Stormy Times in "Anoxic" Basins - Tempestites in the Upper Devonian-Lower Mississippian Bakken Formation of North Dakota and Implications for Source Rock Depositional Models

Egenhoff, Sven [1]; Fishman, Neil [2] (1) Geosciences, Colorado State University, Fort Collins, CO. (2) U.S. Geological Survey, Lakewood, CO.

Conventional depositional models for organic-rich mudstones typically envision tranquil sedimentation in anoxic marine environments. Recently, this paradigm has begun to shift because studies have revealed bed-load transport structures and erosion surfaces in mudstones; however, a comprehensive understanding of the complexity of processes acting in such "anoxic" settings is still in its infancy. This study focuses on the influence of storms on sedimentary facies within the upper shale member of the Upper Devonian-Lower Mississippian Bakken Formation, a major source rock, Williston Basin, U.S. and Canada.

Facies analysis of the upper shale member of the Bakken reveals three distinct facies belts all containing significant amorphous organic material. On a transect from proximal to distal environments, these facies belts are: (1) a heavily bioturbated mudstone largely lacking sedimentary structures, (2) a laminated silt-rich mudstone with vertical bioturbation that partly disrupts sedimentary features, and (3) a radiolarian-rich mudstone with varying content of silt and clay. Storm deposits are evident in all facies belts as sub-millimeter thick fine silt laminae interpreted as distal tempestites. The occurrence of silt grains indicates that oxic/dysoxic water from the shallow-marine realm was transported into the deepest parts of the basin. Thus, it is unlikely that any facies belt was deposited in a continuously anoxic environment. The presence of vertical bioturbation in laminated silt-rich mudstones also argues against continuously anoxic conditions even some millimeters below the sediment-water interface. Only some of the radiolarian-rich facies, devoid of any trace fossils or tempestites, may reflect temporary anoxia, whereas others are rippled indicating bottom-current reworking during deposition.

The upper shale member of the Bakken Formation represents a highstand unit, sandwiched between the overlying Mississippian Lodgepole Formation and the middle Bakken member. Although the basin center was at its greatest depth during periods of elevated sea-level, storms episodically influenced Bakken sedimentation, which indicates that this basin was a relatively shallow trough with maximum depth only slightly below storm wave base, perhaps <100 m. Thus, major organic-rich source rocks such as the upper shale member of the Bakken can be deposited in relatively shallow water, above storm wave base, with tempestites being a major depositional feature.