Geochemical signature of methane-related archaea associated with gas hydrate occurrences in the gas-chimney on the Sakhalin continental slope

DONG-HUN LEE[1], YOUNG-KEUN JIN[2], JONG-KU GAL[1], HIROTSUGU MINAMI[3], AKIHIRO HACHIKUBO[3], KYUNG-HOON SHIN[1]

[1] Department of Marine Sciences and Convergent Technology, Hanyang University, Korea (Shinkh@hanyang.ac.kr)
[2] Korea Polar Research Institute, Korea
[3] Department of Materials Science and Engineering, Kitami Institute of Technology, Japan

Only 3% of the methane (CH4) in the gas hydrate (GH) bearing sediments is released into the atmosphere as the result of the anaerobic oxidation of methane (AOM), which is a specific microbial process (methanotroph) occurring in marine sediments (Juddy, 2004). We investigate the aspect of organic geochemistry in the GH bearing sediment during the project of Sakhalin Slope Gas Hydrate 2014 (SSGH 2014) to identify the molecular and isotopic signature of gas and archaeal lipid biomarkers at the gas-chimney on the sourthwestern Sakhalin Continental Slope (SWSS). At both sites (LV67-07HC and -19HC), the Sulfate Methane Transition Zone (SMTZ) is located at a different sedimentary depth (110 cmbsf at LV67-07HC and 350 cmbsf at LV67-19HC) due to the differences in the biogeochemical sedimentary environments and upwardly CH4 flux. The carbon isotope values of methane ($\delta^{13}C_{CH4} \approx -55.3‰$ to $-39.6‰$) collected from the GH bearing sediment (LV67-07HC) suggests that CH4 is mostly produced by thermogenic sources rather than microbial carbon dioxide reduction (LV67-19HC). Moreover, the isotopic fractionation factor ($\varepsilon C = \delta^{13}C_{CO2} - \delta^{13}C_{CH4}$) near SMTZ in the GH bearing sediment is significantly lower (ca. 20). We consider that abnormally small εC values reflect the faster rate of AOM by the methanotrophic activity. Hence, the methane-related archaeal lipids (archaeol and sn-2-hydroxyarchaeol) are present in relatively high concentrations and have strongly depleted-δ13C values in the SMTZ from LV67-07HC. In this core, monocyclic biphytane (BP-1; which is mainly derived from GDGT-1, produced by the Euryarchaeota) become also predominant and exhibit depleted-δ13C values ($-96.4‰$ to $-89.2‰$), indicating that methanotrophs consume CH4 as carbon source. The molecular and isotopic signature of gas and methane-related archaeal lipid may thus be used as a robust indicator for the migration of CH4 flux in the gas phase and AOM processes by methanothrophs as evidence for “microbial filter”.

Keywords: Sakhalin continental slope, Gas hydrate, Methane, Archaeal lipid biomarker, Carbon stable isotope values.