Depositional Model for the Devonian Woodford Shale, SE Oklahoma, USA

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The upper Devonian Woodford Shale is an unconventional resource play that is preserved across Oklahoma. It unconformably overlies Ordovician to Lower Devonian rocks. Most paleogeographic reconstructions show it having been deposited in a relatively deep basin under anoxic to euxinic conditions. Regional subsurface work, however, shows that at least a portion of the Woodford in the Arkoma Basin and up into Kansas was deposited in a paleovalley incised into a pre-Woodford Lower to Middle Devonian carbonate platform margin. Because of the fine-grained nature of the Woodford, its deposition in eastern Oklahoma is generally thought to have been deposited from suspension settling. Few, if any studies have directly addressed the sedimentology of the formation and as a consequence the Woodford environment of deposition remains poorly understood. Core and petrophysical analyses of the Woodford Shale over a 4 township area reveal depositional facies that vary eastward, away from the carbonate platform. Proximal to the carbonate platform the Woodford facies is dominated by cm-scale, stacked sets of gray, laminated silty mudstones that locally preserve ripple- to plane-bedded, very fine-grained sandstone to coarse-grained siltstone, composed of Tasmanites, radiolarians, and reworked pyrite grains, and sparse conodont fragments and shark teeth. Cut and fill structures are preserved along set boundaries. This facies is consistent with deposits laid down by muddy turbidites.

Further east of the platform is a more distal facies which is dominated by cm-scale couplets that consist of an upper thinly interbedded grey-colored laminated mudstone and a lower darker grey colored, massive mudstone. The laminated mudstone resembles the turbidite facies found in the more proximal setting. By contrast, the darker massive mudstone contains intra-formationally derived mm-scale clasts (microbial mats), and fine-grained sand-size clasts. These mudstones are generally thinner than the overlying laminated mudstones and contain coarser grains. The dark units are also more siliceous than the laminated mudstones and are characterized by vertically compacted silica-filled dewatering structures. Sedimentologically they resemble a thin debris flow deposit formed at the base of a muddy turbidite. The two facies are genetically linked and together form deposits that were rheologically stratified during formation from both non-Newtonian (debris flow) and Newtonian (turbidite) flows.