Eolian Interdunes and their Stratigraphic Influence on Heterogeneity: a Case Study from Early Permian Deposits Saudi Arabia

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Abstract

Eolian interdunes are preserved in the subsurface as localized, ribbon-like lenses that are generally characterized by relatively low porosity and permeability. These lenses can act as effective baffles and may exert significant impact on overall fluid flow within eolian sand bodies. The lateral extent of eolian interdune lenses is highly variable due to changes in controls on sedimentation processes that occur over space and time. This work uses a subsurface case study of Early Permian eolian deposits in Saudi Arabia in conjunction with modern analogues to demonstrate how changes in these controls ultimately affect the geometry and interconnectivity of preserved-morphological forms in eolian deposits.

Core-based and petrological interpretation of samples from the Early Permian deposits, including sedimentology, diagenetic history, and XRD derived mineralogy, were utilized to better understand the lateral growth of impermeable interdune elements. This understanding was then used to predict facies composition and lateral interconnectivity. Interpretations presented in this study were ground-truthed with examples from modern analogues, which demonstrated the size, occurrence and migratory nature of interdune elements.

In this study, two types of interdune elements were observed: mud-prone elements and sand-prone elements. Mud-prone interdune elements were composed of silty, very fine-grained sandstone with common illitic-coated grains packed by detrital or authigenic clay pore-fillings indicative of infiltration and precipitation of clay in intergranular pore spaces. These elements were interpreted to have resulted from repeated fluvial flooding along long-lived interdune corridors in front of advancing eolian dunes, which caused thick, sheet-like muddy layers to develop. Sand-prone interdune elements were thin, isolated lenses composed of relatively coarser grained sandstone. These elements were interpreted to have resulted from infrequent fluvial flooding in isolated hollows in between sinuous-crested dunes, where mud-laden floods were prevented access and relatively coarser sand grains, reworked locally from surrounding dunes, were trapped in wet ponds caused by rising groundwater levels.

Models presented in this study facilitated identification and characterization of mud-prone interdune elements in early Permian eolian deposits. Importantly, the models defined the expected extent and connectivity of these low-permeability baffle units that can control overall fluid flow behavior of eolian sand bodies. The approach developed in this study is broadly applicable to eolian deposits and may serve as useful tool for deciphering possible stratigraphic influences on heterogeneity and assessing resultant potential permeability impacts.