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australian energy producers journal
SUPPLEMENT | EXTENDED ABSTRACT
https://doi.org/10.1071/EP25043

Play analysis in the Daralingie Shelf area of the Eastern Warburton Basin, South Australia

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Accepted: 19 March 2026
Published: 14 May 2026

Cite this: Strong P *et al.* (2026) Play analysis in the Daralingie Shelf area of the Eastern Warburton Basin, South Australia. *Australian Energy Producers Journal* **66**, EP25043. doi:10.1071/EP25043

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ABSTRACT

The Cambrian to Ordovician Warburton Basin lies in northeast South Australia, southernmost Northern Territory and southeast Queensland and covers approximately 400,000 km^2. In South Australia, the eastern part underlies the bulk of the hydrocarbon-producing Permian Cooper Basin. The Warburton, like the Cooper, is hydrocarbon-bearing with many shows recorded from a wide variety of lithologies and stratigraphic intervals. The authors conducted an integrated geological and geophysical study of the Eastern Warburton Basin, providing new insights into the basin stratigraphy, evolution and prospectivity for hydrocarbons. Regional gross depositional environment (GDE) maps were prepared, with a detailed GDE map constructed for the uppermost Warburton interval centred on the Daralingie Shelf region. Play analysis was undertaken to understand the distribution of potential reservoirs, seals, mature source rocks and potential hydrocarbon migration pathways. This required a review of the initial GDE mapping with an iteration made reflecting the newly defined '800–1000' stratigraphic interval. Maps for this interval are presented as an example of the GDE-based play mapping process.

Keywords: 800–100 stratigraphic interval, Cooper Basin, Daralingie Shelf, gross depositional environment maps, hydrocarbons, play analysis, South Australia, Warburton Basin.

Introduction

The Cambrian to Ordovician Warburton Basin lies in northeast South Australia, southernmost Northern Territory and southeast Queensland and covers approximately 400,000 km^2 (Glikson *et al* 2013). It underlies the Cooper Basin and is hydrocarbon-bearing with a significant catalogue of shows, tests and production from a wide variety of lithologies and stratigraphic intervals (Kirk *et al*. 2025). In 2025, the authors conducted an integrated geological and geophysical study of the Warburton Basin in South Australia, providing new insights into the basin stratigraphy and evolution and prospectivity for hydrocarbons (DEM 2025; Rady *et al*. 2025). Regional gross depositional environment (GDE) maps were prepared, with a detailed GDE map constructed for the uppermost interval in the Daralingie Shelf area southwest of Moomba.

Subsequently play analysis of the uppermost newly defined '800–1000' stratigraphic interval (Rady *et al* 2025) section was conducted to understand the distribution of reservoirs, seals, mature source rocks and potential hydrocarbon migration pathways as an important part of highlighting the petroleum prospectivity of this region.

Play analysis

A petroleum 'play' is defined by Rose (2017) as a trend of geologically related leads, prospects and possibly producing oil and gas fields, sharing elements of similar geological history of hydrocarbon charge, reservoir/seal pairs and trap controls. They are typically defined by age, with plays generally separated by a regionally significant seal.

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Play analysis is a technique to understand petroleum systems, integrating tools including seismic and well data to define a series of play maps that can be used to focus exploration strategy and improve prospect chance assessment. Strong and Cubitt (2024) offers a full discussion of the methodology.

2025 Study of the Daralingie Shelf

The study commenced with a regional seismic interpretation across the entire Eastern Warburton Basin in South Australia, with around 50,000-line kilometres of seismic data interpreted by Kirk *et al.* (2025). In parallel, core and seismic interpretation focussed on the Daralingie Shelf area of interest (Fig. 1*a*). This map shows wells that penetrated the Warburton, wells with interpreted Warburton core (2025 study) and wells that penetrated the Carboniferous Big Lake Suite (BLS) granite (Gatehouse *et al.* 1995).

Play analysis of the '800–1000' interval

Kirk (2025) defined the '400–1000' interval that was later subdivided by Rady *et al.* (2025) into the lower '400–800' and upper '800–1000' intervals (Fig. 1*b*). Wells have only penetrated the '800–1000' interval and so this interval became the focus of play mapping. Subsequently, play elements in this interval such as reservoir distribution, presence of a seal and likely charge from potential source rocks were assessed. The results of this work, illustrative of DEM's play mapping methodology, are presented and discussed in the following sections.

