Using Geochemical Proxies in the study of cold seeps in the eastern margin of the Japan Sea

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Cold seeps issuing forth from ocean bottom sediment as a result of plate tectonic motions are collectively an important source of materials and heat that affect ocean circulation. Such seeps exist in the eastern margin of the Japan Sea which is a plate collision/subduction boundary between the North American and Eurasian plates, and is the source of many large-scale earthquakes. The associated tectonic motion likely contributes to the release of methane from seafloor methane hydrates, possibly promoting global warming because methane is a strong greenhouse gas. To investigate the origin and generation mechanisms of cold seeps and methane release, we evaluate the biological activity of chemical synthesis communities and propose geochemical proxies of sediment pore water (e.g., the concentration of major ions and nutrients, and the composition of chlorine and oxygen isotopes). The proxy veracity was confirmed and used to clarify the relationship between cold seeps, methane hydrates and tectonics.

Geochemical data sets are from two explorations: the KT05-11 expedition on the R/V Tansei-Maru and the NT05-09 investigation using the unmanned submersible HYPER-DOLPHIN and its mother-ship R/V Natsushima near the pockmark area off Sado in the Japan Sea. A black-colored area was observed at Kitatorigakubi during dive #442. According to the pore water geochemical characteristics, this black-colored area consists of sulfate-reducing bacteria; the nutrient source feeding this chemical synthesis is CH4 carried from 170 mbsf by cold seep water. This suggests that CH4 gas trapped in the relatively warm anticline was escaping from the sediment, and is converted to methane hydrate in the cold bottom water, which then rises up from sea floor to 300 m water depth. As a result of the water-mass structure clarified by the KT05-11 expedition, in the shallow water, salinity and temperature were lower than the surrounding Tsushima warm current in this area; in deeper water the temperature was lower than the normal JSPW (Japan Sea Proper Water), and shows especially high salinity in bottom water (3m above the bottom). Together with the results of chlorine and oxygen isotope compositions and chlorine concentrations, it was indicated that, methane hydrate generated over the bottom melted in the shallow water. The fresh water derived from this melting of the methane hydrate contributed up to 40% of that calculated by the decrease in the salinity in upper water. In the other words, CH4 of the quantity which corresponds to melting fresh water emission from the sea floor and then transported to the ocean surface. However, it is also possible that CH4 has been trapped by chemical synthesis in bacterial mats, such as those previously reported near the north Eastern Margin of Japan Sea. Further research using geochemical proxies is required to further elucidate these processes.