Comparison of Natural Gas Hydrate Occurrence Observed in the JAPEX/JNOC/GSC Mallik 2L-38 Well, Mackenzie Delta, N.W.T. with Recently Obtained Natural Gas Hydrates

Takashi Uchida[1], Scott R. Dallimore[2], Hailong Lu[3] and Tim S. Collett[4]

[1]JAPEX Research Center, Chiba, Japan
[2]Geological Survey of Canada, Victoria, Canada
[3]JNOC Technology Research Center, Chiba, Japan
[4]US Geological Survey, Denver, USA

The potential of gas hydrates as a future energy resource has stimulated of a number of intensive research programs ongoing in several countries including, Japan, Canada and United States. Concerns have also been expressed in recent years that gas hydrates may play a role in future greenhouse warming because methane is a particularly potent greenhouse gas and gas hydrates are sensitive to changes in temperature. This concern may be magnified in the Arctic since most global change models suggest that global warming will be greater there than in more temperate areas. Although gas hydrates are known to occur in the Arctic in association with deep permafrost and in the offshore at the continental margins, relatively little is known about the geologic aspects controlling their occurrences and distributions. In early 1998, the JAPEX/JNOC/GSC Mallik 2L-38 gas hydrate well was drilled to a depth of 1150 m at the Mackenzie Delta. This project was undertaken through a collaborative agreement between the Japan National Oil Corporation (JNOC) and the Geological Survey of Canada (GSC), with collaboration of many other institutes including the Japan Petroleum Exploration Company (JAPEX) and the U.S. Geological Survey (USGS). Japanese contributions to the project were part of a 5-year research and development program sponsored by the Ministry of International Trade and Industry (MITI; currently METI).

Gas-hydrate dominant layers were identified within the methane hydrate stability zone at depths from 890 to 1110 m beneath 640 m of permafrost. The gas hydrates recovered in core samples were very small in size mostly filling the intergranular porosity of sandy to pebbly sediments. Muddy sediments such as silts and clays which seperated the main gas hydrate layers were free of hydrate or contained low concentrations. Typically hydrate-bearing strata were 10 cm to 1.5 m thick with an estimated porosity of 25 to 35 %. The biggest form of pure methane hydrate was about 2 cm in diameter occurring as fills of intergranular porosity within granular sands. Hydrate concentrations in most hydrate layers were quite high with up to 80 % pore saturation. It was observed that sandy sediments in the cored interval were actually frozen to temperatures as low as -3 degree C due to endothermic cooling during dissociation of gas hydrates when recovered at the surface. Pore-space hydrate was observed filling intergranular pore systems, coatings on granules, veins thinner than 1 mm, and nodule-like hydrates up to 1 cm diameter. It was observed visually that gas hydrates may dissociate violently but more typically relatively calmly with incessant and small-sized bubbling of methane gas, less than a few mm, from intergranular porosity in sandy to pebbly sediments. Judging from these observations, it does not seem to be so drastic and rapid to generate in-situ combustion when temperature increased and depressurized. It may partly be due to the self-preservation phenomena, because laboratory experiments have described the phenomena which is an apparent metastable behavior of gas hydrate whereby the dissociation is slowed at atmospheric pressures and negative temperatures by an ice coating. The role of the ice phase, either within the sediment porosity or as a coating on the surface of the gas hydrate itself, may be critical in some situations when gas hydrates dissociate.

A key goal for the Japanese participation in the Mallik well was to undertake a scientific and engineering study of a known terrestrial gas hydrate occurrence prior to a major gas hydrate exploration well planed in the Nankai Trough. The Nankai Trough runs along the Japanese Island, where distinct and extensive BSRs have been recognized. High resolution seismic surveys and site-survey wells in 1997 have revealed the subsurface gas-hydrate distribution. Following the JAPEX/JNOC/GSC Mallik 2L-38 well in 1998, the MITI Nankai Trough wells were drilled in late 1999 and early 2000 in 945 m of water depth. Excellent gas hydrate-bearing sediment cores were recovered allowing for various laboratory analyses and physical measurements. The anomalies of chlorine contents in extracted pore waters, core temperature depression, core observations as well as visible gas hydrates confirm the presence of pore-space hydrates as intergranular pore filling within moderate to thick sand layers. There were many similarities in appearance and occurrence between the Mallik 2L-38 and the Nankai Trough wells with observations of well-interconnected and highly saturated pore-space gas-hydrate systems within clastic sediments.

Observations from the Mallik well and other gas hydrates suggest subsurface occurrences of natural gas hydrate, which can be classified into six types;

1) Pore-space hydrate fills intergranular porosity of sands and sandstones, and is expected to be interconnected in their pore systems, which should clearly contrast with nodule and disseminated types. Pore-space hydrate is small-sized and ranges up to 10 mm, and, however, is considered to decompose continuously and effectively.
2) Platy hydrate should be similar to thin layer of hydrate, whose thickness may range from 10 to 100 mm.
3) Layered hydrate and massive hydrate are extensively continuous horizontally and concordant to a strata, whose thickness should exceed 100 mm. Difference between a layered hydrate and massive hydrate can not be clearly described since an unquestionable occurrence of massive hydrate has not ever found.

4) Each of disseminated hydrates should approximately range from 1 to 50 mm in size, but may not be interconnected in the pore system of sediments that is different from the pore-space hydrate. A disseminated type should have been conceptual in the past, a part of which should be classified into a pore-space type. Disseminated type and nodule type may appear to distribute commonly within terrestrial and submarine conditions.
5) Nodule hydrate should approximately be bigger than 50 mm in size, and distribute sporadically in sediment strata. This type of occurrence has been frequently documented from many fields such as ODP Leg 164.
6) Vein hydrate and dyke hydrate are usually thin in thickness, and may elongate discordantly to the strata. Those types of occurrence have been reported from ODP Leg 112, Leg 164 and Mackenzie Delta (92GSCTAGLU).

The abundance of gas hydrate and the ideal reservoir characteristics of the host strata suggest that they should represent a considerable natural gas resource in this environment.