Modelling of permeability change caused by CO_2 hydrate in sand layer using numerical simulation

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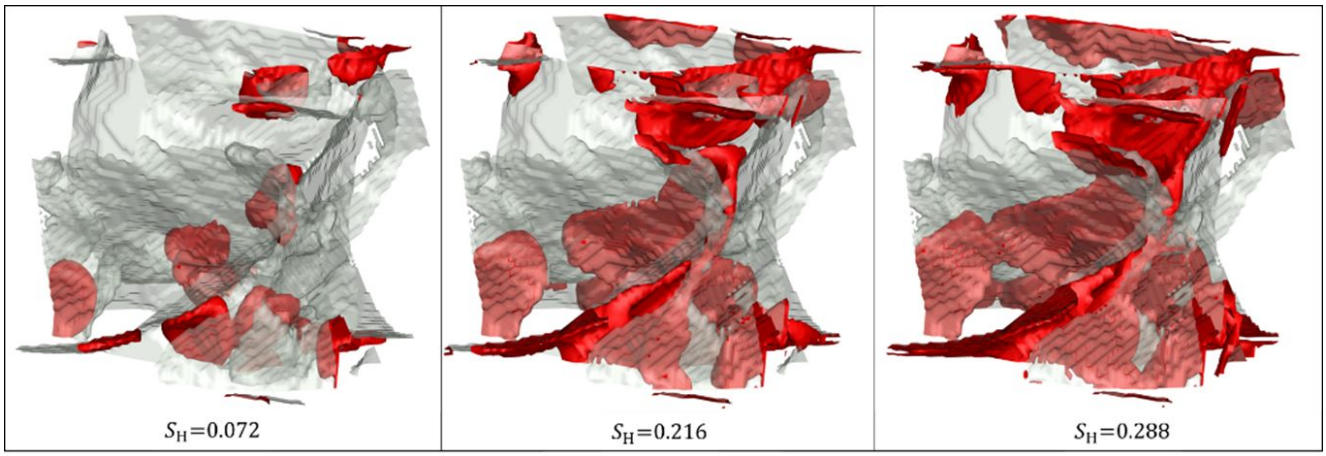
Carbon dioxide capture and storage is an efficient technology to reduce CO_2 emission. One of the reservoirs of CO_2 is an aquifer in the sub-seabed geological formation under a caprock. However, there is a risk of CO_2 leakage even though such probability is extremely low. When the water depth of a storage site is large: say, about 400 m or more, leaked CO_2 changes its form to gas hydrate, which may block CO_2 rise in the sediment. To estimate the sealing potential of CO_2 hydrate, it is necessary to evaluate effective permeability of the sediment after CO_2 hydrate forms. In this study, a series of numerical models were used to investigate microscopic hydrate distribution that essentially controls the effective permeability. The method consists of packing sand grains within microscopic computational domains, arranging water and CO_2 phases in the pore space of the packed sand grains, placing multiple hydrate nuclei, and growing hydrate in the pores of the sand grains. First, we derived a value of the interface mobility of CO_2 hydrate by fitting calculated growth rate of a hydrate spherule to a measurement in the literature. Then, CO_2 hydrate formation was simulated within microscopic computational domains consisting of sand grains and water-CO_2 two phases. Finally, efficient permeability was estimated using the results of the simulation of water flow through the pore space, regarding the formed hydrate as a solid. The calculation results indicated the differences in hydrate distribution in the pore space and in resulting effective permeability, depending on hydrate saturations, initial water saturations, and contact angles of water on the sand surface.

Keywords: Effective permeability, Pore-scale simulation, CO2 hydrate, Lattice Boltzmann method, Phase field model



$S_{W0} = 0.4, \theta_{WS} = 20°$

