

APRIL 2010

PETROLEUM

IN WESTERN AUSTRALIA

WESTERN AUSTRALIA'S DIGEST OF PETROLEUM EXPLORATION, DEVELOPMENT AND PRODUCTION





Government of **Western Australia**
Department of **Mines and Petroleum**



Richard Sellers

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(Photo courtesy of Carmen Krapf, GSWA)

Department of Mines and Petroleum Petroleum Division

Mineral House, 100 Plain Street
East Perth, Western Australia 6004
Tel: +61 8 9222 3622
Fax: +61 8 9222 3799
www.dmp.wa.gov.au

Editor: Karina Jonasson
Email: karina.jonasson@dmp.wa.gov.au
Cover Photo: INPEX's 2008 Ichthys drilling
campaign with the *Songa Venus* (Photo by
Robert Garvey; courtesy of INPEX Browse, Ltd)

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WESTERN AUSTRALIA

Opportunities to Explore

BIDS INVITED FOR ACREAGE

PETROLEUM ACREAGE



Bangemall Supergroup

There are two release areas in the Mesoproterozoic Bangemall Supergroup. These are very large areas – 29,307 km² and 29,147 km².

Mineral holes OD 15 and OD 23, drilled in the eastern area infilled by the Bangemall Supergroup, encountered bitumen and trace oil in vugs in dolomite belonging to the Scorpion Group. The Goldfields Gas Transmission pipeline goes through the eastern flank of L10-3.

Blake Sub-basin

There are two release areas in the Blake Sub-basin of the Neoproterozoic Officer Basin. These are very large areas – 30,795 km² and 30,097 km².

Oil fluorescence has been encountered in the Boondawari 1 and Mundadjini 1 stratigraphic coreholes. The Goldfields Gas Transmission Pipeline skirts the western edge of these release areas.

(Bids close 19 August 2010)

Canning Basin

There is one release area in the Lennard Shelf of the Canning Basin. The area is 4,091 km² in size.

Hydrocarbon shows are widespread on the Lennard Shelf, with economic accumulations of oil immediately southeast of the release area. These accumulations are found in a Devonian carbonate reef and in Permian-Carboniferous clastics.

Perth Basin

There is one area in the coastal waters of the northern Perth Basin. The area is 1,331 km² in size.

The northern Perth Basin has numerous seismic lines, wells, and oil and gas production from Permian reservoirs. Two gas pipelines occur to the east of the release area. A sealed highway connects to the State capital Perth and the Kwinana oil refinery.

(Bids close 4 November 2010)

GEO THERMAL ACREAGE



The first geothermal acreage release of 2010 covers the whole of the State not covered by permits or applications.

Companies are invited to tender for predetermined areas:

Region	Release areas size (approx.)
Perth Basin and adjacent	320 km ²
Carnarvon Basin and adjacent	6,400 km ²
Southeast region	6,400 km ²
Northeast region	8,000 km ²

Companies interested in geothermal acreage are allowed to bid for multiple areas and are expected to drill at least one well to a depth of 400 m during the first two years of obtaining a geothermal title.

(Bids close 22 July 2010)

Acreage release CD packages are available from DMP and a web version is also available:
www.dmp.wa.gov.au/acreage_release

Acreage release packages contain relevant information about the release areas, land access and how to make a valid application for an Exploration Permit.

FURTHER INFORMATION

Richard Bruce
Petroleum Division
Department of Mines and Petroleum
Telephone: +61 8 9222 3273
Email: richard.bruce@dmp.wa.gov.au
Web: www.dmp.wa.gov.au/acreage_release



Hon. Norman Moore MLC
Minister for Mines and Petroleum

Minister's Message

Western Australia's petroleum sector continues to reach new heights despite the lingering effects of the global economic crisis.

The value of petroleum output in Western Australia rose by nine per cent in 2008–09 to reach \$21.3 billion, with an astonishing 67 per cent rise in the value of LNG production making up for a drop in the value of condensate and crude oil production.

The future of the sector also looks bright, with more than \$135 billion worth of upstream and downstream petroleum projects underway, planned or committed during the next few years.

Western Australia will be home to a number of major new LNG projects

such as Gorgon, Browse, Pluto and Wheatstone, which will generate hundreds of billions of dollars in economic growth and government royalties.

The \$43 billion Gorgon project is one of the world's largest natural gas projects and is the industry leader in plans for CO₂ geosequestration.

Future development of the oil and gas sector will be underpinned by some major State Government commitments.

The WA Government is working with the Commonwealth Government to establish a single LNG processing precinct near James Price Point, 60 km north of Broome.

The precinct is being developed to accommodate production of up to 50 million tonnes of LNG per annum from the Browse Basin, starting in 2015.

The Joint Venture partners for the Browse LNG project are progressing the planning and development of onshore infrastructure at the James Price Point site.

The Government is also progressing extensive reform of the State's approval processes to improve certainty and timeliness for resource projects.

In October 2009, the Premier announced the formation of a new "lead agency framework" to provide one point of contact for information on the progress of each project, along with a suite of legislative changes to help achieve this.

These changes have been supported by improvements in online monitoring of approvals, and inter-agency agreements.

The State Government has responded to the Productivity Commission review of the offshore petroleum sector. It has supported 25 of the 30 recommendations contained in the review, but importantly, opposed the establishment of a National Offshore Petroleum Regulator. This proposed new body would remove Western Australia's joint decision-making role on major projects in Commonwealth waters adjacent to the Western Australian coast.

Mineral and energy exploration in Western Australia has also received a significant boost with the introduction of the \$80 million Exploration Incentive Scheme, unveiled by the State Government in 2009 and funded by Royalties for Regions.

The geophysics program, the largest program in the five year EIS scheme, will receive \$8.5 million by the end of this financial year to capture geophysical data for potential new discoveries, with a further \$21.5 million assigned to these programs over the next three years. Much of the information is focused on the extensive sedimentary basins in the desert areas of Western Australia where new geoscientific information encourages exploration by lowering the risk to explorers.

The scheme also contains the Government co-funded drilling program, which subsidises up to half the costs of selected drilling programs in underexplored areas of Western Australia.

The second round of this was made more attractive to petroleum explorers by offering up to \$200,000 per application for innovative programs.

It has been less than 12 months since the EIS was launched by the State Government, yet it is already showing early indications of success with an increase in tenement and acreage up-take, and technical successes in the form of mineral strikes from the co-funded drilling projects.

This new information and increased exploration activity will unearth new mineral and petroleum discoveries leading to the development of new resource projects for future generations.

The Government has also supported the fledgling geothermal energy sector that includes 10 new Geothermal Exploration Permits in the Carnarvon Basin and areas around Esperance with the launch of the Geothermal Centre of Excellence based at The University of Western Australia.

This issue of PWA will provide an insight into the exploration and development potential and opportunities available in Western Australia to the petroleum industry internationally. ■



Bill Tinapple

Executive Director
Petroleum Division

Executive Director's Message

In our last issue I commented on and discussed the issues associated with implementing the Productivity Commission's recommendations for a National Offshore Petroleum Regulator (NOPR). I suggested that industry carefully consider implications before making a final decision as to whether to support implementation or not.

At the time of writing, the process of implementation had already started. In February, the *Offshore Petroleum and Greenhouse Gas Storage Legislation Amendment (Miscellaneous Measures) Bill 2010*, which provides for the Commonwealth to retain fees to fund the establishment of NOPR, was introduced in to the Federal Parliament. Resources Ministers had, however, not yet finalised their all-of-governments' response to the Productivity Commission recommendations.

Approximately two-thirds of Australia's offshore petroleum exists off the coast of Western Australia, whether in terms of resources, exploration levels or production. Exploration for and development of resources utilise Western Australian infrastructure and have a large impact on the State's economic situation. Therefore, arrangements that are in place for regulation of petroleum activities in offshore waters have a very significant impact on this State. The next ten years will see numerous giant LNG projects come on-stream, injecting hundreds of millions of dollars into the Western Australian economy and creating thousands of jobs. The State cannot be divorced from decisions that affect its future wellbeing.

The Joint Authority/Designated Authority model has operated successfully in Western Australia for 40 years and a decision should not be made to move to another model without first ensuring the alternative model will be less complex, provide a lower level of regulation, and truly reduce the overall approval timeframe significantly for offshore projects.

The implementation of NOPR will see the States/Territory being removed from the approvals process for little efficiency gain. NOPR will not be a one-stop-shop regulator, with approvals for safety, environment and native title each performed by separate government agencies. By removing States from the approvals process, NOPR will make the development of matching licence conditions for petroleum projects spanning both State and Commonwealth jurisdiction more difficult.

Given the scenario of a decade of LNG developments and that most LNG projects will have onshore LNG plants, onshore State approvals make up the bulk of approvals. For example, for a typical LNG project with onshore production facilities, offshore approvals to be undertaken by NOPR only make up 38 per cent of all approvals. Any solution must be holistic. Improvements in the process for the bulk of approvals will only be possible if the States retain a role in decision making.

I strongly urge companies to become familiar with the proposed changes, and decide whether it is in their interests for the change to be made. ■



Barrow Island, off Western Australia's north west coast, will house the onshore infrastructure for the massive Gorgon Project
(Photo courtesy of Chevron)

Petroleum Exploration, Production and Development Activity in Western Australia in 2009

Karina Jonasson
 Petroleum Resource Geologist
 Resources Branch



In 2009, 38 new field wildcats were drilled; 4 onshore and 34 offshore, resulting in a success rate of 26 per cent for significant discoveries (Figure 1). This is an increase on 2008 figures in both wildcat drilling as well as success rate. In addition there were 23 appraisal wells and 28 development wells for a total of 89 wells drilled during the calendar year. With most of the new acreage areas being awarded located around established petroleum provinces, very few wells continue to be drilled in offshore or onshore frontier areas.

Offshore seismic acquisition consisted of 2,904 line km of 2D in the Bight Basin, 3,281 line km (2D) and 200 km² (3D) in the Bonaparte Basin, 4,453 km² in the Browse Basin, and 3,608 line km and 21,182 km² in the Carnarvon Basin. A small amount of onshore seismic was acquired in the Canning and Perth basins. Annual statistics can be found at the back of this issue. Over recent years a number of major independent and national oil companies such as Hess Corporation and the China National Offshore Oil Corporation (CNOOC), amongst others,

have taken up exploration acreage and commenced significant exploration programs in Western Australia. Hess committed to drilling 16 wells in its WA-390-P Exploration Permit. The fruits of these labours have led to a number of discoveries, with Hess finding hydrocarbons in 9 out of 11 wells drilled to date. CNOOC Australia E&P Pty won a licence in the Bonaparte Basin off northern Australia in 2007. The company pledged to spend about \$160 million over six years, including drilling five wells in the first three years and five wells in the subsequent period.

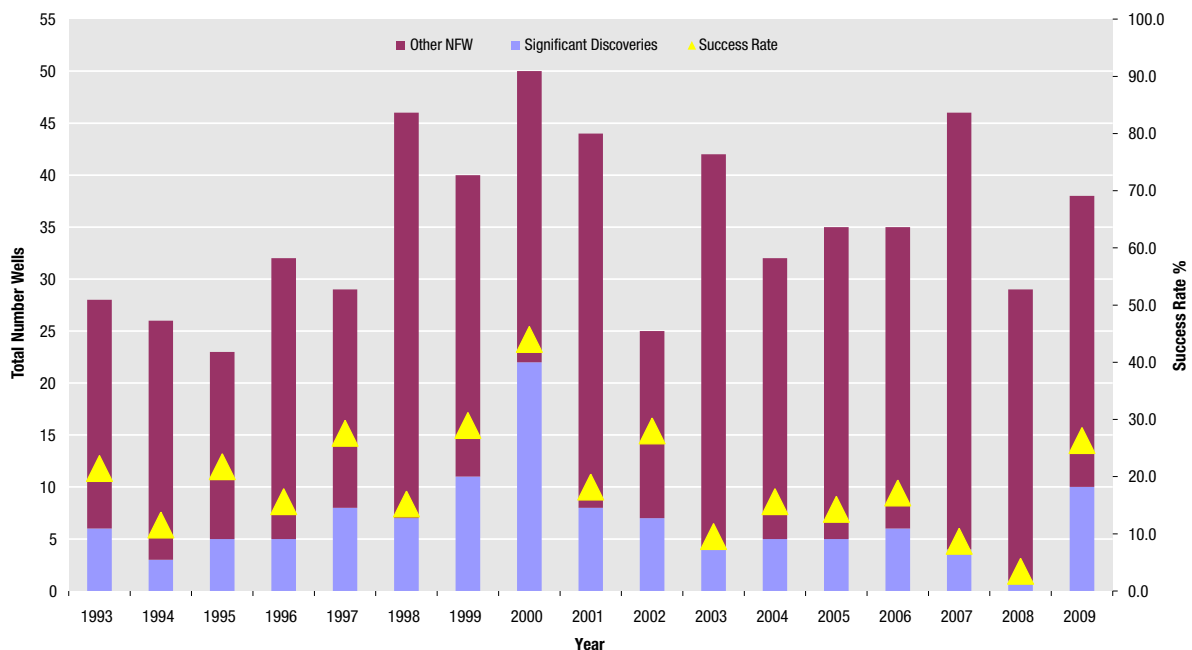


Figure 1 | New field wildcats and significant discoveries in Western Australia 1993-2009

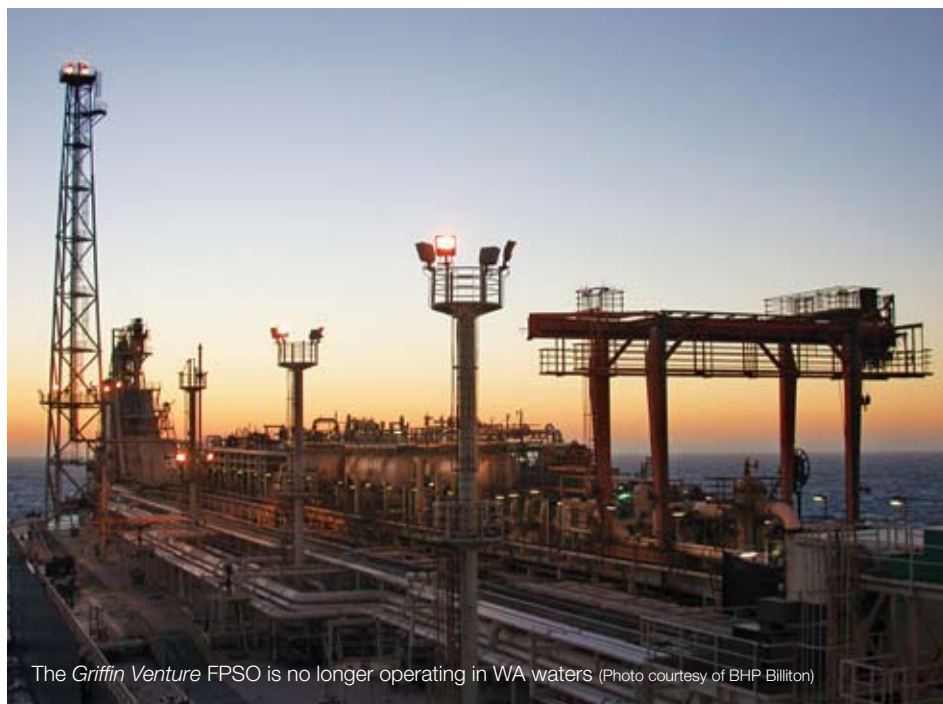
CNOOC drilled its first three wells, Hong Niu 1, Jin Niu 1 and Fu Niu 1 in the Bonaparte Basin in 2009.

Exploration activity among established operators, like Woodside, Santos, Shell, Chevron, Apache and Eni, has also increased in recent times resulting in a number of sizeable gas discoveries in offshore northwest Australia. Adding to the Wheatstone, Iago, Jansz/lo, Prelude, Thebe and Julimar/Brunello discoveries of the recent past, in 2009 we have the Achilles, Satyr, Yellowglen, Brokenwood, Kentish Knock, Poseidon, Concerto and Burnside discoveries, some of which will prove to be commercial (Figures 2–4). In fact, the Concerto 1 discovery, if found commercial, could be included in the Prelude development which Shell ranks highly as a candidate for Floating Liquefied Natural Gas (FLNG) technology.

After 15 years of operation, BHP Billiton ceased production from the Griffin project in October 2009. *The Griffin Venture FPSO* produced oil and gas from the Griffin, Chinook and Scindian fields since 1994. Production had dropped to less than 318 kL/d (2,000 bbl/d) due to natural depletion where it once produced 12.7 ML/d (80,000 bbl/d) oil and 1.4 Mm³/d (50 MMcf/d) gas at its peak. Interests in the project were BHP (45 per cent), ExxonMobil (35 per cent) and Inpex (20 per cent).

Although post the year 2009 reporting period of this issue, we welcome the start of oil production from the BHP Billiton operated Pyrenees fields and the Apache operated Van Gogh development of the northern Vincent field.

Western Australia is looking forward to the approval and development of several greenfields projects which are being proposed for development over the next five to seven years. In this group are the Greater Gorgon project operated by Chevron (at 15 million tonnes per annum - mtpa), which received final environmental approval in September 2009 from the Federal Environment Minister; the 8.6 mtpa Wheatstone project also operated by Chevron; Apache's Julimar/Brunello fields, which will be tied into the Wheatstone development; BHP Billiton's Pilbara LNG project; Shell's 3.5 mtpa Prelude LNG project; Woodside's Browse LNG



The *Griffin Venture* FPSO is no longer operating in WA waters (Photo courtesy of BHP Billiton)

development (15 mtpa from the Torosa, Calliance and Brecknock fields); and the Ichthys project operated by Inpex at 8 mtpa. For the domestic market, we look forward to the Reindeer development, which includes the Devil Creek gas plant, the onshore Warro tight gasfield and exploration for other unconventional gas reserves, which will significantly increase onshore activity in Western Australia.

Relating to the supply side of the gas industry, the *Gas Supply (Gas Quality Specifications) Act 2009* passed in November 2009 by the WA Parliament. The gas specification of the Dampier to Bunbury Natural Gas Pipeline was broadened so that more gas can be made available to supply the WA market. This has enabled the Energy Minister to act to bring WA's gas specifications closer into line with the Australian standard. The previous gas quality specification of the pipeline was one of the narrowest in Australia and was a barrier to increasing natural gas supply in WA. The change in legislation will help secure long term natural gas supplies for the State.

ACTIVITY BY BASIN

Bonaparte

Seven wells were drilled in the Bonaparte Basin in 2009, four new field wildcats – Eni's Windjana 1, and CNOOC's Hong Niu, Jin Niu and Fu Niu wells – and one appraisal and two development wells on the Blacktip field. Two 2D seismic surveys were

completed and one 3D survey was underway at the end of 2009.

Bight

The Bremer Sub-basin of the Bight Basin off Western Australia's southern coastline, where water depths can be up to 4,500 m, was the subject of the first new 2D seismic survey since the 1970s. Arcadia Petroleum and its partner Enovation Resources have carried out the frontier exploration program.

Browse

Five operators were active in the Browse Basin in 2009, drilling eleven wells, comprising eight new field wildcats and three appraisal wells. ConocoPhillips were successful at Poseidon 1 early in the year and followed up with an appraisal of the field at Poseidon 2. Santos announced a significant discovery at Burnside 1 in August. The well encountered a 65 m gross gas column in the primary objective Brewster sandstone, which is the same reservoir in the nearby Ichthys and Prelude fields. Two of three 3D surveys were completed in the Browse Basin in 2009.

Canning

One well was drilled in the onshore Canning Basin in 2009. Kingsway Oil drilled Sally May 2 in EP 429 as a follow-up to the 2005 Sally May 1 well. Two small seismic surveys were also carried out in the basin (103 line km and 223 km²).

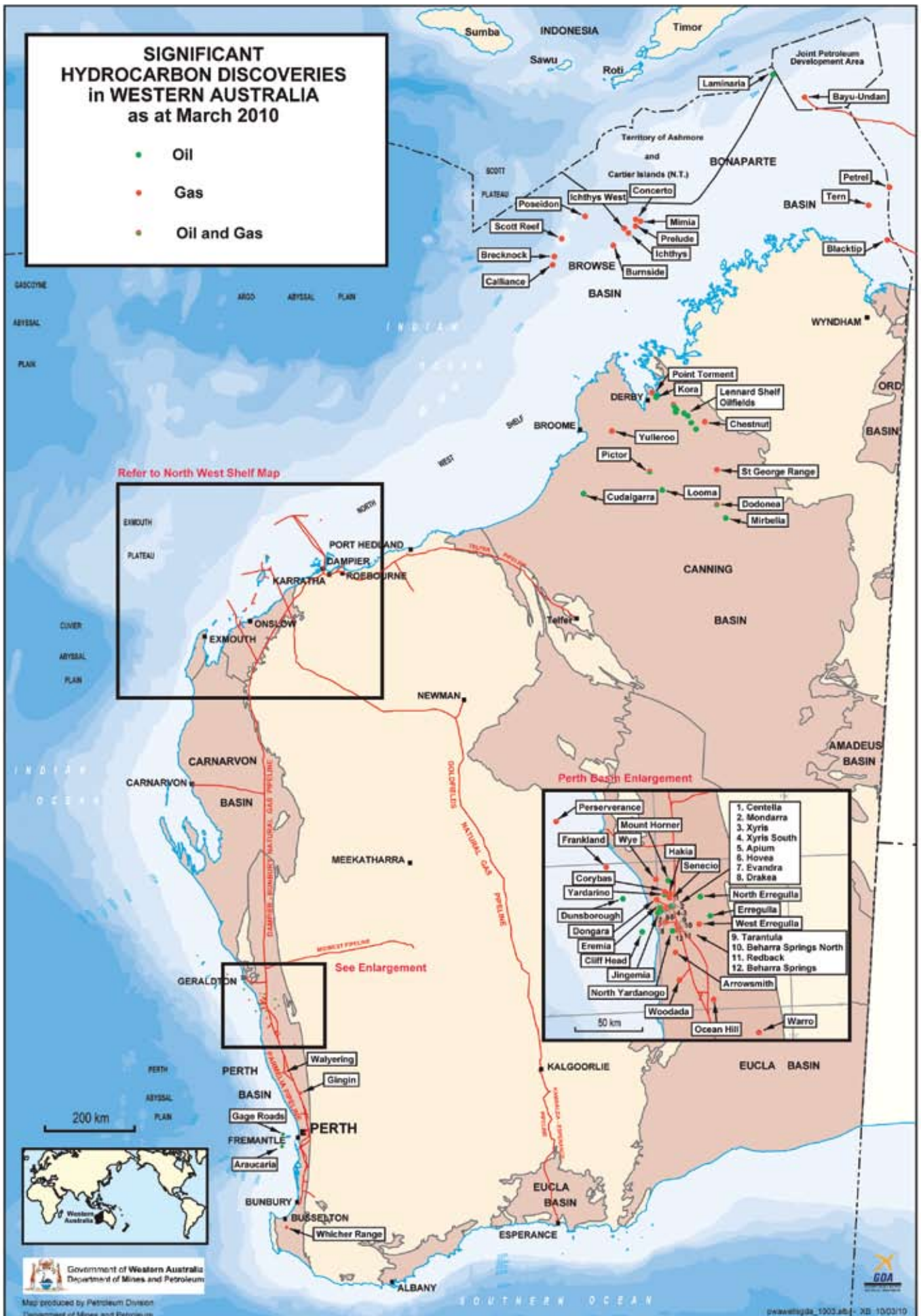


Figure 2 | Significant hydrocarbon discoveries in Western Australia

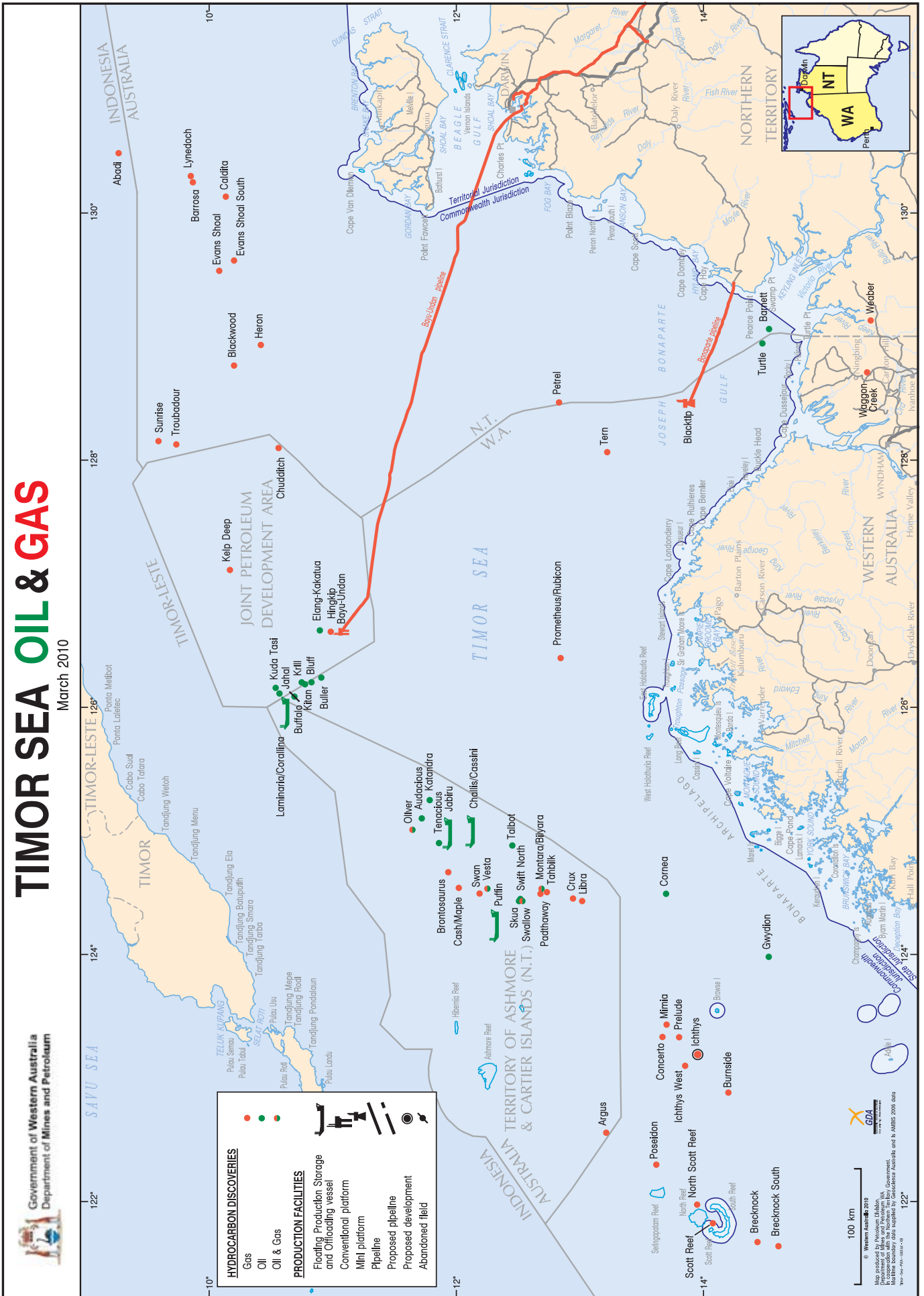


Figure 4 | Timor Sea production facilities and significant hydrocarbon discoveries

Carnarvon

Sixty-four wells were drilled in the offshore Carnarvon Basin, comprising 22 new field wildcats, 18 appraisal wells and 24 development wells. The majority of this year's discoveries were made in the Carnarvon Basin and include wildcats Achilles 1 (with 100 m net gas pay), Brokenwood 1 and 2 (21.8 and 11 m net gas pay respectively), Eris 1 (60 m gross gas pay), Guardian 1, Kentish Knock 1 (34 m of net gas pay), Martell 1 (110 m gross gas pay), Satyr 1 (130 m net gas pay), and Yellowglen 1 (137 m gross gas pay). A large amount of 3D seismic was collected in the basin in 2009.

Perth

Six wells were drilled in the onshore Perth Basin, three new field wildcats – Apium North 1, Gingin West 1 and Redback South 1, one appraisal well at the Warro field and two development wells were drilled at the Jingemias and Hovea fields. A gas discovery was made at Redback South 1. A small 2D seismic survey (28 line km) was carried out in the basin.

EXPLORATION ACTIVITY BY COMPANY

(Compiled from information provided by companies; where there is no report from a WA operating company, it is due to them not submitting one).

Australian Worldwide Exploration Ltd (AWE)

AWE and Origin's most recent round of drilling resulted in the Redback South gasfield discovery. The discovery well (Redback South 1) lies in the L11 permit nearby to the producing Beharra Springs gasfield. The permit is held 33 per cent AWE and 67 per cent Origin. Initial flow rates of up to 1.08 Mm³/d (38 MMscf/d) were recorded on a 1" choke, at a flowing wellhead pressure of 1,750 psi. The well was scheduled to be flowing to sales by 1 April 2010. The Joint Venture may consider the drilling of a further two or three wells during 2010 to further appraise the extent of the Redback South field.

Hovea 13 and 13ST1 wells were drilled in the first half of 2009 as in-field development wells. Hovea 13ST1 reached a total depth of 2,200 m and was completed as an oil producer from the Dongara reservoir. The well intersected a smaller than expected oil



Fracture stimulation work was carried out at Corybas 1
(Photo courtesy of AWE Ltd)

column in this location and preliminary oil production from the well was lower than forecast.

Apium North 1 was drilled in June–July 2009 as a gas exploration well in Production Licence L1 to a depth of 2,655 mMD. The well was plugged and abandoned with no significant hydrocarbon encountered.

Following the success of AWE's 2009 fracture stimulation of the Corybas 1 tight gas well (L1/L2 JV well), plans were initiated to install a sales gas pipeline from the wellsite to the Dongara production facility (held 100 per cent by AWE). The well was planned to be flowing to sales by 1 April 2010. The Corybas fracture stimulation provided AWE with early success in its evaluation of the region's potential for tight gas.

In 2009 AWE launched a study into the unconventional shale gas potential of the onshore Perth Basin. The study involves the Kockatea, Irwin River Coal Measures, and Carynginia shales. These thick shales may have commercial potential. A coring program was planned to commence in the first half of 2010 on the existing Woodada Deep 1 well.

BHP Billiton Petroleum Carnarvon Basin Exmouth Plateau

BHP Billiton holds a 100 per cent working interest in Exploration Permit WA-346-P, immediately adjacent to, and north of, Retention Lease WA-1-R which it holds jointly with Esso Australia (operator). Between them, the blocks

contain the Scarborough (WA-1-R), Thebe and Jupiter gasfields (WA-346-P).

During 2009, BHP Billiton interpreted some 1,466 km² of newly acquired seismic data over WA-346-P from WesternGeco's recently acquired multi-client Keystone 3D seismic survey. The data was used to select the mandatory relinquishment area ahead of the renewal of the permit, which was granted in October 2009. Studies are continuing ahead of the selection of a high graded drill-candidate to satisfy the Year 2 well commitment.

BHP Billiton also operates and holds a 55 per cent working interest in the WA-351-P permit on the southern Exmouth Plateau. In April 2009, the WA-351-P Joint Venture took delivery of the 3,483 km² Aragon multi-client 3D survey, which covers the majority of the permit area. Detailed interpretation of the survey has been undertaken. In June 2009, BHP Billiton farmed in for a 30 per cent interest in the Apache-operated WA-335-P permit, immediately to the south of WA-351-P. A large multi-client 3D survey covering the entire 3,125 km² permit area is currently being acquired.

Exmouth Sub-basin

BHP Billiton is the operator of the WA-255-P and WA-155-P Exploration Permits, as well as several Production Licences, in the Exmouth Sub-basin where the Company's Stybarrow, Pyrenees and Macedon fields are located. During 2009, studies of near-field exploration potential continued, and a renewal application for WA-155-P was lodged.

Dampier Sub-basin

BHP Billiton is a Joint Venture participant in the Woodside-operated North West Shelf Venture, which holds a variety of Exploration Permits and Retention Leases and Production Licences. A number of appraisal and near-field exploration wells were drilled in these leases during 2009.

Browse Basin

BHP Billiton is a participant in the Woodside-operated East & West Browse Ventures, within which the Joint Ventures drilled appraisal wells on the Torosa and Brecknock fields during 2009. At the beginning of 2009, BHP Billiton also operated two other leases in the Browse Basin, AC/RL8 and WA-302-P. In August, BHP Billiton farmed out a 43.33 per cent working interest in AC/RL8 and assigned operatorship to Woodside Browse Pty Ltd. BHP Billiton retains a 40 per cent interest in this Retention Lease. Exploration Permit WA-302-P, in which BHP Billiton is the sole participant, was renewed in September 2009 on a program of seismic reprocessing, which will provide the basis of a decision on whether to commit to exploration drilling later in the permit term.

Chevron Australia Pty Ltd

Chevron is continuing to explore for and appraise Australia's world class natural gas resources with its largest drilling campaign underway offshore northwest Australia.

Chevron Australia participated in 13 exploration and appraisal wells (five operated, eight non-operated) in 2009. Operated exploration wells were successful with five discoveries at Kentish Knock 1, Clio 2, Achilles 1, Satyr 1 and Yellowglen 1.

Greater Gorgon Area

In 2009, work continued to focus on preparing for an extensive exploration and appraisal drilling campaign with the *ENSCO 7500* and the *Atwood Eagle* rigs. The 2009 drilling program contained several commitment wells within various permits in the Greater Gorgon Area. The work to prepare for this campaign has involved extensive seismic processing and interpretation, geological modelling and detailed well planning. Initial well results have been positive with Chevron announcing three gas discoveries in 2009, Achilles 1, Satyr 1 and Yellowglen 1.

Wheatstone

In 2009, work continued to focus on appraisal and resource maturation of the Wheatstone and Iago fields. The 2008–2009 appraisal program, which included seven wells and two well tests, successfully acquired data and information to firm up resource estimates to support the Wheatstone Project.

Exmouth Plateau

Chevron (as operator) and Shell Development (Australia) Pty Ltd hold six frontier permits in the Exmouth Plateau region: WA-364-P, WA-365-P, WA-366-P, WA-367-P, WA-383-P and the recently awarded WA-439-P. The exploration targets on the Exmouth Plateau are Triassic Mungaroo Formation fault blocks and stratigraphic plays in the Cretaceous Barrow Group.

During 2009 the focus of exploration activity was the drilling of two exploration wells in WA-365-P to satisfy the Year 3 work program commitment. The Kentish Knock and Guardian wells confirmed a significant hydrocarbon column. Preparations are underway for the WA-364-P Year 6 commitment well, Brederode 1, scheduled to be drilled in 2010.

