Origins of water and methane in submarine mud volcanoes off Tanegashima

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Submarine mud volcanoes occur along the margins of convergent plates and are formed by the vertical intrusion of low density, deformable sediments from the deep subsurface to the seafloor. Several mud volcanoes have been found at off Tanegashima Island along the northern Ryukyu Trench. Since 2012, we performed an intensive topographic survey of submarine mud-volcanic structures off Tanegashima Island and observed clear mud-flow channels suggestive of the recent mud-volcanic activities at MV#1 (30°53´N, 131°46´E; water depth: 1540 m) and MV#14 (30°11´N, 131°23´E; water depth: 1700 m) based on the side scan sonar image. During the KH-15-2 cruise in 2015, we obtained two sediment cores from the summit of MV#1 (core length: 361 cm) and MV#14 (core length: 311 cm) using a Navigable Sampling System (NSS).
At the MV#1, the chloride (Cl^-) concentration linearly decreased from 550 mM near the sediment surface to 220 mM at 250 cmbsf. Below 248 cm to core bottom, the concentration was constant at ~220 mM. The stable isotopic compositions of pore waters exhibit ^{18}O-enriched and D-depleted isotopic values in proportion to the depletion of the Cl^- concentration, indicating the addition of water from the dehydration of clay minerals that typically occur in the temperature range from 60℃ to 160℃. Generally low concentration ratios of methane to ethane (C_1/C_2: ~ 30) and the stable carbon and hydrogen isotopic compositions of methane ($\delta^{13}C$: ~ −45‰; δD: ~ −120‰) consistently indicate that the hydrocarbon gases are derived from thermal decompositions of organic matter in deep sediments where the *in situ* temperature is >80℃. In contrast to the MV#1, at the MV#14, the Cl^- concentration only slightly decreased from 556 mM near the sediment surface to 490 mM at core bottom, indicating slow fluid advection. This sugggests that the activity of MV#14 is lower than the MV#1. The C_1/C_2 ratios were high as 700-4000, and $\delta^{13}C$ and δD values of methane were −75‰ and −150‰, respectively. These data strongly indicate that most methane is microbially produced via hydrogenotrophic methanogenesis.

Keywords: dehydration from clay mineral, methane, off Tanegashima

