geoconvention
Calgary • Canada • May 15-19 2017

Petroleum systems analysis and reservoir characterization of Devonian shales in the Horn River and Liard Basins

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Summary

Laboratory core analysis combined with regional basin modelling of Devonian strata in the Liard and Horn River Basins were completed for this study. Through this multi-faceted approach we were better able to constrain and understand the complex interplay of lithology, heat flow, depth of burial and kerogen type on the type and amount of retained hydrocarbons.

Introduction

The Horn River and Liard Basins are located within north-eastern British Columbia, Yukon, and Northwest Territories and contain vast resources of unconventional gas hosted within Devonian strata. The stratigraphy of these basins is comprised of thick accumulations of organic-rich, highly prospective fine-grained formations. This includes the Besa River Formation, which dominates the stratigraphy of the Liard Basin and represents an extended period of deposition in a sediment starved anaerobic environment (Ross and Bustin, 2009). Further to the east, the Horn River Basin contains more carbonate packages interlayered with organic-rich transgressive shales (Muskwa, Horn River, and Exshaw Formations) (Switzer et al., 1994; Ferri et al., 2011). Within the Horn River Basin there is an overall thinning and shallowing of these unconventional reservoir units towards the east. The stratigraphic and lateral variation in lithology coupled with variable depth of burial and paleo-heat flow provides an opportunity to investigate the controls on hydrocarbon generation, retention, and producibility from these important shale reservoirs.

Theory and/or Method

Core samples were collected from across the study area and analyzed using helium pycnometry, mercury intrusion porosimetry (MIP), X-ray diffraction (XRD), N_2 and CO_2 gas adsorption, and field emmision/focused ion beam scanning electron microscopy (FE/FIB-SEM) to allow for a comprehensive characterization of porosity, pore structure, and pore size distribution within the Muswka and Horn River Formations. Pyrolysis data from core and 300 cuttings samples was also collected. The pyrolysis data from this study along with thermal maturity data from a large public database was used to calibrate and constrain one-dimensional and three-dimensional basin models which were constructed based on well data.

Conclusions

The laboratory analyses results suggest that total organic carbon (TOC) within the Muskwa is generally between 2 and 4% with porosty values ranging from <1 to 8% for both the Muskwa Formation and Evie Member of the Horn River Formation. Pore size distribution curves from MIP show that the samples mainly contain pores in the meso- and micropore range. The lateral lateral variation on the depth of burial and paleo-heat flow is an important control on reservoir quality and the state of hydrocarbons currently retained within the reservoir intervals.

Acknowledgements

The authors would like to thank Trican Geological Solutions for their logistic support and generosity in providing laboratory analyses. Financial support from Geoscience BC, EnCana Corp., Devon Energy Corp., Husky Energy Inc., Chevron Canada Ltd., Canadian Natural Resources Ltd., and Geologic Systems Ltd. are greatly appreciated.

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