Laboratory Test Program and Physical Properties of Samples Containing Gas Hydrate From the Mackenzie Delta, NWT

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ABSTRACT

The Mallik 2L-38 Gas Hydrate Research Well produced the first samples of gas hydrate-containing sediment recovered beneath a permafrost layer. A collaboration of the Japan Petroleum Exploration Co. Ltd. (JAPEX), Japan National Oil Corporation (JNOC), Geological Survey of Canada (GSC), and the U.S. Geological Survey (USGS) planned and drilled the well to a depth of 1150 m in February and March 1998 to investigate an Arctic gas hydrate occurrence, obtain samples, and evaluate drilling methods and equipment. An international team of investigators conducted field surveys to determine the location and structure of in situ gas hydrate. We found the highest concentrations of gas hydrate were in coarser-grained sands and significantly less gas hydrate was recovered in adjacent silt layers. The overall porosity of the host material was less important than the individual pore sizes. Larger pores were more conducive to forming gas hydrate and preserving it during sample recovery.

We have also performed laboratory tests to quantify the interaction between gas hydrate and host sediment to enable prediction of future behavior. The USGS in Woods Hole, MA performed acoustic and triaxial strength measurements using the Gas Hydrate And Sediment Test Laboratory Instrument (GHASTLI) on samples containing natural gas hydrate in sand collected at depths of 899 m and 913 m. The GSC in Ottawa conducted tests to evaluate pore water salinity and grain size effects on pressure-temperature (P-T) stability thresholds for methane hydrate in reconstituted silt and sand samples recovered from Mallik 2L-38.

The presence of gas hydrate or ice significantly increased strength properties. Triaxial strength of undisturbed sediment containing natural gas hydrate was 3 to 9 times stronger than similar sediment after gas hydrate dissociation. Frozen sediment samples were about 8 times stronger than pure ice (frozen deaired fresh water). Decreased strength induced during gas hydrate dissociation will complicate drilling operations offshore and on continental margins.

The presence of gas hydrate also significantly impacted acoustic properties. Samples containing natural gas hydrate had P-wave velocities of 2.4-2.9 km/s, but dissociation reduced the velocities to 1.7-1.8 km/s. Laboratory-tested sediment containing both natural gas hydrate and ice had velocities as high as 3.9 km/s. Preliminary results indicate natural gas hydrate acts acoustically as if hydrate is part of the sediment grain structure rather than a grain cementing agent. These results are important for models that predict the presence of in situ gas hydrate using remote sensing techniques.