The sedimentology of a large carboniferous fine-grained river: facies, paleohydraulics, and implications for reservoir heterogeneity

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Thick sandstones (up to 60 m) of the Cypress Formation in the Illinois Basin have potential for nonconventional carbon dioxide enhanced oil recovery (CO₂-EOR) and storage, whereby CO₂ injection aims to store appreciable volumes of anthropogenic CO₂ and produce incremental oil at the same time. However, the depositional environments and resultant depositional controls on reservoir heterogeneity are currently poorly understood. This study provides the geologic context necessary for building representative geocellular models and helping select a proper CO₂ injection strategy to co-optimize CO₂ storage and EOR in thick sandstones of the Cypress Formation. Consequently, this study also provides new insight into the dynamics of Carboniferous sedimentation in the Illinois Basin.

Leveraging new outcrops, cores, and well logs, thick sandstones of the Cypress Formation were recognized to be predominantly multistorey, lowstand deposits of a fine-grained (D₅₀ = 132 μm), meandering or anastomosing fluvial system that had a high affinity toward suspended load transport. Mapping, outcrops, and lithofacies associations in core suggest up to three channel fill storeys that form sheet-like or arcuate channel elements in association with abandoned channel clay plugs. In many instances, channel fill storeys coalesce to form thicker, seemingly homogeneous sandstone “blocks.” Where this occurs, storey bases coincide with an abrupt but subtle increase in grain size and permeability that can be unrecognizable in traditional well log suites. These high permeability storey bases may act as thief zones during fluid injection.

This detailed characterization provides new insights into heterogeneity within the thick Cypress sandstones, including scales of flow units and controls on variations in permeability that can otherwise appear homogeneous on wireline logs. Additionally, these results promote a better understanding of the preservation of fluvial mesoforms and macroforms under the influence of suspended-load dominated transport and shows that subtle variations in the sedimentology of sandy fine-grained river systems are key to identifying the formative processes shaping their preserved deposits.