Sedimentary Architectural Response to Autogenic Controls: A Case Study in Paleozoic Saudi Arabia

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Abstract

Terrigenous processes are controlled by factors such as discharge, gradient, proximity to shoreline among others. Cyclic changes in these factors are autogenically-driven and result in phases of degradation and aggradation, producing distinct sedimentary architecture patterns that can be observed in modern environments. These can be difficult to recognize in the ancient record with unknown boundary conditions and limited observations.

However, such patterns can be tested once a paleoenvironment is approximated and a high-density dataset is available.

In a siliciclastic reservoir system in Saudi Arabia represented by ~5,000 ft. of closely-spaced subsurface core data, we estimate a relatively-proximal, dominantly-sandy environment of deposition. The homogeneous distribution of facies makes it difficult to characterize vertical changes in paleoenvironment. However, we observe a subtle increase in monospecific, diminutive bioturbation rates from base to top of the variably, but mostly rhythmically- laminated succession near the center of our strike cross-section. This is coincident with sandstones with post- depositional soft sediment deformation structures that underlie and juxtapose aforementioned bioturbated sandstones, creating a pattern that may display a terrace morphology along strike. More intense deformation is observed closer to the bioturbated sandstones. We interpret the deformation to have occurred following terrace post-depositional sub-areal exposure, incision and sub-aqueous saturation, such that these terraces borderline an active paleochannel.

This model can be tested by cross-referencing petrophysical properties in different well locations. Conceptually, older terraces away from the center of the paleovalley were prone to reduced sorting and increased authigenic heterogeneity as a result of different post-depositional and diagenetic processes. Younger paleovalley fill near the center of the paleovalley, on the other hand, may present better reservoir properties as it displays reduced heterogeneities.

This model presents a sedimentary architectural response to autogentically-driven cyclicity in terrigenous processes that are commonly-observed in modern systems but difficult to constrain in ancient rock record. The high-density subsurface core data in this reservoir system enables observations that help interpret an ancient terrace geomorphology, but with a degree of uncertainty that must be tested using reservoir properties.