Sequence Stratigraphy and TOC Modeling of the Utica-Point Pleasant Interval in the Middle Appalachian Basin

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ABSTRACT

Approximately 400 well logs and two drill cores from eastern Ohio, western Pennsylvania, and northern West Virginia are used to construct a depositional model of the Utica Shale and associated Upper Ordovician strata. Previous studies of outcrop data from the Cincinnati arch and Jessamine dome recognized a number of Late Mohawkian to Early Cincinnatian third-order sequences deposited in an active foreland basin during onset of the Taconic orogeny. Sequences consist of deepening upward successions of transgressive limestone and shale, recording a period of sustained subsidence and rising sea-level along the eastern margin of North America. The transition from a carbonate-dominated system (Black River, Trenton Limestones) to a clastic-dominated system (Point Pleasant, Utica Shale) reflects the drowning of a widespread carbonate platform. The units of the Trenton Group and Lexington Limestone through Utica Shale comprise the transgressive systems tract (TST) of a large second-order sequence, composed of three, smaller scale third-order composite sequences. Third order sequences are regionally correlative, aggradational, and lack low-stand deposits. Sequences are separated by type three sequence boundaries that amalgamate with transgressive surfaces and separate the underlying highstand system tract (HST) from the overlying transgressive systems tract (TST).

Chronostratigraphic surfaces demonstrate that basinal interbedded lime mudstone, shale, and marl facies of the Logana Shale and Point Pleasant Formations are contemporaneous and genetically related to platform limestone on the flanking Trenton and Lexington platforms. Average gamma-ray value contour maps of systems tracts and composite sequences indicate significant accumulation of carbonate sediment and build-up of the platforms during the Late Mohawkian, followed by increased clastic sedimentation and basin fill in the cross-strike Sebree trough and Point Pleasant sub-basin during the early Cincinnatian. Intervals with potentially high total organic carbon (TOC) content were identified using the Passey ΔLogR method and a regression fit between bulk density and TOC, and compared to publicly available source rock data. The Logana through Point Pleasant intervals contain the highest amount of TOC in the area of the Point Pleasant sub-basin in eastern Ohio, with the Utica Shale containing marginal amounts of TOC in the Sebree trough and along the Trenton platform in northwestern Pennsylvania. Rock-eval geochemical data were used to map source potential and thermal maturity. The data shows southwest-northeast trending zones of maximum oil generation, a narrow liquids window, and a wide dry gas window. Maturity maps combined with porosity maps indicate a southwest-northeast trending prospective play fairway of the highest porosity and ideal thermally mature Point Pleasant reservoir, confined to eastern Ohio.