Estimated activities of submarine mud volcanoes off Tanegashima based on vertical profiles of pore water chemistry

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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°C to 160°C. 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 indicates that the activity of MV#14 is lower than the MV#1. However, the data of stable isotopic compositions of pore water and Cl^- concentrations from MV#1 and MV#14 show same trends, indicating that the end members of fluids derived by clay mineral dehydration are same.
We tried the quantitative evaluation of the difference in the vertical profiles of Cl^- concentrations between MV#1 and MV#14 by using the one-dimensional unsteady advective diffusion model. As the initial state of the Cl^- profile just after the mud eruption, we assumed that the Cl^- concentration in the core bottom at MV#1 represents the original value of the deep sourced fluid, and the Cl^- concentrations were constant from deep to surface immediately after the eruption. We estimated the advection rates of fluids and times after the mud eruption by fitting the numerically simulated depth profiles of Cl^- concentrations to the observed depth profiles. As the result, advection rate and the time after the eruption at MV#1 were calculated to be 10–15 mm/y and 100–200 years, respectively, and those at MV#14 were estimated to be <0.1 mm/y and 8,000–10,000 years, respectively. The preliminary result of the nannofossils observation shows that the Quaternary and the Tertiary species mixed in the sediment sample obtained from MV#14 in which the Quaternary species are dominant in top 50 cm. The nannofossils records suggest that the hemi-pelagic Quaternary sediments have covered on the deep sourced Tertiary sediments which were conveyed to the sea surface from deep sedimentary realm by the mud eruption. The result is consistent with our estimation for the activity of MV#14 based on the Cl^- profile.

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