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The Role of Diagenesis in Controlling Reservoir Qualities: The Unayzah Formation, Central Arabia

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ABSTRACT

The reservoir quality of Permian-Carboniferous eolian and fluvial depositional systems in Central Saudi Arabia is strongly influenced by various types of diagenetic overprints. Early diagenesis (T<80°C) in eolian sandstones can be important in porosity preservation and tends to provide the template for later stage diagenetic processes. The spatial distribution of early diagenetic (eogenetic) alteration is controlled by depositional facies, paleoclimate, and detrital composition. The predominant eogenetic alterations in both eolian and fluvial sandstones of the Unayzah Formation are feldspar and unstable grain dissolution such and the formation of kaolinite. The impact of associated biota can also be an important factor influencing the early diagenesis of eolianites, particularly where playas are a common paleoenvironment. Mesodiagenesis (T 80-140°C) is strongly influenced by eogenetic alterations as well as by temperature and pressure evolution and the composition of basinal brines. The dominant mesogenetic alterations in eolian rocks of the Unayzah Formation include feldspar dissolution, illite formation, chemical compaction and quartz cementation. Mesogenetic modification has a very significant impact in reducing reservoir qualities of Unayzah sandstones. During esodiagenesis (T > 140°C), most authigenic kaolinite is altered to illite due to dominant K-feldspar content in Unayzah sandstones, and is formed by chemical reaction of detrital K-feldspar with early authigenic kaolinite with increasing burial temperatures. Authigenic illite is one of two major porosity occluding cements in the sandstones. Illite ceases to precipitate when either of the two reactants is exhausted. There is no evidence that hydrocarbon emplacement, deep brine migration, or discrete thermal events are factors in illite precipitation. Although illite formation can be a major factor in permeability reduction of fluvial and eolian facies during deep burial, it appears to also inhibit nucleation of quartz overgrowths, thereby having the opposite effect and actually preserving reservoir qualities. Despite complex patterns of diagenetic modifications which may be confounding in their effect on the Permian-Carboniferous successions studied, depositional porosity and permeability are systematically better preserved in eolian fluvial sandstone facies. These observations are important for prediction of reservoir-quality distribution and exploration risk evaluation in the central-Arabian basin.