Bond Corp Holdings Ltd	1989	2674	Oil and gas indications
Jarrah 1	BHP Petroleum	1990	359	
Keppler 1	BHP Petroleum	1993	1772	Oil and gas indications
Lameroo 1	Woodside Petroleum (Timor Sea 19) Pty Ltd	1998	3958	Oil indications
Lorikeet 1	BHP Petroleum	1988	1900	Oil show and gas indications

Ludmilla 1	Woodside Oil Ltd	1998	3576	Oil show
Mallee East 1	BHP Petroleum	1996	2245	
Mallonee 1	Santos Ltd	2002	2345	
Mandorah 1	Woodside Offshore Petroleum	1998	3800	
Marrakai 1	Woodside Energy Ltd	1999	1880	
Medusa 1	BHP Petroleum	1994	1958.4	Gas and oil indications
Mindil 1	Woodside Oil Ltd	1999	3235	
Nancar 1 ST1	BHP Petroleum	1989	3650	Oil show and gas indications
Nome 1	BHP Petroleum	1986	1850	Oil and gas indications
Norquay 1	BHP Petroleum	1995	1130	
Stork 1	Lasmo Energy Aust	1990	1400	Gas indications
Voltaire 1	BP Petroleum Dev Aust Pty Ltd	1988	2720	Gas indications

Geoscience Australia's geological databases provide detailed biostratigraphic (STRATDAT), geochemical (ORGCHEM) and less-detailed reservoir, hydrocarbon shows and interpreted depositional environment information (RESFACS) from open file exploration wells (attached Vulcan Data File). These data can also be obtained via the Geoscience Australia Petroleum Well Database interface, www.ga.gov.au/oracle/apcrc.

Table 2. Relevant Wells – Cores & Cuttings Availability

Well	Type	Top (m)	Bottom (m)	Remark
Avocet 1A	Core	1707.3	1751.6	Continuous core for Avocet A-1A well
Avocet 1A	Cuttings	510	2217	Cuttings for Avocet A-1A well
Avocet 1A	Sidewall core	1224	1908	Various intervals
Banka Banka 1		670	2777	missing samples intervals
Barita 1	Cuttings	522	2500	Washed samples
Dillon Shoals 1	Core	1820	1829	Continuous core
Dillon Shoals 1	Cuttings	563	3920	
Eider 1	Cuttings	283.46	2834.64	
Fagin 1	Core	3022.1	3040.64	Continuous core
Fagin 1	Cuttings	600	3261	Washed and dried samples

Fannie Bay 1	Cuttings	1200	4190.6	No returns 2540 - 2555m
Fulica 1	Cuttings	430	2675	Washed and dried samples
Jarrah 1	Cuttings	350	2231	Washed and dried samples
Keppler 1	Cuttings	420	1772	
Lameroo 1	Cuttings	910	3957	
Lorikeet 1	Core	1753.4	1769.4	Continuous core
Lorikeet 1	Cuttings	320	1899	
Ludmilla 1	Cuttings	2180	3575	No returns (3295-3335 and 3340-3370)
Mallee East 1	Cuttings	1766	2245	
Mandorah 1	Cuttings	800	3799	1710 - 2300m no samples
Marrakai 1	Cuttings	1165	1880	
Medusa 1	Cuttings	520	1958.42	
Mindil 1	Cuttings	2225	3235	
Nome 1	Cuttings	360	1849	Washed samples
Norquay 1	Cuttings	190	1130	
Stork 1	Cuttings	360	1400	
Stork 1	Cuttings	360	1400	Washed and dried samples
Voltaire 1	Cuttings	610	2720	Washed and dried samples

Contact Geoscience Australia's Repository for more information or to arranging access to core and cuttings, phone 61 (0)2 6249 9222, e-mail ausgeodata@ga.gov.au.

