Mesoproterozoic Delta-Related Organic-Rich Mudstones: Roper Group, McArthur Basin, Northern Australia

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ABSTRACT

Hydrocarbon exploration in the frontier McArthur Basin has recently focused on the unconventional reservoir potential of the Mesoproterozoic, clastic-dominated Roper Group. This ancient depositional system once covered much of the North Australian Craton, but only a remnant remains due to intense structuration on the basin margins. The latter effectively shielded the remnant basin from significant deformation, which contains pristine preservation of virtually undeformed Roper Group stratigraphy (c. 1 to >5 km). Wells, many with continuous cores (total c. 3.5 km length), and seismic data reveal an overall northward-thinning wedge-shaped, epicontinental ramp-style setting which controlled accommodation space, facies architecture and the distribution of organic-rich mudstones. This exerts a primary control on the spatial distribution of hydrocarbon resources throughout the basin. The Roper Group comprises several major, clastic-dominated, regressive-transgressive successions (c. 10s to 100s m thick) that accumulated in a mud-prone deltaic depositional system. The main sandstone units (Bessie Creek and Moroak) comprise vertically stacked sandier-upward cycles (SUCs), which display evidence of the following: (a) fluvial-tidal currents in fluvial to tide-influenced lower delta plain settings, (b) tidal and wave-/storm-influenced processes in proximal delta front settings, and (c) storm-dominated processes and, more rarely, gravity flow processes, in distal delta front settings. The coeval, mudstone-dominated parts of the SUCs (Velkerri and Kyalla formations) host laterally continuous, organic-rich intervals (TOC 1-10%) with thicknesses in excess of 300 m and the following facies characteristics: (1) thin (mm-/cm-scale) turbidites and minor slumps and debrites, (2) an absence of wave-reworked storm events beds, and (3) gradual vertical facies relationships with distal delta front and prodelta facies. It is concluded that the organic-rich mudstones accumulated in the most distal part of the deltaic source-to-sink sediment transport system, below storm-wave-base, and with extensive deposition by dilute gravity flows. This setting was subject to sea-bed anoxia, probably caused by water stratification enhanced by sediment laden fresh and saline water. The primary origin of the carbonaceous material appears to have been internally sourced, possibly reworked from a zone extending from the intertidal areas (algal mats) to the distal delta front-prodelta (microbial mats).