The Eendracht MC3D seismic acquisition program in WA-367-P was started in 2009 with completion planned in 2010. Planning began for the acquisition of the Agrippina 3D marine seismic survey (MSS) in WA-366-P and WA-439-P which is scheduled to begin in 2010.

ConocoPhillips Australia Pty Ltd

ConocoPhillips holds a significant acreage position in the Timor Sea joint petroleum development area (JPDA) between Timor-Leste and Australia, the site of the major Bayu-Undan development operated by ConocoPhillips. It also has operations located offshore Western Australia and offshore and onshore Northern Territory, including the Darwin Liquefied Natural Gas (LNG) plant located at Wickham Point, Darwin, which processes gas sent from the Bayu-Undan facility via a 502 km subsea pipeline. In late 2008, the company closed on a transaction with Origin Energy to further enhance its long-term Australasian natural gas business. The 50/50 joint venture, named Australia Pacific LNG (APLNG),

is focused on coal bed methane production from the Bowen and Surat Basins in Queensland, Australia, and LNG processing and export sales.

2009 Activity

ConocoPhillips' 2009 activities for offshore Western Australia have included exploration drilling and 3D seismic acquisition in the Browse Basin. ConocoPhillips and Karoon Gas Australia are Joint Venture participants in Browse Basin Exploration Permits WA-314-P, WA-315-P and WA-398-P. ConocoPhillips has 60 per cent interest in these permits with Karoon Gas holding the remaining 40 per cent interest in each permit.

The exploration drilling campaign commenced in January 2009 with the Poseidon 1 well, which was drilled using the Transocean semi-submersible rig *Sedco 703*. Poseidon 1 encountered hydrocarbons but could not be tested due to a mechanical failure. The well was plugged and abandoned and the rig released on 29 May 2009.

Whilst ConocoPhillips is encouraged with the results of this initial discovery well, Poseidon is a large, complex feature that will require a series of appraisal wells to determine both size and commerciality.

The drilling program continued in the second half of 2009 with the Kontiki 1 well, which was drilled in WA-314-P by the semi-submersible rig *Transocean Legend*. The well was plugged and abandoned without testing. The third well in the program, Poseidon 2, was spudded in October 2009 in WA-398-P. The well reached its target depth in December, following which drill stem testing was conducted.

The drilling campaign is continuing into 2010, with the next well in the program being Kronos 1, in Permit WA-398-P. This was spudded in February 2010.

In addition to the drilling campaign, a 3D seismic survey commenced in October 2009 over WA-315-P and WA-398-P, using the CGGVeritas vessel *M/V Geowave Voyager*. The survey comprises over 2,800 km² full fold data and is expected to be completed by March 2010.

Transocean's *Jack Bates* operating in WA-390-P
(Photo courtesy of Hess/Robert Garvey)



Hess Exploration Australia *Carnarvon Basin*

In 2009, Hess continued the wildcat exploration program on its 100 percent owned and operated Exploration Permit WA-390-P, drilling wells back-to-back with the Transocean *Jack Bates* MODU from June 26 to December 31. This followed the successful 2008 campaign which saw the completion of three wildcat gas discovery wells, Glencoe 1, Briseis 1 and Nimblefoot 1, as well as Warrior 1 which was plugged and abandoned with gas shows.

The seven wells drilled in 2009 were as follows: Toporoa 1, located in the northern part of the permit; Dunlop 1 which was drilled near the Briseis 1 location; Lightfinger 1 in the central part of the block; Bravo 1 and Rimfire 1 in the northwest of the block; Mentorc 1 in the southern part of the licence; and, finally, Hijinx 1, again in the central area of the block. The rig went off hire on January 1, 2010. Six of the seven wells drilled in 2009 were gas discoveries.

The *Jack Bates* has now returned to complete the balance of the 16 exploration well commitment, while work continues to analyse data from the 2008

and 2009 drilling programs and evaluate commercialisation options and appraisal requirements.

INPEX Browse, Ltd *Browse Basin*

INPEX remains active in the blocks near the Ichthys field within the highly prospective Browse Basin. Location 9SL/09-0 was declared over the Mimia field, in Exploration Permit WA-344-P. Mimia is a Brewster Member gas-condensate discovery, made in July 2008. In addition, processing has been completed on 3D seismic acquired over Exploration Permit WA-341-P.

OMV Australia Pty Ltd

As at the end of 2009, OMV Australia had interests in nine Exploration Permits located in the offshore Carnarvon Basin within the area administered by the Western Australian Department of Mines and Petroleum and was operator of seven of them, which are reported on here.

In 2009, OMV's activities concentrated on seismic reprocessing. In WA-290-P, a multi-survey 3D seismic time and depth reprocessing project of ~880 km² was conducted. Seismic interpretation

of reprocessed 3D and 2D seismic data and technical studies were conducted in WA-320-P.

Processing of the ~7,900 km Klimt 2D survey (recorded in 2008) was completed and interpretation of this new and vintage 2D data and technical studies were conducted for Exploration Permits WA-362-P, WA-363-P, WA-386-P and WA-387-P.

Time reprocessing of 3D seismic data over WA-391-P was completed and pre-stack depth migration processing was commenced during 2009.

Planned Exploration Activities for 2010

The planned exploration activities for 2010 are as follows:

- Seismic interpretation of the newly reprocessing 3D time and depth cubes and technical studies for WA-290-P.
- Complete interpretation of the reprocessed 3D and 2D seismic data. Determine work program for renewal term of the WA-320-P permit, preparation and submission of permit renewal application.

- Complete interpretation of the 2008 Klimt 2D and vintage seismic data, determine requirement for and scope of infill seismic data over high-graded areas of the WA-362-P, WA-363-P, WA-386-P and WA-387-P permits and prepare for and conduct survey as required.
- Complete 3D pre-stack depth migration processing, seismic interpretation of the reprocessed 3D time and depth cubes and technical studies in WA-391-P.

Origin Energy

In the Perth Basin, Origin continues to have an active and successful exploration and development program. Origin is the operator of Production Licence L14 (49.189 per cent) in which the Jingemia oilfield is located, and Production Licence L11 (66.67 per cent), which includes the Beharra Springs and Tarantula gasfields. Origin also operates EP 413 (49.189 per cent), is a 50 per cent joint venture party with AWE in L1/L2, and holds a 15 per cent interest in EP 368.

During 2009 Origin and its joint venture partners drilled two exploration wells in the northern Perth Basin.

Redback South 1 was drilled to test the hydrocarbon potential of the Wagina Sandstone on a terrace east of the Beharra Springs gasfield in L11. The well encountered high-pressure gas in good quality sands. Pressure data from a cased hole production test and a static pressure gradient survey indicate an entrapped volume of at least 0.28 Gm³ (10 Bcf).

Planned exploration activity for 2010

Origin intends to appraise the extent of the gas resource on the Redback Terrace by the drilling of at least two follow-up wells. One of these wells, Redback 2, will be drilled north of the East-West Redback Fault to investigate the presence of reservoir quality sands and gas pay north of this fault. A second well will evaluate the extent of the Redback South gas entrapment south of the Redback Fault.

Depending on the results of these two wells, additional wells may be drilled, including a well to test the reservoir potential of the High Cliff Sandstone west of the Beharra Springs Fault, beneath the Beharra Springs gasfield.

Origin will also continue its ongoing geoscience studies with a view to maturing additional oil and gas exploration prospects and leads to drillable status.

ROC Oil Company Limited

In 2009, ROC-operated permits offshore Western Australia comprised three Exploration Permits (one in the Abrolhos Sub-basin and two in the Vlaming Sub-basin). ROC also participated in an Exploration Permit in the Carnarvon Basin. This report includes 2009 activity in ROC-operated permits.

Abrolhos Sub-basin (Perth Basin) – WA-286-P and WA-31-L

The prospectivity of WA-286-P was evaluated in conjunction with a work program proposal for the second renewal of the permit, which requires 50 per cent relinquishment. The Permian reservoir play fairway in the eastern part of the permit, which was successful at the Cliff Head oilfield, will be further assessed and analysed during 2010. The Yungarra Prospect has a mean reserve oil potential of 1,900 ML (12 MMbbl) and is a possible drilling candidate for 2011. Further evaluation of the Diana 3D survey (acquired in Q1 2008) will be undertaken, including a Pre-stack Depth migration project in the vicinity of the Frankland gas discovery.

Exploration opportunities in WA-31-L in proximity to the Cliff Head oilfield were reviewed in 2009. The evaluation indicated that the West High and Updip Mentelle structures are relatively small and have risk profiles which ultimately deterred the Joint Venture from testing these near-field structures at this time. Reprocessing of the vintage 2D seismic within the WA-31-L licence commenced in 2009, so that additional structures in the vicinity of the Cliff Head oilfield can be evaluated.

Vlaming Sub-basin (Perth Basin) – WA-381-P and WA-382-P

ROC resigned as operator of both WA-381-P and WA-382-P effective 31 December 2009 and has given notification of its intention to withdraw from these permits during 2010.

Shell Development (Australia) Pty Ltd

Browse Basin

During 2009, Shell Development (Australia) Proprietary Limited (SDA)

submitted an application to drill for the Octans prospect in Exploration Permit AC/P41 and for the Crescendo and Minuet prospects in Exploration Permit WA-371-P. The Concerto 1, Octans 1, Intermezzo 1, Minuet 1 and Crescendo 1 wells were spudded in 2009.

SDA's equity interest in AC/P41 increased to 75 per cent during the year, while Mitsui E&P Australia Pty Ltd equity increased to 25 per cent and Nexus exited the permit. SDA remains operator of the permit.

In 2010 it is expected that three wells will be drilled in WA-371-P and AC/P41.

Carnarvon Basin

During 2009, SDA participated in five non-operated exploration wells (Kentish Knock 1, Achilles 1, Satyr 1, Yellowglen 1 and Guardian 1) and one appraisal well (Clio 2).

SDA completed 2D seismic acquisition in its 100 per cent Exploration Permits WA-384-P, WA-385-P and WA-394-P in the southern Exmouth Sub-basin early in 2009.

SDA, with partner Chevron, was successful in an application for gazettal block WA-439-P in the Exmouth Plateau.

In 2010, it is anticipated that SDA will participate in five exploration wells and two appraisals in the Greater Carnarvon area.

Woodside Energy Ltd

During 2009 Woodside continued to build its seismic and acreage position in the Carnarvon Basin adding 17,000 km² of new 3D seismic and five new permits bringing the total Pluto exploration acreage to more than 40,000 km².

In February 2009, Woodside announced the Martell gas discovery in Exploration Permit WA-404-P in the Carnarvon Basin. Woodside is operator and has a 50 per cent equity interest in the well, which is about 290 km from Karratha and 100 km northwest of the Pluto field. Water depth at the location is 1,290 metres. Pressure testing of sandstones over an interval of 2,778 m to 3,201 m (MDRT) has confirmed a gross gas column of about 110 m and the presence of a gas/water contact.

In August 2009, Woodside announced an exploration program of at least 20 wells in the next 18 months to support the expansion of the Pluto LNG Project.



ROC Oil's Exploration Permit WA-286-P in the offshore Perth Basin

The program represents the biggest continuous deepwater exploration campaign in Australian history.

In the fourth quarter of 2009, Woodside experienced early success at one of these exploration wells, Eris 1 in Permit WA-34-L in the Carnarvon Basin. Woodside has a 90 per cent interest in the well. The Pluto appraisal well, Pelion 1, in WA-34-L, was unsuccessful. Although the Pelion exploration prospect was dry it encountered the Pluto reservoir high to prognosis with the potential to add to Pluto volumes. The ongoing results of this campaign are expected to substantially contribute to an expansion of the foundation Pluto LNG Project.

Exploration wells planned to commence in Q1 2010 are Noblige 1, Larsen 1, and Hine 1 located in WA-404-P, and Dalia South 1 in WA-348-P, all targeting gas. Following that, Woodside plans to drill Courvosier 1, Guerbie 1, Camus 1, Hennessy 1 and Moyet 1 in WA-404-P, Churchill 1 in WA-347-P, Claudius 1 and Constantine 1 in WA-434-P, Esperance 1 in WA-369-P and Gumbo 1 in WA-430-P.

PRODUCTION AND DEVELOPMENT ACTIVITY BY COMPANY

Australian Worldwide Exploration Ltd (AWE)

Perth Basin

The Dongara production facility received an upgrade with the installation of a new reciprocating compressor. The new compressor has an efficiency envelope outside that of the existing turbine compressors and more in line with current production levels. This was planned to lower field operating costs.

AWE has completed a workover on the Eremia 6 well, and installed a pump on the Dongara 31 well.

The field operations of AWE's Hovea Eremia oilfields, Dongara gasfield, and Xyris gasfield have been officially handed over to marginal field specialist operator AGR. This is the second Perth Basin assignment for AGR, who have operated the Cliff Head oilfield since inception. AWE hopes this will reduce the cost of operating oil- and gasfields in the North Perth Basin through efficient use of field personnel, engineering, and logistics support.

BHP Billiton

Stybarrow Field, Carnarvon Basin

BHP Billiton is the operator of the Stybarrow Project, a nine-well subsea development connected to the Stybarrow Venture Floating Storage and Offtake (FPSO) facility.

The Stybarrow oilfield is located approximately 65 km offshore north Western Australia, in the Exmouth Sub-basin. At a water depth of 825 m, Stybarrow is Australia's deepest oilfield development.

During 2009, the Stybarrow Project remained in steady state operation and commenced its inaugural whale monitoring program from the FPSO facility.

Stybarrow and the adjacent small oil rim of the Eskdale field are located in WA-32-L and have recoverable oil reserves estimated in a range from 9.5–14 GL (60–90 MMbbl) of oil. The estimated economic field life is 10 years.

Pyrenees Field, Carnarvon Basin

The Production Licences WA-42-L and WA-43-L are located offshore in the Exmouth Sub-basin, approximately 20 km east of the Stybarrow development (WA-32-L) and 45 km northwest of Exmouth.

The Pyrenees Project incorporates a subsea development and an FPSO facility which processes, stores and

offloads oil to export tankers. Water depth across the development area is between 170 to 250 m.

The centrepiece of the development, the Pyrenees Venture FPSO, is disconnectable, double-hulled and able to process approximately 15 ML/d of oil (96,000 bbl/d). A gas disposal well is located at the nearby Macedon field.

The Pyrenees Project progressed into its execution phase in 2009 with first oil targeted in the first half of 2010. The development drilling campaign commenced in January 2009 and by the end of year, nine subsea wells (seven producers, one gas injector and one water injector) had been completed.

The Pyrenees fields of Crosby, Ravensworth and Stickle, discovered in 2003, have estimated recoverable oil reserves in the range of 12.7–19 GL (80–120 MMbbl) of oil.

The field is estimated to have an economic life of 25 years.

Macedon Field, Carnarvon Basin

In 2009, BHP Billiton progressed to the Definition Phase of the Macedon Gas Development, a proposed domestic gas project using gas from the Macedon field.

The development concept incorporates four subsea wells connected to the Macedon gasfield, which feed gas into an 80 km seabed pipeline which would come ashore at Tubridgi, south



The Stybarrow Venture FPSO (Photo courtesy of BHP Billiton)

of Onslow, to be processed at a small onshore gas treatment facility at a site at Ashburton North before being exported to the Dampier to Bunbury Natural Gas Pipeline.

The Macedon field was discovered in 1992 by the West Murion 3 well. Macedon, in WA-12-R, is located approximately 100 km west of Onslow and 40 km north of Exmouth, at a water depth of approximately 150 m.

Scarborough Field, Carnarvon Basin

The Scarborough gasfield, located in Retention Lease WA-1-R, was discovered in 1979 by the Scarborough 1 well drilled in more than 900 m of water.

During 2009, ExxonMobil and BHP Billiton conducted studies to further investigate development concepts for the commercialisation of the field.

The companies are continuing to review development options and are working together to identify the optimal development plan for the Scarborough gasfield which is located 280 km northwest of Onslow.

North West Shelf

BHP Billiton is a one-sixth participant in the North West Shelf Joint Venture (NWSJV) Project operated by Woodside Energy Limited.

The NWSJV reached two milestones in 2009. In September, the Venture celebrated more than 25 years of domestic gas production and earlier in the year marked 20 years of liquefied natural gas (LNG) exports.

During 2009, two NWSJV projects progressed: the North Rankin Gas Compression Project (NRB), which will recover remaining low-pressure gas from the North Rankin and Perseus gasfields, and the Cossack, Wanaea, Lambert, Hermes (CWLH) Life Extension Project, which is targeting first production from the redeveloped facilities in 2011.

Chevron Australia Pty Ltd

Chevron Australia operates Australia's largest onshore oilfield on Barrow Island together with the Thevenard Island oilfields. The company is leading the development of the Gorgon and Wheatstone Projects; and is a foundation participant in the North West Shelf Venture and the Browse LNG development.

Barrow Island Facility, Carnarvon Basin

Barrow Island is located approximately 56 km from the Pilbara mainland, 1,300 km north of Perth. Since its discovery in 1964, the Barrow Island oilfield has produced more than 47 GL (300 MMbbl) of oil.

Total oil production for Barrow Island (L1H) during 2009 was 313,990 kL. The total volume of water produced with oil during 2009 was 2,807,419 kL and 1,661,709 kL from water source wells. The volume of gas produced in 2009 was 20,673 km³.

Since 1995, a total of 79 infill wells have been drilled in the Windalia reservoir on Barrow Island. The latest campaign took place in 2007–2008, comprising of 13 wells — eight water injectors and five producers. Nine of the 13 wells of this campaign were drilled proximal to the Barrow Fault targeting oil volumes unswept by the existing waterflood. Two of the remaining wells were drilled as production/appraisal wells in Production Blocks S and T on the northern flank of the Windalia oilfield. Preliminary analysis indicates that this campaign has been successful in targeting unswept oil, with results from the S and T Block wells stimulating further infill planning in the area.

This work was complemented in 2009 with waterflood optimisation activities adopted in the Windalia field. The objective of this is to better allocate water and hence production returns. Water injection rates were also increased from less than 8 ML/d (50,000 bbl/d) to in excess of 11 ML/d (70,000 bbl/d).

Enhanced oil recovery (EOR) polymer injection is also being piloted in the Windalia F block to further target unswept oil in the reservoir, with results to determine whether the tertiary recovery technique is to be adopted field wide. These activities are all in line with strategies designed to increase the field life and enhance oil recovery from the reservoir.

Thevenard Island Facility, Carnarvon Basin

Thevenard Island is located about 25 km northwest of Onslow and has been the base for the processing and storage of hydrocarbons from the Saladin, Roller, Skate, Cowle and Crest fields.

Total oil production from the Thevenard production leases during 2009 was 136,153 kL. The volume of water produced during 2009 was 3,867,022 kL and the volume of gas was 15,505 km³. The majority of water produced is re-injected back into the source reservoir.

Greater Gorgon Area Gasfields, Carnarvon Basin

The Gorgon Project plans to develop the Greater Gorgon Area gasfields, located between 130 and 200 km off the northwest coast of Western Australia.

The Greater Gorgon Area gasfields are estimated to contain resources of about 113 Gm³ (40 Tcf) of natural gas and are Australia's largest-known natural gas resource. Development of this substantial asset will secure Australia's position as a leading gas producer and generate a new source of wealth for Western Australia and Australia. The Gorgon Project has an expected economic life of at least 40 years.

The project includes:

- development of the Greater Gorgon Area gasfields involving subsea pipelines to Barrow Island;
- a gas processing facility on Barrow Island consisting of three, 5 mtpa LNG trains and a domestic gas phase with capacity of 300 TJ/d;
- LNG shipping facilities to transport products to international markets; and
- greenhouse gas management via injection of carbon dioxide into deep formations beneath Barrow Island.

A final investment decision (FID) on the Gorgon Project was taken in September 2009. The project is estimated to cost approximately \$43 billion for the first phase of development. First gas is planned for 2014.

Extensive economic modelling by an independent third party, ACIL Tasman, confirmed that the Gorgon Project will be Australia's largest resources project. Other key economic findings — based on the first 30 year operation of a 15 mtpa, three-train development include:

- peak construction employment in Western Australia of around 10,000 with more than 3,500 direct and indirect jobs sustained throughout the life of the Gorgon Project;

- an expected boost to Australia's Gross Domestic Product (GDP) of \$64 billion net present value;
- locally purchased goods and services (local content) of \$33 billion,
- expected Government revenue of around \$40 billion in today's dollars.

The Chevron-operated Gorgon Project is a Joint Venture between the Australian subsidiaries of Chevron (approximately 47 per cent), ExxonMobil (25 per cent), Shell (25 per cent), Osaka Gas (1.25 per cent), Tokyo Gas (1 per cent) and Chubu Electric Power (0.417 per cent).

Wheatstone and Iago Fields, Carnarvon Basin

The Wheatstone gasfield is located about 145 km off Western Australia's Pilbara coast, adjacent to another Chevron-operated field, Iago.

To process the gas from these and other fields, Chevron plans to initially construct two LNG trains with a total capacity of 8.6 mtpa and a domestic gas plant at Ashburton North near Onslow. It eventually could have the capacity to produce up to 25 mtpa of LNG and associated domestic gas.

The Wheatstone Project is set to be one of Australia's largest resource projects, providing greater security of supply and offering significant economic benefits including employment, government revenue and local business opportunities for generations of Australians. The project is expected to create about 6,500 direct and indirect jobs during construction.

The project provides not only a foundation for commercialising the Wheatstone resource, but also future gas development opportunities in the western half of the Carnarvon Basin.

The Wheatstone Project moved into the front-end engineering and design (FEED) phase in July 2009.

In October 2009, Chevron announced the signing of an agreement with Apache Julimar Pty Ltd, a subsidiary of the Apache Corporation, and KUFPEC Australia (Julimar) Pty Ltd, a subsidiary of the Kuwait Foreign Petroleum Exploration Company, as natural gas suppliers at the Wheatstone natural gas hub and equity participants in the project facilities. Under the agreement, Apache and KUFPEC will provide

natural gas from their Julimar and Brunello fields to supply Train 1 and 2 of the Wheatstone Project.

A final investment decision on the Wheatstone Project is targeted for the second half of 2011.

Eni Australia Limited

In WA Eni participates in three Production Licence areas and one Retention Lease, all of which it operates.

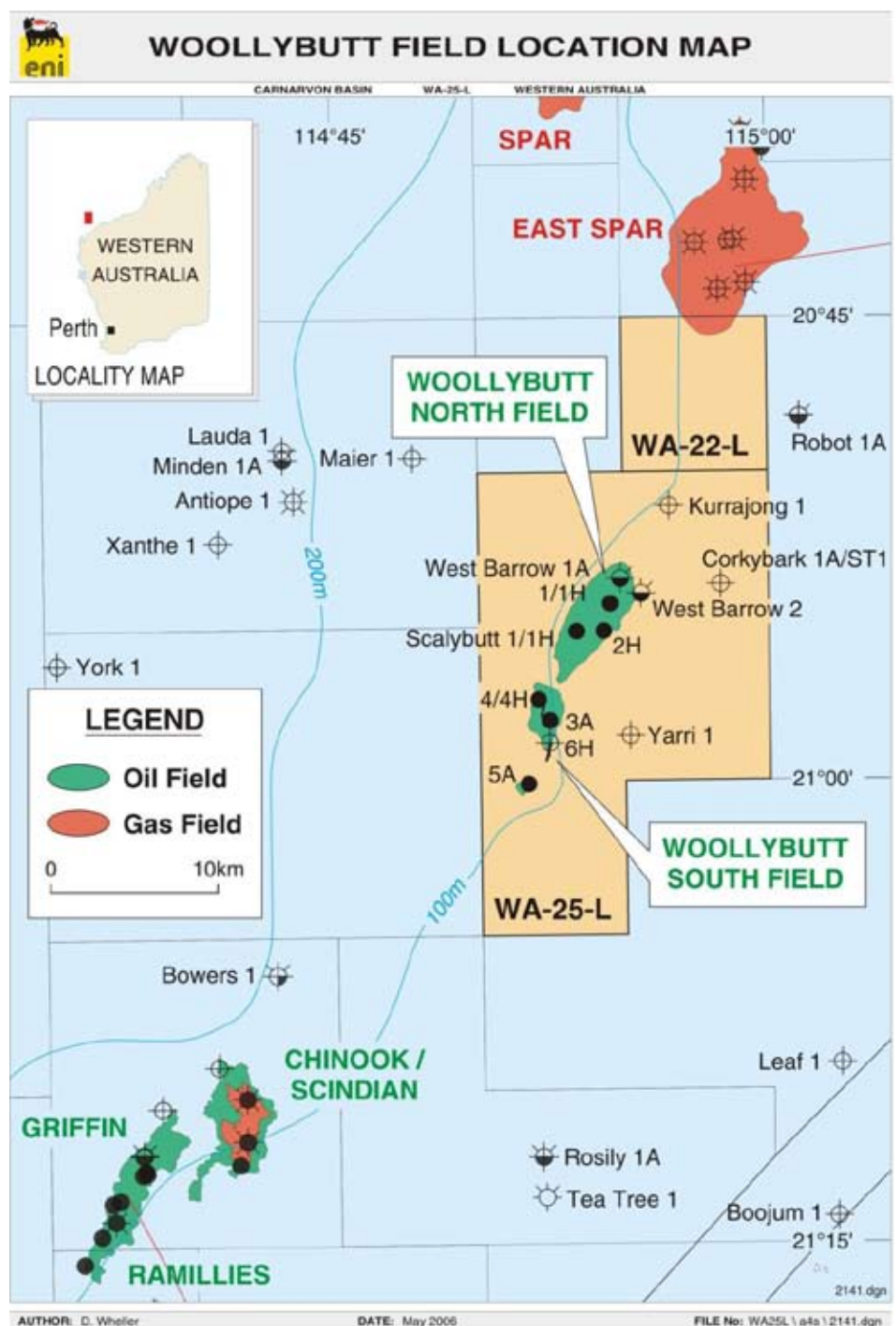
Woollybutt (WA-22-L and WA-25-L)

The Woollybutt oilfield is located in the WA-25-L Production Licence in the

Carnarvon Basin and contains two separate lobes. The North Lobe has been in production since 2003 and its current production is around 1,335 kL/d (8,400 bbl/d).

In May 2009, production from the Woollybutt field was suspended for the purpose of taking the FPSO *Four Vanguard* to Singapore for planned maintenance, re-survey and major equipment refit.

The FPSO, now named *Four Rainbow*, returned to the field toward the end of 2009 to commence preparations for



Eni's Woollybutt oilfield in WA-25-L in the Carnarvon Basin

the resumption of production in early 2010. The refit of the FPSO will ensure the maximum exploitation of the field. Originally expected to have a field life of 3–4 years and total production of 2.9 GL (18 MMbbl), the Woollybutt field has produced over 5 GL (32 MMbbl) to date and has an expected field life of another 2–3 years.

The FPSO *Four Rainbow* has a design production capacity of 6,359 kL/d (40,000 bbl/d).

Eni is operator of the field with 65 per cent equity on behalf of Joint Venture partners Mobil Australia Resources Co Pty Ltd (20 per cent) and Tap West Pty Ltd (15 per cent).

Blacktip (WA-33-L)

The Blacktip field is located in the Production Licence WA-33-L within the Exploration Permit WA-279-P.

In 2006, Eni began the development of the field based on the development concept of an unmanned well head platform connected to an onshore gas plant (OGP) via a 110-km pipeline. The OGP is located at Yelcherr, near the town of Wadeye in the Northern Territory.

The Blacktip gasfield was developed to provide gas to the Northern Territory's Power Water Corporation (PWC) for power generation in the NT. The Gas Sale Agreement, concluded in 2006, is for the supply of gas over a 25 year period, commencing at 23 petajoules per annum (PJ/a) rising to 38 PJ/a over the life of the contract.

Commissioning of the Blacktip Project commenced in mid 2009 with early gas supply starting in September. By mid December, dry sales gas was being provided to the PWC from the Blacktip Project. The onshore gas plant has a design production capacity of 44 PJ/a.

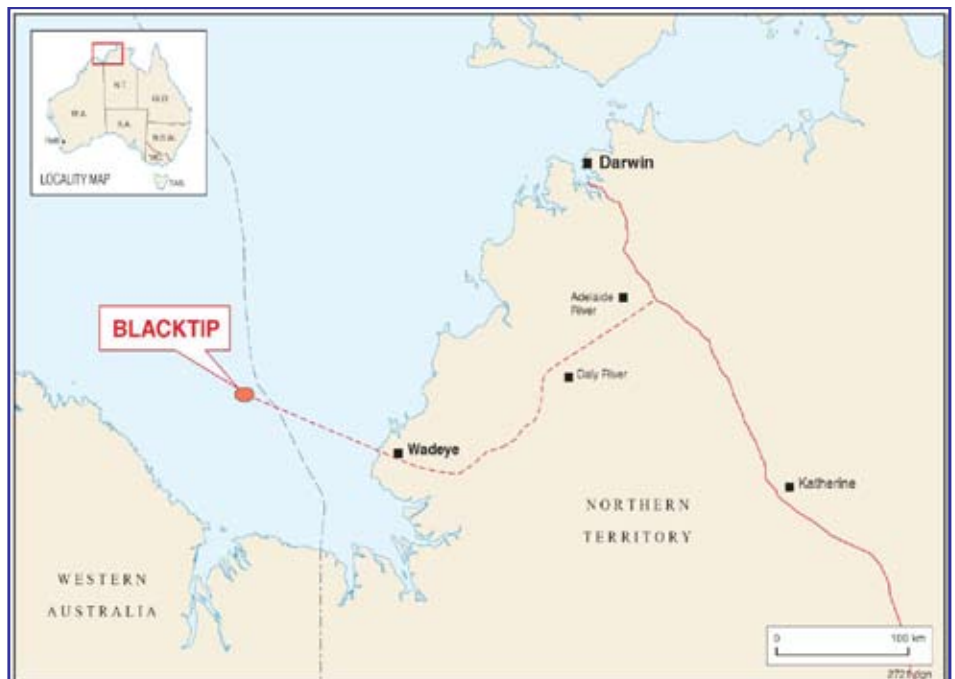
The Blacktip Project is 100 per cent owned and operated by Eni.

INPEX Browse, Ltd

Ichthys Project

INPEX and its Ichthys Project Joint Venture partner Total launched front-end engineering and design (FEED) in early 2009. The project will be one of the largest gas and condensate projects in the world. It will be the first time a semi-submersible central processing facility (CPF) is used in Australia. The majority

The Blacktip well head platform in WA-33-L (Photo courtesy of Eni)



Location of the Blacktip Project in the Timor Sea

of condensate will be processed at the field and exported directly from the floating production storage and offloading (FPSO) vessel, with a storage capacity of more than 159 ML (1 MMbbl). The WA-37-R Retention Lease was granted over the Ichthys field in late 2009.

Origin Energy

Origin Energy is the operator of the Jingemgia oilfield (49.189 per cent) and the Beharra Springs and Tarantula gasfields (66.67 per cent) in the Perth Basin. Origin is also a 50 per cent Joint Venture partner with AWE in the Hovea / Eremia oilfields and Xyris Area Gas Gathering System (XAGGS).

Jingemgia 12 was drilled at a central location in the Jingemgia oilfield in L14. The well intersected 15 m of net pay within the Dongara Sandstone and was completed as an oil producer.

A workover was commenced on Jingemgia 4 to repair well integrity and repair the artificial system. The Jingemgia oilfield produced a total of 30.6 ML (192,000 bbl) of oil.

The Beharra Springs Gas Facility is located 35 km southeast of Dongara and sold a total of 3.1 PJ (8.5 TJ/day) for 2009 from four production wells, all of which are in natural field decline.

The non-operated fields produced a total of 44.5 ML (280,000 bbl) and 1.5 PJ.

Planned development and production activity for 2010

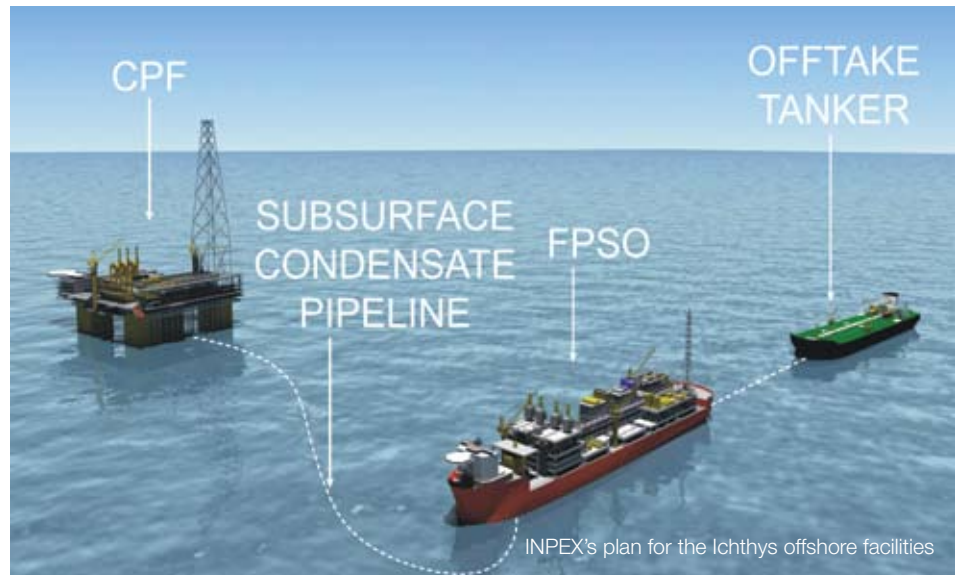
Origin intends to install a 2.2 km 150NB (6 inch) pipeline to tie-in the Redback South 1 discovery to the Beharra Springs Gas Plant. The Redback South 1 well will then be brought online in Q2 2010.

Depending of further success in the exploration campaign, the gas plant may undergo de-bottlenecking or expansion to increase through-put. A concept study will commence into the feasibility of adding a second gas processing train.

ROC Oil Company Limited

Cliff Head Oilfield - WA-31-L

Production operations at Cliff Head continued with good production performance and safety record in 2009. The Cliff Head operations achieved three years Lost Time Injury-Free (LTI-free) in February 2009. Total gross production



in 2009 was 225 ML or 618 kL/d (1,418,165 bbl or 3,885 bbl/d).

Workover operations to replace electric submersible pumps (ESP) at Cliff Head 10 and 6 were recently completed. A larger ESP was installed at Cliff Head 10 and production from the well restarted on 16 December 2009. Workover operations at Cliff Head 6 were completed and production recommenced on 21 January 2010. Further Cliff Head workover opportunities are expected to be pursued during 2010.

