

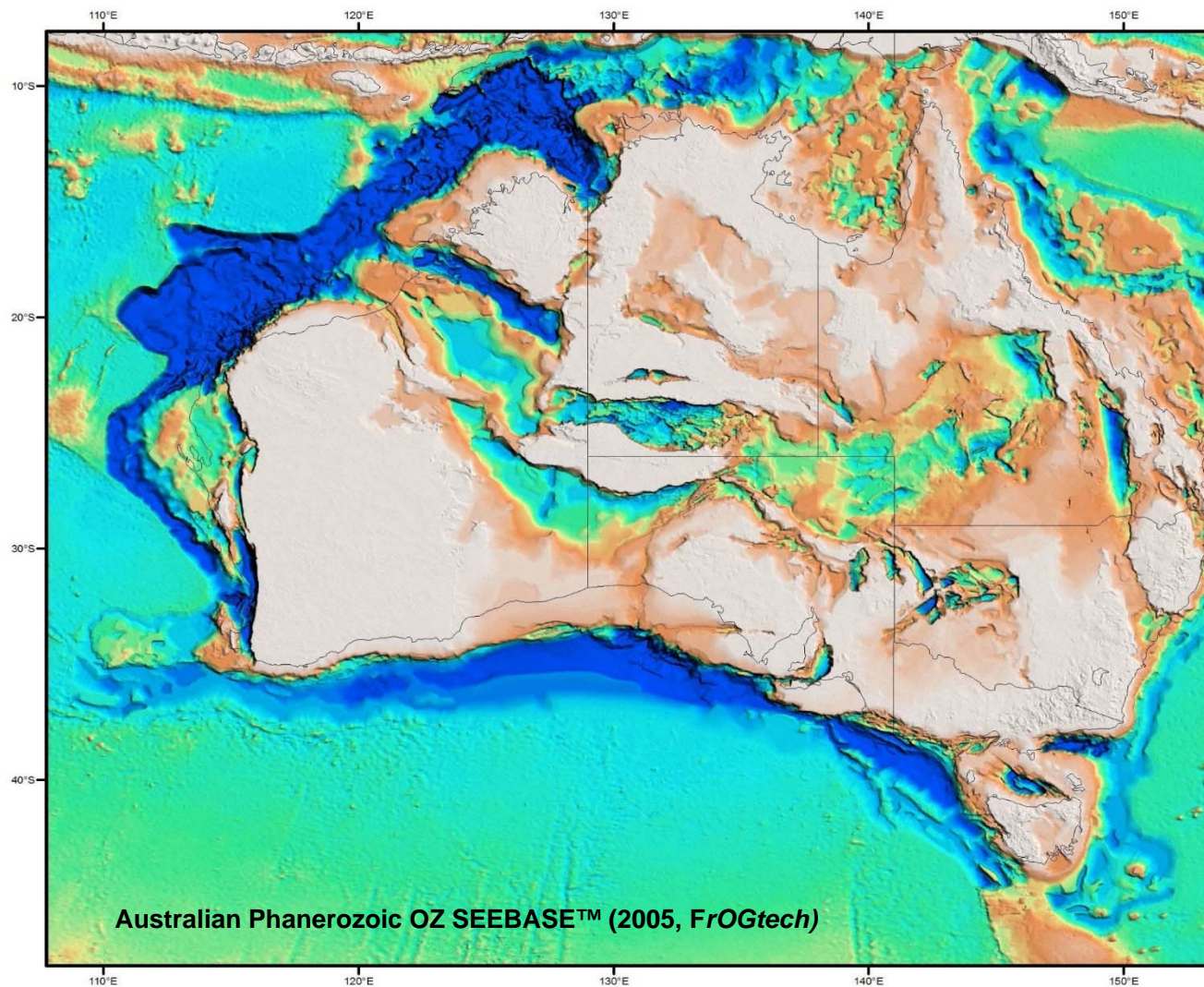
An overview of the petroleum systems of South Australian basins

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www.petroleum.statedevelopment.sa.gov.au



