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Paleozoic and Triassic Sandstones of North Africa and the Middle East: Diagenetic Controls on Reservoir Quality

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Reservoir quality of Paleozoic and Triassic sandstones across the entire North Africa and Middle East region is strongly influenced by diagenesis, which has resulted in overprinting and restribution of depositional porosities. This makes the use of conventional facies models for sandstone reservoir quality distribution unreliable in many areas.

Detrital composition, the influence of uplift (e.g. the Hercynian Orogeny), maximum depth of burial and the timing of hydrocarbon emplacement are all key factors affecting the preservation or destruction of porosity and permeability in Paleozoic sandstones.

Depositional environment, detrital composition and texture influence early diagenetic processes, which, in turn, have a significant effect on later diagenesis. Of particular relevance are grain coatings, formed immediately following deposition of the sands. These early-formed grain coatings are commonly recrystallised to illite or chlorite, which can promote intergranular porosity preservation, by inhibiting quartz cementation. At higher temperatures and pressures, however, the clay coats can accelerate porosity and permeability destruction, by catalysing intergranular pressure dissolution, and/or acting as substrates for development of permeability-destroying fibrous illite.

Cooling, and meteoric flushing, associated with Hercynian, and possibly other uplift events, promoted early quartz cementation, and dissolution, kaolinitisation and albitisation of detrital feldspars. In places, early hydrocarbon emplacement in structural highs following the Hercynian Orogeny resulted in premature termination of diagenesis, due to reduced water saturations and relative permeabilities, preventing further porosity and permeability destruction during subsequent diagenesis. Post-Hercynian re-burial of Paleozoic successions led to a second phase of quartz cementation, and extensive illite authigenesis, as a result of illitisation of kaolinite in the presence of K-feldspar, at temperatures in excess of 100°C.

Late diagenetic development of fibrous, pore-bridging illite is commonly the single most detrimental factor to reservoir quality in these sandstones, and the depth of onset of significant illitisation can be used to define a generalised permeability "floor". Anomalously high porosity and permeability sandstones can be located below this "floor", where illite authigenesis has been retarded by either a lack of source ions for illite development (e.g. in sandstones lacking K-feldspar, due to provenance, or following uplift-associated leaching of detrital feldspar), low geothermal gradient, or early hydrocarbon emplacement.

Diagenetic factors should be carefully considered when risking reservoir quality development in these Paleozoic and Triassic sandstones. By integration of detailed diagenetic studies with burial history and structural data, it may be possible to develop models for post-depositional porosity evolution and identify areas where anomalously high reservoir quality is preserved at depth.