An Overview of South Australian Petroleum Systems*

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Abstract

South Australia is situated between the ancient Archaean Shield of Western Australia and the mobile orogenic belts of the eastern states. As a result of this tectonic setting, the geological record in South Australia has preserved a unique history of sedimentation from the Neoproterozoic to Ordovician, and from the Early Devonian to Tertiary. The basins may be subdivided as follows: 1. Mesozoic basins which either overlie older Early-Late Palaeozoic intracratonic basins or are developed on the rifted southern continental margin of Australia. These include the intracratonic Eromanga Basin and Southern Margin basins - Bight, Otway, and Polda basins. 2. Permo-Carboniferous to Early Triassic basins which overlie early Palaeozoic basins in northern and southern parts of the state. These include the Arckaringa, Cooper, and Pedirka basins. 3. Early Palaeozoic basins (Cambrian to Ordovician) include the Warburton, Arrowie, Stansbury, and Officer basins. These overlie extensive Neoproterozoic sediments of the Adelaide Geosyncline and Officer Basin which are also prospective for hydrocarbons. Crystalline basement comprises Archaean- Mesoproterozoic metamorphic belts, volcanics, and intrusives. The Cooper and Eromanga basins, which span Northeast South Australia and Southwest Queensland, comprise Australia's largest onshore petroleum province. Under-explored Permo-Carboniferous and younger sedimentary basins beyond the main producing region contain similar largely non-marine sequences in intracratonic settings. Extensive and thick Permian coal measures form important oil- and gas-prone source rocks. Continental margin basins on and offshore have very thick Cretaceous fill and include the Otway Basin, a proven gas province and the Bight Basin. In several instances there are identified mature source rocks for petroleum in lacustrine and marginal marine settings associated with reservoir sands. These occur not only in Permian and Cretaceous rocks, but also in basins with thick Neoproterozoic to Ordovician clastics and carbonates with additional source potential in marine settings. Unconventional reservoir plays are also being targeted including shale gas, shale oil, basin centered (continuous) gas, in situ gasification of coal, and coal to liquids projects.

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An overview of South Australian Petroleum Systems

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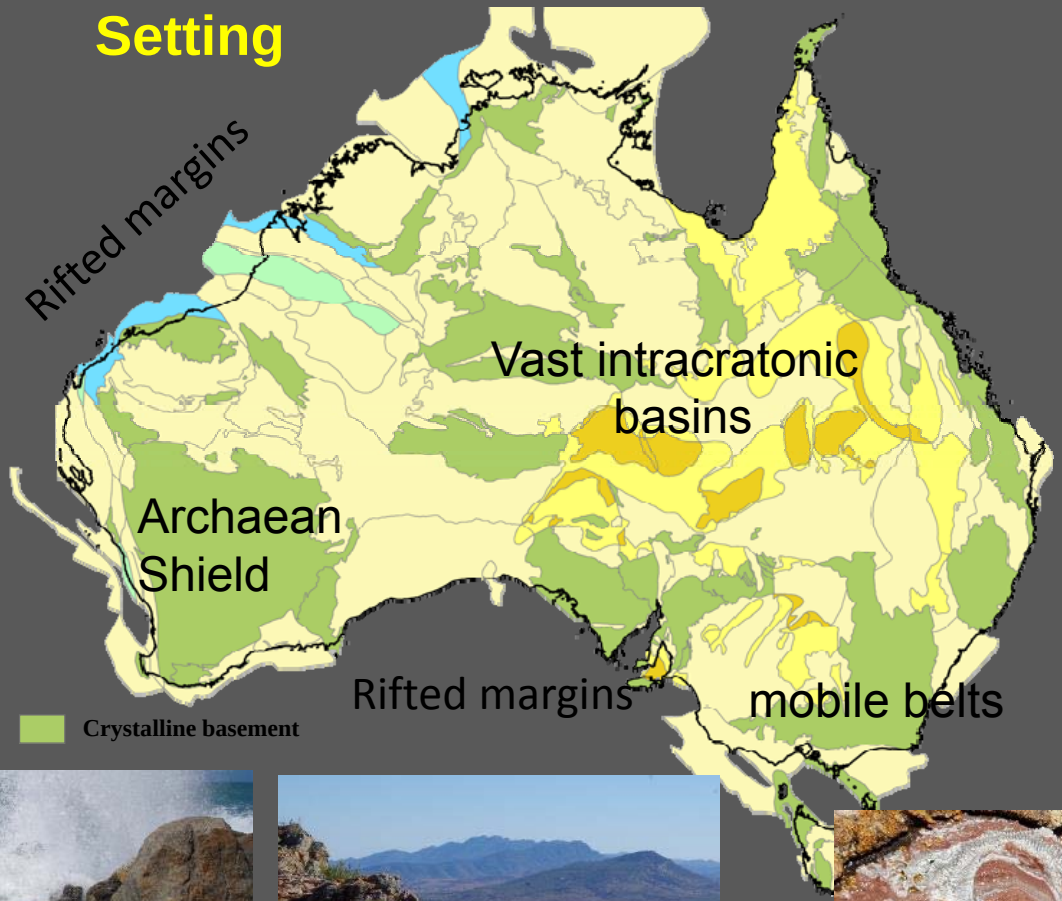
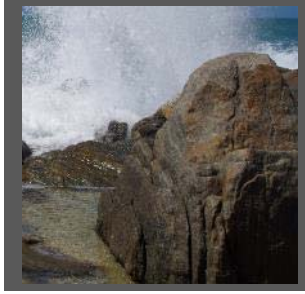
SOUTH AUSTRALIA
Government of South Australia
Department of the Premier and Cabinet

