

Stratigraphy and Petrophysics of the Middle Devonian Black Shale Interval in West Virginia and Southwest Pennsylvania

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In the Central Appalachian basin, the Middle Devonian organic-rich shale interval, including the Marcellus Shale, has become a major target for natural gas exploration and production. This unconventional gas reservoir is widespread across the basin and has significant potential to produce large volumes of gas. Although the Middle Devonian organic-rich shale interval is a large resource, with high economic potential, the stratigraphic distribution, depositional patterns, and petrophysical characteristics are not adequately characterized in the subsurface. Using an extensive log and core database, the lithostratigraphic boundaries of the Marcellus and associated units were established, and correlated throughout West Virginia and southwestern Pennsylvania. Within individual units log characteristics, tied to core information were used to map the lithology, fluid content, distribution and thickness of organic-rich facies across the region. Using previous studies on organic shale, relationships between the natural radioactivity (as measured by the spectral gamma-ray log) were incorporated with techniques to identify potential gas-rich intervals. The comparison between the Uranium content and the measured bulk density and modified saturation equations, identified intervals in the Middle Devonian with high gas saturations. In the study area, the depositional dynamics among thickness, lithology and organic content define fairways of thick gas prone intervals within different Middle Devonian black shale units. However, within a small local area, micro-anoxic environments result in significant variations in black shale deposition and presence of thin limestone intervals from well-to-well. Deposition and spatial distribution of organic-rich facies in the Marcellus, as well as its overlying and underlying units (e.g., Harrell Shale), is a complex process that must account for sediment input and development of micro-anoxic environments. Within a regional subsurface stratigraphic framework of the Middle Devonian in the Appalachian basin, an improved understanding of depositional dynamics can provide a better focus on exploration targets.