[PS]Paleozoic Basins of Western Australia - Conventional Plays Abound*

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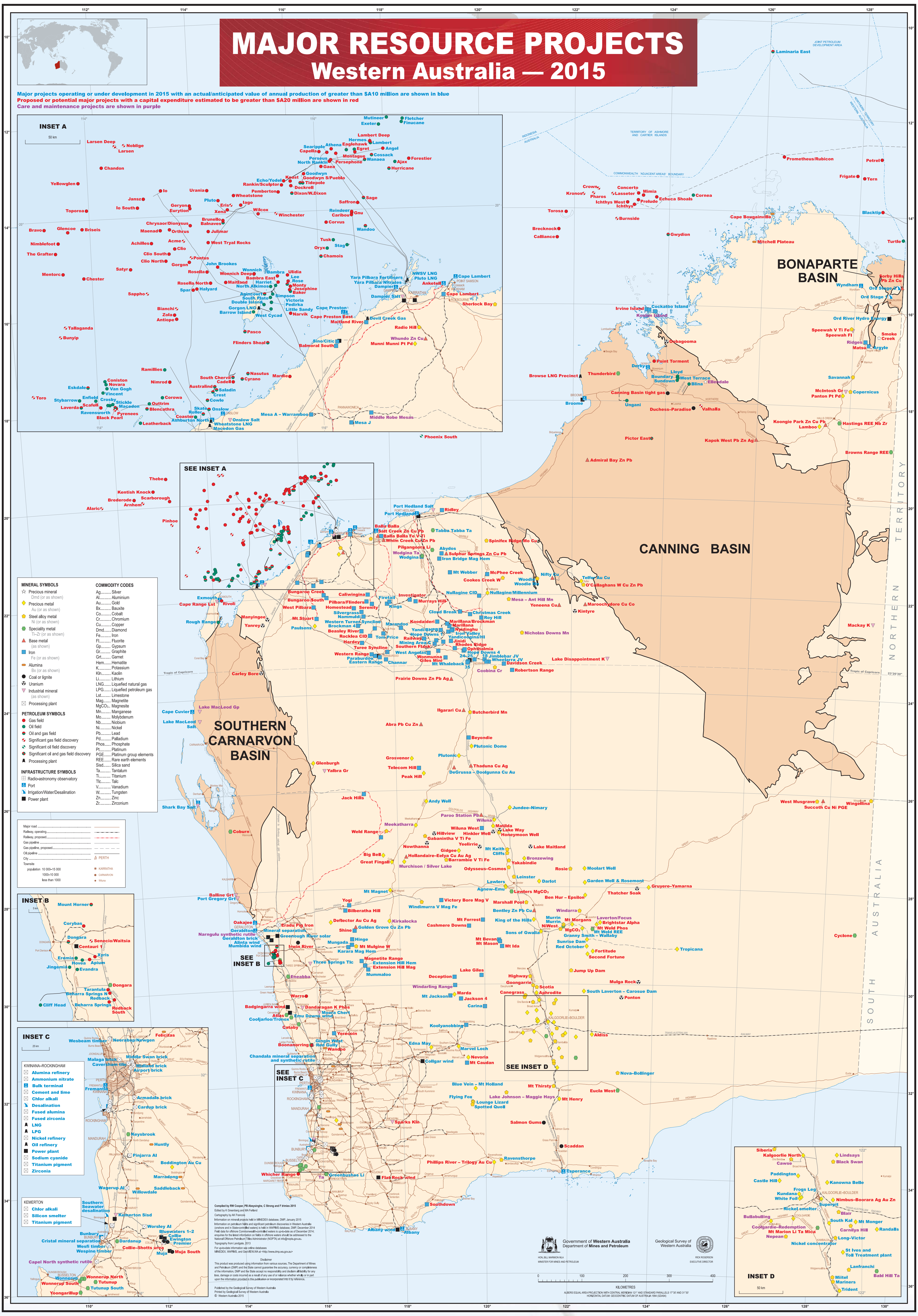
Abstract

The potential of Western Australian onshore Paleozoic basins may be of great interest to companies active in similar North American basins where there is greater exploration maturity and fewer opportunities for discovering significant new conventional oil provinces. The three main Paleozoic basins with petroleum potential in Western Australia are the Canning, Southern Carnarvon and Bonaparte basins. After the discovery of the Blina oilfield in a Devonian reef in the large Canning Basin in 1981, Western Australia's onshore Paleozoic basins attracted a number of players including Canadian and US companies, and exploration accelerated. In the 1980s, a number of small fields discovered in Permo-Carboniferous clastics also came into production along the northern margin of the Canning Basin. The area came off the boil after the oil price crashed in February 1986 and a stock market correction in October 1987. The exploration spotlight shifted from the onshore Canning Basin to the offshore North West Shelf, where new commercial production started coming onstream from the Northern Carnarvon Basin. Interest has returned to the Canning Basin in recent years. In 2011, oil was discovered in dolomitised limestones of the Carboniferous Laurel Formation with the Ungani 1 well. The original target was gas, a sign that the basin may yet provide further pleasant surprises. In addition to proven supra-salt plays (Devonian reefs, Permo-Carboniferous clastics and Carboniferous carbonates), there are sub-salt Ordovician carbonate and sandstone plays which have yet to be proven commercially. In the frontier Southern Carnarvon Basin, geohistory modelling by the Geological Survey of Western Australia indicates that petroleum generation and migration peaked during the Permian for Silurian–Devonian source beds (oil and gas potential) and during the Triassic for Permian source beds (mostly gas prone). The main Paleozoic plays are considered Devonian reefs and sandstones as well as Carboniferous-Permian sandstones. In the onshore Bonaparte Basin, gas has flowed to the surface in subcommercial quantities from the Carboniferous Milligans Formation sands. Tight sandstone and limestone reservoirs in the Carboniferous Langfield Group are also a target in the basin. There is room for further Paleozoic hydrocarbon discoveries in Western Australia and it is up to companies with foresight and determination to unlock the location of potential productive fairways.

MAJOR PROJECTS
WESTERN AUSTRALIA



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WESTERN AUSTRALIA

PALEOZOIC BASINS OF WESTERN AUSTRALIA – CONVENTIONAL PLAYS ABOUND

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INTRODUCTION

- The potential of Western Australian onshore Paleozoic basins may be of great interest to companies active in similar North American basins where there is greater exploration maturity and fewer opportunities for discovering significant new conventional oil provinces.
- The three main Paleozoic basins (refer to major projects poster for basin locations) with petroleum potential in Western Australia are the Bonaparte, Canning and Southern Carnarvon basins.
- Onshore Paleozoic basins of Western Australia remain frontiers and much more exploration is needed to realize their potential.
- With lower oil prices, higher cost exploration and production worldwide has become less economic and even uneconomic. Thus in a number of cases conventional onshore may have advantages over more expensive offshore and onshore unconventional exploration and production.

Some history

- After the 1981 discovery of the Blina oilfield in a Devonian reef on the Canning Basin's Lennard Shelf, Western Australia's onshore Paleozoic basins attracted a number of players including Canadian and US companies, and exploration accelerated.
- However, onshore exploration came off the boil after the oil price crashed in February 1986 and a stockmarket correction in October 1987. The exploration spotlight shifted from the onshore Canning Basin to the offshore North West Shelf, where new commercial production started coming onstream from the Northern Carnarvon Basin.
- Interest has returned to the onshore Paleozoic in recent years. In 2011 oil was discovered and a new play recognized with the Ungani 1 discovery well. The original target was gas, a sign that there may be further pleasant surprises in the underexplored Paleozoic of Western Australia.

Markets

- Western Australia is well located, providing ready access and a similar business time zone to the growing Asian market. Western Australia is a resource-rich State and has a significant place in the mining and LNG world.
- There are two major gas pipelines – one running down the western margin of the State, and one to significant mining centres in the interior. The domestic gas pipeline grid is continuing to expand. A number of mines have changed over from diesel to gas as their power source.
- Crude oil can be trucked south to the Kwinana oil refinery in metropolitan area of the State capital Perth, or trucked to ports in the north of the State for shipment to refineries in Asia. Australia remains a net importer of oil.

Some advantages of exploring in Western Australia

- Business costs, taxation and royalty arrangements are internationally competitive.
- Expertise and many oilfield service companies in the State capital Perth.
- Universities provide a full spectrum of courses including petroleum geology, geophysics and engineering, with on-the-job training.
- Government committed to enhancing WA's prosperity by encouraging new industry activities.
- Regulatory requirements are transparent, predictable and practical.
- Legislation closely mirrors Australian Federal (Commonwealth) offshore legislation.

