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Gas and Water Flow Regulations in Remolded Hydrate-hosting Porous Media Based on Non-Darcy Correction of the Pore Network Modeling

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Natural gas hydrate (NGH) is considered as a type of potential clean energy resource concentrated in permafrost layers and deep ocean floors. The hydrate reservoirs in South China Sea (SCS) have small pore size (0.1 μm -100 μm) and extremely low intrinsic permeability (about 5 mD). and the grains mainly range from clayey silt to silt. Permeability is one of the most decisive parameters in controlling the distribution and concentration of gas hydrate and fluid flow in hydrate-bearing sediments (HBS), which determines the efficiency of gas recovery from hydrate reservoirs.

Due to the extreme complexity of multiphase-flow experiments with hydrate, pore network model (PNM) is widely used to estimate relative permeability. Percolation characteristics simulation results largely rely on the accuracy and feasibility of physical equations in PNM, especially Darcy's theory. The accuracy and feasibility of PNM in simulating the gas and water relative permeability have been proved in the coarse-grained hydrate-bearing porous media. However, in the fine-grained sediments, numerous researchers have found that gas and water flow mechanisms is away from Darcy's theory-the basic theory of the PNM.

In this study, mercury penetration experiments were firstly conducted to obtain pore size distribution of Berea sand and remolded hydrate-host sediments from SCS. Next, we made a criterion of the gas flow regime in these two groups of sand based on the Knudsen number. In the following, Darcy equations in the PNM code was modified based on the non-Darcy flow regime. After that, three-dimensional pore networks were extracted from nano X-ray CT images of these two sand samples. And then, based on the extracted pore network, gas and water flow simulation were conducted by PNM with both original Darcy theory and the corrected no-Darcy function. At last, comparisons were made between the two-phase flow relative permeability results calculated by original and the corrected Darcy function to judge the gas and water relative permeabilities variation.

Results showed that gas-slip effect occurred in remolded hydrate-host sediments. Both gas and water relative permeabilities at the same water saturation calculated by the corrected PNM code with No-Darcy function were lower than those calculated by the original PNM with Darcy theory. Results showed that the PNM used in low-permeability natural gas hydrate reservoir is essential to be calibrated by non-Darcy theory function.

Participation

In-Person

References

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Primary author: Ms ZHOU, Shanshan (Dalian University of Technology & University of Manchester)

Co-authors: Mr XUE, Kunpeng (Dalian University of Technology); Mr LIU, Guanbin (Dalian University of Technology); Mr XUE, Tian (Dalian University of Technology); Prof. NIASAR, Vahid (University of Manchester); Prof. LIU, Yu (Dalian University of Technology)

Presenter: Ms ZHOU, Shanshan (Dalian University of Technology & University of Manchester)

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