

CAMBRIAN PETROLEUM SYSTEMS AND OIL MIGRATION IN THE GEORGINA BASIN, AUSTRALIA

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A decade of petroleum exploration inactivity provided the stimulus to re-evaluate the petroleum systems and oil migration in the Georgina Basin, Northern Territory of Australia. Oil stains, bitumens, fluid inclusion (FI) oils and potential source rocks were sampled from the early Middle Cambrian Thornton Limestone, late Middle Cambrian Arthur Creek Formation and the Late Cambrian Hagen Member (Chabelowe Formation) from 11 wells over a combined depth range from 91 to 1065 m. Gas chromatograms of the saturated hydrocarbons from the oil stains and bitumens reveal a complex charge history of initial biodegradation and subsequent re-charge with *n*-alkane-laden oil. A multiple charge history is also evident from the FI oils. However, the biodegraded component is thought to originate from the surface of the dolomite crystals whereas a non-biodegraded oil charge containing abundant *n*-alkanes is believed to be mainly from the FI oils.

Three oil populations were identified using multivariate statistical analysis and source- and depositional environment-specific biomarkers. Resultant oil populations have a strong correlation with their reservoir units across the basin, suggesting juxtaposition of source and reservoir rocks within the same stratigraphic unit. This relationship is confirmed by oil-source correlations, based on biomarker, bulk carbon isotopes of saturated and aromatic hydrocarbons (Figure 1) and *n*-alkane-specific carbon isotopes, with the identification of the Thornton(!) Petroleum System, Arthur Creek(!) Petroleum System and Hagen(!) Petroleum System. High gammacerane characterises the latter petroleum system, indicating an evaporitic depositional environment. There is an intraformational source for the FI oil from the Arthur Creek Formation. Other oil stains reservoired within the Chabelowe Formation show a close affinity with oil stains from the Arthur Creek(!) Petroleum System, suggesting an interformational Arthur Creek-Hagen(!) Petroleum System at Elkedra-2 and Elkedra-7A. There is a mixed Thornton(!) Petroleum System and Arthur Creek-Thornton(!) Petroleum System at Ross-1, but the FI oil from Ross-1 displays a dominant Thornton Limestone source.

Middle-Late Cambrian hydrocarbons from the Georgina Basin share many geochemical and isotopic characteristics with other Cambrian-sourced oils both within Australia and worldwide. These include strong isotopic depletion in ¹³C, high abundances of

monomethylalkanes, *n*-alkanes biased towards the low molecular-weight hydrocarbons and dominant tricyclic terpanes. Regular steranes range from having a slight C₂₇ to a slight C₂₉ predominance. The strong to weak predominance of *n*-C₁₅, *n*-C₁₇ and *n*-C₁₉ is similar to that found in Lower Palaeozoic hydrocarbons with inputs from the extinct microorganism *Gloeocapsomorpha prisca*. However, the distribution of *n*-alkylcyclohexanes with a strong odd carbon number predominance extending to C₂₁ suggests an ancestral microorganism within the Middle Cambrian sea. Abundant 2,3,6-aryl isoprenoids and the presence of isorenieratane indicate that the Middle Cambrian source rocks of the Georgina Basin were deposited in marine anoxic bottom waters that extended into the photic zone. As such, they represent the local expression of a prolonged Middle–Late Cambrian oceanic anoxic event that led to the deposition of organic-rich ‘black shales’ on a global scale.

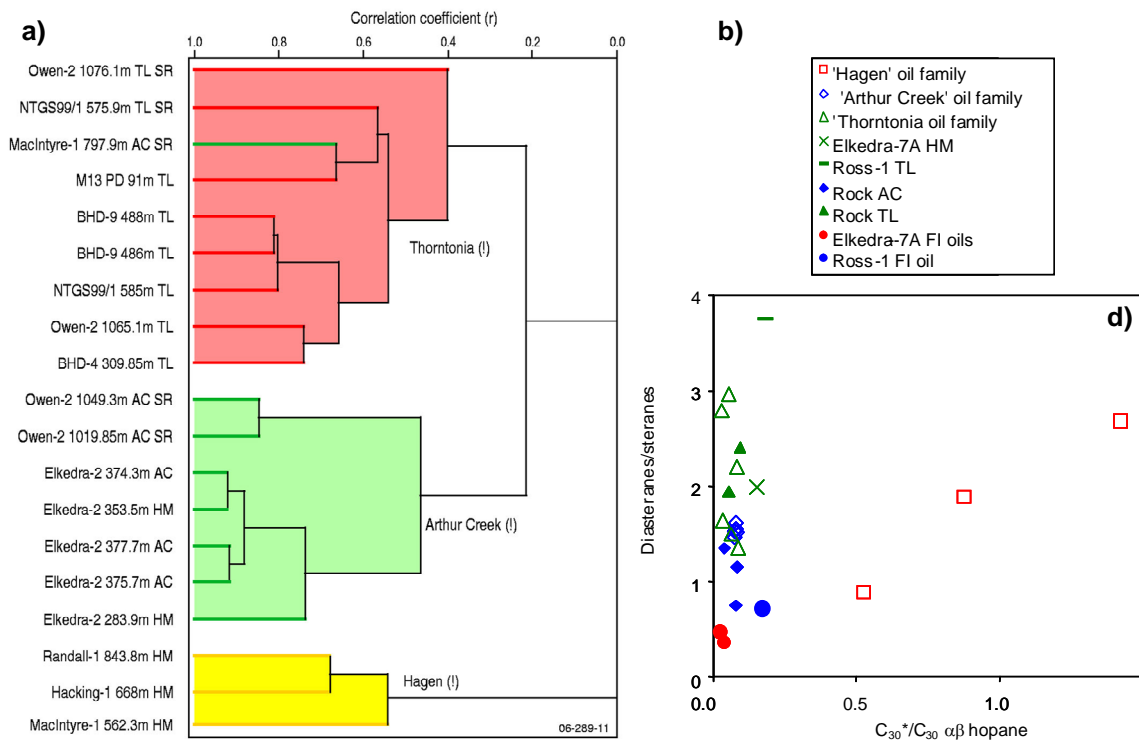


Figure 1. a) Dendrogram from hierarchical cluster analysis showing oil-source correlations in the Georgina Basin. In the left-hand column, oil stains and bitumens are identified by ‘well depth formation’ (TL = Thornton Limestone, AC = Arthur Creek Formation, HM = Hagen Member) whereas potential sources rocks are identified by ‘well depth formation SR’. b) Cross plot of diasteranes/steranes versus C₃₀*/C₃₀ αβ hopane.