Re-interpretation of Sea-Level-Driven Stratigraphic Architectures as the Product of Autogenic Behaviors and Variations in Sediment Flux

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Abstract

Over the last two decades, numerical and physical experiments have repeatedly generated insights that contradict the sequence stratigraphic model that is near-universally used to interpret ancient strata in terms of relative changes in sea-level. This presentation will re-examine Upper Cretaceous strata (Blackhawk Formation. Castlegate Sandstone, Mancos Shale) exposed in the Book Cliffs, east-central Utah, USA, which are widely used as an archtype for the sequence stratigraphy of marginal-marine and shallow-marine strata. Stratigraphic architectures in these strata are classically interpreted to reflect forcing by relative sea level, but key aspects can instead be attributed to autogenic behaviors and variations in sediment flux.

Coastal-plain deposits exhibit only weak stratigraphic organisation related to relative sea-level change. Instead, the architectures, dimensions and distributions of major channelized fluvial sandbodies were controlled principally by avulsion history and local variations in sediment flux and transport capacity. These variations are likely expressed by subtle architectures that record shifts in the location of sediment point sources and variations in local wave climate within coeval shallow-marine parasequences. At larger spatial and temporal scales, parasequences in the lower Blackhawk Formation are stacked to form progradational-to-aggradational shoreline trajectories that may record autogenic behaviour (autoretreat) of the erosion-transport-depositional system. Parasequence stacking in the upper Blackhawk Formation forms aggradational-to-progradational shoreline trajectories that reflect decreasing tectonic subsidence rate and/or increasing sediment flux.

Relative variations in sediment supply can be characterized using a mass-balance framework that captures the rate of upstream-to-downstream loss of sediment (mass) and the spatial distribution of tectonic subsidence. Comparison of the downsystem mass-balance characteristics of eight stratigraphic intervals (each equivalent to a parasequence set) suggests that there were depositional gains and losses of offshore shale in the middle-to-upper Blackhawk Formation, which can be attributed to longshore sediment transport. These results are consistent with complex three-dimensional stratal architectures in the offshore Mancos Shale. The upstream-unconformable base of the Castlegate Sandstone is marked by a pronounced increase in the sand- to gravel-grade mass fraction of the fluvially supplied depositional volume, which can be attributed to hinterland unroofing and/or cannibalization of wedge-top basins that lead to import of coarse-grained sediment into the Castlegate fluvial system.

In summary, experimental work provides concepts that enable interpretation of stratigraphic architectures in the context of the integrated erosion-transport-depositional system, rather than relative sea-level forcing. The challenge for sedimentologists and stratigraphers interpreting

subsurface datasets and their outcrop analogs is to integrate these concepts into their working methods, in order to improve understanding and prediction of stratigraphic architectures and associated play elements.