Geochemical behavior of carbon in shallow sediment within the gas chimney in Hidaka Trough, offshore Hokkaido

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The Hidaka Trough, offshore Hokkaido, has recently been characterized by subsurface gas chimney structures associated with mound/pockmark topography and methane plume, which indicate an intensive gas migration from deep sediments to the surface area. In the region where remarkable gas chimneys are developed such as in offshore Joetsu, shallow marine sediments are characterized by the precipitation of authigenic carbonate, massive gas hydrates and development of chemotrophs because of high methane concentration near the seafloor. In these environments, anaerobic oxidation of methane utilizes both methane and sulfate, resulting in sulfate depleted in shallow sediment. Inorganic carbon generated by methane oxidation does not incorporate only with calcium ion to form carbonate but also is reduced by microbially-mediated methanogenic reaction. Carbon is therefore a key substance near the depth of sulfate methane interface (SMI) in high methane flux area. This study aims to figure out the chemical reaction associated with carbon, which characterizes geochemical environment in shallow sediments, by analyzing concentrations of dissolved ions and hydrocarbons, and stable isotopic composition ($\delta^{13}C$) of dissolved carbons collected from shallow sediments with gas chimney structures in the Hidaka Trough, offshore Hokkaido.
In the area of calyptogena community, the SMI locates at shallow depth and indicates reductive environment is established because of sulfate depletion. The sulfate is depleted at shallower depth in the area with carbonates near the seafloor, where the concentration of calcium ion is also lower than other areas. These results indicate carbonate formed at higher rate in the area with higher methane flux. Total organic carbon amount decrease with depth above the SMI, the residual organic matter in sediment generates methane at depth and enhances the methane flux toward the seafloor. Based on the composition of dissolved hydrocarbons and $\delta^{13}C$ of methane, although the methane is generally of biogenic origin over the research areas in the Hidaka Trough, the $\delta^{13}C$ of methane increase rapidly with depth on the mound center, indicating thermogenic methane predominantly migrate from deeper sediments at the site. Biogeochemical behavior of carbon varies not only among sampling sites but also among relative locations on the single gas chimney structure.

Keywords: SMI, gas chimney, Hidaka Trough

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