Woodside Energy Ltd

2009 Production

Production of 12.8 GL (80.9 MMbbl) of oil equivalent was achieved despite all of Woodside's assets being in natural field decline and no new project start-ups in 2009. This was only marginally lower than Woodside's 2008 record of 12.9 GL (81.3 MMboe).

The North West Shelf (NWS) Venture achieved record LNG production following the first full year of production from Train 5 and the successful modification of Train 5's main cryogenic heat exchangers. During the year, Woodside, as operator of the North West Shelf Venture, loaded 246 cargoes of LNG. Woodside's share of 2009 LNG production was 2.40 million tonnes up from 1.95 million tonnes in 2008.

Additional condensate capacity achieved with the mechanical completion of a sixth condensate stabilisation unit at the Karratha Gas Plant (KGP) in May 2009, adding 3,975 kL/d (25,000 bbl/d) of condensate processing capacity.

Angel

The Angel platform achieved unmanned status. The platform, which commenced production in Q4 2008 and supplies much of the additional gas needed for a five train operation at KGP, is now remotely operated from the North Rankin A (NRA) platform. Gas and condensate from three subsea wells are exported through a 50 km subsea pipeline to the second trunkline to shore.

North Rankin Redevelopment Project

The project continues on cost and on schedule with the North Rankin B (NRB) substructure fabrication ahead of schedule in Indonesia and the topsides fabrication on schedule in Korea. At year end the project was 41 per cent complete. Modification continues on the NRA Platform for process tie-ins and the bridge-link to the NRB platform. The project is expected to cost approximately \$5 billion (\$840 million Woodside share) and is scheduled for completion in 2013.

North West Shelf Oil Redevelopment Project

The project continues on cost and on schedule being 71 per cent complete at year end. Refurbishment and conversion of the Okha vessel, at the Keppel Shipyard in Singapore and topside module fabrication progressed according to plan with installation of processing equipment underway. Refurbishment of existing subsea infrastructure will commence in Q4 2010 with the Okha scheduled for start up in Q1 2011.

Pluto LNG Project

The Pluto LNG Project was 83 per cent complete at the end of 2009 and on target to become the fastest developed LNG project in the world from discovery in 2005 to first gas from the field by late 2010, with first LNG early 2011 contingent on a productive industrial relations environment. A risk mitigation plan is in place, if required, to ensure LNG delivery obligations are covered.

Onshore, more than 90 per cent of the 264 modules for the LNG plant have now arrived from Thailand, including the four gas turbine generators and liquefaction modules.

The flare tower and the jetty structures were assembled and the main cryogenic heat exchangers for the LNG train were lifted into place. The LNG and condensate storage tanks were successfully hydro tested in the second half of 2009.

Offshore, more than 200 km of pipelines were laid, connecting the production wells to the platform and onshore plant. The platform substructure was loaded from the fabrication yard in China in late August 2009 and was successfully launched into the ocean about 190 km northwest of Karratha in October 2009. The topside modules and flare boom were lifted onto the jacket in the following months, completing the assembly of the platform. Commissioning of the platform commenced during Q4 2009 and will continue into 2010.

The second drilling campaign for Pluto's production wells concluded in late 2009. The campaign successfully completed and tested four Pluto production wells providing more than the required production volumes. The timing for completion of the fifth and final well will be determined in 2010.

A review of the cost and schedule of the foundation project in November 2009 resulted in a revision to the expected final costs, due to lower than budgeted productivity in both onshore and offshore construction.

Depending on the drawdown of project contingencies, the final cost of the foundation project is expected to be 6 per cent to 10 per cent over the \$11.2 billion approved by Woodside at the time of the final investment decision in July 2007.

In November 2009 Woodside advised that it had awarded dual front-end engineering design contracts for Pluto Train 2 and Train 3, comprising the same scope of work, to a Foster Wheeler WorleyParsons Joint Venture and KBR. The FEED studies are scheduled for completion in mid-2010.

A final investment decision on Pluto Train 2 and Train 3 is targeted by the end of 2010 and end of 2011 respectively based on accessing sufficient gas through exploration success or other means.

Browse

The path to Final Investment Decision (FID) is now clear with the State and Federal Governments mandating a material work program with defined deliverables and timeline as conditions for the Browse Retention Lease renewals.

The renewed leases, granted on 24 December 2009, require the Browse Joint Venture to undertake a \$1.25 billion work program to complete Basis of Design in 2010 and FEED in 2011 to enable an FID by mid-2012.

In 2009 Woodside executed a number of agreements in relation to the State Government's Browse LNG Precinct. In April, Woodside signed a Heads of Agreement (HOA) with the Kimberley Land Council (on behalf of Traditional Owners) and the State of Western

Australia. The HOA commits Woodside and the State to a range of financial and other benefits for the Indigenous people of the Kimberley, triggered by stages in the development of the Precinct. In addition Woodside entered into a Preliminary Development Agreement with the State of Western Australia, which appoints Woodside as the foundation commercial proponent for the Precinct.

In early 2010 the Browse LNG development achieved a number of further significant milestones. Seven weeks ahead of the government mandated schedule, the Browse Joint Venture selected the West Australian Government's Browse LNG Precinct at James Price Point as the location to process gas from Browse Basin fields, completing the development concept phase.

Completion of the development concept select phase was closely followed by an announcement that the Browse LNG development had entered into the Basis of Design (BOD) phase for the development. The BOD phase determines the major design parameters which would enable the optimal development of the offshore gasfields and the onshore facilities at James Price Point. Contracts for BOD for both the onshore and offshore components were awarded in early 2010 and workforce numbers are increasing to support the work program. ■



Installation of the platform for the Pluto field in late 2009
(Photo courtesy of Woodside Energy)

The liquefaction module arriving at the Pluto site
(Photo courtesy of Woodside Energy)





Seabird's *Aquila Explorer* mobilising in Fremantle before heading to the Bremer Sub-basin

Company Focus: Arcadia Petroleum Limited

The Australian Southern Margins AVO Based Exploration of the Bremer Sub-basin

Arcadia Petroleum Limited, London

Arcadia Petroleum Limited is part of a group of interrelated privately owned enterprises operating worldwide, including downstream companies Golar LNG Shipping, Frontline Shipping and Seadrill. Arcadia Petroleum Limited started life around 22 years ago as a crude oil and products trading company owned by Mitsui, which was eventually sold to the private Farahead Holding Company in 2005.

In 2006 Arcadia diversified its activities into the upstream exploration business as proven reserves were selling at record prices. A farm-in venture into Mayfair Petroleum's onshore Block 22 in Yemen yielded a small prospect, which Arcadia drilled in late 2006 to find a marginal accumulation of gas and thin oil. This led to involvement in new upfront low cost ventures within frontier and semi-frontier areas such as the Falklands Islands and offshore Namibia, with the objective to become a significant independent player in the upstream business within 10 years.

As a Joint Venture Partner in the Desire Petroleum group operating in the North Falkland Isles Basin, Arcadia Petroleum is presently awaiting the results of drilling of two offshore wells on two structures with a combined P50 net of 1,600 MMboe recoverable resources. In these assets, Arcadia holds 35 per cent and 70 per cent net equity interest. Furthermore, the company is undertaking the shooting of a 1,600 km² 3D seismic survey over its offshore deepwater Namibia licence 0010 as 85 per cent interest holder and operator in this 23,000 km² block.

In August 2008 Arcadia acquired a 90 per cent interest in the two Bremer Sub-basin WA-379-P and WA-380-P Exploration Permits from Plectrum Petroleum Ltd. As in all its other ventures, Arcadia Petroleum undertook the approach of staged de-risking in exploration of the Western Australia Bremer Sub-basin. This involved the reprocessing and analysis of all available 2D seismic data to AVO followed by

interpretation. Only when positive results are seen at each de-risking stage, would planning for drilling commence. The use of AVO analysis as a de-risking tool in exploration is nowadays considered an industry standard to ascertain whether reservoir and hydrocarbon charge are present within clastic dominated petroleum systems.

During the period 2004 to 2005, and under the funding support and direction of the State and Commonwealth Governments, Geoscience Australia (GA) undertook the immense task of conducting a comprehensive evaluation of the exploration potential of the frontier Bremer Sub-basin in time for release in the 2006 Licensing Round.

The work program encompassed the acquisition, processing, interpretation and integration of 3,524 line km of 1974 vintage and 2004 long offset seismic, the construction of the basin stratigraphic framework and conduct of hydrocarbon source maturity evaluations.

Acquisition of New Data Sets

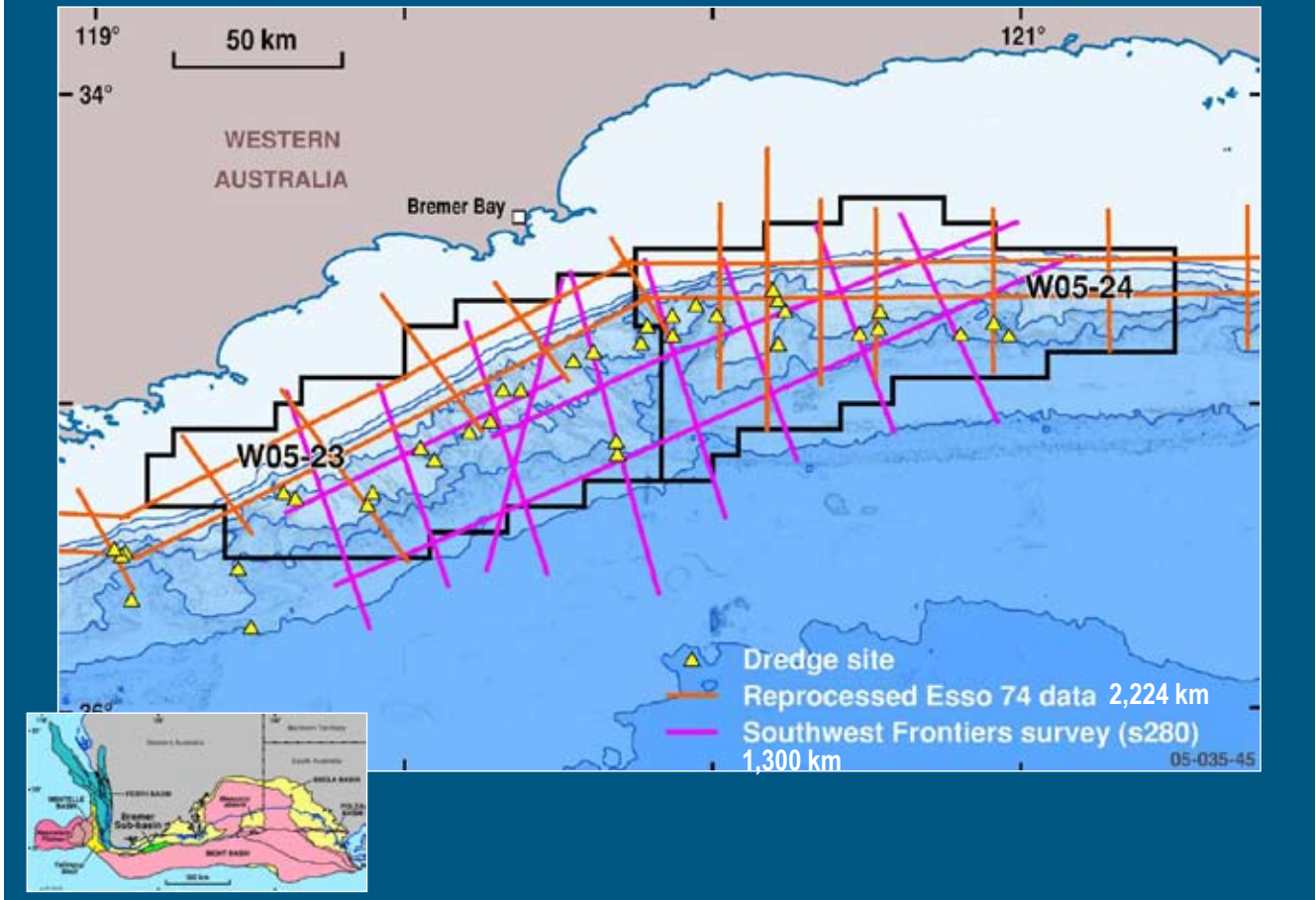


Figure 1 | The Bremer Sub-basin licences, seabed canyon system, seismic and rock dredge sites (after Geoscience Australia)

Other refraction seismic work provided the interval velocities necessary to estimate formation depths within the area.

Seabed in the Bremer Sub-basin area is heavily dissected with many deep canyons trending largely in northwest–southeast directions. The presence of the canyons provided GA with a clear and unique opportunity of access to deeper geological formations by application of rock sample dredging down the canyon walls (Figure 1).

The dredge locations were optimised to capture the maximum information by targeting specific geological formations observed on the seismic data. Geological and biostratigraphic analysis of the samples collected further presented the means of assignment of lithologies, formation age and deposition environments to the various locations within the basin (Figure 2).

With formation sub-crop control outlined, interpretation of the 1974

and 2004 seismic surveys allowed the definition of a robust stratigraphic framework through the integration of all the available information. The data interpretation also noted the presence of many structural and stratigraphic features that could provide ideal hydrocarbon traps on which exploration attention would be focused in the future.

Geological mapping of the basin covered an area greater than 25,000 km² utilising a grid of seismic lines ranging from around 15 x 15 km to 20 x 30 km. This delineated a number of regional sequences covering events of Jurassic, Cretaceous and Tertiary age to produce a broad definition of the basin architecture and its lateral extent. The dredged samples also provided direct evidence of presence of hydrocarbon source rocks within the basin. These were largely deposits of continental fluvial to fluvio-lacustrine and shallow shelf origin, with coals and clays ranging in age from Tithonian to Valanginian.

Definition of the stratigraphy, geological formations, lithologies, the hydrocarbon source rocks and their geochemistry, provided the basis necessary for the reconstruction of the basin history in terms of depth of burial, estimates of the source maturity, and onset of migration timing (Figure 3).

The integrated sets of information thus evidenced the presence of active petroleum systems, hydrocarbon generation, migration and trapping, pointing to the significant exploration potential of the basin and prompting the Commonwealth Government to release the area for licensing in August 2006.

Two contiguous frontier licence permits; WA-379-P and WA-380-P covering the whole of the Bremer Sub-basin comprising approximately 20,000 km² in area were awarded to a small UK based exploration company; Plectrum Petroleum Ltd. Title of these permits was subsequently transferred over

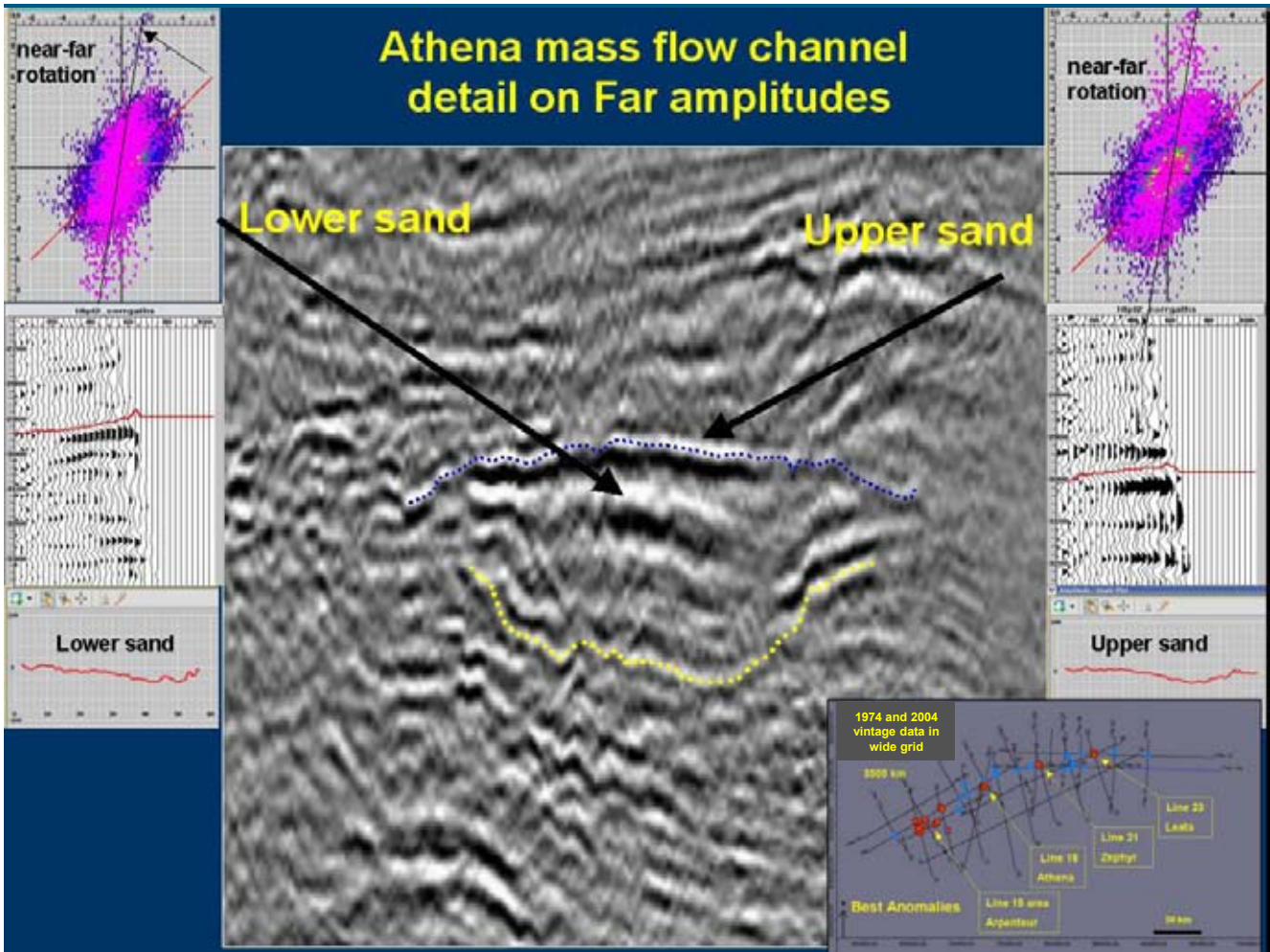


Figure 4 | Showing typical AVO response of hydrocarbon charged sands within a channel system and distribution of AVO anomalies in the vintage seismic (after Arcadia Petroleum Limited 2009)

to Arcadia Petroleum and Enovation Resources in August 2008, and before completion of the Primary Term designated seismic work obligations.

Immediately upon confirmation as operator of Licences WA-379-P and WA-380-P, Arcadia chose to reprocess all of the 1974 and 2004 vintage seismic data. This was to condition the pre-stack gathers for AVO analysis while carefully maintaining the relative amplitude characteristics of the data. The project was started in August 2008, and the reprocessing work completed in July 2009 by Weinman Geoscience (in Dallas), who specialise in AVO work.

The reworked effort carried out by Arcadia confirmed the presence of strong AVO responses in over 48 different clusters in stacked sands present within significant size structural and stratigraphic features, some of which are clearly of mass flow channel and fan origins (Figure 4).

The GA Bremer studies have indicated the potential generation of gas as well as hydrocarbon liquids in the basin from the various Early Cretaceous sources. The AVO responses demonstrated the presence of typical Class 3 and Class 2 anomalies in which the rotation of the AVO polarisation planes may be reflecting variations in the nature of the hydrocarbon fill within these clastics. Whether these techniques or others can be used to differentiate between gas and liquids remains to be seen in the new seismic survey data.

On receipt of the AVO results, the earliest available opportunity of acquiring a new seismic survey was to be taken in order to acquire a new high fold and long offset 2D infill program covering the whole of the Bremer Sub-basin down to the 3,500 m water depth contour.

Since the Bremer Southern Ocean offshore areas are environmentally sensitive, the new survey of

4,600 line km was acquired (by Seabird Exploration) during the period December 2009 to January 2010. Careful coordination with the designated authorities and local stakeholders was undertaken in accordance with the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* to ensure compliance with environmental guidelines and to avoid and minimise interference with marine fauna and fishing operations.

The new 2D seismic survey was increased in size by 40 per cent above the original work commitment of 3,300 km to a total of 4,600 full fold km with average North–South line lengths around 57 km and the longest lines in East–West directions at around 250 km. The final resulting infill grid ranged from a minimum of 5 x 5 km in the west to 6.5 x 6.5 km in central areas to a maximum 9 x 9 km in the eastern areas (Figure 5).

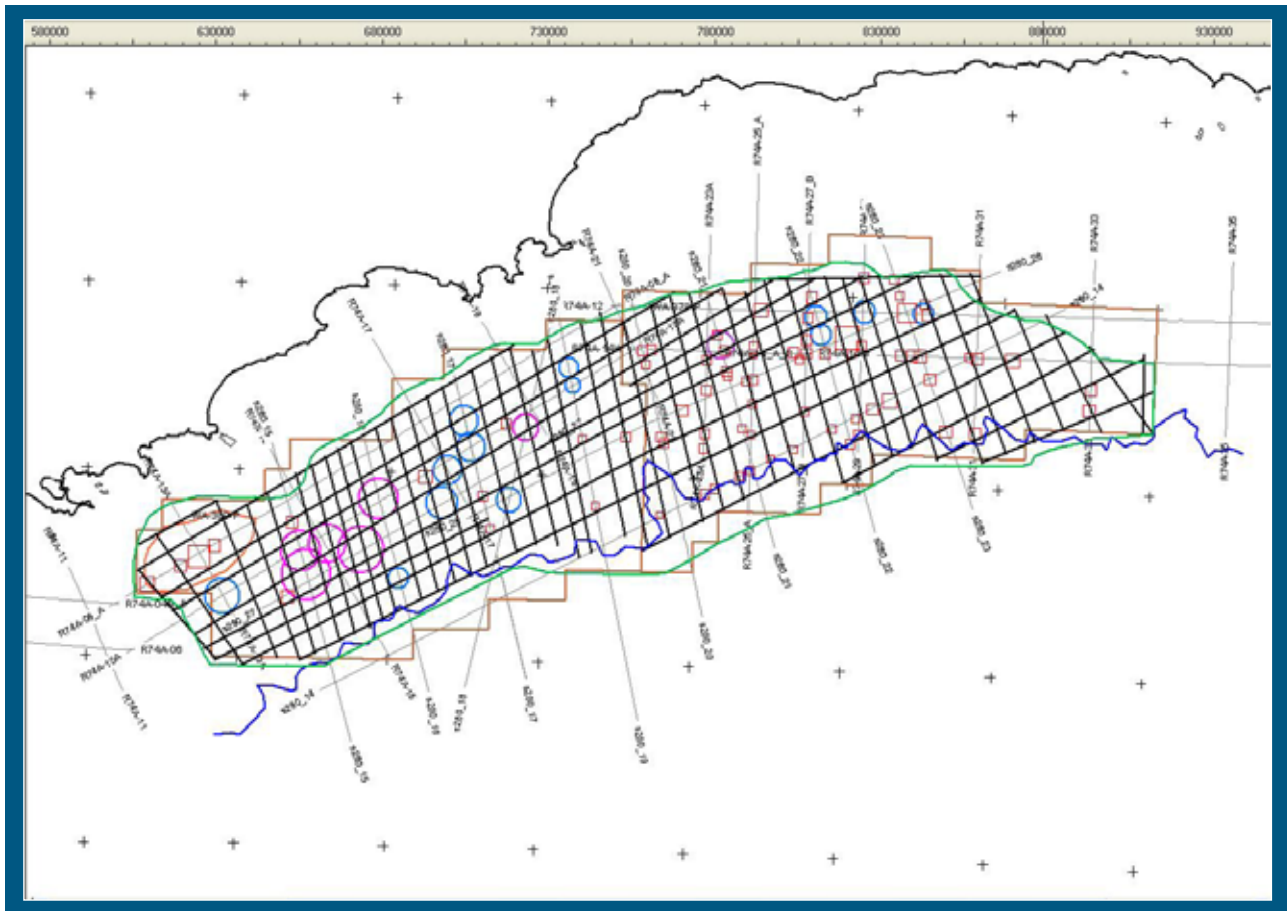


Figure 5 | Showing the new 2009–2010 2D Seismic survey, the 1974 and 2004 data and the location of the AVO anomaly clusters found in the vintage data (After Arcadia Petroleum Limited 2009)

The new survey data processing was contracted to CGGV for careful conditioning to AVO. Work started in late January 2010 and it is expected that the processing, AVO analysis, data interpretation and integration will take up to end 2010 to complete. Following this, a decision is to be made to acquire a 3D survey over the most robust and least risk traps in preparation for drilling.

Preliminary work conducted on the 2009–2010 survey QC stacks from the seismic vessel has already provided an insight in the geological controls

on deposition and the continuity of geological elements within the basin. Some rather interesting potential structural and stratigraphic traps are found over significant tracts of the survey area, indicating possible extension of the AVO anomalies observed to date. Other direct indicators of hydrocarbons can also be seen in these stacks but cannot yet be ascertained until processing and analysis are completed. However, we feel confident that the results of exploration in the basin will provide some prime rewards in the near future.

The initial basin evaluation work made by Geoscience Australia has proved to be critical to the recognition of the exploration potential of the Bremer Sub-basin. Had this not been done in advance, the release of the area for licensing and the follow on work carried out by Arcadia would not have been possible. In this respect, the Bremer Sub-basin may yet prove to be a frontier of successful exploration and will hopefully provide significant contribution to the future economy of Western Australia. ■

Awards of Exploration Permits

Richard Bruce

Exploration Geologist
Resources Branch



The Jack Bates drilling rig (Photo courtesy of Hess Australia)

Commonwealth Award of Exploration Permits

These new permits result from the second round of the 2008 Acreage Release that closed on 9 April 2009.

Commonwealth award information was sourced from the Australian Petroleum News October 2009.

The total indicative value of work commitments for the following Commonwealth permits is \$259.06 million. Four areas were awarded in Designated Frontier Areas. There is an immediate uplift to 150 per cent on petroleum resource rent tax (PRRT) deductions for exploration expenditure in designated offshore frontier areas.

In July 2009 permits granted were WA-434-P to WA-438-P inclusive.

WA-434-P (released as W08-21) in the Carnarvon Basin off Western Australia has been awarded to *Woodside Energy Ltd.* The company proposed a guaranteed work program of 1,505 km of 2D seismic reprocessing, 2,610 km² of new 3D seismic surveying and four exploration wells to an estimated value of \$121.52 million. The secondary work program consists of geotechnical studies and one exploration well to an estimated value of \$24.0 million. WA-434-P has been designated as a Frontier Area. There were two other bids for this area.

WA-435-P (released as W08-11) in the Roebuck Basin off Western Australia

has been awarded to *Carnarvon Petroleum Ltd.* The company proposed a guaranteed work program of 2,500 km of 2D seismic reprocessing and geotechnical studies to an estimated value of \$0.50 million. The secondary work program consists of 400 km² of new 3D seismic surveying, one exploration well and geotechnical studies to an estimated value of \$48.25 million. There was one other bid for this area.

WA-436-P (released as W08-12) in the Roebuck Basin off Western Australia has been awarded to *Finder Exploration Pty Ltd.* The company proposed a guaranteed work program of 4,550 km² of new aeromagnetic surveying, 500 km of 2D seismic reprocessing and geotechnical studies to an estimated value of \$0.47 million. The secondary work program consists of 250 km of new 2D seismic surveying, geotechnical studies and one exploration well to an estimated value of \$6.60 million. There were no other bids for this area.

WA-437-P (released as W08-14) in the Roebuck Basin off Western Australia has been awarded to *Finder Exploration Pty Ltd.* The company proposed a guaranteed work program of 2,350 km² of new aeromagnetic surveying, 500 km of 2D seismic reprocessing and geotechnical studies to an estimated value of \$0.42 million. The secondary work program consists of 250 km of new 2D seismic surveying, geotechnical studies

and one exploration well to an estimated value of \$6.60 million. There was one other bid for this area.

WA-438-P (released as W08-15) in the Roebuck Basin off Western Australia has been awarded to *Finder Exploration Pty Ltd.* The company proposed a guaranteed work program of 6,050 km² of new aeromagnetic surveying, 500 km of 2D seismic reprocessing and geotechnical studies to an estimated value of \$0.55 million. The secondary work program consists of 250 km of new 2D seismic surveying, geotechnical studies and one exploration well to an estimated value of \$6.60 million. WA-438-P has been designated as a Frontier Area. There were no other bids for this area.

In August 2009 permit WA-439-P was granted.

WA-439-P (released as W08-22) in the Carnarvon Basin off Western Australia has been awarded to *Chevron Australia Pty Ltd and Shell Development (Australia) Proprietary Limited.* The companies proposed a guaranteed work program of 501 km² of new 3D seismic surveying, geotechnical studies and one exploration well to an estimated value of \$25.25 million. The secondary work program consists of geotechnical studies and 500 km of new 2D seismic surveying to an estimated value of \$1.15 million. WA-439-P has been designated as a Frontier Area. There were two other bids for this area.



(Photo courtesy of Arc Energy)

In September 2009 permits WA-440-P and WA-441-P were granted.

WA-440-P (released as W08-6) in the Bonaparte Basin off Western Australia has been awarded to *Goldsborough Energy Pty Ltd*. The company proposed a guaranteed work program of geotechnical studies and 450 km of new 2D seismic surveying to an estimated value of \$1.55 million. The secondary work program consists of geotechnical studies and one exploration well to an estimated value of \$15.6 million. There was one other bid for this area.

WA-441-P (released as W08-4) in the Bonaparte Basin off Western Australia has been awarded to *Goldsborough Energy Pty Ltd*. The company proposed a guaranteed work program of geotechnical studies and 550 km of new 2D seismic surveying to an

estimated value of \$1.55 million. The secondary work program consists of geotechnical studies and one exploration well to an estimated value of \$15.6 million. WA-441-P has been designated as a Frontier Area. There were no other bids for this area.

State Award of Exploration Permits

The total indicative value of work commitments for the following State permits is \$11.95 million.

EP 465 in the Canning Basin was awarded in July 2009 to *Global International (Australia) Pty Ltd*. In the firm two-year period the company proposed geotechnical studies and 2,000 km seismic reprocessing with an indicative value of \$0.55 million. The secondary program includes an aeromagnetic survey, 200 km 2D

seismic survey and an exploration well to an indicative value of \$5.8 million.

EP 466 in the Northern Carnarvon Basin was awarded in September 2009 to *Rough Range Oil Pty Ltd*. In the firm two-year period the company proposed 500 km 2D seismic reprocessing and seismic interpretation with an indicative value of \$0.2 million. The secondary program includes three exploration wells to an indicative value of \$1.9 million.

EP 467 in the southern Perth Basin was awarded in December 2009 to *ERM Gas Pty Ltd*. In the firm two-year period the company proposed geotechnical studies and an 80 km 2D seismic survey with an indicative value of \$0.6 million. The secondary program includes 100 km 2D seismic reprocessing and an exploration well to an indicative value of \$2.9 million. ■

State Areas Released for Petroleum Exploration May 2010

Richard Bruce

Exploration Geologist
Resources Branch



DMP continues to promote the petroleum potential of Western Australia's vast sedimentary basins using a specific area release system.

A CD package accompanies the acreage release and contains information about the prospectivity of release areas, available data listings, land access and how to make a valid application for an Exploration Permit.

In May 2010, DMP released a total of six blocks (Fig. 1). This comprised one block in the Canning Basin, two blocks in the Bangemall Supergroup area, two blocks in the Blake Sub-basin of the Officer Basin, and one block in the Perth Basin's State Waters.

Interest in the Canning Basin has increased in recent times, particularly with Arc Energy and Arc's spinoff company Buru Energy taking up extensive acreage holding, drilling wells and acquiring 2D and the basin's first 3D seismic. The size of the Canning Basin block is 4,091 km² (L10-1).

Release area L10-1 is situated on the Lennard Shelf. Hydrocarbon shows are widespread on the Lennard Shelf, with economic accumulations of oil immediately southeast of L10-1. These accumulations are found in a Devonian carbonate reef and in Permian-Carboniferous clastics.

The size of the Bangemall Supergroup and Blake Sub-basin blocks is very large, reflecting the very frontier nature of these release areas.

These release areas were configured after interest was expressed by several companies.

Release areas L10-2 (29,307 km²) and L10-3 (29,147 km²) are located to the south and west of Newman in the Pilbara region, in an area predominantly within the Edmund and Collier Basins, the depocentre for the Mesoproterozoic Bangemall Supergroup.

Mineral holes OD 15 and OD 23, drilled in the eastern area infilled by the Bangemall Supergroup, encountered bitumen and trace oil in vugs in dolomite belonging to the Scorpion Group.

Release areas L10-4 (30,795 km²) and L10-5 (30,097 km²) are principally within the Blake Sub-basin of the Officer Basin and are situated to the south and east of Newman in the Pilbara region.

The Officer Basin is a Neoproterozoic Basin. The Blake Sub-basin is a frontier area but oil fluorescence has been encountered in the Boondawari 1 and Mundadjini 1 stratigraphic coreholes.

Release area T10-1 is situated in the State Waters of the northern Perth Basin

and covers 1,331 km². The region has a thick Lower Triassic source and seal interval, as well as likely source intervals in the Lower Jurassic.

Work program bids for the Bangemall Supergroup and Blake Sub-basin release areas close at 4pm on Thursday 19 August 2010. Work program bids for the Canning and Perth Basin release areas close at 4pm on Thursday 4 November 2010.