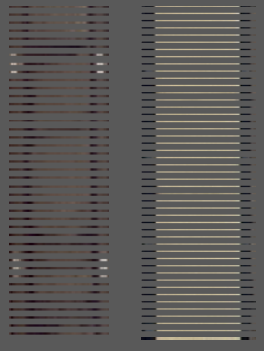
Setting

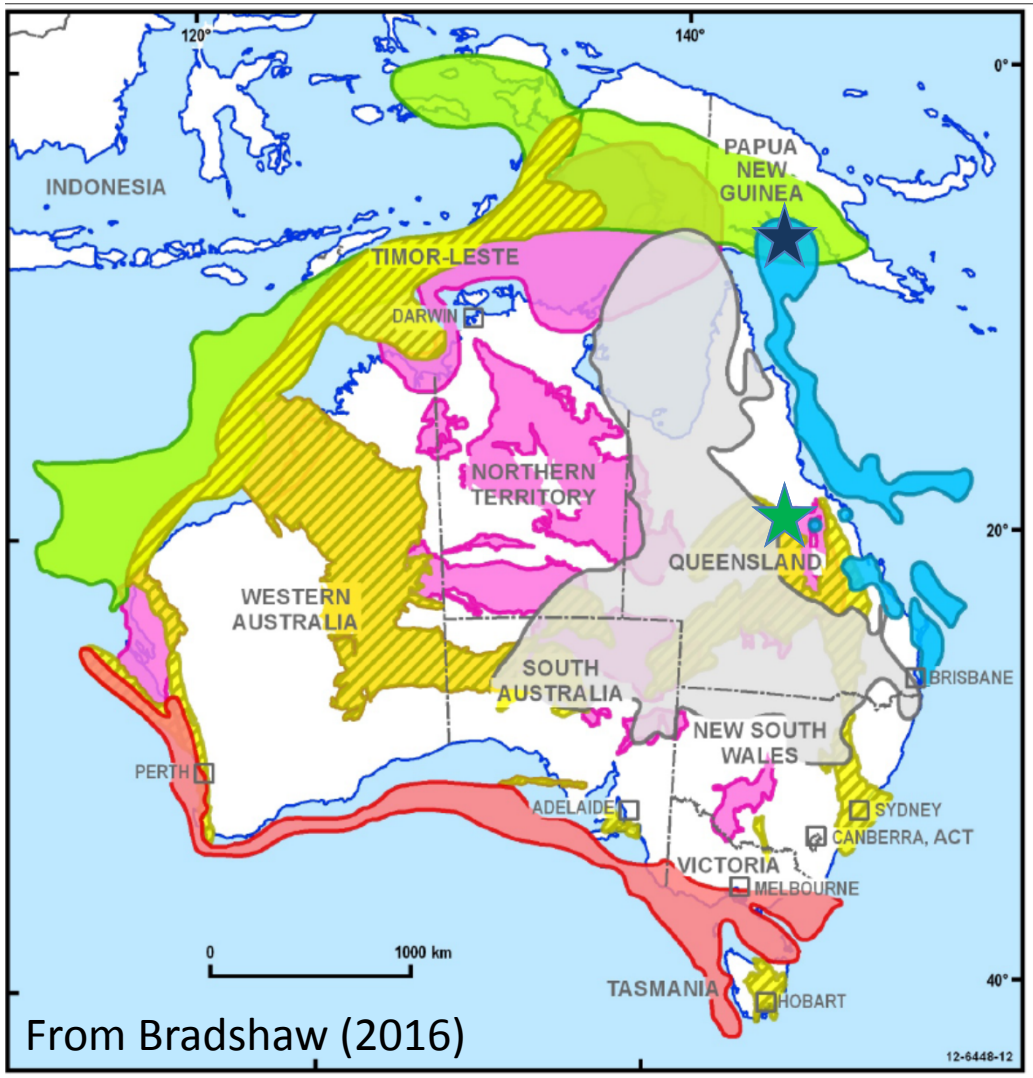


SA is situated between the Archaean Shield and eastern orogenic belts.

As a result, the State's geological record has preserved a unique history of sedimentation from Proterozoic - Ordovician and from Early Devonian - Cenozoic







URAPUNGAN - Mesoproterozoic
- McArthur Basin

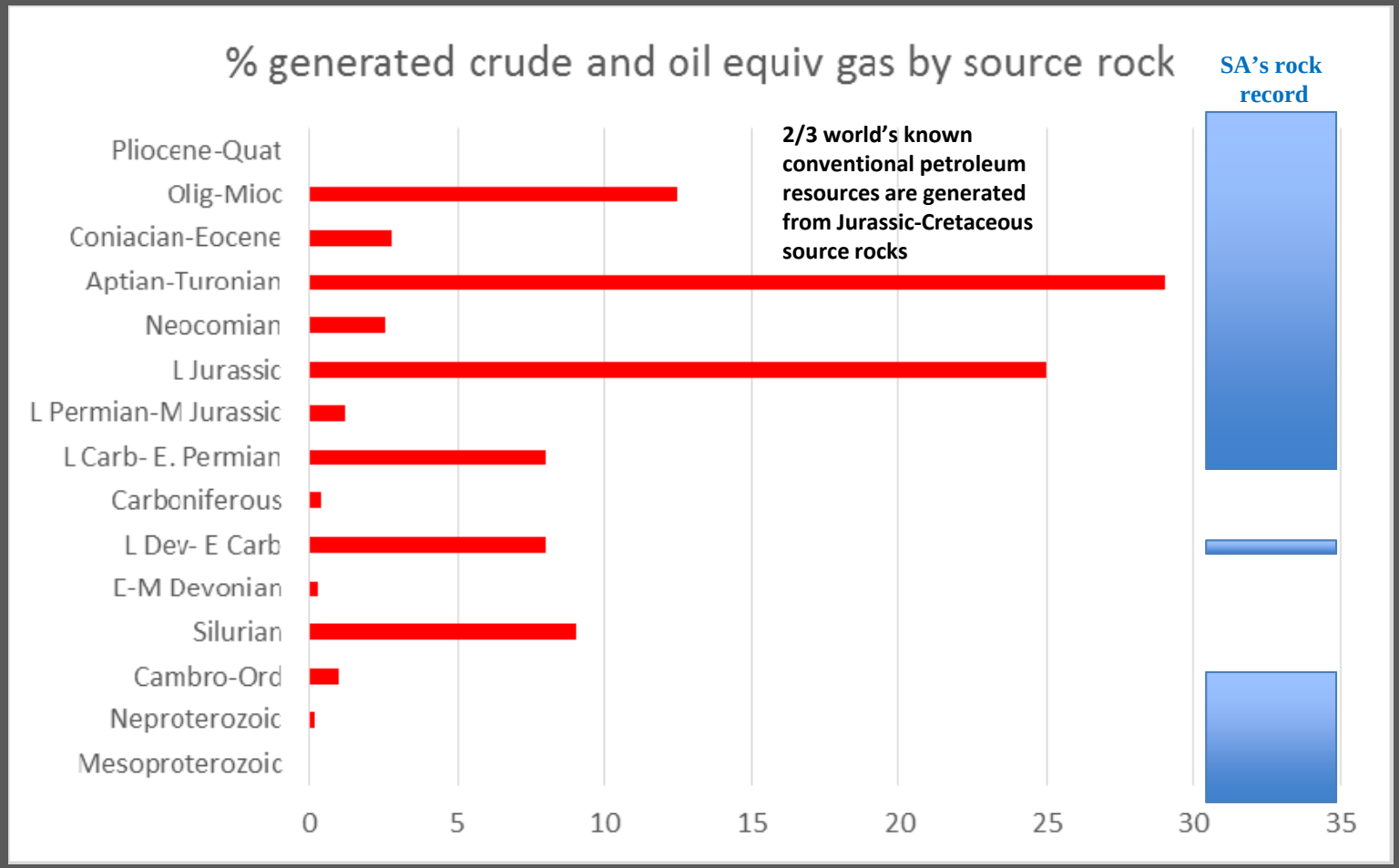
CENTRALIAN - Neoproterozoic
- Amadeus (NT), Officer

LARAPINTINE - Early Palaeozoic
- tropical seaways, marine source rocks from Australia to China

GONDWANAN - Late Palaeozoic
- mountain building, glaciation
- extensive and thick coal measures

