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MOLECULAR SIGNATURES OF SEQUENTIALLY EXTRACTED RESIDUAL OILS REVEAL CAMBRIAN PETROLEUM IN THE COOPER AND EROMANGA BASINS, SOUTH AUSTRALIA

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The Cooper and Eromanga Basins together host Australia's premier onshore petroleum province. Its oil and gas pools occur within non-marine successions of Carboniferous to Cretaceous age. However, the first exploration well drilled in the region, Gidgealpa-1, encountered shows of partly biodegraded oil in vuggy carbonates of the Kalladeina Formation, which is part of the subjacent Cambro-Ordovician Warburton Basin. Gidgealpa-2 discovered commercial gas in the Cooper Basin, but also recorded oil staining and fluorescence in the Early Cambrian Mooracoochie Volcanics (Roberts *et al*., 1990). This pristine aromatic-intermediate oil is clearly of marine origin. Shales of the Kalladeina Formation (TOC up to 1.5%; Type II kerogen) are its likely source, but several important questions remain unanswered. When did these Cambrian source beds enter the oil generation window? Is Cambrian oil confined to the lower reaches of the Gidgealpa Field, or is it more widespread? And if so, during its secondary and tertiary migration, did this oil reach the Permian and Jurassic reservoirs of the overlying Cooper and Eromanga Basins?

The nine wells from which core samples of oil-bearing reservoirs were selected for analysis are from seven fields (including Gidgealpa) located on or adjacent to the southern end of the Gidgealpa-Merrimelia-Innamincka (GMI) Ridge. Residual oils were recovered sequentially from the intact pore system of sandstone core plugs by high-pressure solvent flow-through extraction (SFTE: Schwark *et al*., 1997). This analytical approach is based on the 'first in, last out principle' which assumes that the last oil to enter the reservoir (free oil) is the first to be extracted, whereas the initial charge (adsorbed oil) is recovered last. Molecular distributions of alkanes, aromatic hydrocarbons and alkylcarbazoles in the residual oil fractions (n = 2-5) recovered from each core plug were compared with those of end-member Cambrian, Permian and Jurassic oils and selected source rocks. This allowed determination of the extent of in-reservoir mixing, and helped constrain the charge histories of the fields sampled.

Three Permian oil types can be recognised using a methylphenanthrene source-maturity cross-plot (Arouri and McKirdy, 2005): Family 1 expelled by Early Permian coals (Ro = 0.9-1.2%) in the central Patchawarra Trough (but not represented here), Family 2 generated from lower rank coaly facies of the Patchawarra Formation and a new Family 3 apparently derived from the Epsilon and/or Toolachee Formations. In Eromanga reservoirs, these oils have mingled with locally sourced Jurassic crudes to give mixtures in which the Permian component is 40-75% of the total. End-member Cambrian oil from Gidgealpa-2 has a methylphenathrene signature similar to those of Family 2 Permian oils.

Cambrian contributions to Permian and Jurassic reservoirs are reflected by lower pristane/phytane and elevated C_{27}/C_{29} sterane ratios in their residual oils, relative to those in younger non-marine crudes, and by the high 1,7/1,6-dimethylcarbazole ratios in some residual oils from the Gidgealpa Field (Hallmann *et al*., 2006a,b). A Cambrian input is particularly evident in the Patchawarra reservoir of the Daralingie Field (Wooloo Trough), the Toolachee reservoir at Gidgealpa-8 (GMI Ridge) and in the earliest charges to the Namur reservoir of the Taloola Field (Patchawarra Trough).

Maturity modelling of Gidgealpa-1, coupled with the measured maturity of Cambrian-sourced residual oils, constrains the expulsion of oil from Kalladeina source beds to the late Middle Cretaceous. Local Permian oil generation filled the Patchawarra reservoir prior to the arrival of Cambrian hydrocarbons. Thus, Cambrian oil entered this reservoir among its last charges, or migrated further up section to become the first charge into younger sandstones.

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