The Influence of Backwater Morphodynamics on Spatial Variability in Fluvial-Deltaic Reservoir Quality

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Backwater condition (i.e., spatial deceleration of flow velocity as a river approaches the receiving basin) is an important control on the geomorphology of modern fluvial-deltaic systems, because downstream varying hydrodynamics regulate the dispersal of sediments (sand vs. mud), and transport system kinematics (e.g., lateral migration and channel avulsion). However, the influence of backwater hydrodynamics on the development of stratigraphy is not well understood. Here, we hypothesize that the spatial variability in fluvial-deltaic reservoir size and quality is controlled by the backwater hydrodynamics. To test our hypothesis, we use numerical models to generate synthetic stratigraphy and validated the results with field data from the Mississippi River. In particular, we examine the architecture and heterogeneity of stratigraphy from the scale of cross-beds to channel belts, and link channel mobility (e.g., migration rate and avulsion frequency) to variability of river sinuosity, backwater hydrodynamics and bank strength. Results suggest that systematic down-dip changes in architecture and dimension of fluvial sandstones arise due to spatially varying channel aggradation and lateral migration rates. For example, backwater morphodynamic models show that spatial variability in bed aggradation rate, dune celerity and size drive an increase in cross-bed thickness at the upstream onset of backwater condition. As a result, such increase in thickness abruptly reaches a maximum within short downstream distance, and decreases towards the river outlet. Preliminary findings suggest that point bar width scales with backwater-induced spatial variations in sinuosity and bank strength. Finally, we examine whether changes in fluvial-deltaic reservoir architecture and quality produce significant differences in patterns of fluid flow or resolvable signatures in well log or seismic data.

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