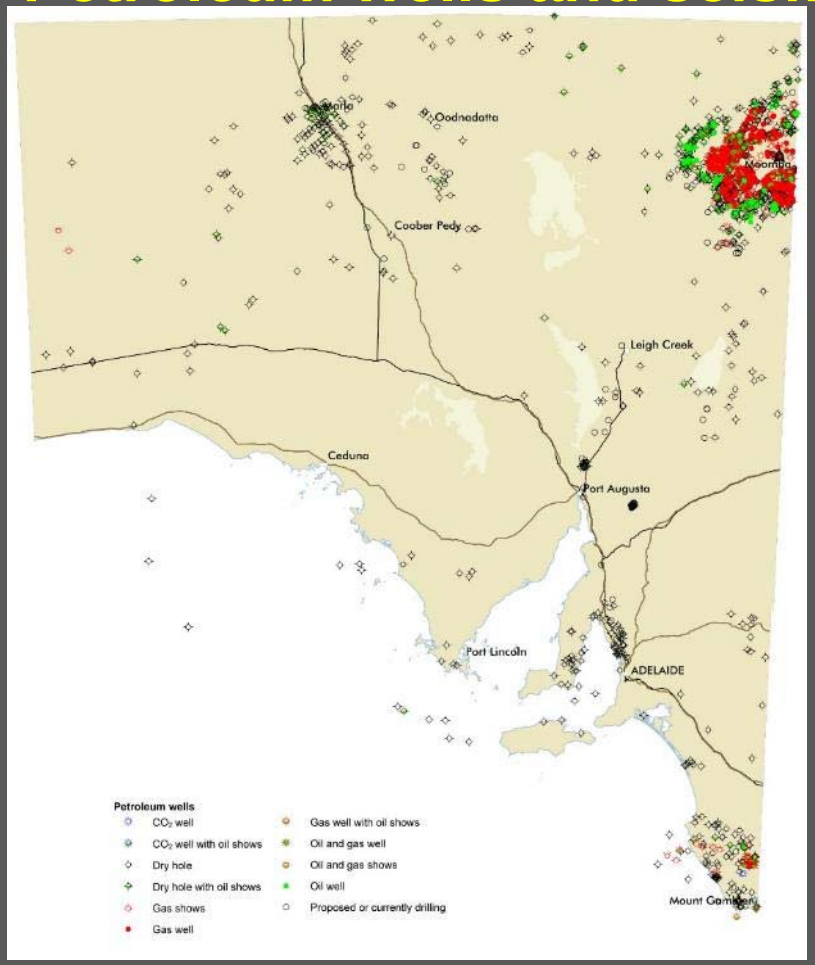
WESTRALIAN, MURTA, AUSTRAL - Mesozoic
- Gondwana break up
- oil & gas in rifted margins
- Intracratonic basins

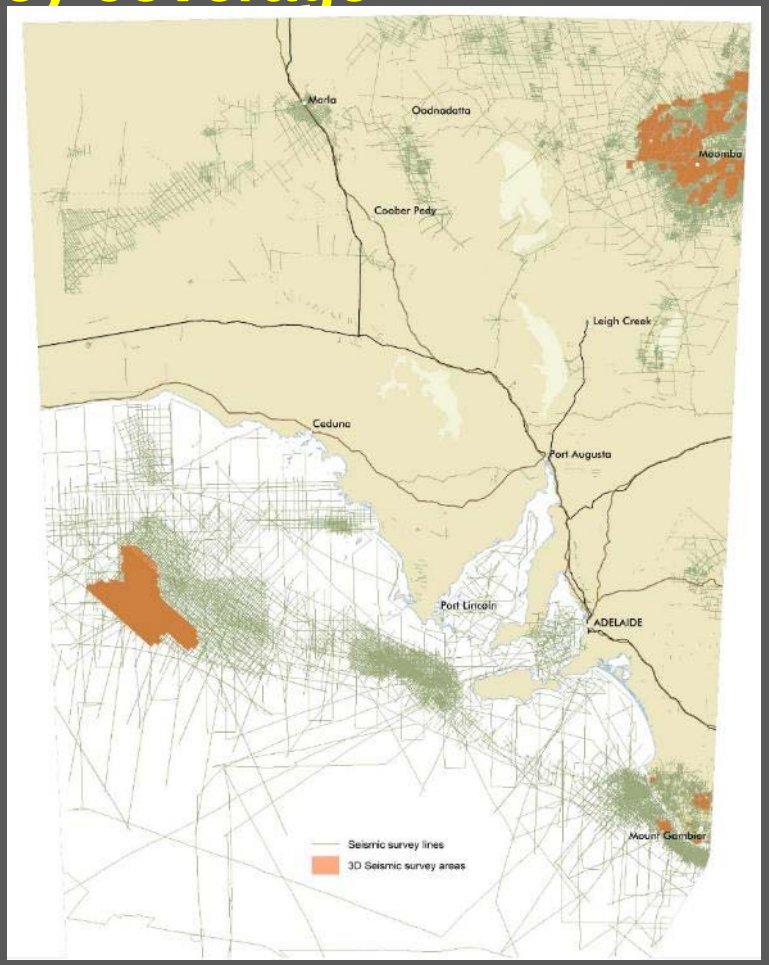
CAPRICORN - Eocene
- Oil shales in rifts
- Carbonate system



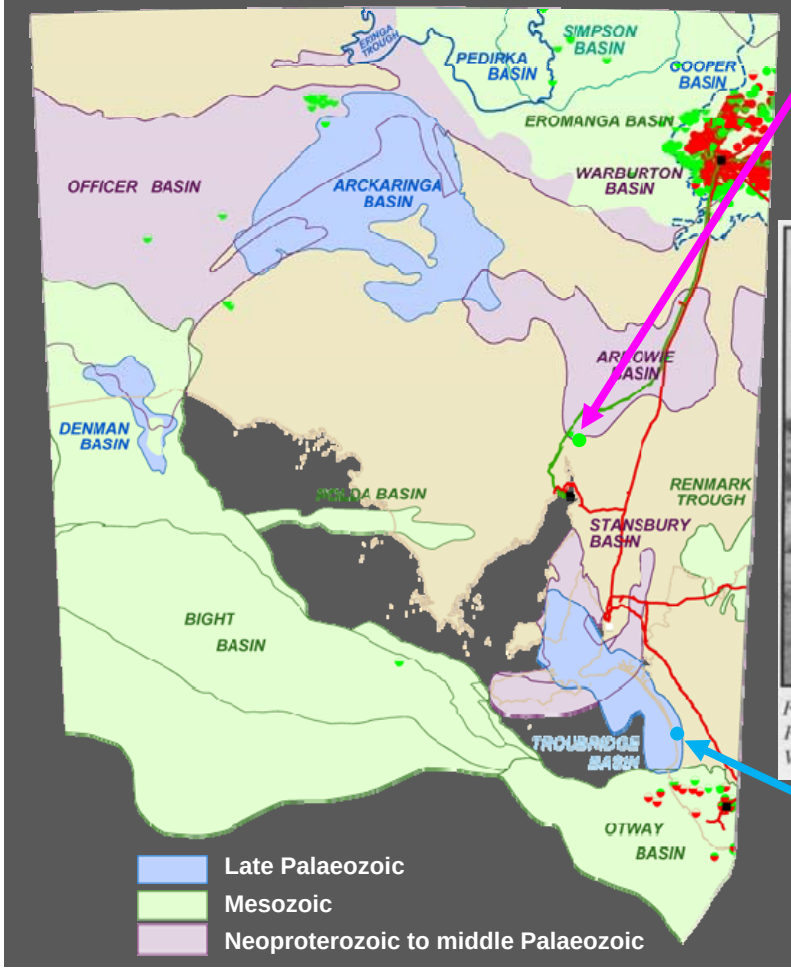
Modified from Sorkhabi, R. (2009). Oil and gas around the World. *Earth*, 54(12).