Availability of acreage through DMP

- Exploration acreage is available through work program bidding for areas released by the Department of Mines and Petroleum's Petroleum Division. Generally five to ten blocks are released twice a year.There is also an “over-the-counter” method of applying for acreage unique to Western Australia, called a Special Prospecting Authority with an Acreage Option. *www.dmp.wa.gov.au/1695.aspx*
- In support of the exploration effort the Department's Geological Survey Division conducts basin studies. In addition, after a confidentiality period the Geological Survey makes petroleum data available to industry at cost of transcription or free online.

Corporate opportunities (refer to Petroleum Titles poster)

- Farmin - much of the prospective areas of the State is held or under application by existing titleholders. Many operators would welcome acceleration of their exploration efforts by way of farmin funding. With lower oil prices there are junior exploration companies that lack funds for drilling. The key benefit of a granted title is that the native title agreement has been reached and there is commercial certainty pertaining to indigenous land access and land usage expectations and requirements. Now is an opportune time for new players with a long-term view to take up an acreage position.
- Takeover - most of the participants in onshore Western Australia are junior companies. There may be scope for acquiring acreage by means of company takeover, subject to Foreign Investment Review Board guidelines.

Much more exploration needed

These basins are substantially underexplored to date.

Basin	Onshore size(km^2)	Wells/10 000 km^2
Bonaparte	~6 500	~15
Canning	~530 000	~6
Southern Carnarvon	~115 000	~9

In contrast, North American Paleozoic basins are the most intensively explored with ~500-wells/10 000 km^2.

BONAPARTE BASIN

The onshore basin straddles the Western Australia - Northern Territory border. This poster focusses on the Western Australian onshore portion of the basin. The main tectonic units of the basin are the southern Petrel Sub-basin, bounded to the west and east respectively by the Carlton and Burt Range shelves.

Despite being underexplored, the onshore Bonaparte Basin is prospective for conventional oil and gas (in the Upper Paleozoic sequence). The basin may be prospective for shallow accumulations of oil and deeper gas accumulations.

Working petroleum systems have been demonstrated from:

- existing gas discoveries
- oil and gas shows found in most wells
- biodegraded bitumen, oil staining and live oil has been encountered in shallow mineral exploration coreholes around the edge of the basin, primarily in the Ningbing and Cockatoo Groups. This is indicative of surface oil seeps.

Favourable petroleum system elements include:

- mature organic-rich marine source rocks
- reservoir rock and carrier bed potential found in all of the major stratigraphic sequences
- regional seal - Milligans Formation shale, and more localized seal - Ningbing Group basinal facies
- traps, both structural and stratigraphic
- appropriate timing of formation of structures with regard to hydrocarbon charge.

To date the quality of seismic lines in the onshore basin has been poor, possibly due to poor coupling in the dry superficial sands. Most wells may not have been valid crestal tests and some reservoirs may have been damaged during drilling.

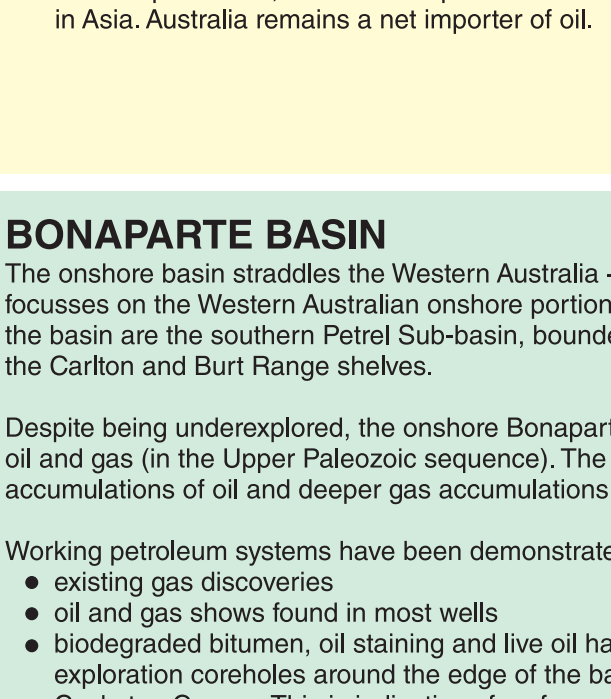

Figure 1. Map of the onshore Bonaparte Basin, showing 2D seismic lines and wells

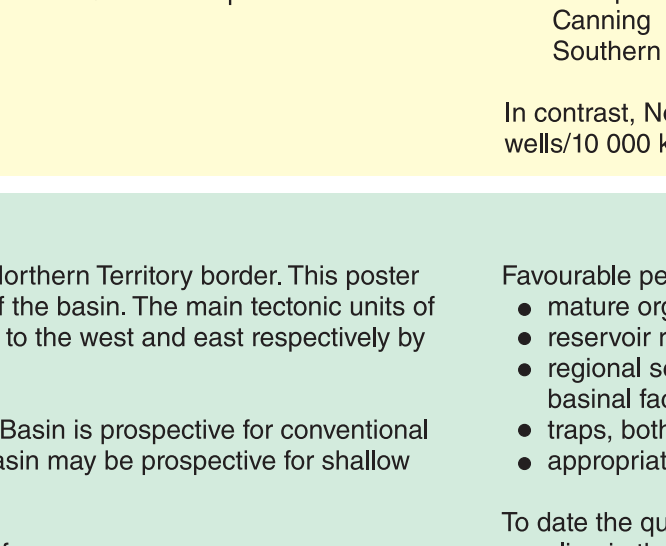

Figure 2. Onshore Bonaparte Basin stratigraphy and petroleum potential (modified Mory and Beere, 1988)

Table 1. Some well results for the onshore Bonaparte Basin

Age	Formation	Hydrocarbons	Year	Operator	Well
Lower Carboniferous	Milligans Formation	Small oil shows	1960	Westralian Oil	Spirit Hill 1 (NT)
		Gas flow 1.5 MMCFG/D	1963	Alliance Oil Development	Bonaparte 2
		Gas flowed at 3.0 MMCFG/D.	1969	Australian Aquitaine Petroleum	Keep River 1 (NT)
		Re-entered by Advent Energy and flowed 1.3 MMCFG/D.	1995	Amity Oil	Waggon Creek 1
	Langfield Group	Gas field discovery. Re-entry flowed 4.5 MMCFG/D.	1982	Australian Aquitaine Petroleum	Weaber 1
	Milligans Formation and Langfield Group	1000 m of naturally fractured limestone and interbedded shale with elevated mud gas readings	2014	Beach Energy	Cullen 1
Lower Carboniferous, Upper Devonian	Milligans Formation Ningbing Group	Gas flowed at 2.1 MMCFG/D.	1998	Amity Oil	Vienta 1
Upper Devonian	Kamilili Formation of Ningbing Group	Small undegraded oil show	1982	Australian Aquitaine Petroleum	Ningbing 1
	Cockatoo Group	Gas flowed at 0.75 MMCFG/D.	1988	Santos	Garimala 1

Gas flow rates from Advent Energy 2014
(NT) = Northern Territory

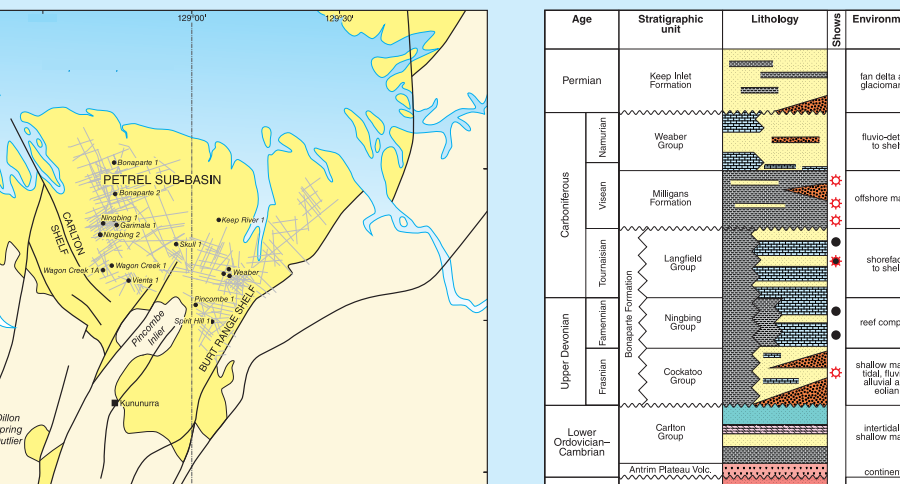

Figure 3. Onshore Bonaparte Basin plays schematic

Table 2. Onshore Bonaparte Basin plays

Age	No.	Formation	Target
Lower Carboniferous (Mississippian)	1	Weaber Group	• sandstone • carbonate
	2	Milligans Fm	• sandstone
	3	Langfield Group	• sandstone • carbonate
Upper Devonian	4	Ningbing Group	• sandstone • drowned fault blocks • stromatolite reefs
	5	Cockatoo Group	• sandstone