Table 3. Relevant Wells – Available Analysis Reports

Well	**Report No.**	**Title**	**Company**	**Year**
Avocet 1A	DAR0851	New Palynology from Avocet 1A well	BP Australia Ltd	1991
Avocet 1A	DAR1035	results of TOC, Rock Eval pyrolysis, Pyrolysis GC from ten offshore well	PGA Consultants	1992
Avocet 1A	DAR1040	X-Ray diffraction analyses of drill cuttings samples from ten wells	Amoco Petroleum Company	
Avocet 1A	DAR1201	VR Analysis	AGSO	1998
Dillon Shoals 1	DAR0417	Source rock data from the Perth, Carnarvon, Canning, Browse & Bonaparte Basins	CSIRO	1980

Dillon Shoals 1	DAR0522	Results of geochemical evaluation of eleven wells, Browse Basin, WA.		1983
Dillon Shoals 1	DAR0526	Palynology report on the Northern Browse basin, Australia.		1984
Dillon Shoals 1	DAR0613	XRD mineralogy and TS description of samples from 6 wells on NW Shelf	Amoco Aust Pet Co	1992
Dillon Shoals 1	DAR0747	Petrography, mineralogy of samples from North West Shelf wells, Aust.	IEDS, London	1990
Dillon Shoals 1	DAR0852	New Palynology from Dillon Shoals 1 well	BP Australia Ltd	1991
Dillon Shoals 1	DAR1040	X-Ray diffraction analyses of drill cuttings samples from ten wells	Amoco Petroleum Company	
Dillon Shoals 1	DAR1063	X-Ray diffraction analysis of cuttings samples from ten wells	Amoco Production Company	1993
Eider 1	DAR0475	Diagenesis of sandstones from the Bonaparte Basin North Aust - a pilot study	Shell Co of Aust Ltd	1982
Eider 1	DAR0650	Petroleum Geology & Geochemistry - NW Shelf WA - Phase 2 Vol 3 Part 6c.	Robertson Research (Aust) Pty	1986
Eider 1	DAR0776	Bulk Fluid Inclusion Mass Spectrometry on samples from Eider 1 well	Amoco Aust Pet Co	1991
Eider 1	DAR0854	New Palynology from Eider 1 well	BP Australia Ltd	1991
Eider 1	DAR1035	Results of TOC, Rock_Eval pyrolysis, Pyrolysis GC from ten offshore well	PGA Consultants	1992
Eider 1	DAR1045	Reconnaissance palynological survey in thirteen wells from NW Aust.	Amoco Aust Pet Co	1993

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Table 4. Relevant Seismic Surveys

Uno	Survey	Year	Operator
S0660096	Sahul Shelf Seismic	1966	Arco Australia Ltd
S0670082	Sahul Rise Seismic	1967	Arco Australia Ltd
S0690097	Van Diemen Rise Seismic	1969	Arco Australia Ltd
S0720001	Baldwin Bank Marine Seismic	1972	Arco Australia Ltd
S0720002	Pago Marine Seismic	1972	Arco Australia Ltd
S0730003	Cartier Marine Seismic	1973	Arco Australia Ltd
S0730001	Hat Point Marine Seismic & Magnetic	1973	Arco Australia Ltd
S0740001	Cape Talbot Marine Seismic	1974	Arco Australia Ltd
S6770008	Van Cloon Shoal Marine Seismic	1977	Getty Oil Dev Co Ltd
S6820018	Glenys Marine Seismic	1982	Mesa Aust Ltd
S6850006	Maura Marine Seismic	1985	Wesminco Oil P/L
S6860001	B-1/85 Marine Seismic	1986	Bond Corp Holdings Ltd
S6880009	B-1/88 2D Marine Seismic	1988	Bond Corp Holdings Ltd
S6880051	Tamar and Central Bonaparte Marine Seismic	1988	Geophysical Service Inc
S6880051	Tamar and Central Bonaparte Marine Seismic	1988	Geophysical Service Inc
S6880009	B-1/88 2D Marine Seismic	1988	Bond Corporation
S6900010	90N Marine Seismic	1990	Norcen Inter Ltd
S6900041	AGSO Survey 97;Vulcan Graben 1 Marine Seismic	1990	AGSO
S6900042	AGSO Survey 98;Vulcan Graben 2 Marine Seismic	1990	AGSO
S6910014	Caspian Marine Seismic	1991	Lasmo Energy Aust
S6910030	Myrmidon Marine Seismic	1991	Lasmo Energy Aust
S6910009	PW91 Marine Seismic	1991	Phillips Aust Oil Co
S8910010	AGSO Survey 100;Petrel Sub-Basin Marine Sesimic	1991	AGSO
S8920004	Caulerpa Marine Seismic	1992	Woodside Offshore Petroleum
S6920031	Stuart Marine Seismic	1992	Phillips Aust Oil Co
S6930023	AGSO Survey 122 Sahul Shoals Marine Seismic	1993	AGSO
S8930003	AGSO Survey 116A;Timor Sea Tie Marine Seismic	1993	AGSO
S6940028	Endeavour Marine Seismic	1994	SAGASCO Resources

