沖縄トラフ伊是名海穴における海底熱水系の数値モデリング
Numerical modeling of seafloor hydrothermal system in the Izena Caldron, Okinawa Trough

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Regional heat flow measurements in the Izena Caldron and detailed heat flow measurements in the Jade hydrothermal field situated on the NE slope of the Izena Caldron were conducted by Kinoshita et al. (1997). They clarified that an enormous heat flow variation (10^{-1} to 10^{2}W/m^{2}) in the Jade site. In addition, near the Jade black smoker, the heat flow varies from >30W/m^{2} at a hydrothermally altered area to 1.7W/m² within 100m distance from it. From large-scale heat flow measurements, 500m-wide rectangular zone (hereinafter called "Corridor") with high heat flow (>1W/m^{2}) along the NE suggests the existence of linear heat source under the Corridor. In the research cruise of CK16-05, drilling and temperature measurements using Thermo Label were conducted in the Hakurei site, hydrothermal area of southern part in the Izena Caldron, and high temperature over 290℃ was measured at C9026. Although many heat flow data were obtained in the Izena Caldron, no heat flow data was obtained in the Hakurei site. Therefore, in this study, we conducted dense heat flow survey at 11 points with 550m measurement length and 50m measurement interval along EW direction in the Hakurei site in the research cruise of KM18-08C in September 2018. Moreover, we conducted a numerical simulation of multi-phase fluid flow using TOUGH2 to reveal distribution of physical properties and hydrothermal fluid flow pattern in the seafloor hydrothermal systems in a back-arc basin.
Heat flow value is calculated as the product of temperature gradient and thermal conductivity. In this study, we obtained temperature gradient values on the seafloor using a stand-alone heat flow (SAHF) meter operated by ROV. In the simulation, the size of study area was defined as 4.8×5.6×1.7 km and the seafloor was set as the top boundary where the temperature and pressure were fixed at 4 ℃ and hydrostatic condition, respectively. As the initial condition, we assigned the hydrostatic pressure, the average thermal gradient 0.16 ℃/m around the Izena Cauldron except for the hydrothermal area, and physical rock properties by referring to the borehole data. The values of discharge rate, mass in rate, and permeability (*k*) were adjusted appropriately through trial and error. As the geologic settings, we set conduits with $k = 1.0\times10^{-13}$m^{2} under the discharge area of Jade and Hakurei sites and fault with k=3.0×10^{-14}m^{2} under the Corridor along the vertical direction from bottom to surface, to realize the vertical flow of hydrothermal fluids from the deep part. In addition, caprock with k= 1.0×10^{-16}m^{2} was located near the surface to generate the lateral hydrothermal fluid flow. Other places were set as volcanic rock with k= 1.0×10^{-14}m^{2}. Under these conditions, we simulated a natural state condition.
From heat flow measurements, we clarified very high heat flow (76W/m^{2}) at a 150m west site covered by mud from C9027, which suggests an existence of hydrothermal fluid flow beneath the seafloor at shallow part. In other places, the heat flow was varied from 3 to 12W/m^{2}. Through the simulation, a plausible large-scale temperature distribution and flow pattern were obtained. In terms of heat flow, by comparing the calculated and measured values along the Corridor and Hakurei site, the calculated values were conformed to correspond well with the measured values. According to the sensitivity analysis, the importance of caprock and conduit in the seafloor hydrothermal system was revealed. By a model without the conduit, the hydrothermal fluids did not ascend to the seafloor along the vertical direction and the

tendency of measured heat flux could not be reproduced. Furthermore, by a model without caprock, heat cannot be preserved because it flows in all directions and the calculated heat flux did not accord with the observed flux. Consequently, the location and physical properties of the conduit and caprock were identified as the critical control factors on the accuracy of hydrothermal fluid flow simulation.

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