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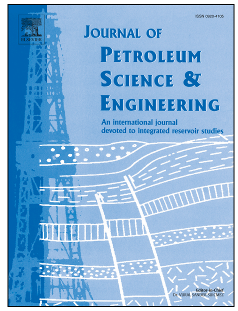

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Gas Transport in Self-Affine Rough Microchannels of Shale Gas Reservoir

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Abstract: The matrix of shale gas reservoirs is always characterized by rough surfaces and the roughness of the topography significantly influences the gas flow characteristics. However, most existing models are based on smooth surface. Moreover, the roughness effect leads to a complex velocity distribution and can influence the apparent permeability through its own transport mechanism. In this study, a generalized lattice Boltzmann method with nonequilibrium extrapolation boundary conditions was developed to simulate the rarefied shale gas flow through nanochannels with rough surface. Fractal geometry was introduced to model the rough surface, and the roughness was characterized by two parameters, namely, relative roughness height and fractal dimension. Triple-effect permeability estimation model was adopted to calculate the apparent permeability accounting for multiple roughness characteristics including surface tortuosity, hydraulic tortuosity, and local roughness. Effects of fractal dimension, relative roughness, and tortuosity on velocity distribution were investigated. The effect of pressure and roughness characteristic parameters on the apparent permeability at different Knudsen numbers was also studied. The results showed that the influence of fractal dimension and relative roughness on the permeability was affected by the rarefaction effect. The roughness effect on gas flow behavior became more evident when associated with the enhanced rarefaction effect. Moreover, relative roughness was found to play a significant role in determining the permeability in the transient flow regime.

Keywords: Shale; Roughness effect; Triple-effect permeability model; Lattice Boltzmann method; Permeability

1. Introduction

Shale gas is a very important unconventional energy resource, capable of modifying today’s economic scenario on global scale. Organic shale is known to be composed of microsystems consisting of microfractures and micropores with channel sizes ranging from 4 to 200 nm (Cao, 2016). Nanochannels reduce the intermolecular collisions and enhance the molecule-wall collisions. As a consequence, gas flow through nanochannels is described by a strong microscale effect, in particular, near the wall (Yang, 2016). Surface topography roughness significantly affects the surface-gas interaction, particularly when the Knudsen number (*Kn*) is very high. For gas flow in

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