Concentration of gas hydrate in sandy sediments relevant to accumulation of pore water with methane

Takashi Uchida[1]; Amane Waseda[2]; Takatoshi Namikawa[3]

[1] JAPEX Res Cntr; [2] JAPEX Research Center; [3] JOGMEC

Gas hydrate is a crystalline substance composed of water and hydrocarbon gases like methane, ethane and propane, in which solid water lattices accommodate those guest molecules in clathrate structures. Gas hydrates are widespread in many deep marine environments along continental margins worldwide as well as in several Arctic sedimentary basins associated with permafrost. The potential of gas hydrates as a future energy resource has stimulated a number of intensive research programs ongoing in Japan and other countries.

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.

The Mallik 2L-38 and Mallik 5L-38 production research wells were drilled to the depth of 1166 m at the Mallik site, Northwest Territories, Canda, 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 (intrapermafrost gas hydrate) and beneath the base of ice bonding (sub-permafrost gas hydrate) as well. All of gas hydrates occur in clastic sandy sediments of Tertiary Kugmallit and Mackenzie Bay Sequences.

Plenty of gas hydrate-bearing sand core samples have been obtained from the Mallik wells as well as the Nankai Trough wells. 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 the common occurrence of pore-space hydrates, which clarified the characteristics of subsurface natural gas hydrate beneath the deep sea floor and the permafrost zone. It should be remarked that there are many similarities in appearance and occurrence between the Mallik and Nankai Trough areas with observations of well-interconnected and highly saturated pore-space hydrate within sandy sediments.

According to grain size distributions most of pore-space gas hydrates are contained in medium- to very fine-grained sandy strata mostly filling the intergranular pore systems of sands as pore-space hydrate, whose hydrate saturations are evaluated up to 80 % in pore volume throughout most hydrate-dominant sandy layers. Pore-space gas hydrates are scarcely contained in finer-grained sediments such as siltstone and claystone. Concentrations of gas hydrate may need gas accumulation associated with pore water and original pore space large enough to occur within host sediments, and 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. This appears to be a similar mode for conventional oil and gas accumulations, and it is necessary for evaluating subsurface fluid flow behaviors to know both of porosity and water permeability of gas hydrate-bearing sediments. Subsequent analyses in sedimentology and geochemistry performed on gas hydrate-bearing sandy core samples and FMI (fullbore formation microimager) log data also revealed important geologic and sedimentological controls on the formation and preservation of natural gas hydrate. Although geologic and geophysical issues controlling gas hydrate occurrence, accumulation, and distribution are still remained, these knowledge and information are crucial to predicting the location of other hydrate deposits and their eventual energy resource.