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New Insights into the Prospectivity of the Eastern Warburton Basin, South Australia

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SUMMARY

A seismic interpretation and prospectivity screening study has been undertaken in the Eastern Warburton Basin in the Daralingie Shelf region of NE South Australia, integrating recently reprocessed 2D/3D seismic data with 82 wells, including 35 interpreted cores. The study builds upon the seismic sequence stratigraphic framework developed by Kirk et al (2025) by combining seismic attributes, structural and seismic facies mapping and core descriptions/interpretations to develop gross depositional environment (GDE) and updated reservoir distribution maps for the uppermost '400-1000' section. This work has provided new insights into the basin stratigraphy, evolution and prospectivity for hydrocarbons. Three play concepts are presented as recommendations for further work.

Key Words: Seismic, Stratigraphy, Depositional Environment, Prospectivity

INTRODUCTION

The Eastern Warburton Basin (Warburton) underlies the Cooper-Eromanga Basins in the project area (Figure 1). Over 80 wells have penetrated the uppermost '400-1000' section, while only Gidgealpa 1, 3, 5 and 7 penetrate a significant stratigraphic interval in the immediate area. Most of the project area comprises the uppermost '400-1000' seismic package as defined by Kirk et al, (2025) in press, which has historically been referred to as Dullingari group (Pando/Lycosa Fm). Hydrocarbons have been discovered in this interval with oil (e.g. Spencer, Sturt) and gas (e.g. Moolalla-1, Lycosa-1) being currently produced from pre-Permian reservoirs. Several more wells have flowed hydrocarbons on test or recorded oil & gas shows (Figure 1).

The primary objectives of the study were to integrate the latest well and seismic data with core interpretations and production/test data and apply a chronostratigraphic framework to update the Warburton sub-crop map, identify likely reservoir fairways and any prospectivity deemed worthy of further study by industry.

METHODOLOGY

The TGS 2Dcubed and 2D3Dcubed seismic volumes were loaded to DUG Insight and well-ties computed, based on acquired or nearby check shot surveys. A regional time-depth function was developed for wells without check shots and matched to implied interval velocities from DT log integrated transit times when applying stretch-squeeze. Coherency and pseudo-relief attributes were computed to characterise major faults, igneous intrusions and seismic geomorphology such as erosional scarps and valleys in section and map view. Several GIS layers were created to highlight dominant lithology intersections, depositional environment (DE), hydrocarbon shows, tests and production. Regional gravity and magnetic datasets were used to differentiate crystalline basement and igneous bodies from Warburton Basin sediments. Formation tops and core intervals were taken from the PEPS database and wireline logs provided by the SA Department for Energy and Mining.

The Warburton Basin sub-crop map was reinterpreted based on the tied well tops. The pick is challenging, with no consistent phase or character, and is often a subtle angular unconformity obscured beneath Patchawarra coals or Merrimelia Fm/Tirrawarra Sst packages. On basement highs, top Warburton becomes a high amplitude trough associated with a large acoustic impedance increase. Picks were gridded at 100m cell size and smoothed. The mapping has been completed on the PSTM volumes in two-way time and no depth conversion has been undertaken, although the regional time-depth function is provided as a starting point.

