Sequence stratigraphy, mineralogy and rock properties in the Woodford Shale, Permian Basin

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An integrated stratigraphic, sedimentological, geochemical and petrophysical analysis of a long core in the Upper Devonian Woodford Shale from Pecos County, West Texas, demonstrates variations in shale lithofacies, mineralogy and rock composition at multiple scales. Cyclic deposition is evident, marked by the repetition of sequences beginning with a massive carbonate bed, overlain by thick intervals of laminated black mudstone and then a package of interbedded lithofacies, including black mudstone, laminated carbonate and siltstone. These cycles are interpreted as 3rd or 4th order stratigraphic sequences.

At the formation scale, the organic geochemical character varies systematically, with maximum values of 5 to 10% total organic carbon (TOC) in the Middle Woodford. High TOC values in the Middle Woodford are mirrored by high Mo/TOC and high TOC/P, suggesting that organic carbon deposition was linked to both redox conditions and organic productivity and that the latter two were linked through a positive feedback relationship.

The proportion of clay decreases and the proportion of biogenic silica increases systematically upward. This is interpreted as a function of a 2nd order fall in sea level, with the delivery of continent-derived dissolved silica increasing upward as the basin became more isolated from the global ocean. The proportion of biogenic silica appears to significantly influence rock properties, with lower values of Poisson's Ratio in the Upper Woodford. Clay-rich intervals in the Lower Woodford can act as barrier to hydraulic fracture propagation.

This has major implications for well completion and stimulation design.