geoconvention
Calgary • Canada • May 15-17 2023

Experimental Evaluation of Relative Permeability in Low-Permeability Rocks: Examples from the Montney and Bakken Formations (Canada)

A. Ghanizadeh, C. Song, A. Younis, C.R. Clarkson
Department of Geoscience, University of Calgary, Alberta, Canada

Summary

This work presents results from a laboratory study investigating two-phase fluid (gas/oil) flow mechanisms in low-permeability ('tight') siltstone and sandstone reservoirs. The primary objectives were to 1) determine two-phase (gas-oil) relative permeability characteristics of selected intervals within the prolific Montney and Bakken formations in western Canada and 2) analyze the impact of different geological controls (e.g., rock composition/fabric, porosity, permeability, pore size distribution) on relative permeability.

A suite of core plug samples with variable mineralogy, fabric, and reservoir quality (helium porosity: 8-12%, permeability: 0.0045-0.008 md) were drilled parallel to bedding (horizontally) from vertical cores drilled from the Montney and Bakken formations. A diverse suite of screening analyses was employed to characterize the samples at multiple scales. The experimental techniques included X-ray diffraction (bulk/clay XRD), scanning electron microscopy equipped with elemental mapping (SEM-EDS), helium pycnometry, low-pressure gas (N_2) adsorption (pore size distribution, surface area, and pore volume within pore sizes between 2 and 300 nm), and pulse-decay gas (N_2) permeability. Modified Dacy technique (Dacy, 2010; Ghanizadeh et al., 2021) was used for determining relative permeability at variable fluid saturations.

Comparing Montney and Bakken samples, distinct variations were observed between gas-oil relative permeability datasets at prevailing experimental conditions. In particular, no S-shape behaviour – that was evident for the Montney samples – was observed for the Bakken samples. As opposed to the Bakken samples, the gas relative permeability values were suppressed at lower liquid saturations for the Montney samples. The observed variations could be attributed to the variations in preferential wettability and reservoir quality.

The reliable evaluation of relative permeability is among the key technical challenges for characterizing multiphase fluid flow processes in low-permeability unconventional reservoirs. The findings of this study are beneficial to operators developing the low-permeability siltstone/sandstone resources by allowing them to identify controls on relative permeability for the purpose of optimizing production.

Acknowledgements

The authors thank the sponsors of the Tight Oil Consortium hosted at the University of Calgary. The authors also thank Natural Sciences and Engineering Research Council of Canada (NSERC) for providing partial funding for this work through an NSERC Alliance grant (ALLRP 548652-19).

References

Dacy, J.M. (2010). Core Tests for Relative Permeability of Unconventional Gas Reservoirs. SPE Annual Technical Conference and Exhibition, SPE Paper 135427. https://doi. org/10.2118/135427-MS.

Ghanizadeh, A., Song, C., Clarkson, C.R., Younis, A. (2021). Relative permeability of tight hydrocarbon systems: An experimental study. *Fuel*, 294, 119487. https://doi.org/10.1016/j.fuel.2020.119487.