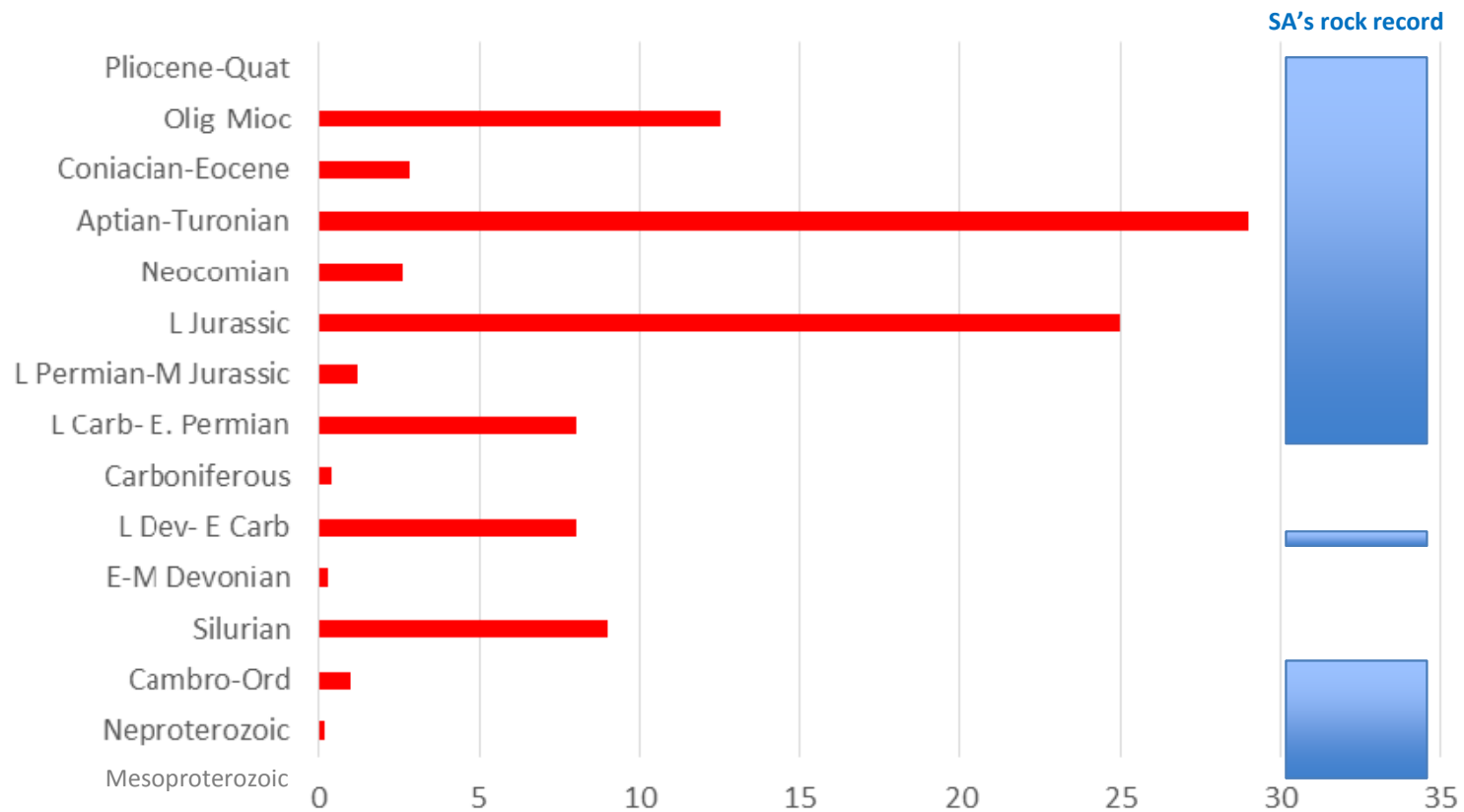


SA is situated between the Archaean Shield and eastern orogenic belts. As a result, the State's geological record has preserved a unique history of sedimentation from Proterozoic - Ordovician and from Early Devonian - Cenozoic

Viable Petroleum Systems have:
Source, reservoir and seal.
Trap formation, then generation & migration, and Preservation

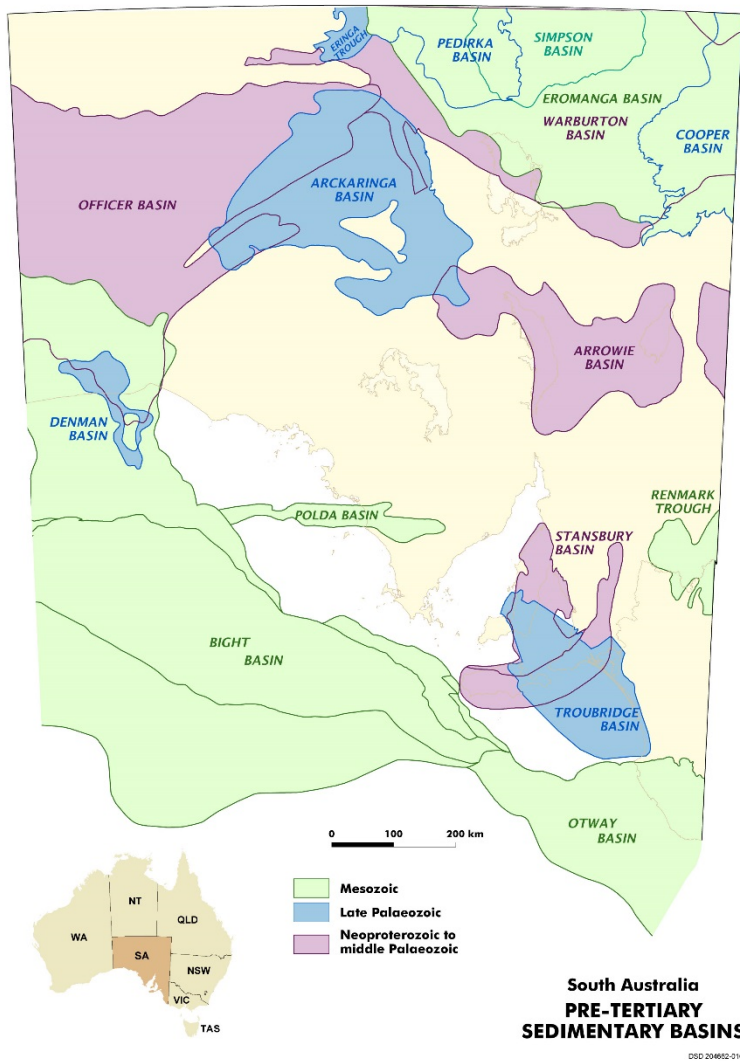
Petroleum Systems – GA's Australian scheme (Bradshaw 1993).

% generated crude and oil equiv gas by source rock



>2/3 world's known conventional petroleum resources are generated from Jurassic-Cretaceous source rocks

Modified from Sorkhabi, R. (2009). Oil and gas around the World. *Earth*, 54(12).



SA's petroleum portfolio

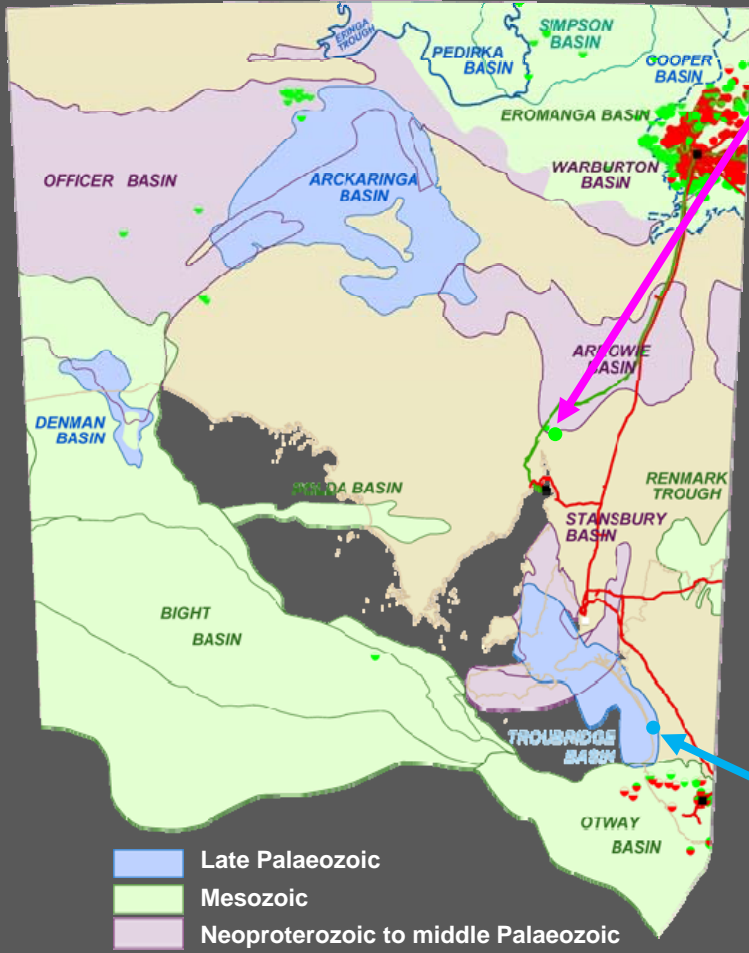
Proven plays:

- Cooper-Eromanga basins oil & gas
- Otway Basin gas

Prospective plays:

- On and offshore frontier basins, conventional plays yet to be explored in producing basins
- Deep coal/source rocks – Cooper Basin
- Tight gas/Basin Centred Gas/composite plays - Cooper Basin
- Shale gas - Cooper and other basins
- Oil shale – Arckaringa? Eromanga?
- Coal extraction for syngas and synfuel projects, in situ gasification (Telford Basin)

Oil and Gas shows in SA basins

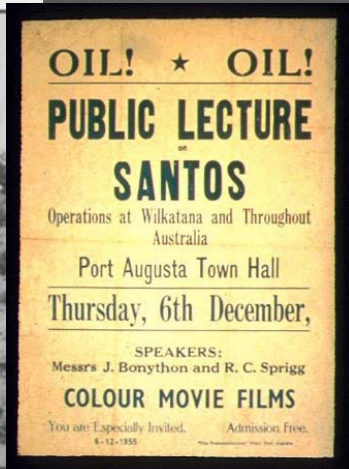


Santos Wilkatana 1 (1955): Cambrian oil shows focussed interest on SA

Bona fide oil shows discovered in many frontier basins which remain only lightly explored.



