CSPG ROCK ANALYSIS WORKSHOP
March 21-22, 2019 | University of Calgary & AER Core Research Centre

High-resolution characterization of reservoir heterogeneity in the Duvernay Formation: An integrated core and log analysis approach

Henry Galvis-Portilla, Marco Venieri, Per Kent Pedersen

University of Calgary, Department of Geosciences

Summary

The Late Devonian Duvernay Formation is an important low-permeability organic-rich mudstone reservoir in western Canada and is being developed using multi-fractured horizontal wells. Reservoir performance of the Duvernay is strongly influenced by changes in lithological facies and their geochemical, petrophysical and geomechanical properties. These are often scale-dependent, and therefore it is critical to understand the degree of heterogeneity within the organic-rich mudstones to identify sweet spots for hydrocarbon production. Different analytical methods ranging from micro- to meter-scale resolution demonstrate that no single technique can resolve the full spectrum of reservoir variability, implying that multi-scale integration is essential to capturing geological heterogeneity within the Duvernay Formation.

This study integrates high-resolution core data with multiple wireline log suites in order to define relationships of core-measured rock properties detectable in non-cored wells. Cores have been characterized by organic and inorganic geochemistry, mechanical hardness, and petrography for fabric, texture and pore architecture. Our work suggests that, at the cm-scale, rock samples homogeneous in mineral and elemental composition may be highly heterogeneous in rock fabric and mechanical hardness, proving a strong correlation between these two last rock properties. Organic-rich facies in the Duvernay have lower carbonate contents and generally higher porosity compared to the carbonate-rich, TOC-poor facies. Concerning the carbonate-rich facies, microscopic observations reveal that different types of carbonate minerals are associated with different pore architecture. Calcite crystals occur as pore-filling cements whereas dolomite is present as euhedral rhombs embedded in the organic-rich matrix. Therefore, in some instances, regardless of the amount of carbonate content the mineral texture is more important as a control of pore types and pore network distribution. The well log-based part of this study entails upscaling core properties to well log resolution using a heterogeneity index. Our results show that wireline log response can be deployed to discriminate between the organic-rich and organic-poor lithofacies identified in drill cores. Similarly, trends in mechanical rock hardness and porosity also match with variations between the organic-rich and organic-poor facies detected by well log interpretation.