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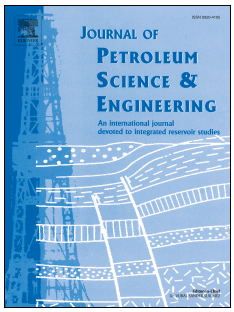

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ACCEPTED MANUSCRIPT

Spontaneous Imbibition Analysis in Shale Reservoirs Based on Pore Network Modeling

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Abstract

Capillary spontaneous imbibition is vital to the successful development of shale reservoirs. The two-phase flow macro-properties of shale are significantly difficult to be measured in the laboratory. A pore network model is proposed in this work. The model is validated in the conventional Bentheimer sandstone and then applied to shale matrix with the consideration of variable wettability. Some representative relative permeability and capillary pressure curves are obtained from this pore network model. Based on an analytical solution of spontaneous imbibition, we propose a computational algorithm to calculate the oil recovery factors using the calculated macro-properties from our pore network model. Combining these two, the effects of wettability and absolute permeability on the spontaneous imbibition are studied. The absolute permeability plays an important role in the oil recovery factor induced by spontaneous imbibition. The recovery factor is proportional to the quartic root of absolute permeability. A relative small portion of oil w recovery drops dramatically. The attempt of this work is made to investigate the two-phase flow and spontaneous imbibition of shale reservoirs in the perspective of micro-scale.

Keywords: Spontaneous Imbibition; Shale; Pore Network Modeling; Two-phase Flow

1. Introduction

Since the shale boom in the United States, water intake by shale has drawn many researchers' attention. Only a small fraction of the injected fracturing water is recovered in the US across all shale pays. The lost water plays a significant role in the productivity and hydrocarbon recovery of shale reservoirs. Singh (2016) reviewed the studies of water intake by shale and summarized the mechanisms including: capillary imbibition (i.e., spontaneous water imbibition induced by

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