Geochemical Study on Gas Generation and Hydrate Formation in the Eastern Nankai Trough

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Gas samples were collected from three offshore gas hydrate-bearing areas (Tokai-oki, Daini-Atsumi Knoll and Kumano-nada) in the eastern Nankai Trough. The gas molecular and isotopic data suggest that the main origin of gas in gas hydrates is microbial in all three areas whereas the contribution of thermogenic gas differs according to the area. In Tokai-oki area, no thermogenic gas component is recognized. Supposing the molecular and isotopic compositions for possible microbial and thermogenic end members, the contribution of thermogenic gas is estimated to be less than 5% in Daini-Atsumi Knoll area while it is estimated to be up to 30-40% in Kumano-nada area. The higher thermogenic gas contribution in Kumano-nada area could be related to mud volcanoes located in this area.

The microbial methanogenesis activities in gas hydrate-bearing marine sediments, usually shallower than 500 mbsf (meters below sea floor), can be evaluated based on the carbon isotope data of gas samples. The carbon isotope compositions of methane and co-existing CO_2 become heavier with depth in the upper 100 meter-sediments in all three areas in the Eastern Nankai Trough. These carbon isotopic parallel changes of CH_4 and CO_2 with depth are consistent with the closed-system Rayleigh conversion of CO_2 to CH_4. However, the curvature of the trend line for the Rayleigh fractionation model supposing a constant conversion rate is different from the observed data. This indicates that the conversion rate, or microbial activity, rapidly decreases with depth. Based on alkalinity and methane concentration profiles, similar microbial methane production profiles are obtained at Hydrate Ridge, Cascadia Margin. Methane production rates at northern flank of the summit and the slope basin of Hydrate Ridge are high just beneath the sulfate reduction zone and rapidly decrease in the upper 100 meter-sediments (Claypool et al., 2006). Another difference between the Rayleigh model and observed data is found in the deeper sediments. Below 100mbsf, the carbon isotope compositions of the methane and CO_2 no longer become heavier. Paull et al. (2000) explained the phenomena successfully, based on a simulation of the isotope profiles of the Blake Ridge gases, supposing upward gas migration through sediment column.

Based on mass balance calculations, TOC contents in marine sediments are not enough for in situ formation of highly concentrated (more than 50% in pore) gas hydrate, suggesting some migration and accumulation processes should be necessary. Active fluid flow in accretionary prism sediments could accumulate microbial methane into turbidite sands with high permeabilities within gas hydrate stability zone.

As mentioned above, considerable amount of thermogenic gas was detected in the Kumano-nada area. At MITI Nankai Trough Well drilled in the Tokaioki area, thermogenic gases was found in sediments below 1500 mbsf. Moreover, an oil field, Sagara Field, existed on land in this area although it was already depleted. These data suggest that large amount of thermogenic gas should have generated in deep mature sediments in the eastern Nankai Trough and gas hydrates of thermogenic origin could form locally in shallow or seafloor sediments where permeable conduits develop for migration of thermogenic gas, such as mud volcanoes or large fault systems.

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REFERENCES CITED

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