Geochemical perspectives on the petroleum habitat of the Cooper and Eremanga Basins, central Australia

BERND HEINRICH MICHAELSEN

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Department of Geology and Geophysics
The University of Adelaide
South Australia

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Geochronological and petrographic techniques have been used to investigate genetic relationships between potential source rocks and hydrocarbon accumulations in the Cooper (Late Cretaceous–Tertiary) and Eromanga (Jurassic–Cretaceous) Basins of central Australia.

The liquid hydrocarbons trapped within the Cooper Basin were generated at varying maturation levels from terrestrial organic matter, principally within the Patchewarra Formation (Early Permian). The condensate-phase Family 1 oils (46–50°API) which are exceptionally mature (R₀ ≥ 0.95%; reorganized hopanes ≫ 17α-hopanes) are presently reservoired in the northern Patchewarra Trough (South Australia) where the maturity of the Patchewarra Formation is ≥ 1.0% R₀. Commercially produced crude oil from the Tirawarra Sandstone in the Tirawarra, Fly Lake and Moorooduc/Weebilla Fields belong to this family. Masking reorganized hopane distributions in Cooper Basin oils is evidence that these high maturity oils were predominantly derived from local coals (via short-range migration), rather than shales which have a more conventional hopane distribution. The latter is a feature of the heavier Family 2 oils (34–38°API) which are reservoired along the western and northern margin of the Cooper Basin within various reservoirs at Dimondale, Griggina, Mulgoona and Stuart (R₀ ≤ 0.54%; reorganized hopanes < 17α-hopanes) where the Patchewarra Formation is less deeply buried and less mature (R₀ = 0.75–1.0%).

Both Family 1 and Family 2 oils have penetrated into the superjacent Eromanga Basin, but loose pure Permian oils have survived herein. Notable exceptions in the South Australia sector include hydrocarbons trapped within the Hutton Sandstone (Family 1 affinity) at Reg Sprigg, and a very small pool trapped within the Murrta Formation (quasi-Family 2 affinity) at Garinoole. In Queensland, the Hutton Sandstone oils at Coogee and Nuecoolly South also represent pure Permian hydrocarbons and are related to Family 1.

The Birkenhead Formation (Middle–Late Jurassic) is the major hydrocarbon source unit in the Eromanga Basin where its best source facies comprise coals containing Type II kerogen. It has contributed to Eromanga-reservoired oils over a wide area of the southern Cooper Basin. The Murrta Formation early Cretaceous reservoirs appear to be solely Jurassic, and most Jurassic-derived oils migrated from their source rocks at the threshold of the conventional oil window (R₀ = 0.7 MPa × 0.22 = 0.5–0.6%). Murrta oils with low R₀ values include those trapped along the Mernerree Ridge (South Australia) and the southeast extension of the Nucn coch-lachar Ridge (Queensland). Notable exceptions are the Murrta crude oils at Big Lake (R₀ = 0.74%), Murrumala (R₀ = 0.75%) and Griggina (R₀ = 0.66%) for which higher maturities (and deeper source beds) are indicated. A predominant Jurassic (Birkenhead Formation) source is implied for these oils. In contrast to coals from the Murrta Formation and Nucn coch Sandstone, those in the Birkenhead and Hutton reservoirs generally have maturities that indicate they were expelled from their respective source rocks at somewhat higher maturation levels (South Australia: R₀ = 0.50–1.22%; Queensland: R₀ = 0.61–1.08%).

A novel combination of aromatic source and maturity parameters has enabled the recognition of multiple petroleum systems, instances of migration from Permian kitchens into Jurassic and Cretaceous reservoirs, and Eromanga traps which have received charges from both Permian and Jurassic/Cretaceous source rocks. As such, mixing of Permian and Jurassic/Cretaceous hydrocarbons can be quantified using the biomarker ratios 2-MPh/1-MP and 1-MPh/9-MP. Two mixing curves are defined for oils in South Australia and a single mixing curve for coals in Queensland. Regional analysis of oils of mixed origin has allowed the mapping of migration paths of Permian hydrocarbons into the Jurassic/Cretaceous sequence, thereby demonstrating long-distance lateral migration (> 50 km) of Cooper Basin hydrocarbons into the Eromanga succession and highlighting the potential of Eromanga-Birkenhead source–reservoir complexes beyond the margins of the Cooper Basin.

The prospectivity of the Eromanga Basin beyond the Cooper Basin "zero edge" is further enhanced with the recognition of significant and widespread vitrinite reflectance suppression in resinite-imregnated coals of the Birkenhead Formation as indicated by fluorescence alteration of multiple minerals (P-AMM). Widespread (but not severe) vitrinite reflectance suppression in organic-rich lithologies of the Pooldawarra and Murr Formations is also inferred.