Kerogen associations and paleoenvironmental interpretation of the Upper Triassic Mungaroo Formation in the Gorgon Area, Northern Carnarvon Basin, Western Australia

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SUMMARY

Kerogen slides were made from 92 core samples selected from the Upper Triassic Mungaroo Formation in four wells in the Gorgon area of the Northern Carnarvon Basin. The slides were examined to investigate relationships between kerogen assemblages and their depositional environments ("depofacies"). Although the assemblages naturally vary and overlap to an extent, each depofacies has a characteristic kerogen assemblage. Moreover, depofacies which are genetically similar tend to have similar assemblages even though they may have been deposited in different parts of the delta. For example, active channels tend to have similar kerogen assemblages (abundant black-opaque particles, few cuticles, sparse palynomorphs) irrespective of whether they are fluvial, crevasse or distributary channels; in this case, it is inferred that the overwhelming factor in the kerogen assemblages is the high energy level of the environment of deposition, and its consequent inhibition of local vegetation and promotion of mechanical degradation of organic particles.

Key words: Kerogen analysis, Mungaroo Formation, fluvio-deltaic, Triassic, Northern Carnarvon Basin

INTRODUCTION

The Northern Carnarvon Basin, Australia's premier hydrocarbon province, has witnessed several major gas developments during recent decades including Chevron's Gorgon project. Drilling in the Gorgon area has resulted in the acquisition of several very long continuous conventional cores in the gas-bearing Mungaroo Formation, a thick, laterally extensive fluvio-deltaic unit ranging in age from Ladinian to Rhaetian. These cores provide an exceptional opportunity to examine kerogen assemblages from the wide range of depofacies and lithofacies found in the Mungaroo Formation.

Kerogen (or palynofacies) analysis is based on examination of the entire organic content of an unoxidized palynological slide, not just the palynomorph fraction. The underlying assumption in kerogen analysis is that each depofacies has a characteristic kerogen assemblage reflective of not only factors which affect the sedimentology of siliciclastic particles but also by a wide range of biological, ecological and preservational factors which affect the distribution, abundance and behaviour of organic particles.

METHOD AND RESULTS

Ninety-two core samples were selected for this study from GOR-1D (50 samples), West Tryal Rocks-4A (32), Gorgon-1 (4) and Central Gorgon-1 (6). Nearly all of the samples (89) are from the upper *Samaropollenites speciosus* Zone with the remainder from the basal *Minutosaccus crenulatus* Zone (Dolby & Balme, 1976). The samples were described and assigned to a depofacies prior to palynological processing at UWA using standard processing techniques (e.g. (Traverse, 2007; Tyson, 1995). The kerogen assemblages found in these samples were correlated with their depofacies and lithofacies in order to enhance understanding of the complex Mungaroo Formation

Based on key recognition criteria, 15 depofacies were defined in the Mungaroo Formation cores in fluvial channel, floodplain, crevasse splay, distributary channel and tidal zone paleoenvironments (Fig 1) (Ellis, 2013). Sediments as varied as laminated mudstones, massive siltstones, immature soils showing pedogenic alteration, coals and cross-bedded fine to coarse-grained sandstones are represented in the cores. The kerogen was logged in 20 initial categories (later combined) and statistically analysed to enable the full characterisation of each sample and ascertain relationships between samples.

The relative abundance of the main kerogen groups varies greatly between depofacies (Fig 2). For example, black-opaque particles dominate in active fluvial and crevasse channels but brown wood and cuticle particles become increasingly common as channels are progressively abandoned, energy levels wane, the mud/sand ratio increases and the substrate stabilises. The relative abundance of the various palynomorph types in the various depofacies also varies enormously due to a wide range of factors including the bioproductivity of the environment, the type and stability of the substrate, water table levels and the capacity to preserve organic particles (lower in high energy environments such as active channels).

Depofacies were also grouped into five depositional regimes (active channels, abandoned channels, lakes/regularly flooded, soils/swamps, tidally influenced) based on the dominant depositional process/outcome in each regime. Kerogen assemblages in the same depositional regime tend to be similar, while, for example, those from soils or swamps are overwhelmingly different to those from active channels. Kerogen particles found in lower energy environments (e.g. floodplain lakes) are on average larger, less rounded, more elongate and better preserved than kerogen particles found in high energy environments (e.g. active channels).

Sampling at close spacing in continuously deposited intervals also enables rapidly changing kerogen assemblages to be assessed. For example, the four samples collected in a 28 cm interval in West Tryal Rocks-4A display kerogen assemblages which are indicative of a change from crevasse channel to proximal/distal splay to overlying coaly swamp (Fig 3).

