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Sedimentology and Ichnology of Paleozoic Estuarine and Shoreface Reservoirs, Morrow Sandstone, Lower Pennsylvanian of Southwest Kansas, USA

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ABSTRACT

Integration of ichnologic, sedimentologic, and stratigraphic studies of cores from Lower Pennsylvanian oil and gas reservoirs (lower Morrow Sandstone, southwest Kansas) allows researchers to distinguish between estuarine- and open-marine deposits. This study represents one of the first published ichnologic analyses of a Paleozoic reservoir and, therefore, provides a unique opportunity to test the applicability of models based on observations from Mesozoic and Cenozoic reservoirs. Fifteen facies grouped in two facies-assemblages (estuarine and open-marine) were recognized from the lower Morrow.

The estuarine facies-assemblage includes both interfluve and valley-fill deposits, encompassing a variety of depositional environments, such as fluvial channels, interfluve paleosols, upper-estuarine channels, estuary bay, restricted tidal flats, tidal channels, and estuary mouth. The presence of a low-diversity, opportunistic, impoverished-marine ichnofauna dominated by infaunal structures, which represents a mixed *Skolithos* and depauperate *Cruziana* ichnofacies, supports a brackish-water setting. Overall distribution of ichnofossils along the estuarine valley was mainly controlled by the salinity gradient, with other parameters, such as oxygenation, substrate and energy, acting at a more local scale. The lower Morrow estuarine system displays the classical tripartite division (seaward marine sand plug, fine-grained central bay, and sandy landward zone) of wave-dominated estuaries, with local evidence of tidal action. The estuarine valley displays a northwest-southeast trend, draining to the open sea towards the southeast. A major lowstand of sea level at the Mississippian-Pennsylvanian boundary is thought to be responsible for incision of the estuarine valley.

The open-marine facies assemblage includes upper-shoreface, middle-shoreface, lower-shoreface, offshore-transition, offshore, and shelf deposits. In contrast to the estuarine assemblage, open-marine ichnofaunas are characterized by highly diverse biogenic structures produced by a benthic fauna developed under conditions of normal salinity. Trace-fossil and facies analyses allow environmental subdivision of the shoreface and offshore packages and suggest deposition in a weakly storm-affected nearshore area. An onshore-offshore replacement of the *Skolithos* ichnofacies by the *Cruziana* ichnofacies is clearly displayed. Identification of incised valley systems in the lower Morrow has implications for hydrocarbon exploration and subsequent production because reservoir quality is largely determined by facies distribution and external geometry. While the open-marine model predicts a layer-cake style of facies distribution as a consequence of strandline-shoreline progradation, recognition of valley-fill sequences points to more compartmentalized reservoirs, due to heterogeneity created at different scales by valley incision and distribution of facies and

facies assemblages. The emergent picture is one of a heterogeneous and compartmentalized reservoir, displaying high variability in sedimentary facies and a complex pattern in distribution and connectivity of reservoir sandstones.

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