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# Visualization of CH<sub>4</sub> Hydrate Dissociation Under Permafrost Temperature Conditions Using High-Pressure Micromodel

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## Abstract

Methane (CH<sub>4</sub>) gas hydrate formation, dissociation, and stability in permafrost sediments are essential to model these systems concerning global warming and in schemes of CH<sub>4</sub> recovery and/or carbon dioxide (CO<sub>2</sub>) storage. It is known that CH<sub>4</sub> hydrate is thermodynamically less stable than CO<sub>2</sub> hydrate due to the lower activation energy of the decomposition. However, recent studies show that CH<sub>4</sub> hydrate's dissociation slows down in subzero temperature due to the self-preservation mechanism. Thus, a fundamental understanding of CH<sub>4</sub> hydrate distribution, dissociation mechanism, and self-preservation in sediments at the pore-scale level, is essential to optimize the CH<sub>4</sub> gas production method from permafrost-affected hydrate reservoirs.

In this study, CH<sub>4</sub> hydrate dissociation was visualized using a high-pressure, water-wet, silicon-wafer based micromodel with pore network of actual sandstone rock. A total of nine runs were performed, and CH<sub>4</sub> hydrate was formed between 60-85 bar, and between 273.15 K-275 K. CH<sub>4</sub> hydrate was dissociated between 270-275K by pressure depletion to evaluate the effect of hydrate and fluid saturation on dissociation rate, self-preservation, and risk of hydrate reformation. Below 273.15K, the CH<sub>4</sub> gas production was limited due to rapid formation of ice from liquid water liberated from initial hydrate dissociation. The liberated CH<sub>4</sub> gas was immobilized and trapped by the formed ice. Consequently, we demonstrate the ineffectiveness of depressurizing CH<sub>4</sub> hydrate without thermal stimulation. The results highlight the importance of initial hydrate/ice/gas saturations and free gas availability in characterizing hydrate dissociation patterns.