Preliminary taxonomic logging indicates that although *Falcisporites australis* dominates most palynofloras, in some cases contributing 80-90% of the assemblage, there is a greater diversity of spores than pollen in most depofacies. Several types of assemblages can be distinguished according to taxonomic composition and abundance of spores, suggesting that a mosaic of diverse and distinctive plant associations characterized the vegetation of the Middle to Late Triassic deltaic environments of southeastern Gondwana; similar patterns have been documented in northwestern Europe.

Few dinocysts or acritarchs were observed in the logged slides suggesting minimal marine influence in this part of the Mungaroo Formation.

CONCLUSIONS

Although there is a lot of natural variation and overlap between samples, each depofacies has a characteristic kerogen assemblage. Moreover, depofacies which are genetically similar tend to have similar assemblages.

As kerogen is an integral part of a sedimentary rock, kerogen analysis of the type undertaken in this study results in a more complete view of depositional environments. The methodology used in this study could be extended to other localities to more evaluate its potential as a tool to characterise depositional environments in deltas in general.

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REFERENCES

Dolby, J. H., and Balme, B. E., 1976, Triassic Palynology of the Carnarvon Basin, Western Australia: Review of Palaeobotany & Palynology, 2*2*(2), 105-168.

Ellis, C., 2013, GOR-1D, Carnarvon Basin: WA-37-L, Final Well Completion Report: Well Completion Report, Chevron Australia Pty Ltd, Perth.

Heldreich, G., Redfern, J., Legler, B., Gerdes, K., and Williams, B., 2017, Challenges in characterizing subsurface paralic reservoir geometries: a detailed case study of the Mungaroo Formation, North West Shelf, Australia: Geological Society, London, Special Publications, 444(1), 59-108. doi: https://doi.org/10.1144/SP444.13

Traverse, A., 2007, Paleopalynology (Second ed. Vol. Topics in Geobiology). Dordrecht, Netherlands: Springer Netherlands.

Tyson, R. V., 1995, Sedimentary Organic Matter: Organic Facies and Palynofacies: Chapman & Hall.

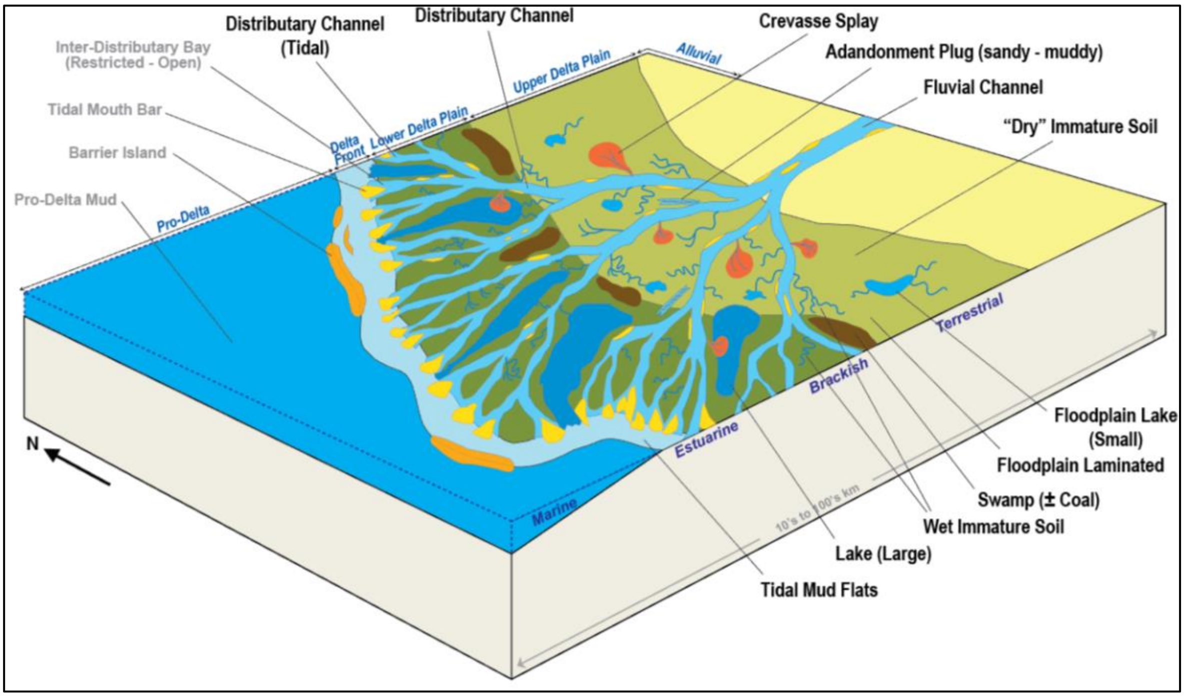

Fig 1: Schematic block model of the Mungaroo delta showing main environments of deposition and depofacies. (After Heldreich et al, 2017).

