An Integrated Method to Evaluate the Reservoir Properties of the Horn River Group shale, Middle and Upper Devonian, Northeastern British Columbia, Canada

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Abstract

This study evaluates pore systems and reservoir properties of the Horn River shale from macro-scale observation of core samples to micro-scale imaging by SEM and TEM techniques. Samples from the Middle and Upper Devonian, Horn River Group shale were examined by core description, porosity and permeability measurements, SEM and TEM imaging of ion milled samples, nitrogen adsorption measurements and mercury injection analysis in order to develop a better understanding of controls of organic and inorganic rock constitutes on porosity development and pore microstructure.

At least nine distinct shale lithofacies were identified in hand-core and thin section analyses, which can be classified into three primary categories, siliceous mudstones, argillaceous mudstones and calcareous mudstones. Porosity ranges from 0.8% to 7.54% and shows a wide variety in different lithofacies. Siliceous mudstones with high TOC content have the highest porosity, whereas argillaceous mudstones with low TOC content have the lowest porosity. SEM and TEM images suggest that several kinds of sites are provided for porosity development, including organic matter, pyrite framboids, clay platelets, quartz rims, carbonate grains and fractures. Organic matter-hosted pores, intraparticle pores and interparticles are present in this study, which are probably caused by conversion of kerogen to hydrocarbon, partial dissolution of carbonate mineals and rearrangement of phyllosilicate platelets under mechanically compaction. Pore throats as small as 2 nm scale can be observed under by the TEM technique, which provides a higher resolution than SEM images, enabling us to characterize the internal structure of organic matter. A moderately strong positive relationship between TOC and porosity indicates that many pores are developed in organic matter. A positive relationship between quartz and porosity is also observed, which may be due to the positive correlation between quartz and TOC, as quartz is mainly biogenic in origin derived from radiolarians. In sum, porosity development is significantly related to organic matter content; however, it is a combined function of organic matter, mineral components, fabric and fractures.

The Muskwa member is the best target for shale gas development, as it primarily comprises siliceous mudstones so that it has the best quality reservoirs. The Otter Park member is the least effective reservoir, because it has the lowest porosity and permeability resulting from its lithofacies, which mainly consists of argillaceous mudstones.