From left, John Bonython, Reg Sprigg and Robert Bristowe in discussion at Wilkatana, 1955.

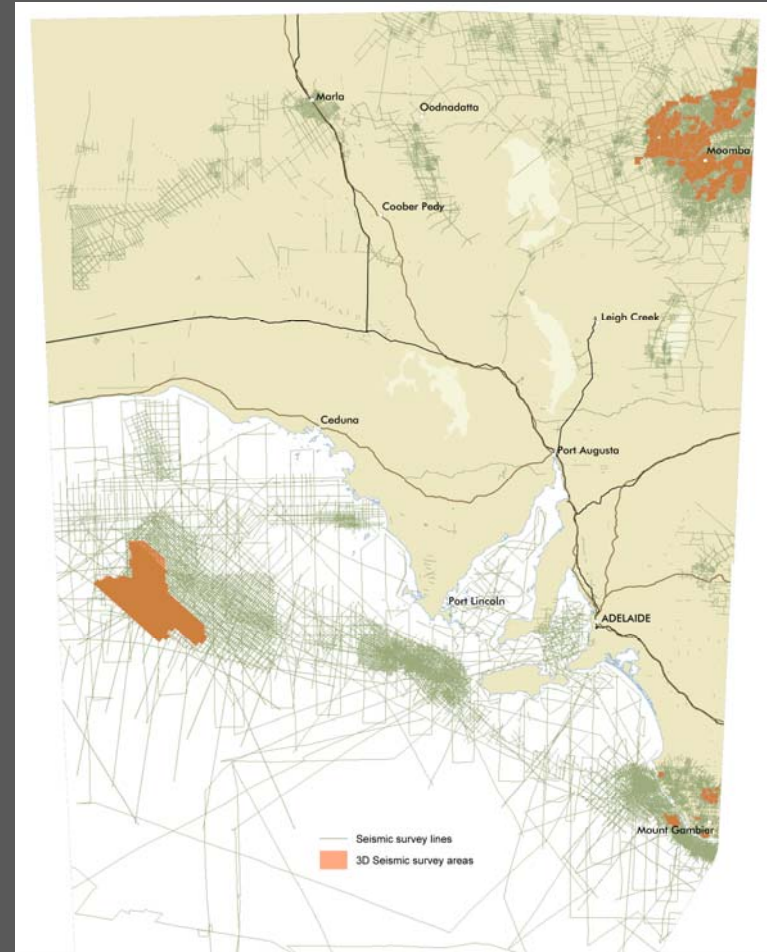
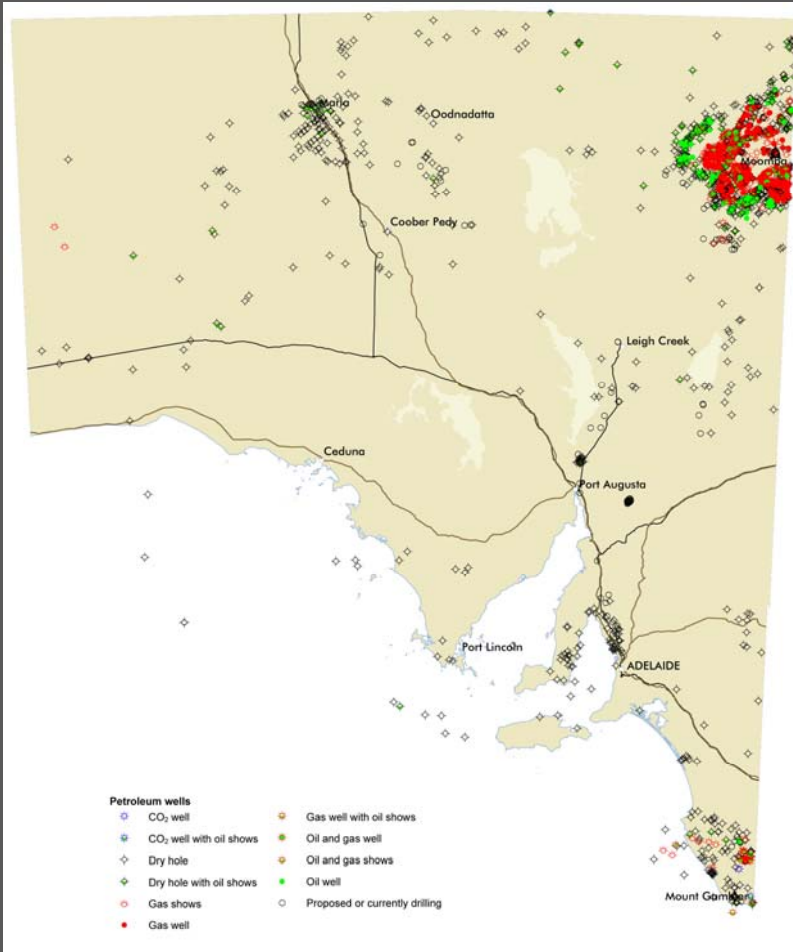


'Alf Flat 1' drilled to 7.6 m depth in 1866-68. First oil well in Australia.