Selected references

Advent Energy Limited 2014, presentation at Excellence in Oil & Gas conference, Sydney, March 2014.
Ahmad, M. and Munson, T.J., 2013. Chapter 36: Bonaparte Basin: in Ahmad, M. and Munson, T.J. (compilers). Geology and mineral resources of the Northern Territory. Northern Territory Geological Survey, Special Publication 5.
Earl, K.L., 2004 (compiler), The petroleum systems of the Bonaparte Basin, Geoscience Australia, GEOCAT #61365.
GSWA, 2011, Summary of petroleum prospectivity, Western Australia 2011, Amadeus, Bonaparte, Bight, Browse, Canning, Officer, Perth, Northern Carnarvon and Southern Carnarvon Basins.
Kennard, J.M., Deighton, I., Edwards, D.S, Boreham, C.J., & Barrett, A.G., 2002. Subsidence and thermal history modelling: New insights into hydrocarbon expulsion from multiple petroleum systems in the Petrel Sub-basin, Bonaparte Basin. The Sedimentary Basins of Western Australia 3: Proceedings of the Petroleum Exploration Society of Australia Symposium, Perth, WA, 2002, 409-437.
Lavering, I.H. and Ozimic, S., 1989 – Bonaparte Basin, N.T. & W.A., Bureau of Resource Sciences, Australian Petroleum Accumulations Report 5.
Mory, A.J. and Beere, G.M., 1988, Geology of the onshore Bonaparte and Ord basins in Western Australia, GSWA Bulletin 134.
www.australianoilandgas.com.au/pdf/AOG_Bonaparte_Basin.pdf

AUGUST 2015

PALEOZOIC BASINS

CANNING BASIN

The onshore Canning Basin is a large, intracratonic, predominantly Paleozoic basin that ranges in age from Ordovician to Cretaceous.

The basin may be the least explored of Paleozoic basins of the world with proven petroleum systems. The new commercial oil play discovered by the Ungani 1 well in 2011 demonstrates that the basin is seriously under-estimated as a potential major hydrocarbon resource area, and that more exploration is warranted. Coming relatively late in the exploration history, the Ungani discovery challenges accepted wisdom that larger fields tend to be discovered early.

Commercial discoveries

- 1981 Blina oilfield in an Upper Devonian carbonate reef on the Lennard Shelf. World-renowned Devonian reefs exposed in the Lennard Shelf provide an excellent insight into the subsurface carbonate geology.
- In the 1980s a number of small fields were discovered in Permo-Carboniferous clastics also came into production along the northern margin of the Canning Basin.
- In October 2011 oil was discovered in dolomitised limestones of the Lower Carboniferous Laurel Formation with the Ungani 1 well, on the southern margin of the Fitzroy Trough. Ungani was originally a gas target. The well flowed at 1647 barrels of oil per day (BOPD), on a ½ inch choke. Buru Energy was granted Production Licenses for the Ungani oilfield on 2 July 2015. The field is situated on the margin of the Jurgurra Terrace and the Fitzroy Trough.

Room for a giant?

- A giant field is yet to be found in the Canning but some factors in its favour include:
  - Excellent oil-prone source rocks such as the Ordovician Goldwyer Formation
  - Excellent salt seals
  - It is a large intracratonic basin with some deep troughs
  - Widespread shows at many stratigraphic levels and in different geological settings.
  - At least three active petroleum systems.
- Worldwide there
  - "is a statistical predominance of giant fields and major petroleum reserves in cratonic sag … basins" (Demaison and Huizinga, 1991).
  - "are more than 130 giant and super-giant oil and gas fields with Paleozoic source and reservoir that are similar to the Canning Basin." (Carlsen & Ghori, 2005)
- Paleozoic petroleum systems with high productivity are favoured by basin developments that produce excellent source rock, good reservoir, and world-class seal. Synchronous trap formation with petroleum generation, migration and accumulation, along with preservation over significant time, also plays a major role in forming giant fields. (Carlsen & Ghori, 2005)

New exploration approaches needed

Only a small number of valid structural tests exist in the basin. Seismic misties may have been one factor. In addition, early exploration for faulted anticlines in the basin was unsuccessful as it is thought that structuring may have post-dated migration.

Examples of alternative concepts include:

- mapping the hydrocarbon fluid systems of the subsalt succession before identifying of large traps.
- trapping of early generated hydrocarbons in a variety of stratigraphic traps, and not just Devonian reefs.
- preservation of porosity and permeability eg dolomitised limestones; fracture permeability
- association with topographic features such as basement arches and noses

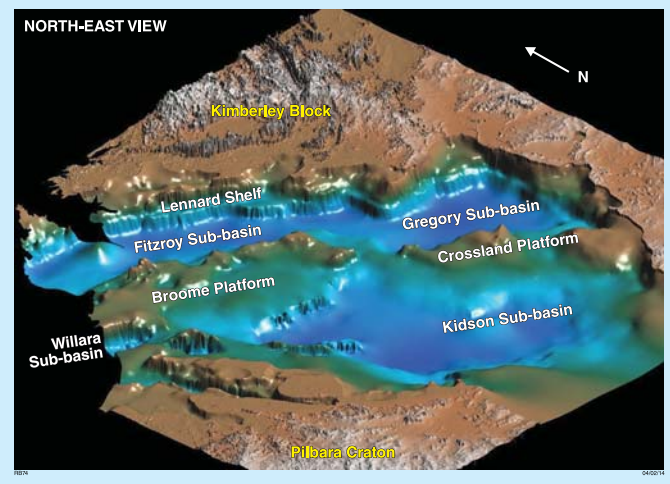

Figure 1. Image of interpreted depth-to-basement for the Canning Basin (adapted from SRK Consulting Pty Ltd, 1998)

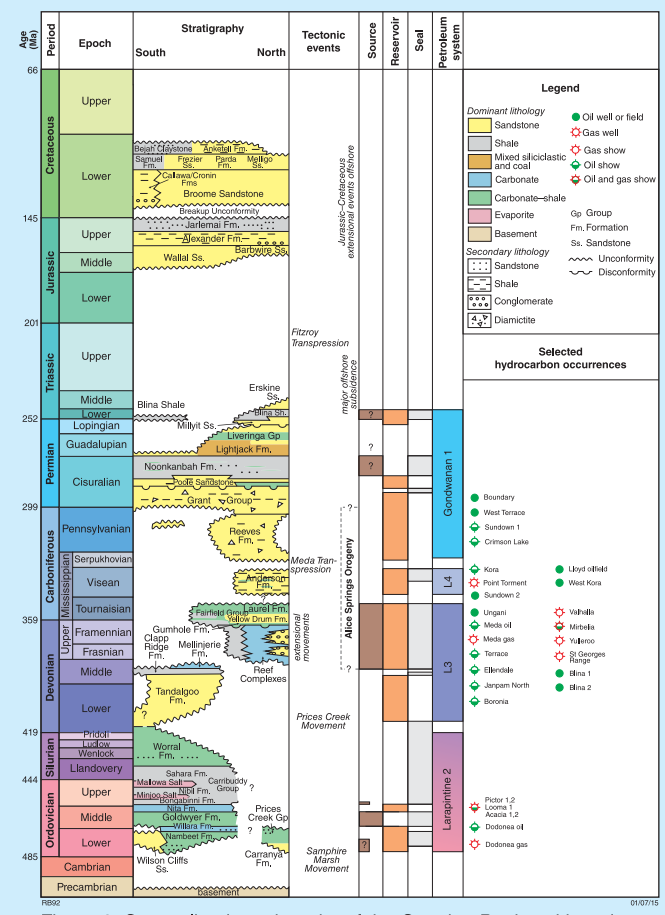

Figure 2. Generalized stratigraphy of the Canning Basin, with major petroleum elements and hydrocarbon occurrences indicated