Should you require any further information or assistance, please contact Richard Bruce (08 9222 3314) of DMP's Petroleum and Environment Division or Jeff Haworth (08 9222 3214) of the Geological Survey of Western Australia. All enquiries will be dealt with in strictest confidence. ■



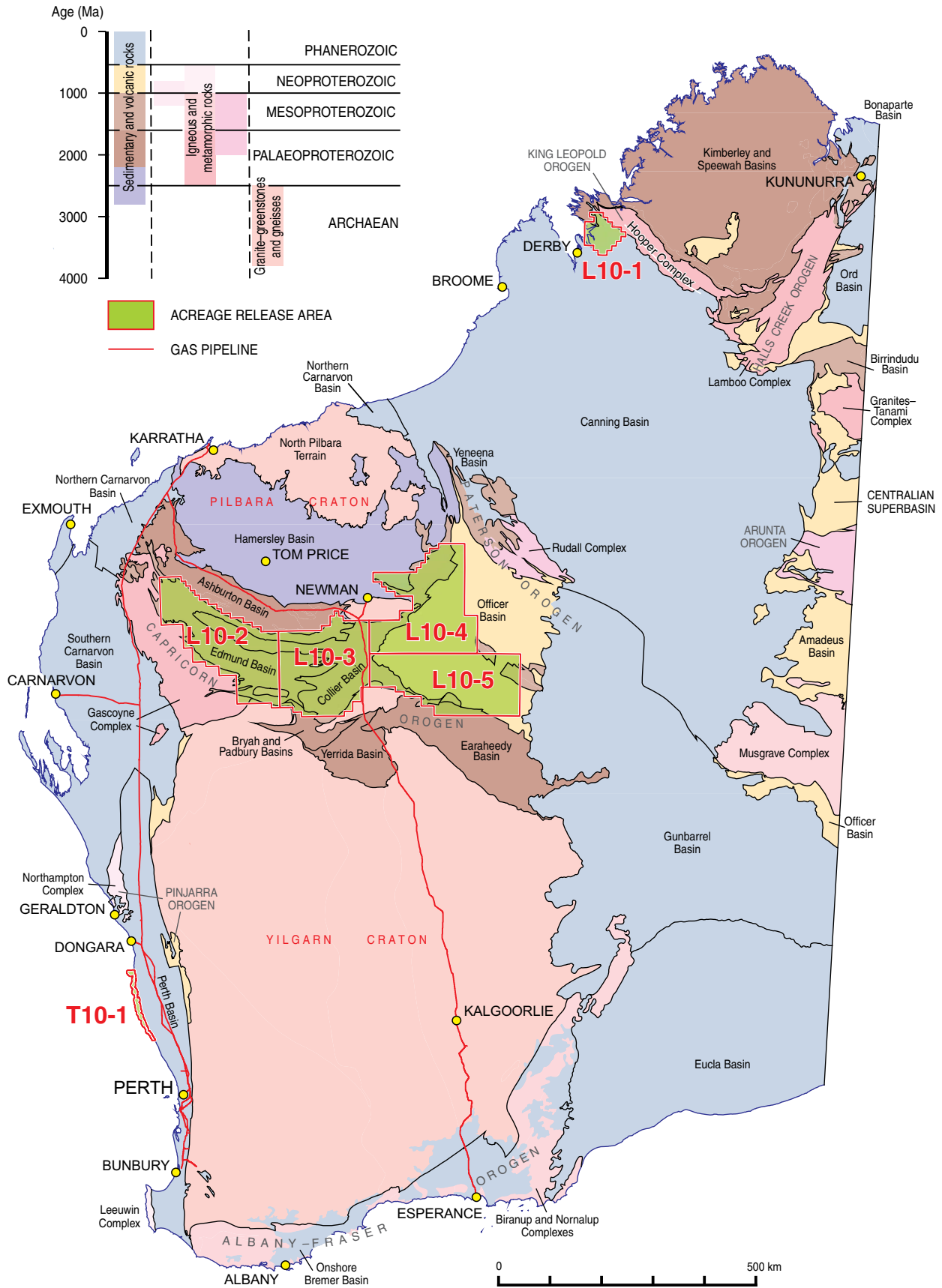


Figure 1 | May 2010 State petroleum release areas

Geothermal Acreage Release in Western Australia – All-of-State

Mike Middleton

Senior Energy Geotechnologist
Resources Branch



(Photo courtesy of Geodynamics Ltd)

The Department of Mines and Petroleum (DMP) has planned a geothermal acreage release in Western Australia for 9 April 2010. This release will be an all-of-State release, wherein all onshore Western Australia is available for application, other than those areas already under title or with an application being currently considered (see Figure 1). The closing date for applications is 22 July 2010. The release will be advertised internationally in conjunction with the World Geothermal Congress in Bali from 26 to 30 April 2010.

DMP has currently granted, or is assessing applications, for around 50 geothermal permits throughout Western Australia. Figure 2 shows the granted geothermal permits and areas under application prior to the first acreage release for 2010.

The initial 2010 all-of-State release is limited to blocks and part blocks landward of the mean high water mark (mainland coastline only) and does not include any coastal waters or islands. For this release, the State is divided into four regions (see Figure 1), and the release area configuration differs in

size for each region. The release area configuration is made up of a series of contiguous 5' x 5' graticular blocks. The number of 5' x 5' graticular blocks for each region is shown in Table 1.

Considerable interest has already been shown in Region 1, which comprises the Perth Basin and adjacent area (see Figure 2). This region is currently perceived as the most prospective in Western Australia, due to its proximity to the greater part of the population concentration in the State. Hot aquifer geothermal resources are considered to be the main exploration target in this region. These geothermal resources may be used for both low-grade, heat-conversion applications and electricity generation by low-temperature organic-cycle turbines.

Reasonable interest has also been shown in Region 2. This region includes the onshore Carnarvon Basin and much of the Pilbara region. The interest is largely concentrated on the coastal area north of Carnarvon. This particular stretch of land is well known for its hot springs and warm artesian aquifers, which often have water temperatures in the vicinity of 60 °C close to the surface.

Region 3 lies in the southeast of the State. Two Geothermal Exploration Permits have been granted in this region. The region essentially lies over the Yilgarn Craton and Albany–Fraser Orogen, which largely consists of outcropping igneous rocks and metasediments. There is a thin sedimentary cover in the south and southeast of the region.

Some interest has been shown in Region 4, which includes portions of the Canning, Ord, Gunbarrel, Officer and Kimberley basins, as well as other large regions of Precambrian sediments, metasediments and igneous rocks. This region is also known to contain hot springs and artesian bores in parts of the Canning and Ord basins. Most of the interest to date in Region 4 has been in the western Canning Basin and central Officer/Gunbarrel Basin.

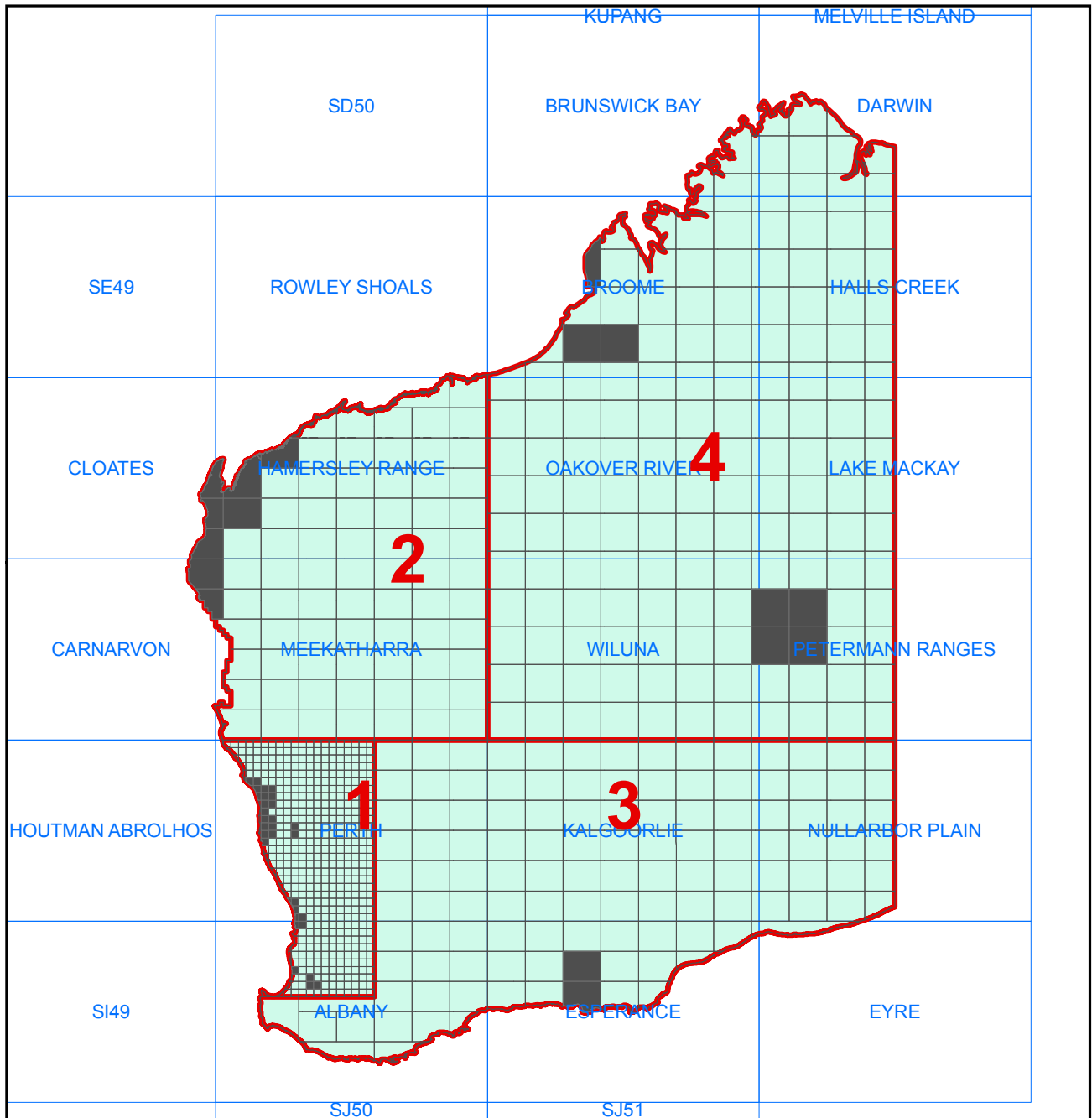
Large tracts of land with good geothermal potential remain vacant. This all-of-State release provides an excellent opportunity for explorers to obtain geothermal permits with good potential in key locations of the State.

Table 1. Release area configuration for different regions of the State

Region Number	General Location	Number Of Contiguous 5' X 5' Graticular Blocks Per Release Area
1	Perth Basin & adjacent	4
2	Carnarvon Basin & adjacent	80
3	Southeast	80
4	Northeast	100

GEOTHERMAL RELEASE AREAS FOR ALL OF STATE RELEASE WITH 1:1 000 000 GRATICULAR MAP INDEX

Petroleum & Geothermal Energy Resources Act 1967



Legend

□ Release_blocks

The 4 state regions open 06/04/2010 until 05/08/2010

- Region 1 - Maximum release area (4x5'x5' graticular blocks)
- Region 2 & 3 - Maximum release area 80 graticular blocks
- Region 4 - Maximum release area 100 blocks



Geothermal_Million_AllofState_rel.mxd -NS 07/01/1010

Figure 1 | The Western Australia all-of-State geothermal release. The State is divided into four release areas of different block sizes. The shaded blocks are not available for application.

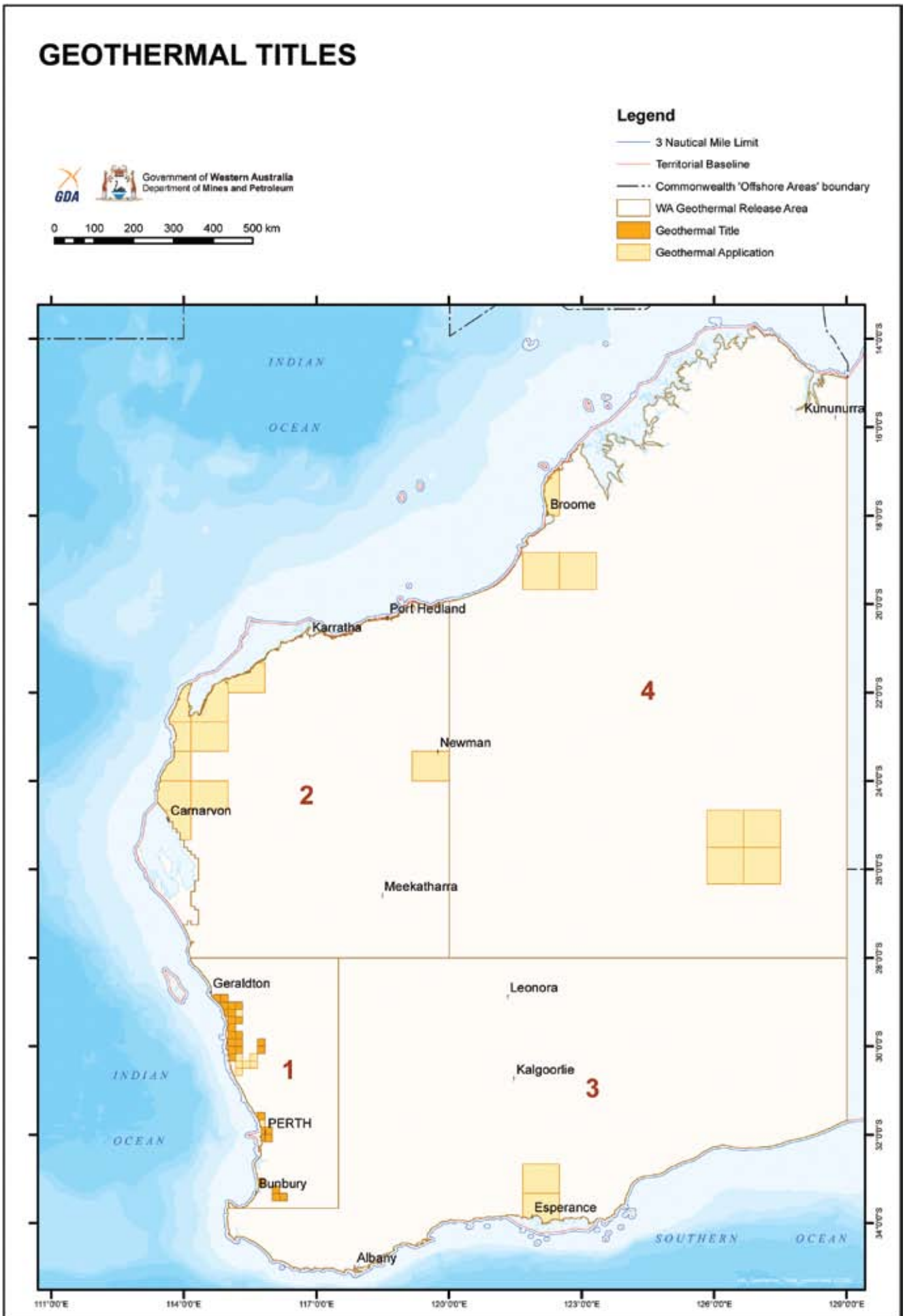


Figure 2 | Geothermal titles map, showing granted permits and areas currently under application.



(Photo courtesy of Geodynamics Ltd)

Applications, together with supporting data, should be submitted to the Department of Mines and Petroleum. An applicant must satisfy the Minister of its capacity to undertake its proposed work program, particularly:

- the adequacy of financial resources and technical expertise available to each applicant;
- the likelihood that the applicant will continue to have access to sufficient resources to meet the requirements of the proposed work program as well as other commitments previously entered into in other permit areas;
- the future viability of any consortium lodging an application, including evidence that a satisfactory Joint Operating Agreement has or can be reached; and
- the applicant's past performance in other geothermal exploration areas in Australia or, if relevant, elsewhere.

The grant of geothermal permits, whether by sole or competing bid, is

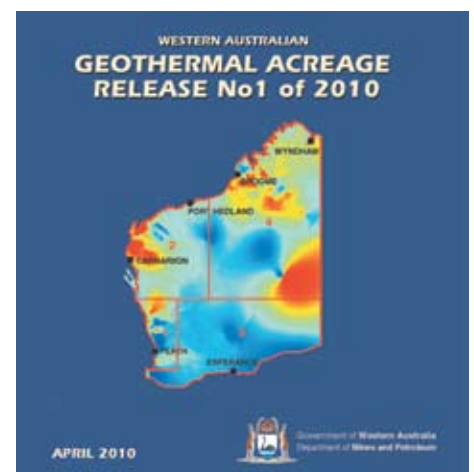
made on merit, consideration being given to the extent and appropriateness of the work proposals, together with the applicant's technical and financial ability. In all cases, the holders of exploration and development titles are required to meet work commitments and comply with the conditions of approval to retain the rights to explore.

The holder of a Geothermal Exploration Permit (GEP) has a statutory right to the grant of a Geothermal Production Licence (GPL) for a commercial resource or a Geothermal Retention Lease (GRL) if the resource is not presently commercially viable but likely to become so in 15 years. Titles issued for the actual extraction of geothermal energy are issued subject to appropriate conditions relative to safety, resource management, protection of the environment, etc. An applicant for a GPL is required to submit a notice outlining the nature of the proposed development, the method of operation and its environmental impact.

An information package including information such as how to apply for

acreage, land access, basin geology and available data is available on a CD or via the DMP website (www.dmp.wa.gov.au/6060.aspx).

Should further information or assistance be required, please contact Mike Middleton (08 9222 3076) or Richard Bruce (08 9222 3314) of DMP's Petroleum Division or Jeff Haworth (08 9222 3214) of the Geological Survey of Western Australia. All enquiries will be dealt with in strictest confidence. ■



Some Considerations for Geothermal Exploration in the Perth Basin

Mike Middleton

Senior Energy Geotechnologist
Resources Branch

(Photo courtesy of Geodynamics Ltd)



INTRODUCTION

This article reviews hot sedimentary aquifers in the Perth Basin for potential geothermal energy projects and presents some considerations in terms of the lifetime of projects, where hot water in the aquifers flows between a line of injection and production wells. The geology and geophysics of two specific locations in the Perth Basin with demonstrated hot sedimentary aquifers is reviewed in the context of potential geothermal energy projects.

Geothermal energy projects require heat energy to be extracted from the subsurface over an extended period of time. Due to significant start-up costs, the lifetime of a project might be expected to extend over 30 or 40 years, and preferably longer, for a sufficient return to be made on the initial investment.

The lifetime of a project should also be balanced against the fact that, in most hot sedimentary aquifer projects, cool water is being re-injected into the aquifer, which can have a significant cooling effect on the aquifer if the extraction rate (or average flow rate of water through the aquifer) is too high. Therefore, it is of some value to examine how the flow rate impacts on the time taken for an aquifer to appreciably cool, and accordingly deplete the heat energy within the aquifer.

SIMPLE MODEL OF GEOTHERMAL AQUIFER FLOW

Figure 1 shows a simple model of a hot sedimentary geothermal aquifer. In this model hot water (at 120 °C for example) is extracted from a confined aquifer by a line of production wells. This hot water is used for geothermal energy purposes, and once the heat is extracted from the water it is returned to the aquifer (at say 20 °C) by a line of injection wells. A flow regime will be set up in the aquifer whereby a front of 20 °C water will move at an average velocity (V) from the line of injectors to the line of producers. The project is no longer

viable when the 20 °C water-front reaches the line of producers, and this defines the lifetime of the project.

The average velocity (V) of water flow between the injectors and producers is directly related to the pressure difference between the two lines of wells. Hence, the higher the pressure difference: the faster the flow. Correspondingly, the flow rate can be diminished by decreasing the pressure difference between the producers and injectors. Therefore, the lifetime of a project can be extended by decreasing the flow rate, or pressure difference.

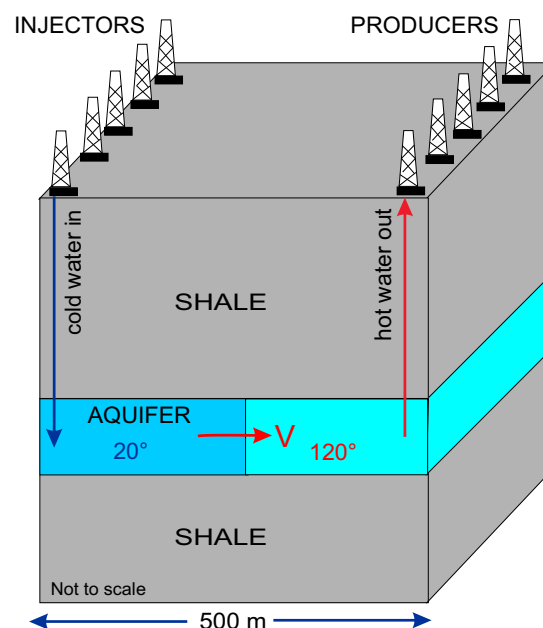


Figure 1 | Schematic model of a hot sedimentary aquifer geothermal development with a row of producing wells (producers) and injection wells (injectors) off-set by 500 m. The producers extract water at a temperature of 120 °C, and the injectors return the water at 20 °C, after the heat energy has been extracted. The cold water front from the injectors moves through the initially hot aquifer at a velocity (fluid flow rate) designated as " V "

Table 1. Lifetime of geothermal project for different pressure regimes and aquifer permeability

Pressure Difference (psi)	Lifetime (years)		
	k = 5,000 md	k = 500 md	k = 50 md
200	0.4	4.0	40
500	0.15	1.5	15
1,000	0.08	0.8	8

Table 1 shows the lifetime of such a hot sedimentary aquifer project as a function of (1) the pressure difference established between the producers and injectors, and (2) the permeability (k) of the aquifer. In this case, the distance between the producers and injectors is 500 m, which is typical for projects now underway in the Cooper Basin (Wyborn, 2009; Yanagisawa *et al.*, 2009).

This simple model suggests that for a geothermal project to have a lifetime

that will make the project economic, the pressure difference (at 500 m separation) should be 200 psi or less, and the aquifer permeability should be about 50 md. The caveat is made that these estimates are approximate, and the technical conditions that will make a project economic are also dependent on many other factors, such as aquifer porosity, aquifer thickness, configuration and spacing of wells, amongst others.

Nevertheless, this model suggests that project lifetime is strongly linked to aquifer permeability, and this should not be too great, lest the heat be drained too rapidly from the aquifer.

Two examples of hot sedimentary aquifers in the Perth Basin are now reviewed in the light of these considerations. Aquifers with permeability in the range of 50 md to 200 md may be more desirable for a long-term geothermal application, due to the reduced rate of fluid flow within them.

PERTH BASIN EXAMPLES

The two locations to be inspected in relative detail are (1) near the Yallallie 1 and Cypress Hill 1 petroleum wells, about 30 km northwest of Moora, and (2) near the Moore River, about 50 km east of Lancelin (see Figure 2). A generalised stratigraphy of the northern part of the Perth Basin is shown in Figure 3.

Location 1: Yallallie-Cypress Creek Impact Structure

Chopra and Holgate (2005) produced a series of maps showing crustal temperatures in Australia at a depth of 5 km. Their maps show a temperature anomaly near Moora, north of Perth. This temperature anomaly appears to be associated with the Cypress Hill petroleum exploration well, which has a temperature of 57 °C recorded at approximately 990 m (Higgins, 1988). The Cypress Hill 1 well was drilled on a large structure proposed by Dentith *et al.* (1999) and Economo (1991) to be a meteorite impact structure. The structure was also intersected by the Yallallie 1 exploration well (Economo, 1991). The region has received considerable attention from hydrologists from the Geological Survey of Western Australia (Balleau and Passmore, 1972) and Passmore, 1969). These sources supply lithological, porosity and some permeability on the aquifers in this region.

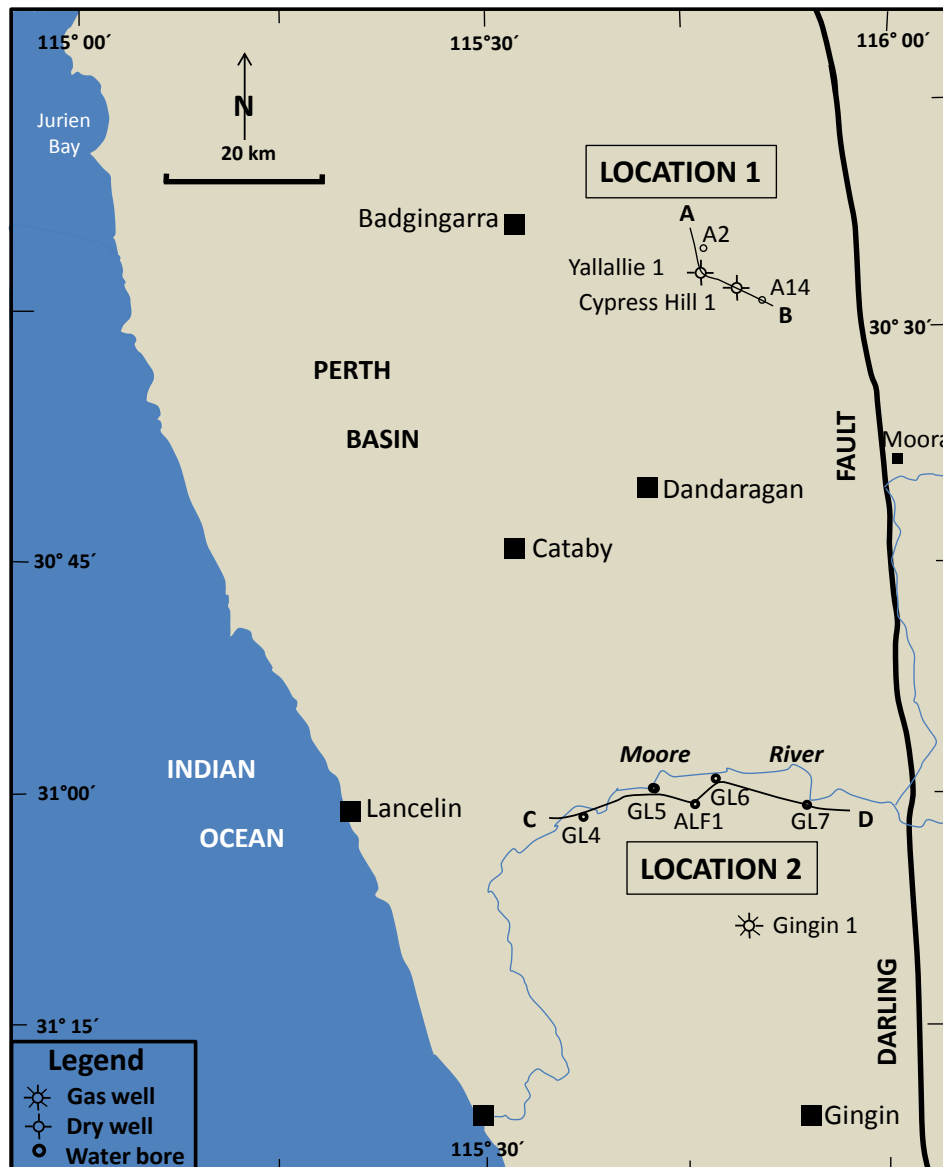


Figure 2 | Location of two Perth Basin examples used in this paper. Location 1 is an interpreted impact structure that has been intersected by the Yallallie 1 and Cypress Hill 1 petroleum exploration wells; the location of a North-South cross-section through this structure is also shown. Location 2 is where the Moore River passes over the Gingin Scarp, approximately 50 km east of Lancelin; the location of a West-East cross-section is also shown

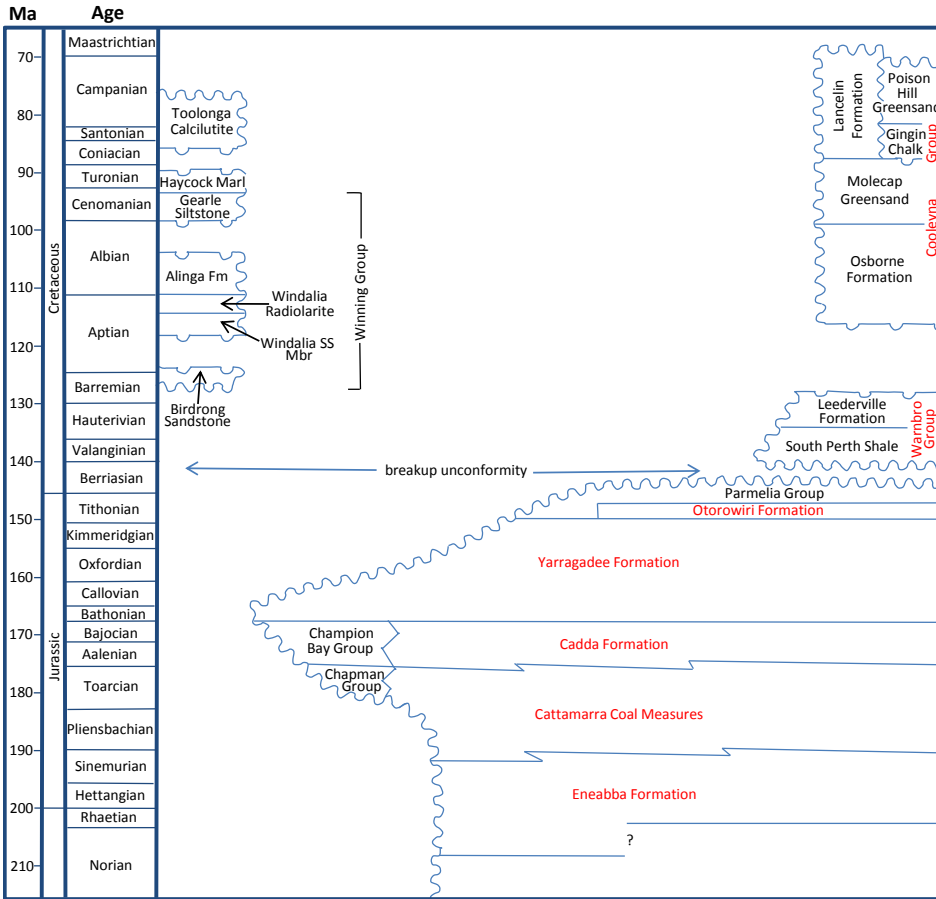


Figure 3 | Generalised Jurassic–Cretaceous stratigraphy of the northern part of the Perth Basin (after Mory et al., 2005)

Figure 4 shows a cross-section through this structure, based on a seismic survey carried out by the exploration company Ampolex. The vertical axis in seismic two-way time (seconds) derived directly from the seismic reflection data. The geometry of the impact structure can be seen in this cross-section, with listric faults from either side of the structure “soleing-out” at the base of the impact; reflectors are seen to form an anticlinal structure beneath the impact zone. Also shown are three temperatures recorded in the two petroleum exploration wells, and together with the seismic data, seem to suggest that the base of the impact structure resides at a temperature of about 57 to 58 °C. We know from the wells that the temperature is 57 °C at 990 m for Cypress Hill 1 and 58 °C at 1,594 m for Yallallie 1. Water at approximately 57 °C is possibly percolating through a brecciated zone on the faults around the edge of the impact structure. A temperature of 57 °C is anomalously high for the sediments in the Perth Basin, and this location may make a desirable site for a geothermal development.

In terms of the characteristics of the rocks at this locality, the water bores have intersected glauconitic sandstone, siltstone and clay from the Warnbro and Coolyena Groups of Cretaceous age. Hydraulic conductivity of the sandstone units range from 1.8 to 27.1 m³/day/m², which corresponds to permeabilities of 2.2 to 32.7 darcy, respectively. The average permeability of sandstones from the shallow Warnbro and Coolyena Groups is 5.7 darcy.

The Parmelia Group sediments were intersected below 346 m to total depth (990 m) in Cypress Hill 1. Between 845 and 934 m, interbedded sandstone, siltstone and claystone was intersected with sandstone porosity from cores ranging from 24.5 to 33.6 % and permeability ranging from 142 md to 930 md.

The Yarragadee Formation was intersected below 340 m in the Yallallie 1 well, but no cores were taken. The Yarragadee Formation sandstones within the deformed zone of the impact structure had very poor intergranular porosity, and tended to be quartzite near the top of the impact zone. A zone with good intergranular porosity sandstone layers was reported in the depth interval

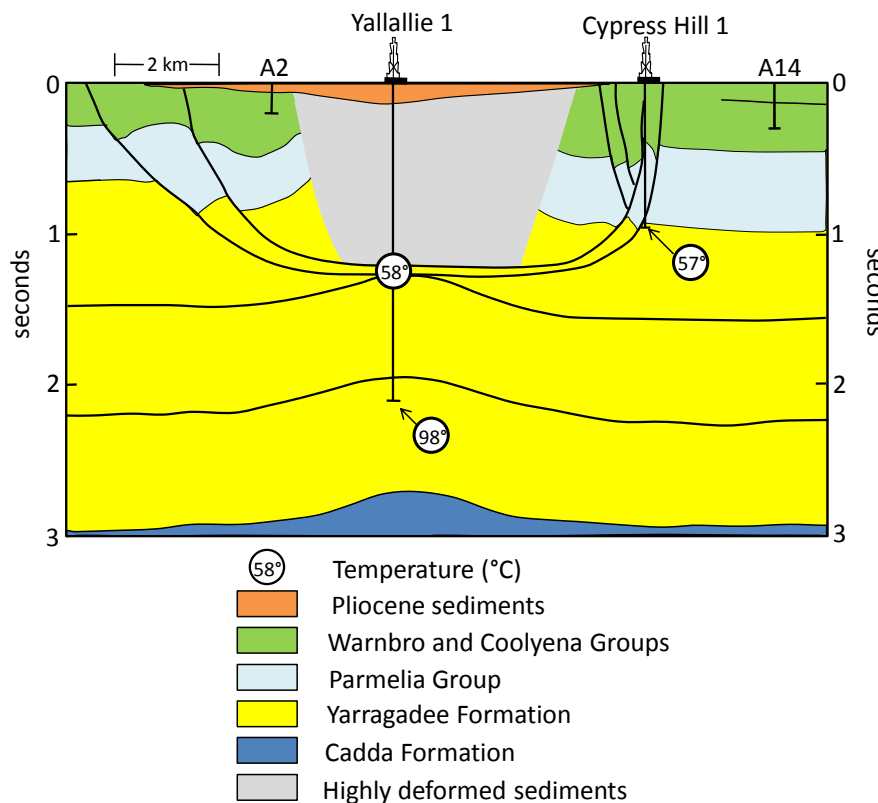


Figure 4 | Cross-section (based on seismic reflection data) passing approximately North–South through the Yallallie-Cypress Creek impact structure; the vertical axis is in two-way time (seconds). The geometry of the impact structure is evident in the cross-section. Temperatures measured in the two petroleum exploration wells are shown, and the fault zone around the base and sides of the structure may be at about 57–58 °C to depths less than 1,000 m

of approximately 1,460 m to 1,670 m, and wireline log porosity ranged from 13 to 16 % in sandstone beds. Beneath this zone, the porosity again became poor and decreased with depth. The best porosities in the Yarragadee Formation appeared to coincide with the base of the impact zone, where the temperature was recorded at 58 °C. This more porous zone may be continuous around the edges of the impact structure, and allow water in the vicinity of 57 °C to flow to shallower depths, as observed in the Cypress Hill 1 well.

This location may be suitable for low to moderate temperature (60 – 120 °C) geothermal applications, and appears to have permeabilities in a range suitable for longer-term applications.

