Origin and Occurrence of Clay Minerals in Surface and Subsurface Clastic Sequences using SEM Imaging and Characterization

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Abstract

Clay minerals are complex and important components of sandstone reservoirs, which form under various depositional processes and environments, pressure, and temperature conditions. Their types, mode of occurrence, and distribution within sandstone reservoirs significantly impact reservoir porosity and permeability. Accurate characterization and prediction of clay minerals have both scientific and economic significance for a better understanding of the controls on reservoir quality of clastic deposits. In this study, we employed Scanning Electron Microscopy (SEM) imaging technique to investigate the morphological features, types, and distribution of clay minerals in both shallow- and deeply-buried sandstones to understand their transformations and impact on reservoir quality. There are five main types of clay minerals that occur in clastic deposits: kaolin, illite, chlorite, smectite, and mixed-layer varieties. The crystallographic differences between these are a function of temperature condition, which is mainly controlled by the depositional environment and burial depth. The origin and distribution of clay minerals in clastic sequences are controlled by many interrelated sedimentary and diagenetic factors, including depositional environments, relative sea levels, climatic conditions, weathering, and geothermal gradients. Various modes of occurrence of clay minerals (e.g., grain-coating, pore-bridging, and pore-filling) from the surface and subsurface clastic sequences in Saudi Arabia will be investigated to establish their origin and the impacts on reservoir quality. The characterization and quantification of clay minerals based on their occurrence and distribution within pore systems would enable the establishment of the minimum thresholds beyond which they either preserve or destroy reservoir quality. The study would give invaluable insights into clay minerals that would enhance production in mature hydrocarbon fields and reduce exploration risks in frontier areas.