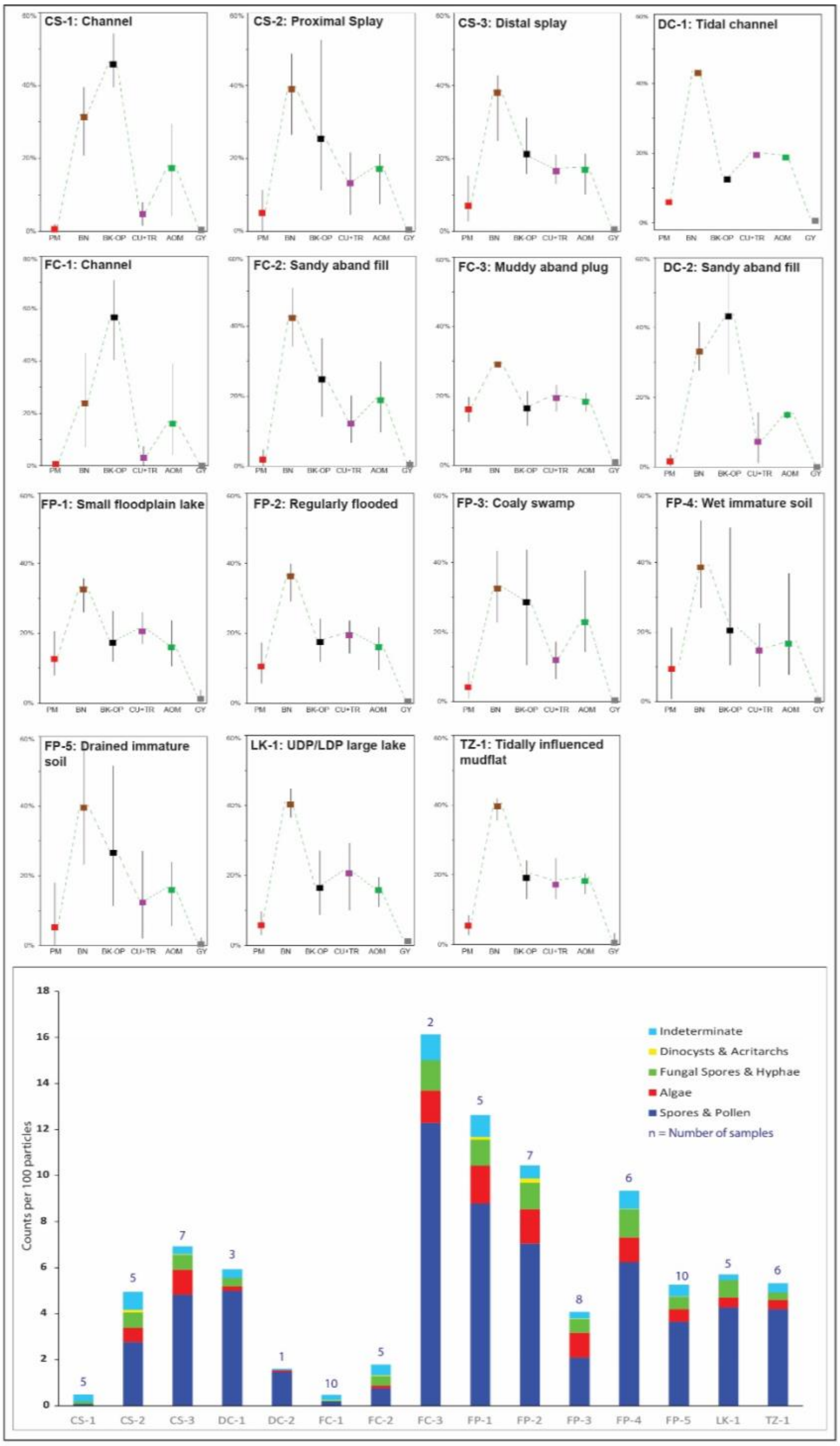

Fig 2: Kerogen trace and abundance diagrams for the depofacies identified in the Mungaroo cores. The relative abundance of the main palynomorph groups and the number of samples (n) collected from each depofacies are shown in the histogram. The box-and-whisker plots show the mean abundance (small colored boxes) for the main kerogen components and the absolute range (whiskers). The kerogen categories are palynomorphs (PM), brown wood particles (BN), black-opaque particles (BK-OP), cuticles & transparent particles (CU-TR), amorphous organic matter (AOM) and charcoal (GY).

