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

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Only 3% of the advective methane in gas hydrates 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. We investigate the molecular and isotopic signature of gas and archaeal lipid biomarkers at gas hydrate bearing core sediments during the project of Sakhalin Slope Gas Hydrate 2014 (SSGH 2014). Our objective of this expedition is to identify relative abundance of methane-related archaea and pathway for understanding of the geochemical methane cycles between two core sediments (gas hydrate occurrence site and background site). At both sites, the molecular and isotopic data (δ13CCH4 and δ13CCO_2) of gases indicate that methane is originated from microbial production via carbon dioxide reduction. The isotopic fractionation factor (εC = δ13CCO_2 – δ13CCH4) near Sulfate Methane Transition Zone (SMTZ) in gas hydrate bearing sediment is significantly lower (ca. 20), considering more faster rates of AOM by the methanotrophic activity. Additionally, there is no correlation of bulk sediments (Total Orgaic Carbon (TOC), Total Sulfur (TS)) in gas hydrate occurrence site demonstrating that reduced sulfur is incorporated into the TS during the microbial AOM processes. The depleted-δ34STS values as low as –32.95‰ suggest that sulfate reduction coupled to AOM was more active and affect the sulfur isotope values of TS. The relative higher abundance of archaeal lipid biomarkers (archaeol, sn-2-hydroxyarchaeol, GDGT-1 and -2) and their depleted-δ13C values (sn-2-hydroxyarchaeol : –100‰ can be considered as the evidences of AOM by methanotroph related with euryarchaeota, consuming the methane migrated from the deeper reservoirs such as gas hydrate. Consequently, the geochemical signature of molecular and isotope values in analyzed gases and archaeal lipid biomarkers in the Sakhalin Slope can be used as a possible indicators which can distinctly reveal a crucial role of AOM processes by methanotroph.