Location 2: Gingin Scarp – Moore River

This location is about 50 km east of Lancelin (see Figure 2). A series of water bores (Gillingara Line) have been drilled at this location by the Geological Survey of Western Australia (Moncrieff, 1989). Temperature logs were run during this drilling program, and reasonable shallow temperature information is available. Figure 5 shows a cross-section through this location, based on the study by Moncrieff, 1989). Temperatures in excess of 55 °C occur at depths of about 1,000 m in the GL6 water bore. A temperature of 56 °C is reported by Moncrieff (1987) at the base of GL6 bore (975 m). These higher temperatures reside essentially within the Yarragadee Formation, which at this location consists of interbedded sandstone and mudstone.

No hydraulic conductivity (permeability) information is available from the hydrogeological bores this location. The closest petroleum exploration well is Gingin 1, which lies about 25 km south of GL6. Analysis of cores from this well indicates that the Yarragadee Formation possesses porosities ranging from 5 to 39 %, and permeabilities ranging from 3 md to 7.87 darcy. These values are in the range for a good geothermal sedimentary aquifer.

The Yarragadee Formation in this locality may provide a good opportunity for a low to moderate temperature geothermal development at relatively shallow depths (in the vicinity of 1,000 – 1,500 m).

CONCLUSIONS

The basic modelling conducted in this article suggests that the lifetime of a hot-sedimentary-aquifer geothermal project is closely coupled to the subsurface pressure established in the production-injection couple system, and the petrophysical parameters of the aquifer, especially permeability. Two locations in the Perth Basin suggest that low to moderate temperatures can be found at depths in the order of 1,000 m with aquifers possessing the petrophysical characteristics to provide geothermal energy projects with lifetimes exceeding 30 years.

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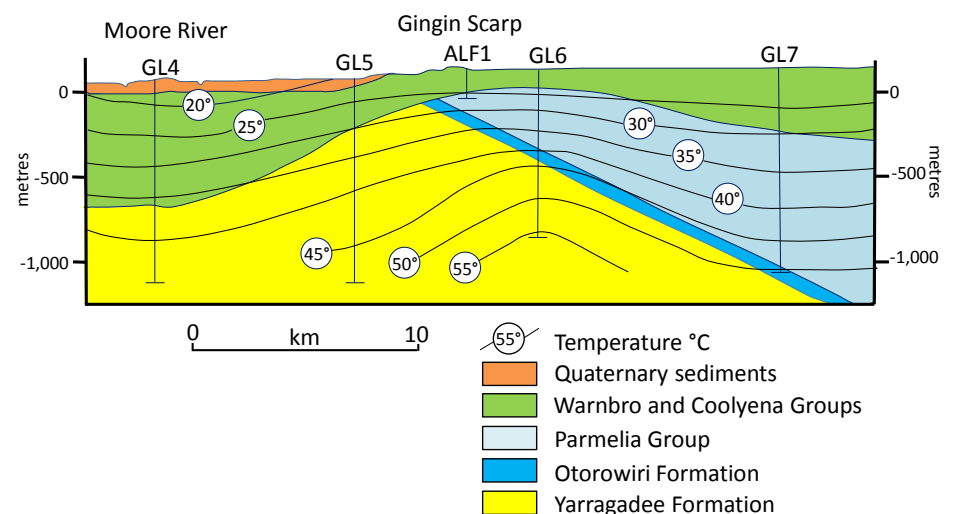
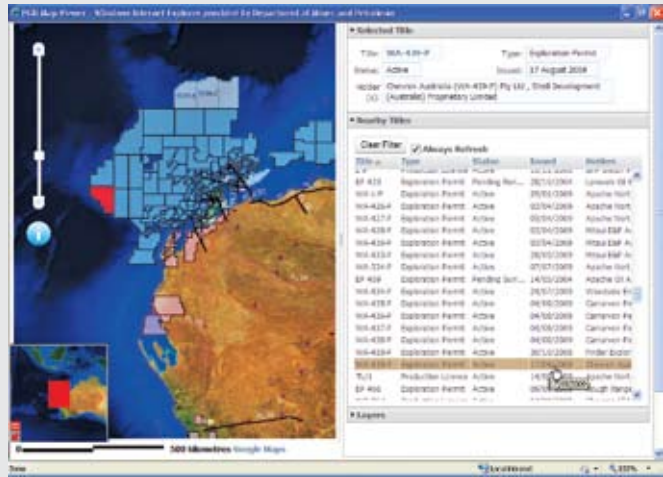


Figure 5 | Cross-section (modified from Moncrieff, 1989) passing East–West through the Gingin Scarp-Moore River location. Temperature contours shown are based on temperature logs in hydrogeological bores. A temperature of 56 °C was measured at the base of Bore GL6 at 972 m

The Petroleum and Geothermal Register (PGR) Continues to Lead the Way Nationally

Hazel Harnwell

Project Coordination and Information Management Manager
Strategic Business Development Branch



PGR's Map Viewer feature

The Petroleum and Geothermal Register (PGR) is the electronic titles register for the Petroleum Division of the Department of Mines and Petroleum. The latest version went live on 4 March 2010 with a previous release on 11 January 2010.

These releases introduced:

- a detailed Map Viewer displaying the location of petroleum, geothermal and pipeline titles;
- online lodgement of Pipeline Licence renewals and variations;
- integration with the Department's Environmental Assessment and Regulatory System (EARS) allowing Petroleum Environmental Registrations against petroleum or geothermal titles to be displayed within PGR; and
- a new and improved layout for general title details.

The Information Services Branch PGR project team worked throughout the Christmas and New Year period to deliver the enhancements in early January 2010. Staff from the Strategic Business Development and Petroleum Tenure and Land Access Branches of the Petroleum Division assisted with the development by providing valuable input as well as assisting in testing the new features prior to them going into production.

PGR Project Manager, Information Services, Mark Firth said, "new functionality within PGR continues to be introduced at a rapid rate thanks to the talented and hard working team we have in place, in conjunction with

the great co-operation we continue to receive from the Petroleum Division".

In 2010, further upgrades to PGR will include:

- the ability to lodge and track well applications online;
- the ability to view and track Titles and applications by project;
- Electronic Funds Transfer (EFT) facilities for the payment of fees; and
- the ability to lodge and track more title applications online.

The Executive Director, Petroleum Division, Bill Tinapple, said that PGR continued to attract much interest from other government agencies around Australia including the Department of Resources, Energy and Tourism in Canberra.

"The Department of Mines and Petroleum (DMP) continues to lead by providing comprehensive titles information and an online lodgement facility for the petroleum and gas industry. The PGR system is a credit to the DMP staff and industry participants who have been integral to its development and success".

General Manager of the Business Development Branch, Mark Gabrielson said that the PGR project had been both challenging and rewarding. "Staff and industry have embraced the system. Enthusiasm to complete the project has remained high by everyone involved", he said. "Development of the system has enabled us to stop and look at our processes and question whether there

is a better way of doing things. As a result we have, at each stage, reviewed the current processes and streamlined them to improve workflows. Industry has also played a significant role in assisting in the development of PGR by providing quality feedback and actively participating with testing", he added.

Previous releases of the PGR online system included:

- the online lodgement of pipeline licence applications;
- a customised home page for registered users of online payments and/or online lodgement;
- the issuing of tax invoices and receipts;
- the ability to pay all fee types online; and
- the ability to track the progress of applications.

A successful external audit conducted in February 2010 demonstrated that the Division continues to meet statutory and regulatory requirements by following set procedures to ensure consistency in customer services as part of the Division's certification for its Quality Management System (QMS) Australian Standard ISO 9001:2008. Certification was accredited in February 2009 after the Division demonstrated continual improvement of their management systems. In addition to PGR, the QMS system forms an integral part in improving approvals times by streamlining processes and procedures. ■

Exploration Incentive Scheme

Margaret Ellis

EIS Coordinator

Department of Mines and Petroleum



In early April 2009, in fulfillment of an election commitment, the Western Australian Government announced funding of a five-year, \$80 million Exploration Incentive Scheme (EIS) to encourage exploration in Western Australia for the long-term sustainability of the State's resources sector. Most of the six broad programs (Table 1) under the EIS are focused in under explored greenfields regions and frontier basins.

Implementation of the EIS, involving additional expenditure of between \$16 and \$20 million per annum over the period from 2009–10 to 2012–13 effectively means more than a doubling

of the Geological Survey of Western Australia's (GSWA) budget over the period. However, with only eight Public Service contract positions approved as part of the scheme, contracting-out of services, and collaborative programs with university and government research groups and centres will be required to undertake the massive work program.

The EIS will have an enormous impact on the work of the Department of Mines and Petroleum (DMP) over the next four years and will result in a step-wise increase in the amount of pre-competitive geoscience information available for the State.

Outline of the EIS

The Exploration Incentive Scheme objective is to encourage exploration in Western Australia, particularly in frontier petroleum basins and under-explored minerals greenfields areas, and maintain it at the levels needed for the long-term sustainability of the State's resources sector. In the absence of any viable alternative, Western Australia's economy and its citizens' lifestyle will continue to depend in the medium- to long-term on development of the State's resources. The scheme addresses this longer term need as well as providing some shorter term stimulus for the exploration industry during the exploration downturn caused by the global financial crisis. Importantly, the funding of a large exploration incentive package at this time signals that the State Government is serious about fostering investment in the State's resources sector and is concerned about the sustainability of resource production if discovery rates are not increased.

Two major components of the Scheme are the completion of the State's coverage by airborne magnetic surveys at 400 m (or less) line spacing and a major expansion of the area covered by gravity surveys with stations spaced less than 2.5 km apart.

Table 2 sets out the budgets and staffing for the six programs. Projects are described in more detail later. Analysis of planned expenditures under the scheme suggests that individual

Table 1. Exploration Incentive Scheme

Exploration Incentive Scheme activity	Funding (\$ million)	
Exploration and Environmental Coordination in DMP		1.5
Drilling		
Industry–Government co-funded	20.9	
Stratigraphic	6.0	26.9
Geophysical and geochemical surveys		
Airborne geophysics	21.0	
Ground geophysics and geochemistry	11.5	32.5
3D Geological mapping		13.8
Promoting strategic research with industry		
MERIWA	1.4	
Embedding researchers in industry	0.9	2.3
Sustainable working relations with Indigenous communities		
Petroleum	2.0	
Minerals	1.0	3.0
Total		80.0

activities totaling \$24 million out of the \$80 million will directly benefit the petroleum, unconventional gas and geothermal industries.

EIS Programs

Exploration and Environmental Coordination

In keeping with the objective of the EIS to encourage exploration in Western Australia it is essential to support the exploration industry with a robust tenement application and management system. Enhancements are required to the web-based title systems, to facilitate online tenement application

and management, and provide comprehensive approvals-tracking.

These enhancements will integrate the environmental application and approval process into the minerals and petroleum tenement management systems and provide comprehensive tracking of tenement applications through the various approval stages, with online access to the status of tenement applications available to external stakeholders via a secure sign-on. In addition to the online lodgment and processing of tenement applications, associated reporting obligations will also be facilitated online.

Innovative Drilling

The Co-funded Government–Industry Drilling Program is designed to stimulate geoscience exploration and contribute to the economic development of underexplored areas of Western Australia. It is preferentially funding high-quality, technically and economically sound projects that promote new exploration concepts and new exploration technologies.

Consultation with industry is facilitated by representatives of industry bodies in Western Australia, including APPEA, acting through the Drilling Advisory Committee. The Committee has a

Table 2. Components and projects making up the EIS — budgets and employees

Component	Planned Cash Flow (\$ millions)						Public Servants
	2008-09	2009-10	2010-11	2011-12	2012-13	Total	
Exploration and Environmental Coordination (Total: \$1.5 million)	0.36	0.44	0.50	0.10	0.10	1.50	—
Innovative Drilling (Total: \$26.9 million)	0.20	4.18	6.51	8.28	7.73	26.90	—
Government – industry co-funded exploration drilling	0.06	3.19	5.35	5.95	5.95	20.50	1
Targeted international exploration promotion	0.04	0.09	0.09	0.09	0.09	0.40	—
Stratigraphic drilling	0.10	0.90	1.07	2.24	1.69	6.00	—
Geophysical and Geochemical Surveys (Total: \$33.33 million)	0.65	7.395	9.085	9.615	6.585	33.330	—
Completion of State-wide coverage by airborne magnetic and radiometric surveys	—	4.845	5.80	6.40	4.00	21.045	—
Deep crustal seismic lines	—	0.65	1.385	2.315	1.935	6.285	—
Regional gravity surveys	0.25	1.50	1.50	0.50	0.25	4.00	—
Geochemistry of the Yilgarn Craton and its margins	0.40	0.40	0.40	0.40	0.40	2.00	—
3D Geological Mapping (Total: \$13.8 million)	0.69	2.86	4.63	4.12	1.50	13.80	—
WA geology online — information delivery	0.10	0.50	0.50	—	0.10	1.20	1
Modernise petroleum information delivery system	0.36	0.44	—	—	—	0.80	—
3D geoscience	—	0.20	0.40	0.45	0.15	1.20	2
Open file geochemistry information delivery	—	—	0.60	0.20	—	0.80	—
Mineral drillhole database	0.15	0.50	0.45	0.45	0.45	2.00	1
Geological mapping and interpretation	0.05	0.75	0.75	0.75	0.40	2.70	1
Enhanced geochronology	—	0.20	0.20	0.20	0.20	0.80	—
Unconventional energy studies	0.03	0.27	1.73	2.07	0.20	4.30	1
Promoting Strategic Research with Industry (Total: \$2.3 million)	—	0.65	0.65	0.65	0.35	2.30	—
WA Regional Researcher Initiative	—	0.30	0.30	0.30	—	0.90	—
Supporting MERIWA	—	0.35	0.35	0.35	0.35	1.40	—
Sustainable Working Relations with Indigenous Communities (Total: \$2.17 million)	—	0.555	0.565	0.535	0.515	2.170	—
Developing Indigenous Land Use Agreements	—	0.050	0.120	0.120	0.120	0.410	—
Access-ready land for exploration	—	0.250	0.250	0.250	0.250	1.000	1
Heritage clearance for geothermal licences	—	0.160	0.040	0.010	0.010	0.220	—
Community awareness — mineral exploration	—	0.075	0.060	0.060	0.060	0.255	—
Regional heritage agreements for mineral exploration	—	0.020	0.095	0.095	0.075	0.285	—
TOTAL	1.90	16.08	21.44	23.30	16.78	80.0	8.0

mandate to provide recommendations on the broad policy framework of the co-funded drilling program as well as annually reviewing the operations of the program and recommending amendments to the programs guidelines.

Core collected by companies that gain co-funding will be available on open-file access in the relevant core library after a six-month confidentiality period. Reports of the drilling programs will also be released online after a similar confidentiality period.

Stratigraphic drilling will be undertaken by the Geological Survey of Western Australia (GSWA) to validate seismic interpretation and will provide additional pre-competitive geoscience information for use by both petroleum and mineral explorers.

This project will complement other mineral and petroleum drilling programs, and will fund coring of holes in the Canning, Eucla, and southern Perth basins. Drilling in the Eucla Basin will be aimed at identifying the nature of its crystalline basement.

It will provide data to aid interpretation of formations where there is little current information, as well as help to identify potential for hydrocarbons and geothermal energy. In addition, drilling in the southern Perth Basin will test sedimentary units that could be used for carbon dioxide geosequestration.

Geophysical and Geochemical Surveys

Prior to implementing the EIS, only 70 per cent of the State was covered by medium-resolution airborne magnetic and radiometric surveys with about 30 per cent of the area of Western Australia having only low-resolution (1,600 m) airborne magnetic and radiometric coverage. These data were acquired around 40 years ago and have little current exploration value. This project will largely complete the medium-resolution airborne magnetics and radiometrics (400 m) coverage of the State (Fig. 1).

A network of deep seismic traverses to image WA's crustal structure at depth will be generated, as shown in Figure 2. Integrated geophysical and geological transects are planned across the West Australian Craton and its margins, and adjacent Proterozoic orogens and

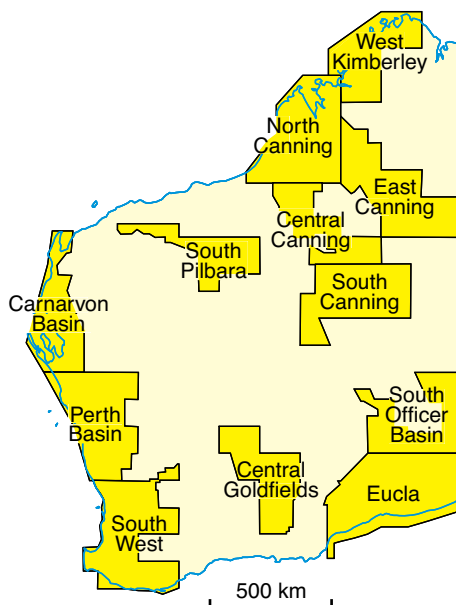


Figure 1 | Planned airborne magnetic and radiometrics surveys

Phanerozoic basins, to provide a key to the geological evolution of the West Australian lithosphere. Such traverses will aid our understanding of the localisation of mineral systems within the upper crust.

The lines extend and integrate pre-existing deep seismic lines, and follow existing roads wherever possible to minimise costs.

A program of regional gravity surveys will be undertaken. The objective of this program is to provide 3D geological information to complement GSWA's geological mapping in selected greenfield exploration areas.

Additionally, regional geochemical surveys will provide multi-element geochemical coverage of under-explored parts of the Yilgarn Craton to stimulate mineral exploration there. Data collected from the surveys will then be incorporated into GSWA's web-based geochemical database.

3D Geological Mapping

A series of activities falling under the 3D geological mapping program will focus on the capture of geoscientific information at depth and its seamless delivery.

The WA Geology Online project will improve geoscience information services to DMP clients by developing an integrated system that allows all geoscience databases to be accessed seamlessly online. In addition to better integrating GSWA's online information,

the WA Geology Online project will develop and facilitate new databases and services linked to current and future map layers. Through this activity, GSWA clients will be able to generate customised reports and maps.

The upgrade of DMP's Western Australian Petroleum and Geothermal Information Management System (WAPIMS) will be completed. This will help to provide a more streamlined information submission and release system for the petroleum industry, and will ensure that the WAPIMS system is interoperable with other departmental computer systems.

Another project will build and maintain interactive 3D geological models — from prospect scale to crustal scale — for selected greenfield exploration areas. 3D geological models can be used to test various structural models and interpretations, and to visualise the Earth at depth. They can be used as predictive models to characterise areas of known mineralisation, as well as identify similar patterns to generate new exploration targets. Once developed, the 3D models will be available to view and download from the DMP website.

The existing GSWA geochemistry database will be upgraded so that it can accept the uploading of digital geochemistry data submitted by companies, as well as existing GSWA geochemistry data. This newly designed web-based facility will allow the query and extraction of both open-file company and GSWA geochemistry. Similarly, the mineral drillhole information database project will improve online information services to DMP customers with an integrated system that allows all mineral drillhole data, and related geochemistry, to be queried and integrated with other GSWA online data. These improvements will enable open-file company mineral exploration drillhole locations and down-hole geochemistry to be accessible via the DMP website.

Another project will involve undertaking regional geoscience mapping and the interpretation, from geophysical data, of bedrock under thin soil and sedimentary basin cover. The focus will be on remote greenfield areas including the basement to the Eucla Basin, the Central Desert area, the Kimberley region and the Capricorn Orogen. Such a project will be built on an expanded program of isotopic dating providing

information on the timing of rock units and specific geological events.

Alternative energy sources include geothermal, tight gas, and enhanced petroleum recovery from depleted reservoirs. The national commitment to ‘clean’ energy also provides a requirement to look at coal technologies to reduce the State’s carbon dioxide footprint. New geoscience information relating to the use of geosequestration to store carbon dioxide emissions is another key aspect of this project. The geothermal project will review current data for geothermal energy, conduct desktop studies on prospective basins, and provide new field data in areas with little coverage (Fig.3).

Promoting Strategic Research with Industry

One of the key objectives of the EIS will be helping to promote strategic research with industry. As part of achieving this goal, \$900,000 will be used to develop the Western Australian Regional Researcher Initiative.

The new initiative is aimed at the rapid transfer of new geoscience concepts, skills, and technologies into the Western Australian minerals exploration industry. It will involve the placement of three embedded researchers into company exploration teams focused on greenfields areas. The researchers will be employed by CSIRO. Funding

to support these employees will be split evenly between the EIS and the participating exploration company sponsors. Overall, the Western Australian Regional Researcher Initiative will help promote the flow of information between research teams and industry sponsors and create a two-way training process for industry professionals and researchers.

Increased funding of \$1.4 million will also be provided to the Minerals and Energy Research Institute of Western Australia to support the minerals and petroleum-related research the organisation funds throughout the State in association with industry.

Sustainable Working Relations with Indigenous Communities

The State Government will dedicate funding from the EIS to providing initiatives designed to assist Indigenous and environmental approvals for prospecting, geoscience mapping, and mining and petroleum exploration and production. The strategy and work program will target under explored onshore areas of the State that have access corridors to major interior basins. In addition, a model Indigenous land use agreement will be developed, which can be utilised where Native Title has been determined, and where it remains as a claim. Key objectives of this program are to address Indigenous heritage, the Future Act process under the *Native Title Act 1993*, and access to the land where exclusive Native Title exists. ■

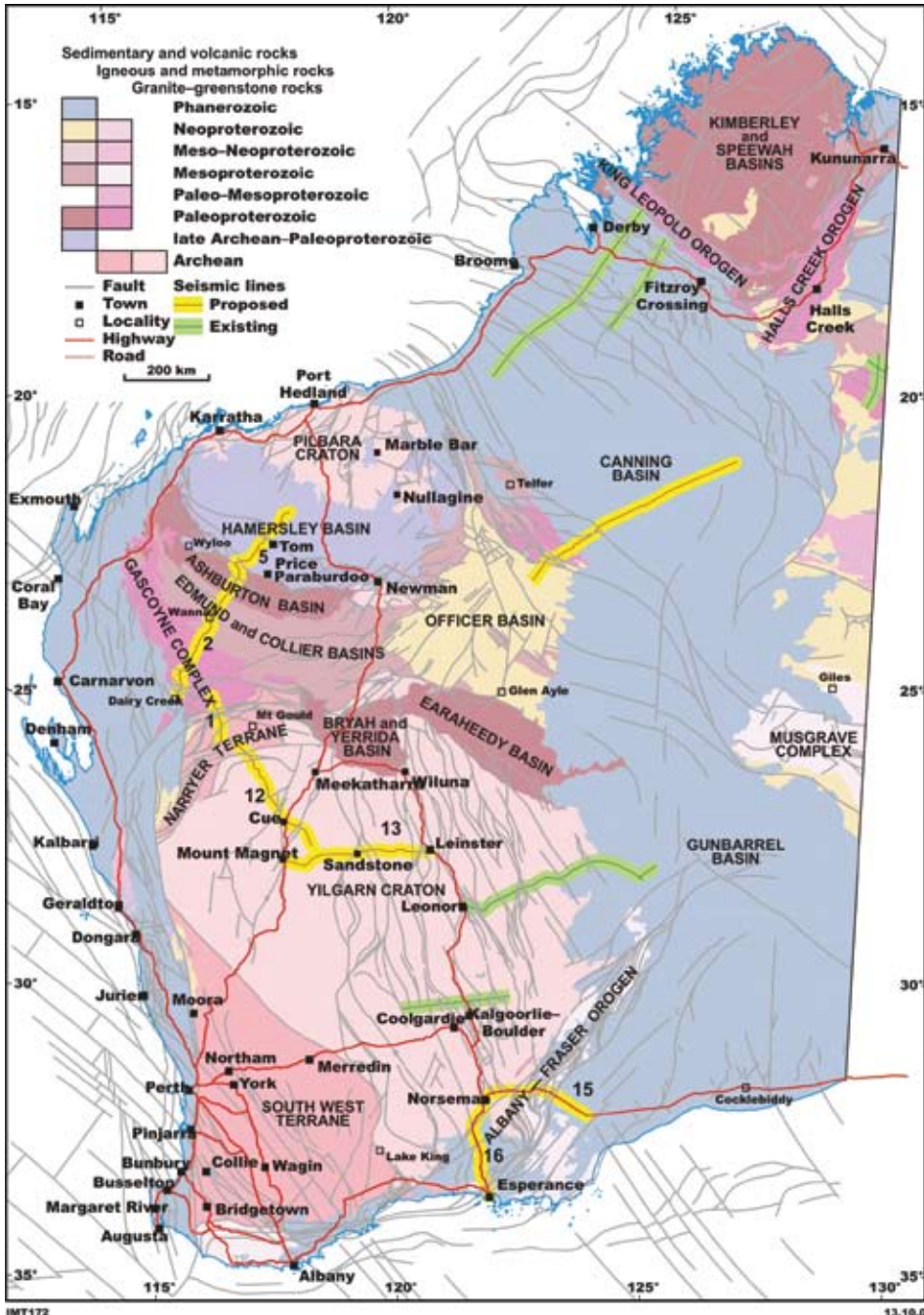


Figure 2 | Planned deep crustal seismic traverses

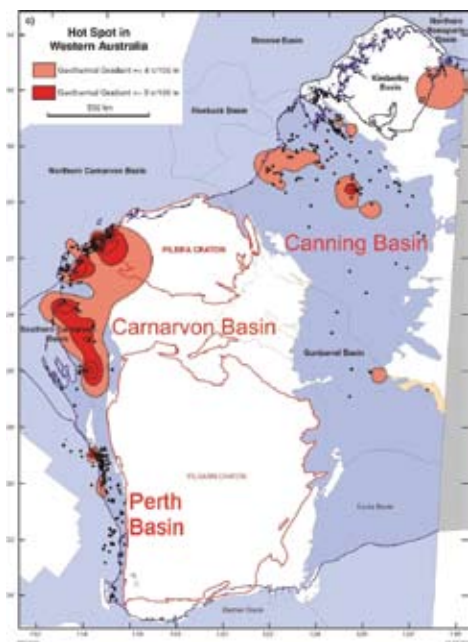
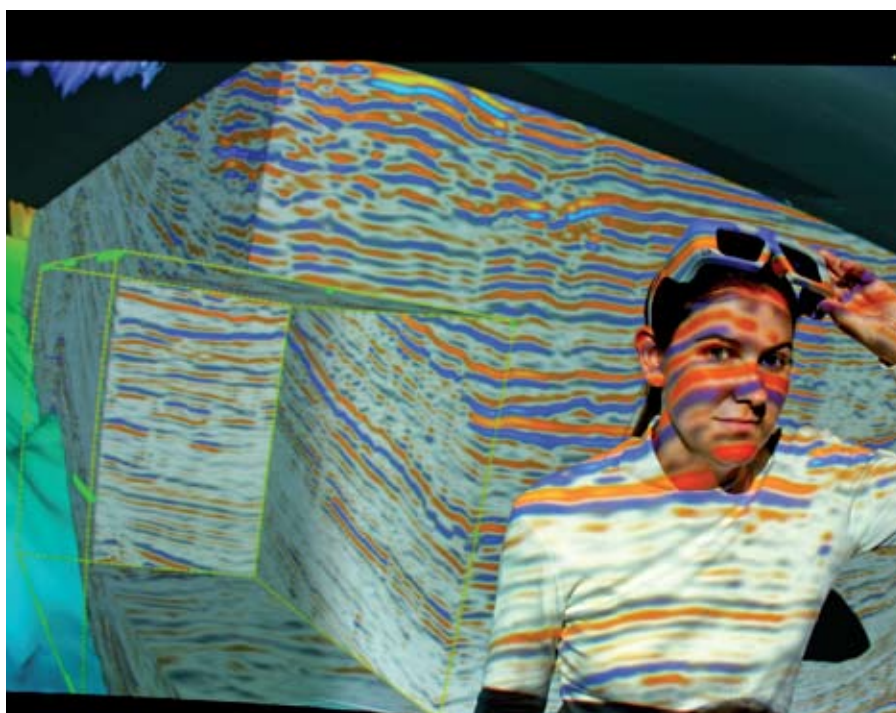


Figure 3 | Geothermal hot spots in Western Australia based on estimated present-day geothermal gradients

Seismic Techniques and Tools Supporting the Exploration Industry

Jim Dirstein

Total Depth Pty Ltd



A number of innovative technologies have recently evolved which can be applied to exploration for minerals, petroleum and coal bed methane. Techniques include (1) seismic facies mapping, (2) pre-interpretation of 3D seismic, (3) seismic facies volumes, (4) seismic inversion, (5) data enhancement, (6) spectral analysis, (7) prediction of rock properties, (8) amplitude versus offset, and (9) the airborne impulse survey.

Seismic Facies Mapping

There are a number of commercial applications which enable different approaches to unsupervised and supervised classification of seismic waveforms. Depending on the data to be analysed, the best suited algorithm is selected to map the progressive change of the seismic waveform in that volume. Once this stage has been completed all traces are then classified and assigned to the model trace that it best matches.

The key objective of seismic facies maps generated from the seismic and/or seismic attribute volumes would help establish and validate geological models of the main zones of interest. The advantage of using seismic facies mapping is the speed in which geological patterns can be extracted for use in prospect generation, development and the assessment of geo-hazards. Seismic waveform mapping is commonly applied to the following seismic volumes: (1) time domain volumes using full-stack,

angle stacks, spectrally enhanced and pseudo-impedance processed data, and (2) frequency domain volumes with estimated wavelet spectra, residual wavelet spectra and normalised attenuation spectra.

Pre-interpretation of 3D Seismic Volumes

Total Depth Pty Ltd has partnered with SEISNETICS LLC to provide pre-interpretation services using a radically new methodology that delivers an unbiased extraction of virtually all surfaces from 3D seismic volumes. Without human intervention, the volume is automatically segmented and organised into populations of genetically related waveforms. These populations, referred to as Geo-Populations™, consist of Trough and/or Peak surfaces. The process is independent of and complimentary to all workflows currently undertaken by professionals interpreting 3D seismic data, regardless of which seismic interpretation tools are used.

The rapid extraction of high-quality pre-interpretation surfaces from 3D seismic volumes will enable more focus on understanding the results and their economic potential, thereby reducing risk, accelerating the decision making process, better utilisation of resources, time and corporate assets.

As an example, Figure 1 shows two slices using this technique on the same 3D volume. The first slice shows a pattern of stratigraphic features, and

the second slice shows the appearance of deeper structural features within the volume using this technique.

Seisnetics™ has applications in many areas, such as pre-interpretation, processing QC, Time-Lapse (4D), and modelling for basin structure, depth and velocity analysis, and migration pathway studies. The process has been successfully applied to time domain (full-stack, angle stacks, and spectrally enhanced, pseudo-impedance and reflectivity processed data) and frequency domain (estimated wavelet spectra, residual wavelet spectra and normalised attenuation spectra) seismic volumes.

The requirements for Seisnetics™ processing are simply a copy of the 3D data (i.e. processing Archive SEG-Y format), loading parameters and (x,y) co-ordinates. The workflow is (1) load seismic data, (2) start seisnetics™ processing, (3) review Geo-Populations™ in the Seisnetics™ 3D viewer, and (4) export ASCII files (Inline, Xline, TWT, Fitness, Amplitude).

Seismic Facies Volumes

This process is similar to processes used in seismic facies mapping. However, the output is a facies block (volume). The process can be computationally intensive depending on the number of volumes used as input. The selection of meaningful and independent seismic attributes is essential to obtaining a good result.

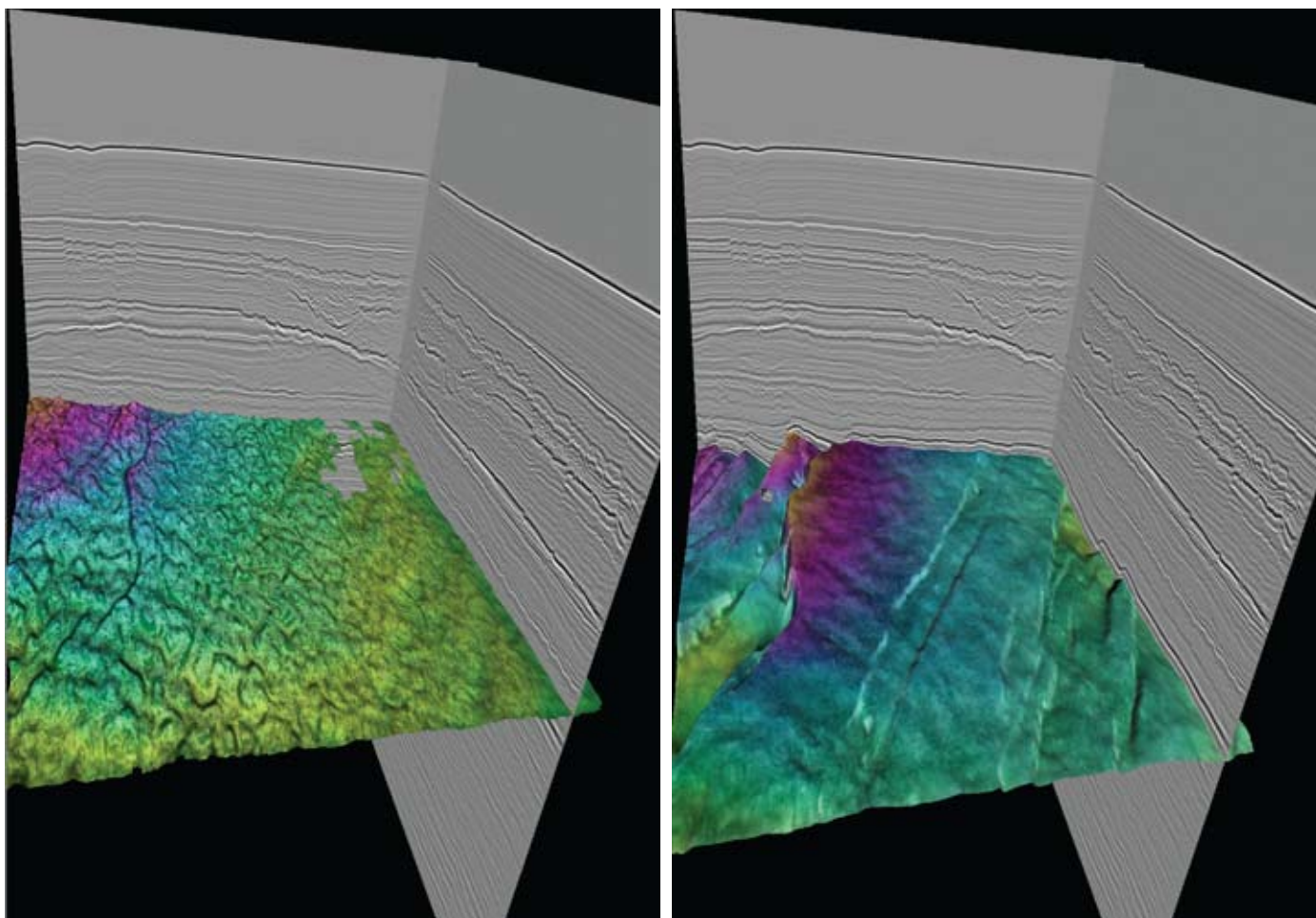


Figure 1 | An example of the use of the Seisnetics™ technique

The seismic-facies-blocks process is generally undertaken as a refinement to seismic facies mapping.

