Hydrate plumes transport methane to shallow water: consideration from analyses of dissolved methane, eastern margin of Japan Sea

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A fish-finder (38 kHz Echo-sounder) and SEABAT(multi narrow beam system) have detected a number of gigantic methane plumes on the sea floor of gas hydrate field, about 900 mbsl off Joetsu, eastern margin of Japan Sea. The heights of plumes are surprisingly at around 300 mbsl where almost all the plumes suddenly disappear. ROV dives on the sea floor observed a number of methane seep sites, where small vent holes were actively emitting gas bubbles of 0.5 cm in diameter. Gas bubbles were immediately crystallized to form methane hydrate spheres or perhaps covered by methane hydrate shells at extremely low temperature conditions (0.2deg) on the sea floor. The hydrate bubbles were observed to ascend at a rate of 20cm per sec and finally dissociated at 250-300 mbsl, the upper limit of methane hydrate stability, to supply methane to shallow waters. Methane concentration of sea water in and around plumes and just above seep sites widely range from 16 to 15000 nmol per liter, while those of the sea water of the Joestu basin were mostly between 5 to 20 nmol per liter. These values are significantly higher than the baseline level of Japan Sea waters of 2 to 5 nmol per liter. High concentration anomalies in the basin appear at different horizons from site to site, though the bottom and shallow waters at 200 to 300 mbsl are often characterized by anomalously high CH4 values. The bottom high is probably due to direct effects from the sediments, while the 200-300mbsl high is explained to have been caused by dissociation of methane hydrate bubbles at that level. ADCP and LADCP deployments have revealed complex current system of seawater for the entire depth range of the basin. Surface waters generally flew north to northeast at 10 to 20 cm per sec, while methane enriched shallow waters moved west to southwest at 15 to 38 cm per sec as observed in July to August 2006. The current profiles imply that methane-bearing shallow water mass was being swept away by westerly moving subsurface current, while the high concentration level has been sustained by high methane supply through dissociation of methane hydrate bubbles of plumes. Carbon isotopic compositions of dissolved methane at reference site in the Oki Trough far west of Noto peninsula are -49.1 to -45.8 permil VPDB, while those of methane seep and methane hydrates are around -35 to -40 permil, a typical thermogenic signature. Methane in shallow waters are similar to the isotopically heavy seep methane, -30 to -45 permil, indicating that deep methane has been transported to shallow waters without significant isotopic fractionation. Methane emitted to deep cold waters is effectively transported to shallow waters because it has been conveyed in the form of solid methane hydrate.