Significance of Pyrite Morphology to the Geochemistry and Sequence Stratigraphy of the Woodford Shale, Permian Basin, West Texas

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The upper Devonian Woodford Shale in the Permian Basin, west Texas, is an organic-rich pyritic black shale, typical of many ancient black shales and modern, anoxic marine sediments such as the Black Sea. The Permian Basin was a restricted marginal basin during the late Devonian, where reducing conditions developed under a stagnant water column, enhancing preservation of organic matter and limiting the availability of trace elements.

We have correlated geochemical and sequence stratigraphic data with occurrences of pyrite in a Woodford core from Pecos County to test the relationship between sea level, water column chemistry and pyrite morphology. Pyrite averages 4% by weight and occurs as macroscopic lamina, as replacement of microfossils, and as dispersed anhedral masses, euhedral crystals and framboids. Pyrite content decreases up section, corresponding with falling sea level in the upper Devonian.

Size distributions of the diameters of framboids in sediments have been related to redox conditions at the time of deposition. Sediments deposited under euxinic conditions contain smaller framboids of more uniform diameter, while framboids are more variable in size in sediments that deposited under only anoxic, dysoxic, and/or fresher water columns. Wider size ranges are interpreted as having deposited during periods of more mixing and greater oxygenation of the water column.

Redox proxies and TOC data indicate a relatively unstable and more oxygenated environment in the upper and lower Woodford, and a more stable, reducing environment in the middle Woodford. Framboid diameters vary widely with depth in core from the lower Woodford. The middle Woodford exhibits the smallest, most uniform framboid diameters, while relatively constant TOC and low phosphate contents point to a stable water column during a long-term regression, with increased restriction and lower oxygenation. Core samples from the upper Woodford are sparse in framboids, but contain those with the largest diameters, suggesting depletion of sulfur in the water column. Size distributions also demonstrate correlations with systems tracts, with the overall smallest diameters and tightest size ranges occurring in high stands, except in the upper Woodford, and greatest variability occurring in low stands. These results show that pyrite morphology records the complex interaction between sea level, nutrient supply and organic productivity, water column mixing and organic matter accumulation.