GDE mapping

GDE mapping is one method of understanding the distribution of potential reservoirs by integrating many data types such as core and seismic (Cubitt *et al.* 2024). The GDE map for the Warburton '400–1000' interval as outlined in Rady *et al.* (2025) was used as a starting point, with review and revision using isochron mapping and reservoir facies identified from seismic interpretation to help derive a new '800–1000' interval GDE map. This 'iteration of interpretation' process is required as part of play mapping whereby individual play element maps (reservoir, seal and charge) are reviewed numerous times reflecting the latest information and interpretation. Fig. 2*a* illustrates the results of numerous iterations for the '800–1000' interval showing interpreted BLS granitic bodies which intruded into, and in some places through, the Warburton Basin during the Carboniferous. Nine wells have intersected the BLS, highlighting the potential for the development of a viable reservoir-seal pair within this interval.

Seal

The GDE map illustrated in Fig. 2*a* is drawn at the most progradational time. Hence, high-frequency sea level rise and fall may result in sealing by shelf facies over delta and tidal plain deposits. Mudstones, siltstones and dolomitic limestones deposited primarily over the inner shelf may also act as suitable seals (e.g. as reported in the open-file Lycosa 1 Well Completion Report). In the northwest, volcanic ashfall deposits are described in core in Sturt 7 as welded ignimbrites by Cubitt and Tiainen (2026) and are also regarded as effective seals. Fig. 2*b* shows the likelihood of suitable sealing facies for the '800–1000' interval reservoirs.

Source rocks and hydrocarbon migration

The presence of oil and gas in the study area is thought to be due to migration from proven Permian source rocks that overly the Warburton, although suitable Cambrian source rocks may exist in the basin. Rady *et al.* (2025) illustrates the potential charge from Permian source rocks via updip migration into potential Warburton reservoirs.

A common technique used in the Cooper–Eromanga Basins for estimating if a present day structure is likely to have been hydrocarbon-charged involves the relationship between the Eromanga Basin Winton Formation (or Cadna-owie Formation as a proxy) and the top of the target formation; the resultant isopach/isochron between the intervals approximates the target surface structure at time of migration, with thin isopach/isochron areas suggestive of highs indicating potential migration paths. In this example, the isochron between the Cadna-owie Formation two-way time (TWT) and the Base Cooper Basin/Warburton '1000 Marker' TWT structure was used, with potential migration paths from this map illustrated in Fig. 3*a*, indicating potential gas charge into '800–1000' interval reservoirs.

Also indicated in Fig. 3*a* are potential migration windows of 10 and 20 km around the interpreted edge of marginally mature Permian source rocks to illustrate the potential distances that hydrocarbons may have migrated in porous reservoirs within the '800–1000' interval. Fracturing/faulting within the Warburton may provide additional migration paths for hydrocarbons.

Play mapping

Once the distribution of each of the individual elements were determined, they were combined on one map, to allow review of where suitable elements may overlap each other to provide potential sweet spots for hydrocarbon accumulations (Fig. 3*b*). The map illustrated in Fig. 3*b* constitutes the play map for the '800–1000' interval, whereby the fairways (shown in dark/light green) account for known hydrocarbon shows/production and highlight the most prospective regions of undiscovered hydrocarbon accumulations in this interval.

