Formative processes of methane derived carbonates nodules on Umitaka spur off Joetsu

Akihiro Hiruta[1]; Ryo Matsumoto[2]; Hitoshi Tomaru[3]

[1] Earth and Planetary Sci, Tokyo Univ.; [2] Earth and Planetary Sci., Univ. of Tokyo; [3] EES, Univ. Rochester

Introduction–Methane derived carbonate nodules and plumes have been observed on the Umitaka spur, about 30 km off Joetsu. Pockmarks and mounds on the spur seem to have been caused by the methane seep events. We studied the formative processes of the nodules to document past methane seep events.

Samples and measurement–A number of nodules (5 to 20 cm in diameter) have been recovered by piston coring during the cruise, UT04 and UT06 of R&TV Umitaka maru, and KY05-08 of Kaiyo. ROV dives of Hyper Dolphin also collected carbonates from the sea floor during the cruises, NT05-09 and NT06-19. We analyzed the microtexture of the nodules, determined the mineral composition, and measured the carbon and oxygen isotopic composition of nodules. We also conducted geochemical analyses of the interstitial waters of sediment cores.

Result and discussion–(1) Carbon isotope composition of DIC decreases from about 0 down to -10 to -40 permil(VPDB) at around the SMI (sulfate-methane interface) of 1 to 4 meters below sea floor, then increase to about 0 permil(VPDB) at 5 to 7 mbsf. Alkalinity shows inflection around the SMI depth. These results imply anaerobic oxidation of methane (AOM) in sediments. (2) Nodules are considered to have been formed within the sediments because the primary sedimentary structures such as lamination and bioturbation were recognized within nodules. We observed intraclasts and flow structures in some nodules. These indicate that the surface sediments on the spur had been reworked and blown up probably by strong venting of fluids. (3) Some nodules contain pores and cavities. Some pores, 0.2 to 0.7 mm in diameter, and cavities are filled with white aragonite crystals. We observed actively venting methane gas bubbles from the sea floor during NT06-19 cruise. The bubbles were soon coated by methane hydrate. Aragonite-filled pores and cavities in carbonate nodules are likely to have originated in gas bubbles (=gas pocket) or micro hydrate sphere in sediments. (4) The carbonates are either aragonite or calcite. Some contain both aragonite and calcite. Considering that the cavities and gas pockets are all filled by aragonite, aragonite represents the later stage of carbonate precipitation. (5) Carbon and oxygen isotopic composition of nodules range between -40 and -10 permil(VPDB), and 3.5 and 5.5 permil(VPDB), respectively. The carbon isotope compositions are almost identical to those of DIC around the SMI depths, implying that the nodules have been formed around the SMI in relation with AOM. (6) Nodules are grouped into type A, B, and C, based on isotopic compositions. Carbon and oxygen isotope compositions in type A demonstrate clear positive correlation, whereas, only carbon isotopic compositions vary in Type B nodules. Isotopic composition in Type C nodules tend to cluster in a narrow range. Variation in carbon isotopic compositions in Type A and B nodules has been controlled by the variation in carbon isotopic composition of DIC and deepening of SMI. That is, the methane fluxes were weakened during the formation of carbonate nodules. Change of the methane fluxes may also have decreased the heat flow and fluid temperature. This may explain increases values of oxygen isotopic composition. Alternatively, heavy oxygen of late carbonates may reflect a massive dissociation of methane hydrate. Type B nodules were also formed under the influence of changing SMI. But temperature did not change a lot. Type C nodules were quickly formed.

Conclusion–Sediments in nodules indicate that the surface sediments had been reworked and blown-up, probably by strong methane seeps. Carbon isotope compositions of nodules and DIC at Umitaka spur indicate these nodules were formed around SMI depths. Carbon and oxygen isotope variations of some nodules indicate that these were formed in sediments when both methane flux and geothermal gradient were decreased.