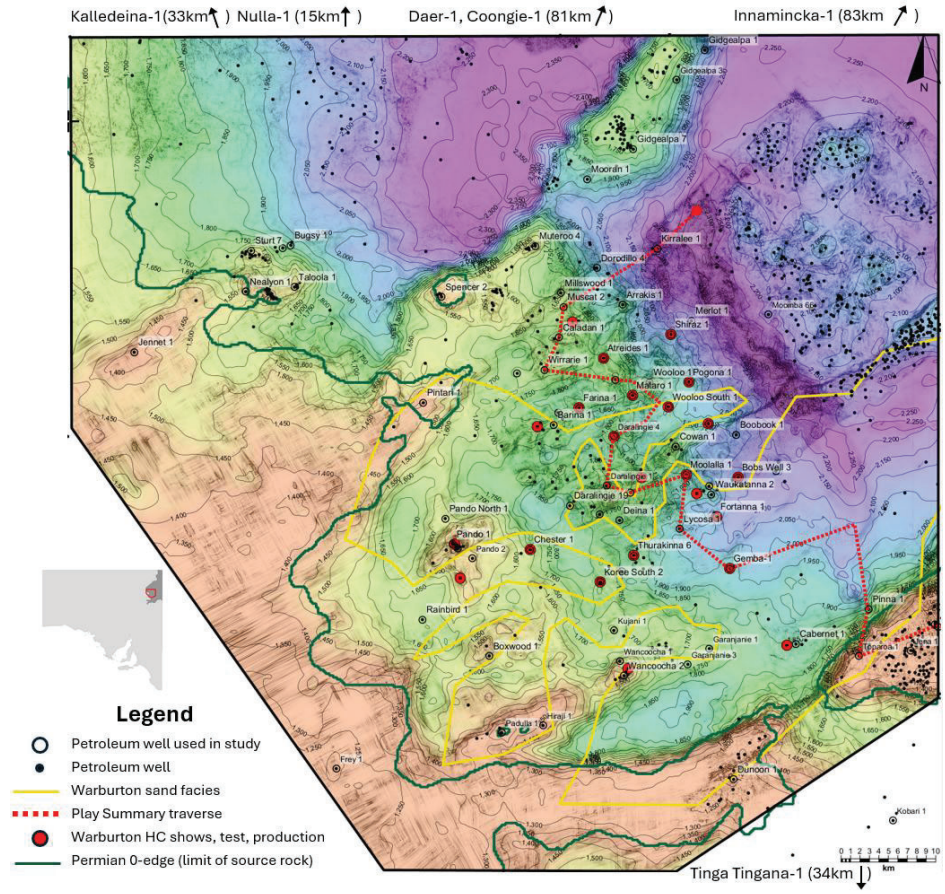

Figure 1: Study location map, showing the Warburton sub-crop TWT map (contours in milliseconds), co-rendered with coherency attribute to highlight structural lineaments such as faults and erosional scarps. Input well data are labelled.

DISCUSSION

The basin generally thickens to the east, coinciding with increasingly marine conditions. Thickness mapping and core analysis shows the Pando/Worrior and Daralingie Fields are located on old highs, with shallow water deltaic to shoreface conditions and younger onlapping packages (Figure 2). Coherency extractions show these structures are dissected by erosional valleys, which may have defined a paleo coastline and slope, acting as entry points for the marine basin to the east (Figure 1). This study uses the chronostratigraphic framework developed by Kirk et al, 2025 in press and defines an additional package - the '800-1000' interval - which represents the final stage of deposition prior to uplift and erosion and contains some of the best gas production rates and flow tests in the area. The Warburton sands at Daralingie are possibly older (400-800 interval) than those at Moolalla-1. Primary porosity of the sands is very low and there is likely a tectonically-induced fracture enhancement caused by uplift in the Cowan and NM Horst areas, which is important for the prospectivity.

Several wells in the Topwee-Wooloo high intersected fresh and weathered granite of the Big Lake Suite and previous interpretations consider a broad pluton to exist beneath this and the Moomba-Big Lake areas. Seismic attributes, gravity grids and tied wells show that the upper Warburton section is also present across this area and the intrusions are narrow, localised pillars that support the enhanced drape structures that have been drilling targets in the overlying Permian section. Away from these intrusions, the Warburton basin succession typically remains within broad structural closure. Many wells in the area recorded oil & gas shows (Figure 1) and it is frontal to the large kitchens that source Moomba-Big Lake fields. These intrusions may also provide local fracture enhancement or occlude porosity via contact metamorphism and hydrothermal processes.

Marine conditions are interpreted at Dunoon-1 and around 40 wells along the NM Horst, yet these are now prominent highs with Permian onlap and Eromanga drape. Sub-aerial extrusive volcanics at Murteree-1A, Jena Field and the Kobari region are present above the Warburton section, indicating that these are younger than Mooracoochie age (517Ma +/-9Ma) and that uplift and emergence of the Dunoon and NM Horsts must have occurred post 400-1000 time, potentially juxtaposing Warburton reservoirs against Permian source rocks.