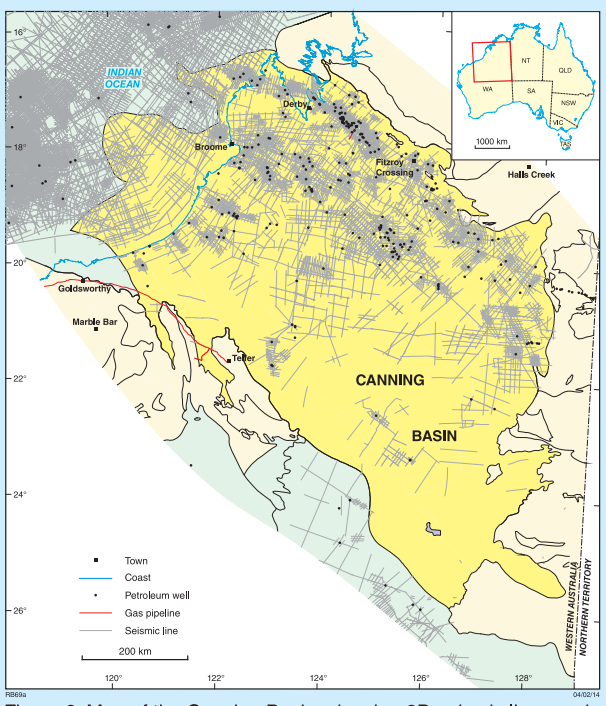

Figure 3. Map of the Canning Basin, showing 2D seismic lines and wells

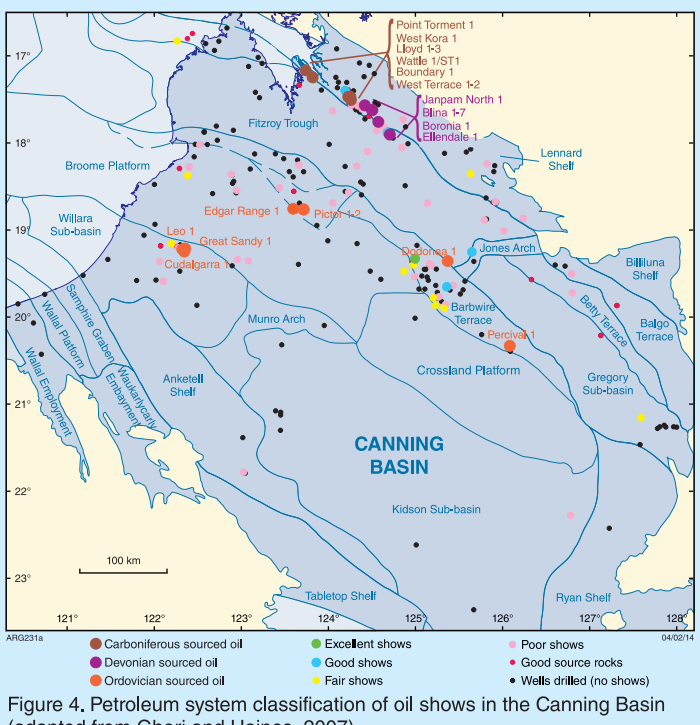

Figure 4. Petroleum system classification of oil shows in the Canning Basin (adapted from Ghori and Haines, 2007)

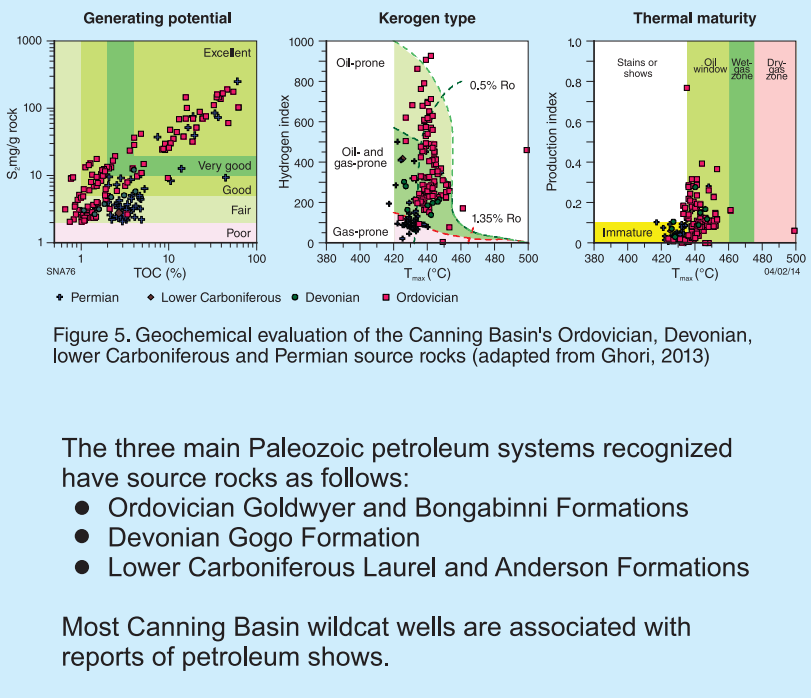

Figure 5. Geochemical evaluation of the Canning Basin's Ordovician, Devonian, lower Carboniferous and Permian source rocks (adapted from Ghori, 2013)

The three main Paleozoic petroleum systems recognized have source rocks as follows:

- Ordovician Goldwyer and Bongabinni Formations
- Devonian Gogo Formation
- Lower Carboniferous Laurel and Anderson Formations

Most Canning Basin wildcat wells are associated with reports of petroleum shows.

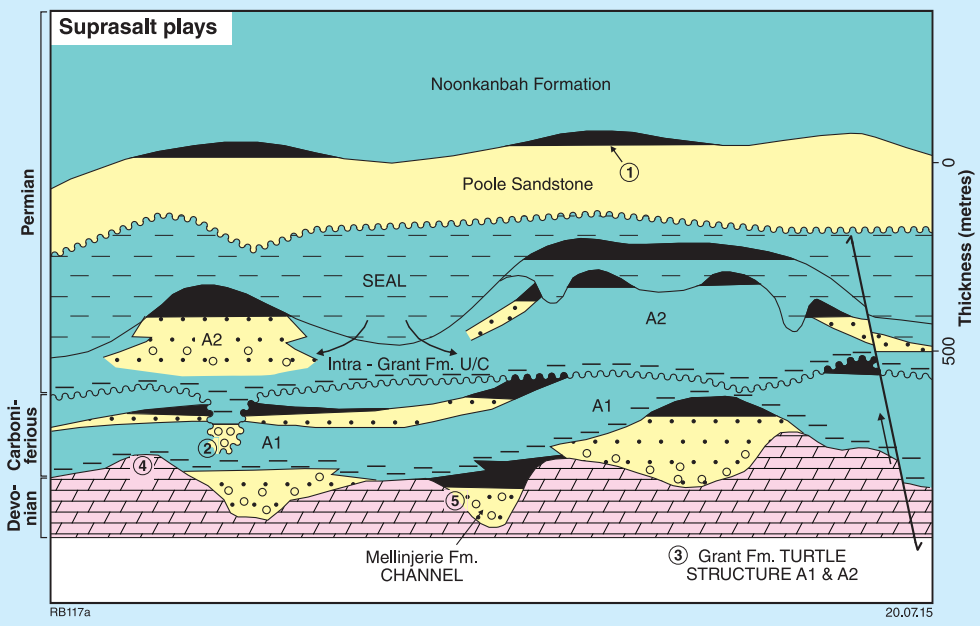

Figure 6. Canning Basin suprasalt plays schematic

Table 1. Canning Basin suprasalt plays

Age	No.	Play	International analogs
Permian	1	Poole Sandstone sealed by Noonkanbah Fm.	
	2	Truncated reservoirs, base Permian unconformity	
		Grant Group suprasalt sombrero dissolution features	Eastern flank of South Oman Salt Basin, giant oilfields
Permian Carboniferous	3	Grant Group, clastics	Unayzah Fm., Saudi Arabia; Oman
Lower Carboniferous–Upper Devonian	4	Laurel Fm., dolomites	Dnieper–Donets Basin, Ukraine
Devonian	5	Carbonate reefs and channel sands (stratigraphic traps)	Alberta Basin giant oilfields, Canada
Silurian		Worral Fm suprasalt sombrero dissolution features	Eastern flank of South Oman Salt Basin, giant oilfields

Figure 7. Canning Basin subsalt Ordovician plays schematic

Table 2. Canning Basin subsalt Ordovician plays

Age	No.	Play	International analogs
Silurian–Ordovician		Carribuddy Group Goldwyer Fm. Nita Fm.	Upper Carboniferous Paradox Basin, US
Ordovician	6	Fractured Nita and Goldwyer Fms	W. Texas Cambrian - Ordovician Ellenburger Dolomite, giant gasfields
	7	Nita Fm. dolomite and Upper Willara Fm., carbonate	Dolomite reservoirs, e.g. prolifically producing Red River Fm, Williston Basin
	8	Acacia Sst Mbr of Willara Fm.	
	9	Nambeet Fm., sandstone	Possibly Sirte Basin, Libya, giant gasfields and Murzuk Basin, Libya, giant oilfields

Selected references:

Cadman, S. J., Pain, L., Vuckovic, V. & le Poidevin, S. R., 1993 – Canning Basin, W.A., Bureau of Resource Sciences, Australian Petroleum Accumulations Report 9, 1993.

