Constraints on Development of Anoxia through Geochemical Facies Mapping of Devonian Black Shales in the Southern Mid-Continent

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The Woodford Shale of the US southern midcontinent is an Upper Devonian/Lower Mississippian black shale sequence that includes the Frasnian-Famennian boundary. Black shales are commonly enriched in transition metals. While the details of the chemical reactions and feedbacks responsible for trace metal enrichment are debated, these elements continue to be valuable for constraining paleoenvironmental conditions and potential source rock characteristics. While anoxic conditions are thought to favor the preservation of high concentrations of trace metals and total organic carbon (TOC), debate continues concerning the specific role of anoxia in the preservation of TOC, as well as the importance of eustatic sea-level shifts in the development of anoxia during Woodford Shale deposition—and by extension in other shale gas units.

To determine the cause of anoxic conditions in the Woodford Shale, we are implementing an integrated lithologic-geochemical study of several outcrops located in south-central Oklahoma. Trace metal concentrations are measured in the field using a hand-held XRF instrument, with TOC concentrations measured in the laboratory. Trace metal concentrations (Fe, Mo, V) vary with lithology—higher concentrations are observed in fissile units as opposed to cherty layers. Metal/TOC ratios vary systematically with depth in these units within single outcrop, providing constraints on the role of bottom-water restriction in the development of these shales. Geographic variations in proxies for anoxia (i.e., higher trace metal concentrations at outcrops interpreted to be further from shore), TOC concentrations and shale lithologies provide evidence for a key role played by water-column productivity in the development of anoxia.