A Geologic Play Book for Utica Shale Appalachian Basin Exploration

Abstract

Reservoir Porosity and Permeability

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The Study used a multi-disciplinary approach to assess Utica reservoir porosity and permeability characteristics. The research team employed scanning electron microscopy (SEM) and X-ray Computed Axial Tomography (CT X-ray) techniques to visualize and describe pore space characteristics at different scales of resolution. Due to a lack of access to relatively new (i.e., "fresh") core samples, we augmented our data set using laboratory-derived porosity and permeability data obtained from other earlier research activities in the Study area. The resulting data set represents a compilation of both legacy and newly generated analyses from publicly available Utica/Point Pleasant core and rock cuttings samples collected in the Appalachian basin.

Petrographic studies indicate there is little to no matrix porosity in Utica/Point Pleasant rocks, and standard SEM imaging confirmed the tight nature of the shale matrix in these rocks. SEM analyses of ion-milled samples, however, illustrated various pore types and sizes. Pore types include phyllosilicate framework pores (due to presence of clay mineral platelets in various orientations or state of compaction), dissolution pores (from the dissolution of carbonate minerals) and organic matter pores (resulting from out-migration of hydrocarbons). Pores vary in size, and from location to location, but generally range from tens or hundreds of nanometers (nm) to as much as 1 micron (μm) or more. Based on these observations, we have interpreted the organic matter pores, formed during maturation of hydrocarbons, to be the dominant contributor to hydrocarbon production in the Utica/Point Pleasant play.

Two cores were selected for CT X-ray analysis as part of the Study: (1) the Lost River core, collected as geotechnical samples from a dam site in the eastern panhandle of West Virginia in 1978; and (2) the Fred Barth No. 3 (API#3403122838), collected in Coshocton County, Ohio, in 1976. The Lost River core was taken from an interval of shelf carbonate in the limestone facies associated with the lower portion of the Martinsburg Formation, approximately equivalent in age to the Utica Shale, while the Fred Barth No. 3 core comprises organic-rich, calcareous black shales more commonly associated with the Utica/Point Pleasant interval.

Intact segments of the Lost River core were run through a Geotek© Multi-Sensor Core Logger. Measurements included magnetic susceptibility, acoustic impendence via P-wave velocity, gamma density using a Caesium-137 source and elemental composition via X-ray fluorescence spectrometry. The Barth No. 3 core had been too extensively sampled, plugged and slabbed to provide usable material for the Geotek© scanner. Selected samples of both cores were imaged using CT X-ray techniques. This method

produces a three-dimensional, digital reconstruction of the scanned object by measuring the contrast as X-rays are attenuated by areas of different density within a sample.

Porosity and permeability analyses were not performed on either the Barth No. 3 or Lost River cores as part of the Study because both were too old to provide reliable results. Nonetheless, a considerable amount of legacy core data was available for the Barth core. The measured porosity to gas in this core ranged from 2 to 8%, with an average porosity of 5.6% across the entire interval tested. The permeabilities of most of the Barth samples were below the minimum reporting limit of 0.1 millidarcy. Oil saturations varied from about 20 to 60% of pore volume, with an average oil saturation of 40.6%. The average water saturation in the core interval tested was 35.2%.

Citation

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