Methane hydrates on the seafloor and methane plumes off Naoetsu, eastern margin of Japan Sea

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A series of knolls and spurs have been formed along the eastern margin of Japan Sea for the last few million years. Large pockmarks and mounds develop on a small spur, Umitaka Spur, 1000m below sea level, off Naoesu, Niigata Prefecture. Umitaka-maru cruise, UT04, identified tens of magnificent methane plumes, approximately 600 m high, on the spur. 3D seismic surveys have recognized gigantic gas columns, 1 to 2 km in diameter, in the spur and high amplitude BSRs at around 150 meter below sea floor, which are consistent with regional geothermal gradient of 10degree per 100m. ROV Dolphin Natsushima NT05-09 and DeepTow Kaiyo KY05-08 have revealed ocean floor methane hydrates, white bacterial mats, and carbonate crusts near plume sites. Piston coring successfully recovered methane hydrate samples. Penetration of piston corers were often blocked by hard methane hydrate horizons at around 3 to 4 mbsf. The depths of the SMI, sulfate-methane interface, have been defined at 1.5 to 3.5 mbsf, which suggests that the methane flux on the spur was several to 10 times than those in Blake Ridge and Nankai trough. Methane of the plumes and hydrates were thermogenic with carbon isotopic composition of -40 permil PDB, while the sediment gases near the plume sites were mixed microbial and thermogenic with -40 to -70 permil and those away from the plume sites were mostly microbial with -60 to -90 permil. As expected from prominent methane plumes, methane concentration of seawater over the spur reaches up to 2040nmol. High concentration anomaly zones have also been recognized at around 600-800 mbsf and 200-300 mbsf. Temperature of seawater was 2.0 to 3.0 deg C at 300m and lower than 1.0 deg C below 400m. This implies that the intermediate and bottom waters are well within the stability zone of methane hydrate. Thin layer of methane hydrate would instantaneously cover methane bubbles exposed to such waters. The pressure of the hydrate-coated bubbles would become significantly higher than the hydrostatic pressure with ascent, and then the bubbles would burst to form smaller bubbles and flakes of methane hydrate. The burst event should correspond to the 600 to 800 meter anomaly. The smaller bubbles would be again coated by methane hydrate, float up to the upper limit of the methane hydrate stability, at which methane hydrate would be dissociated to release methane to the shallow waters, causing 200 to 300 meter anomaly. Methane from the seafloor venting would be efficiently transported to shallow waters and atmosphere through low temperature water masses.