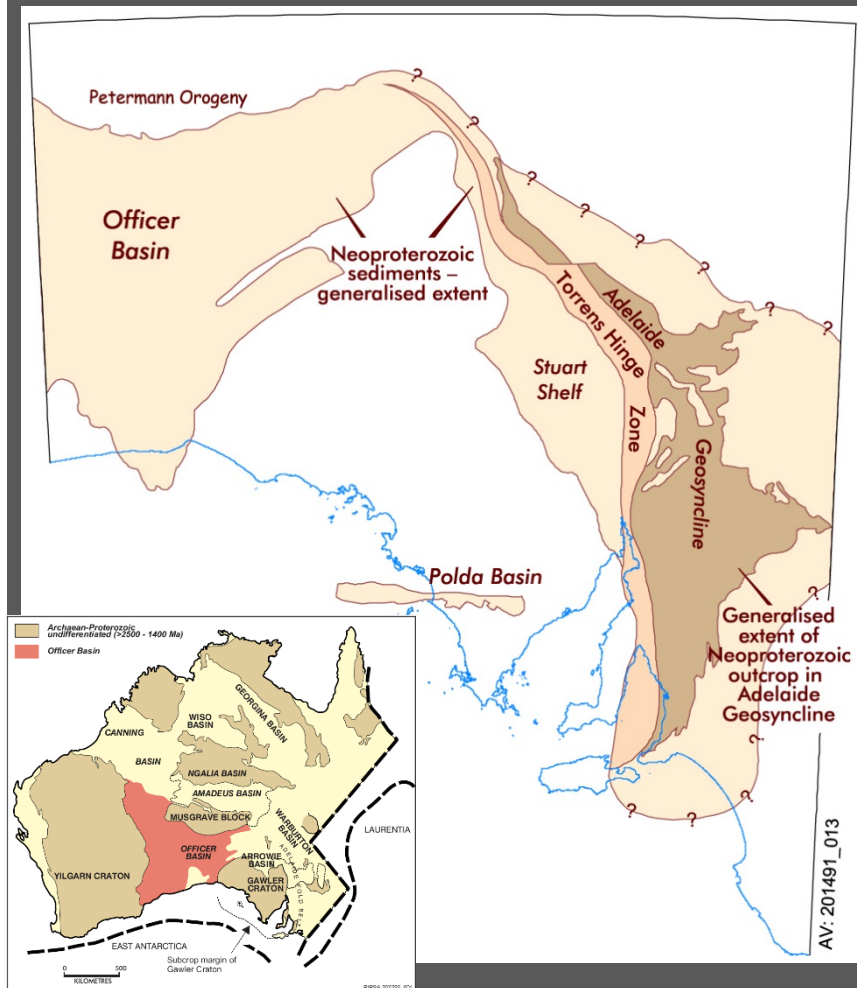


Reconstruction of steam powered rig used near Salt Creek

Petroleum wells and seismic survey coverage



Proterozoic basins



MESOPROTEROZOIC

URAPUNGAN PETROLEUM SYSTEM

No evidence of viable petroleum systems in SA, unlike the NT's McArthur Basin.

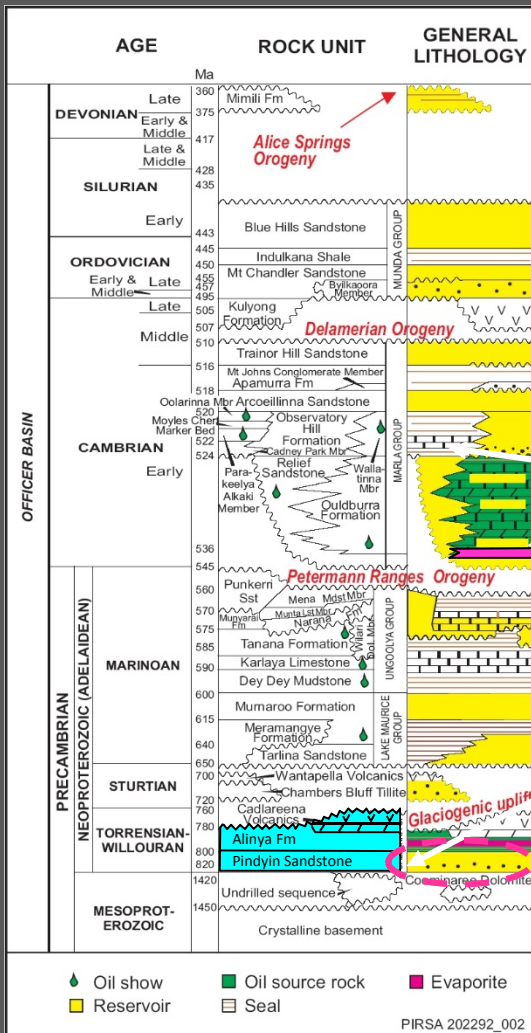
NEOPROTEROZOIC

CENTRALIAN PETROLEUM SYSTEM

Widespread marine to non-marine deposition, in a rift setting, minor igneous activity.

Adelaide Fold Belt - potential source rocks, reservoirs, seals, shale gas plays, but folded, faulted, uplifted – preservation risk. Blinman 2 recorded traces of gas in 1992.

Officer Basin – widespread oil shows, oil bleeds indicate viable source rocks, reservoirs, seals (salt) and traps – timing, preservation?

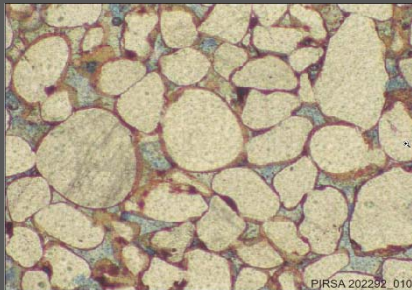


Officer Basin

Seals



Reservoir



Pindyin Sandstone

Porosity = 22.6% Permeability = 1.5 Darcies

Charge



Observatory Hill Fm.
219.75m

CENTRALIAN PETROLEUM SYSTEM

Shows – oil shows across basin and stratigraphy (bleeds, staining, fluorescence).

At least 2 Neoproterozoic petroleum systems identified (McKirdy & Tingate, 2003).

Source – black pyritic shales

Reservoir – sandstone and carbonate

Seal – marine shale and salt

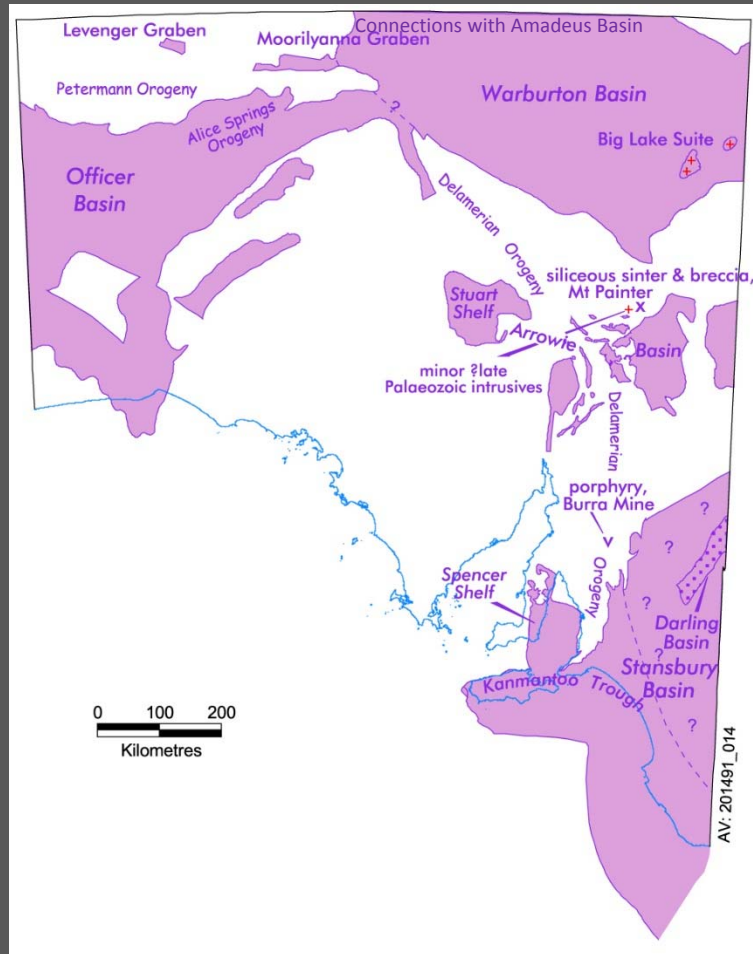
Traps – variety of structural styles, salt diapirs

Migration – shows

Preservation risk in some areas due to Peterman Ranges Orogeny, Delamerian Orogeny and Alice Springs Orogeny.