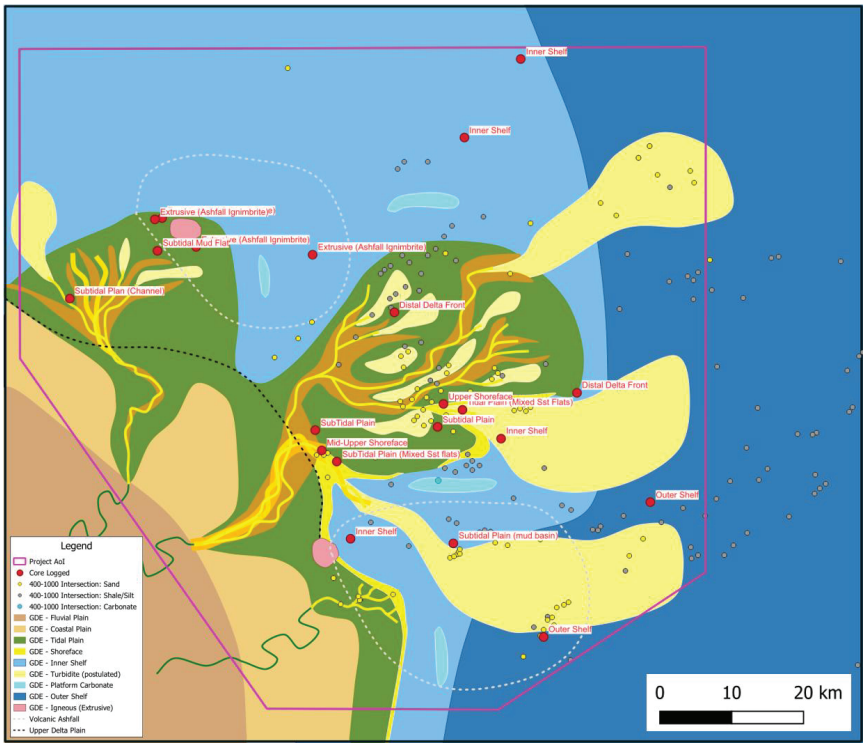

Figure 2: GDE map for the 400-1000 interval. Primary control points are core descriptions. Composite log and mudlog descriptions from Warburton intersections and seismic isochore and facies mapping provided supplemental control.

PLAY TYPES

This study focuses on exploration plays combining Permian source rocks and Warburton reservoir-seal pairs. Pre-Permian petroleum systems and plays have not been considered due to a relatively thin basin section and lack of deep well control in the area. Three priority plays have been identified as warranting further study:

1. Topwee-Wooloo High: Fractured '400-1000' sands between Big Lake Suite granitic intrusions
2. Lycosa-Moolalla Area: Strat-structural traps and fractured '800-1000' sands
3. Dunoon-NM Horst Buried Hill Play

Topwee-Wooloo High

This area is a proven gas province (red symbols, Figure 1) and 9 wells have intersected fresh granite and the granite wash of Big Lake Suite granite. Seismic attribute analysis using coherency and pseudo-relief, as well as the gravity 1VD and residual maps shows that several discreet intrusions set up the small Permian structures and sub-culminations. In particular, the Daralingie Field is comprised of several small, roughly circular anticlines (between Topwee-1 & Daralingie-4, Figure 3). Rather than reverse faulting, these structures may have been formed by differential compaction and drape over narrow columns of relatively hard granitic rock. The equivalent '400-1000' sedimentary section appears to be present between these intrusions and may have been locally enhanced by inflation anticline stress-fracturing, or diagenetically degraded by heat and fluids. The area is a broad structural focus adjacent the Wooloo Trough and on the direct migration pathway.

Stratigraphic-Structural traps

Identification of stacked, high-amplitude continuous seismic facies and an onlapping '800-1000' package (black-dark blue horizon, Figure 3) highlights the possibility of a younger shelf-slope depositional fairway in the south. The stacked sands at Moolalla-1 and Lycosa-1 are on the northern flank of this fairway and may not be in the reservoir sweet spot. Structural traps in the Gemba-Garanjanie area may contain better quality reservoir. Identifying traps is a key challenge for this play. Reverse faults will play a key role in fracture enhancement.