A key objective in carrying out the seismic-facies-blocks process is to enable a seismic-facies block, once generated, to be loaded into 3D visualisation software, so individual facies can be isolated, thereby increasing visualisation capabilities beyond amplitude.

After a seismic-facies block is generated, the block itself can be used for further integration with other time or frequency domain volumes.

The initial data required for this process are a copy of the 3D data, horizon data or several seed points, well logs, well completion reports or description of detailed well results. A typical workflow entails loading the seismic data, QC and the refinement and extension (if necessary) of horizon picks, selection of intervals of interest and seismic attributes, creation of seismic-facies blocks and 3D visualisation.

Seismic Inversion

There are a number of different commercial “model based” inversion algorithms, one of which is “Seismic Consistent Inversion” (Reflect software) which is different from other seismic inversion techniques, as it does not require well information or horizon information to estimate reflectivity or pseudo-impedance. The advantage of this process is particularly apparent in areas where well control is sparse and/or the interpretation is complex. Since well data or horizon information is not used in the estimation of reflectivity and pseudo-impedance, any available well data or horizon data can be used to validate the quality of the inversion or integrity of the well data or interpretation. Combined with other attributes this inversion can assist with the understanding of reservoir seal pair geometries. The inversion technique is applicable on either post-stack or partial stack data.

An initial objective of “Seismic Consistent Inversion” is to provide a

volume of pseudo-impedance data, which will help validate trap geometries suggested by other techniques, such as AVO or spectral attenuation analysis. A further objective, especially as the number of wells increase, can be to apply the “Seismic Consistent Inversion” volume as an input attribute for statistically derived estimations of acoustic impedance.

Data Enhancement

The post-stack enhancement of seismic data is an important stage for the interpretation process. The seismic processing software products PC-Filter™ and Resolve™ are powerful tools in the removal of noise and improvement in resolution of stack seismic data.

In terms of signal-to-noise ratio enhancement with PC-Filter™, coherent and random noise can be removed. The unique features of PC-Filter™ are: (1) design and application in the time domain (simple, without artifacts), (2) initial model(s) of noise is not required,

(3) examination of the residual data validates that ‘noise’ has been removed, (4) amplitude preservation, (5) improved signal to noise ratio, resulting in better attribute extraction, (6) it can be applied pre-stack or post-stack, and (7) it can be applied in a horizon consistent manner.

Application of Resolve™ can provide improved resolution of seismic data. Conventional deconvolution techniques often assume white reflectivity for operator design. However, most sedimentary basins in Australia do not exhibit white reflectivity. The improved signal-to-noise ratio and spectral integrity after application of Resolve™ will benefit most attribute extraction techniques. The unique features of Resolve™ include the fact that the deconvolved wavelet is estimated from the “signal” rather than directly from the data, and the wavelet is shaped according to the signal-to-noise spectrum. Further, the technique uses a proprietary pole-zero modelling technique, which is very accurate for short time windows.

Spectral Analysis

Several techniques are used in the industry to examine different types of seismic spectral signatures. Typically, spectral signatures reflect a response to either lithological or petrophysical changes. Lithological variations, caused by changes in geomorphology, are often identified by techniques such as spectral decomposition. However, petrophysical variations caused by different pore fluid affect the spectral attenuation of seismic frequencies (i.e. gas attenuates seismic frequencies more than oil, and oil more than water). Accordingly, petrophysical variations in spectral attenuation are potentially of greater economic significance than lithological variations.

The spectral attenuation technique we apply has been used successfully to identify, and predict, both structurally and stratigraphically trapped gas and oil accumulations. The technique utilises a pole-zero modelling algorithm to provide much higher quality spectral estimations compared to fast-fourier-transform (FFT) or instantaneous methods. The objective of applying the technique to a 3D volume is to determine the extent of the spectral attenuation anomalies identified on the 2D extracts, and also to try to understand the relationship between spectral signatures and those noted at

hydrocarbon accumulations. The initial data required to apply the technique are a copy of the 3D seismic data, horizon data, well logs (to be used for validation of results), and well completion reports or description of detailed well results.

Figure 2 shows an example of spectral analysis of seismic line PP88B-102 over the Tubridgi gasfield. The upper panel shows the seismic section and horizon being analysed. The middle three panels show plots of estimated wavelet spectra above, below and residual wavelet spectra below the horizon of interest. The bottom panel shows normalised attenuation, where the red indicates maximum attenuation, which in this environment is an indication of the presence of gas in the pore space.

Prediction of rock properties

Log properties of rocks such as P-impedance and porosity can be predicted over an entire 3D volume using the seismic, a database of existing well log data and multi-attribute mapping using multi-attribute mapping software. The software integrates well log data, seismic data and external attributes in order to find a relationship between each at the borehole locations in a study area. This relationship is then applied to predict or estimate a volume

of the selected log property at all locations of the seismic volume.

The technique combines seismically tied boreholes together with the “spectrally shaped” seismic volume and other attributes. A Probabilistic Neural Network (PNN) is used to calculate, and apply a transform, which when applied to the seismic attribute data would best predict the “target log” (e.g. P-impedance).

Amplitude Versus Offset

Amplitude versus offset (AVO) analysis can be used as a direct indication of the presence of hydrocarbons. However, the effectiveness of the technique can be very sensitive to data quality and the area of application. Given this sensitivity, the application workflow needs to be tailored to specific aspects of the seismic data, available well information and knowledge of the variability of rock properties.

The data example here (Figure 3) demonstrates AVO analysis being performed on a high amplitude feature to determine its potential for hydrocarbons. This seismic line is from a deep-water area where well log data are unavailable, making any modeling efforts prone to high levels of non-uniqueness.

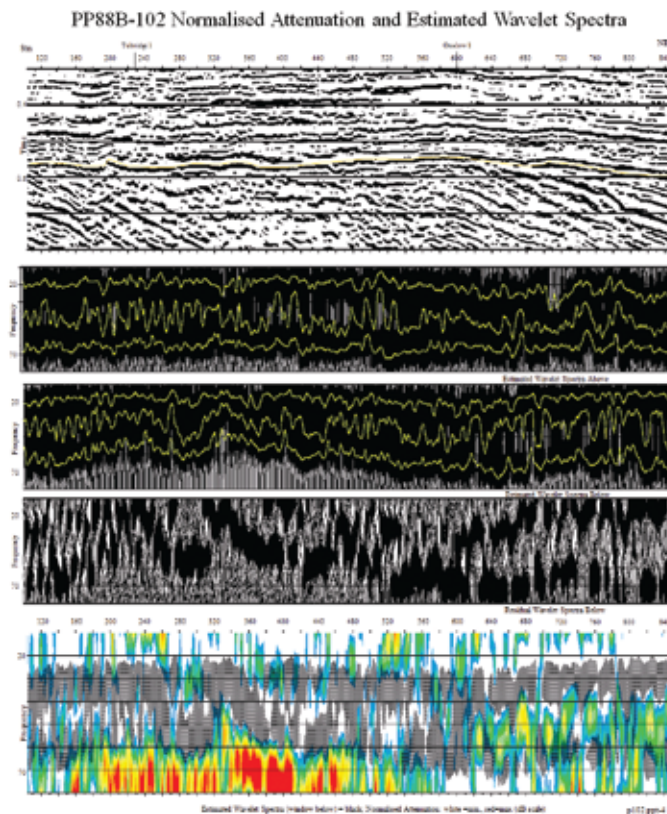


Figure 2 | An example of spectral signatures of the Tubridgi gasfield

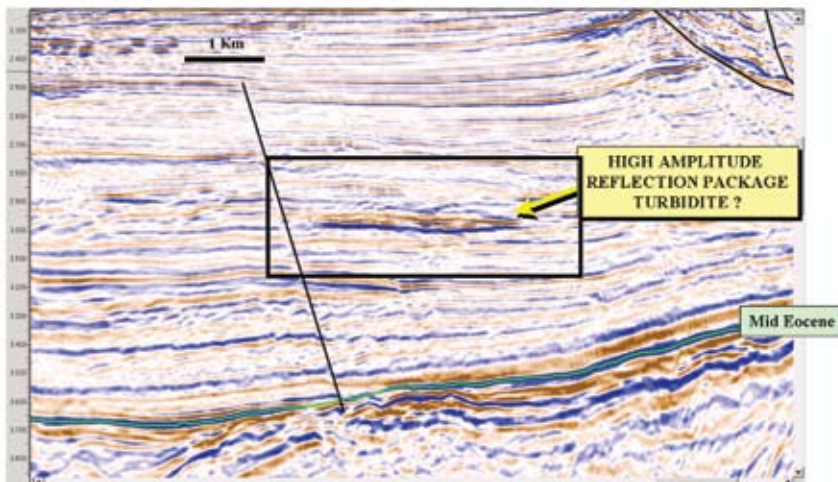


Figure 3 | An example of AVO analysis

The prospect appears as a large amplitude “brightspot” on the common-depth-point (CDP) stack section, and is interpreted as a possible turbidite feature. The objective of this application is to use a number of methods that relate the behavior of seismic amplitudes with offset as an indicator of hydrocarbons without unduly biasing our expectations using sparse or inaccurate detail for modelling.

In this particular case history, which is from Circum Makassar, Indonesia, an interpreted turbidite sand has high seismic amplitudes (“brightspot”). Analysis by Intercept and Gradient methods indicates that three zones emerge (see graph in Figure 3): green and red zones, suggestive of oil- or gas-filled matrix, and a blue zone theoretically corresponding to a water-filled matrix. These different zones are plotted on the turbidite seismic anomaly in the lower panel of Figure 3. This analysis lends support to the possibility of hydrocarbons being present in the interpreted turbidite mound.

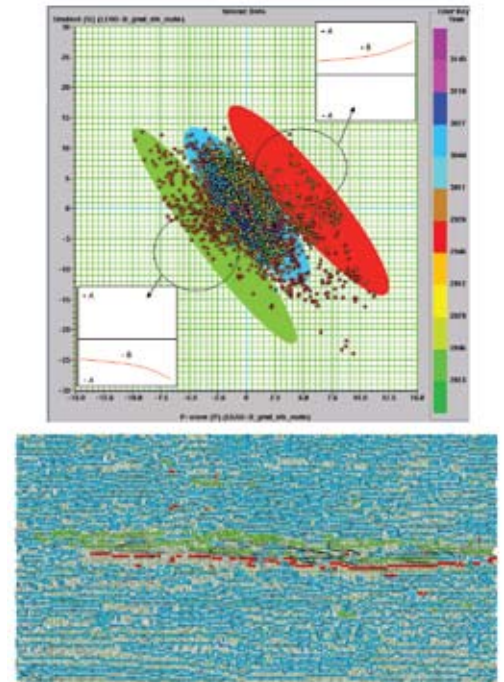
Airborne Impulse Survey

This innovative airborne geophysical survey is described as a magnetic impulse survey (Passive Transient Electro Magnetics - PTEM), and

measures naturally occurring increases in magnetic component electromagnetic impulses associated with the secondary magnetic fields over a hydrocarbon reservoir. The instrument incorporates precision gain with an amplitude detector that counts the impulse activity, and compares it against the overall background activity count for the area being surveyed.

Pinemont has developed an economic method of conducting the survey utilising, in most cases, a small plane (Cessna) flying low and slow, along a grid. GPS coordinates are downloaded to a computer and then mapped using mapping software; anomalous areas are highlighted for map reference. Digital data is recorded as a CSV txt file format x,y,z data set, that is compatible with most all mapping software packages. Data is poled every 100 milliseconds, averaged and recorded every second.

More than 200,000 nautical miles of survey lines have been run in productive areas, both on land and over the sea. Pinemont Technologies developed the survey in 2001, and first employed the survey in 2002. Since then, data has been acquired on a confidential basis in the United States, Canada, Australia, and New Zealand. More than 30 discovery wells have been documented



as being associated with PTEM anomalies. Figure 4 shows an example PTEM applied to the Cooper Basin gasfields.

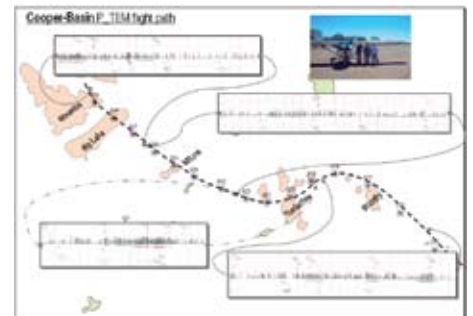


Figure 4 | An example of a PTEM survey over known gasfields

Conclusion

This article has described a number of services using different techniques to collect or process or analyse data for minerals, petroleum and coal bed methane exploration and exploitation.

As each project presents its own unique technical challenges, it is reasonable to expect that the solution which best addresses these challenges will be made up for a combination of different and independent approaches. Ultimately, the explorationist needs to evaluate and select those tools which they feel are both technically and economically effective. ■



The Songa Venus drilling rig (Photo courtesy of Inpex Browse, Ltd)

Table 1. 2009 Production by Field and Cumulative Production as at 31 December 2009

Field	Operator	2009 Production by Field			Cumulative Production			Permit
		Oil	Condensate	Gas	Oil	Condensate	Gas	
		kL	kL	10 ³ m ³	kL	kL	10 ³ m ³	
Albert	Apache	6,202	2	1,567	57,334	28	5,171	TL/6
Angel	Woodside	0	2,251,058	7,337,073	0	2,442,503	8,084,589	WA-3-L
Apium	AWE	0	77	7,606	0	291	26,253	L1
Artreus	Apache	213	0	106	32,827	14	3,813	TL/6
Bambra	Apache	102,964	19,419	207,666	241,135	84,620	523,038	TL/1
Barrow Island	Chevron	318,990	0	45,574	49,985,141	0	5,280,015	L1H
Beharra Springs	Origin	0	293	35,374	0	23,870	2,238,167	L11
Blacktip	Eni	0	532	61,327	0	532	61,327	WA-33-L
Blina	Buru Energy	1,372	0	0	296,127	0	0	L6
Boundary	Buru Energy	50	0	0	20,451	0	0	L6
Chinook/Scindian	BHP Billiton	37,741	0	23,149	4,802,479	0	1,832,979	WA-10-L
Cliff Head	ROC Oil	225,581	0	757	1,430,068	0	5,867	WA-31-L
Cossack	Woodside	403,621	0	10,632	12,584,664	0	377,935	WA-9-L
Cowle	Chevron	2,712	0	1,362	526,746	1,748	87,767	TL/4
Crest	Chevron	422	0	1,157	274,755	108	61,991	L12, L13
Dongara	AWE	1,575	159	27,568	191,877	49,677	12,870,043	L1, L2
Double Island	Apache	14,067	4	3,553	676,011	2,776	45,051	TP/8
Echo/Yodel	Woodside	0	369,035	408,917	0	10,571,539	13,366,709	WA-23/24-L
Enfield	Woodside	1,679,578	0	188,371	7,603,055	0	652,060	WA-28-L
Eremia	AWE	8,460	0	1,977	239,789	0	11,608	L1
Eskdale	BHP Billiton	84,133	0	80,273	311,285	0	182,042	WA-32-L
Exeter	Santos	128,830	0	589	2,485,256	0	4,848	WA-27-L
Goodwyn	Woodside	0	1,646,622	8,249,768	0	42,811,458	121,322,386	WA-5-L
Griffin	BHP Billiton	124,440	0	8,617	21,694,436	0	1,801,247	WA-10-L
Gudrun	Apache	54	0	4	118,719	75	7,740	TL/1
Harriet	Apache	11,066	2	4,184	8,181,756	60,035	1,484,787	TL/1
Hermes	Woodside	1,186,098	0	82,012	11,420,386	0	755,101	WA-16-L
Hovea	AWE	35,750	1	3,013	1,168,642	251	98,136	L1
Jingemia	Origin	31,893	0	1,466	691,402	0	31,746	L14
John Brookes	Apache	0	155,814	2,605,403	0	577,878	9,116,895	WA-29-L
Laminaria East	Woodside	17,055	1,304	0	1,533,033	70,625	24,854	WA-18-L
Lee	Apache	0	25,462	194,741	0	92,585	585,207	TL/1
Legendre North	Apache	169,592	0	119,021	6,658,950	0	1,662,090	WA-20-L
Legendre South	Apache	39,025	0	259,428	849,248	0	998,449	WA-20-L
Little Sandy	Apache	3,749	1	892	88,148	444	11,708	TL/6
Lloyd	Buru Energy	244	0	0	30,124	0	0	L8

Table 1. 2009 Production by Field and Cumulative Production as at 31 December 2009

Field	Operator	2009 Production by Field			Cumulative Production			Permit
		Oil	Condensate	Gas	Oil	Condensate	Gas	
		kL	kL	10 ³ m ³	kL	kL	10 ³ m ³	
Mohave	Apache	745	1	360	141,595	108	18,358	TL/6
Mount Horner	AWE	2,499	0	0	296,431	0	0	L7
Mutineer	Santos	354,260	0	1,653	5,792,300	0	11,503	WA-26-L
North Alkimos	Apache	3,316	0	7,261	10,055	89	20,191	TL/6
North Rankin	Woodside	0	171,143	1,599,129	0	24,461,711	191,255,493	WA-1-L
Pedirka	Apache	13,253	4	4,128	314,560	1,204	30,638	TL/6
Perseus	Woodside	0	2,350,929	10,895,516	0	19,791,583	96,441,763	WA-1-L
Roller	Chevron	60,301	0	14,623	7,077,946	0	743,075	TL/7
Rose	Apache	0	10,075	64,173	0	199,355	957,123	TL/1
Saladin	Chevron	72,718	0	25,170	15,402,317	0	1,718,413	TL/4
Searipple	Woodside	0	383,079	374,219	0	755,966	741,020	WA-1-L
Simpson	Apache	13,517	282	4,204	835,012	6,525	80,605	TL/1
Skate	Chevron	0	0	19,609	266,950	8,873	156,181	TL/7
South Plato	Apache	5,929	8	3,555	697,544	883	50,635	TL/6
Stag	Apache	391,426	0	5,495	8,218,169	0	394,455	WA-15-L
Stybarrow	BHP Billiton	1,729,176	0	106,463	5,822,312	1	352,723	WA-32-L
Sundown	Buru Energy	2,838	0	0	70,539	0	0	L8
Tarantula	Origin	0	239	29,155	0	3,858	308,064	L11
Victoria	Apache	2,188	2	1,233	49,578	367	7,841	TL/6
Vincent	Woodside	1,052,176	0	376,113	1,594,845	0	586,900	WA-28-L
Wanaea	Woodside	611,685	0	143,135	38,703,478	0	8,297,150	WA-11-L
Wandoo	Vermillion	453,096	0	39,005	12,196,952	0	967,976	WA-14-L
West Cycad	Apache	17,309	15	8,337	193,180	225	23,691	TL/9
West Terrace	Buru Energy	783	0	0	38,516	0	0	L8
Wonnich	Apache	0	33,636	378,881	0	402,564	3,926,186	TL/8
Woodada	AWE	0	61	9,314	0	10,603	1,496,326	L4, L5
Woollybutt*	Eni	152,977	0	4,158	5,033,644	0	142,618	WA-25-L
Xyris	AWE	0	391	28,975	0	3,505	258,885	L1
Xyris South	AWE	0	54	4,015	0	116	7,183	L1
Yammaderry	Chevron	0	0	1,312	857,361	0	98,725	TL/4
Yardarino	AWE	0	0	204	1,567	771	143,783	L2
Zephyrus	Apache	1,133	1	223	62,490	27	3,034	TL/6
Cumulative production for developed fields currently not producing					13,062,034	3,257,169	17,633,324	
Total		9,576,799	7,419,704	34,122,762	250,933,218	105,696,561	510,495,480	

* includes Woollybutt South

Table 2a. Petroleum Reserves Estimates by Basin as at 31 December 2008 (Metric Units)

Basin	Oil		Sales Gas		Condensate	
	GL		Gm ³		GL	
Category 1	P50	P90	P50	P90	P50	P90
Canning*	0.00	0.00	0.00	0.00	0.00	0.00
Northern Carnarvon	68.44	32.78	525.65	442.77	31.57	22.53
Perth	1.91	1.14	0.43	0.19	0.01	0.01
Total	70.35	33.92	526.08	442.96	31.58	22.54
Category 2	P50	P90	P50	P90	P50	P90
Bonaparte	0.00	0.00	22.34	17.93	0.90	0.36
Browse	0.00	0.00	456.30	290.15	60.00	35.68
Northern Carnarvon	21.69	15.14	1,894.42	1,138.60	44.87	25.38
Total	21.69	15.14	2,373.06	1,446.68	105.77	61.42
Category 3	P50	P90	P50	P90	P50	P90
Bonaparte	0.00	0.00	38.82	11.09	0.00	0.00
Browse	0.00	0.00	523.83	353.70	94.39	62.90
Northern Carnarvon	50.24	27.32	399.46	209.55	24.56	13.19
Perth*	0.00	0.00	0.00	0.00	0.00	0.00
Total	50.24	27.32	962.11	574.34	118.95	76.09
GRAND TOTAL	142.28	76.38	3,861.26	2,463.98	256.30	160.05

* too small to measure

Table 2b. Petroleum Reserves Estimates by Basin as at 31 December 2008 (Field Units)

Basin	Oil		Sales Gas		Condensate	
	MMbbl		Tcf		MMbbl	
Category 1	P50	P90	P50	P90	P50	P90
Canning*	0.00	0.00	0.00	0.00	0.00	0.00
Northern Carnarvon	430.39	206.15	18.56	15.64	198.54	141.69
Perth	12.03	7.17	0.02	0.01	0.06	0.06
Total	442.42	213.32	18.58	15.64	198.60	141.75
Category 2	P50	P90	P50	P90	P50	P90
Bonaparte	0.00	0.00	0.79	0.63	5.65	2.26
Browse	0.00	0.00	16.11	10.25	377.34	224.39
Northern Carnarvon	136.41	95.22	66.90	40.21	282.19	159.61
Total	136.41	95.22	83.80	51.09	665.18	386.27
Category 3	P50	P90	P50	P90	P50	P90
Bonaparte	0.00	0.00	1.37	0.39	0.00	0.00
Browse	0.00	0.00	18.50	12.49	593.62	395.58
Northern Carnarvon	315.99	171.82	14.11	7.40	154.47	82.95
Perth*	0.00	0.00	0.00	0.00	0.00	0.00
Total	315.99	171.82	33.98	20.28	748.09	478.53
GRAND TOTAL	894.81	480.35	136.36	87.01	1,611.87	1,006.55

* too small to measure

NOTES

Category 1 comprises current reserves of those fields which have been declared commercial.

Category 2 comprises estimates of recoverable reserves which are held under Retention Leases and have not yet been declared commercially viable.

Category 3 comprises estimates of recoverable reserves which are held in other licences and have not yet been declared commercially viable.

The Petroleum Division is currently reviewing its reserves reporting process and as such are publishing estimated reserves and resources in a similar fashion to Geoscience Australia.

Table 3. Seismic Surveys in Western Australia 2009 Calendar Year — Statistical Summary

		2D (line km)	3D (km ²)
Bight Basin	Onshore		
	Offshore	2,904	
Bonaparte Basin	Onshore		
	Offshore	3,281	200
Browse Basin	Onshore		
	Offshore		4,453
Canning Basin	Onshore	103	223
	Offshore		
Carnarvon Basin	Onshore		
	Offshore	3,608(a)	21,182(b)
Perth Basin	Onshore	28(c)	
	Offshore		
Subtotal	Onshore	131	223
	Offshore	9,793	25,835
Total		9,924	26,058

The above table lists the quantity of 2D seismic (line km) and 3D seismic (km²) acquired during the calendar year.

For surveys that commenced before 1 January 2009, only acquisition after this date is included.

(a) Includes acquisition from Guacamole 2D M.S.S. commenced 2008

(b) Includes acquisition from Cazadores 3D M.S.S. commenced 2008

(c) Warner Glen 2006 2D S.S. acquisition

Non-seismic surveys for the year include Lockier and Xanadu FTG surveys.

The attached listing of surveys operating in the calendar year (Table 5) includes all data gathered prior to 31 December 2009.

Table 4. Petroleum Wells in Western Australia 2009 Calendar Year — Statistical Summary

		NFW		EXT		DEV		Subtotal		Total	
		Wells	Metres	Wells	Metres	Wells	Metres	Wells	Metres	Wells	Metres
Bonaparte Basin	Onshore										
	Offshore	4	12,005	1	3,286	2	6,603	7	21,894	7	21,894
Browse Basin	Onshore										
	Offshore	8	38,029	3	9,042(a)			11	47,071	11	47,071
Canning Basin	Onshore	1	1,983					1	1,983		
	Offshore									1	1,983
Carnarvon Basin	Onshore										
	Offshore	22	54,136	18	39,203(b)	24	72,820(c)	64	166,159	64	166,159
Perth Basin	Onshore	3	10,457	1	3,688	2	5,602	6	19,747		
	Offshore									6	19,747
Subtotal	Onshore	4	12,440	1	3,688	2	5,602	7	21,730		
	Offshore	34	104,170	22	51,531	26	79,423	82	235,124	89	256,854
Total		38	116,610	23	55,219	28	85,025	89	256,854		

The above table lists the number of wells spudded and metres drilled (subsurface) during the 2009 calendar year.

For wells spudded before 1 January 2009, only metres drilled during the calendar year are included.

(a) Includes Torosa 5 spudded 2008.

(b) Includes Rosella 2 and Tidepole 2 spudded 2008.

(c) Includes Pluto and Vincent/Van Gogh wells spudded 2008.

Table 5. Seismic Surveys in Western Australia Operating 2009 Calendar Year

Survey Name	Class	On Off	Title	Operator	Commenced	Completed	2D Line km @ 31/12/2009	3D km ² @ 31/12/2009	Non Seismic km
Bight Basin									
Bremer Basin 2D M.S.S.	2D	Off	WA-379-P, WA-380-P	Arcadia	9/12/2009		2,904		
Bonaparte Basin									
Gold 2D M.S.S.	2D	Off	WA-375-P, WA-376-P	Goldsborough	25/02/2009	18/03/2009	1,875		
RIL 2D 09/10 M.S.S.	2D	Off	WA-405-P	Reliance E&P	4/12/2009	17/12/2009	1,406		
RIL 3D 09/10 M.S.S.	3D	Off	WA-405-P	Reliance E&P	24/12/2009			200	
Browse Basin									
Adele Trend 2008 Q3D Multiclient 3D M.S.S.	3D	Off	2SL/09-0	Western Geco	29/09/2009	29/10/2009		925	
Poseidon 3D M.S.S.	3D	Off	WA-314-P, WA-315-P, WA-389-P	Conoco Phillips	11/10/2009			2,075	
Zeemeermin 3D M.S.S.	3D	Off	1SL/09-0	Fugro	15/11/2009	15/12/2009		1,453	
Canning Basin									
Bunda 3D S.S.	3D	On	EP 129 R5, L 6 R1, L 8 R1	Buru Energy	14/08/2009	13/09/2009		223	
Paradise 2009 2D S.S.	2D	On	EP 371 R1, EP 428	Arc Energy	17/09/2009	24/09/2009	103		
Carnarvon Basin									
DS08 2D M.S.S.	2D	Off	WA-352-P	Drillsearch	7/01/2009	10/01/2009	330		
Guacamole 2D M.S.S.	2D	Off	WA-384-P, WA-385-P, WA-394-P	Shell	24/11/2008	6/01/2009	3,452		
Quiberon Non-Exclusive 2D M.S.S.	2D	Off	3SL/09-0	Searcher Seismic	4/11/2009		2,678		
Artemis 3D M.S.S.	3D	Off	WA-360-P	NWS Exploration Ltd	10/03/2009	1/04/2009		258	
Cazadores 3D M.S.S.	3D	Off	WA-347-P, WA-348-P	Woodside	20/12/2008	24/03/2009		4,551	
Claudius 3D M.S.S.	3D	Off	WA-434-P	Woodside	22/10/2009			3,361	
Eendracht 3D M.S.S.	3D	Off	6SL/09-0	Fugro	8/06/2009			3,223	
Foxhound 3D Non-Exclusive M.S.S.	3D	Off	7SL08/09	Searcher Seismic	13/04/2009	7/08/2009		7,440	
Greater West Anchor 3D M.S.S.	3D	Off	WA-214-P R3, WA-29-L	Apache Energy	8/01/2009	15/03/2009		2,232	
Judo 3D M.S.S.	3D	Off	WA-412-P	Japan Energy	24/05/2009	6/06/2009		568	
Perth Basin									
Warner Glen 2006 2D S.S.	2D	On	EP 446	Red Mountain Energy	8/02/2008	17/02/2009	39		
Lockier Airborne 3D FTG	GRAVITY	On	EP 368 R3	Westbranch	10/09/2009	11/09/2009			400
Xanadu FTG Survey	GRAVITY	On	TP/15 R1	Norwest Energy	4/09/2009	9/09/2009			625

Class - Classification:

2D - 2D Reflection, 3D - 3D Reflection, GRAVITY - Airborne Gravity, OBC - On Bottom Cable

Table 6. Petroleum Wells in Western Australia Operating 2009 Calendar Year

Well Name	Class	On Off	Title	Operator	Latitude		
Bonaparte Basin							
Blacktip P 1	DEV	OFF	WA-33-L	ENI	13	53	41.84
Blacktip P 2	DEV	OFF	WA-33-L	ENI	13	53	41.84
Blacktip 2	EXT	OFF	WA-33-L	ENI	13	53	55.68
Hong Niu 1	NFW	OFF	WA-406-P	CNOOC	10	49	2.32
Jin Niu 1	NFW	OFF	WA-406-P	CNOOC	10	49	45.92
Windjana 1	NFW	OFF	WA-280-P R1	ENI	14	29	41.60
Fu Niu 1	NFW	OFF	WA-406-P	CNOOC	10	42	53.71
Browse Basin							
Brecknock 4	EXT	OFF	WA-32-R	Woodside	14	21	45.87
Cornea 3	EXT	OFF	WA-342-P	Hawkestone Oil	13	41	53.28
Poseidon 2	EXT	OFF	WA-398-P	Conoco Phillips	13	40	7.14
Torosa 5	EXT	OFF	WA-30-R	Woodside	13	59	19.69
Braveheart 1 ST1	NFW	OFF	WA-333-P	Hawkestone Oil	13	51	42.99
Burnside 1 ST1	NFW	OFF	WA-281-P R1	Santos	14	12	47.36
Concerto 1 ST1	NFW	OFF	WA-371-P	Shell	13	40	28.15
Crescendo 1	NFW	OFF	WA-371-P	Shell	13	30	16.17
Intermezzo 1	NFW	OFF	WA-371-P	Shell	13	33	25.87
Kontiki 1	NFW	OFF	WA-314-P	Conoco Phillips	13	24	44.02
Minuet 1	NFW	OFF	WA-371-P	Shell	13	33	45.52
Poseidon 1	NFW	OFF	WA-315-P	Conoco Phillips	13	37	22.46
Canning Basin							
Sally May 2	NFW	ON	EP 429	Kingsway Oil	19	48	5.00
Carnarvon Basin							
Crosby 3H	DEV	OFF	WA-12-R R1	BHP Billiton	21	32	43.01
Crosby 4H	DEV	OFF	WA-12-R R1	BHP Billiton	21	32	42.98
Crosby 5H	DEV	OFF	WA-12-R R1	BHP Billiton	21	31	44.60
Crosby 6H	DEV	OFF	WA-12-R R1	BHP Billiton	21	31	44.56
ENE 01	DEV	OFF	WA-28-L	Woodside	21	28	53.29
John Brookes 6 ST1	DEV	OFF	WA-29-L	Apache	20	26	50.44
Macedon 6	DEV	OFF	WA-12-R R1	BHP Billiton	21	34	2.42
PLA 01	DEV	OFF	WA-34-L	Woodside	19	54	49.27
PLA02	DEV	OFF	WA-34-L	Woodside	19	54	48.22
PLA03	DEV	OFF	WA-34-L	Woodside	19	54	48.30
PLA04	DEV	OFF	WA-34-L	Woodside	19	54	48.57
PLA 05	DEV	OFF	WA-34-L	Woodside	19	54	48.84
Ravensworth 3H	DEV	OFF	WA-12-R R1	BHP Billiton	21	32	19.80
Ravensworth 4H	DEV	OFF	WA-155-P R4	BHP Billiton	21	32	19.03
Ravensworth 5H	DEV	OFF	WA-155-P R4	BHP Billiton	21	32	17.13
Ravensworth 6H	DEV	OFF	WA-155-P R4	BHP Billiton	21	32	16.61
Ravensworth 8H	DEV	OFF	WA-12-R R1	BHP Billiton	21	31	46.24
Ravensworth 7AH	DEV	OFF	WA-12-R R1	BHP Billiton	21	31	48.10

