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Relative permeability of tight rocks: Examples from the Montney Formation (Canada)

C. Song, C.R. Clarkson, A. Ghanizadeh, A. Vahedian

Department of Geoscience, University of Calgary (Calgary, Canada)

Summary

Relative permeability is an important property used in the evaluation of primary and enhanced recovery of oil in tight reservoirs. The primary objectives of this work are to 1) compare different laboratory-based techniques for the determination of gas/liquid relative permeability and 2) examine the impact of a variety of geological and operational controls on relative permeability of selected samples obtained from the Montney Formation (Alberta, Canada).

Using a customized liquid/gas-liquid permeameter designed and built in-house, relative permeability tests are conducted with formation oil using hydrocarbon/non-hydrocarbon gases (CH_4, N_2) on intact Montney core plug samples. Two direct methods for measuring gas/liquid relative permeability data are investigated including the modified Dacy's and the "gas breakthrough" (GBT) techniques. The Dacy technique is based on the stationary-liquid approach, resulting in relative permeability estimation as a function of fluid saturation. The GBT technique uses "forced" drainage/imbibition cycles, resulting in relative permeability estimation as a function of time and pressure difference.

Relative permeability values are affected by the methodology applied, gas type, fluid saturation, effective stress, hysteresis and other sample-to-sample variations. Using the GBT method, the maximum relative permeability values measured after gas breakthrough on fully/partially oil-saturated core plug samples vary between 0.002 and 0.3, depending on gas type (CH_4, N_2), effective stress, differential pressure and hysteresis path. After gas breakthrough, the relative permeability decreases consistently with decreasing differential pressure. Using the modified Dacy's method, the relative permeability values measured on fully/partially oil-saturated core plug samples increases (0.006-0.2) with decreasing saturation (70-35%).

Relative permeability, while a critical control on multi-phase flow in tight oil reservoirs, is notoriously difficult to measure for low-permeability rocks in the laboratory. The systematic datasets provided herein are of significant importance for 1) rate-transient analysis models used to characterize reservoir and hydraulic fracture properties and 2) numerical simulation studies of primary and enhanced recovery schemes including cyclic gas injection (huff-n-puff).

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