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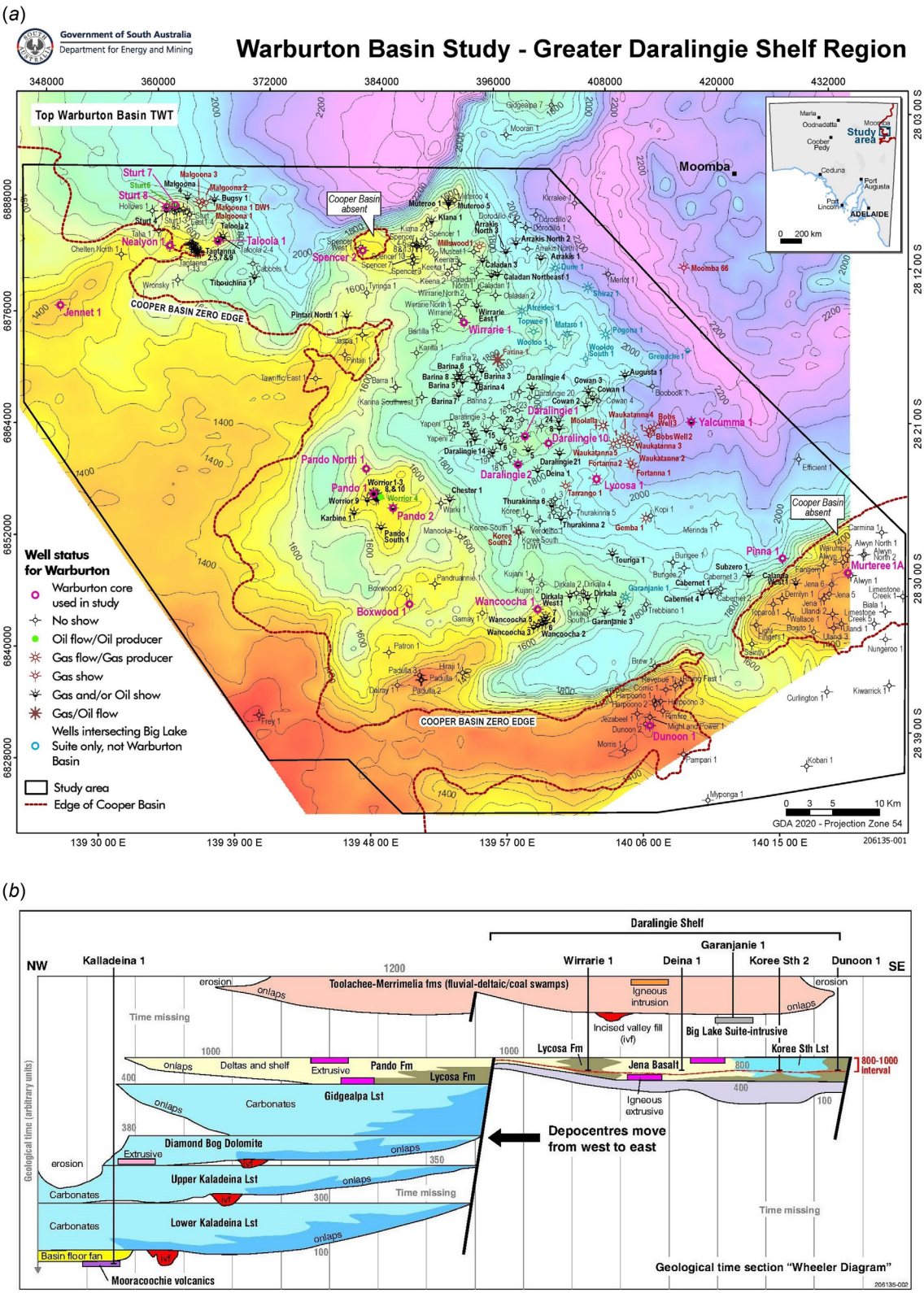


Fig. 1. (*a*) Study location map showing top Warburton Basin TWT structure, study wells, wells with interpreted Warburton core data (pink) and hydrocarbon shows within the Warburton Basin. (*b*) Regional Warburton Basin Wheeler Diagram (modified from Kirk 2025), with the reviewed play highlighted in red.

