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Applications of pore network modelling in predicting the permeability in hydrate-bearing sediment

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Permeability plays a pivotal role in governing the fluid flow within hydrate-bearing sediment (HBS) and significantly influences the efficiency of natural gas production from hydrate reservoirs. However, the measurement of HBS permeability is challenging due to the complexities of maintaining phase equilibrium conditions during testing. This study focused on the sandy hydrate-bearing sediments and intended to elucidate the evolution of absolute and relative permeability as a function of hydrate saturation by the mean of pore network modelling. In the developed model, the hydrate formation process in the porous media is simulated incorporating two key sub-processes: hydrate nucleation and hydrate growth. We integrated various theories from hydrate kinetics, including the random nucleation theory, interface growth theory, Ostwald-Ripening effect, and pore water activity theory, to control the hydrate formation process. For modeling fluid flow within the pore networks, we utilized the conductivity calculation method. The constructed pore network model was employed to analyze permeability variations within different pore networks. Simulation results from a series of regular networks demonstrated that the distribution of formed hydrate and the permeability of HBS are influenced by factors such as model dimension, hydrate nucleation fraction, and hydrate growth type. Further simulations based on CT images showed the changes of absolute permeability and gas-water two-phase permeability during hydrate formation within different sandy sediments. As a result of these simulations, we provided parameter ranges suitable for the application of the Masuda model in predicting absolute permeability in sandy hydrate reservoirs, as well as the Brooks-Corey model and van Genuchten model for predicting two-phase gas-water permeability. This study is hoped to bring new insights into the field of micro-scale seepage research within hydrate reservoirs.

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References

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