Courtesy Dr Peter Boulton (2005)

Cambrian – Ordovician



LARAPINTINE PETROLEUM SYSTEM

Low latitudes, marine shale and carbonates, volcanism, intrusions, orogeny.

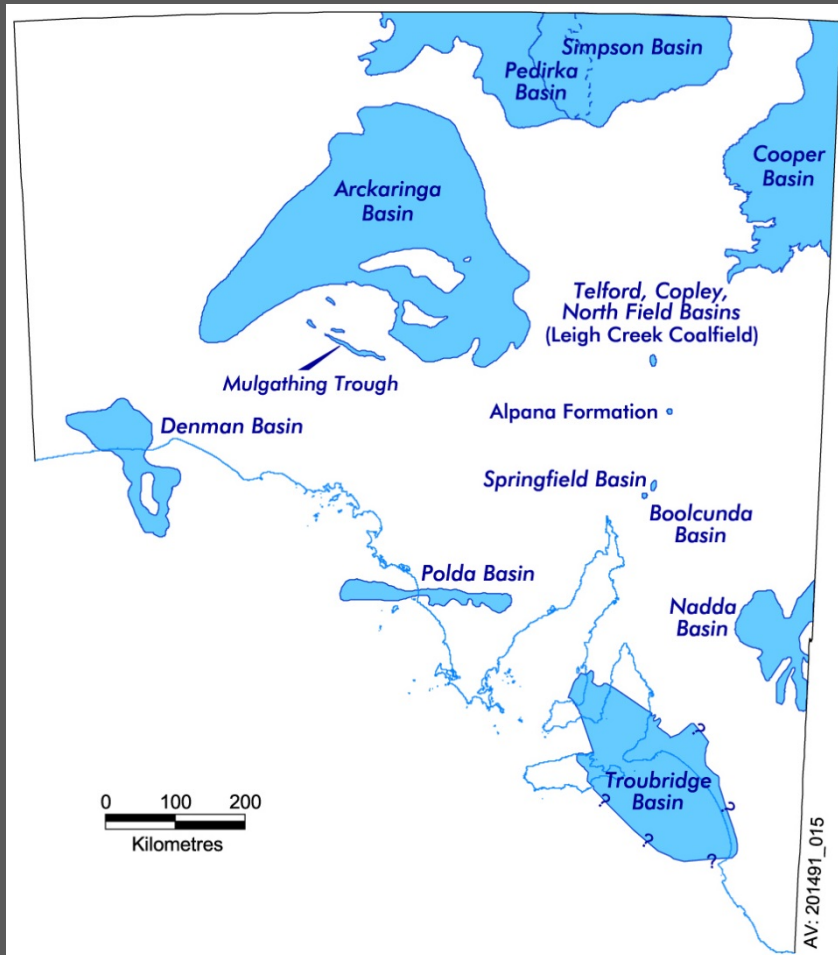
Officer Basin – 2 Cambrian petroleum systems identified by McKirdy and Tingate (2003).

Warburton Basin – Santos' original exploration target, traces of marine-sourced oil in Permian-Mesozoic reservoirs, but primarily charged by Permian and Mesozoic hydrocarbons. Ordovician Dullingari Gp black shales – poorly understood.

Arrowie Basin – oil shows at Wilkatana and gas shows in Moorowie 1, potential marine shale and carbonate source rocks. Trap preservation? Lightly explored.

Stansbury Basin – traces of oil recorded. Trap preservation? Lightly explored for oil and gas as well as gas storage.

Late Carboniferous to Triassic basins



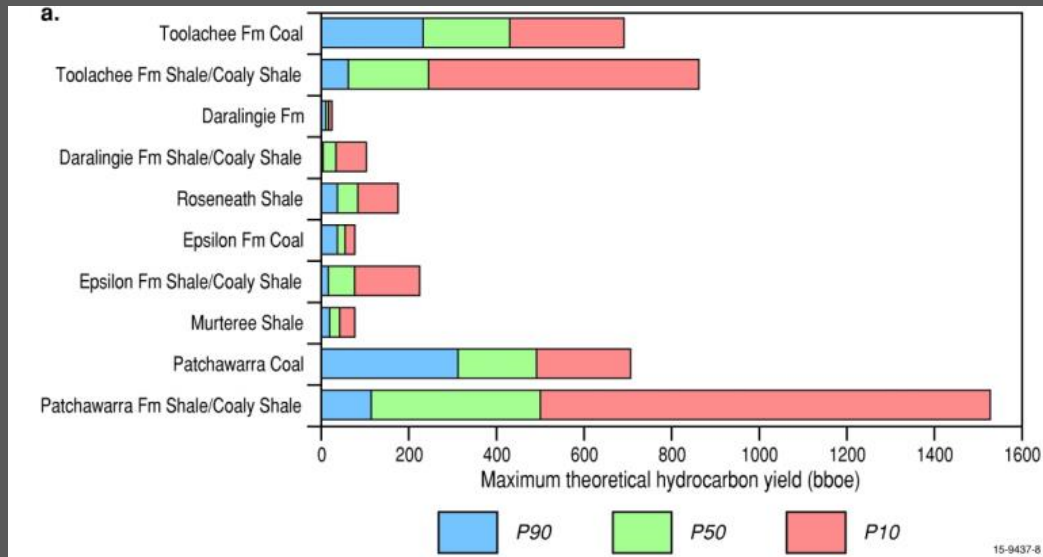
GONDWANAN - Late Palaeozoic

Most productive onshore Petroleum System

- High latitudes, mountain building, glaciation followed by extensive and thick coal deposition. Coals important source of Cooper Basin oil and gas.
- Coal measures in Pedirka and Arckaringa basins – CSG, conventional potential.
- Evidence of active petroleum system: Cooper Basin production, Pedirka - shows, Arckaringa – Stuart Range Fm shale oil play.
- Triassic coal in Poolowanna Trough, Cooper Basin and in small intramontaine basins (e.g. Telford, Springfield and Boolcunda basins).

