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Shallow accumulation of gas hydrates and evolution of gas hydrate mounds, Joetsu Basin, Eastern Margin of Japan Sea

Ryo Matsumoto[1*], MANABU Tanahashi[2], HITOSHI Tomau[1], Mineo Hiromatsu[1]

[1]Dept of Earth & Planet Sci Univ of Tokyo, [2]AIST

During the R/V Marion Dufresne expedition in June 2010, a robust box corer CASQ deployed on hydrate mounds has recovered 2 to 10 m long strongly disturbed soupy sediments with abundant massive and platy gas hydrates and carbonate nodules. This confirmed that the mounds are made up of the massive accumulation of mixed gas hydrate and carbonate nodules. Giant piston corer CALYPSO could not penetrate through the mixed hydrate-carbonate zones, and was often bent or broken during the deployment, however the corer was powerful to penetrate down the sediments as deep as 40 mbsf off mound area of low methane flux. The standard sequence is represented by (I) 5-10 m thick bioturbated unit, (II) 30-35 m thick unit composed of inter-bedded dark gray thinly laminated beds, bioturbated beds and occasional debris flow deposits, and (III) 5 m thick massive units. Unit boundaries I/II and II/III have been dated by C-14 and tephra chronology as approximately 20 ka and 100 ka, respectively. Dark gray laminated beds are likely to have deposited in stagnant bottom waters during the low sea-level of LGM and stadial episodes. AUV-Urashima and Tuna-Sand surveys have revealed ultra-high resolution bathymetry, topographic features, and subsurface structures over the Joetsu gas hydrate field in August 2010. MBES (multi beam echo sounder, 400kHz) identified two types of hydrate mounds. One is a conical shaped low hills with gentle smooth surface, while the other is characterized by high relief topography with strong backscatter, crater-like depression and outer rim. SBP (sub-bottom profiler, 1-6 kHz chirp) has demonstrated high-resolution sedimentary sequences down to 30-50 mbsf, which are well consistent with the lithologic units I, II, and III of the CALYPSO cores. SBP of hydrate mounds is represented by column-shaped acoustic transparent zones, representing gas charged sediments. The columns are either capped by high amplitude reflectors at around the boundary II/III, I/II or extrude on the seafloor to form hydrate mounds. Hard caps atop the acoustic columns are probably composed of mixed gas hydrate and carbonates. In conclusion, thermogenic gases migrate through gas chimneys to accumulate gas hydrate above the base of gas hydrate stability (BGHS) at 120 mbsf, whereas the formation of hydrate is limited by the amount of free waters in sediments. The excess methane continues to move up through the dry sediments into the shallow, water-saturated sediments, where the methane forms gas hydrate at around II/III and I/II. On the other hand methane and seawater-derived sulfate react to increase alkalinity and precipitate carbonates through AOM. The ceiling of the columns is considered as a front of the mineralization of gas hydrate and carbonates, and the buildups finally grow up to the seafloor. The exposed gas hydrate-carbonate buildups eventually collapse and decay through rift-up and dissolution to the seafloor. The present study has been partially supported by the national methane hydrate program MH21.

Keywords: gas hydrate, Eastern margin of Japan Sea, R/V Marion Dufresne, AUV Urashima