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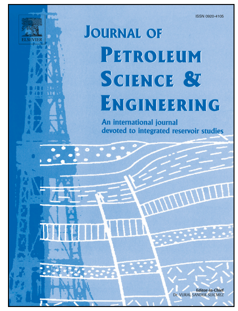

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Imbibition Oil Recovery from Tight Rocks with Dual-Wet Pore-Network

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Abstract

Previous studies demonstrate that the Montney rock samples have a dual-wettability pore network. Recovery of the oil retained in small hydrophobic pores is a unique challenge. In this study, we apply dual-core imbibition (DCI) method on several Montney core plugs and introduce imbibition-recovery (IR) trio to investigate the recovery mechanisms in rocks with dual-wettability pore network. First, we evaluate the wetting affinity of five twin core-plugs from the Montney Formation by measuring spontaneous imbibition of reservoir oil and brine, and by measuring equilibrium contact angle. We place one plug of each pair in the oil and the other in the brine, and measure the weight change periodically. Second, we place the oil-saturated samples in the brine to visualize the expelled oil droplets and measure volume of the recovered oil. We comparatively analyze the spontaneous imbibition data from the first step and the oil recovery data from the second step in one imbibition-recovery trio (oil imbibition, brine imbibition, and imbibition oil recovery). The results of air-liquid contact angle and spontaneous imbibition tests on dry samples suggest that affinity of the samples to oil is higher than that to brine, in an air-liquid system. However, the results of liquid-liquid contact angle and counter-current imbibition tests suggest that affinity of the samples to water is higher than that to oil, in a liquid-liquid system. For each twin set, the oil recovery curve follows the trend of brine imbibition curve, and the final oil recovery is always less than the equilibrated water uptake of dry samples. This observation indicates that water can only access the hydrophilic part of the pore network initially saturated with oil.

Introduction

Tight sandstone alongside shale reservoirs and coal bed methane are three major classes of unconventional reservoirs(Wang et al., 2014). Until recently, interest in tight and shale reservoirs was limited due to lack of well-developed technology for characterization and development of such reserves (Levorsen and Berry, 1967). Spontaneous imbibition of aqueous phases (water, brine, or surfactant solutions) in fractured sandstone has been studied as a possible mechanism for enhanced oil recovery (Balogun et al., 2007; Barzegar Alamdari et al., 2012; Gilman, 2003). Extensive experimental and mathematical investigations have been conducted for relating the imbibition rate and total oil recovery to the capillary and gravity forces and the geometrical parameters (Ma et al., 1999; Zhang et al., 1996). However, rock-fluid interactions in tight and shale reservoirs are more complicated than those in conventional reservoirs. In addition to capillary forces, organic materials (Lan et al., 2015) and reactive clay minerals (Dehghanpour et al., 2013) can influence flow and storage capacity of unconventional reservoirs. In particular, affinity of reservoir rock to a fluid depend on rock mineralogy and properties of the organic matter that coats the pores (Lan et al., 2014). Investigating hydrocarbon production from tight/shale reservoirs requires representative characterization of their petrophysical properties such as porosity, permeability, pore size distribution and wettability.

Capillary pressure, which is a function of interfacial tension, rock wettability, and pore radius, is the main driving force behind spontaneous imbibition in shale/tight rocks(Ghanbari, 2015). Therefore, spontaneous imbibition has been used as a laboratory protocol to characterize the wettability of reservoir rocks such as