Facies, Stratigraphy, and Reservoir Heterogeneity of the Upper Wolfcamp Formation (Wolfcamp A- Equivalent) in the Glass Mountains of West Texas

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Abstract

The Upper Wolfcamp Formation, which includes most of the classic Early Permian (Artinskian-Kungurian) Skinner Ranch Formation, is exposed along the Glass Mountains in Brewster County, Texas. These outcrops comprise the southern part of the Ouachita Fold-and- Thrust Belt and have exposures that have remained largely unstudied by geologists for the past 50+ years. This study of the Skinner Ranch Formation (Upper Wolfcamp; Wolfcamp A-equivalent) uses an outcrop-based sequence stratigraphic and chemostratigraphic analysis to identify distinct chemo/litho facies within a regionally correlative framework for improved reservoir characterization of organic-rich mudrock successions. Moreover, modern advances in chemostratigraphy through integration of Energy Dispersive – X-Ray Fluorescence (ED-XRF), Fourier Transform Infrared (FTIR) Spectroscopy, and FTIR Total Organic Carbon (TOC) content helps improve understanding of depositional constraints on reservoir quantity (spatio-temporal variations) and quality (compositional, TOC richness) within this mixed carbonate-siliciclastic system.

Five facies are recognized from the integration of geochemical and petrographic thin section analysis of mudstone, siltstone, and limestone within the Poplar Tank Member of the Upper Wolfcamp Formation. This includes Facies 1 (skeletal wackestone/packstone/grainstone; Avg. TOC 0.7 wt.%), Facies 2 (calcareous silty mudstone; Avg. TOC 1.7 wt.%), Facies 3 (argillaceous shale/mudstone; Avg. TOC 0.9 wt.%), Facies 4 (siliceous mudstone/siltstone; Avg. TOC 1.6 wt.%), and Facies 5 (siliceous shale/siltstone; Avg. TOC 0.1 wt.%). Depositional heterogeneity and stratigraphic cyclicity of the of the Upper Wolfcamp Formation is expressed via vertical distribution of facies and constituent elemental proxies within alternating patterns or couplets of turbidites, debris flows, and hybrid event beds.

Among the key recent learnings included are: (1) seismic-scale geometries of lowstand conglomerate beds within the Decie Ranch Member and Sullivan Peak Member include gravity flow deposits of toe-of- slope debris flow aprons and mixed hybrid event beds of channelized sands, (2) Facies 1 and 2 have high values of redox-sensitive proxies and low values of detrital proxies within the carbonate-rich facies, indicating deposition within anoxic/suboxic conditions during the late TST and early HST, (3) Facies 3 and 4 low redox proxy values and high detrital proxy values indicate oxic/suboxic environments during early- to-mid TST and mid-to-late HST, and (4) intermittent deposition of carbonate debrites and turbidites alternating with siliceous/argillaceous mudstone deposition within HSTs is indicative of distal fringe deposition within mixed carbonate-siliciclastic sea-floor fans. This outcrop study improves understanding of spatio-temporal variation, and lithologic and geochemical heterogeneity, of basin-floor strata that comprise the unconventional source rock plays of the Wolfcamp A Formation.

Student Posters Tuesday, July 26 5:30 PM