Discharging flux of deep-sourced fluid from submarine mud volcanoes off Tanegashima

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Submarine mud volcanoes are small hills in which sediments with high pore fluid pressure migrate upward as mud diapir and vent out the seafloor. Mud volcanoes have been found around plate convergence or thick sediments areas in the world. Around Japan, these have been found in a fore-arc basin off Tanegashima and Kumano Basin in the Nankai Trough. The existence of fifteen mud volcanoes off Tanegashima, the field of this study has been discovered. From two volcanoes, the chemical and isotopic compositions of pore fluid collected was investigated in this study. The purpose of this study is to determine the original temperature, the origin of the fluid, and the advective velocity. We evaluated them by comparing with the data of other Tanegashima mud volcanoes in the previous study.
From September 9 to 18, 2019, surface sediments (<5 m length) were collected from two submarine mud volcanoes (MV2 and MV3) off Tanegashima Island using *R/V Hakuho-Maru*. Pore fluid was extracted from the collected sediment, and the pH and NH_4^+ concentration were measured on board. On land, anions, cations, $\delta^{18}O_{H2O}$ and δD_{H2O} were measured.
In the sampled pore fluid profiles, the Cl^- concentration of each mud volcano decreased as the depth increased. The concentration of SO_4^{2-} was similar to that of seawater just below the seafloor, but decreased significantly to about 1 mM around 60 cmbsf. Li concentration was much higher than that of seawater at all mud volcanoes. B concentration at MV2 was higher than seawater, but at MV3 it was about the same as or slightly higher than seawater. At MV2, $\delta^{18}O_{H2O}$ was higher than seawater, and δD_{H2O} was lower than seawater.
The reason why the concentration of chemically stable Cl^- is lower than that of seawater is that a fluid having a low Cl^- concentration migrates from deep below the seafloor. The remarkable decrease of SO_4^{2-} concentration suggests that the anaerobic methane oxidation could have caused sulfate reduction. Applying the advection-diffusion equation to the change in Cl^-concentration, the advection velocity of fluid was estimated to be 1 cm/yr for MV1, 5 cm/yr for MV2, 21 cm/yr for MV3, and 2 cm/yr for MV14. In regard to the isotope ratio of fluid, the $\delta^{18}O_{H2O}$ value is higher than that of seawater and the δD_{H2O} value is lower than that of seawater; suggesting that it would be affected by the fluid originating from the dehydration of clay minerals. The higher B and Li concentrations than in seawater would also be due to the release of B and Li inside the clay mineral due to clay mineral dehydration. The origin temperature of fluid was estimated using a geothermometer with Na and Li concentrations, and the origin depth was estimated from the obtained temperature and the geothermal gradient of the seabed off Tanegashima. The origin temperature is estimated to be 235±17 ℃ for MV1, 310 ±3 ℃ for MV2, 313±3 ℃ for MV3, and 119±53 ℃ for MV14. The origin depth is 4.0±0.3 km for MV1, 5.2±0.1 km for MV2, 5.2±0.1 km for MV3, and 2.0±0.9 km for MV14. These differences could be due to differences in the activity of mud volcanoes. A tendency was found to be inversely related to the activity, comparing the size of the mountain. This suggests that currently active mud volcanoes are in the growth phase, while large mud volcanoes are currently in a period of stagnation. The entire fluid flux from the submarine mud volcanoes off Tanegashima is comparable to *ca.* 20-40% of the fluid supplied from the subducting plate to the lower part of the accretionary prism. Compared with the Kumano mud volcanoes existing in the Nankai Trough and mud volcanoes in Taiwan, the ratio is relatively large.
In this study, it is clarified that submarine mud volcanoes off Tanegashima have a variation in the term of

the origin depth, flux, size for each volcano. The estimation of fluid fluxes from mud volcanoes indicates that mud volcanoes off Tanegashima serve as a relatively major pathway to drain fluid below the accretionary complex.

Keywords: mud volcano, off Tanegasima, deep-sourced fluid, discharging flux

