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A new Triassic source rock in the Cooper Basin, Australia?

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SUMMARY

The geochemical results from a recent production test in the Triassic section at Kiwi 1 in the Cooper Basin, potentially indicate the presence of an anomalous hydrocarbon source rock. A relatively low pristane/phytane ratio and pour point contrast with higher ratios and pour points typical of Permian source rocks.

A quick-look core and seismic study combined with geochemistry has identified a potential source set up by compression-related piggybacking and relative sea level rise resulting in the development of a genetically distinct sub-basin. This study provides a framework for understanding the development of this potentially distinct sub-basin, source, and play.

Key words: Cooper Basin, Triassic, source rock, piggyback basin

INTRODUCTION

The Nappamerri Group is the uppermost stratigraphic unit of the Cooper Basin, Australia and it comprises from its base the coal-bearing Toolachee Formation, the Arrabury Formation (with the Callamurra and Paning Members), and the Tinchoo Formation. This stratigraphic interval spans the Permian-Triassic mass extinction event (PTME).

Kiwi 1 (Figure 1A) was drilled in 2004 and from drill stem test (DST) 1 across the Callamurra Member flowed gas to surface at 9.6 mmcf/d plus a significant but unquantified amount of condensate (53.5° API @ 24°C). The well was subsequently suspended as a potential gas producer. A more recent extended flow test (EFT) undertaken by Bass Oil Limited in 2024 reported gas to surface at 4.1 mmcf/d and condensate (63.4° API @ 15°C) at 988 barrels/day. The well is in a relatively underexplored part of the basin and is relatively distant from tie-in infrastructure.

DISCUSSION

Recent gas chromatography (GC) of the condensate from the Kiwi 1 EFT reports a pristane/phytane ratio of 2 and a pour point of -15 °C (Petrolab 2024). Plummer's (2020) review of 1,332 GC n-alkane traces from the Cooper and Eromanga Basins "indicate the shape of any GC trace is primarily controlled by the degree of organic maturity" and not the depositional environment of the source rock/s. In this instance the GC trace is dominated by relatively low n-alkane numbers and the trace itself is concave up suggesting a late (as opposed to early or peak) expulsion time. Further the relatively low pristane/phytane (Pr/Ph) ratio compared to those from a 162-oil sample study (Figure 1B) by Boreham and Summons (1999) and the low pour point imply sub-oxic depositional conditions and an algal rather than woody terrestrial source, respectively.

Quick-look reviews of conventional cores spanning the Permian Triassic (PT) boundary at Coonatie 1 (cores 1 and 2 2850-2868.7m) and Merrimelia 3 (cores 9 and 10, 2356.7-2386.6m) were conducted. Vertical to sub-vertical, blebby to ptigmatic, often filled features were observed in both wells and are interpreted syneresis cracks (Figure 1D and E). Intervals with bioturbation ranging from bioturbation index 1 up to 4 (Figure 1C) mud drapes including bidirectional indicators (Figure 1 F) were also observed. In combination, these features suggest increased salinity of pore waters and tidal influence when compared to the underlying alluvial section.

Using seismic and the afore mentioned wells, supplemented with wells from the area with palynology, a Triassic correlation (Figure 2A) has been interpreted. Based on this correlation Coonatie 1 and has penetrated an older section (PP6) than that cored at Merrimelia 3 (PT1). This has been interpreted as indicating areas of upland. The PP6 section (Figure 2 sub light green dashed line), recently recalibrated and