Carlsen, GM and Ghori, KAR, 2005, Canning Basin and global Palaeozoic petroleum systems – a review, APPEA Journal 2015, 349-363

Edwards, D.S., Summons, R.E., Kennard, J.M., Nicoll, R.S., Bradshaw, J., Bradshaw, M., Foster, C.B., O'Brien, G.W. and Zumberge, J.E.,1997,

Geochemical characteristics of Palaeozoic petroleum systems in northwestern Australia, APPEA Journal, v. 37, p. 351-379

Edwards, P.B. and Streitberg, E., 2013, Have We Deciphered the Canning? Discovery of the Ungani Oil Field, Western Australian Basins Symposium 2013, Perth, WA, 18-21August 2013, p. 1-13.

Ghori, K.A.R., 2013, Petroleum geochemistry and petroleum systems modelling of the Canning Basin, Western Australia, Geological Survey of Western Australia, Report 124, 33p.

Ghori, K.A.R., and Haines, P.W., 2007, Paleozoic petroleum systems of the Canning Basin, Western Australia: a review, in Extended abstracts: American Association of Petroleum Geologists, AAPG International Conference and Exhibition, Perth, Western Australia, 5 November 2006, 6p

Ghori, K.A.R. and Haines, P.W., 2006, Petroleum Geochemistry of the Canning Basin, Western Australia: Basic Analytical Data 2004-5.

Goldstein, B., 1989, Waxings and wanings in stratigraphy, play concepts and prospectivity in the Canning Basin, APEA Journal 1989, p. 466-508.

SRK Consulting Pty Ltd, 1998, Canning Basin Project, 1998. Report prepared for Shell Development Australia: Geological Survey of Western Australia, petroleum exploration report, P6353 R1 A5 (unpublished), 124p.

WA DMP, 2014, Summary of Petroleum Prospectivity: Canning Basin, Western Australia, 21p.

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CONVENTIONAL PLAYS

SOUTHERN CARNARVON BASIN

The Southern Carnarvon Basin is a major, mainly Paleozoic depocentre that ranges in age from Ordovician to Neogene.
Although underexplored, the onshore Southern Carnarvon Basin is regarded as being prospective since working petroleum systems have been demonstrated from existing oil and gas shows, and geochemical studies indicate that oil and gas-prone source intervals are present across the basin.
The basin consists of two main structural elements

- The Gascoyne Platform to the west is a ?Cambrian to lower Carboniferous succession with mainly flat-lying Cretaceous–Cenozoic cover.
- The Merlinleigh and Byro Sub-basins to the east form a single mid- Carboniferous – Permian depocentre, comprising a set of half-grabens separated by basement of the Carrandibby Inlier.

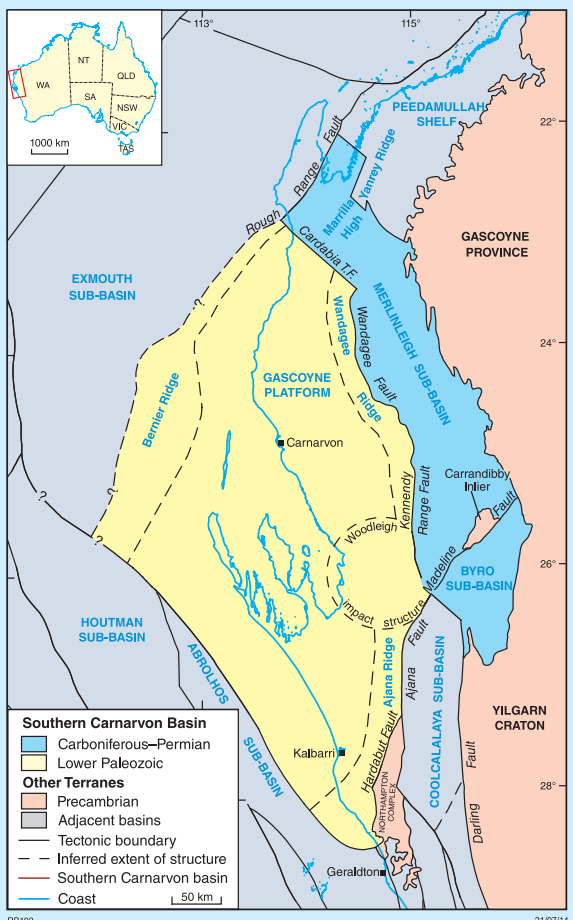

Figure 1. Map of the Southern Carnarvon Basin, including tectonic units (modified from Iasky et al., 2003)

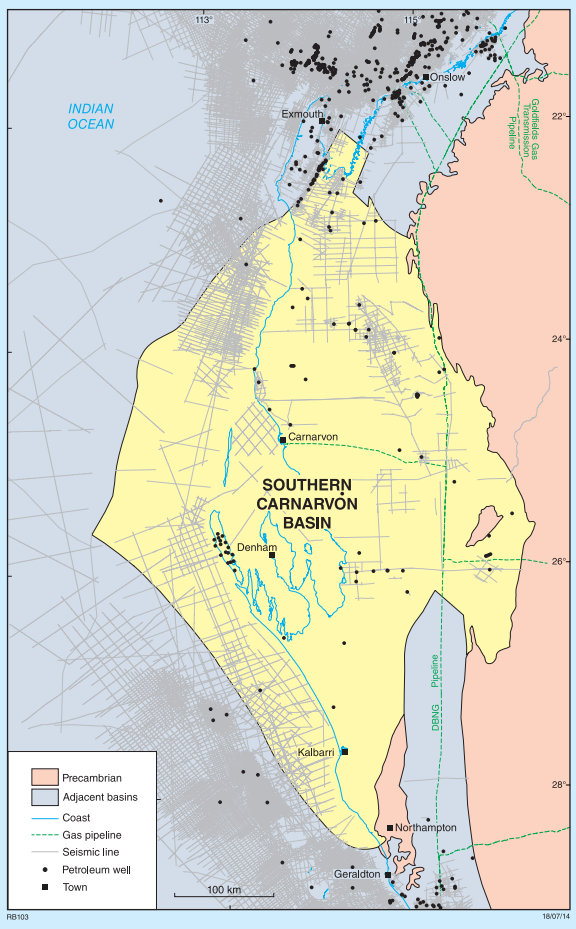

Figure 2. Map of the Southern Carnarvon Basin, showing 2D seismic lines and wells

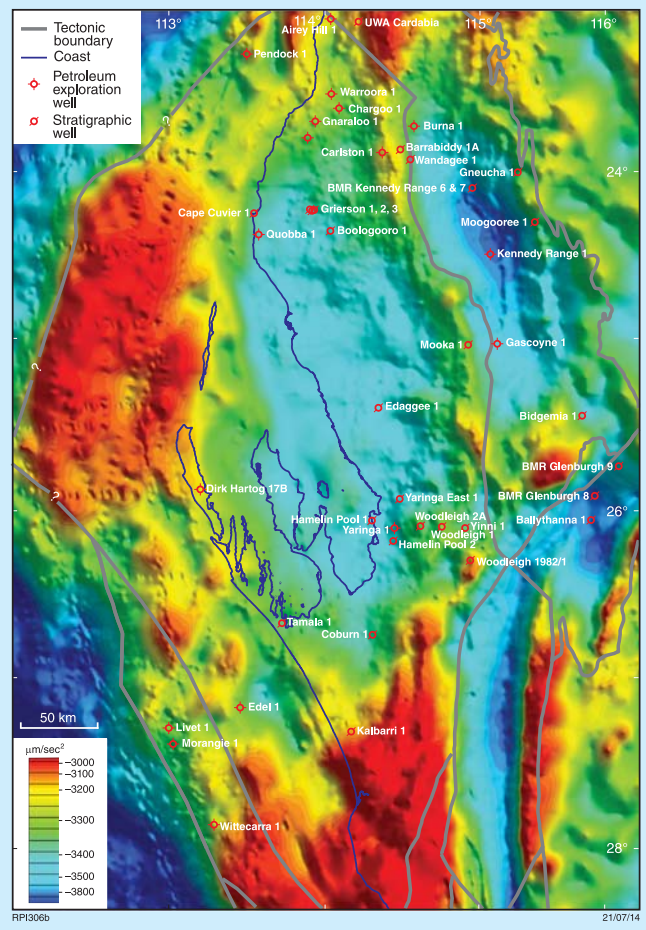

Figure 3. Isostatic residual gravity image of the Southern Carnarvon Basin, showing exploration and stratigraphic wells (Mory et al., 2003)

