Methane plumes transport methane to shallow waters: in situ experiments and observation of plumes by ROV HyperDolphin

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ROV Hyper-Dolphin dives during the 2006-Natsushima cruise (NT06-19), September 2006, have finally found active venting of methane from the seafloor of the Umitaka spur and Joetsu knoll, where a number of gigantic (about 600 meter high) methane plumes, sea-floor gas hydrates, bacterial mats, and methane-derived carbonates had been observed during the 2004-2006 expeditions. Considering magnificent and strong images of the plumes on echograms, we expected large vent holes emitting strong and continuous gas streams. However, the vent holes were quite small, 10 to 20 cm across, identified as a group of several holes in the plume sites at the depth of water of about 890 m. Vent hole zones are paved by carbonate crusts, covered by patches of bacterial mat, and occasionally associated by crabs and benthic shrimps. Solid accumulation of methane hydrates was recognized in and around the active holes. Gas bubbles are approximately 0.5 to 1.0 cm in diameter, mostly spherical but some are flattened and elliptical. With an intention to estimate the flow rate of methane bubbles, we tried to collect the methane bubbles in an acryl funnel. We failed to measure the exact flux rate because the funnel was not large enough to collect unstable and dispersed flow of methane bubbles, but the bubbles trapped in the funnel demonstrated that the bubbles were not gas bubbles but were all coated by dense and thick, white methane hydrate. As the temperatures of bottom waters on the spur and knoll are 0.2 to 0.5 degree C, we predicted that thin films of methane hydrate should coat methane bubbles during ascent through such cold waters. To our surprise, the bubbles were observed to have been covered by solid methane hydrate and converted to hydrate spheres soon after the emission from the holes. Methane hydrate bubbles trapped in a funnel very look like styrene foam. We ascent within a plume to observe the behavior of rising hydrate bubbles. Methane hydrate bubbles (or spheres) started to dissociate at around 285 m below sea level, and completely melted at 251 m, which corresponds to the upper limit of methane hydrate stability in the water column of Joetsu basin. In situ experiment on the behavior of methane bubbles has successfully tested and confirmed our hypothesis of 2004 that the methane plumes are not composed of methane bubbles but of methane hydrate coated bubbles, which ascend in cold water column without significant dissolution or dissociation. Finally, methane hydrate rinds are dissociated at 250 m, the upper limit of the hydrate stability, supplying methane to ambient shallow waters.