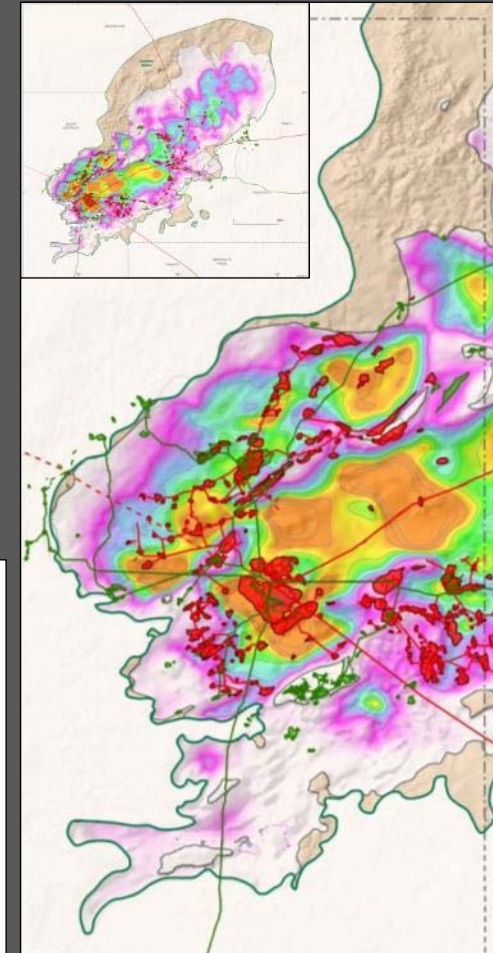
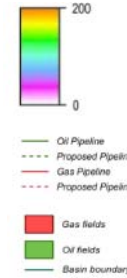
Hydrocarbon Generation Potential

- Total hydrocarbons generated by formation and lithology: the best source rocks are the Patchawarra coals and coaly shales, followed by those of the Toolachee Formation
- Total Hydrocarbons generated from the Permian Gidgelpa Group > 2000 billion bbls oil equiv



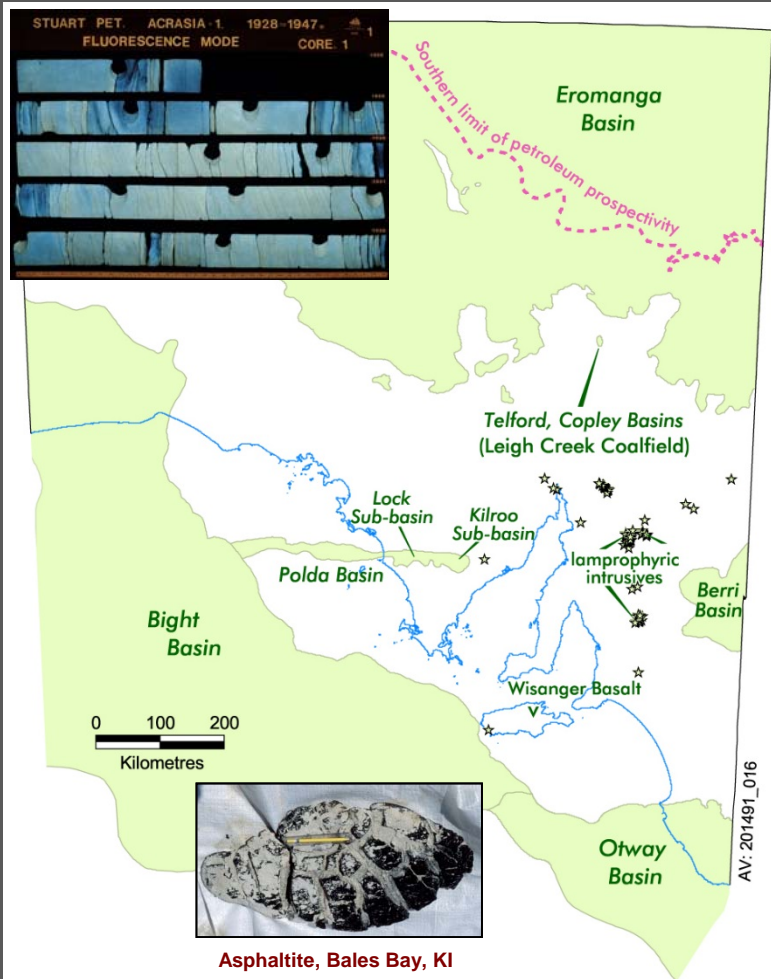
Hydrocarbon Generation by Formation and Lithology (bboe)

Permian HCs Generated (mmbœ/km²)



From Dr Lisa Hall (GA) 2016

Jurassic to Cretaceous basins



MURTA PETROLEUM SYSTEM - *Eromanga Basin* - extensive intracratonic deposition, depocentres – Cooper region and Poolowanna Trough. Excellent reservoirs, seals. Source – how much indigenous Eromanga oil vs migrated hydrocarbons from down-dip Permian? Oil shows in Poolowanna Trough. Preserved structural & stratigraphic traps. Toolebuc Fm oil shale? Poolowanna Fm?

AUSTRAL PETROLEUM SYSTEM

Southern rifted margin, Gondwana break up
Otway Basin – massive thickness of sediment, oil shows & economic gas onshore, offshore asphaltite strandings and shows, fault seal risk.
 Bight Basin – oil shows in Greenly 1, gas anomalies offshore, GA's Jurassic oil shale grab sample.

AGE	ROCK UNIT		LITHOLOGY	DEPOSITIONAL ENVIRONMENT	COMMENTS
	WEST	EAST			
TERTIARY-RECENT	LAKE EYRE BASIN			Fluvial and lacustrine	
	WINTON FORMATION 1200m (660m)		MT HOWIE SANDSTONE	Non-marine to marginal marine	
CRETACEOUS	Late	MACKUNDA FORMATION 200m (102m)		Marginal marine	Regional seal
		OODNADATTA FORMATION 300m (225m)	ALLARU FORMATION 300m (225m)	Marine	Oil shale potential
		COORIKIANA SS. 20m (15m)	TOOLEBUC FORMATION 60m	Restricted marine - stratified and anoxic	Lenticular sand, variable reservoir quality
		BULLDOG SHALE 320m (265m)	WALLUMBILLA FORMATION 450m (300m)	Regressive marine shoreface	Regional seal to Cadna-owie Formation
		CADNA-OWIE FORMATION 90m (72m)	MURTA FORMATION 60m (50m)	Non-marine to marginal marine	Regional sand sheet
	Early		MURTA FORMATION 60m (50m)	Lacustrine turbidites, deltas	Stratigraphic, diagenetic to structural traps. Variable reservoir quality. Oil prone source rocks.
			MURTA FORMATION 60m (50m)	Lacustrine shoreface	Poor - fair reservoir quality
			NAMUR SANDSTONE 210m (103m)	Braided fluvial, with intertonguing lacustrine facies	Fair to excellent reservoir quality. Predominantly anticlinal traps. Tertiary structuring has influenced hydrocarbon migration
			ALCIBUCKINA SANDSTONE 192m	Low energy meandering fluvial & overbank floodplain	Fair source rock Thin lenticular sandstones Potential for stratigraphic structural traps
			ADORI SANDSTONE 60m	Braided fluvial	Fair reservoir quality
JURASSIC	Middle	BIRKHEAD FORMATION 20m (60m)	Fluvio-lacustrine backswamp	Variable reservoir quality. Structural-stratigraphic traps. Oil prone source rocks	
		HUTTON SANDSTONE 290m (135m)	Braided fluvial with aeolian influence	Good to excellent reservoir quality. Predominantly anticlinal traps, some stratigraphic traps at Birkhead interface	
	Early	POOLOWANNA FORMATION 130m (50m)	Meandering-anastomosing fluvial	Strong facies control on reservoir development. Stratigraphic and structural trapping of Permian generated oil. Oil prone source rocks	
		CUDDAPAN FM 50m	Fluvial	Erosional remnants.	
LATE TRIASSIC	SIMPSON BASIN				
CARB. - MID TRIAS.	COOPER BASIN				
CARB. - ORDOV.	WARBURTON BASIN				
NEOPROT.	ADELAIDE GEOSYNCLINE				

