Pore-Scale Analysis of Methane Hydrate Formation and Dissociation in Brine using Micro-Raman Spectroscopy

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Most investigations of methane hydrate formation and dissociation have been performed at macroscopic scales without direct microscopic observations. We use micro-Raman spectroscopy to study these phenomena at the pore scale (1 μm resolution) and link to macroscopic observations. We synthesize methane hydrate in a porous sample of medium-grained glass beads or industrial sand, packed in a stainless-steel cell with a sapphire window and pore fluids (freshwater and 3.5–7.0 wt% NaCl solutions) and methane gas at a range of temperatures and pressure. Methane hydrate is a nonstoichiometric crystalline solid composed of water and methane molecules. Converting water and methane into hydrate or dissociating hydrate are first-order phase transitions, and the phase boundary is a function of pressure, temperature, and salinity in the surrounding. In a closed system, when hydrate forms from water and methane in brine, salt is excluded from the hydrate and therefore the salinity of the remaining brine increases; when hydrate dissociates, freshwater is added to the brine, decreasing its salinity. We plan to directly observe these phenomena by mapping out the variations in salinity in space and time during hydrate formation and dissociation.