# SEDIMENTARY HISTORY, DIAGENESIS AND ORGANIC FACIES OF THE TRIASSIC MUNGAROO FORMATION, BARROW SUB-BASIN, W.A.

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# STATEMENT

## STATEMENT OF AUTHENTICITY AND AVAILABILITY

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference is made in the text.

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(John Ťiang-Shen Jong)

# ABSTRACT

The Triassic, largely regressive fluvio-deltaic Mungaroo Formation was studied in the vicinity of the Barrow Sub-basin within the North West Shelf, Western Australia. The Barrow Sub-basin is a Jurassic to Cretaceous rift and downwarp underlain by a more extensive, sheet-like Triassic sequence. Cretaceous reservoirs provide the most interest in the region in terms of oil production but Triassic sandstones of the Mungaroo Formation form the major economic and potentially economic reservoirs along the relatively up-faulted western margin of the sub-basin with some similar potential along the eastern and southern margins. The centre of the sub-basin contains up to 10 000 m of post-Triassic fill thereby preventing drill intersection of the Mungaroo Formation in that area. This study aims to add to the knowledge of the Mungaroo Formation by looking in detail at the sandstone petrography, diagenesis and organic petrography of the unit. These studies are supported by a range of techniques including core logging, transmitted and reflected light microscopy, scanning electron microscopy, microprobe and isotopic analyses and source rock geochemistry. The Mungaroo Formation is investigated as both a source and reservoir.

Triassic depositional 'supercycle' started with the transgressive marine Locker Shale. Fluvio-deltaic conditions became dominant by the Middle Triassic with the deposition of the Mungaroo Formation; a sequence of interbedded sandstone, siltstone and shale with coal which lies comfortably on the Locker Shale. Sedimentary and palaeogeographic investigations of the formation indicate a north-westerly prograding fluvio-deltaic system with sediments sourced from the Archaen Pilbara Block to the east of the basin. This study is the first to detail the petrography of the unit along the eastern flank of the sub-basin and tie this with the descriptions along the gas-prone western margin or Rankin-Alpha Trend. Regional sedimentary facies analysis, aided by palynological information reveals two distinctive packages of Mungaroo Formation sediments: an older deltaic package common to the east of the basin and along the Peedamullah Shelf characterised by the common presence of *S. quadrifidus* and minor occurrence of *T. playfordii* palynological zones, and a younger, predominantly lower fluvial-plain sequence that is common to the north of the basin and Rankin Trend areas. This observation is one of the bases for the interpretation of the progradation of the Mungaroo Formation fluvio-deltaic system towards north-west. Palynological, petrography, sedimentological and organic geochemical lines of evidence all point to the formation having been deposited in a far more marine-influenced setting than previously described by most authors.

The present study also represents the first major regional study of the diagenetic history of the Mungaroo Formation. The sandstones of the Mungaroo Formation can be generally regarded as quartz-arenite with an average present day framework grain composition of $Q_{92.7}F_{3.3}R_{4.0}$. The Mungaroo Formation sandstones have a complex diagenetic history which includes the formation of authigenic quartz, kaolin, carbonates, compaction and secondary porosity development during late diagenesis as the most significant diagenetic changes. The full diagenetic history of the formation is as follows:

1. precipitation of pyrite (I) (framboidal);
2. siderite (I) (micritic) cementation: precipitation of microcrystallised siderite rhombs in voids and around quartz grains;
3. Kaolinisation of feldspars --> kaolin + quartz (major quartz overgrowths), early cementation of framework grains;
4. dissolution of quartz along microstylolites and formation of minor quartz overgrowths, which continue after (5);
5. calcite and siderite (II) (zoned);
6. ferroan dolomite/ankerite;
7. Hydrocarbon generation;
8. dissolution of authigenic carbonates --> dissolution secondary porosity;
9. formation of pyrite (II) (cubic) and minor kaolin;
10. illitisation of kaolin, feldspars and lithic fragments;
11. Hydrocarbon migration.

The early cementation of the formation (Event 3) by quartz has helped preserve primary porosity and significantly reduced the effect of mechanical compaction. Carbonate cementation, however, and the development of secondary porosity (Events 5, 6 and 7) represent important controls on reservoir quality in the Mungaroo Formation.

Maceral analysis of the potential source rocks of the Mungaroo Formation reveals that the dispersed organic matter (DOM) of these source rocks is either vitrinite- or inertinite-rich with generally less than 10% liptinite, reflecting source rocks typical of a fluvio-deltaic depositional setting. Higher percentages of liptinites were observed for the older deltaic sediments of the eastern Barrow Sub-basin. This scenario can be attributed to better preservation of the liptinite macerals within a deltaic environment and their close proximity to the source area. Locally, liptinite-rich intervals have also been identified within the study area which have the potential of generating liquid hydrocarbons. TOC analyses of these source rocks indicate good to very good generative potential (average TOC value = 2%). Rock-Eval pyrolysis data indicate mainly Type III kerogen with minor Type II/III component (Organic Facies C and CD). Gas is therefore the most likely product with oil generation possible from local liptinite-rich intervals which contain the Type II/III kerogen (where mature). Thermal maturity investigation based on vitrinite reflectance ($R_o$) and Rock-Eval pyrolysis data implies that source rocks from the Rankin Trend area are currently mature and are contributing to the gas-condensate reserves in the area. Source rocks from the Barrow Sub-basin range from sub-mature (flanks) to post-mature (depocentre). Even though immature, source rocks from the north-eastern Barrow Sub-basin/Candace Terrace area have the best hydrocarbon potential. GC and GC-MS studies of selected samples confirmed the deltaic depositional environment of the Mungaroo Formation. Biomarker analysis shows that its mainly terrestrial OM input was extensively reworked by bacteria, both aerobics and anaerobics. These findings are consistent with the common presence of vitrinite, inertinite and framboidal pyrite. The present study also demonstrates that the biomarker maturity parameters of the Mungaroo Formation, in general, are consistent with the $R_o$ and $T_{max}$ data illustrating their potential usefulness in future maturity studies of the formation.

This study has shown that the Mungaroo Formation represents an attractive prospect for hydrocarbon exploration in the study area, especially along the Rankin Trend with excellent reservoir characteristics and good potential source rocks. In general, variations in facies type in the intersected Mungaroo Formation interval cause only subtle changes in reservoir and source rocks character and the generative potential of both oil and gas.

# SEDIMENTARY HISTORY, DIAGENESIS AND ORGANIC FACIES OF THE TRIASSIC MUNGAROO FORMATION, BARROW SUB-BASIN, W.A.

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