Reservoir Architecture of a Low Net-To-Gross Fluvial Succession Based on Integration of Channel-Body Geometry and Paleosol Characterization

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Abstract

Channel bodies in low net-to-gross fluvial successions form proven hydrocarbon reservoirs. Modeling such successions is usually based on constraint of the geometry and distribution of channel bodies. However, analyses of mudrock-dominated floodplain deposits also have predictive value. Paleosols are common in these fine-grained deposits and, despite their complex stratigraphy, outcrop and subsurface examples show that variations in paleosol composition and structure may be controlled by position relative to primary channel bodies.

Laterally continuous exposures (5 km) of the low net-to-gross Esplugafreda and Claret Formations (Paleogene, Arén, southern Pyrenees, Spain) are used to develop a reservoir analog study based on integration of the geometry of fluvial channel bodies and pedogenic features present in adjoining floodplain deposits. This succession represents the preserved expression of ephemeral streams developed in an arid environment; it therefore provides an opportunity to model low net-to-gross fluvial systems formed under different conditions to those of more commonly studied deposits of perennial rivers in humid paleoenvironments.

Outcropping channel and floodplain bodies have been mapped using high-resolution orthophotographs, LiDAR DEM's and GPS measurements; facies compositions and element architectures have been constrained by field analysis. Channel elements form spatially discrete, narrow ribbons and weakly channelized sheet-like bodies. Amalgamated complexes with better lateral continuity are restricted to the uppermost part of the succession and signify a major paleoclimatic change associated with the Paleocene-Eocene Thermal Maximum.

The finer-grained upper parts of channel deposits and adjacent channel-proximal paleosols are characterized by horizons with prominent root traces, vertical and horizontal burrows; these represent the development of riparian ecosystems associated with water-logged or intermittently flooded areas with perched water tables. Elsewhere, paleosols in intervals devoid of channel bodies contain only rare fossil traces but instead possess abundant gypsum precipitates indicating formation under drier, well-drained, rarely flooded conditions. Pedogenic features serve as predictors of proximity to different types of channel bodies and form the basis for a model to estimate channel location that can be applied to subsurface well data.