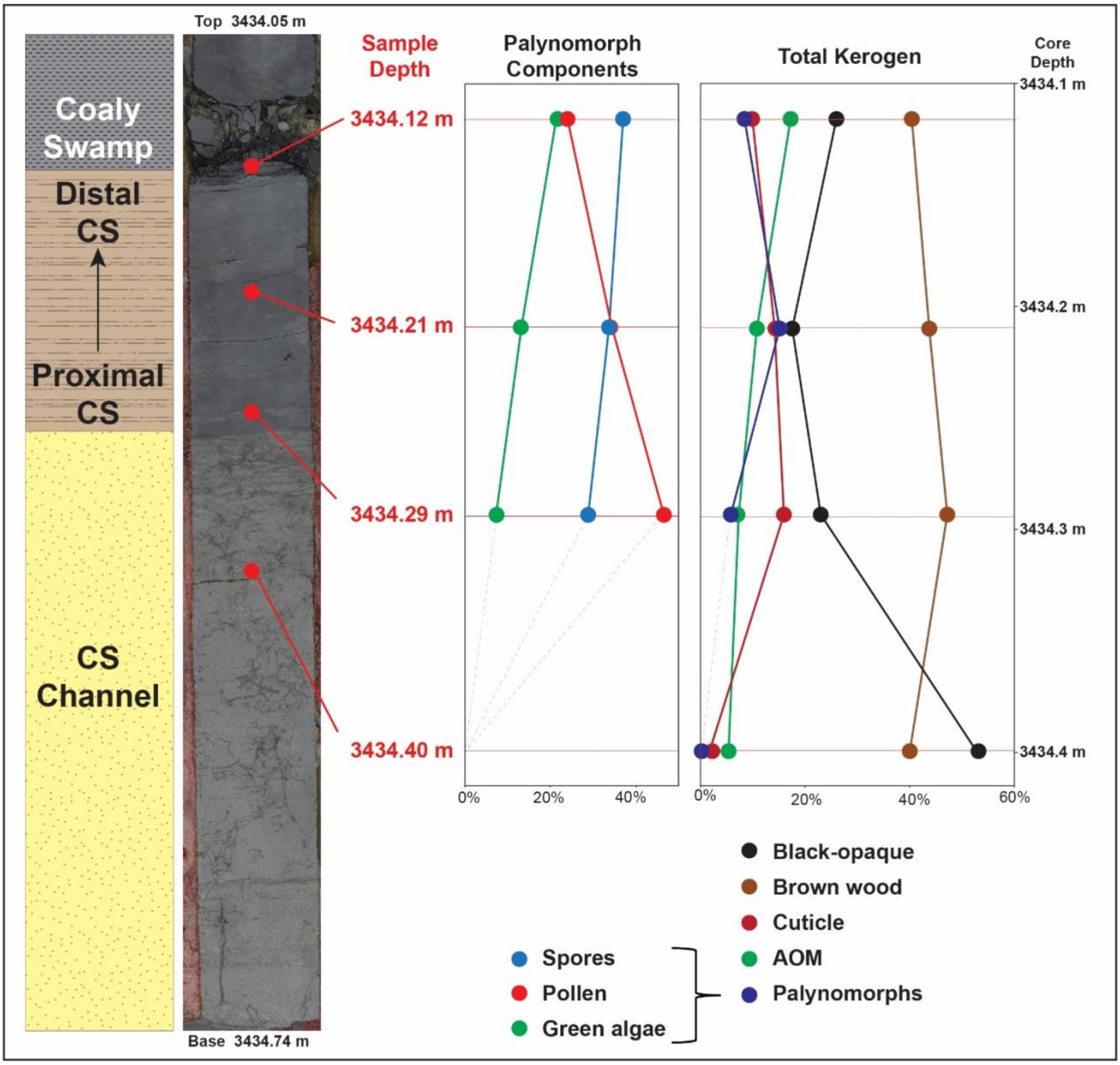

Fig. 3: Cored interval from West Tryal Rocks-4A illustrating change in kerogen assemblages from the basal crevasse splay channel (3434.73-3434.31m), proximal to distal splay (3434.31-3434.14 m) and overlying coaly swamp (3434.07-3434.14 m). Samples were collected from all depofacies over the 28 cm interval as indicated. The kerogen assemblages and a breakdown of the palynomorph components are shown in the trace diagrams on the RHS. ***Core image courtesy of Chevron Australia Pty Ltd.***