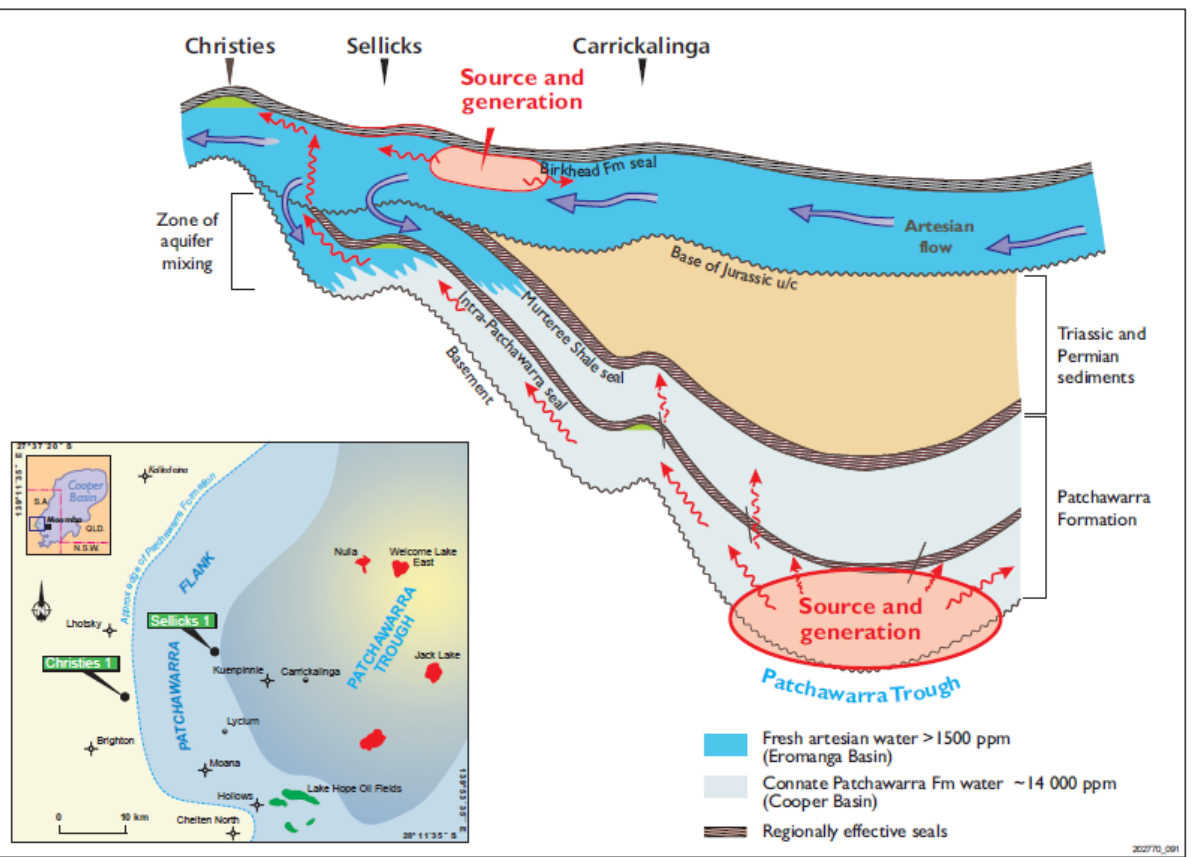
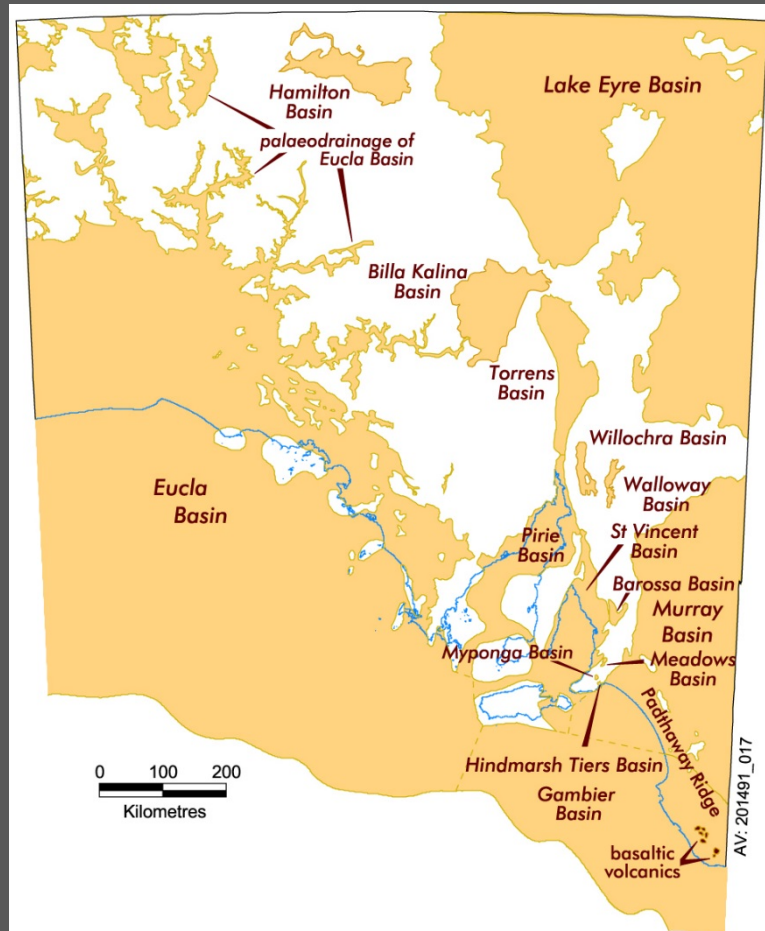


Figure 10.6 Schematic representation of the Patchawarra Trough showing the migration of oil towards the Patchawarra sub-crop margin and the increased susceptibility to water washing with exposure to the open aquifer system of the Great Artesian Basin (after Altmann and Gordon, 2004; Errock, 2005).