Longitude			Ground Elev/ Water Depth	RT KB	Spud Date	TD Date	Rig Rel Date
128	29	2.84	51	48	15/07/2009	7/08/2009	4/09/2009
128	29	2.84	51	48	28/05/2009	14/06/2009	4/09/2009
128	27	11.11	51	20	26/01/2009	25/02/2009	15/03/2009
126	9	21.04	193	25	12/09/2009	24/09/2009	30/09/2009
126	13	10.92	116	25	13/08/2009	5/09/2009	10/09/2009
128	30	35.80	24	43	19/03/2009	6/04/2009	15/04/2009
126	3	30.87	316	25	3/10/2009	16/10/2009	20/10/2009
121	39	33.81	651	22	31/03/2009	7/05/2009	20/05/2009
124	29	39.73	82	25	11/12/2009	25/12/2009	28/12/2009
122	13	32.23	497	22	10/10/2009	7/12/2009	
121	58	32.77	429	26	8/11/2008	10/01/2009	22/01/2009
124	5	45.63	116	25	29/12/2009		
122	53	38.38	216	22	16/06/2009	31/07/2009	14/08/2009
123	20	38.01	278	22	10/01/2009	3/04/2009	11/04/2009
123	30	50.04	260	25	8/07/2009	3/08/2009	9/08/2009
123	26	25.93	287	48	24/05/2009	29/05/2009	5/06/2009
122	8	46.82	554	22	22/07/2009	25/09/2009	8/10/2009
123	25	14.00	287	25	12/04/2009	13/05/2009	5/06/2009
122	18	25.82	493	26	26/01/2009	28/04/2009	29/05/2009
124	27	27.00	229	230	27/06/2009	13/08/2009	15/08/2009
114	5	42.52	203	22	20/02/2009	28/10/2009	
114	5	40.43	203	22	21/02/2009	17/11/2009	
114	6	5.91	202	22	10/02/2009	13/08/2009	
114	6	3.79	201	22	16/02/2009	22/07/2009	
113	59	17.19	523	23	5/04/2009	30/04/2009	31/05/2009
115	7	12.64	52	45	15/02/2009	11/03/2009	27/03/2009
114	10	19.55	180	22	9/06/2009	22/06/2009	
115	7	54.53	829	22	25/10/2008	5/08/2009	25/12/2009
115	7	54.10	829	22	20/10/2008	13/07/2009	26/12/2009
115	7	54.79	829	22	18/10/2008	24/07/2009	27/12/2009
115	7	55.92	829	22	19/09/2008	9/10/2008	28/12/2009
115	7	56.57	829	22	22/10/2008	19/08/2009	25/12/2009
114	5	3.11	208	22	5/03/2009		
114	5	3.47	209	22	21/03/2009		
114	5	4.37	209	22	15/03/2009		
114	5	4.39	231	22	11/03/2009		
114	5	7.01	209	22	28/03/2009		
114	5	5.79	211	22	2/04/2009	25/12/2009	

Table 6. Petroleum Wells in Western Australia Operating 2009 Calendar Year

Well Name	Class	On Off	Title	Operator	Latitude		
Carnarvon Basin cont.							
Stickle 4H	DEV	OFF	WA-12-R R1	BHP Billiton	21	31	23.63
Stickle 5H	DEV	OFF	WA-12-R R1	BHP Billiton	21	32	17.13
Stickle 6H	DEV	OFF	WA-12-R R1	BHP Billiton	21	31	21.51
VGA 6H L1	DEV	OFF	WA-155-P R4	Apache	21	23	50.49
VN-A 5H	DEV	OFF	WA-28-L	Woodside	21	26	22.00
VN-A 6H	DEV	OFF	WA-28-L	Woodside	21	26	23.21
VN-B 3H L1	DEV	OFF	WA-28-L	Woodside	21	26	1.25
Wanaea 11A	DEV	OFF	WA-11-L	Woodside	19	35	32.18
Balnaves 2	EXT	OFF	WA-356-P	Apache	20	4	9.56
Chandon 2	EXT	OFF	WA-268-P R1	Chevron	19	32	59.09
Clio 2	EXT	OFF	WA-205-P R3	Chevron	20	21	55.51
Coniston 2H ST1	EXT	OFF	WA-35-L	Apache	21	20	37.81
Coniston 3	EXT	OFF	WA-255-P R2	Apache	21	19	20.23
Coniston 4 ST1	EXT	OFF	WA-35-L	Apache	21	20	4.21
Coniston 5 CH1	EXT	OFF	WA-35-L	Apache	21	20	17.40
Coniston 6	EXT	OFF	WA-255-P R2	Apache	21	19	50.28
Coniston 7	EXT	OFF	WA-35-L	Apache	21	19	57.43
Coniston 9	EXT	OFF	WA-35-L	Apache	21	20	30.99
Fletcher 4	EXT	OFF	WA-191-P R4	Santos	19	14	47.79
Iago 5	EXT	OFF	WA-17-R	Chevron	19	50	45.53
Jansz 4	EXT	OFF	WA-18-R	Mobil	19	51	8.92
Lady Nora 3	EXT	OFF	WA-28-P R7	Woodside	19	51	19.07
Lambert 9	EXT	OFF	WA-16-L	Woodside	19	25	10.79
Linda North 1	EXT	OFF	TL/1	Apache	20	33	18.54
Novara 2	EXT	OFF	WA-35-L	Apache	21	20	47.60
Novara 3H	EXT	OFF	WA-35-L	Apache	21	20	47.60
Rosella 2 ST1 CH1	EXT	OFF	WA-214-P R3	Apache	20	31	36.42
Tidepole 2	EXT	OFF	WA-5-L R1	Woodside	19	45	55.85
Achilles 1	NFW	OFF	WA-374-P	Chevron	20	12	54.80
Balnaves 1	NFW	OFF	WA-356-P	Apache	20	4	9.56
Balthazar 1	NFW	OFF	WA-356-P	Apache	20	5	26.28
Bravo 1	NFW	OFF	WA-390-P	Hess	20	3	51.72
Brokenwood 1 ST1	NFW	OFF	WA-356-P	Apache	20	0	52.82
Brokenwood 2	NFW	OFF	WA-356-P	Apache	20	0	52.82
Crummock 1	NFW	OFF	WA-357-P	Apache	21	20	4.29
Dunlop 1	NFW	OFF	WA-390-P	Hess	20	5	40.12
Eris 1	NFW	OFF	WA-34-L	Woodside	19	55	41.33
Guardian 1	NFW	OFF	WA-365-P	Chevron	19	40	10.79
Hijinx 1	NFW	OFF	WA-390-P	Hess	20	13	30.96
Kentish Knock 1	NFW	OFF	WA-365-P	Chevron	19	40	10.79
Larsen 1	NFW	OFF	WA-404-P	Woodside	19	24	12.27
Lightfinger 1	NFW	OFF	WA-390-P	Hess	20	11	41.59

Longitude			Ground Elev/ Water Depth	RT KB	Spud Date	TD Date	Rig Rel Date
114	6	35.25	197	22	22/01/2009	26/05/2009	
114	5	4.37	198	22	4/02/2009	29/03/2009	
114	6	33.11	198	22	31/01/2009	28/04/2009	
114	4	4.58	367	25	14/01/2008	8/06/2009	20/06/2009
114	2	49.00	363	23	23/12/2009		
114	2	47.28	363	23	28/12/2009		
114	1	58.66	416	23	4/01/2008	15/02/2009	28/03/2009
116	26	8.84	79	23	22/10/2009	23/11/2009	16/12/2009
115	10	27.47	137	22	13/05/2009	21/05/2009	28/05/2009
114	7	47.79	1168	22	27/11/2009		
114	39	25.94	994	22	14/04/2009	4/05/2009	18/05/2009
114	3	13.43	407	25	8/08/2009	24/08/2009	5/09/2009
114	3	48.61	398	25	29/06/2009	3/07/2009	7/07/2009
114	4	58.25	373	25	16/09/2009	20/09/2009	23/09/2009
114	4	3.88	386	25	1/12/2009	5/12/2009	12/12/2009
114	2	32.99	434	25	24/09/2009	28/09/2009	3/10/2009
114	3	19.95	410	25	12/12/2009	15/12/2009	19/12/2009
114	2	49.05	415	25	20/12/2009	26/12/2009	28/12/2009
116	47	48.04	156	22	8/01/2009	10/01/2009	17/01/2009
115	19	41.51	171	22	29/12/2009		
114	30	51.03	1313	22	8/04/2009	29/04/2009	28/06/2009
115	39	23.09	85	25	3/03/2009	19/03/2009	29/03/2009
116	29	54.42	131	25	18/01/2009	22/09/2009	2/03/2009
115	42	31.84	33	45	19/01/2009	3/02/2009	13/02/2009
114	5	0.93	365	25	9/07/2009	13/07/2009	7/08/2009
114	5	0.93	365	25	17/07/2009	26/07/2009	7/08/2009
114	58	1.90	103	39	17/12/2008	3/01/2009	17/01/2009
115	53	19.21	114	25	11/12/2008	6/01/2009	17/01/2009
114	32	13.71	1151	22	24/07/2009	17/09/2009	4/10/2009
115	10	27.47	137	22	28/04/2009	10/05/2009	28/05/2009
115	9	45.76	134	25	31/12/2009		
113	35	59.41	1064	29	28/08/2009	5/09/2009	18/10/2009
115	9	48.53	180	25	13/03/2009	4/04/2009	27/04/2009
115	9	48.53	180	25	11/04/2009	22/04/2009	27/04/2009
114	4	58.25	373	25	7/09/2009	12/09/2009	23/09/2009
113	57	24.50	1124	29	24/07/2009	1/08/2009	9/08/2009
115	14	55.64	180	22	24/10/2009	4/11/2009	11/11/2009
112	47	45.78	1228	22	28/03/2009	1/04/2009	11/04/2009
113	41	36.87	1115	29	14/11/2009	2/12/2009	1/01/2010
112	47	45.78	1228	22	6/03/2009	21/03/2009	11/04/2009
114	15	13.93	1279	32	26/12/2009		
113	43	50.26	1116	29	11/08/2009	17/08/2009	26/08/2009

Table 6. Petroleum Wells in Western Australia Operating 2009 Calendar Year

Well Name	Class	On Off	Title	Operator	Latitude		
Carnarvon Basin cont.							
Martell 1	NFW	OFF	WA-404-P	Woodside	19	23	42.17
Mentorc 1 CH1	NFW	OFF	WA-390-P	Hess	20	26	10.38
Pelion 1	NFW	OFF	WA-34-L	Woodside	19	59	38.56
Rimfire 1	NFW	OFF	WA-390-P	Hess	20	3	51.72
Satyr 1	NFW	OFF	WA-374-P	Chevron	20	25	21.24
Toporoa 1	NFW	OFF	WA-390-P	Hess	19	55	20.93
Yellowglen 1	NFW	OFF	WA-268-P R1	Chevron	19	41	37.23
Zeus 1	NFW	OFF	WA-361-P	MEO	19	30	17.67
Crosby 7WI	WIW	OFF	WA-12-R R1	BHP Billiton	21	29	57.63
ENC 01 RD2	WIW	OFF	WA-28-L	Woodside	21	29	14.87
ENC 05	WIW	OFF	WA-28-L	Woodside	21	29	15.92
Ravensworth 9WI	WIW	OFF	WA-12-R R1	BHP Billiton	21	30	9.55
Stickle 7WI	WIW	OFF	WA-12-R R1	BHP Billiton	21	30	9.28
VGA 12W	WIW	OFF	WA-155-P R4	Apache	21	23	50.83
Perth Basin							
Hovea 13 ST1	DEV	ON	L 1 R1	AWE	29	19	5.00
Jingemia 12	DEV	ON	L 14	Origin Energy	29	20	22.91
Warro 3	EXT	ON	EP 407 R1	Latent	30	10	40.76
Apium North 1	NFW	ON	L 1 R1	AWE	29	17	12.56
Gingin West 1	NFW	ON	EP 389 R1	Empire Oil	31	10	50.31
Redback South 1	NFW	ON	L 11	Origin Energy	29	27	28.05

Classification

DEV Development Well
EXT Extension Well
NFW New Field Wildcat
WIW Water Injector Well

Longitude			Ground Elev/ Water Depth	RT KB	Spud Date	TD Date	Rig Rel Date
114	18	38.60	1289	22	2/02/2009	21/02/2009	3/03/2009
113	44	46.90	1129	29	21/10/2009	29/10/2009	12/11/2009
115	7	51.30	234	22	4/10/2009	15/10/2009	22/10/2009
113	35	59.41	1064	29	12/09/2009	6/10/2009	18/10/2009
114	20	33.87	1073	22	5/10/2009	31/10/2009	20/11/2009
113	58	48.68	1081	29	1/07/2009	10/07/2009	21/07/2009
113	55	4.88	1231	22	21/11/2009	10/12/2009	21/12/2009
115	50	6.63	214	25	17/01/2009	10/02/2009	18/02/2009
114	7	36.33	198	22	20/09/2009	2/10/2009	
113	58	30.70	550	29	8/03/2005	4/09/2009	21/09/2009
113	58	31.39	550	23	25/06/2009	21/07/2009	7/08/2009
114	5	43.14	213	22	14/04/2009		
114	8	41.59	191	22	19/04/2009		
114	4	5.61	367	25	22/01/2008	22/06/2009	28/06/2009
115	2	33.50	62	70	20/04/2009	3/06/2009	12/06/2009
114	59	18.83	6	14	18/07/2009	30/07/2009	9/08/2009
115	44	12.05	289	297	30/01/2009	21/02/2009	20/03/2009
115	3	45.44	103	110	21/06/2009	4/07/2009	8/07/2009
115	49	35.96	145	153	18/11/2009	19/12/2009	24/12/2009
115	9	43.51	65	72	25/08/2009	22/09/2009	27/09/2009

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

OFFSHORE PETROLEUM AND GREENHOUSE GAS STORAGE ACT 2006 Exploration Permit			
Title	Registered Holders (* denotes Nominee)		
WA-1-P R7	Apache Northwest Pty Ltd	WA-261-P R2	Apache Northwest Pty Ltd
	Santos Limited		Bow Energy Ltd
WA-18-P R6	Bonaparte Gas & Oil Pty Limited		Strike Energy Limited
	Santos Offshore Pty Ltd		Tap (Shelfal) Pty Ltd
	* Santos Limited	WA-264-P R1	Beach Petroleum Limited
WA-28-P R7	BHP Billiton Petroleum (North West Shelf) Pty Ltd		Kufpec Australia Pty Ltd
	BP Developments Australia Pty Ltd		* Santos Offshore Pty Ltd
	CNOOC NWS Private Limited	WA-268-P R1	Chevron (TAPL) Pty Ltd
	Chevron Australia Pty Ltd		Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd		Mobil Australia Resources Company Pty Limited
	Shell Development (Australia) Proprietary Limited		Shell Development (Australia) Proprietary Limited
	Woodside Energy Ltd	WA-269-P R1	Japan Australia LNG (MIMI) Pty Ltd
WA-155-P R4	Apache Permits Pty Ltd		Total E & P Australia
	BHP Billiton Petroleum (Australia) Pty Ltd		Woodside Energy Ltd
	Inpex Alpha Ltd	WA-271-P R2	Mitsui E&P Australia Pty Limited
WA-191-P R4	Kufpec Australia Pty Ltd		* Woodside Energy Ltd
	Nippon Oil Exploration (Dampier) Pty Ltd	WA-274-P R1	Chevron Australia (WA-274-P) Pty Ltd
	Woodside Energy Ltd		Inpex Browse Ltd
	* Santos Limited		* Coveyork Pty Limited
WA-192-P R4	Kufpec Australia Pty Ltd	WA-275-P R2	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	* Apache Northwest Pty Ltd		BP Developments Australia Pty Ltd
WA-202-P R3	Apache Northwest Pty Ltd		Chevron Australia Pty Ltd
WA-205-P R3	Chevron (TAPL) Pty Ltd		Shell Development (Australia) Proprietary Limited
	Shell Development (Australia) Proprietary Limited		Woodside Energy Ltd
	* Chevron Australia Pty Ltd	WA-279-P R1	Eni Australia B.V.
WA-208-P R3	Apache Northwest Pty Ltd	WA-280-P R1	Eni Australia B.V.
	Beach Energy Limited	WA-281-P R1	Beach Energy Limited
	Eni Australia Limited		Chevron Australia (WA-281-P) Pty Ltd
	Mosaic Oil NL		Inpex Browse Ltd
	Santos Limited		* Santos Offshore Pty Ltd
	Santos Offshore Pty Ltd	WA-285-P R1	Inpex Browse Ltd
WA-209-P R3	Santos Offshore Pty Ltd		Total E & P Australia
	* Apache Northwest Pty Ltd	WA-286-P R1	ARC (Offshore PB) Limited
WA-214-P R3	Santos (BOL) Pty Ltd		AWE Oil (Western Australia) Pty Ltd
	* Apache Northwest Pty Ltd		Cieco Energy Australia Pty Ltd
WA-246-P R2	Kufpec Australia Pty Ltd		Roc Oil (WA) Pty Limited
	Pan Pacific Petroleum (South Aust) Pty Ltd	WA-290-P R1	Nippon Oil Exploration (Dampier) Pty Ltd
	Santos Offshore Pty Ltd		Santos Offshore Pty Ltd
	Tap (Harriet) Pty Ltd		Tap (Shelfal) Pty Ltd
	* Apache Northwest Pty Ltd		* OMV Australia Pty Ltd
WA-253-P R2	Chevron (TAPL) Pty Ltd	WA-291-P R1	Rialto Energy Limited
	* Chevron Australia Pty Ltd	WA-302-P R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
WA-254-P R2	Apache Northwest Pty Ltd	WA-313-P R1	Eni Australia B.V.
	First Australian Resources Limited	WA-314-P	ConocoPhillips (Browse Basin) Pty Ltd
	Pan Pacific Petroleum NL		Karoon Gas Browse Basin Pty Ltd
	Sun Resources NL	WA-315-P	ConocoPhillips (Browse Basin) Pty Ltd
	Victoria Petroleum NL		Karoon Gas Browse Basin Pty Ltd
WA-255-P R2	Woodside Energy Ltd	WA-320-P	Tap (Shelfal) Pty Ltd
	* BHP Billiton Petroleum (Australia) Pty Ltd		* OMV Australia Pty Ltd
		WA-322-P	United Oil & Gas Pty Ltd
		WA-323-P	Strata Resources N.L.
			* Octanex N.L.

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

WA-329-P	United Oil & Gas Pty Ltd	WA-359-P	Cue Exploration Pty Ltd
WA-330-P	Strata Resources N.L.		Exoil Limited
	* Octanex N.L.		North West Shelf Exploration Pty Ltd
WA-332-P	Braveheart Energy Pty Ltd	WA-360-P	Cue Exploration Pty Ltd
	Braveheart Oil & Gas Pty Ltd		North West Shelf Exploration Pty Ltd
	Braveheart Petroleum Pty Ltd		Rankin Trend Pty Ltd.
	Braveheart Resources Pty Ltd	WA-361-P	Cue Exploration Pty Ltd
	Browse Petroleum Pty Ltd		Gascorp Australia Ltd
WA-333-P	Braveheart Energy Pty Ltd		North West Shelf Exploration Pty Ltd
	Braveheart Oil & Gas Pty Ltd		Resource Development International Limited
	Braveheart Petroleum Pty Ltd	WA-362-P	Eni Australia Limited
	Braveheart Resources Pty Ltd		Exmouth Exploration Pty Ltd
	Browse Petroleum Pty Ltd		Octanex N.L.
WA-334-P R1	Tap (Harriet) Pty Ltd		Strata Resources N.L.
	* Apache Northwest Pty Ltd		* OMV Australia Pty Ltd
WA-335-P	BHP Billiton Petroleum (North West Shelf) Pty Ltd	WA-363-P	Eni Australia Limited
	Kufpec Australia Pty Ltd		Exmouth Exploration Pty Ltd
	* Apache Northwest Pty Ltd		Octanex N.L.
WA-341-P	Inpex Browse Ltd		Strata Resources N.L.
	Total E & P Australia		* OMV Australia Pty Ltd
WA-342-P	Coldron Pty Ltd	WA-364-P	Chevron Australia (WA-364-P) Pty Ltd
	Cornea Energy Pty Ltd		Shell Development (Australia) Proprietary Limited
	Cornea Oil & Gas Pty Ltd	WA-365-P	Chevron Australia (WA-365-P) Pty Ltd
	Cornea Petroleum Pty Ltd		Shell Development (Australia) Proprietary Limited
	Cornea Resources Pty Ltd	WA-366-P	Chevron Australia (WA-366-P) Pty Ltd
WA-343-P	Inpex Browse Ltd		Shell Development (Australia) Proprietary Limited
	Total E & P Australia	WA-367-P	Chevron Australia (WA-367-P) Pty Ltd
WA-344-P	Inpex Browse Ltd		Shell Development (Australia) Proprietary Limited
	Total E & P Australia	WA-368-P	ARC (Offshore PB) Limited
WA-346-P R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd		Nexus Energy Australia NL
WA-347-P	Kansai Electric Power Australia Pty Ltd	WA-369-P	Japan Australia LNG (MIMI) Pty Ltd
	Tokyo Gas Pluto Pty Ltd		Total E & P Australia
	Woodside Burrup Pty Ltd		* Woodside Energy Ltd
WA-348-P	Woodside Burrup Pty Ltd	WA-370-P	Japan Australia LNG (MIMI) Pty Ltd
WA-350-P	Kansai Electric Power Australia Pty Ltd		Total E & P Australia
	Tokyo Gas Pluto Pty Ltd		* Woodside Energy Ltd
	Woodside Burrup Pty Ltd	WA-371-P	Shell Development (Australia) Proprietary Limited
WA-351-P	BHP Billiton Petroleum (North West Shelf) Pty Ltd	WA-374-P	Mobil Australia Resources Company Pty Limited
	Roc Oil (WA) Pty Limited		Shell Development (Australia) Proprietary Limited
	Tap (Shelfal) Pty Ltd		* Chevron Australia (WA-374-P) Pty Ltd
WA-352-P	Drillsearch Energy Limited	WA-375-P	Goldsbrough Energy Pty Ltd
WA-353-P	Woodside Burrup Pty Ltd	WA-376-P	Goldsbrough Energy Pty Ltd
WA-354-P	BHP Billiton Petroleum Pty Ltd	WA-377-P	Shell Development (Australia) Proprietary Limited
	* Apache Northwest Pty Ltd		* Nexus Energy WA377P Pty Ltd
WA-355-P	Apache Northwest Pty Ltd	WA-378-P	Mitsui E&P Australia Pty Limited
WA-356-P	Apache Julimar Pty Ltd		Toyota Tsusho Gas E&P Browse Pty Ltd
	Kufpec Australia Pty Ltd		Woodside Energy Ltd
WA-357-P	Inpex Alpha Ltd	WA-379-P	Arcadia Petroleum Limited
	* Apache Northwest Pty Ltd		Enovation Resources Limited
WA-358-P	OMV Australia Pty Ltd	WA-380-P	Arcadia Petroleum Limited
	Santos Offshore Pty Ltd		Enovation Resources Limited

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

WA-381-P	Emphazise Pty Ltd		Rankin Trend Pty Ltd.
	Lempika Pty Ltd	WA-410-P	Chevron Australia (WA-410-P) Pty Ltd
	Westralian Petroleum Pty Ltd		Inpex Browse Ltd
	* Roc Oil (WA) Pty Limited		Santos Offshore Pty Ltd
WA-382-P	Emphazise Pty Ltd	WA-411-P	Beach Energy Limited
	Lempika Pty Ltd		Inpex Browse Ltd
	Westralian Petroleum Pty Ltd		Santos Offshore Pty Ltd
	* Roc Oil (WA) Pty Limited	WA-412-P	Japan Energy E&P Australia Pty Ltd
WA-383-P	Shell Development (Australia) Proprietary Limited	WA-413-P	Hunt Oil Australia Permit 413 Holding Company Pty Ltd
	* Chevron Australia (WA-383-P) Pty Ltd	WA-414-P	Hunt Oil Australia Permit 414 Holding Company Pty Ltd
WA-384-P	Shell Development (Australia) Proprietary Limited	WA-415-P	Woodside Energy Ltd
WA-385-P	Shell Development (Australia) Proprietary Limited	WA-416-P	Woodside Energy Ltd
WA-386-P	Eni Australia Limited	WA-417-P	Woodside Energy Ltd
	Exmouth Exploration Pty Ltd	WA-418-P	Finder Exploration Pty Ltd
	* OMV Australia Pty Ltd	WA-419-P	Emerald Gas Pty Ltd
WA-387-P	Eni Australia Limited	WA-420-P	Goldsborough Energy Pty Ltd
	Exmouth Exploration Pty Ltd	WA-421-P	Goldsborough Energy Pty Ltd
	* OMV Australia Pty Ltd	WA-422-P	National Oil Corporation Pty Ltd
WA-388-P	Bharat PetroResources Limited	WA-423-P	Diamond Resources Australia Pty Ltd
	Gujarat State Petroleum Corporation Limited		PTTEP Australia Offshore Pty Ltd
	Hindustan Petroleum Corporation Ltd		* Murphy Australia Oil Pty Ltd
	Oilex Limited	WA-424-P	Nexus Energy VICP56 Pty Ltd
	Sasol Petroleum Australia Ltd	WA-425-P	Hunt Oil Australia Permit 425 Holding Company Pty Ltd
	Videocon Industries Ltd		SK Energy Co., Ltd
WA-389-P	Cue Exploration Pty Ltd	WA-426-P	Apache Northwest Pty Ltd
WA-390-P	Hess Exploration Australia Pty Limited	WA-427-P	Apache Northwest Pty Ltd
WA-391-P	OMV Australia Pty Ltd		Kufpec Australia Pty Ltd
WA-392-P	Chevron Australia (WA-392-P) Pty Ltd	WA-428-P	Mitsui E&P Australia Pty Limited
	Mobil Australia Resources Company Pty Limited		Woodside Energy Ltd
	Shell Development (Australia) Proprietary Limited	WA-429-P	Mitsui E&P Australia Pty Limited
WA-394-P	Shell Development (Australia) Proprietary Limited		Woodside Energy Ltd
WA-396-P	Mitsui E&P Australia Pty Limited	WA-430-P	Mitsui E&P Australia Pty Limited
	Toyota Tsusho Gas E&P Browse Pty Ltd		Woodside Energy Ltd
	Woodside Energy Ltd	WA-431-P	Hunt Oil Australia Permit 431 Holding Company Pty Ltd
WA-397-P	Mitsui E&P Australia Pty Limited		SK Energy Co., Ltd
	Toyota Tsusho Gas E&P Browse Pty Ltd	WA-432-P	Mitsui E&P Australia Pty Limited
	Woodside Energy Ltd		Woodside Energy Ltd
WA-398-P	ConocoPhillips (Browse Basin) Pty Ltd	WA-433-P	Mitsui E&P Australia Pty Limited
	Karoon Gas Browse Basin Pty Ltd		Woodside Energy Ltd
WA-399-P	Carnarvon Petroleum Limited	WA-434-P	Woodside Energy Ltd
	Rialto Energy Limited	WA-435-P	Carnarvon Petroleum Limited
WA-400-P	Apache Northwest Pty Ltd		Finder Exploration Pty Ltd
WA-401-P	Finder Exploration Pty Ltd	WA-436-P	Carnarvon Petroleum Limited
WA-402-P	Total E & P Australia		Finder Exploration Pty Ltd
WA-403-P	Total E & P Australia	WA-437-P	Carnarvon Petroleum Limited
WA-404-P	Hess Exploration (Carnarvon) Pty Limited		Finder Exploration Pty Ltd
	* Woodside Energy Ltd	WA-438-P	Carnarvon Petroleum Limited
WA-405-P	Reliance Exploration & Production DMCC		Finder Exploration Pty Ltd
WA-406-P	CNOOC Australia E&P Pty Ltd	WA-439-P	Chevron Australia (WA-439-P) Pty Ltd
WA-407-P	Goldsborough Energy Pty Ltd		Shell Development (Australia) Proprietary Limited
WA-408-P	Total E & P Australia	WA-440-P	Goldsborough Energy Pty Ltd
WA-409-P	Cue Exploration Pty Ltd	WA-441-P	Goldsborough Energy Pty Ltd

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

OFFSHORE PETROLEUM AND GREENHOUSE GAS STORAGE ACT 2006 Infrastructure Licence	
Title	Registered Holders (* denotes Nominee)
WA-1-IL	Kansai Electric Power Australia Pty Ltd
	Tokyo Gas Pluto Pty Ltd
	Woodside Burrup Pty Ltd
OFFSHORE PETROLEUM AND GREENHOUSE GAS STORAGE ACT 2006 Pipeline Licence	
Title	Registered Holders (* denotes Nominee)
WA-1-PL	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-2-PL	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-3-PL	Inpex Alpha Ltd
	Mobil Exploration & Producing Australia Pty Ltd
	* BHP Billiton Petroleum (Australia) Pty Ltd
WA-4-PL	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-5-PL	Apache East Spar Pty Limited
	Apache Kersail Pty Limited
	Santos (BOL) Pty Ltd
	* Apache Oil Australia Pty Ltd
WA-6-PL	Apache Northwest Pty Ltd
	Santos (GLOBE) Pty Ltd
	Santos Offshore Pty Ltd
WA-7-PL	Apache Northwest Pty Ltd
	Santos Limited
WA-8-PL	ConocoPhillips Pipeline Australia Pty Ltd
	ENI GAS & POWER LNG AUSTRALIA B.V.
	Inpex DLNGPL Pty Ltd
	Santos Timor Sea Pipeline Pty Ltd
	TEPCO Darwin LNG Pty Ltd
	Tokyo Gas Darwin LNG Pty Ltd
WA-9-PL	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-10-PL	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-11-PL	Apache Northwest Pty Ltd
	Santos (BOL) Pty Ltd
WA-12-PL	ARC (Offshore PB) Limited
	AWE Oil (Western Australia) Pty Ltd
	Cieco Energy Australia Pty Ltd
	Roc Oil (WA) Pty Limited
WA-13-PL	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	Woodside Energy Ltd
WA-14-PL	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Holdings Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	Woodside Energy Ltd
WA-15-PL	Eni Australia B.V.
WA-16-PL	Kansai Electric Power Australia Pty Ltd
	Tokyo Gas Pluto Pty Ltd
	Woodside Burrup Pty Ltd
WA-17-PL	Kansai Electric Power Australia Pty Ltd
	Tokyo Gas Pluto Pty Ltd
	Woodside Burrup Pty Ltd
WA-18-PL	Apache Northwest Pty Ltd
	Santos Offshore Pty Ltd
OFFSHORE PETROLEUM AND GREENHOUSE GAS STORAGE ACT 2006 Production Licence	
Title	Registered Holders (* denotes Nominee)
WA-1-L R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	CNOOC NWS Private Limited
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	Woodside Energy Ltd
WA-2-L R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	CNOOC NWS Private Limited
	Chevron Australia Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd
	Shell Development (Australia) Proprietary Limited
	Woodside Energy Ltd

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

WA-3-L R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd	WA-14-L	Vermilion Oil & Gas Australia Pty Ltd
	BP Developments Australia Pty Ltd	WA-15-L	Santos Offshore Pty Ltd
	CNOOC NWS Private Limited		* Apache Northwest Pty Ltd
	Chevron Australia Pty Ltd	WA-16-L	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd		BP Developments Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited		CNOOC NWS Private Limited
	Woodside Energy Ltd		Chevron Australia Pty Ltd
WA-4-L R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd		Japan Australia LNG (MIMI) Pty Ltd
	BP Developments Australia Pty Ltd		Shell Development (Australia) Proprietary Limited
	CNOOC NWS Private Limited		Woodside Energy Ltd
	Chevron Australia Pty Ltd	WA-17-L	ConocoPhillips Australia Gas Holdings Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd		* Mobil Australia Resources Company Pty Limited
	Shell Development (Australia) Proprietary Limited	WA-18-L	Talisman Oil & Gas (Australia) Pty Ltd
	Woodside Energy Ltd	WA-20-L	Apache Northwest Pty Ltd
WA-5-L R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd		Santos Limited
	BP Developments Australia Pty Ltd	WA-22-L	Mobil Australia Resources Company Pty Limited
	CNOOC NWS Private Limited		Tap West Pty Ltd
	Chevron Australia Pty Ltd		* Eni Australia Limited
	Japan Australia LNG (MIMI) Pty Ltd	WA-23-L	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	Shell Development (Australia) Proprietary Limited		BP Developments Australia Pty Ltd
	Woodside Energy Ltd		CNOOC NWS Private Limited
WA-6-L R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd		Chevron Australia Pty Ltd
	BP Developments Australia Pty Ltd		Japan Australia LNG (MIMI) Pty Ltd
	CNOOC NWS Private Limited		Shell Development (Australia) Proprietary Limited
	Chevron Australia Pty Ltd		Woodside Energy Ltd
	Japan Australia LNG (MIMI) Pty Ltd	WA-24-L	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	Shell Development (Australia) Proprietary Limited		BP Developments Australia Pty Ltd
	Woodside Energy Ltd		CNOOC NWS Private Limited
WA-8-L	Kufpec Australia Pty Ltd		Chevron Australia Pty Ltd
	Tap (Shelfal) Pty Ltd		Japan Australia LNG (MIMI) Pty Ltd
	* Santos Limited		Shell Development (Australia) Proprietary Limited
WA-9-L	BHP Billiton Petroleum (North West Shelf) Pty Ltd		Woodside Energy Ltd
	BP Developments Australia Pty Ltd	WA-25-L	Mobil Australia Resources Company Pty Limited
	CNOOC NWS Private Limited		Tap West Pty Ltd
	Chevron Australia Pty Ltd		* Eni Australia Limited
	Japan Australia LNG (MIMI) Pty Ltd	WA-26-L	Kufpec Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited		Nippon Oil Exploration (Dampier) Pty Ltd
	Woodside Energy Ltd		Woodside Energy Ltd
WA-10-L	Inpex Alpha Ltd		* Santos Limited
	Mobil Exploration & Producing Australia Pty Ltd	WA-27-L	Kufpec Australia Pty Ltd
	* BHP Billiton Petroleum (Australia) Pty Ltd		Nippon Oil Exploration (Dampier) Pty Ltd
WA-11-L	BHP Billiton Petroleum (North West Shelf) Pty Ltd		Woodside Energy Ltd
	BP Developments Australia Pty Ltd		* Santos Limited
	CNOOC NWS Private Limited	WA-28-L	Mitsui E&P Australia Pty Limited
	Chevron Australia Pty Ltd		* Woodside Energy Ltd
	Japan Australia LNG (MIMI) Pty Ltd	WA-29-L	Apache Northwest Pty Ltd
	Shell Development (Australia) Proprietary Limited		Santos (BOL) Pty Ltd
	Woodside Energy Ltd	WA-30-L	BHP Billiton Petroleum (North West Shelf) Pty Ltd
WA-12-L	Mobil Australia Resources Company Pty Limited		BP Developments Australia Pty Ltd
	* BHP Billiton Petroleum (Australia) Pty Ltd		CNOOC NWS Private Limited
WA-13-L	Apache East Spar Pty Limited		Chevron Australia Pty Ltd
	Apache Kersail Pty Limited		Japan Australia LNG (MIMI) Pty Ltd
	Santos (BOL) Pty Ltd		Shell Development (Australia) Proprietary Limited
	* Apache Oil Australia Pty Ltd		Woodside Energy Ltd

