Hydrocarbon Entrapment in Triassic to Late Jurassic Reservoirs in the Timor Sea, Australia: New Insights

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Abundant oil-filled fluid inclusions at quartz overgrowth/detrital quartz boundaries and in fractures cutting quartz grains are often used as the primary evidence of palaeo-oil columns in Triassic to Late Jurassic reservoirs in numerous wells in the Timor Sea. Based on fluid inclusion analysis of sandstone reservoirs in present oil columns, a Grains containing Oil Inclusions (GOI) value of 5% has been used as a threshold with values >5% indicating palaeo-oil columns. However, values <5% have been measured in present oil columns, indicating that low GOI values do not necessarily preclude past or present oil entrapment as the trapping of oil in inclusions is dependent upon reservoir conditions conducive to formation of fluid inclusions at the time of oil entrapment.

Other indications of palaeo-oil columns are evident below and/or within GOI-define palaeo-oil columns; good to excellent direct and cut fluorescence on cuttings and/or core, elevated resisistivity and/or reservoir diagenesis. In the case of oil shows these hydrocarbon indications have been discounted as indicating focussed oil migration below a palaeo-oil/water contact rather than indicating a palaeo-oil column.

While GOI provides valuable data to support the interpretations of palaeo-oil columns, it provides a picture at one instance in the hydrocarbon entrapment history and therefore should not be used in isolation. Other hydrocarbon indications are equally valid proof of oil entrapment at one or more different times in the hydrocarbon entrapment history, and should be used with GOI data to provide a comprehensive picture of the evolution of a hydrocarbon trap. Case histories from wells Eclipse-2, East Swan-2, Oliver-1 and Crux-1 in the Timor Sea illustrate how an integrated picture of hydrocarbon entrapment history can be developed and demonstrate that structures in the Timor Sea have undergone more than one phase of oil entrapment and leakage with each phase potentially from a different source.

Reverse Structures in Accommodation Zone and Early Compartmentalization of Late Jurassic Extensional System, Laminaria High (NW Shelf, Australia)

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The sediments dynamic and structural development associated with the Late Jurassic rifting phase represent the key factor on the accumulation of hydrocarbon in the Timor Sea. On the Laminaria High (Bonaparte Basin) the main Oxfordian-Kimmeridgian E-W fault systems form structural traps where several discoveries have been made.

These E-W fault systems consist of a complex series of sub-parallel faults that connect via relay ramps or accommodation zones. One of these zones is associated with a transverse anticline resulting from the development of a positive flower structure. This secondary reverse structure, associated with significant impedance anomalies, has been revealed by the integration of 3D seismic interpretation, attribute mapping and classification and classic structural analysis.

The formation of such a reverse structure in extensional setting is related to the evolution of the main associated E-W fault plan which grows by addition of secondary, en echelon, tip faults. Isopach analysis and displacement pattern suggest a zone of differential displacement occurring between the parent and a tip segment of the main associated E-W fault plan and inducing a local left-lateral strike-slip movement associated with transpressional uplifts.

This structure compartmentalizes the early development of the adjacent graben and then controls the distribution of the syn-rift Frigate Fm (Oxfordian-Kimmeridgian). It possibly affects the local migration of fluids as highlighted by amplitude anomalies associated with the domal anticlines and the reverse faults on the top of the Laminaria sandstone (Callovian-Oxfordian).

Origin of the Late Jurassic-Early Cretaceous Erosional Surface of the Browse Basin (NW Australia)

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A detailed cartography of the erosional surface located between the Jurassic and Cretaceous sequence of the Browse basin (NW Australia) shows the presence of a major paleorelief (500 to 800 m). Paleo-valleys and characteristic drainage patterns allow to demonstrate the continental origin of this relief. The valley infill is likely made of continental deposits passing to marine ones during the early Cretaceous flooding of the area. The erosional pattern is certainly controlled by Jurassic extensional tectonic related to the opening of the Argo abyssal plain ocean. The extension seems to predate the erosion, therefore the uplift of part of the margin is either due to rift shoulder thermal uplift or ridge-push effect during the early stage of spreading. Potential stratigraphic traps could be defined, depending on the type of valley infill and the type of seal that could be envisaged in that area at that time. The problem in defining the valley infill type comes from the absence of good well calibration, only one well (Londonderry) has penetrated the erosional surface in a low, on the other hand the presence of gas has already been demonstrated in the region.

Hydrocarbon Fill-History of the Cliff Head Oil Field, Offshore Perth Basin, using Integrated Fluid Inclusion, Geochemical and Geological Data

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The hydrocarbon fill-history of the Cliff Head oil field (offshore Perth Basin) and adjacent areas has been investigated by integrating petroleum fluid inclusion, petrographic, geochemical and geological data.

Palaeo-oil water contacts above the current OWC in the Cliff Head-3 (CH-3) and CH-4 wells suggest that the Permian siliciclastic reservoir experienced structural growth after oil inclusions were formed. The reservoir was further filled by redistribution of oil within the trap or by additional oil charge. The conformance of both palaeo and current OWC's at CH-1 confirms that the low relief, relatively un-faulted area to the south of the main horst was filled close to spill when oil inclusions were formed.

In CH-3 and CH-4 abundant oil inclusions with yellow fluorescence colours are hosted in quartz overgrowths, and, in the adjacent Mentelle structure, yellow fluorescing inclusions also occur in late-stage dolomite cement. CH-3 and CH-4 reservoir sandstones also contain blue fluorescing oil inclusions pre-dating quartz overgrowth. Whereas the yellow fluorescence suggests the late inclusion oil has a lower API gravity, consistent with 31° API produced oil at Cliff Head, early blue-fluorescing oil inclusions may contain oils of higher API gravity.

Fluid inclusion oil from the Permian in Leander Reef-1 is probably derived from the Early Permian Irwin River Coal Measures, and trace biomarkers typical for Kockatea Shale source are interpreted to be leached from this cap rock into the palaeo-oils. At Cliff Head, the blue and yellow fluorescing inclusion oils may reflect oils from different source rocks. Therefore, prospects in the Cliff Head–Leander Reef region may have received oil from more than one petroleum system.

The Geology and Petroleum Potential of the Bremer Sub-Basin – A Potential Deep-water Petroleum Province on Australia's Southwest Margin

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The Bremer Sub-basin is a Middle Jurassic – Late Cretaceous half-graben complex that forms the western-most depocentre of the Bight Basin. It is located across the continental slope off the southern coast of Western Australia in water depths of 100 – 4000 m. The sub-basin is a rank frontier area for petroleum exploration with no wells previously drilled. Through integrating dredge sample data with regional seismic interpretations, it has been possible to develop a structural and stratigraphic framework for the sub-basin, and assess the petroleum exploration potential using conventional basin analysis techniques. Structurally, the sub-basin comprises a series of en-echelon SW-NE trending fault-bounded half graben, and a significant intra-basin fault system that developed during rifting between Australia and Antarctica. Of particular importance to petroleum exploration are three major cycles of lacustrine and fluvial sedimentation in Late Jurassic – Early Cretaceous strata, which provide key petroleum system elements of both organic-rich source rocks to generate hydrocarbons, and sandstones overlain by thick mudstones that could potentially reservoir hydrocarbons. Exploration opportunities and play types vary across the sub-basin. A large potential source kitchen area occurs in the central part of the sub-basin, where sediments are 4 to 9.5 km thick. Here, the main exploration play is fault block traps in water depths of 1000 – >2500 m. Smaller depocentres with up to 5 km of sediment fill occur in the western and eastern parts of the basin and host large anticlinal structures in water depths of 500 – 800 m.