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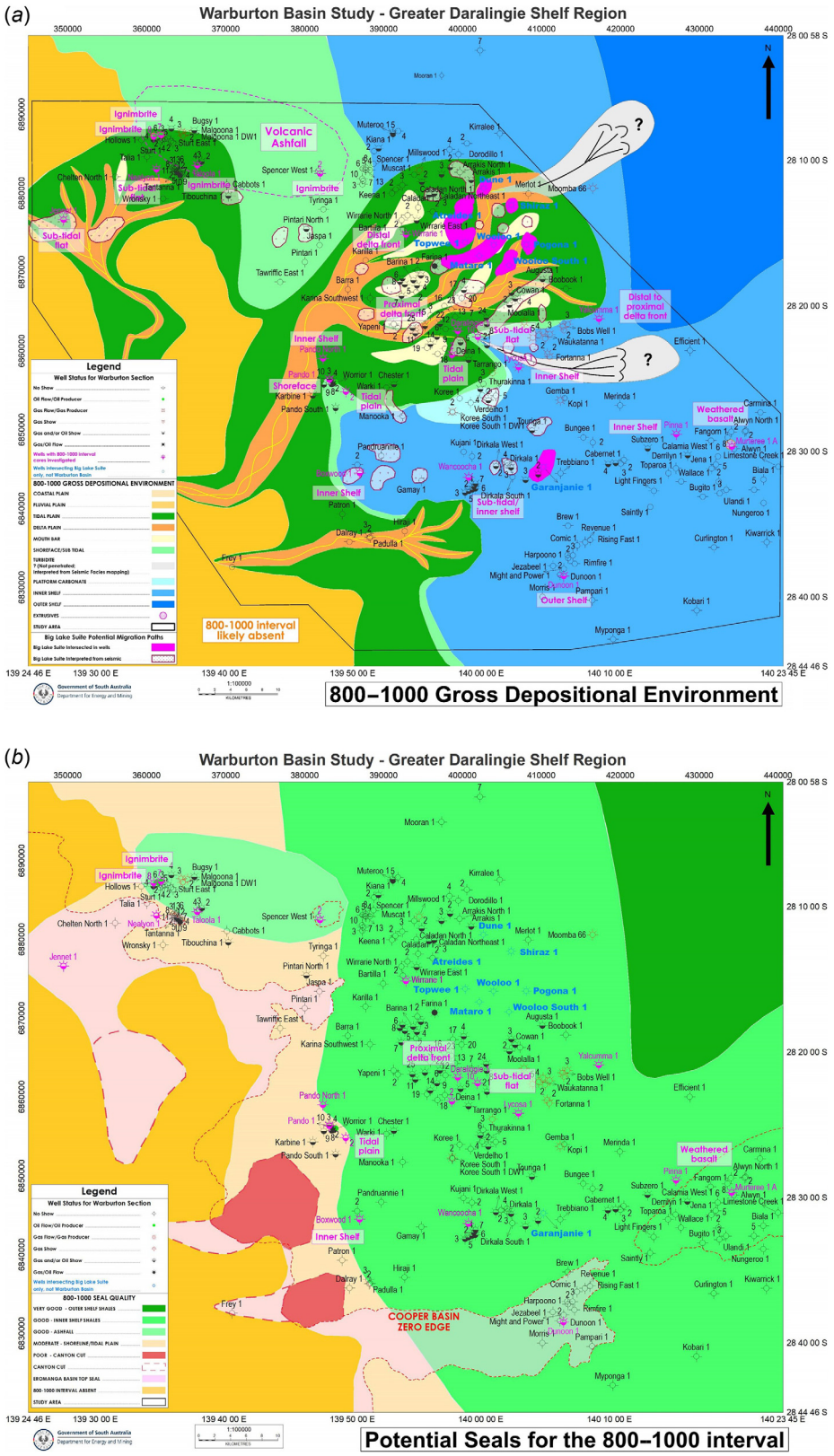


Fig. 2. (*a*) GDE map of the '800–1000' interval showing Present Day occurrence, including drilled and interpreted Big Lake Suite granite intrusions. (*b*) Seal map for '800–1000' interval reservoirs.

