Iron Mineral Cementation in Shallow Marginal Marine Sandstone: Controls on Porosity Preservation by Chlorite Grain Coatings – A Case Study From Cook Formation, Knarr Field, North Sea

Auwalu Yola Lawan[1], Richard H Worden[1], James Churchill[2]

[1]Earth, Ocean and Ecological Sciences, University of Liverpool, Liverpool, Merseyside, United Kingdom.
[2]Shell, Aberdeen, United Kingdom.

ABSTRACT

The dominant cause for porosity- and permeability-loss in sandstone reservoirs, at depth greater than 2.5 km and temperature exceeding 80 0C, is the growth of authigenic quartz cement. However, grain–coating chlorite cement can inhibit, or even prevent, the nucleation of authigenic quartz cement overgrowths on detrital quartz grains in deeply buried sandstone petroleum reservoirs and thus it can preserve anomalously high porosity and permeability. The Lower Jurrassic Cook Formation of the Knarr field in the Norwegian sector of the North Sea is characterised by iron-rich chlorite coats on sand grains that has prevented quartz cement growth and thus preserved high porosity (>20%) at depths over the range 3.9 to 4.1 km. High-resolution core description and facies analysis from three wells from the Knarr field was conducted with discrimination of lithology, grain size, sedimentary structures, degree and type of bioturbation and carbonate cementation. Eleven sedimentary facies associations were identified. Core samples for further study were taken from points directly adjacent to where core analysis plugs had been collected; thus allowing a direct link between petrography and mineralogy and petrophysical data; these data were further related to wireline analysis data from open-hole logs. Seventy six polished thin sections were analysed using an automated mineralogy SEM-EDS (QEMSCAN). Grain-coating chlorite was predominantly found within the tidally-influenced to shallow marine sandstone of the Cook Formation where porosity is routinely greater than 20% and permeability as high as 4,000mD. Ongoing research is tackling the role of clay-supply at the time of deposition as well as clay-to-grain attachment mechanisms and the effects of low- to high-temperature diagenetic transformation of the initial penecontemporaneous clay coats on sand grains. Chlorite grain coats were found to enhance reservoir quality only where the degree of coat coverage was very high. Even medium degrees of chlorite coating (50-70% coverage) were not able to inhibit quartz cementation since quartz cement could nucleate on a clean part of a quartz grain and grow over the partial chlorite-coat. The key factors that influence the anomalously high porosity are specific depositional environment and the degree of coverage of the detrital grain by the clay coat.