Petroleum wells and seismic survey coverage



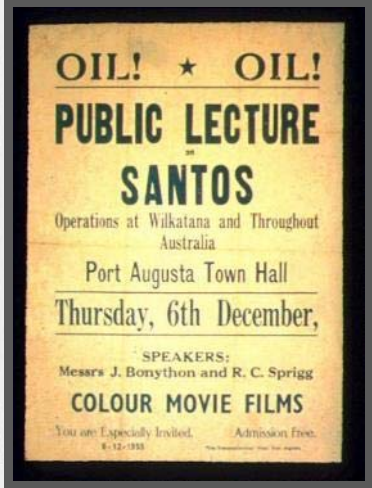


Oil and Gas shows in SA basins



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

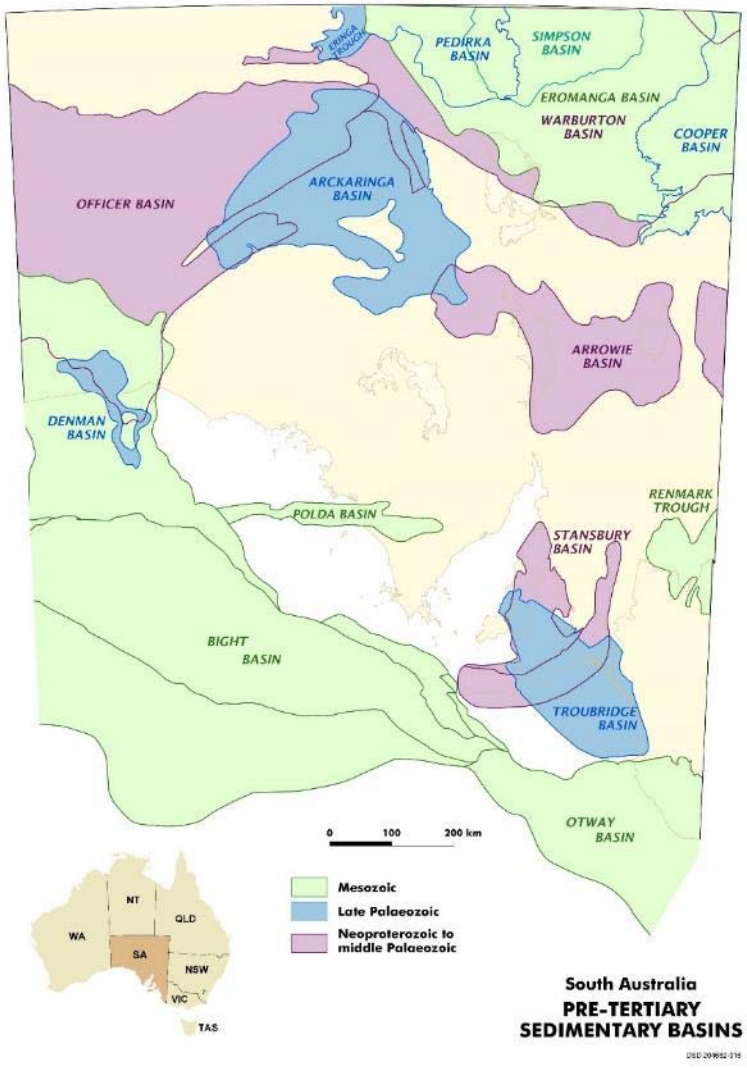
From left, John Bonython, Reg Sprigg and Robert Bristowe in discussion at Wilkatana, 1955.



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

'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



SA's petroleum systems

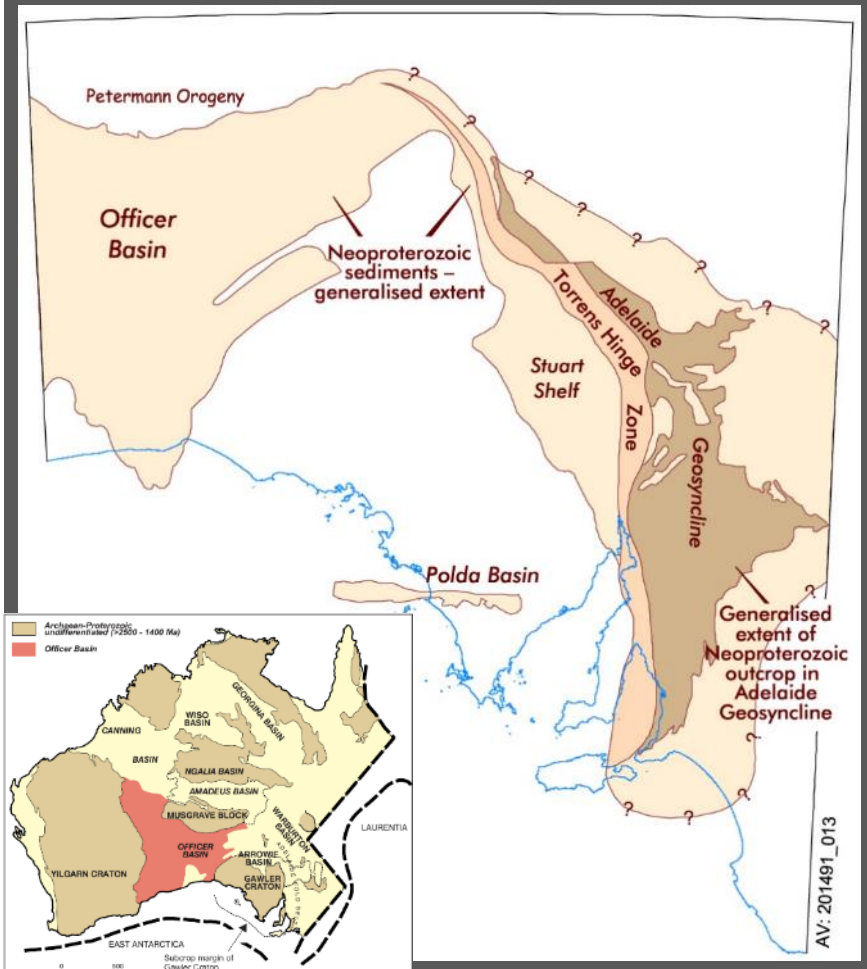
CENTRALIAN - Neoproterozoic
- Amadeus (NT), Officer

LARAPINTINE - Early Palaeozoic
- tropical seaways, marine source rocks from Australia to China

GONDWANAN - Late Palaeozoic
- mountain building, glaciation
- extensive and thick coal measures

MURTA - Mesozoic
- Gondwana break up
- Intracratonic basins – Jurassic non-marine deposition, E Cret. marine then

Proterozoic basins



MESOPROTEROZOIC

URAPUNGAN PETROLEUM SYSTEM

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

NEOPROTEROZOIC

CENTRALIAN PETROLEUM SYSTEM

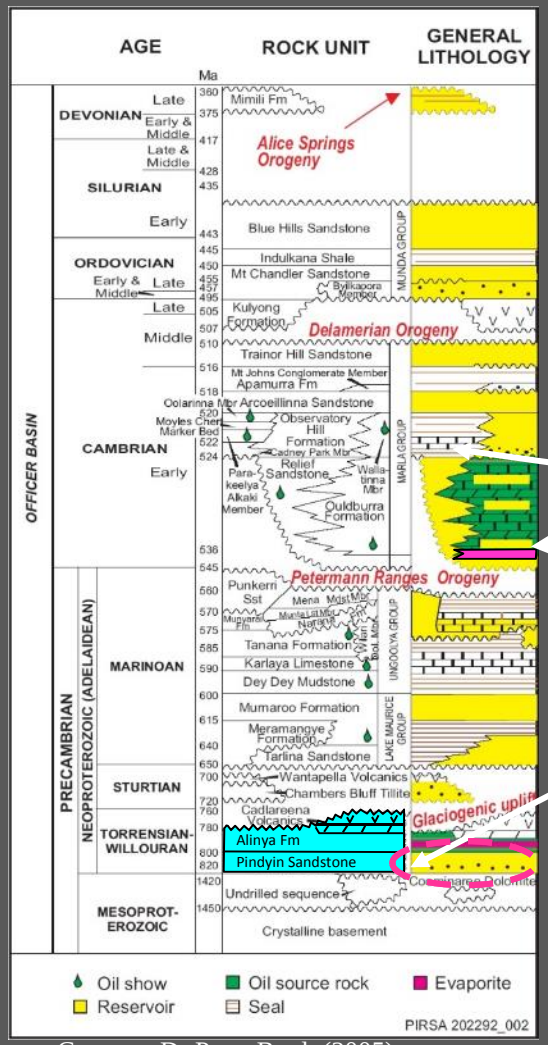
Widespread marine to non-marine deposition, in a rift setting, minor igneous activity.

