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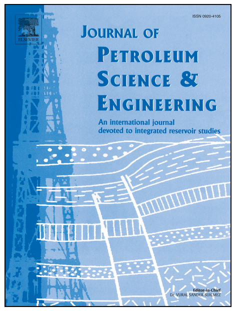

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A coupled, non-isothermal gas shale flow model: application to evaluation of gas-in-place in shale with core samples

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Abstract

Shale gas is emerging as an important unconventional resource. To determine the gas-in-place in shales the so-called direct method is often used. However, the traditional direct method may have significant errors in evaluation of the lost gas amount during the retrieval process of a core sample, because it did not take into account the impact of the pertinent pressure and thermal history to the gas emission profile. The relevant thermal effect, in addition to the effect of pressure change, may play a critical role in the process because it can greatly affect the gas sorption/desorption behaviour in the core; it may also significantly change the relevant Knudsen number and alters the gas transport mechanisms in those nanopores in the core. Thus a flow model incorporating the thermal effect becomes crucially important in this context.

We propose a non-isothermal flow model for gas shales in this study. The model is fundamentally based on the concept of the dusty-gas model, but with several important extensions. The major extensions include: (1) Two separate sets of gas transport equations are formulated in the model, one for free gas and the other for adsorbed gas. The two sets of equations are coupled through a term which characterises the conversion between the free and the adsorbed gas. (2) The transport equations are fully coupled with a thermal convection/conduction equation. (3) The formulated permeability and diffusion model accommodates the stochastic characteristics of pore-size distribution in shales, and produces a fully self-consistent description for the gas flow behaviour when the flow regimes are altered with variations of pressure and temperature.

Two application examples are presented here, one for a Canadian shale play and the other for a Chinese one. Both cases are concerned with the evaluation of the lost gas amount and the gas-in-place in the shales, where thermal effects are significant and cannot be ignored. The results obtained show that the model developed in this study can well characterise the sophisticated transport mechanisms involved and can accurately describe the relevant emission profiles. The predicted lost gas content and the gas-in-place can be used with more confidence than the results reported in the two original studies.

Key words: shale; gas flow and transport; dusty-gas model; thermal effect; numerical simulation, core analysis

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