Laboratory Investigations of Natural Gas Hydrates at the Geological Survey of Canada

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Natural gas hydrates have been identified in association with deep-water marine environments and in areas of thick permafrost in northern Canada, Alaska and Russia. Typically, the presence of gas hydrate has been inferred from indirect evidence collected during the course of hydrocarbon drilling or marine seismic surveys. A limited number of dedicated scientific drilling projects have also been conducted in several marine environments (Ocean Drilling Program} and more recently in Canada's Mackenzie Delta (JAPEX/JNOC/GSC Mallik 2L-38 Research Well). While this research has advanced the understanding of geologic factors controlling the distribution of gas hydrates within the natural system, few high quality laboratory data are available describing the physical character and stability of the gas hydrate within the host sediments. In part, this is due to the difficulty of retrieving gas hydrate core samples at the surface without promoting significant gas hydrate dissociation. Even where pressurized coring systems are utilised, the extraction of core samples at atmospheric pressure induces substantive physical changes. An alternate to the retrieval of *in situ* gas hydrate samples is the induction of gas hydrate growth in laboratory test media under controlled pressure and temperature conditions. Fundamental laboratory studies facilitate assessment of the influences of sediment grain size, mineralogy, and pore water salinity on pressure-temperature (P-T) thresholds for gas hydrate stability. Investigation of the kinetics of gas hydrate formation and dissociation support the development of geologic models of gas hydrate occurrence and permit identification of practical constraints to production due to gas flux ceilings or unfavorable heat flow conditions.

The Geological Survey of Canada has established laboratory capabilities for investigating factors influencing the growth and stability of natural gas hydrates in porous media. Two state-of-the-art gas hydrate test reactors enable continuous recording of P-T conditions during the course of an experiment, permitting qualitative and quantitative analysis of (1) the kinetics of gas hydrate formation and dissociation, (2) amounts of gas incorporated into hydrate, and (3) pressure-temperature thresholds for gas hydrate stability. Research to date has been closely linked to Arctic field studies, with laboratory tests on core samples from the Mallik 2L-38 Research Well enabling precise mapping of the pressure-temperature stability thresholds for gas hydrate reservoir sands of varying salinity. Similar studies were conducted on Mallik silts, for which little or no gas hydrate was observed *in-situ*. P-T stability data from laboratory tests agree favorably with field observations, suggesting that an observed upward shift in the theoretical base of methane hydrate stability at Mallik is caused by porous media effects and pore water salinity. Quantitative data from laboratory studies also provide insights regarding the relative capacity of different sediments to host gas hydrate under similar pressure-temperature regimes.

GSC researchers, in collaboration with Japanese agencies, are currently investigating the dielectric properties of methane hydrate using time domain reflectomety (TDR). This work has led to the development of a technique for direct measurement of the amounts of gas hydrate formed in laboratory test media, independent of estimates of gas consumption derived from pressure-temperature relations. This work may be applicable

to the development of improved downhole logging techniques for identifying and quantifying natural gas hydrate occurrences in terrestrial and marine settings.