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X-ray computed tomography observations of phase distribution during methane hydrate formation and dissociation process in a sediment sample

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The recovery schemes for natural gas caged in the solid state have not been commercialized. Depressurization has been known as a promising method due to its economic feasibility according to previous lab-scale experiments and simulation studies. However, the results of few field tests showed that the production characteristics of real field differed from that of predicted results. To reliably predict the production performance of real fields, it is necessary to understand quantitative changes of phase distribution and fluid flow in sediments in response to hydrate dissociation by depressurization.
In this study, we observed and analyzed the phase distribution and flow behavior during methane hydrate formation and dissociation using X-ray computed tomography which provides high-resolution density distribution. Artificial particles having similar grain size distribution of sandy layers found in real hydrate field were packed into X-ray transparent aluminum vessel. Information on pore distribution within a sediment sample was achieved by comparing CT images between dry condition and fully water-saturated condition. Dynamic changes of phase saturation were observed during gas flooding, through which potential flow pathway was estimated. Hydrate formation and dissociation significantly affected phase distribution and flow pathway. Hydrate distribution was extremely heterogeneous in every tests of hydrate formation repeated with same amount of water. It was inferred that water saturation prior to hydrate formation was not directly correlated to the hydrate distribution. There were definite differences of hydrate dissociation behavior between gas-saturated and water-saturated hydrate-bearing sample. The production of gas and water lasted quite a while even after the production pressure reached the target level of depressurization.