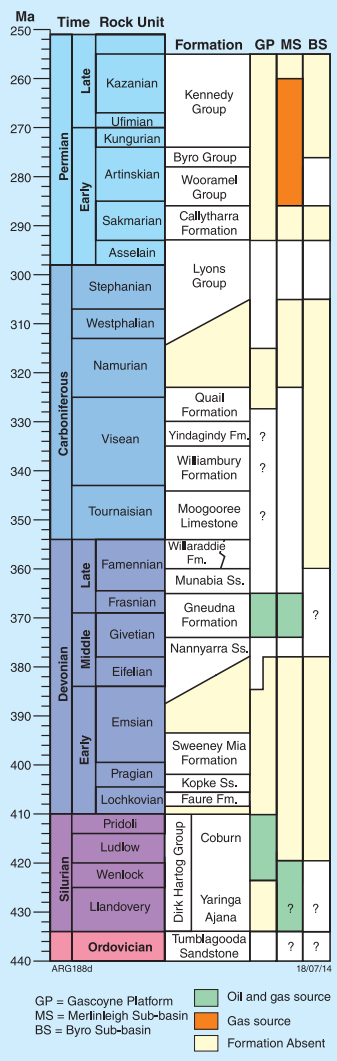

Figure 4. Generalized stratigraphy of the Southern Carnarvon Basin (Ghori et al., 2005)

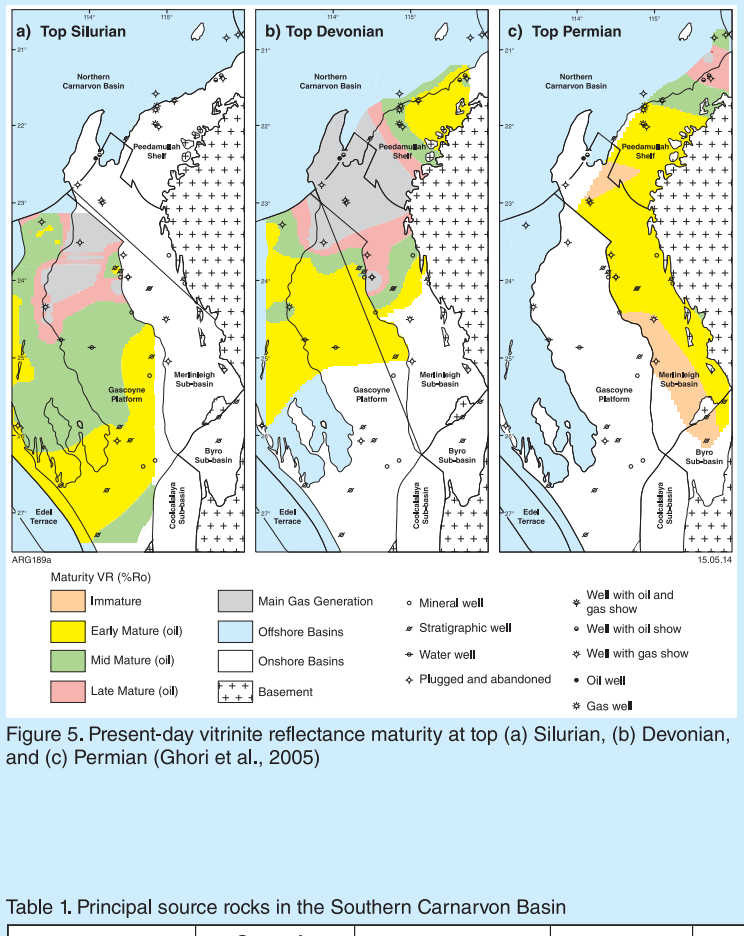

Figure 5. Present-day vitrinite reflectance maturity at top (a) Silurian, (b) Devonian, and (c) Permian (Ghori et al., 2005)

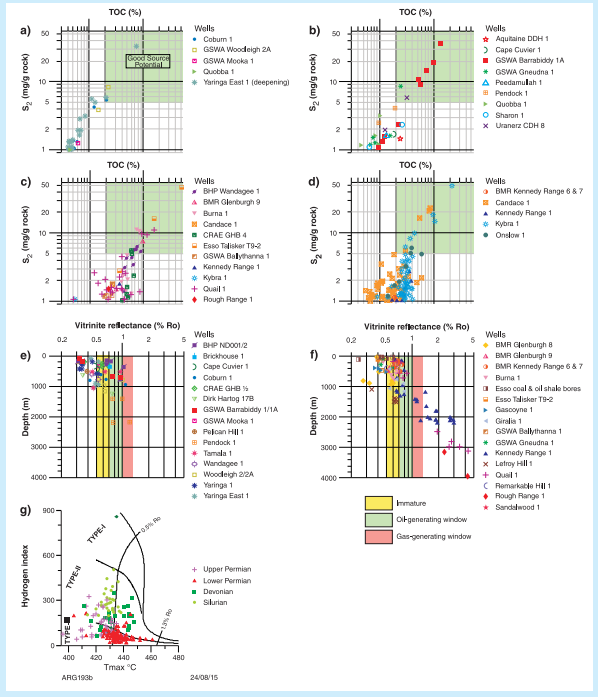

Figure 6. Geochemistry plots related to petroleum-generating potential:
a) Dirk Hartog Group;
b) Gneudna Formation;
c) Wooramel and Byro Groups;
d) Kennedy Group;
e) and f) vitrinite reflectance by depth for Gascoyne Platform and Merlinleigh Sub-basin, respectively;
g) kerogen types for Silurian, Devonian and Permian potential source rocks
(Ghori et al., 2005)

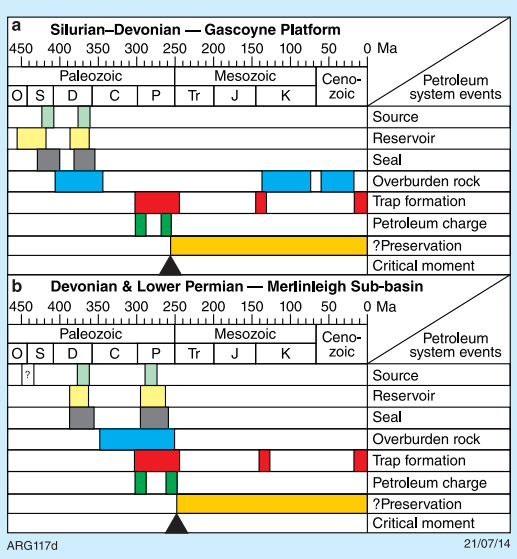

Figure 7. Petroleum system essential elements:
a) Gascoyne Platform; b) Merlinleigh Sub-basin
(Ghori et al., 2005)

Table 1. Principal source rocks in the Southern Carnarvon Basin

Age and source rocks	Organic richness (% TOC)	Potential yield (S1 + S2 mg/g)	Hydrogen index	Comments
Lower Permian Wooramel and Byro Groups	up to 16, average 7	up to 12, average 6	mostly gas generating	Within the Merlinleigh and Byro Sub-basins beds appear to be thick and widespread. Regionally immature to marginally mature and mostly. gas prone
Upper Devonian Gneudna Formation	up to 13.5	up to 40	up to 267	Thin beds and probably of limited extent. Goodpotential for both oil and gas generation
Silurian Coburn Formation	over 7	38	up to 505	Thin beds and probably of limited extent. Oil prone.

Table 2. Summary of shows in the Southern Carnarvon Basin

Gascoyne Platform					
Formation Age	**Formation**	**Shows**	**Year**	**Operator**	**Well**
Cretaceous	Birdrong Sandstone	7.5 m oil column First well in Australia to flow at 550 BOPD.	1953	WAPET	Rough Range 1
		6.2m oil column	1987	Ampol Exploration	Parrot Hill 1
		~2.5m oil column	1986	Ampol Exploration	Roberts Hill 1
Devonian	Gneudna Formation	High background C_4	1984	Canada Northwest	Quobba 1
Devonian and Silurian		Minor oil and gas shows	1969	Genoa Oil	Pendock 1 (offshore)
Silurian	Dirk Hartog Group	Traces of gas and residual oil	1955	WAPET	Dirk Hartog 1
		Residual oil	1973	Oceania Petroleum	Tamala 1
?Ordovician	?Tumblagooda Sandstone	Minor gas	1962	WAPET	Wandagee 1
Merlinleigh Sub-basin					
Formation Age	**Formation**	**Shows**	**Year**	**Operator**	**Well**
Lower Permian	Moogooloo Formation	Fair gas shows	1966	WAPET	Kennedy Range 1
Devonian	Gneudna Formation	Trace oil	1963	WAPET	Quail 1
Ordovician	Tumblagooda Sandstone	Poor gas show	1962	WAPET	Wandagee 1