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



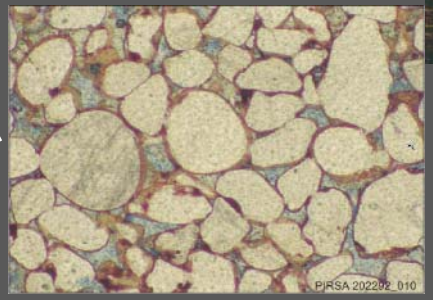
Courtesy Dr Peter Boult (2005)

Seals

Charge

Observatory Hill Fm.
219.75m

Reservoir



Pindyin Sandstone

Porosity = 22.6% Permeability = 1.5 Darcies

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

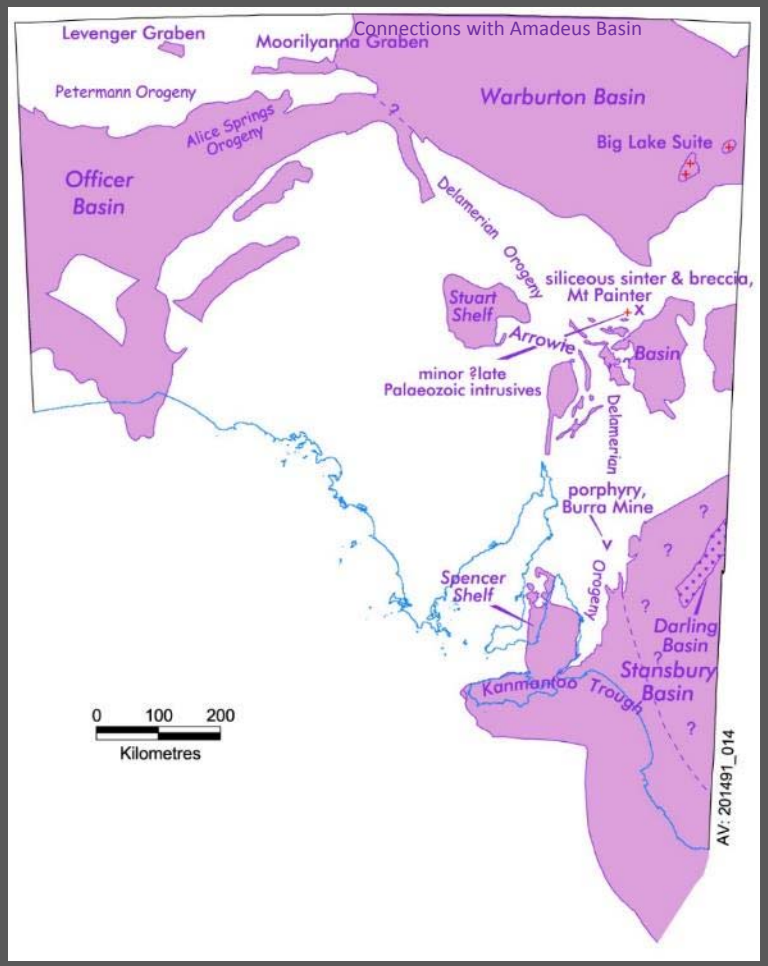
Seal – marine shale and salt

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.

Cambrian – Ordovician



LARAPINTINE PETROLEUM SYSTEM

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

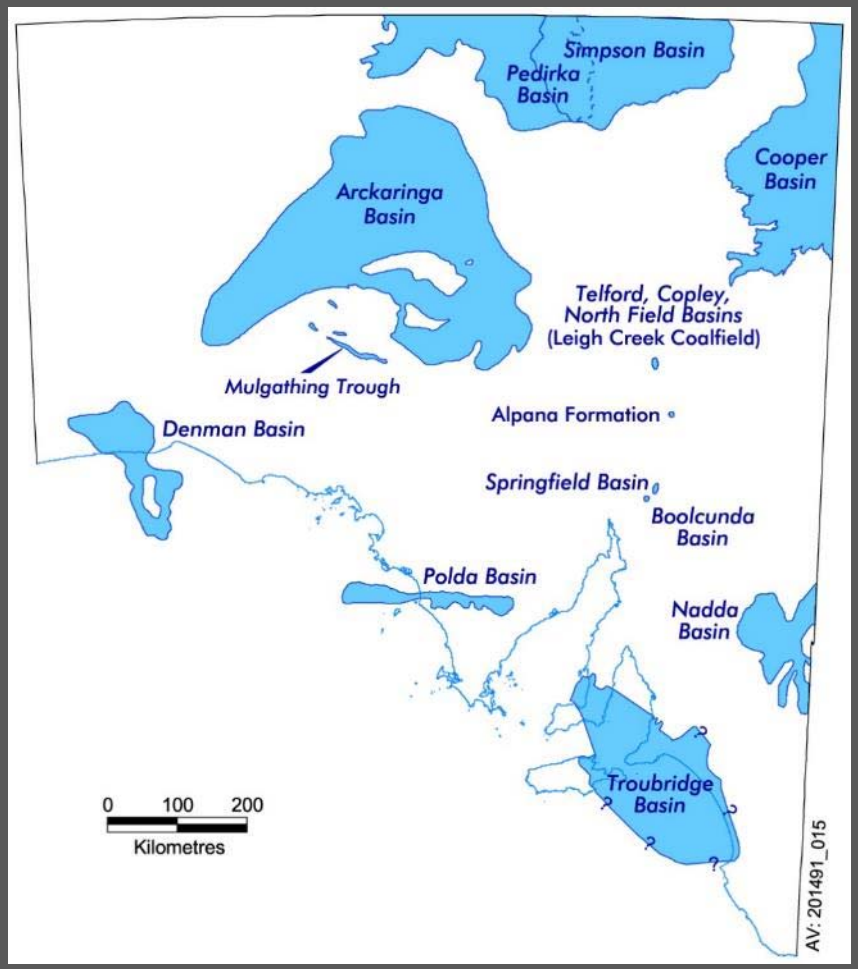
Officer Basin – 2 Cambrian petroleum systems identified by McKirdy and Tingate (2003).

