

## Geochemical characteristics of shallow gas hydrates and sediment pore waters obtained from 2021 drilling survey at a knoll off Sakata in the eastern margin of the Japan Sea

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As a potential future energy resource, marine gas hydrates distributed around the Japanese islands have been an important subject of resource assessment and production development. The gas hydrates around Japan occur either as pore fillings in sand layers mainly on the Pacific side or as massive deposits in shallower sediments on the Japan Sea side and around Hokkaido. At a knoll called the Sakata Knoll in the eastern margin of the Japan Sea, the presence of massive gas hydrates was suggested by the physical property anomalies obtained by Logging While Drilling (LWD) surveys (Tanahashi et al., 2017). During the PS21 cruise for geotechnical survey at the knoll in August 2021, seafloor drilling was carried out to confirm the presence and to investigate the distribution of gas hydrates. In this cruise, core drilling was conducted to reach ~60 m below seafloor (bsf) and recovered gas hydrates. We here present the preliminary results of geochemical analyses on cores obtained in the PS21 cruise and characterize the origin of methane in the gas hydrates and relevant properties of sediment pore waters.

Drilling was carried out at two sites in the knoll, the summit where the presence of hydrates was suggested (hydrate site RC2102A, ~530 m water depth) and the slope as a reference site (RC2101A, ~555 m water depth). The hydrate site was within an area where a bottom-simulating reflector (BSR) is distributed, while the reference site was outside the BSR distribution area. At the hydrate site, seafloor was covered with microbial mat and flakes and chunks of gas hydrates were collected at 8 m, 16 m, and 21 m bsf. The pore water sulfate concentration at the reference site decreased downcore from ~20 mM at 1 m bsf to ~0 mM at 6 m bsf, while at the hydrate site the sulfate was near zero at 1 m bsf. These results indicate higher fluxes of methane and fluid from the subsurface at the hydrate site than at the reference site. In the hydrate-bearing intervals at the hydrate site, significant decreases in the chloride concentration were observed. The stable oxygen and hydrogen isotopic compositions of the original pore water before methane hydrate formation were estimated from the isotopic compositions of hydrate melts and the isotope fractionation factors between hydrate and seawater. Comparing the measured and estimated values, the oxygen and hydrogen isotopic compositions of pore waters are similar to or slightly more enriched in heavy isotopes than those of the original pore water. The decrease in the chloride concentration and the high oxygen and hydrogen isotope ratios of the pore waters indicate the input of water from the gas hydrate dissociation. The methane concentration in sediments was in the similar range at the tow sites, showing maxima just below the sulfate-methane interface (SMI), in which the sulfate concentration was near zero, and decreasing with depth. The stable carbon and hydrogen isotopic compositions of methane and the carbon isotopic composition of dissolved inorganic carbon (DIC) indicate that the methane was produced through hydrogenotrophic methanogenesis. Methane contained in the gas hydrates exhibited the similar isotopic compositions to those of the headspace methane. Measurement of the microbial methane production rate and genetic analyses are ongoing to reveal the main depth interval for methanogenesis and the formation mechanism of the shallow gas hydrates.

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Keywords: Drilling core, Gas hydrate, Methane, Pore fluid