A Geologic Play Book for Utica Shale Appalachian Basin Exploration

Abstract

Core Studies

High-Resolution Core Photography and Spectral Gamma-Ray Logging

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A key element for successful exploration of the Upper Ordovician shales in the Appalachian basin, as with any shale play, is the amount of Total Organic Carbon (TOC) present in the shale. The percentage of TOC is a vital factor in determining the potential for hydrocarbon generation, as well as understanding its areal distribution, both of which allow exploration efforts to focus on higher potential areas in a given basin.

TOC data are usually acquired by collecting and analyzing core or drill cuttings. Due to the limited volume of rock samples typically available, however, understanding the regional distribution of TOC can be challenging. This challenge has been managed in other stratigraphic units and shale basins (e.g., Marcellus Shale and Alberta basin) by identifying a proxy for predicting TOC using downhole wireline logs. In these cases, the Uranium-to-TOC or Density-to-TOC relationship could be used to accurately predict the percentage of organic carbon present in the rocks.

For this study, high resolution photography, spectral gamma-ray (SGR) and TOC data were collected from 11 Appalachian basin cores. A detailed examination of the relationships between gamma-ray (GR), uranium (U), thorium (Th) and potassium (K) to TOC was studied to identify a proxy for predicting TOC in the Upper Ordovician Utica and Point Pleasant shales using more abundant downhole wireline logs.

Study results indicate that Upper Ordovician shales in the Appalachian basin do not exhibit a direct correlation of TOC to the SGR signature. The GR intensity for Utica and equivalent rocks is dominated by the presence of potassium, and there is no correlation with the amount of organic matter. Factors that may prevent such a relationship include, but are not limited to, the volume of carbonate material, the lack of available uranium in seawater, or the amount of oxygen in the system. This investigation clearly demonstrates that TOC does not directly correlate to any radioactive material in the Utica/Point Pleasant interval. Other methods, including the density to TOC relationship, appear to be better gauges for predicting TOC in these Ordovician shales.

Sedimentology, Stratigraphy, Carbonate Content, Organic Content and Depositional Environment Characteristics ofUticalPoint Pleasant in Ohio and New York

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The Utica/Point Pleasant interval in Ohio is equivalent to the Flat Creek-Dolgeville Indian Castle interval in New York. These can be correlated using carbon isotopes and logs. The Point Pleasant in Ohio is

equivalent to the Flat Creek and Dolgeville formations in New York, which also are carbonate- and organic-rich and significantly thicker. Carbonate content is in the 40-80% range and TOC ranges from 1-3% in New York and up to 5% in Ohio. The organic-rich Utica in Ohio is equivalent to the Lower Indian Castle Formation in New York which has carbonate content around 25%. TOC ranges from 1-3% in both Ohio and New York.

Five long cores of the Utica-Point Pleasant-Trenton interval in Ohio were studied in detail. Thin sections were described semi-quantitatively and used to aid in centimeter-scale core description. TOC and carbonate content were analyzed down to one-foot scale in organic-rich intervals.

The basal Kope and uppermost Utica Shale consist of interbedded gray and black shale. The black shale beds have TOC up to 3%. Carbonate content is generally <10% in this interval. The middle portion of the Utica Shale is composed of black shale with TOC up to 3.5% and carbonate content generally around 25%. At the base of the Utica is an interval consisting of gray shale and coarse limestone storm beds with abundant bryozoans and crinoids. This interval is organic-poor with TOC generally <1 % and carbonate content of 25-50%. There is an apparent unconformity at the top of this interval.

The organic-rich limestone interval that is the main target for drilling incorporates three stratigraphic units: the Point Pleasant Formation and the upper Lexington and Logana members of the Lexington/Trenton Formation. The organic-rich Point Pleasant has abundant carbonate storm beds. TOC values are up to 5% and carbonate content is generally in the 40-60% range. The upper Lexington member has higher carbonate content and some well-developed limestone beds at the top where there is evidence for an erosional unconformity. Higher TOC was measured immediately above and below this apparent unconformity with values up to 4.5%. The upper Lexington generally has carbonate content around 70%. The underlying Logana member has TOC up to 5% and contains abundant ostracods. The upper Logana has few limestone beds, but the lower part has some laterally-extensive brachiopod rudstone beds interbedded with high-TOC strata.

There is good evidence for storms and currents throughout the main organic-rich reservoir interval, with burrows and benthic fossils interpreted to be in situ within the organic-rich facies. This suggests that the organic-rich strata were deposited in a relatively shallow water environment that was affected by frequent storms. Water conditions were not permanently anoxic but may have been seasonally anoxic.

Citation

Please use the following text for citations of this section:

Erenpreiss, Matthew S., 2015, High resolution core photography and spectral gamma-ray logging, in Patchen, D.G. and Carter, K.M., eds., *A geologic play book for Utica Shale Appalachian basin exploration, Final report of the Utica Shale Appalachian basin exploration consortium,* p. 36-49, Available from: http://www.wvgs.wvnet.edu/utica.

Smith, Langhorne B., Jr., 2015, Core description, petrography, sedimentology, stratigraphy, TOC and depositional environment, in Patchen, D.G. and Carter, K.M., eds., *A geologic play book for Utica Shale Appalachian basin exploration, Final report of the Utica Shale Appalachian basin exploration consortium*, p. 49-73, Available from: http://www.wvgs.wvnet.edu/utica.