Diagenetic Controls on Porosity Evolution of Deeply Buried Sandstone Reservoirs

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ABSTRACT

Diagenesis plays a significant role in porosity destruction, enhancement and preservation in deeply buried sandstone reservoirs. Precipitation of quartz cement on detrital sandstone grains is the most important porosity destroying process at elevated temperatures and greater depths. There are many factors that may retard or prevent the formation of quartz overgrowths and, hence, preserve reservoir quality. These include grain coatings of clays and microquartz, reservoir overpressuring, and early hydrocarbon introduction and emplacement. Grain-coating minerals (e.g., chlorite, illite, and micro-quartz) play a critical role in reservoir quality preservation in deeply buried sandstones. Eogenetic grain-coating berthierine, odinite, and smectite, formed mostly in deltaic and estuarine sandstones, are transformed into ferrous chlorite during mesodiagenesis, helping to preserve reservoir quality through inhibition of quartz cementation. Infiltration of grain-coating smectitic clays is more extensive in braided than in meandering fluvial sandstones; the coatings aid in forming flow barriers within braided amalgamated reservoirs. In such cases, porosity preservation may be enhanced during burial because of quartz overgrowth inhibition, or preservation may be reduced by facilitating intergranular pressure dissolution. However, clay mineral coatings have no effect on porosity preservation in sandstones having high amount of mud intraclasts, which induce porosity-permeability reduction owing to ductile deformation. Linking the types and distribution of diagenetic processes to the depositional facies of clastic successions provides a powerful tool to predict the distribution of diagenetic alterations controlling reservoir quality and heterogeneity. At the end, a case study from the Devonian Jauf Formation in Saudi Arabia will be presented to demonstrate the impact of grain-coating on reservoir quality.