Table 3. Southern Carnarvon Basin plays

Age	No.	Play
Cenozoic	1	Anticlines on northern edge of basin (Rough Range, Giralia,Marrilla)
	2	Untested high adjacent to major faults, along eastern Gascoyne Platform. (Quail 1 was drilled downdip from the highest part of a large anticlinal structure)
Cretaceous	3	Incised channels filled by Birdrong Sandstone and sealed by Muderong Shale
	4	Birdrong Sandstone sealed by Muderong Shale. (Miocene anticlinal structures on hanging wall of pre-breakup normal faults reactivated with reverse movement).
Paleozoic	5	Silurian and Devonian reservoir rocks in rotated fault blocks (Created by Mid to late Permian and Late Jurassic With low dips rifting; sealed by intraformational seals and small fault displacements traps can be large).
	6	Muderong Shale sealing dipping Paleozoic reservoir rocks (Northern Gascoyne Platform)
	7	Fault plays present throughout the Merlinleigh Sub-basin (along the eastern margin they are proximal to Devonian source rocks that are presently in the oil window. Further west, such traps may be prospective for gas).
Carboniferous	8	Untested high at Gascoyne 1 (May allow hydrocarbon migrationvia vertical conduits)
Lower Carboniferous	9	Truncation traps below the Lyons Group (If basal shales seal the unconformably underlying Lower Carboniferous sandstone charged from Devonian or older source rocks).
Devonian	10	Fault traps (Especially Nanyarra Sandstone away from the eastern margin of the Merlinleigh Sub-basin, where Devonian source rocks are in the oil window).
	11	Gneudna Formation carbonate sections (If lenticular, could form stratigraphic traps charged from intraformational shales)

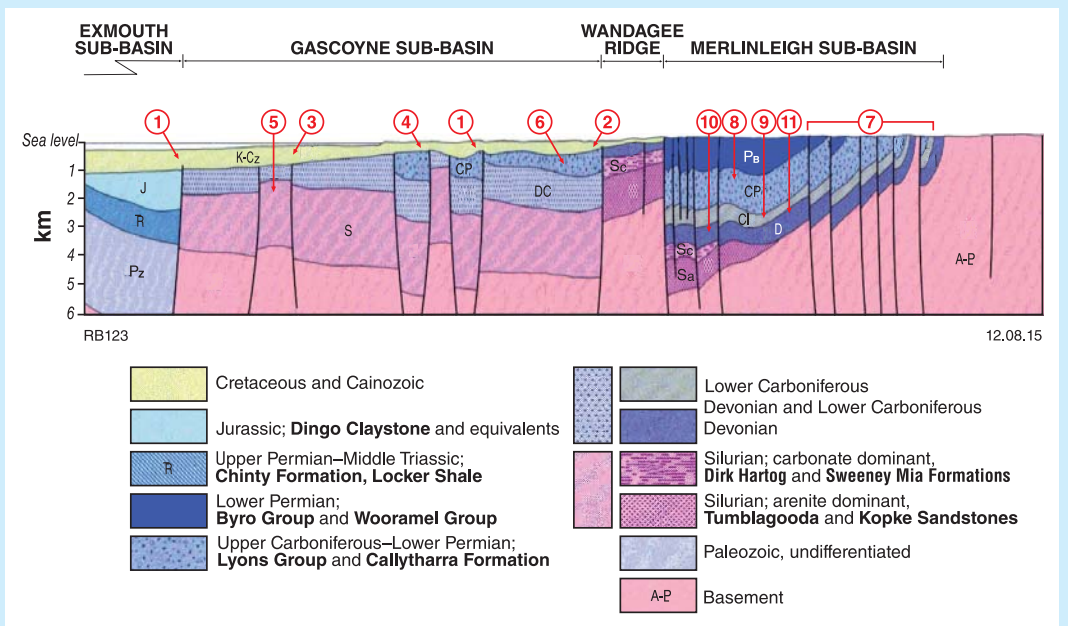

Figure 8. Onshore Southern Carnarvon Basin plays schematic

Selected references

Crostella, A., 1995, The structural evolution and the hydrocarbon potential of the Merlinleigh and Byro Sub-basins, Carnarvon Basin, Western Australia,Geological Survey of Western Australia, Report 45.

Ghori, K.A.R., 1998. Petroleum Generating Potential and Thermal History of the Palaeozoic, Carnarvon Basin, Western Australia, in Purcell, P.G. & R. R. (Eds), 1998, The Sedimentary Basins of Western Australia 2: Proceedings of Petroleum Exploration Society of Australia Symposium, Perth, WA, 1998.

Ghori, K.A.R., Mory, A.J., and Iasky, R.P., 2005, Modeling petroleum generation in the Paleozoic of the Carnarvon Basin, Western Australia: Implications for prospectivity, AAPG Bulletin, 89(1): 27-40.

Gorter, J., Mory. A. and Nicoll, R., 1998, Sequence Stratigraphy and Hydrocarbon Potential of the Middle to Upper Devonian Sequences in the Southern Carnarvon Basin, WA in Purcell, P.G. & R. R. (Eds), 1998, The Sedimentary Basins of Western Australia 2: Proceedings of Petroleum Exploration Society of Australia Symposium, Perth, WA, 1998.

Iasky, R.P., D'Ercole, C., Ghori, K.A.R., Mory, A.J. and Lockwood, A.M., 2003, Structure and petroleum prospectivity of the Gascoyne Platform, Western Australia, Geological Survey of Western Australia, Report 87.

Mory, J., Iasky, R.P., and Ghori, K.A.R., 2003, A summary of the geological evolution and petroleum potential of the Southern Carnarvon Basin Western Australia, Geological Survey, Report 86, 26p.

WA DMP, 2014, Summary of Petroleum Prospectivity: Southern Carnarvon Basin, Western Australia, 23p.

CONCLUSION

- As Phoenix South 1 and Ungani 1well results in recent years have shown, the lack of commercial discoveries in less well explored regions does not mean there is nothing to be found. We can't know what is really there until active explorers mount a drilling campaign and not just drill a single wildcat and walk away. The cost of onshore drilling and development is usually much less expensive than the cost for offshore drilling and development.
- The Paleozoic basins of Western Australia have demonstrated petroleum systems and their full prospectivity has not yet been revealed. There is room for further hydrocarbon discoveries in these basins and it is up to companies with foresight and determination to unlock the location of potential productive fairways. The present low petroleum price regime may potentially provide significant opportunities to take up an acreage position in these Paleozoic basins.

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General references

Mory, A.J., and Haines, P.W., 2013, A Paleozoic perspective of Western Australia, West Australian Basins Symposium 2013, Perth, WA, 18-21 August 2013, pp 1-25.

Scott, J., 1994. Source rocks of Western Australia – distribution, character and models. In P. G. & R. R. Purcell, (Eds)., The Sedimentary Basins of Western Australia: Proceedings of the Western Australian Basins Symposium, Perth 1994, PESA, p. 41-155.

Warris, B. J., 1993. The hydrocarbon potential of the Palaeozoic basins of Western Australia, APPEA Journal, v. 33, p. 123-137.