S6940031	AGSO Survey 130;Browse Basin Infill Marine Seismic	1994	AGSO
S6950037	AGSO Survey 163;Vulcan Tertiary Tie Marine Seismic	1995	AGSO
S6950038	AGSO Survey 165;Vulcan Tertiary Tie Extension Marine Seismic	1995	AGSO
S6960001	HB96 2D Marine Seismic	1996	BHP Petroleum (Aust) Pty Ltd
S6960006	HZI96 2D Marine Seismic	1996	BHP Petroleum (Aust) Pty Ltd
S6960028	Bonaparte-Browse Tie 1996 Marine Seismic	1996	Western Geophysical
S6980002	SPA BR 98 Marine Seismic	1998	Aust Seismic Brokers P/L

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Table 5. Initial Reserves

Field	Oil Reserves MMBBLS	Condensate MMBBLS	Gas Reserves TCF	Source
Bayu-Undan	0.00	400.00	3.40	RIU Register
Brewster	NA	NA	NA	No data available
Buffalo	4.43	0.00	0.00	GSWA
Challis and Cassini	56.60		0.00	NT DBIRD
Corallina	54.60		0.00	NT DBIRD
Cornea	NA	NA	NA	No data available
Elang/Kakatua/ Kakatua North	26.60	0.00	0.00	RIU Register
Gorgonichthys	0.00	88.40	10.70	GSWA
Hingkip	NA	NA	NA	No data available
Jabiru	107.20		0.00	NT DBIRD
Laminaria	128.80		0.00	NT DBIRD
Laminaria East	2.38	0.00	0.00	GSWA
Montara	144.67		3.71	NT DBIRD
Skua	20.50		0.00	NT DBIRD
Talbot	22.01		0.00	NT DBIRD

NT DBIRD – Northern Territory Government Department of Business, Industry and Resource Development
GSWA – Geological Survey Western Australia

References and useful sources

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Figures

Figure 1. Location map of Areas AC04-1 and 2, sea floor bathymetry and existing petroleum title areas.

Figure 2. Areas AC04-1 and 2 known petroleum fields and previous exploration drilling.

Figure 3. Stratigraphy of the Vulcan Sub-basin.

Figure 4. Schematic cross-section and sequence correlations through the Vulcan Sub-basin south of the vacant areas AC04-1 and 2.

Figure 5. Oil-source correlations for the Bonaparte Basin and Browse Basin.

Figure 6. Cluster analysis of major source and petroleum accumulations in the Bonaparte and Browse Basins.

Graticular Block Listings and Map

Bids close 31st March 2005

Area AC04-1
Vulcan Sub-basin, Bonaparte Basin, Territory of Ashmore & Cartier Islands

Map Sheet SC 51

2300(part) 2371(part) 2372(part) 2373 2374 2375(part) 2376(part)
2443(part) 2444 2445 2446 2447 2448(part) 2515 2516 2517 2518
2519(part) 2520(part) 2587 2588 2589 2590 2591(part) 2659 2660
2661 2662 2663(part) 2732 2733 2734(part) 2735(part) 2803 2804
2805 2806(part) 2875 2877(part) 2878(part) 2948 2949(part) 3019
3020(part) 3021(part) 3090 3091 3092(part) 3161 3162 3163(part)
3164(part) 3235(part) 3307(part)

Map Sheet SC 52 (Melville Island)

2305(part)

