New Insights into the Geology and Petroleum Prospectivity of the Northern Arafura Basin, Offshore Northern Australia

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Strong evidence for at least one active Palaeozoic petroleum system in the undrilled northern Arafura Basin is provided by a new geological framework study, based on seismic and new well interpretations, and a seepage survey. Evidence for hydrocarbon generation is provided by oil and gas shows and indications and interstitial solid bitumens in wells in the Goulburn Graben, SAR anomalies, and shallow gas indications in sub-bottom profile, side-scan sonar and echosounder data. Deposition in the Arafura Basin commenced in the Neoproterozoic during a period of upper crustal extension that resulted in the formation of large NE-SW trending half graben. The overlying Palaeozoic section is more or less structurally conformable, despite long periods of non-deposition and erosion. Potential source rocks were deposited in the Middle Cambrian, Late Devonian and Late Carboniferous to Early Permian, in shallow-marine and deltaic environments. In comparison with the highly-deformed Goulburn Graben in the southern part of the basin, the northern Arafura Basin has undergone only minor deformation. As a result, many of the risk factors for the accumulation of hydrocarbons identified in the Goulburn Graben, such as timing of generation and expulsion, and reservoir quality, are reduced in this region. New geohistory models suggest that early expelled hydrocarbons are likely to be preserved in the northern Arafura Basin, and that in some locations, expulsion from Early Palaeozoic source rocks occurred in the Mesozoic to Cenozoic. Early formed traps are likely to have remained intact and reservoir quality should be higher as a result of reduced hydrothermal alteration and/or shallower burial.

Late Devonian and Earliest Carboniferous Shallow Water Carbonates and Associated Basinal Shales of the Southeastern Bonaparte Basin – Petroleum Potential

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Klemme and Ulmishek (1991) estimated that 8% of the world's original petroleum reserves was generated from Late Devonian-Tournaisian black shale facies source rocks, primarily deposited on platforms and, to a lesser extent, in intracratonic sags. 80% of the reserve is oil. Late Devonian shaly sources are known in Australia from the Canning Basin, and possibly the Carnarvon Basin. In the Southeastern Bonaparte marine shales of this age have been loosely described as the Bonaparte Formation in wells, but locally other terminology has been used. Palaeogeographic reconstructions of the Late Devonian indicate the Bonaparte Basin lay in the arid belt about 10° S of the palaeoequator, and suggest that carbonate-rich sedimentation was likely.

During the Late Frasnian the northern part of the onshore basin contained intertidal to marine environments associated with reefs. Interbedded with the carbonates are shaly facies, such as the Kamilili Formation, and unassigned strata intersected by petroleum wells.

Of interest to the petroleum exploration of the area is the transgressive/regressive shales of the Kamilili Formation. From isolated outcrop and stratigraphic relationships, mostly from mineral exploration bore holes, the Kamilili Formation is estimated to attain about 750 m in the basinal areas off the mapped reef edge.

Of added exploration interest is the occurrence of earliest Carboniferous carbonate platforms fringing eroded Devonian topography. Two wells have produced hydrocarbons from this facies. Similar facies may be present in the offshore southeastern Bonaparte Basin west of the Turtle High.

Paleozoic Petroleum Systems of the Canning Basin, Western Australia: A Review

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The productivity of Paleozoic petroleum systems depends on timing (Paleozoic–Cenozoic) and preservation (sub–suprasalt) of charge, as exemplified by super-giant, giant and small oil and gas fields within the Paleozoic basins of North America, North Africa, North Caspian, and the Canning Basin.

Within the Canning Basin, subsalt Ordovician sourced oil has been recovered in Cudalgarra 1, Dodonea 1, Edgar Range 1, Great Sandy 1, Leo 1, Percival 1, Pictor 1 and 2, and Solanum 1. Suprasalt Upper Devonian sourced oil is produced from the Blina field, and oil shows are present in Boronia 1, Ellendale 1, and Janpam 1. Suprasalt Lower Carboniferous sourced oil is produced at the Boundary, Lloyd, Sundown, West Kora, and West Terrace fields and a gas accumulation is present at Point Torment 1. These petroleum systems are part of the Australia-wide Larapintine 2 (Ordovician), 3 (Devonian), and 4 (Early Carboniferous) and Larapintine–Gondwanan Transition petroleum supersystems.

