

Sulfur Systematics in the Izena Hole Seafloor Hydrothermal Systems, Okinawa Trough: Stable Isotope, Mineralogy and Redox Equilibria

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Understanding of sulfur sources in seafloor hydrothermal systems is essential for the discussion of formation mechanisms of seafloor hydrothermal deposits. Sulfur sources in the Okinawa Trough seafloor hydrothermal systems, however, have been poorly discussed, because hemipelagic sediments cover makes the fluid-sediment interaction complicate compared with the sediment-starved hydrothermal systems. The Izena Hole in the mid-Okinawa Trough (27°15'N, 127°04'E, ~1500m in depth) has two active hydrothermal fields: thinly sedimented JADE-site and thickly sedimented HAKUREI-site. Comparing geochemical characteristics between these two sites enables us to evaluate the effect of fluid-sediment interaction (Kawagucci et al., 2010; Ishibashi et al., 2014). This study aimed to elucidate the sulfur sources and sulfur isotopic systematics in the Izena Hole by comparing the hydrothermal precipitates in JADE and HAKUREI-sites in terms of mineral assemblage, chemical composition and sulfur and oxygen isotope.

The active chimneys in JADE-site have Kuroko-type sulfide mineral assemblage including Fe-poor sphalerite, tennantite, galena, pyrite and chalcopyrite. In contrast, the active chimneys in HAKUREI-site are mainly composed of euhedral pyrrhotite, Fe-rich sphalerite, galena and isocubanite with chalcopyrite lamellae, in which mineralogical characteristics resemble those of sediment-covered Guaymas Basin and Middle Valley rather than JADE-site.

It is possible to calculate f_{O_2} - f_{S_2} conditions of hydrothermal fluids around 300°C using appropriate thermodynamic data and compare them with mineralogically estimated redox conditions in f_{O_2} - f_{S_2} diagram of Fe-Cu-S systems. The calculated redox conditions are in accord well with those based on mineral assemblages and Fe% in sphalerites in both JADE and HAKUREI-sites. In contrast to JADE-site with higher f_{O_2} - f_{S_2} comparable with sediment-starved PACMANUS, HAKUREI-site indicates lower f_{O_2} - f_{S_2} corresponding to Guaymas Basin and Middle Valley. Therefore, HAKUREI-site is in relatively reducing hydrothermal environment because of organic matter decompositions in the sediment layer, whereas, the thin sediment layer in JADE-site does not affect the redox state of the hydrothermal field.

The $\delta^{34}S$ values of chimney sulfides 1.8-4.2‰ in HAKUREI-site is lower than those (5.1-6.7‰) in JADE-site. That is not attributed to sulfur isotope equilibrium between seawater sulfate and hydrothermal H_2S , because $\delta^{18}O$ values of barite and anhydrite show oxygen isotopic disequilibrium with hydrothermal H_2O at the fluid venting temperature and sulfur isotope exchange reaction rate is much slower than oxygen isotope exchange rate. In addition, relatively high $\delta^{34}S$ and f_{S_2} state in JADE-site cannot be accounted by leached H_2S from sulfur-poor island-arc volcanic rocks, suggesting the presence of another sulfur source.

Although magmatic degassing SO_2 contribution has been reported in some island-arc and back-arc seafloor hydrothermal systems, no sign of magmatic SO_2 degassing has been found in the Izena Hole despite the large magmatic CO_2 contributions. Assuming SO_2 - H_2S gas equilibrium and hematite-magnetite buffer, most of degassed SO_2 are predicted to be converted into H_2S at equilibrium temperature <400°C, producing H_2S with relatively high $\delta^{34}S$ of island-arc melt signature. The HAKUREI-site sulfides with lower $\delta^{34}S$ would be caused by contributions of isotopically light H_2S generated by bacterial activities in the sediment layer or by contributions of low $\delta^{34}S$ H_2S produced by hydrolysis with larger SO_2 proportion at higher equilibrium temperature

in HAKUREI-site than in JADE-site.

Keywords: Izena Hole seafloor hydrothermal systems, Okinawa Trough, sulfur isotope, redox conditions, mineral assemblage