Assessed to contain 55 blocks

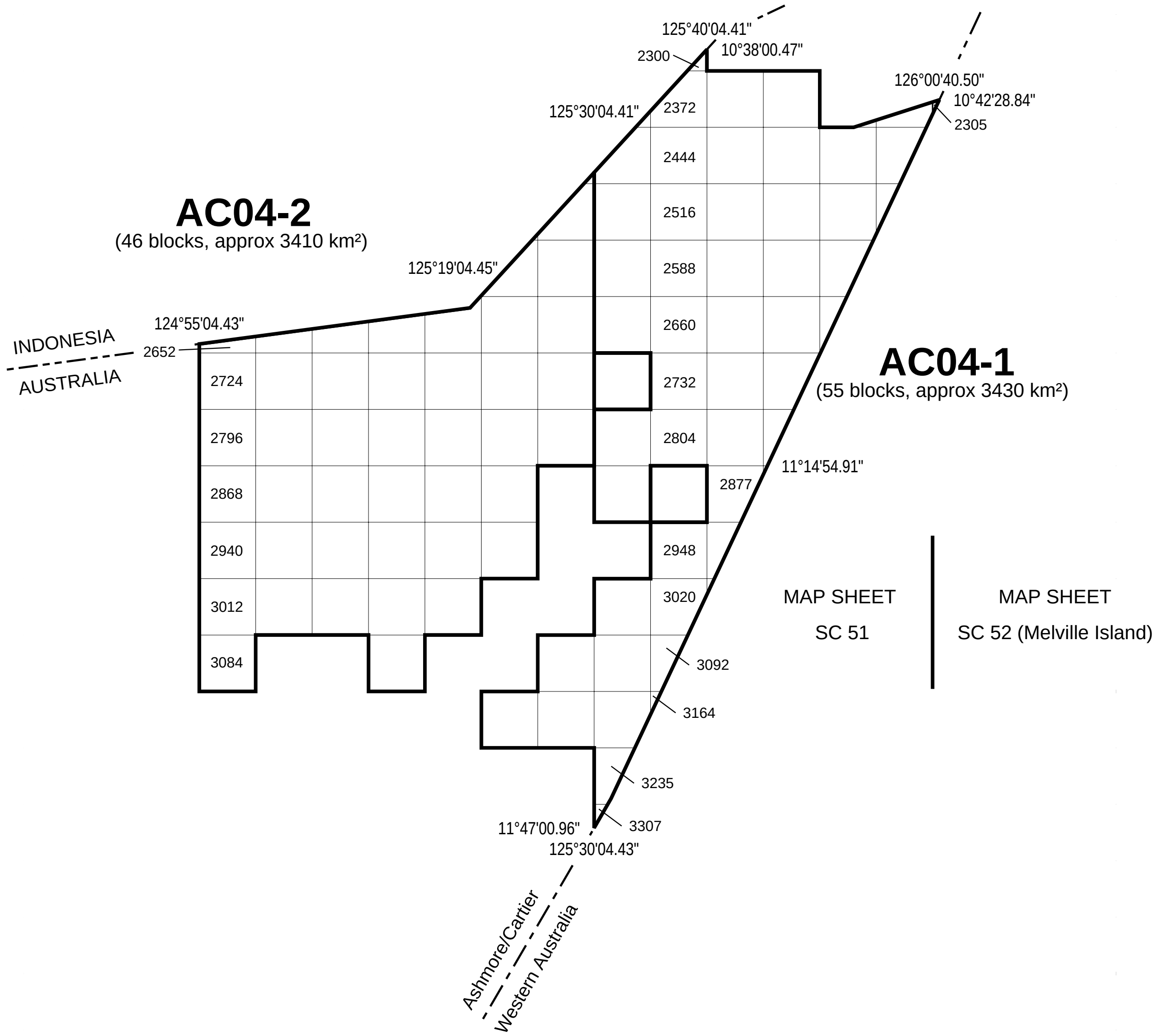
Area AC04-2
Vulcan Sub-basin, Bonaparte Basin, Territory of Ashmore & Cartier Islands

Map Sheet SC 51

2442(part) 2513(part) 2514(part) 2584(part) 2585(part) 2586
2652(part) 2653(part) 2654(part) 2655(part) 2656(part) 2657 2658
2724 2725 2726 2727 2728 2729 2730 2796 2797 2798 2799 2800
2801 2802 2868 2869 2870 2871 2872 2873 2940 2941 2942 2943
2944 2945 3012 3013 3014 3015 3016 3084 3087

Assessed to contain 46 blocks

2004 Release Areas
Vulcan Sub-basin, Bonaparte Basin, Territory of Ashmore & Cartier Islands



Grid coordinates on this map are presented with reference to the Geocentric Datum of Australia (GDA94). Permit areas are based on the same grid, Australian Geodetic Datum (AGD66), that has defined areas since the Petroleum (Submerged Lands) Act was proclaimed in 1967. However, with the adoption of GDA94, the gridlines are no longer referred to in whole multiples of 5 minutes as they were under AGD66.

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