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Pore network modelling to study dynamic permeability evolution of hydrate-bearing sediments considering media deformation

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Permeability is a key parameter determining fluid flow dynamics and production behavior of hydrate-bearing sediments. Figuring out the evolution of dynamic permeability during hydrate phase transition considering media deformation effect is of great significance for the safe and efficient development of hydrate-bearing deposits. In this work, an unstructured pore network with the combination of complex pore-throat morphology and anisotropy is firstly constructed based on the analysis of microscopic pore structures from the marine sediments in the South China Sea. After the validation, grain-coating hydrate is assigned to the pore bodies, connected throats and adjacent pore bodies from large to small elements in the network while considering media deformation effect. Based on the generated hydrate-bearing networks with different hydrate saturation, the dynamic permeability evolution law coupling media deformation effect is calculated. Furthermore, the effect of media deformation on the effective pore structures and dynamic permeability evolution during hydrate phase transition is analyzed in detail. Results show that the absolute permeability grows smaller at the same hydrate saturation due to the compaction of the effective pore body and throat radius caused by media deformation. However, the dynamic permeability decline rate turns slower with the increase of hydrate saturation since hydrate just needs to possess less pore bodies and throats to arrive at the same hydrate saturation when considering media deformation effect. Therefore, the difference of the dynamic permeability with and without considering media deformation becomes smaller at the same hydrate saturation. With an increase in effective stress, a decrease in elastic modulus, and a reduction in Poisson's ratio, the influence of media deformation on the effective pore structures in hydrate-bearing sediments intensifies, resulting in a greater decrease in the effective pore-throat radius and a larger reduction in the dynamic permeability at the same hydrate saturation. In addition, the number of hydrate occupied pore bodies and throats grows much smaller at the same increase degree of hydrate saturation as media deformation effect becomes more pronounced, which results in much slower rate of dynamic permeability reduction and smaller difference of the permeability at different values of parameters relavant to media deformation.

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