Smectite Grain Coatings: A New Discovery on Its Positive Effect on Porosity Preservation

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ABSTRACT

Devonian sandstone reservoirs have rarely been the main target for petroleum exploration in the UK. In part this is due to the perception that such ancient sandstones are likely to have low reservoir quality. However, our research reveals that such sandstones may have very good porosity and permeability due to the efficiency of grain coating smectite as a porosity-preserving mechanism. This study reports on the factors controlling reservoir quality of deeply buried Upper Devonian Buchan Formation in the Ardmore Field, Block 30/24, UK Central North Sea. Core material and well data from five wells were examined using sedimentological and petrographic analysis. Sedimentological analysis was performed through core logging and facies identification. Optical microscopy, X-ray diffraction and SEM provided the database for the petrographic analysis. The sandstones with reservoir potential in the Upper Devonian Formation are interpreted as mixed fluvial-aeolian facies deposited in a semi-arid to arid climatic setting. Apart from conventional analysis on sandstone compositional and textural features, special attention was given to the positive effect and origin of smectite grain coatings. Thick (>5μm), continuous and well-developed smectite grain coatings occur only in aeolian facies sandstones. The clay coats effectively prevented precipitation of quartz overgrowth on the detrital grains. This was crucial for preservation of porosity in aeolian facies sandstones at deep burial depth. While smectite grain coatings are absent in fluvial facies sandstones and thus the primary porosity is significantly occluded by quartz overgrowth. This is the first time the effect of grain coating smectite and its influence on porosity preservation has been reported. Smectite grain coatings were formed by mechanical infiltration from adjacent fluvial-origin clay-bearing water at an early post-depositional stage and before the onset of any significant compaction. Furthermore, illitization is restricted in the Devonian strata due in part to the relatively shallow burial depth (<500m) until the end of Cretaceous, and then rapidly buried from Palaeocene to present day maximum burial depth (2.7-3.0 km). This research highlights the potential for similar age depositional facies to have reservoir potential in the North Sea and other hydrocarbon basins.