Ouldburra Formation as a potential source and reservoir for petroleum in the Manya Trough, eastern Officer Basin

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The petroleum potential of the Ouldburra Formation in the Manya Trough of the eastern Officer Basin has not been investigated adequately. The present study addresses the topic by focusing on the sedimentary history, porosity and permeability trends, organic richness and source rock quality, and thermal maturity of this widespread Early Cambrian unit. The type section in Manya-6 comprises 1114 m of mixed carbonates and siliciclastics, marine calcareous and dolomitic carbonates, and evaporites including halite and anhydrite (Brewer et al. 1987) in which Gravestock and Hibburt (1991) recognised three depositional sequences (C1.1 – C1.3). The first sequence starts with a lowstand tract which was deposited in isolated salinas on a shallow marine to emergent sandy mudflat fringed by aeolian dunes (Relief Sandstone). These initial deposits pass upwards into transgressive shallow marine carbonates including archaeocyathan and cyanobacterial bioherms. Withdrawal of the sea and subaerial exposure is marked by a carbonate breccia at the top of the sequence. A second transgressive-regressive cycle resulted in deposition of a thick sequence of subtidal wackestones overlain by sabkha evaporites and redbeds (C1.2). The upper Ouldburra Formation is a regressive sequence of shallow marine to exposed carbonate mudstones and red anhydritic siltstones. Drillcore from four stratigraphic wells (Manya-6; Marla-3,-6,-7) was examined and sampled for analysis.

Conventional petrography, together with XRD, CL and SEM analysis on both carbonate and siliciclastic lithologies showed dolomite to be the dominant cement with intercrystalline porosity providing the main reservoir potential. Core plug analysis on twenty samples shows that quartz sands have porosities of 1 to 23% and permeabilities in the range 0.01 to 596 md, whereas the corresponding values for thicker sandy dolomites are 6 to 23% and 23 to 1640 md.

The total organic carbon (TOC) content of the Ouldburra carbonates is highly variable within the range 0.04 to 1.87% indicating poor to good source richness. A detailed profile of the formation in Manya-6, compiled from 93 TOC analyses, reveals that subtidal, sabkha and halite-associated carbonates are equally lean (mean TOC = 0.25–0.3%). The richest potential source beds are thin, but probably widespread, and occur sporadically in both the sabkha and highstand shallow marine facies. TOC values in excess of 0.75% are recorded at Marla-3 (n = 3), Marla-6 (n = 2) and Manya-6 (n = 4) but the kerogen is of uniformly poor quality (hydrogen index, HI = 5–91). Small, ill-defined S_2 peaks in the Rock-Eval pyrograms render T_{max} unreliable as a maturity indicator for the organic matter in these carbonates. Bitumen or extractable organic matter (EOM) concentrations are generally low (104–258 ppm), as are hydrocarbon yields (2–28 mg/g TOC; 19–57% EOM). One sample from 1279 m depth in Manya-6 appears to be stained by migrated hydrocarbons (production index, PI = 0.60; hydrocarbons = 83% of EOM).

Isomer ratios of diaromatic and triaromatic hydrocarbons in the bitumen (e.g. dimethylnaphthalene ratio, DNR-1; methylphenanthrene ratio, MPR; methylphenanthrene index, MPI-1: Radke et al. 1984; Boreham et al. 1988) provide an alternative measure of thermal maturity. With the exception of the aforementioned stained sample which has an anomalously low apparent maturity (MPI-derived VR_{calc} = 0.82%), calculated vitrinite reflectances are in the range 1.0 to 1.7% and indicate that the Ouldburra carbonates are mature to overmature in the study area. This contrasts with the situation farther west in the Tallaringa Trough where better quality, oil-prone Type II kerogen is preserved (HI = 123–409; atomic H/C = 0.86–1.06) and maturation levels correspond to the main phase of oil generation (VR_{calc} = 0.8%) (McKirdy et al. 1984; McKirdy 1993).

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