geoconvention
Virtual Event
September 21-23
2020
CSPG • CSEG • CWLS • GAC • MAC • IAH

Lithological Controls on Oil Permeability of Tight Oil and Liquid-rich Gas Reservoirs: An Experimental Study

Chengyao Song, Kesu Zhong, Adnan Younis, Christopher R. Clarkson, Amin Ghanizadeh
Department of Geoscience, University of Calgary

Quantification of oil permeability is a critical step in the evaluation of production potential of tight oil and liquid-rich gas reservoirs. The composition of tight rocks with multi-mineral and organic matter components varies both vertically and horizontally in producing tight oil/gas reservoirs. However, due to technical complexities associated with laboratory-based measurement of oil permeability, there is typically not enough of this kind of data available per formation to represent all possible rock types and flow units. Understanding the impact of mineralogical composition and pore network structure on liquid hydrocarbon permeability is important for identifying controls on fluid transport properties in these unconventional hydrocarbon systems.

Focusing on multiple prolific tight oil and liquid-rich gas reservoirs in western Canada (Bakken, Montney, Duvernay), the primary objective of this work is to examine lithological controls (organic/inorganic contents, porosity, pore size distribution, surface area) on liquid hydrocarbon permeability of tight rocks. Using an in-house liquid permeameter (Ghanizadeh et al., 2018), non-steady-state oil permeability measurements are conducted with formation oil (dewaxed/filtered) on eight selected core plug samples, differing in mineralogical composition (quartz: 30-45 wt.%; feldspars: 5-30 wt.%; carbonates: 15-40 wt.%; clay minerals: 5-35 wt.%) and pore network characteristics. The experiments are performed on the same core plugs used previously for pulse-decay gas (N_2) permeability tests under similar experimental conditions (i.e. temperature, injection pressure). The results of oil permeability measurements are combined with the outcomes of a comprehensive suite of geochemical (i.e. Rock-Eval pyrolysis, X-ray diffraction) and petrophysical [i.e. low-pressure gas (N_2, CO_2) adsorption] analyses previously conducted on the same samples (end-trimmed pieces) to investigate the impact of organic/inorganic composition and pore network attributes (surface area, pore volume, pore size distribution) on oil permeability.

Experimental observations indicate that oil permeability values increase consistently (**Fig. 1a**), ranging from $8.7 \cdot 10^{-5}$ and $6.7 \cdot 10^{-3}$ md, with increasing helium porosity (5.5 - 13.1%). In addition, it is observed that oil permeability values 1) increase (up to about an order of magnitude; **Fig. 1b**) with increasing k-feldspar content (5 - 15 wt.%), 2) decrease (up to about two orders of magnitude; **Fig. 1c**) with increasing calcite content (1-12 wt.%), and 3) decrease (up to about an order of magnitude) with increasing illite content (5-35 wt.%; **Fig. 1d**). The latter observations are attributed to a combination of possible diagenetic controls (e.g. cementation and dissolution) on porosity and pore size distribution and the presence of pore-filling clays. The geological controls on oil permeability identified herein are further compared to those previously reported for other Canadian/American tight oil formations for comparison purposes.

Lithological controls on oil permeability are not yet fully understood. Measuring formation oil permeability on selected tight rock samples with varying lithology and pore network structure, the current study provides insights into the evaluation of primary and enhanced oil potential in western Canadian tight reservoirs with permeabilities down to the nanodarcy range.