assigned to the Triassic (Smith et al, 2017) comprises the lowest known section. Core from Coonatie 1 in this interval comprises from the base an initially relatively heavily bioturbated carbonaceous silty claystone (Figure 1C), giving way to relatively unbioturbated carbonaceous silty claystone and finally a fine-grained sandstone. Core from Merrimelia 3 in the younger package comprises, from the base, Permian aged carbonaceous claystone, and weakly developed coal before suddenly giving way to silty claystone with common syneresis cracks. Up section sand-sized content increases before interpreted fluvial conditions are established at approximately 2334.5m. Carbonaceous content, at least visually, is higher in the older package compared to the younger. Geochemical analysis (Morante, 1995) at Merrimelia 3 supports this observation. Assuming deposition is continuous through the Permian Triassic contact (as it appears to be), the package is bound at its base, by a flooding surface (FS) and at its top by an interfluvial sequence boundary (IFSB) (Figure 2A). Gamma ray (GR) wireline trends show an initial fining or flooding trend (early transgressive systems tract, TST) followed by an overall coarsening trend to the IFSB (highstand systems tract, HST) where a shift to overall aggrading GR trends (early lowstand systems tract LST) begins. Above the IFSB sedimentation is more broadly isopach and this pattern continues for the overlying Eromanga Basin (Figure 2A). The above observations suggest increased salinity and tidal influence, and do not show classical fluvial character until above the FS.

The older package is wedge shaped and is thickest closest to the Innamincka Dome (Figure 2a). Away from this edge the package thins and progressively onlaps towards Crumpa 1 (Figure 2a) until the interfluvial via onlapping, is eventually topped. The initial older fill may be relatively organic rich, have greater preservation potential (due to relatively higher subsidence, Figure 2A) and potentially have source rock potential unlike the interfluvial where total organic content (TOC), is relatively low, albeit at one, relatively distant well, Merrimelia 3. This in combination with the low Pr/Ph ratio and pour point from EPT recovered oil may suggest the presence of an unrecognised early Triassic source rock. Structurally this wedge may represent a piggyback basin developed on top of a moving thrust sheet in response to the wedging of the Innamincka Dome (Figure 2B) during late Permian-early Triassic compression associated with the Hunter-Bowen orogeny. This observation corresponds to Roeth and Littkes' (2022) observation of significant Triassic aged sedimentation re-establishing in the Patchawarra Trough at that same time. The above observations, particularly those from core, suggest potential for a marine influenced source rock in the oldest Triassic package.

CONCLUSIONS

A source-conducive (early TST) depositional environment set up by compression-related piggybacking and influenced by relative sea level change may have resulted in the development of a potentially genetically separate sub-basin and source rock in the study area. The geochemistry confirms a sub-oxic environment and an algal source that is distinct from published data on other source rocks. The quick-look core and seismic work provides an initial framework for understanding the development of this potentially distinct sub-basin and source.

FUTURE WORK

The idea of a new source rock, in a relatively under-explored area of the Cooper Basin, warrants further work. This may include but not be limited to targeted geochemistry and biostratigraphy, a review of spectral GR should it be present in the area, a review for analogue production, and a more detailed seismic mapping effort to constrain the geometries of the piggyback basin and subsequently prospectivity-scale mapping.

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Petrolab 2025 Reservoir fluids study of Kiwi 1 well for Bass Oil Pty Ltd, results used with permission.