Dunoon-NM Horst Structural Play

The Dunoon-NM Horst area is a large structural feature adjacent to thick Permian depo-centres of the Allunga and Wooloo Troughs and Dunoon Embayment and currently produces hydrocarbons from the Eromanga Basin. Over 40 wells have intersected the '400-1000' interval across the high, recording interbedded marine sand, silt and shale, however the average penetration is <30m and typically driven by operational requirements for wireline logging, thus there are no deep, targeted tests of Warburton stratigraphy on the entire trend. Dunoon-1 core describes marine shale in an outer shelf setting, while several wells have also intersected sands (Toparoa-1) and volcanics (cored and described in Murteree-1A). Volcanics are mappable on seismic and appear to flow down Merrimelia Fm valleys. Therefore, uplift, potential fracture enhancement and erosion has occurred post-deposition of the 400-1000 interval and reservoir-seal pairs may be present beneath the wells, juxtaposed against Permian source rocks (Figure 3). Pinna-1 and Sub Zero-1, located down-dip on the frontal flank, recorded fluorescence in basal Patchwarra Fm and Lycosa Fm, indicating lateral migration along deep carrier beds. Although high risk, the large GRV and potential for stacked sands warrants further work.

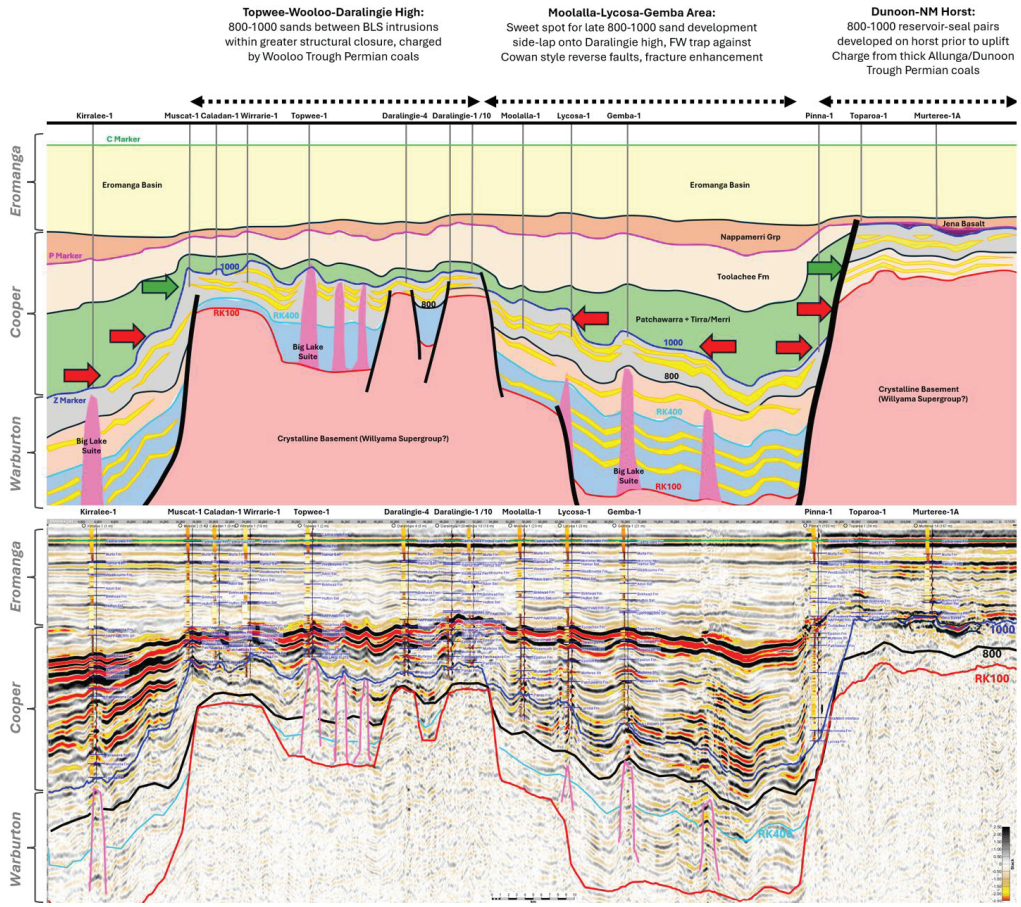

Figure 3: Arbitrary seismic line and play summary, illustrating the major packages and play types identified in the region.

CONCLUSIONS

This study provides an updated interpretation and review of prospectivity for the Eastern Warburton Basin, integrating seismic, well log and core data to apply a chronostratigraphic framework based on seismic facies packaging and reflector relationships. Several new insights have emerged regarding the environment of deposition, basin evolution and prospectivity for hydrocarbons, which should be of interest to explorers.

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