Cenozoic



Trap formation, migration.
Reactivations, uplift – traps breached in some basins/places. Neotectonics.

Summary

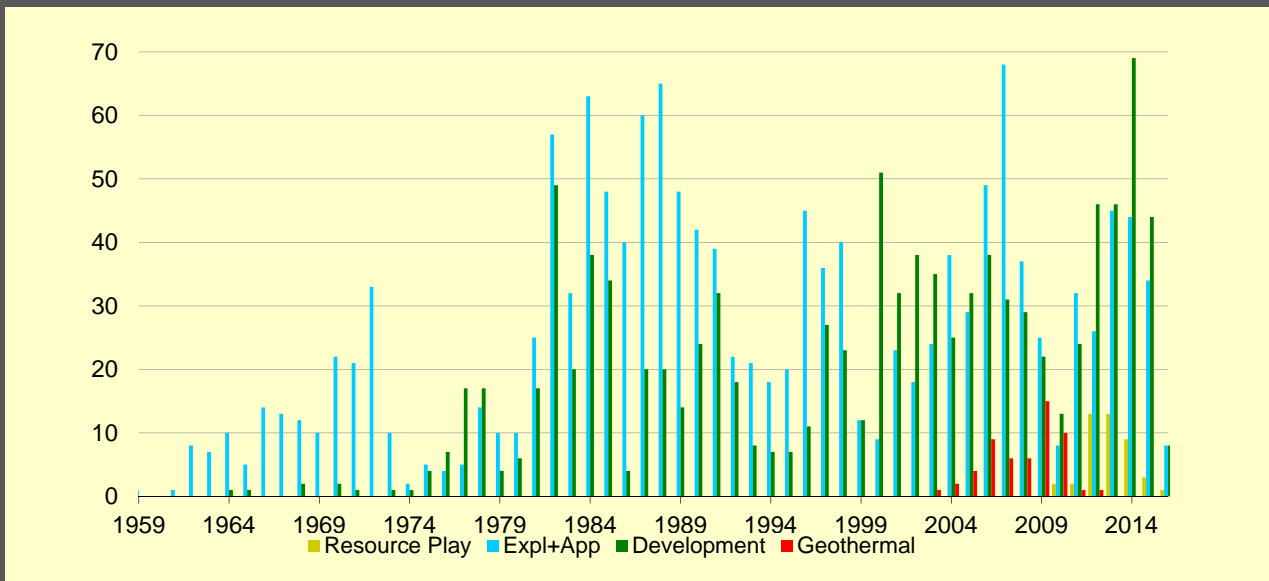
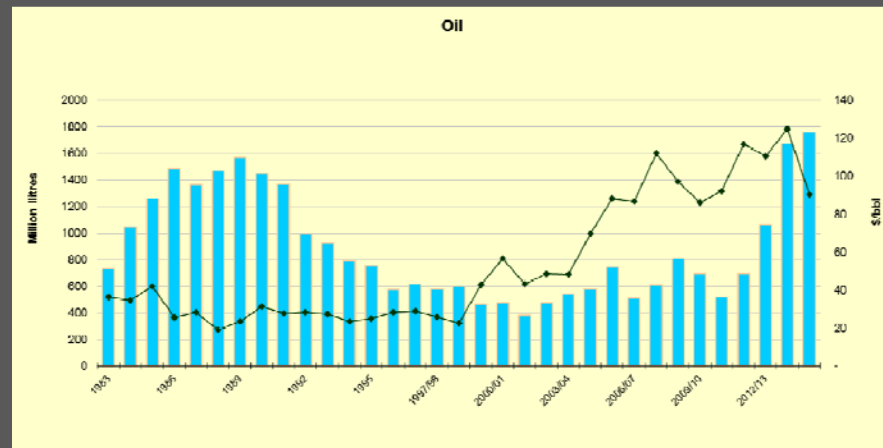
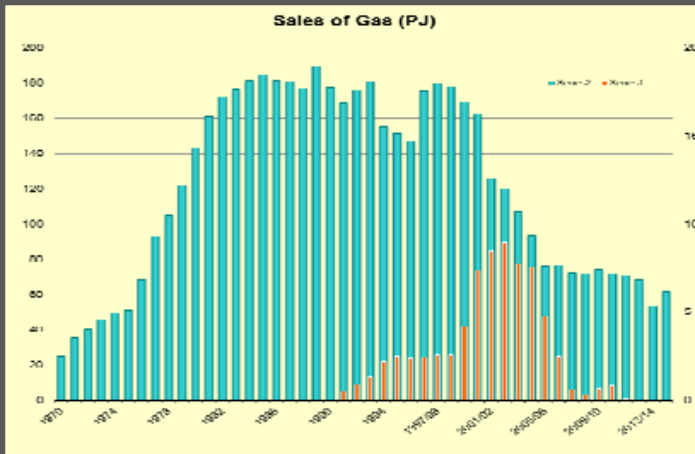
URAPUNGAN – no evidence yet of viable petroleum system in SA.

CENTRALIAN – at least 2 potential petroleum systems identified in Officer Basin.

LARAPINTINE – at least 2 potential Cambrian petroleum systems identified in Officer Basin, elsewhere no evidence yet for viable Cambro-Ordovician petroleum systems.

GONDWANAN – Cooper Basin production, unconventional reservoir plays. Potential in Pedirka and Arckaringa basins?

AUSTRAL AND MURTA – production from Eromanga (Cooper region) and Otway basins. Potential for Eromanga oil beyond Cooper Basin margin - Poolowanna Fm? E. Cretaceous Toolebuc Fm oil shale potential in SA? Potential for oil and unconventional gas plays in Otway Basin? Potential for conventional oil and gas plays in Bight Basin?



What can we do to address gas production trend and sustain oil trend?

Develop new play concepts in mature basins - Cooper, Eromanga, Otway.
 Foster exploration in frontier onshore basins – Officer, Pedirka, Arckaringa.
 New Data, Technologies, ideas

Energy Resource Division is:

- Undertaking pre-competitive prospectivity research to better understand the State's prospectivity and address critical uncertainties for priority basins - in collaboration with ASP, SACGER, GA, international (e.g. USGS) and interstate.
- Generating new datasets, reports and products – e.g. Cooper Basin Atlas. Otway Basin next for review and modelling.
- Collating data to build new models for key SA basins. Review overlooked basins and plays.
- Developing new data products – e.g. PEPS-SA online, downloadable well logs, more data in SARIG.
- Developing the 2nd Edition of the Roadmap for Oil and Gas in SA – late 2017.

Please say G'day to the ERD reps at the DSD stand to discuss further.

South Australia's door is open.

Rated most attractive petroleum jurisdiction in Australia by Fraser Institute

Bight Basin attracting billions in exploration investment

Cooper Basin remains Australia's largest onshore oil and gas province

A framework placing local companies into a global supply chain

Australia's first roadmap for unconventional gas projects

Oil and gas roundtable with hundreds of members working to address priorities



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