Applying Stratigraphy to the Search for Unconventional Reservoir in the Upper Tyler Formation (Lower Pennsylvanian), Southern Williston Basin

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ABSTRACT

The upper Tyler Formation comprises a prospective unconventional resource play that extends beyond the prolific Bakken-Three Forks play into largely undeveloped acreage along the southern Williston Basin. The upper Tyler is a mixed clastic-carbonate system composed of primarily very fine grained calcareous mudstone (limestone) interbedded with argillaceous-siliceous mudstone (shale) deposited within a brackish water lagoonal setting. The gross thickness of the upper Tyler section is typically around 50 ft. and holds conservative oil in place estimates of 3 to 5 million barrels of oil (MBO) per section (6-10 MBO/1280 acres). A couple relatively recent unconventional test wells targeted upper Tyler carbonate beds which yielded sustained oil production but at low flow rates with negligible produced formation water. A preliminary reexamination of the upper Tyler's geology using sequence stratigraphy reveals five sequences (S1-S5 in ascending stratigraphic order) that were identified and correlated across the study area of southwestern North Dakota using several dozen cores and several hundred wireline logs. Sequence boundaries are observed/interpreted as thin (<1 ft), discontinuous paleosols and/or caliche/calcrete crusts that formed during subaerial exposure when the Tyler seaway receded. Directly above and below the exposure surfaces/sequence boundaries are typically intervals of ripple-laminated fossil grainstone interlaminated with darkly colored organic-rich mudstone interpreted as intertidal deposits. These intertidal, interlaminated fossil grainstone-mudstone intervals can either fall within the transgressive systems tracts (TST) or highstand systems tracts (HST), and are further separated by very fine grained argillaceous-siliceous mudstone (shale) beds that constitute the maximum flooding surfaces of the upper Tyler sequences. Overall, upper Tyler sediments tend to be very fine grained across most of the study area and core plug porosity values of the carbonate beds are typically 1-8% with permeability values that often range from <0.01 to 10 millidarcies. However, the upper Tyler sediments overall coarsen moving eastward towards the Dickinson Field, and core plug porosity values within a the carbonate interval spanning the upper S1 (RST-high stand systems tract) and lower S2 (TST) sequences increase to upwards of 20% with 80-90% oil saturation within an area extending along the eastern Fryburg and southern Zenith oil fields. This more highly porous and oil saturated carbonate interval is typically 8-12 ft. thick (with additional prospective pay zones in close stratigraphic proximity), forms a curvilinear trend that parallels the S1-S2 paleo shoreline, and laterally separates interpreted very dark grey to black subtidal mudstone (west) from grey to red supratidal deposits (east). Future unconventional exploration of the upper Tyler along this higher porosity carbonate trend may ultimately lead to unlocking another resource play within the Williston Basin. The upper Tyler Formation comprises a prospective unconventional resource play that extends beyond the prolific Bakken-Three Forks play into largely undeveloped acreage along the southern Williston Basin. The upper Tyler is a mixed clastic-carbonate system composed of primarily very fine grained calcareous mudstone (limestone) interbedded with argillaceous-siliceous mudstone (shale) deposited within a brackish water lagoonal setting. The gross thickness of the upper Tyler section is typically around 50 ft. and holds conservative oil in place estimates of 3 to 5 million barrels of oil

(MBO) per section (6-10 MBO/1280 acres). A couple relatively recent unconventional test wells targeted upper Tyler carbonate beds which yielded sustained oil production but at low flow rates with negligible produced formation water. A preliminary reexamination of the upper Tyler's geology using sequence stratigraphy reveals five sequences (S1-S5 in ascending stratigraphic order) that were identified and correlated across the study area of southwestern North Dakota using several dozen cores and several hundred wireline logs. Sequence boundaries are observed/interpreted as thin (<1 ft), discontinuous paleosols and/or caliche/calcrete crusts that formed during subaerial exposure when the Tyler seaway receded. Directly above and below the exposure surfaces/sequence boundaries are typically intervals of ripple-laminated fossil grainstone interlaminated with darkly colored organic-rich mudstone interpreted as intertidal deposits. These intertidal, interlaminated fossil grainstone-mudstone intervals can either fall within the transgressive systems tracts (TST) or highstand systems tracts (HST), and are further separated by very fine grained argillaceous-siliceous mudstone (shale) beds that constitute the maximum flooding surfaces of the upper Tyler sequences. Overall, upper Tyler sediments tend to be very fine grained across most of the study area and core plug porosity values of the carbonate beds are typically 1-8% with permeability values that often range from <0.01 to 10 millidarcies. However, the upper Tyler sediments overall coarsen moving eastward towards the Dickinson Field, and core plug porosity values within a the carbonate interval spanning the upper S1 (RST-high stand systems tract) and lower S2 (TST) sequences increase to upwards of 20% with 80-90% oil saturation within an area extending along the eastern Fryburg and southern Zenith oil fields. This more highly porous and oil saturated carbonate interval is typically 8-12 ft. thick (with additional prospective pay zones in close stratigraphic proximity), forms a curvilinear trend that parallels the S1-S2 paleo shoreline, and laterally separates interpreted very dark grey to black subtidal mudstone (west) from grey to red supratidal deposits (east). Future unconventional exploration of the upper Tyler along this higher porosity carbonate trend may ultimately lead to unlocking another resource play within the Williston Basin