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

WA-31-L	ARC (Offshore PB) Limited		Origin Energy Bonaparte Pty Limited
	AWE Oil (Western Australia) Pty Ltd		Santos Offshore Pty Ltd
	Cieco Energy Australia Pty Ltd		* Santos Limited
	Roc Oil (WA) Pty Limited	WA-7-R R2	BHP Billiton Petroleum (North West Shelf) Pty Ltd
WA-32-L	BHP Billiton Petroleum (Australia) Pty Ltd		BP Developments Australia Pty Ltd
	Woodside Energy Ltd		CNOOC NWS Private Limited
WA-33-L	Eni Australia B.V.		Chevron Australia Pty Ltd
WA-34-L	Kansai Electric Power Australia Pty Ltd		Japan Australia LNG (MIMI) Pty Ltd
	Tokyo Gas Pluto Pty Ltd		Shell Development (Australia) Proprietary Limited
	Woodside Burrup Pty Ltd		* Woodside Energy Ltd
WA-35-L	Apache Permits Pty Ltd	WA-9-R R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BHP Billiton Petroleum (Australia) Pty Ltd		BP Developments Australia Pty Ltd
	Inpex Alpha Ltd		CNOOC NWS Private Limited
WA-36-L	Chevron (TAPL) Pty Ltd		Chevron Australia Pty Ltd
	Chevron Australia Pty Ltd		Japan Australia LNG (MIMI) Pty Ltd
	Mobil Australia Resources Company Pty Limited		Shell Development (Australia) Proprietary Limited
	Shell Development (Australia) Proprietary Limited		Woodside Energy Ltd
WA-37-L	Chevron (TAPL) Pty Ltd	WA-10-R R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	Chevron Australia Pty Ltd		BP Developments Australia Pty Ltd
	Mobil Australia Resources Company Pty Limited		CNOOC NWS Private Limited
	Shell Development (Australia) Proprietary Limited		Chevron Australia Pty Ltd
WA-38-L	Chevron (TAPL) Pty Ltd		Japan Australia LNG (MIMI) Pty Ltd
	Chevron Australia Pty Ltd		Shell Development (Australia) Proprietary Limited
	Mobil Australia Resources Company Pty Limited		Woodside Energy Ltd
	Shell Development (Australia) Proprietary Limited	WA-14-R R1	Chevron (TAPL) Pty Ltd
WA-39-L	BP Exploration (Alpha) Ltd		Mobil Australia Resources Company Pty Limited
	Chevron (TAPL) Pty Ltd		Shell Development (Australia) Proprietary Limited
	Chevron Australia Pty Ltd		* Chevron Australia Pty Ltd
	Mobil Australia Resources Company Pty Limited	WA-15-R R1	Chevron (TAPL) Pty Ltd
	Shell Development (Australia) Proprietary Limited		Chevron Australia Pty Ltd
WA-40-L	BP Exploration (Alpha) Ltd		Mobil Australia Resources Company Pty Limited
	Chevron (TAPL) Pty Ltd		Shell Development (Australia) Proprietary Limited
	Chevron Australia Pty Ltd	WA-16-R	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited		Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited		Shell Development (Australia) Proprietary Limited
WA-41-L	Apache Northwest Pty Ltd	WA-17-R	Chevron (TAPL) Pty Ltd
	Santos Offshore Pty Ltd		* Chevron Australia Pty Ltd
WA-42-L	Apache PVG Pty Ltd	WA-19-R R1	Chevron (TAPL) Pty Ltd
	BHP Billiton Petroleum (Australia) Pty Ltd		Chevron Australia Pty Ltd
WA-43-L	Apache Permits Pty Ltd		Mobil Australia Resources Company Pty Limited
	BHP Billiton Petroleum (Australia) Pty Ltd		Shell Development (Australia) Proprietary Limited
	Inpex Alpha Ltd	WA-20-R R1	Chevron (TAPL) Pty Ltd
			Chevron Australia Pty Ltd
			Mobil Australia Resources Company Pty Limited
			Shell Development (Australia) Proprietary Limited
		WA-21-R R1	Chevron (TAPL) Pty Ltd
			Chevron Australia Pty Ltd
			Mobil Australia Resources Company Pty Limited
			Shell Development (Australia) Proprietary Limited
		WA-22-R R1	BP Exploration (Alpha) Ltd
			Chevron (TAPL) Pty Ltd
			Mobil Australia Resources Company Pty Limited
			Shell Development (Australia) Proprietary Limited
			* Chevron Australia Pty Ltd

OFFSHORE PETROLEUM AND GREENHOUSE GAS STORAGE ACT 2006 Retention Lease	
Title	Registered Holders (* denotes Nominee)
WA-1-R R3	BHP Billiton Petroleum (North West Shelf) Pty Ltd * Esso Australia Resources Pty Ltd
WA-4-R R2	Santos Offshore Pty Ltd
WA-5-R R3	Chevron (TAPL) Pty Ltd Mobil Australia Resources Company Pty Limited Shell Development (Australia) Proprietary Limited * Chevron Australia Pty Ltd
WA-6-R R2	Bonaparte Gas & Oil Pty Limited

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

WA-23-R R1	BP Exploration (Alpha) Ltd
	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Shell Development (Australia) Proprietary Limited
	* Chevron Australia Pty Ltd
WA-24-R R1	BP Exploration (Alpha) Ltd
	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Shell Development (Australia) Proprietary Limited
	* Chevron Australia Pty Ltd
WA-27-R R1	Bonaparte Gas & Oil Pty Limited
	Santos Offshore Pty Ltd
	* Santos Limited
WA-28-R R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-29-R R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-30-R R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-31-R R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-32-R R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
WA-33-R R1	Apache Oil Australia Pty Ltd
	Pan Pacific Petroleum (South Aust) Pty Ltd
	Santos (BOL) Pty Ltd
	Tap (Shelfal) Pty Ltd
	WM Petroleum Limited
WA-34-R	Encana International (Australia) Pty Ltd
	Eni Australia B.V.
	SK Energy Co., Ltd
	Tap (Shelfal) Pty Ltd
WA-35-R	Japan Australia LNG (MIMI) Pty Ltd
	Woodside Energy Ltd
WA-36-R	Mitsui E&P Australia Pty Limited
	* Woodside Energy Ltd
WA-37-R	Inpex Browse Ltd
	Total E & P Australia

**PETROLEUM (SUBMERGED LANDS) ACT 1982
Access Authority Survey**

Title	Registered Holders (* denotes Nominee)
AAS 1T/08-9	Chevron (TAPL) Pty Ltd
	Chevron Australia Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Shell Development (Australia) Proprietary Limited

**PETROLEUM (SUBMERGED LANDS) ACT 1982
Exploration Permit**

Title	Registered Holders (* denotes Nominee)
TP/7 R3	Apache Oil Australia Pty Ltd
	Pan Pacific Petroleum (South Aust) Pty Ltd
	Santos (BOL) Pty Ltd
	Tap (Shelfal) Pty Ltd
TP/8 R3	Apache Northwest Pty Ltd
	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
TP/9 R3	* Apache Northwest Pty Ltd
TP/15 R1	Westranch Holdings Pty Ltd
TP/23	Apache Northwest Pty Ltd
TP/24	Emerald Gas Pty Ltd

**PETROLEUM (SUBMERGED LANDS) ACT 1982
Pipeline Licence**

Title	Registered Holders (* denotes Nominee)
TPL/1	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd
TPL/2	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd
TPL/3	Apache Oil Australia Pty Ltd
	Pan Pacific Petroleum (South Aust) Pty Ltd
	Santos (BOL) Pty Ltd
	Tap (Shelfal) Pty Ltd
TPL/4	Apache Oil Australia Pty Ltd
	Pan Pacific Petroleum (South Aust) Pty Ltd
	Santos (BOL) Pty Ltd
	Tap (Shelfal) Pty Ltd
TPL/5	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd
TPL/6	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd
	* Chevron Australia Pty Ltd
TPL/7 R1	Apache Oil Australia Pty Ltd
	Pan Pacific Petroleum (South Aust) Pty Ltd
	Santos (BOL) Pty Ltd
	Tap (Shelfal) Pty Ltd
TPL/8	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

TPL/9 R1	Chevron (TAPL) Pty Ltd		* Apache Northwest Pty Ltd
	Mobil Australia Resources Company Pty Limited	TL/2	Apache Oil Australia Pty Ltd
	Santos Offshore Pty Ltd		Pan Pacific Petroleum (South Aust) Pty Ltd
	* Chevron Australia Pty Ltd		Santos (BOL) Pty Ltd
TPL/10	Inpex Alpha Ltd		Tap (Shelfal) Pty Ltd
	Mobil Exploration & Producing Australia Pty Ltd	TL/3 R1	Chevron (TAPL) Pty Ltd
	* BHP Billiton Petroleum (Australia) Pty Ltd		Mobil Australia Resources Company Pty Limited
TPL/11	Chevron (TAPL) Pty Ltd		Santos Offshore Pty Ltd
	Mobil Australia Resources Company Pty Limited		* Chevron Australia Pty Ltd
	Santos Offshore Pty Ltd	TL/4	Chevron (TAPL) Pty Ltd
	* Chevron Australia Pty Ltd		Mobil Australia Resources Company Pty Limited
TPL/12	Apache East Spar Pty Limited		Santos Offshore Pty Ltd
	Apache Kersail Pty Limited		* Chevron Australia Pty Ltd
	Santos (BOL) Pty Ltd	TL/5	Kufpec Australia Pty Ltd
	* Apache Oil Australia Pty Ltd		Tap (Harriet) Pty Ltd
TPL/13	Apache East Spar Pty Limited		* Apache Northwest Pty Ltd
	Apache Kersail Pty Limited	TL/6	Kufpec Australia Pty Ltd
	Apache Northwest Pty Ltd		Tap (Harriet) Pty Ltd
	Apache Oil Australia Pty Ltd		* Apache Northwest Pty Ltd
	Kufpec Australia Pty Ltd	TL/7	Chevron (TAPL) Pty Ltd
	Santos (BOL) Pty Ltd		Mobil Australia Resources Company Pty Limited
	Tap (Harriet) Pty Ltd		Santos Offshore Pty Ltd
TPL/14	Kufpec Australia Pty Ltd		* Chevron Australia Pty Ltd
	Tap (Harriet) Pty Ltd	TL/8	Kufpec Australia Pty Ltd
	* Apache Northwest Pty Ltd		Tap (Harriet) Pty Ltd
TPL/15	BHP Billiton Petroleum (North West Shelf) Pty Ltd		* Apache Northwest Pty Ltd
	BP Developments Australia Pty Ltd	TL/9	Kufpec Australia Pty Ltd
	Chevron Australia Pty Ltd		Tap (Harriet) Pty Ltd
	Japan Australia LNG (MIMI) Pty Ltd		* Apache Northwest Pty Ltd
	Shell Development (Australia) Proprietary Limited		
	* Woodside Energy Ltd		
TPL/16	BHP Billiton Petroleum (North West Shelf) Pty Ltd		
	BP Developments Australia Pty Ltd		
	Chevron Australia Pty Ltd		
	Japan Australia LNG (MIMI) Pty Ltd		
	Shell Development (Australia) Proprietary Limited		
	* Woodside Energy Ltd		
TPL/17	Apache Northwest Pty Ltd		
	Santos (BOL) Pty Ltd		
TPL/18	ARC (Offshore PB) Limited		
	AWE Oil (Western Australia) Pty Ltd		
	Cieco Energy Australia Pty Ltd		
	Roc Oil (WA) Pty Limited		
TPL/19	Kansai Electric Power Australia Pty Ltd		
	Tokyo Gas Pluto Pty Ltd		
	Woodside Burrup Pty Ltd		
TPL/20	Apache Northwest Pty Ltd		
	Santos Offshore Pty Ltd		

PETROLEUM (SUBMERGED LANDS) ACT 1982	
Retention Lease	
Title	Registered Holders (* denotes Nominee)
TR/1 R1	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd
TR/2 R1	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd
TR/3 R1	Apache Northwest Pty Ltd
TR/4	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd
	* Chevron Australia Pty Ltd
TR/5 R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
TR/6	Chevron (TAPL) Pty Ltd
	Chevron Australia Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd

PETROLEUM (SUBMERGED LANDS) ACT 1982	
Production Licence	
Title	Registered Holders (* denotes Nominee)
TL/1 R1	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967 Access Authority Survey		EP 129 R5	Buru Energy Limited
Title	Registered Holders (* denotes Nominee)	EP 307 R4	Kufpec Australia Pty Ltd
AAS 1/08-9	Chevron (TAPL) Pty Ltd		Tap (Harriet) Pty Ltd
	Chevron Australia Pty Ltd		* Apache Northwest Pty Ltd
	Mobil Australia Resources Company Pty Limited	EP 320 R3	ARC (Beharra Springs) Pty Ltd
	Shell Development (Australia) Proprietary Limited		* Origin Energy Developments Pty Limited
PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967 Access Authority to Deviated Well		EP 321 R3	Latent Petroleum Pty Ltd
Title	Registered Holders (* denotes Nominee)	EP 325 R3	Advent Energy Ltd
ADW 8/90-1	Chevron (TAPL) Pty Ltd		Bow Energy Ltd
ADW 10/92-3	Kufpec Australia Pty Ltd		Victoria Petroleum NL
ADW 12/91-2	Kufpec Australia Pty Ltd		* Strike Energy Limited
ADW 8/90-1	Mobil Australia Resources Company Pty Limited	EP 357 R2	Chevron (TAPL) Pty Ltd
	Santos Offshore Pty Ltd		Mobil Australia Resources Company Pty Limited
ADW 10/92-3	Tap (Harriet) Pty Ltd		Santos Offshore Pty Ltd
ADW 12/91-2	Tap (Harriet) Pty Ltd		* Chevron Australia Pty Ltd
ADW 10/92-3	* Apache Northwest Pty Ltd	EP 358 R2	Apache Northwest Pty Ltd
ADW 12/91-2	* Apache Northwest Pty Ltd		Kufpec Australia Pty Ltd
ADW 8/90-1	* Chevron Australia Pty Ltd		Tap (Harriet) Pty Ltd
PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967 Drilling Reservation		EP 359 R2	Lansvale Oil & Gas Pty Ltd
Title	Registered Holders (* denotes Nominee)		Pace Petroleum Pty Ltd
DR 9	Backreef Oil Limited		* Rough Range Oil Pty Ltd
DR 10	Red Mountain Energy Pty Ltd	EP 363 R3	Kufpec Australia Pty Ltd
DR 11	Westralian Gas and Power Limited		Tap (Harriet) Pty Ltd
DR 12	Flamestar Corporation Pty Ltd		* Apache Northwest Pty Ltd
	Red Mountain Energy Pty Ltd	EP 368 R3	Westranch Holdings Pty Ltd
DR 13	Flamestar Corporation Pty Ltd	EP 371 R1	Buru Energy Limited
	Red Mountain Energy Pty Ltd	EP 381 R2	Whicher Range Energy Pty Ltd
PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967 Exploration Permit		EP 386 R2	Advent Energy Ltd
Title	Registered Holders (* denotes Nominee)	EP 389 R1	Empire Oil Company (WA) Limited
EP 61 R6	Chevron (TAPL) Pty Ltd		Wharf Resources PLC
	Mobil Australia Resources Company Pty Limited	EP 390 R2	Buru Energy Limited
	Santos Offshore Pty Ltd	EP 391 R2	Buru Energy Limited
	* Chevron Australia Pty Ltd	EP 406	Euro Pacific Energy Pty Ltd
EP 62 R7	Chevron (TAPL) Pty Ltd		* Victoria Diamond Exploration Pty Ltd
	Mobil Australia Resources Company Pty Limited	EP 407 R1	Latent Petroleum Pty Ltd
	Santos Offshore Pty Ltd	EP 408 R1	Whicher Range Energy Pty Ltd
	* Chevron Australia Pty Ltd	EP 409 R1	Apache Oil Australia Pty Ltd
EP 104 R5	Arc Energy Limited		OMV Australia Pty Ltd
	First Australian Resources Limited	EP 412 R1	Bounty Oil & Gas NL
	Gulliver Productions Pty Ltd		* Rough Range Oil Pty Ltd
	Indigo Oil Pty Ltd	EP 413 R2	Arc Energy Limited
	Pancontinental Oil & Gas NL		Geary, John Kevin
	Phoenix Resources PLC		Norwest Energy NL
EP 110 R4	Carnarvon Petroleum Limited		Origin Energy Developments Pty Limited
	Pancontinental Oil & Gas NL		Roc Oil (WA) Pty Limited
	Strike Energy Limited		Victoria Petroleum Offshore Pty Ltd
		EP 416 R1	Allied Oil & Gas Plc
			* Empire Oil Company (WA) Limited
		EP 417	New Standard Exploration Pty Limited
		EP 419	Exoma Energy Limited

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

EP 424	Carnarvon Petroleum Limited		* Buru Energy Limited
	Pancontinental Oil & Gas NL	EP 451	New Standard Exploration Pty Limited
	* Strike Energy Limited		* Buru Energy Limited
EP 425	GCC Methane Pty Ltd	EP 453	Budside Pty Limited
EP 426	Allied Oil & Gas Plc		Pobelo Pty Ltd
	Black Fire Energy Ltd	EP 454	Empire Oil Company (WA) Limited
	ERM Gas Pty Ltd	EP 455	Westralian Gas and Power Limited
	Empire Oil Company (WA) Limited	EP 456	New Standard Exploration Pty Limited
EP 427	Valadon Pty Ltd		* Buru Energy Limited
	* Grange Court Pty Ltd	EP 457	Rey Resources Ltd
EP 428	Buru Energy Limited	EP 458	Rey Resources Ltd
EP 429	Kingsway Oil Limited	EP 460	Rough Range Oil Pty Ltd
EP 430	Empire Oil Company (WA) Limited	EP 461	Rough Range Oil Pty Ltd
EP 431	Buru Energy Limited	EP 462	Westralian Gas and Power Limited
EP 432	Allied Oil & Gas Plc	EP 463	Emerald Gas Pty Ltd
	* Empire Oil Company (WA) Limited	EP 464	Exceed Energy (Australia) Pty Ltd
EP 433	Lansvale Oil & Gas Pty Ltd	EP 465	Global International (Australia) Pty Ltd
	Pace Petroleum Pty Ltd	EP 466	Rough Range Oil Pty Ltd
EP 434	Pace Petroleum Pty Ltd	EP 467	ERM Gas Pty Ltd
	Rough Range Oil Pty Ltd		
	* Lansvale Oil & Gas Pty Ltd		
EP 435	Australian Oil Company No 3 Pty Limited		
	Bounty Oil & Gas NL		
	Rough Range Oil Pty Ltd		
EP 436	Buru Energy Limited		
EP 437	CalEnergy Resources (Australia) Limited		
	* Arc Energy Limited		
EP 438	Gulliver Productions Pty Ltd		
	Indigo Oil Pty Ltd		
	* Buru Energy Limited		
EP 439	Falcore Pty Ltd		
	Indigo Oil Pty Ltd		
	Longreach Oil Limited		
	Rough Range Oil Pty Ltd		
	Vigilant Oil Pty Ltd		
EP 440	Empire Oil Company (WA) Limited		
EP 441	Apache Northwest Pty Ltd		
EP 442	New Standard Exploration Pty Limited		
	* Buru Energy Limited		
EP 443	New Standard Exploration Pty Limited		
	* Buru Energy Limited		
EP 444	Rough Range Oil Pty Ltd		
EP 445	Red Mountain Energy Pty Ltd		
EP 446	Red Mountain Energy Pty Ltd		
EP 447	GCC Methane Pty Ltd		
EP 448	Buru Energy Limited		
	Gulliver Productions Pty Ltd		
	Indigo Oil Pty Ltd		
	United Orogen Limited		
EP 449	Kingsway Oil Limited		
EP 450	New Standard Exploration Pty Limited		

PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967 Geothermal Exploration Permit	
Title	Registered Holders (* denotes Nominee)
GEP 1	Green Rock Energy Limited The University of Western Australia
GEP 2	Green Rock Energy Limited
GEP 3	Green Rock Energy Limited
GEP 4	Green Rock Energy Limited
GEP 5	Granite Power Limited
GEP 6	Granite Power Limited
GEP 7	Geothermal Power Pty Ltd
GEP 8	Geothermal Power Pty Ltd
GEP 9	Geothermal Power Pty Ltd
GEP 10	BHP Billiton Worsley Alumina Pty Ltd Green Rock Energy Limited
GEP 11	BHP Billiton Worsley Alumina Pty Ltd Green Rock Energy Limited
GEP 12	BHP Billiton Worsley Alumina Pty Ltd Green Rock Energy Limited
GEP 13	New World Energy Limited
GEP 14	New World Energy Limited
GEP 15	New World Energy Limited
GEP 16	New World Energy Limited
GEP 17	New World Energy Limited
GEP 18	New World Energy Limited
GEP 19	New World Energy Limited
GEP 20	New World Energy Limited
GEP 21	New World Energy Limited
GEP 22	AAA Energy Pty Ltd
GEP 23	Arc Energy Limited Green Rock Energy Limited

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

GEP 24	Arc Energy Limited
	Green Rock Energy Limited
GEP 25	Arc Energy Limited
	Green Rock Energy Limited
GEP 26	Arc Energy Limited
	Green Rock Energy Limited
GEP 27	Arc Energy Limited
	Green Rock Energy Limited
GEP 28	Arc Energy Limited
	Green Rock Energy Limited

PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967 Production Licence	
Title	Registered Holders (* denotes Nominee)
L 1 R1	APT Parmelia Pty Ltd
	Arc Energy Limited
	Origin Energy Developments Pty Limited
L 2 R1	Origin Energy Developments Pty Limited
	* Arc Energy Limited
L 4 R1	Arc Energy Limited
L 5 R1	Arc Energy Limited
L 6 R1	Buru Energy Limited
L 7 R1	Arc Energy Limited
L 8 R1	Buru Energy Limited
L 9 R1	BHP Billiton Petroleum (Australia) Pty Ltd
L 10 R1	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd
	* Chevron Australia Pty Ltd
L 11	ARC (Beharra Springs) Pty Ltd
	* Origin Energy Developments Pty Limited
L 12	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd
	* Chevron Australia Pty Ltd
L 13	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd
	* Chevron Australia Pty Ltd
L 14	Arc Energy Limited
	Geary, John Kevin
	Norwest Energy NL
	Origin Energy Developments Pty Limited
	Roc Oil (WA) Pty Limited
	Victoria Petroleum Offshore Pty Ltd
L 1H R2	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd
	* Chevron Australia Pty Ltd

PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967 Retention Lease	
Title	Registered Holders (* denotes Nominee)
R 1	Arc Energy Limited
	First Australian Resources Limited
	Gulliver Productions Pty Ltd
	Indigo Oil Pty Ltd
	Pancontinental Oil & Gas NL
	Phoenix Resources PLC
R 2 R1	BHP Billiton Petroleum (North West Shelf) Pty Ltd
	BP Developments Australia Pty Ltd
	Chevron Australia Pty Ltd
	Shell Development (Australia) Proprietary Limited
	* Woodside Energy Ltd
R 3	Oil Basins Ltd
	Tap (Shelfal) Pty Ltd

PETROLEUM PIPELINES ACT 1969 Pipeline Licence	
Title	Registered Holders (* denotes Nominee)
PL 1 R1	APT Parmelia Pty Ltd
PL 2 R1	APT Parmelia Pty Ltd
PL 3 R1	APT Parmelia Pty Ltd
PL 5 R1	APT Parmelia Pty Ltd
PL 6 R3	Arc Energy Limited
PL 7 R1	Buru Energy Limited
PL 8 R1	Mitsui Iron Ore Development Pty Ltd
	Nippon Steel Australia Pty Limited
	North Mining Limited
	Sumitomo Metal Australia Pty Ltd
	* Robe River Mining Co Pty Ltd
PL 12	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd
PL 14	Apache Oil Australia Pty Ltd
	Pan Pacific Petroleum (South Aust) Pty Ltd
	Santos (BOL) Pty Ltd
	Tap (Shelfal) Pty Ltd
PL 15	Chevron (TAPL) Pty Ltd
	Mobil Australia Resources Company Pty Limited
	Santos Offshore Pty Ltd
	* Chevron Australia Pty Ltd
PL 16	BHP Petroleum (Ashmore Operations) Pty Ltd
PL 17	Kufpec Australia Pty Ltd
	Tap (Harriet) Pty Ltd
	* Apache Northwest Pty Ltd
PL 18	ARC (Beharra Springs) Pty Ltd
	* Origin Energy Developments Pty Limited
PL 19	BHP Petroleum (Ashmore Operations) Pty Ltd
PL 20	Inpex Alpha Ltd
	Mobil Exploration & Producing Australia Pty Ltd
	* BHP Billiton Petroleum (Australia) Pty Ltd

Table 7. List of Petroleum and Geothermal Titles and Holders in Western Australia as at 5 January 2010

PL 21	Chevron (TAPL) Pty Ltd	PL 55	Talisson Wodgina Pty Ltd
	Mobil Australia Resources Company Pty Limited	PL 56	Epic Energy (WA) One Pty Ltd
	Santos Offshore Pty Ltd	PL 57	Australian Gold Reagents Pty Ltd
	* Chevron Australia Pty Ltd	PL 58	BHP Billiton Petroleum (North West Shelf) Pty Ltd
PL 22	Epic Energy (Pilbara Pipeline) Pty Ltd		BP Developments Australia Pty Ltd
PL 23	APT Parmelia Pty Ltd		Chevron Australia Pty Ltd
PL 24	Alinta DEWAP Pty Ltd		Japan Australia LNG (MIMI) Pty Ltd
	Southern Cross Pipelines (NPL) Australia Pty Ltd		Shell Development (Australia) Proprietary Limited
	* Southern Cross Pipelines Australia Pty Limited		* Woodside Energy Ltd
PL 25	Southern Cross Pipelines Australia Pty Limited	PL 59	Esperance Pipeline Co. Pty Limited
PL 26	Southern Cross Pipelines Australia Pty Limited	PL 60	Gas Transmission Services WA (Operations) Pty Ltd
PL 27	Southern Cross Pipelines Australia Pty Limited	PL 61	APT Parmelia Pty Ltd
PL 28	Southern Cross Pipelines (NPL) Australia Pty Ltd	PL 62	Kufpec Australia Pty Ltd
PL 29	Apache East Spar Pty Limited		Tap (Harriet) Pty Ltd
	Apache Kersail Pty Limited		* Apache Northwest Pty Ltd
	Santos (BOL) Pty Ltd	PL 63	Gas Transmission Services WA (Operations) Pty Ltd
	* Apache Oil Australia Pty Ltd	PL 64	Arc Energy Limited
PL 30	Apache East Spar Pty Limited		Origin Energy Developments Pty Limited
	Apache Kersail Pty Limited	PL 65	Dalrymple Resources NL
	Santos (BOL) Pty Ltd		LionOre Australia (Wildara) NL
	* Apache Oil Australia Pty Ltd	PL 67	Hamersley Iron Pty Ltd
PL 31	Epic Energy (Pilbara Pipeline) Pty Ltd	PL 68	Gas Transmission Services WA (Operations) Pty Ltd
PL 32	APT Pipelines (WA) Pty Limited	PL 69	DBNGP (WA) Nominees Pty Limited
PL 33	APT Pipelines (WA) Pty Limited	PL 70	ARC (Offshore PB) Limited
PL 34	Newmont Yandal Operations Pty Ltd		AWE Oil (Western Australia) Pty Ltd
PL 35	Plutonic Operations Limited		Cieco Energy Australia Pty Ltd
PL 36	Australian Pipeline Limited		Roc Oil (WA) Pty Limited
PL 37	Norilsk Nickel Cawse Pty Ltd	PL 72	EDL NGD (WA) PTY LTD
PL 38	Epic Energy (Pilbara Pipeline) Pty Ltd	PL 73	Redback Pipelines Pty Ltd
PL 39	Origin Energy Pipelines Pty Limited	PL 74	EDL LNG (WA) PTY LTD
PL 40	DBNGP (WA) Nominees Pty Limited	PL 75	EIT Neerabup Power Pty Ltd
PL 41	DBNGP (WA) Transmission Pty Limited		ERM Neerabup Pty Ltd
PL 42	Apache East Spar Pty Limited	PL 76	APA Group
	Apache Kersail Pty Limited	PL 77	Sino Iron Pty Ltd
	Apache Northwest Pty Ltd	PL 78	Hamersley Iron Pty Ltd
	Apache Oil Australia Pty Ltd	PL 80	Latent Petroleum Pty Ltd
	Kufpec Australia Pty Ltd	PL 81	Apache Northwest Pty Ltd
	Santos (BOL) Pty Ltd	PL 82	Epic Energy (Pilbara Pipeline) Pty Ltd
	Tap (Harriet) Pty Ltd	PL 83	WA Gas Networks Pty Ltd
PL 43	Western Power Corporation		
	* APT Pipelines (WA) Pty Limited		
PL 44	APT Parmelia Pty Ltd		
PL 45	APT Parmelia Pty Ltd		
PL 46	APT Parmelia Pty Ltd		
PL 47	DBNGP (WA) Transmission Pty Limited		
PL 48	Energy Generation Pty Ltd		
PL 52	APT Parmelia Pty Ltd		
PL 53	APT Parmelia Pty Ltd		
PL 54	Western Power Corporation		
	* APT Pipelines (WA) Pty Limited		

Please consult DMP's online Petroleum and Geothermal Register for the most current information on Titles and Holdings.

DEPARTMENT OF STATE DEVELOPMENT TRADE AND INVESTMENT OFFICES

Perth — Western Australia

Tel: +61 8 9222 0490
Fax: +61 8 9222 3862
Email: invest@dsd.wa.gov.au
www.dsd.wa.gov.au

Europe — London

Tel: +44 20 7240 2881
Fax: +44 20 7240 6637
Email: europe@wago.co.uk

India — Mumbai

Tel: +91 22 6630 3973
Fax: +91 22 6630 3977
Email: middleeastindia@dsd.wa.gov.au

India — Chennai

Tel: +91 44 2640 0407
Fax: +91 44 2643 0064
Email: middleeastindia@dsd.wa.gov.au

Indonesia — Jakarta

Tel: +62 21 5290 2860
Fax: +62 21 5296 2722
Email: southeastasia@dsd.wa.gov.au

Japan — Tokyo

Tel: +81 3 5157 8281
Fax: +81 3 5157 8286
Email: wa.tokyo@wajapan.net

Japan — Kobe

Tel: +81 78 242 7705
Fax: +81 78 242 7707
Email: wa.kobe@wajapan.net

Malaysia — Kuala Lumpur

Tel: +60 3 2031 8175/6
Fax: +60 3 2031 8177
Email: southeastasia@dsd.wa.gov.au

Middle East — Dubai

Tel: +971 4 343 3226
Fax: +971 4 343 3238
Email: middleeastindia@dsd.wa.gov.au

People's Republic of China — Shanghai

Tel: +86 21 5292 5899
Fax: +86 21 5292 5889
Email: china@dsd.wa.gov.au

People's Republic of China — Hangzhou

Tel: +86 571 8795 0296
Fax: +86 571 8795 0295
Email: china@dsd.wa.gov.au

South Korea — Seoul

Tel: +82 2 722 1217
Fax: +82 2 722 1218
Email: japankorea@dsd.wa.gov.au

KEY PETROLEUM CONTACTS

DEPARTMENT OF MINES AND PETROLEUM



Government of **Western Australia**
Department of **Mines and Petroleum**

EXECUTIVE

DIRECTOR GENERAL

Richard Sellers TEL: (08) 9222 3555

A/Deputy Director General Approvals

Tim Griffin TEL: (08) 9222 3160

PETROLEUM DIVISION

TEL: (08) 9222 3622

FAX: (08) 9222 3799

EXECUTIVE

EXECUTIVE DIRECTOR

Bill Tinapple TEL: (08) 9222 3291

RESOURCES

GENERAL MANAGER

Reza Malek TEL: (08) 9222 3759

SENIOR PETROLEUM TECHNOLOGIST

Steve Walsh TEL: (08) 9222 3267

SENIOR FIELD DEVELOPMENT ADVISOR

Mark K Stevens TEL: (08) 9222 3011

PETROLEUM RESOURCE GEOLOGIST

Karina Jonasson TEL: (08) 9222 3445

EXPLORATION GEOLOGIST

Richard Bruce TEL: (08) 9222 3314

SENIOR ENERGY GEOTECHNOLOGIST

Mike Middleton TEL: (08) 9222 3076

TECHNICAL OFFICER

Mark Fletcher TEL: (08) 9222 3652

PETROLEUM TENURE AND LAND ACCESS

GENERAL MANAGER

Beverley Bower TEL: (08) 9222 3133

MANAGER LAND ACCESS

Maryie Platt TEL: (08) 9222 3813

MANAGER PETROLEUM REGISTER

Stephen Collyer TEL: (08) 9222 3318

MANAGER PETROLEUM AND GEOTHERMAL
INFRASTRUCTURE

Walter Law TEL: (08) 9222 3319

STRATEGIC BUSINESS DEVELOPMENT

GENERAL MANAGER

Mark Gabrielson TEL: (08) 9222 3010

PRINCIPAL LEGISLATION AND POLICY OFFICER

Colin Harvey TEL: (08) 9222 3315

PRINCIPAL POLICY OFFICER

Richard Wilson TEL: (08) 9222 3108

PROJECT COORDINATION AND INFORMATION
MANAGEMENT MANAGER

Hazel Harnwell TEL: (08) 9222 3490

APPROVALS MONITORING OFFICER

Hayden Samuels TEL: (08) 9222 3362

ENVIRONMENT DIVISION

GENERAL MANAGER PETROLEUM BRANCH

Kim Anderson TEL: (08) 9222 3142

SENIOR ENVIRONMENTAL ASSESSOR

Zoe Jones TEL: (08) 9222 3658

SENIOR ENVIRONMENTAL ASSESSOR

Chris Zadow TEL: (08) 9222 3159

RESOURCES SAFETY DIVISION

PETROLEUM SAFETY

DIRECTOR

Alan Gooch TEL: (08) 9358 8113

MANAGER PETROLEUM PIPELINES

Khalil Ihdayahid TEL: (08) 9358 8118

GEOLOGICAL SURVEY DIVISION

TEL: (08) 9222 3222/3168

FAX: (08) 9222 3633

EXECUTIVE

A/EXECUTIVE DIRECTOR

Rick Rogerson TEL: (08) 9222 3170

CHIEF GEOSCIENTIST

Roger Hocking TEL: (08) 9222 3590

RESOURCES

MANAGER PETROLEUM GEOLOGY

Jeffrey Haworth TEL: (08) 9222 3214

MANAGER PETROLEUM EXPLORATION INFORMATION

Felicia Irimies TEL: (08) 9222 3268

STRATEGIC POLICY GROUP

ROYALTIES

GENERAL MANAGER

David Norris TEL: (08) 9222 3304

MANAGER SYSTEMS AND ANALYSIS

Vince D'Angelo TEL: (08) 9222 3524

MANAGER PETROLEUM ROYALTIES

Angelo Duca TEL: (08) 9222 3662