A Geologic Play Book for Utica Shale Appalachian Basin Exploration

Abstract

Source Rock Geochemistry

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Reported source rock geochemistry incorporates both legacy and newly-generated data, and includes evaluations of organic matter content, quality and thermal maturity. The research team performed total organic carbon (TOC) analyses, reviewed legacy RockEval data and performed bitumen reflectance analyses to assess the thermal maturity of these reservoir rocks. Well cuttings and core samples were analyzed to assess their TOC content. TOC values greater than 1% are interpreted to have the potential for hydrocarbon production, presuming that adequate thermal maturation has occurred. A total of 1,094 samples, from 29 wells, were analyzed for TOC content during the course of the Study. Additional TOC data were incorporated using values from existing TOC datasets that were collected for other projects. These legacy data include 3,054 Upper Ordovician TOC data points from Ohio and 4,652 TOC data points from New York wells (including some shallower data). Collectively, a total of 368 well locations with TOC data were used to determine vertical and spatial variability of TOC in the Utica Shale. Using these data, regional maps were generated for (in stratigraphically descending order), the Kope, Utica and Point Pleasant formations, and the upper Lexington/Trenton, Logana and Curdsville members.

Once the regional TOC data had been compiled for the studied units, numerous data comparisons and crossplots were made. The one commonly recorded parameter that appears to correlate with TOC abundance is the bulk density log. This correlation appears to be the strongest within the upper Lexington/Trenton and Logana members, and with diminished correlation within the more shale-rich Point Pleasant Formation and Utica Shale. The Kope Formation and Curdsville Member displayed little to no correlation between density and TOC.

Historical results for 1,900 RockEval analyses of Upper Ordovician strata were examined for the Study. Thorough inspection of these data revealed a high degree of variability in the RockEval results. This variability was noted both between adjacent wells and even within the same unit of individual wells. The variation appears to be the result of weak, or poorly defined, S2 peaks on the pyrolysis curves for these units. Whether this is due to the oxidation of older cuttings samples, or it is just the nature of the specific organic material within these units, is unclear.

More than 500 samples of the Utica Shale from Kentucky, Ohio and Pennsylvania were taken from exploration wells and examined petrographically in reflected light to obtain bitumen reflectance measurement data (Ro). Of these, roughly half had sufficient amounts of bitumen to analyze. In Ohio, the level of thermal maturity in the Utica shows a progression in increasing bitumen reflectance from west to east, with a very steep increase occurring in eastern Ohio. Ro random values from central Ohio ranged from 0.66 to 0.84%, where sample depths were between 100 and 4,800 ft. In eastern Ohio, sample depths ranged from 8,700 ft to more than 15,000 ft, and corresponding Ro values ranged from 0.94 to 1.43%. Thermal maturity analyses of bitumen reflectance broadly matched expected maturities based upon the fluid content (oil, wet gas, dry gas, etc.) from initial production reports in the eastern Ohio Utica Play area.

In northwestern Pennsylvania, reflectance samples ranged from 1.1 to 1.4%. In a south to southeasterly direction, reflectance values increased from 1.7%, in areas that border Ohio and West Virginia, to more than 2.0% in the central portion of the state.

Conodont Alteration Index (CAI) is a well-known technique used to evaluate the level of thermal maturation in source rocks. Their color alteration is both time- and temperature-dependent, and is a progressive, irreversible condition, making them ideal for correlating to maximum reservoir temperatures (Tmax). The Study's CAI dataset incorporates measurements collected specifically for this project (ten Ohio wells) as well as those compiled from a previously published USGS report. These data report values between 1.0 and 1.5 for samples from the western-most portion of the Study area, and values between 1.5 and 2.0 for central and east-central Ohio. Values of 2.0 or greater were observed only in eastern-most Ohio, near the borders of Pennsylvania and West Virginia. These data illustrate an increased maturity from west to east, very similar to the bitumen reflectance pattern observed for Ohio.

Collectively, the bitumen reflectance, RockEval, and CAI data indicate that petroleum liquids and wet gas are predicted to be the principle recoverable resource in central and east-central Ohio, as well as northwestern Pennsylvania. In eastern-most Ohio, and the majority of Pennsylvania, elevated levels of thermomaturation indicate wet and dry gas to be the dominant hydrocarbon resource.

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