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Study on the pore-scale multiphase seepage characteristics of clayey-silt sediments

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The sediment of natural gas hydrate reservoir in the South China Sea is primarily composed of clayey silt, exhibiting characteristics such as loose structure, lack of consolidation, high clay content, and complex pore structure. These features contribute to the complexity of reservoir seepage characteristics, making it challenging for conventional experimental methods to accurately describe the evolution of permeability and the main controlling factors. By combining seepage experiments with micro-CT, the seepage characteristics and distribution patterns of multiphase fluids at the pore scale are obtained. The results indicate that in single-phase water seepage experiments, the pore structure of clayey-silt samples undergoes creep as the seepage process progresses. With increasing seepage pressure, the pore and throat radius of the samples decreases, leading to a significant decrease in permeability. In gas displacement experiments, fluid in larger pores is initially displaced, and with increasing displacement pressure, water in smaller pores is further displaced. The gas phase permeability gradually increases, and when the displacement pressure exceeds the initial consolidation pressure, the sample generates the dominant flow channels composed of fractures. Once the dominant flow channels appear, the gas phase permeability remains constant. The two-phase relative permeability curves of the samples are obtained through gas-water displacement experiments, showing a narrow range of co-permeability for both phases, lower co-permeability point, and high bound water saturation. The research findings help clarify the multiphase seepage characteristics during the development of clayey-silt natural gas hydrate, providing theoretical guidance for improving recovery efficiency of hydrate reservoirs.

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