Investigation of distribution of mud volcanoes in East China Sea using distribution of methane concentrations in seawater

*Tomohiro Toki[1], Hideki Chibana[1], Teppei Shimabukuro[1], You Yamakawa[1]

1.Faculty of Science, University of the Ryukyus

Methane in the atmosphere is one of strong greenhouse gases with about 20 times of global warming coefficient of the carbon dioxide (IPCC, 2007). Methane in seawater of continental shelf and coastal area plays a role as a source of methane to the atmosphere (Bange et al., 1994; Bange, 2006; Holmes et al., 2000). In the East China Sea, methane in seawater of continental shelf area was accumulated in summer, and was released in winter to the atmosphere in association with development of mixed layers in the surface water (Tsurushima et al., 1996). In the continental shelf and the Okinawa Trough, mud volcanic geographical features were reported in the East China Sea (Yin et al., 2003), and the existence of chemosynthetic biological communities was observed in the continent slope area (Kuhara et al., 2014). The methane supply from seafloor in the shallow area of the sea can be a source of methane to the atmosphere, requiring a detail survey of distribution of the methane sources. In this study, we investigated methane distribution in the East China Sea, and clarified distribution of methane sources, including mud volcanoes, cold seeps, or hydrothermal systems.

Seawater samples were collected from several sites in the East China Sea during cruise training classes around May or June in 2011, 2012, and 2015. The seawaters were collected by Niskin sampler, and were distributed to 100-mL vials. These samples in vials were added with saturated $HgCl_2$ solution to stop microbial activities, and were capped with butyl rubber caps. They were stored in a refrigerator, and analyzed for methane concentration. During their samplings, CTD monitoring sensors were attached to the Niskin sampler, and they recorded conductivity, temperature, and pressure, etc.

The methane concentrations were measured by GC-FID (Shimadzu; GC-2014A) after gas extraction using extraction equipment. The concentration were determined by 10-ppm standard gas for a calibration, and the precision was within 8%.

Based on the CTD data, we classified the area into continental shelf area, continental slope area, and Kuroshio Current area. First, seawater in continental shelf area contained relatively much methane, suggesting the effects of continental water flows enriched in organic matter, or of seafloor sediments on the shelf. Next, in the continental slope area, seawater showed high methane concentrations around 100-200 m. On the other hand, in Kuroshio Current area, seawater showed the equilibrium concentration with the atmosphere at the surface water, 1-2 nmol/kg above 600 m, and <1 nmol/kg below 600 m. The methane anomaly around 100-200 m in the continental slope area was associated with low salinity, which would be derived from the continental shelf water.

The seawater at some sites in the continental slope area showed anomalous methane concentrations around several hundred meters. These sites include places that have never been reported as mud volcano area, cold seep area, nor hydrothermal area. We cannot identify phenomenon of the methane source, but hydrothermal systems are unlikely considering tectonic setting. Mud volcanoes and cold seeps are likely in this area. Below the seafloor, Shimajiri Group or Yaeyama Group may be distributed, which is rich in organic matter, and normal faults would be distributed associated with rifting activities of back-arc basin, which would play a role as a pathway of methane from deep layers to surface layers of sediments. In these areas, methane would be released from the seafloor as mud volcanoes, cold seeps, or pock marks. Depending on a scale or numbers, the methane sources can play a role a source of methane to the atmosphere. We will investigate methane distribution in the seawater and observe the seafloor by submersibles, and clarify the details of methane releasing phenomenon.

Keywords: seawater, methane, East China Sea, mud volcano