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

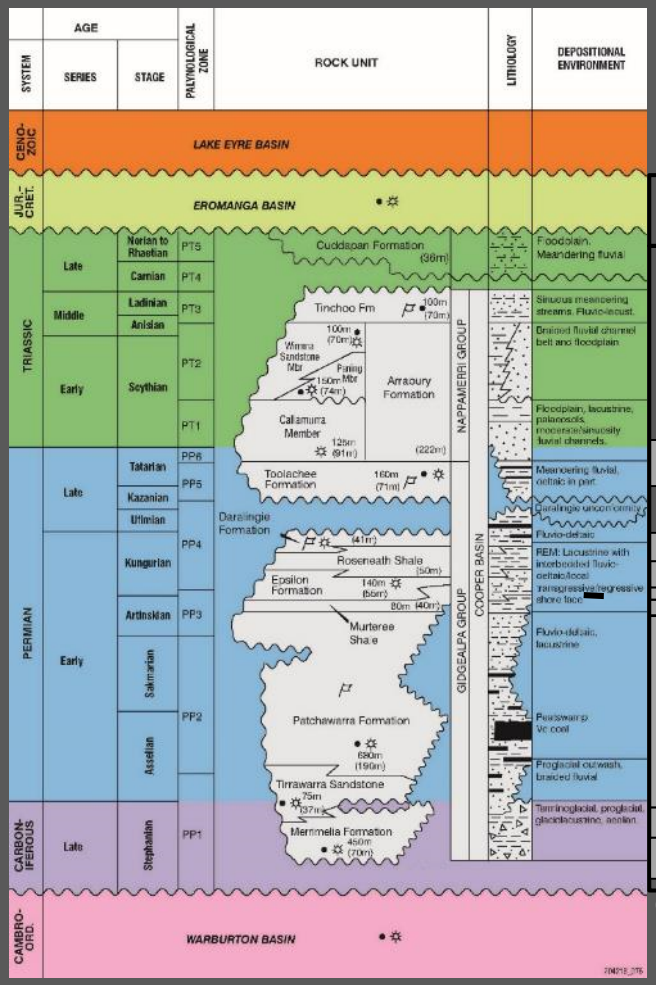


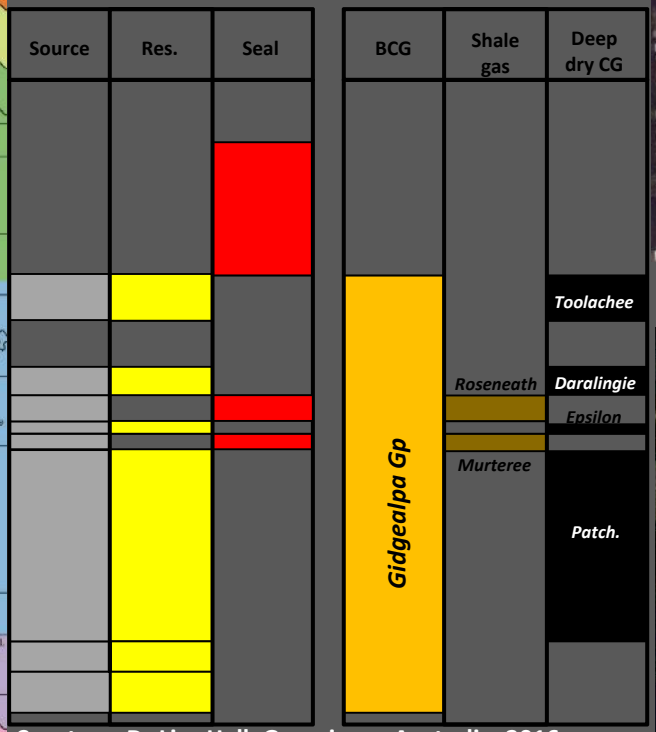
GONDWANAN - Late Palaeozoic

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).

Cooper Basin





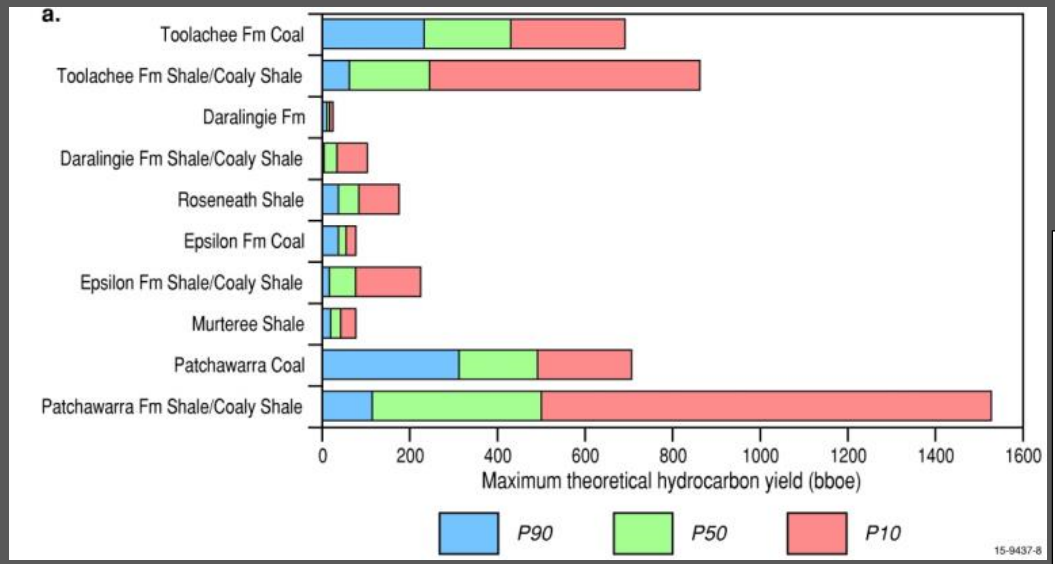
Courtesy: Dr Lisa Hall, Geoscience Australia, 2016

Toolachee Fm

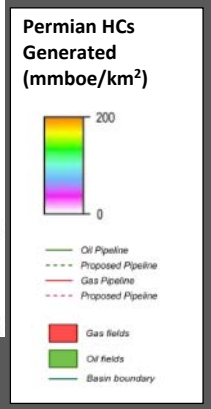
Patchawarra Fm

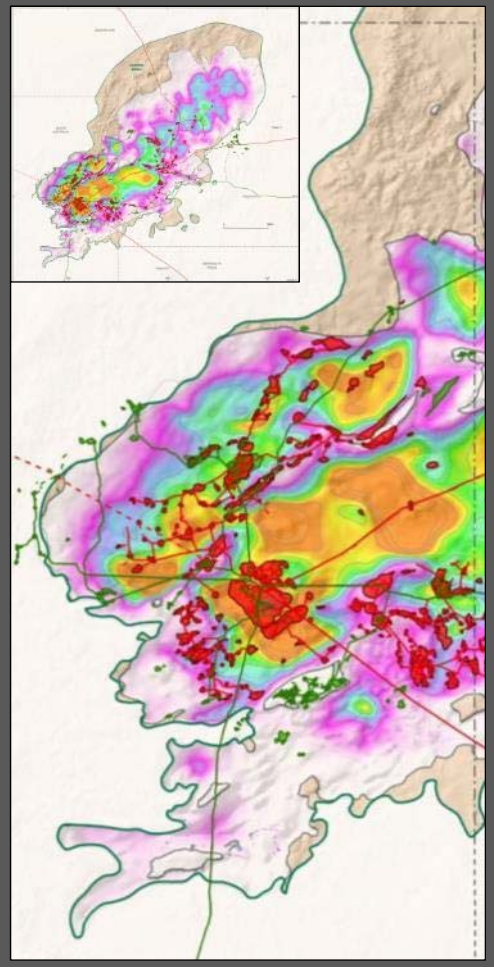
Hydrocarbon Generation Potential

- 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 Gidgealpa Group > 2000 billion bbls oil equiv



