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Possible Occurrences of Gas Hydrates in Permafrost at the Mallik Site of Mackenzie Delta in Canada

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In 2002, an onshore gas hydrate production test by hot water circulation method was conducted at the Mallik site of Mackenzie Delta in Northwest Territories, Canada. The production test tried to extract methane gas from gas hydrate-bearing layers and became the first success in the world (Yamamoto, 2009).

Three wells that were called 3L-38, 4L-38, and 5L-38 were drilled for the production test, and DTS (Distributed Temperature Sensor)s were installed along casing pipes to measure the vertical temperature before/during/after the production test. The measurement was continued for almost one and a half year after the production test. It is estimated by DTS and logging data that permafrost layers are distributed up to approx. 600m depth below ground.

Mud logging data of all three wells while the drillings show high hydrocarbon (mainly methane) concentrations (methane sources) in mud at the following depth below ground; (1)100-130m interval, (2)600-700m interval (expected depth because of hole washout) and (3)900-1,100m interval. It has been recognized that methane source at 900-1,100m interval corresponded with gas hydrate-bearing layers by logging and coring data, and the lower part of gas hydrate-bearing layers became target zones of the production test.

In case of the methane source at 100-130m interval, it is unlikely that the methane in mud is derived from dissolved methane in the formation water because the amount of methane is large. The C1/(C2+C3) in mud is over 100 as well as the methane source at 900-1,100m interval. The top of gas hydrate stability zone calculated by gas hydrate equilibrium is estimated to be at 190m depth. Therefore the methane source is speculated as a gas pocket, however, DTS data during/after the production test shows lowering of temperature at 100-130m interval. This could cause dissociation of gas hydrates (e.g. Chuvilin et al., 1998). Such a lot of examples of metastable gas hydrate at shallower depth were reported in the permafrost area in Russia, and there is an indication of metastable gas hydrates at other borehole of the Mallik site (Dallimore and Collett, 1995).

The methane source at 600-700m interval is also unlikely to derive from dissolved methane. The depth estimation of mud logging data is calculated by the mud volume in open-hole and casing pipes, however, it is impossible to calculate the correct depth at this interval because of terrible hole washout. It is estimated that the correct depth should be shallower than 600-700m depth. DTS data during/after the production test shows a lowering of temperature at 570-600m interval. Therefore the existence of gas hydrate is expected at the interval. It is easy to identify the existence of gas hydrates by electrical logging because gas hydrate is a high-resistivity material, however, ice is also a high-resistivity material. Thus we cannot distinguish the hydrates and the ices. Gas hydrates may co-exist with ices in permafrost at 570-600m interval. The C1/(C2+C3) in mud is lower than 100 at this interval.

If gas hydrates exist in shallow zones of permafrost which is out of gas hydrate stability zone, the gas hydrates might influence the climatic variation. Furthermore the climatic variation might influence the generation mechanism of the metastable gas hydrates.

This study has been conducted as a part of studies of the Research Consortium for Methane Hydrate Resources in Japan.

References

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