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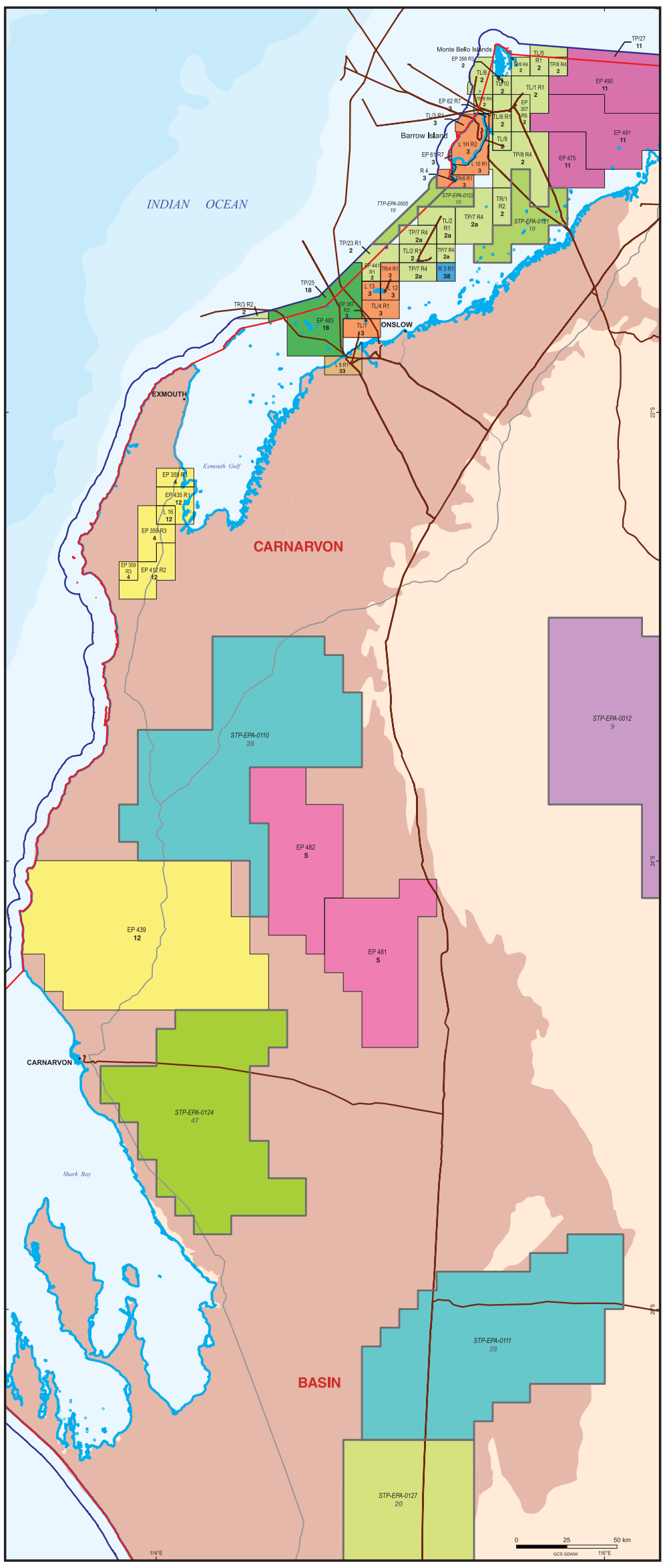
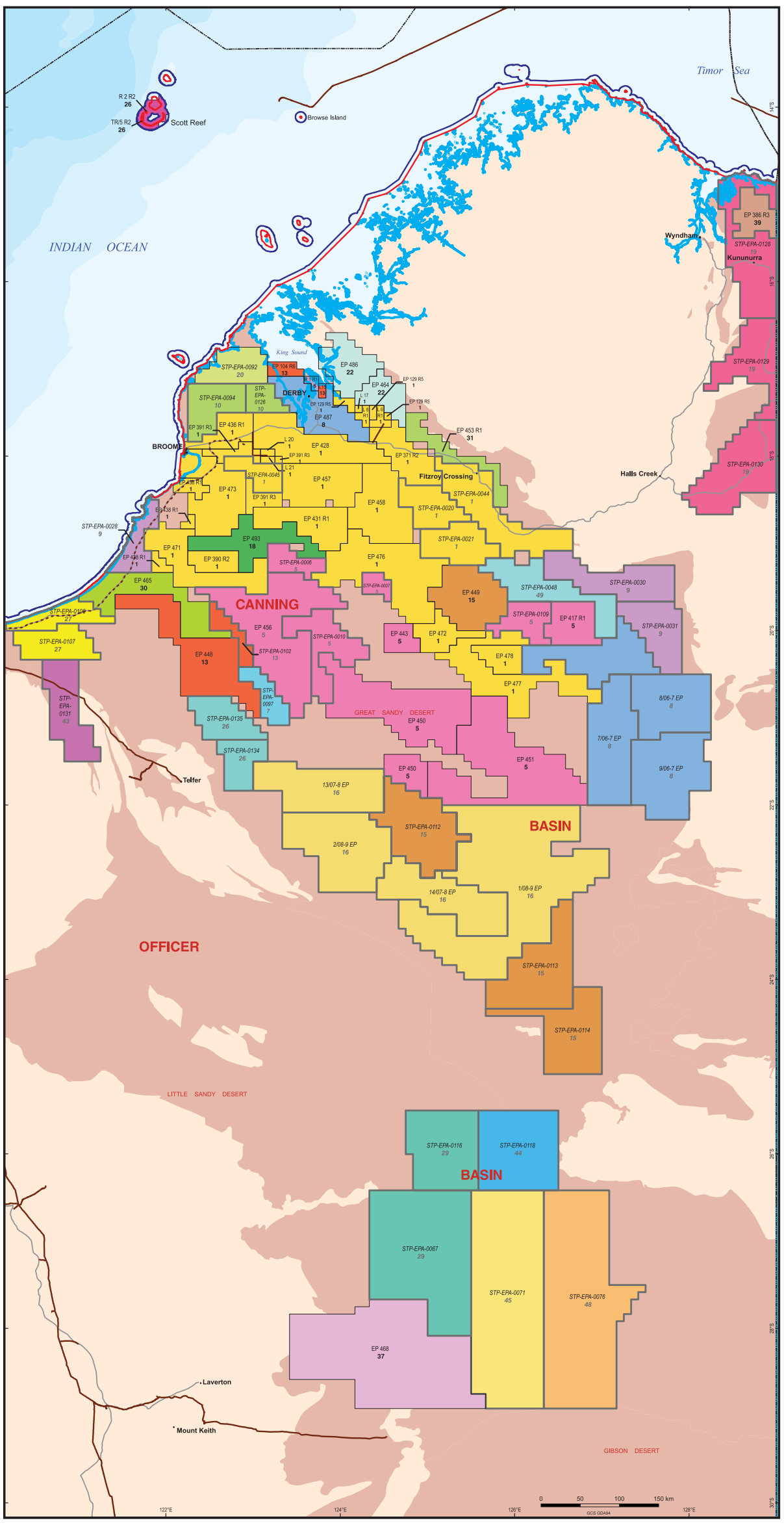
PETROLEUM TITLES

CANNING, BONAPARTE & OFFICER BASIN

CARNARVON BASIN



CANNING BASIN AND BONAPARTE BASIN



CARNARVON BASIN

Operators

- 2 Quadrant Northwest
- 2a Quadrant Oil Australia
- 3 Chevron Australia
- 4 Empire Oil *
- 5 New Standard Onshore
- 11 Carnarvon Petroleum
- 12 Rough Range Oil *
- 18 Finder No 3
- 33 DBP Development
- 38 Oil Basins

Applicants

- 9 Pangaea Resources
- 10 Goshawk Energy ‡
- 20 Green Rock Energy
- 28 Rusa Resources
- 47 Fleet Energy

Outer Limit of WA Coastal Waters (AMB 2014)
Territorial Baseline (AMB 2014)
Road
Pipeline Licence
Proposed Pipeline
SPA 1 AO Special Prospecting Authority with Acreage Option
Basement Rock
Sedimentary Basin

Note:
*** # + ‡ Symbols indicate associated companies**

State Mainland and Coastal Waters

Petroleum Lease	L1H
Exploration Permit	EP 1
Production Licence	L 1
Retention Lease	R1
Drilling Reservation	DR 1
Special Prospecting Authority	SPA 1 AO
Exploration Permit Application	*1/09-0 EP / STP-EPA-0001*
Production Licence Application	*1/09-0 L / STP-PRA-0001*
Retention Lease Application	*1/09-0 R / STP-RLA-0001*
Drilling Reservation Application	*1/09-0 DR / STP-DRA-0001*
Special Prospecting Authority Application	*SPA 1/09-0 AO / STP-SPA-0001*

State Offshore

Territorial Sea Exploration Permit	TP/1
Territorial Sea Production Licence	TL/1
Territorial Sea Retention Lease	TR/1
Territorial Sea Pipeline Licence	TPL/1
Territorial Sea Exploration Permit Application	*TTP-EPA-0001*
Territorial Sea Production Licence Application	*TTP-PRA-0001*
Territorial Sea Retention Lease Application	*TTP-RLA-0001*
Territorial Sea Pipeline Licence Application	*TTP-PLA-0001*

CANNING BASIN AND OFFICER BASIN

Operators

- 1 Buru Energy
- 5 New Standard Onshore
- 6 AWE Perth
- 8 Backreef Oil
- 13 Gulliver Productions #
- 15 Hess Australia (Canning)
- 18 Finder Shale
- 22 Exceed Energy (Australia)
- 24 Woodside Energy
- 30 Australia Zhongfu Oil Gas Resources
- 31 Budside ‡
- 37 Officer Petroleum
- 39 Onshore Energy

Applicants

- 1 Buru Energy
- 5 New Standard Onshore
- 7 UIL Energy
- 8 Backreef Oil
- 9 Pangaea Resources
- 10 Goshawk Energy ‡
- 13 Gulliver Productions #
- 15 Hess Australia Exploration
- 16 Kingsway Oil
- 19 Canning Petroleum
- 20 Green Rock Energy
- 26 Goldfields Oil & Gas
- 27 Oilex
- 29 Tamboran Resources
- 43 Admiral Oil
- 44 Australasian Energy
- 45 Australian Petroleum Portfolio
- 48 Liberty Petroleum
- 49 Strata-X

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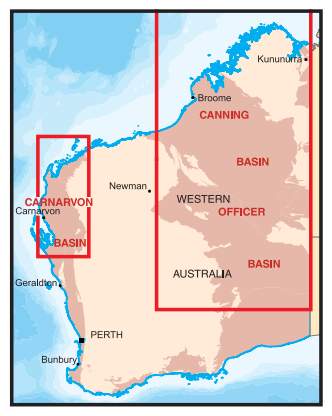

Photo courtesy Buru Energy

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