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.

Selected References


Tingate, P.R., and D.M. McKirdy, 2003, Exploration Opportunities in the Officer Basin: Primary Industries and Resources, South Australia, Report Book 2003/1, 8 p.
An overview of South Australian Petroleum Systems

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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

From Bradshaw (2016)
2/3 world’s known conventional petroleum resources are generated from Jurassic-Cretaceous source rocks.
Petroleum wells and seismic survey coverage
Oil and Gas shows in SA basins

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

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

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.

Officer Basin

Seals

Reservoir

Charge

Pindyin Sandstone

Porosity = 22.6% Permeability = 1.5 Darcies

Courtesy Dr Peter Boul (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).


**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.
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

Conventional Resource Plays

<table>
<thead>
<tr>
<th>Source</th>
<th>Res.</th>
<th>Seal</th>
<th>BCG</th>
<th>Shale gas</th>
<th>Deep dry CG</th>
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**Toolachee Fm**

- **Gidgealpa Gp**
  - **Roseneath**
  - **Daralingie**
  - **Murteree**
  - **Patch.**

**Gidgealpa Gp**

- **Patchawarra Fm**

Courtesy: Dr Lisa Hall, Geoscience Australia, 2016
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.

*From Dr Lisa Hall (GA) 2016*
Jurassic to Cretaceous basins

**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.
Eromanga Basin

Poolowanna Trough, Birdsville Track Ridge, Patchawarra Trough, Inaminka Dome, Nappamerri Trough

Cretaceous marine sediments

Algebuckina, Namur Sandstone, Sandstone, Poolowanna Formation, Simpson Desert Basin, Cooper Basin

Figure 10.4 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 Alleman and Gordon, 2004; Emrick, 2009).
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
- 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
- Oil and gas roundtable with hundreds of members working to address priorities
- Australia’s first roadmap for unconventional gas projects

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