Methane Plumes over a Marine Gas Hydrate System in the Eastern Margin of the Sea of Japan

Ryo Matsumoto[1]; Yoshihisa Okuda[2]; Chiharu Aoyama[3]; Yasushi Ishida[4]; Akihiro Hiruta[5]; Hideki Numanami[6]; Michinari Sunamura[7]; Hitoshi Tomaru[8]; Glen Snyder[9]; Junko Komatsubara[10]; Rika Takeuchi[4]; Mineo Hiromatsu[11]

[1] Earth and Planetary Sci., Univ. of Tokyo; [2] AIST; [3] Natural Sci.Dept.,Japan's Independent Institute; [4] Earth and Planetary Sci., Tokyo Univ; [5] Earth and Planetary Sci, Tokyo Univ.; [6] Tokyo Kasei-Gakuin Univ; [7] Univ. Tokyo; [8] Univ. Rochester; [9] Dept of Earth Sci., Rice Univ; [10] Univ. of Tokyo; [11] SAP

Naoetsu-oki sedimentary basin in the northwestern part of the northern Fossa Magna is the southern extension of Japan's most productive hydrocarbon provinces and is filled by a thick pile of the Neogene organic-matter rich sediments. METI/JOGMEC has been conducting oil/gas exploration in the basin for the last decades. In 2003, the exploration program identified a number of depressions and mounds at a water depth of 900 - 950 m on a small tongue-shaped ridge and wide distribution of BSRs (Bottom Simulating Reflectors) at about 170 meter below seafloor (mbsf). These findings strongly suggest gas and gas hydrate related phenomena over the area.

In the mid-Summer of 2004, we sailed R&T/V Umitaka-maru of Tokyo University of Marine Science and Technology to the small ridge (now named UT04 Ridge) with an intension to explore the origin of the unique structures and gas seeps, to recover ocean floor gas hydrates, and to examine the relation between shallow gas hydrate system and deep-seated gas reservoirs. Detailed bathymetric and seismic profiles have revealed a number of mud volcanoes (20 to 40 m high and 300-500 m across), pockmarks (40-70 m deep and 300-500 m across), and collapse structures within 3 km x 4 km area on the UT04-Ridge. Large pockmarks develop in the NNE-SSW direction, parallel to the strain-belt between the Eurasian and North American Plates. Fathometer and quantitative Echo sound survey have depicted 36 magnificent flares of plumes over the area, each ranging about 100 m in diameter and 600 to 750 m in height, reaching up to the shallow water zone of 200 to 350 m below sea level.

Seawater was sampled at every 100-200 m in the water column over the seep sites. Onboard GC measurements have demonstrated characteristic methane profiles as 10 to 50 nmon/L for the bottom waters, 5 to 8 nmol/L for the intermediate waters, 20-45 nmol/L at 200 to 300 m, and again about 5 nmol/L for the surface water. High concentration anomalies of methane at 200-300 m may have been caused by high-methane waters of shelf and perhaps rivers, although the methane concentration on the shelf is not so high as observed over the seep sites. Alternatively, the anomalies may imply a vertical transportation of methane by gas hydrate plumes. CTD has shown anomalously low temperatures, 0.25deg, for the bottom and intermediate waters, and abrupt increase at about 300 m up to about 25deg at surface. Methane bubbles from seep sites would form gas hydrate sooner or later at such conditions, 900 m and 0.25 deg, favorable for the formation of gas hydrate. Gas hydrate crystals, 0.91 g/cm3, could potentially float upward until they reach the warm waters at 200-300 m, where gas hydrate would be dissociated to supply methane to shallow waters.

Piston cores, 5.5 m long, recovered mottled, dark-brownish gray to dark gray silt/very fine sand with occasional small carbonate nodules inter-bedded with laminated, dark gray silt and clay. The sediments slightly fizzled and bubbled probably due to degassing from the interstitial waters and/or dissociation of disseminated gas hydrates. Onboard geochemical analysis of the interstitial waters has shown the sulfate-methane interface (SMI) at around 1.5 m to 3.0 m. A piston core deployed on an active seep site penetrated only 3.5 m into the dark gray silty clay which contains a number of chunks of gas hydrate and small carbonate nodules. The piston core was probably blocked by a massive gas hydrate layer at 3.5 mbsf. Gas hydrate is dominated by methane with minor ethane, whereas the d13C of gas hydrate methane is -40 to -42 permil PDB. This is the first recovery of thermogenic gas hydrate from around Japan islands. According to the deep-exploratory drilling near the survey area (METI/JOGMEC, 2004), deep-seated gases are dominated by thermogenic methane with -40 permil PDB. Gas seeps and ocean floor gas hydrates are likely to be connected with deep-thermogenic gas reservoirs.