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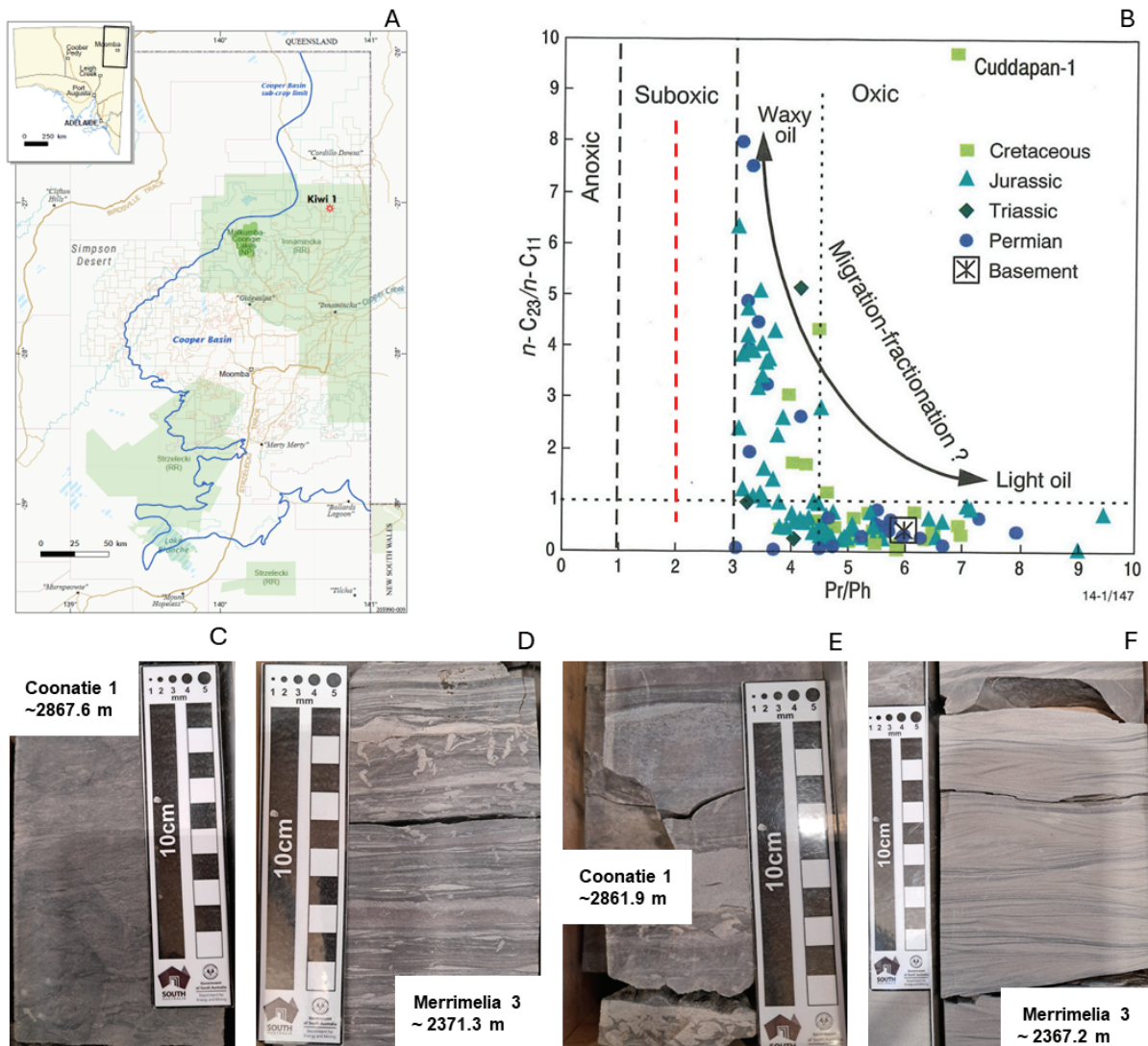


Figure 1 A Kiwi 1 location map B, modified after Boreham and Summons 1999, Kiwi 1 sample Pr/Ph ratio value plots along red vertical line, y axis value not determined, C core photograph showing bioturbation index 4, D core photograph showing syneresis cracks, E core photograph showing syneresis cracks, F core photograph showing bi-directional flow

