Meteoric Alteration and Kaolinite Influence on Porosity in the Mungaroo Formation, Carnarvon Basin, Australia.

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The Triassic fluvio-deltaic Mungaroo Formation is the main reservoir in the multi-TCF gas plays offshore Northern Carnarvon Basin, Western Australia. The Triassic fluvial channel sandstones of various types represent the main exploration and development targets in the Mungaroo Formation.

Reservoir quality data were compiled from sedimentological descriptions, petrographic analytical data sets (i.e., petrography, QXRD, MICP, and SEM) and routine core analysis data from various fields in the basin. A lithofacies analysis was performed on the sampled intervals to provide sedimentological context to the petrology data and to evaluate the compositional variation in diagenesis. Mungaroo Formation sandstones are mostly subarkose and quartzarenite with sublitharenite and rare arkose, lithic arkose, feldspathic litharenite and litharenite. Sands are typically fine-to coarse-grained and moderately-to well-sorted. Framework grains are dominated by mono crystalline quartz, with minor polycrystalline quartz, feldspar and lithic fragments, mica, heavy minerals, organic matter and detrital clay are rare.

Jurassic uplift exposed the Mungaroo formations to meteoric processes resulting in feldspar dissolution and kaolinitic alteration and/ or replacement of the Triassic sediments. Petrographic evidence of grain (either feldspar or rock fragments) dissolution is frequent in these rocks. With regard to the evolution of the reservoir qualities during this alteration stage, feldspars and micas, if present, are altered to kaolinite as pore fillings (as kaolinite cement) and grain replacements. Porous kaolinite occurs in primary pores and grain dissolution pores that are observed in these sandstones. The amount of precipitation of pore-filling kaolinite highly depends on the degree of feldspar dissolution. Kaolinite exhibits at least four morphological textures ranging from fine-grained (<1 µm), medium-grained (1-10 µm) vermicules, to coarse-grained vermicules with individual diameters of up to 20 µm (10-20 µm) and coarse compact blocky crystals (>20 µm). Vermicular kaolinite has visible porosity of about 20–60% within the kaolinite cemented zones, while finer grained (<1 µm) seem to have the high microporosity association. Feldspar dissolution and kaolin development accounts for the majority of "kaolin porosity" (macroporosity within kaolin) enhancement and rearranges the porosity distribution in sandstones of the Mungaroo Formation. The "kaolin porosity" type contains a variety of pore throats that are formed through different kaolinite morphology, some of which are not well correlated to permeability. The absence of k-feldspar in the sandstone units due to kaolinisation prevent illitisation and thus retain the permeability. Principal cementing agents include authigenic quartz that reduces porosity; however kaolinite improvement inhibits later quartz cementation and thereby help preserving the primary porosity. Feldspar dissolution pores become significant at deeper depth because of the commencement of quartz cementation at these depths. The quartz cement is predominantly precipitated in the primary pores, leaving the kaolin pores open. These remaining kaolin pores do not contribute to permeability as much as primary intergranular pores. It is essential to understand the types of pores in sandstone before attempting to forecast porosity and especially permeability.

Notes