

Methane Accumulation for High Concentration of Gas Hydrate in Deep Marine and Terrestrial Sandy Sediments

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Gas hydrates are widespread in many deep marine environments along continental margins worldwide as well as in several Arctic sedimentary basins associated with permafrost. Plenty of gas hydrate-bearing sand core samples have been obtained from the Mallik wells as well as the METI wells drilled in the Nankai Trough area. The chloride content anomalies in extracted pore waters, core temperature depression, core observations, visible gas hydrates as well as continuous downhole well log data confirm common occurrences of pore-space hydrate as intergranular pore filling within sandy layers, which clarified the characteristics of subsurface natural gas hydrate beneath deep sea floors and permafrost zones. Gas hydrate saturations are evaluated up to 80 % in pore volume, which may need gas accumulation associated with pore water and original pore space large enough to occur within host sediments. According to grain size distributions most of pore-space gas hydrates are contained in medium- to very fine-grained sandy strata, and they are scarcely contained in finer-grained sediments such as siltstone and claystone.

The Nankai Trough runs along the Japanese Island from offshore Tokai to offshore Kyushu, where forearc basins and accretionary prisms developed extensively. Distinct BSRs (bottom simulating reflectors) as well as intensive thrust/growth faults have been broadly recognized by extensive seismic surveys since 1971. The MITI Nankai Trough wells and METI Tokaioki to Kumanonada wells were successfully drilled at the eastern Nankai Trough area in 2000 and 2004, respectively. Water depths range from 720 m to 2033 m, and those wells delineated distributions and occurrences of subsurface gas hydrate in the submarine sediments in a continental margin. Carbon and hydrogen isotopic compositions of methane and hydrocarbon compositions in gas hydrate and gas hydrate-bearing shallow sediments in the Nankai Trough show that methane is generated by microbial reduction of CO₂, which suggests progressive decreases in microbial activity with depth and upward gas migrations through the sediment column.

The Mallik 2L-38 and Mallik 5L-38 research wells were drilled to the depth of 1166 m at the Mallik site, Northwest Territories, Canada, in 1998 and 2002, respectively. In the areas associated with thick permafrost, methane hydrate may exist at subsurface depths up to about 1500 m depending on the geothermal gradient, and can form within ice-bearing sediments as intrapermafrost gas hydrates and beneath the base of ice bonding as sub-permafrost gas hydrates as well. All of gas hydrates occur in clastic sandy sediments of Tertiary Kugmallit and Mackenzie Bay Sequences. In the Mackenzie Delta, methane in gas hydrate is generated by thermogenic decomposition of kerogen.

Based on the geochemical and geological data, gas migration processes are estimated to be active flow to permeable sandy layers in the Nankai Trough, and long migration of thermogenic gas generated in deep mature sediments through faults in the Mackenzie Delta. It should be noted that there are many similarities in appearance and occurrence between the terrestrial (Mallik) and the marine (Nankai Trough) areas with observations of well-interconnected and highly saturated pore-space hydrate within sandy sediments, and then distributions of porous and coarser-grained host rocks should be one of the important factors to control the occurrence of gas hydrate, as well as physicochemical conditions. These knowledge and information are crucial to predicting other hydrate deposits and their eventual energy resource.