A review of published and unpublished open-file data supplemented by new analyses, including 73 total organic carbon content, 26 Rock-Eval pyrolysis, 8 extract analyses for source rock potential, 30 organic petrological analyses for source maturity, 14 apatite fusion track analysis to understand generation history, and 100 Quantitative Grain and Extract Fluorescence for presence of paleo and present hydrocarbon in reservoirs, indicate generation and migration of hydrocarbons within the basin. The basin is underexplored with only 4 wells/10000 km^2 as compared to North America with 500 wells/10000 km^2. There is need for further exploration studies on source, reservoir and seal distribution, timing of trap formation and generation– accumulation, and its preservation within diverse tectonic units.

Platform Evolution, Facies Patterns, and Cyclicity Across the Late Devonian Frasnian/Famennian Boundary – Barnett Spring Platform, Canning Basin, Western Australia

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Significant changes in platform architecture and cyclicity are observed in the Canning Basin across the

Frasnian/Famennian (F/F) extinction boundary. These variations have largely been attributed to the F/F faunal turnover. However, based on mapping, lidar, and measured section data from Barnett Spring, the argument can be made that long-term decreases in accommodation space also played a major role in shaping Famennian platform architecture. Barnett Spring's continuous outcrop exposures provide an excellent opportunity to document the relative importance of accommodation vs. biotic change in platform evolution.

The Barnett Spring platform developed as a progradational, slender (3.5 x 1km) promontory with a steep escarpment margin. This morphology was controlled by antecedent topography created by a late Frasnian–early Famennian ridge-like stromatolite-sponge bioherm complex, along which Famennian shallow-water carbonates were able to nucleate and prograde.

The Famennian platform interior is characterized as accommodation limited, consisting of a complex mosaic of high-energy grainstone shoals, tepee-pisolite complexes, and fenestral laminites. Tepee complexes up to 13.5m thick, and stacked ooid grainstones replace the mud-dominated facies of the Frasnian platform interior, with a similar shift to grain-dominated facies reflected in the Famennian slope. Average high-frequency cycle thickness decreases from 3.50 m in the Frasnian to 1.25 m in the Famennian with supratidal-capped cycles (e.g. fenestral laminites, tepees, beachrock).

While it is clear that a fundamental change in faunal composition of Canning Basin's carbonate platforms occurred across the F/F boundary, the accommodation-driven shift to high-energy shoal-water systems is equally significant and appears to have a corresponding global signature.

Resolving Climatic and Tectonic Controls on Grant Group Deposition, Evidence from Sedimentological and Seismic Analysis

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The hydrocarbon-bearing Grant Group of the Canning Basin has been subject to several studies examining its depositional evolution. The aims of this study is to constrain existing models by adopting an integrated approach involving sedimentological and lithofacies analysis of Grant Group outcrops and subsurface cores, and 2D seismic interpretation of surveys from the Barbwire Terrace, Fitzroy Trough and Lennard Shelf areas.

Facies analysis of cores from the Canning Basin reveal a glacially-influenced succession interpreted to record the retreat of an ice sheet, consistent with evidence for glaciation from outcrop that includes striated pavement. A common brecciated contact with Devonian dolomites is overlain by diamictite containing faceted, occasionally striated clasts, interbedded with turbiditic and glacial outwash sandstone and siltstone that suggests reworking in a sub-aqueous environment. This lower glacially influenced sequence is transgressed by a fossiliferous marine claystone and heterolithic facies interpreted to record sea-level rise during deglaciation. This in turn is succeeded by regressive shallow marine facies, possibly recording isostatic uplift and subsequent rejuvenation of hinterland clastic source areas. A dominantly tectonic control on sedimentation is not consistent with observations from seismic data that indicate although syn-sedimentary faults are present, they are limited in extent and cannot be solely reconciled with Grant Group facies associations. This study forms part of a broader scale project investigating the regional evolution of the glaciogenic Grant Group, with important implications for future hydrocarbon exploration in the Canning Basin.