Distribution of hydrothermal plumes around the seamounts in Ryukyu arc and microbial chemoautotrophic activities within the plumes

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High temperature hydrothermal fluids emitted from seafloor vents are less dense than the surrounding bottom sea water, and form buoyant plumes that rise rapidly, entraining ambient water, until neutral buoyancy is achieved. They then spread out laterally along constant density surfaces to form lateral plumes. Throughout the processes of ascending and subsequent lateral advection away from the area of the source, hydrothermal fluids entrain large quantities of ambient seawater so that most of the hydrothermal derived chemical anomalies are diluted and the plume waters become indistinguishable from ambient seawater. Even the effluent hydrothermal plumes, however, contain several orders of magnitude higher concentrations of some components, especially reduced chemicals, such as methane, hydrogen, hydrogen sulfide, and manganese, than the surrounding ambient sea water, because of their extreme enrichment in seafloor venting hydrothermal fluids. Elevated numbers of microbes have also been detected in hydrothermal plumes, apparently because the reduced chemicals support their growth. Such microbial chemoautotrophic activities may play an important role in organic carbon production in deep oceans or may occasionally enhance zooplankton aggregation around a plume. Besides, microbes in hydrothermal plumes are also likely to be very important for tracing thermophile or hyperthermophile microbes that might live under the seafloor and have been released into the ocean. Our present understanding for the microbial chemoautotrophic activities within hydrothermal plume, however, is far from neither qualitative nor quantitative.

The Ryukyu volcanic arc is located on the eastern margin of the Eurasian plate where the Philippine Sea plate is subducting. Related to the subduction and lithospheric dislocation caused by Eurasian plate dynamics, a number of northeast-southwest direction back-arc rifts including the nascent Okinawa Trough are formed in the western (back-arc) part of the arc. Past seafloor surveys using submersibles etc. have located high temperature hydrothermal sites on the seamounts in the Ryukyu arc, such as Minami-Ensei Knoll, Clam site, Jade site, Iheya Ridge North Knoll, Hatoma Knoll, and No. 4 Yonaguni Knoll. All the studied high temperature hydrothermal fluid from the seamounts exhibit enormous methane enrichment more than mmol/kg, reflecting significant methane contribution from surrounding organic-rich sediments supplied from the Eurasian continent. Such methane enrichment in the source fluid of hyrothermal plumes suggest us that microbial activities might be active in the plumes. Besides to those seamounts where extensive seafloor surveys had done in past, however, much more volcanic-like seamounts are located on the Ryukyu arc.

During KT05-26 cruise of Tansei-maru (JAMSTEC) on 17-26 Oct., 2005, effluent hydrothermal plumes are investigated using geochemical and microbial tracers in the water column around 20 seamounts in Ryukyu arc, including the 7 seamounts (Minami-Ensei Knoll, Clam site, Iheya Ridge North Knoll, Irabu Knoll Corn, Irabu Knoll Caldera, and Kuroshima Knoll), in which seafloor hydrothermal/gas-venting sites had been located. Vertical hydrocasts were done for every 10-20 layers at 26 stations using CMS, together with in-situ monitoring system using the sensors such as CTD, optical backscatter, Eh, and GAMOS.

Based on the distribution of methane, Eh, and light attenuation anomalies in the water column around the studied seamounts, we found plume emissions from 10 seamounts, including both all the 7 seamounts in which hydrothermal sites had been already located in past studies, and 3 seamounts in which no seafloor surveys had done. Besides, we detected the evidence for rapid microbial consumption of methane in the plumes, based on the carbon isotopic compositions of methane. We conclude that the methane enrichment in seafloor venting fluids result in active microbial methane oxidation in the plumes.