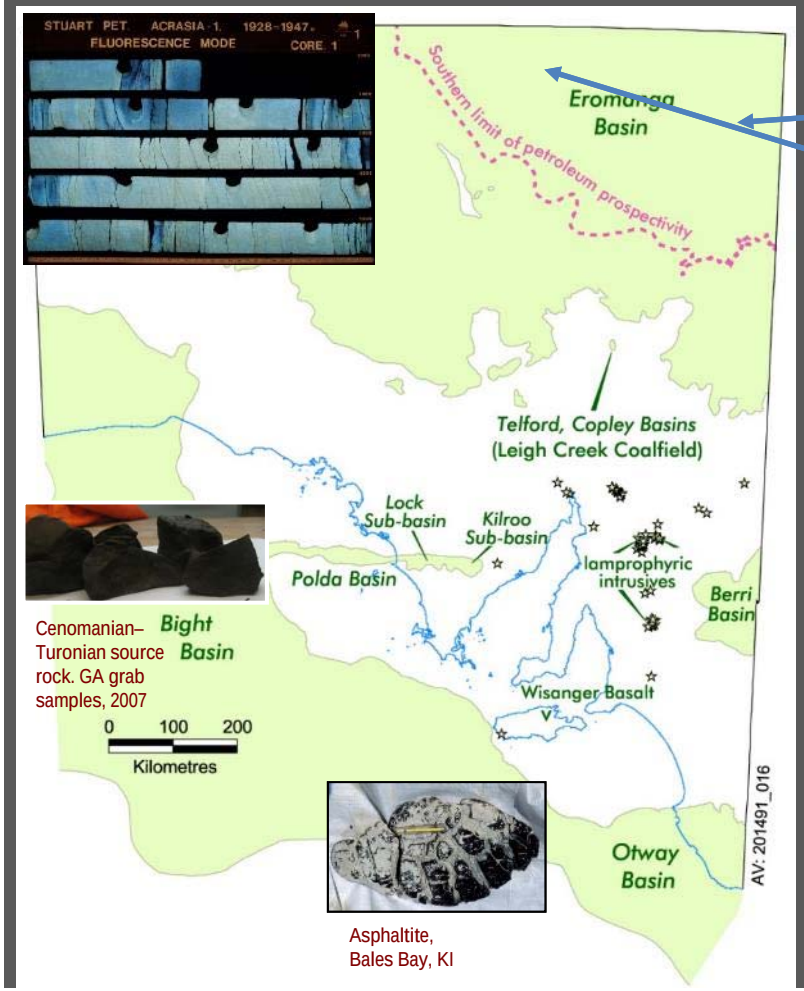
Hydrocarbon Generation by Formation and Lithology (bboe)





From Dr Lisa Hall (GA) 2016

Jurassic to Cretaceous basins

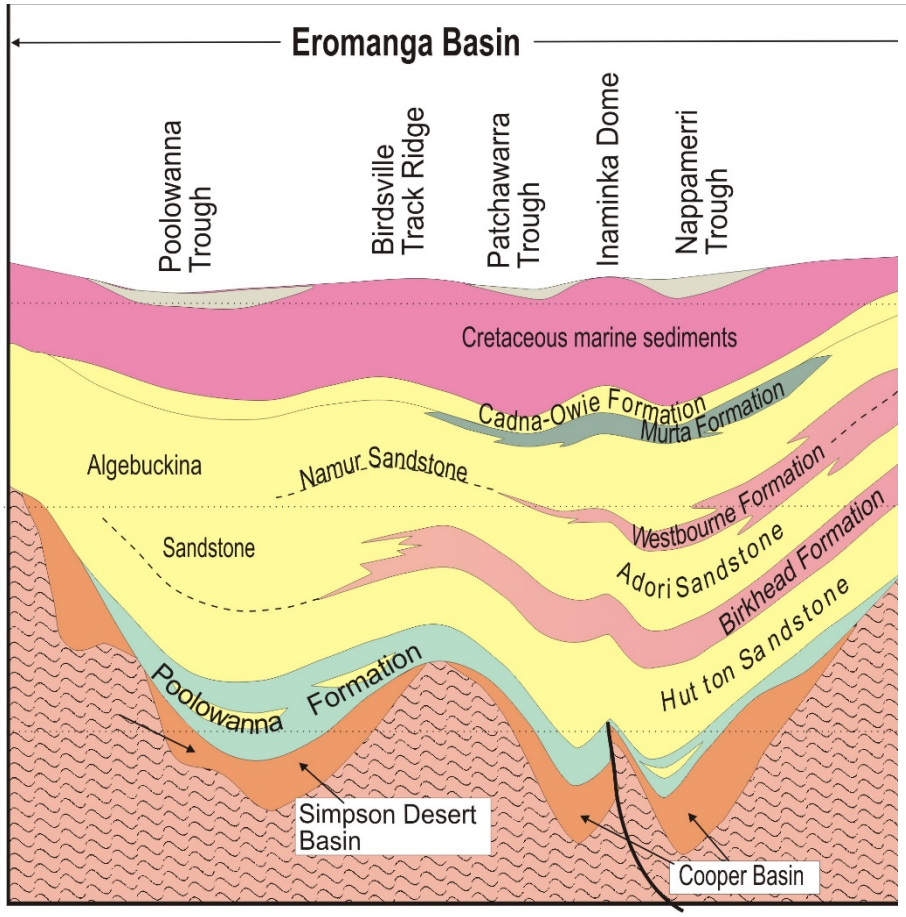


Cenomanian–Turonian source rock. GA grab samples, 2007

Asphaltite, Bales Bay, KI

MURTA PETROLEUM SYSTEM - *Eromanga Basin* -
extensive intracratonic deposition, thick depocentres –
Cooper region (>3km) and
Poolowanna Trough (>3 km).
Excellent reservoirs, seals. Source – how much Eromanga oil vs oil from down-dip Permian?
Oil shows in Poolowanna Trough. Structural & stratigraphic traps.
E Cretaceous Toolebuc Fm oil shale?
E Jurassic Poolowanna Fm?

AUSTRAL PETROLEUM SYSTEM
Southern rifted margin, Gondwana break up
Otway Basin – massive thickness of sediment (>9km), oil shows & economic gas onshore, offshore asphaltite strandings and shows, fault seal risk.
Bight Basin – 15km thick. Oil shows in Greenly 1, gas anomalies, GA's Jurassic oil shale grab sample.