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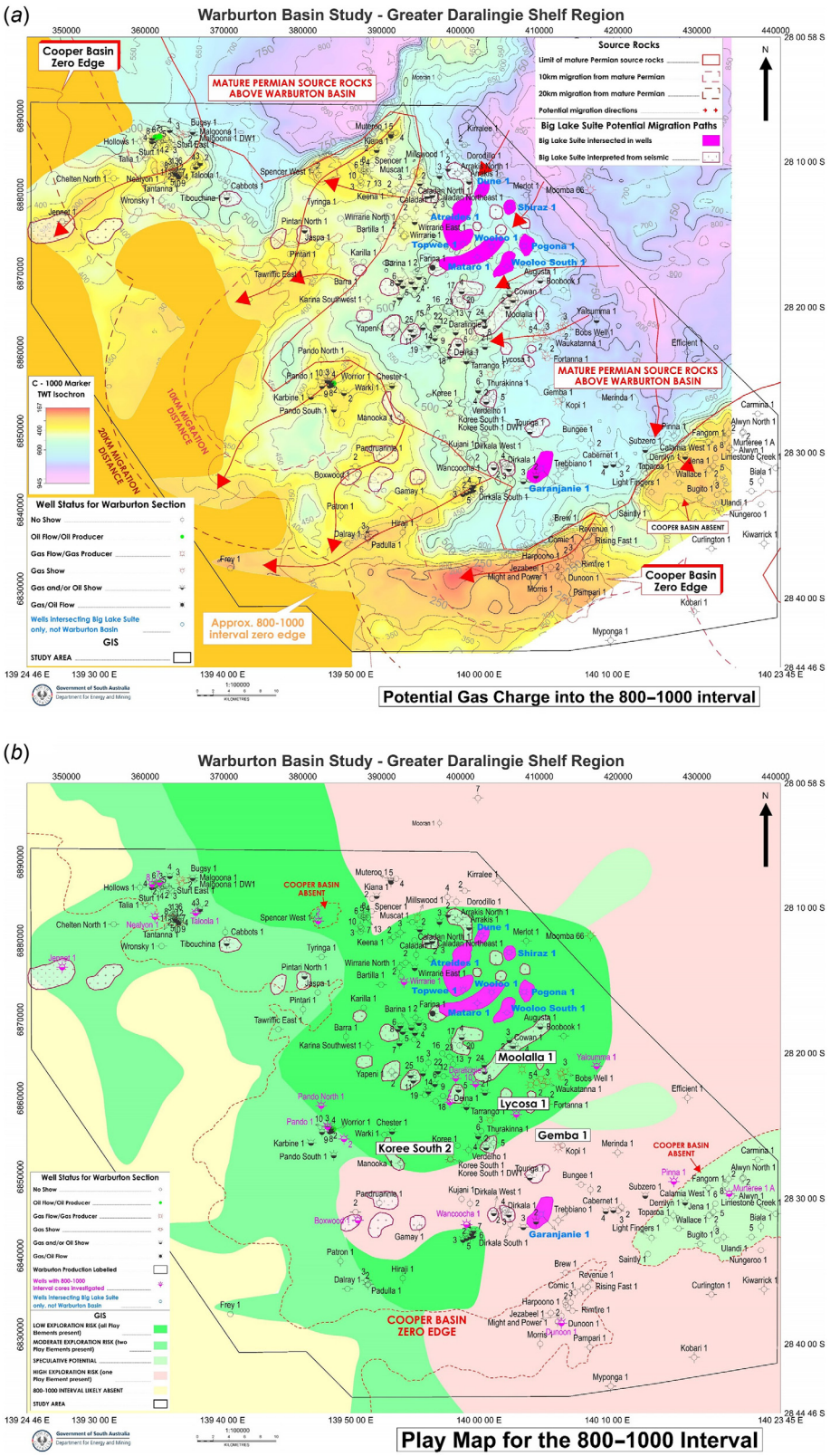


Fig. 3. (*a*) Potential hydrocarbon charge into the '800–1000' interval. (*b*) Play map for the Warburton Basin '800–1000' interval, showing sealed reservoir with likely charge in green.

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Conclusions

- The newly defined '800–1000' interval was the focus of iterative play mapping whereby a new GDE map was interpreted. Subsequently reservoir, seal and charge play element maps were combined into an interval specific play map.
- The '800–1000' play map reveals two NW-SE-trending fairways centred on this interval's coastal plain and deltas, with the NM Horst area also considered potentially prospective.

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Data availability. All data are available through the South Australia Department for Energy and Mining website.

Conflicts of interest. The authors declare that no conflicts of interest exist.

Declaration of funding. This research did not receive any specific funding.

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