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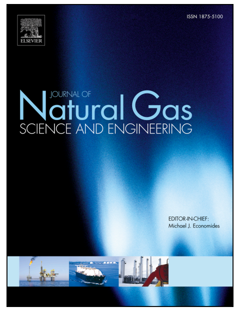

A discrete model for apparent gas permeability in nanoporous shale coupling initial water distribution

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A discrete model for apparent gas permeability in nanoporous shale coupling initial water distribution

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Abstract

Understanding and predicting gas transport in gas-shale reservoirs matrix containing abundant nanopores have tremendous implications for the development of gas-shale reservoir. However, there are many literatures focusing on establishing gas transport models in a single nanopore, which is too ideal for the heterogeneous nanoporous shale. Besides, the water film and capillary water that existed on the inorganic pore and its effect on gas transport capacity are usually overlooked. In this work, based on the SEM (scanning electron microscope) images, the nanopores in OM (organic matter) are assumed as circular cross section shape, while that in inorganic are slit-like shape. The Beskok's model are employed to quantify the bulk-gas transport, and the additional flux contribution by surface diffusion in organic pore are also imbedded. The apparent gas permeability (AGP) model in a single nanopore is upscaled to sample scale with Monte Carlo sampling method, which successfully represents the heterogeneities of shale matrix including pore size distribution, total organic carbon (TOC) content, and water distribution. The proposed model fully takes into account the gas transport mechanisms, the complex flow boundary and the significant heterogeneity of the nanoporous shale. The reliability of the present model is successfully verified with the experimental data from different literatures. Results show that Knudsen diffusion and surface diffusion are the two key transport mechanisms dramatically enhancing the AGP of shale matrix when the pressure is less than 6 MPa. The AGP of shale matrix containing abundant organic micropores (< 2 nm) is possibly higher than that with larger pores because of the surface diffusion. The initial water saturation in the form of water film or capillary water in the IOM (inorganic matter) have significant impacts on the AGP. Although the pore size within OM are universally smaller than IOM, the AGP of shale matrix is still possibly enhanced with the increase of TOC content when accounting for the surface diffusion and water distribution.

Keywords: shale gas; apparent gas permeability; discrete model; water distribution; reservoir condition.

1. Introduction

Recent years, unconventional natural gas plays an increasingly important role in global gas