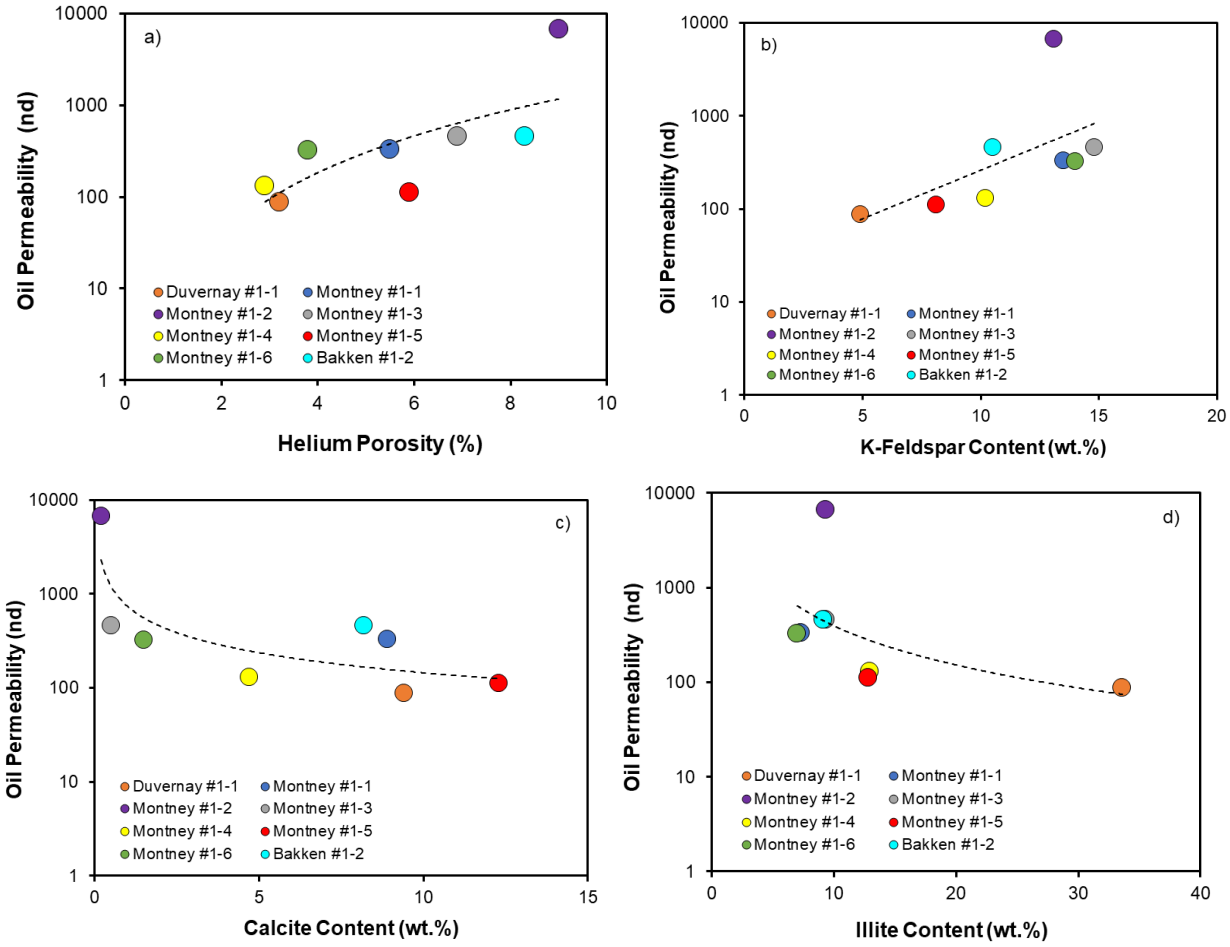

Fig. 1 – Effect of helium porosity (a), K-feldspar content (b), calcite content (c) and illite content (d) on oil permeability

Acknowledgements

The authors gratefully thank the sponsors of the Tight Oil Consortium hosted at the University of Calgary. Chris Clarkson would like to acknowledge Ovintiv Inc. (former Encana Corporation) and Shell for support of his Chair position in Unconventional Gas and Light Oil research at the University of Calgary, Department of Geoscience. The authors further thank Natural Sciences and Engineering Research Council of Canada (NSERC) for providing funding for this work through a Collaborative Research and Development (CRD) grants (CRDPJ 505339-16).

References

Ghanizadeh, A., Clarkson, C.R., Song, C., Vahedian, A., DeBuhr, C., Deglint, H.J., 2018. Controls on Liquid Hydrocarbon Permeability of Tight Oil and Liquid-Rich Gas Reservoirs: Examples from Bakken and Montney Formations (Canada). URTeC Paper 2902898. Presented at the Unconventional Resources Technology Conference held in Houston, Texas, USA, 23-25 July 2018.