Methane plumes and methane-derived carbonates of the Tatar Trough and Tatar Strait, northern part of the Sea of Japan

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A number of giant methane plumes have been observed to form a long and narrow cluster zone along the 200 to 300 meter contours on the eastern slope of the Tatar Strait, between 47_40N ~ 48_20N. Methane plumes seem to occur on the boundary of geologic units, suggesting an active migration of deep seated thermogenic gases through boundary faults. On the other hand, similar cluster of giant methane plumes have been observed off Svalbard and the west coast of North America. Strong plumes along the 200-300 m contours seem to suggest a massive dissociation of gas hydrates at the base of gas hydrate stability (BGHS) responding to oceanic and global change.
Gas Hydrate Research Laboratory (GHRL) and Pacific Oceanological Institute of Russian Academy of Science (POI-FEB-RAS) have conducted a joint expeditions (Lv81 and Lv85) in 2018 and 2019 to elucidate the causes and consequences of plumes in the northern part of the Sea of Japan; origin of gas, ocean flux, geologic controls, and environmental impact on global climate.
Gravity coring recovered sediment cores of < 3.5 m long at 51 sites on the shelf to the basin floors at the water depth of 185 m to 3,657 m. “Gas chimney-like structures” were recognized on seismic profiles. However gas hydrates were not recovered from the “structure” probably because the penetration was not deep enough but only for some carbonate concretions. In Tatar Strait, hydro-corer was deployed on the shelf to basin floors of 301 m to 1060 m, in which gas chimneys or “acoustic turbid zones” and pockmarks have been documented in previous cruises. Hydro-core recovered 13 sediment cores of < 5 m long with vein and granular hydrate aggregates and lots of carbonate concretions.
U-Th age of the formation of carbonates ranges between 1.0 ka and 53 ka, while mostly between 15 ka and 20 ka. Age of the carbonates is similar or a little younger than the stratigraphic age of the host sediments, suggesting that the carbonates were formed as MDACs (methane-derived authigenic carbonates) in AOM just below the sea floor. The d13C of MDACs of Tatar Trough are between -50.0 ‰ PDBto -55.3 ‰PDB, microbial origin, while those of the Tatar Strait fall in the range of -14.4 ‰PDBto -55.2 ‰PDB, with bimodal peaks at -25 ‰PDBand -53‰PDB, corresponding to thermogenic and microbial respectively. Thermogenic-methane-dominated sites are around gas chimneys and pockmarks, implying that the flux of thermogenic gases are enhanced in the northern part of plume zone. The d18O of the study area are mostly between +3.0 ‰PDBand +4.5 ‰PDB, which correspond to the precipitation from 0.0 +/- 0.5 ‰SMOW watersat the temperature of 0.0℃to 0.5℃, which are expected values of Tatar area during MIS2-3. However, some MDACs are anomalously depleted in ^{18}O (+1.0 ‰PDBto +2.5 ‰PDB). Japan Sea is believed to have been capped by low salinity water during the LGM, and the low salinity water mass is responsible for the oxygen depleted carbonates. Inorganic carbonates of marine environments are to contain 10 to 15 mol% Mg, while Mg content of some of MDACs in the study area is only 3 to 5 mol.%. This also suggest the precipitation from low salinity waters. Formation of MDACs has been caused by glacial-low stand and methane flux from the dissociation of gas hydrates at BGHS due to pressure decrease.
However the question as to the relative contribution between thermogenic and microbial and the mechanism and geologic control for high methane flux of giant plumes has not been answered as yet.

Deep coring down to the BGHS at around 100 mbsf should provide secular variation in the methane flux and the ultimate source of methane.

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