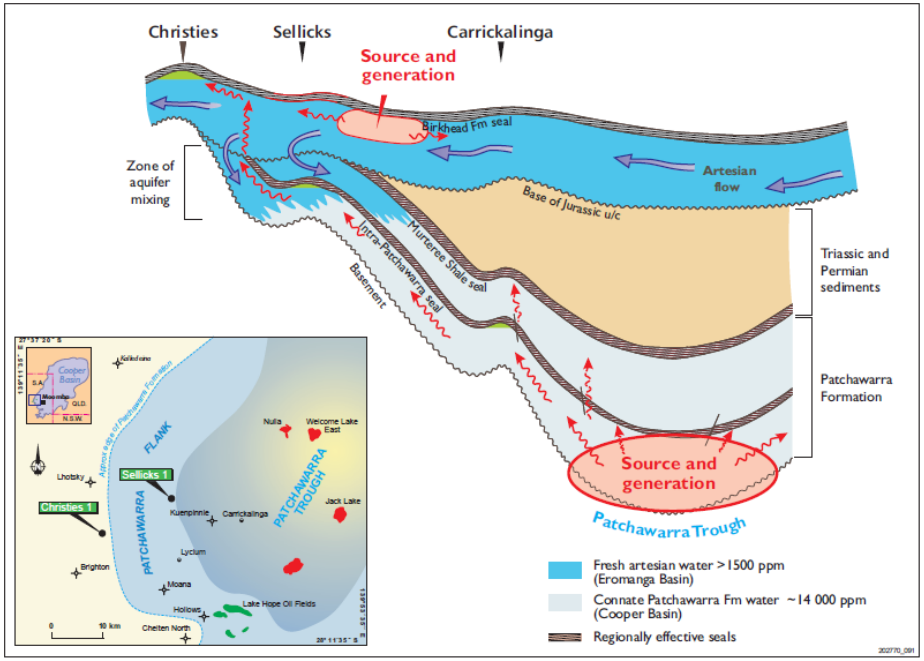
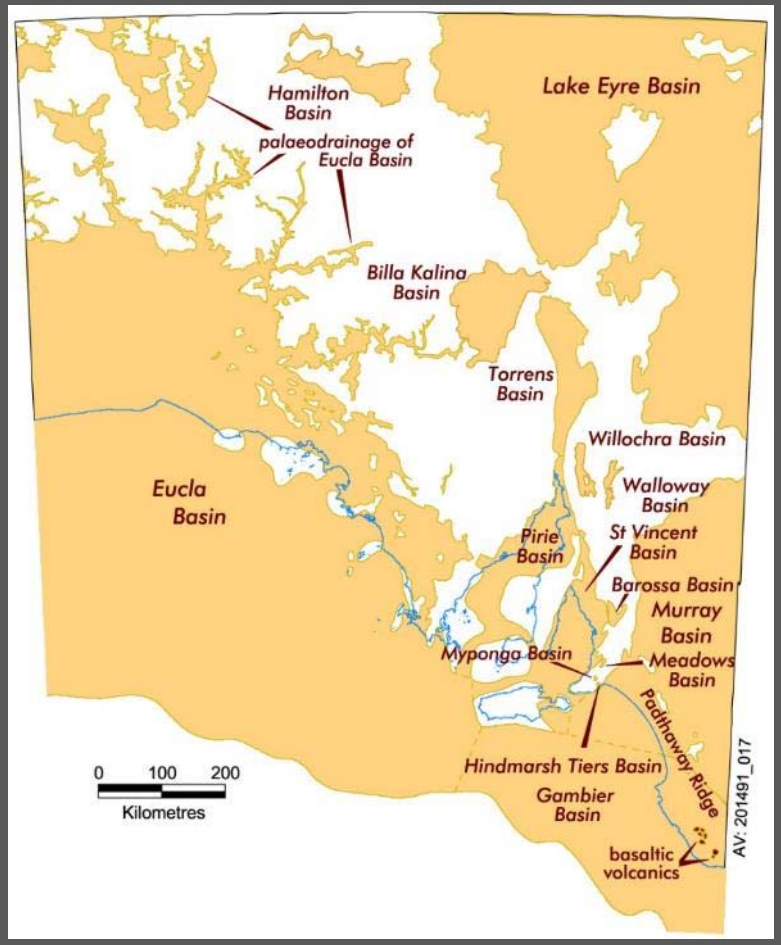


Figure 10.6 Schematic representation of the Patchawarra Trough showing the migration of oil towards the Patchawarra sub-crop margin and the increased susceptibility to water washing with exposure to the open aquifer system of the Great Artesian Basin (after Altmann and Gordon, 2004; Errock, 2005).

Cenozoic



Trap formation, migration.
Reactivations, uplift – traps breached in some basins.
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?

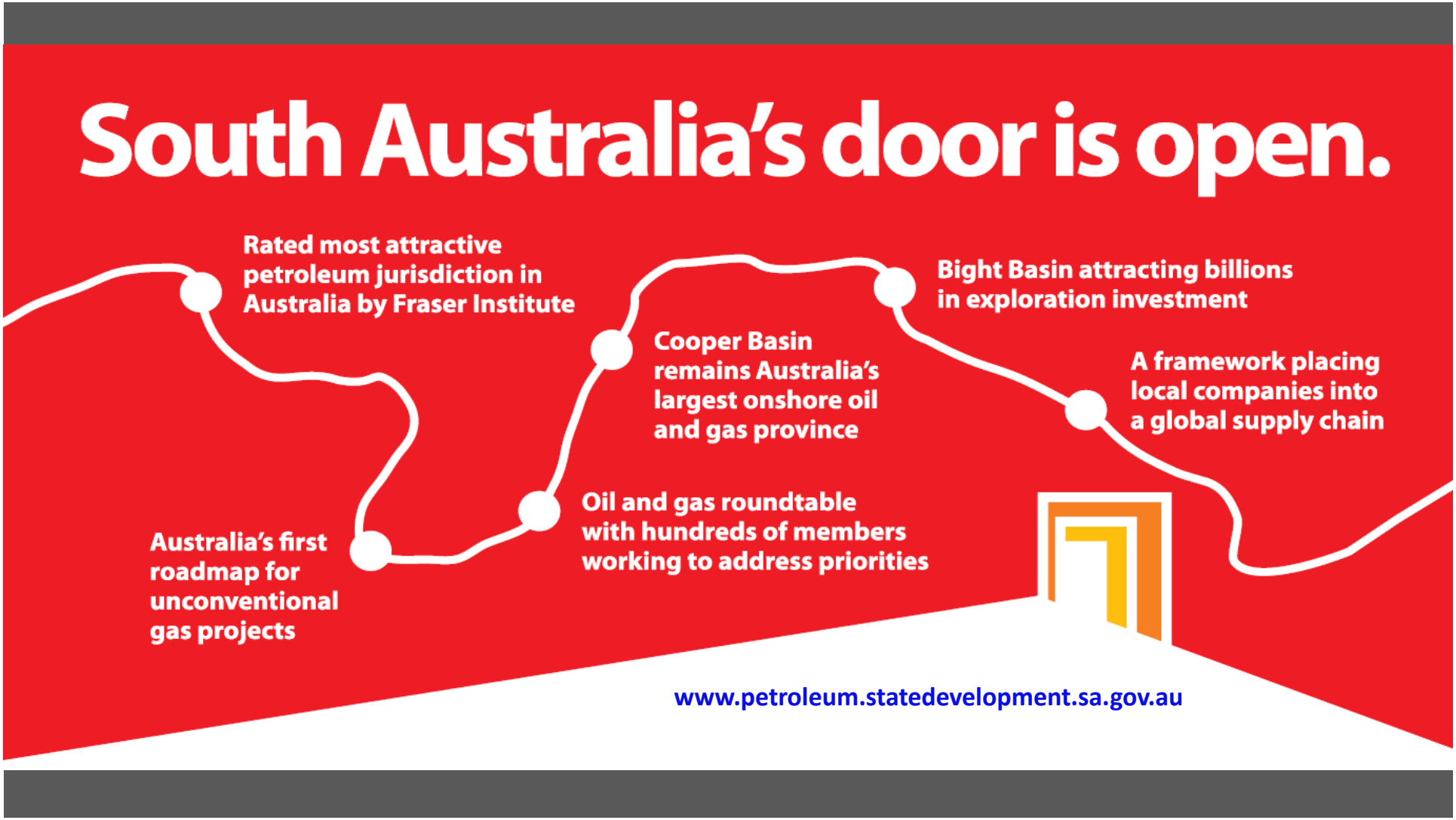
Potential for oil and unconventional reservoir plays in Otway Basin?

Potential for conventional oil and gas plays in Bight Basin?

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 using Trinity package.
- Collating data to build new models for all key SA basins. Review overlooked basins and plays.
- Developing new data products – e.g. PEPS-SA online, downloadable LAS well logs, seismic, more GIS data.

Please say G'day at the Australian stand to discuss further.


South Australia's door is open.
Rated most attractive petroleum jurisdiction in Australia by Fraser Institute
Cooper Basin remains Australia's largest onshore oil and gas province
Bight Basin attracting billions in exploration investment
A framework placing local companies into a global supply chain
Oil and gas roundtable with hundreds of members working to address priorities
Australia's first roadmap for unconventional gas projects
www.petroleum.statedevelopment.sa.gov.au