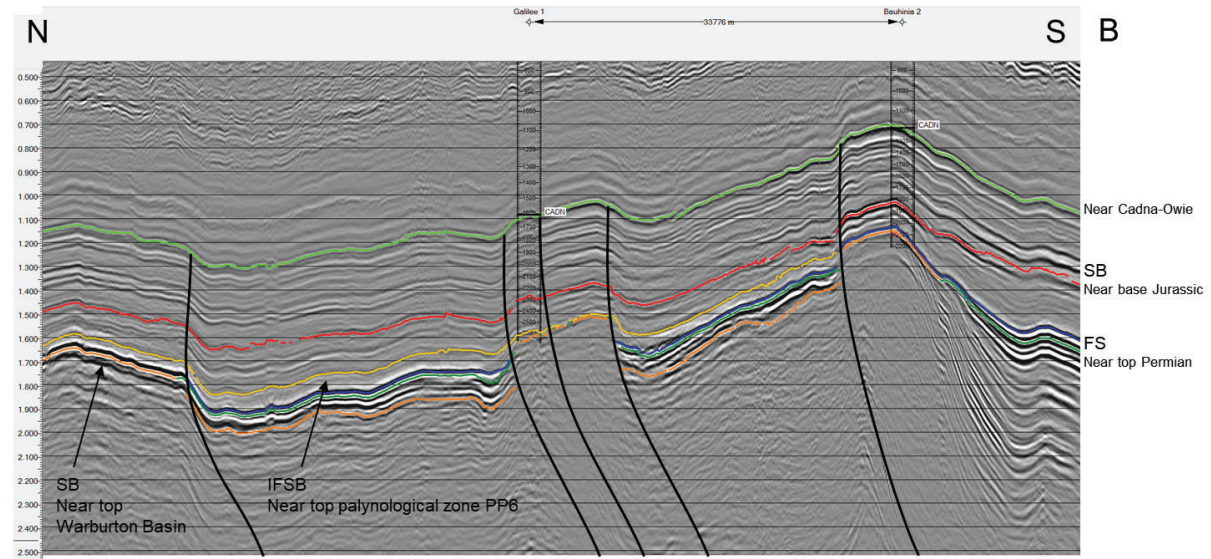
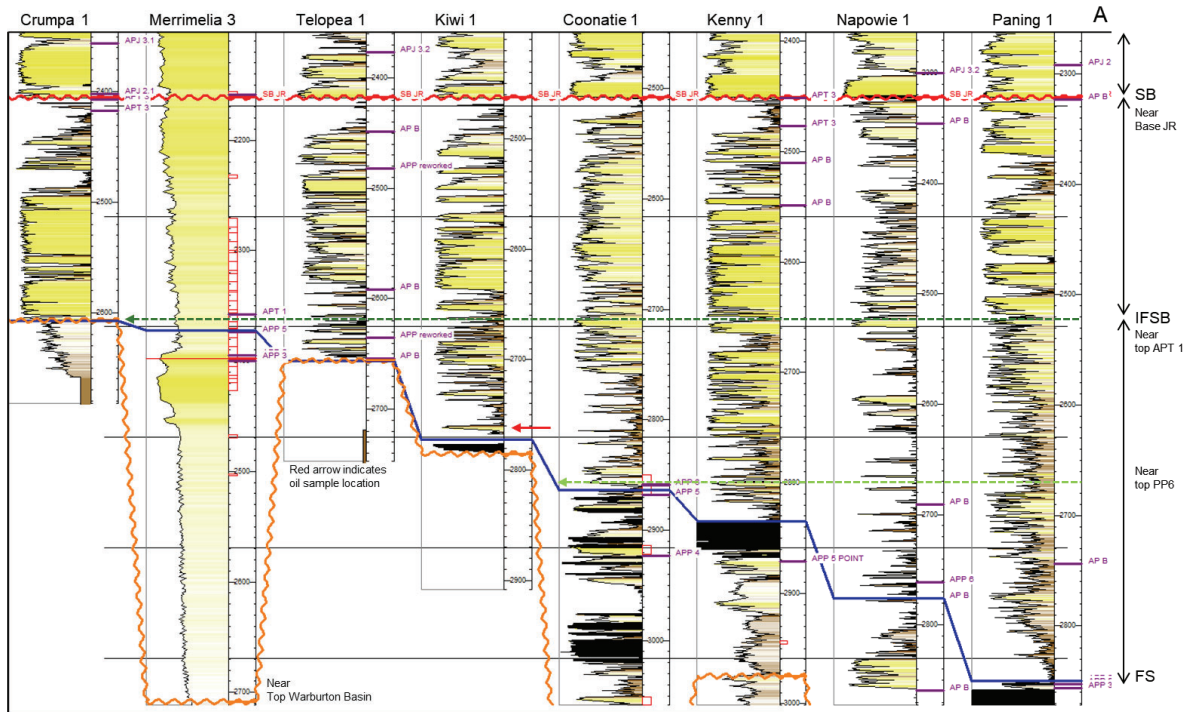


Figure 2 A cross-section through selected wells, flattened on Jurassic sequence boundary/base Eromanga Basin, B 2DCubed crossline 11,732, with interpretation and showing piggyback developing above the blue FS due to compression and 'foreland' style basin developing ahead of the wedge front, piggybacking occurs as sediment loading forces further thrust complex/es (faults young from south the north), indicative fault traces shown in black