

MEASURING AND OBSERVING METHANE HYDRATE BEHAVIOR UNDER NATURAL CONDITIONS

Timothy J. Kneafsey, Liviu Tomutsa, George J. Moridis, Yongkoo Seol, and Barry M. Freifeld

Contact: Timothy J. Kneafsey, 415/486-4414, tjkneafsey@lbl.gov

RESEARCH OBJECTIVES

Naturally available gas hydrates present in suboceanic and permafrost environments are thought to contain a vast amount of natural gas, amounts that could eventually be exploited as an energy source. Efficiently tapping this incompletely comprehended energy source will require strong modeling capabilities and significant laboratory and field efforts to determine modeling parameters and constitutive models. Natural samples are difficult to obtain for testing purposes because the hydrates are unstable at atmospheric pressure and typically dissociate upon recovery.

Our research objective is to provide model parameters and constitutive models for the Berkeley Lab simulator TOUGH-Fx/HYDRATE. To do this, we make laboratory measurements under realistic conditions on samples of hydrate in porous media, which we synthesize to model natural samples. Monitoring pressure and temperature, we use x-ray computed tomography (CT) to make detailed observations of density changes during tests.

APPROACH

We synthesize large methane hydrate samples in partially water-saturated sand samples in an x-ray-transparent pressure vessel contained within a temperature-controlled heat exchanger. Temperature is monitored at multiple locations, pressure is monitored during hydrate synthesis and dissociation tests, and we use CT to monitor density changes that occur in response to changes in temperature and pressure.

ACCOMPLISHMENTS

We have synthesized methane hydrate in the pore space between mineral grains, with our samples being the largest laboratory samples in the world. We have dissociated the hydrate by both thermal stimulation and depressurization, and have used our measurements to determine the thermal conductivity of the

hydrate-bearing medium, and to estimate the parameters of dissociation kinetics. From this work, we have learned that the presence of hydrate in the pore space alters the capillary pressure-saturation curve affecting water movement, and that formation and dissociation of hydrate in partially saturated sand may induce mechanical changes that cause the sample size to change (Figure 1).

SIGNIFICANCE OF FINDINGS

We have begun to develop parameters and constitutive models that are useable to model gas production from hydrate accumulations, in addition to observing processes via CT. We are the first to use CT to quantitatively measure changes during hydrate formation and dissociation, leading to improvements in conceptual models.

RELATED PUBLICATIONS

Kneafsey, T.J., L. Tomutsa, G.J. Moridis, Y. Seol, B. Freifeld, C.E. Taylor, and A. Gupta, Methane hydrate formation and dissociation in a partially saturated core-scale sand sample. *Journal of Petroleum Science and Engineering* (submitted), April 2005. Berkeley Lab Report LBNL-57300.

Moridis, G.J., Y. Seol, and T.J. Kneafsey, Studies of reaction kinetics of methane hydrate dissociation in porous media. In: *Fifth International Conference on Gas Hydrates*, Trondheim, Norway, 2005. Berkeley Lab Report LBNL 57298.

ACKNOWLEDGMENTS

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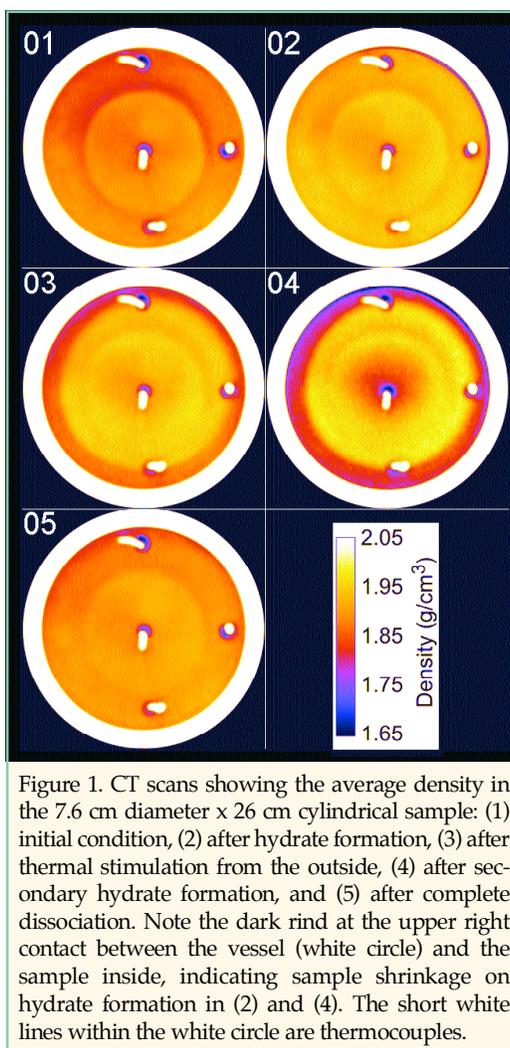


Figure 1. CT scans showing the average density in the 7.6 cm diameter x 26 cm cylindrical sample: (1) initial condition, (2) after hydrate formation, (3) after thermal stimulation from the outside, (4) after secondary hydrate formation, and (5) after complete dissociation. Note the dark rind at the upper right contact between the vessel (white circle) and the sample inside, indicating sample shrinkage on hydrate formation in (2) and (4). The short white lines within the white circle are thermocouples.