

Microbial sulfate reduction within the Iheya North subseafloor hydrothermal system constrained by quadruple sulfur isoto

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Sulfate reduction may be one of the dominant microbial metabolisms among the subseafloor ecosystem. In order to demonstrate and quantify the potential sulfate reducing activity, we analyzed sulfur isotopes ($^{32}\text{S}/^{33}\text{S}/^{34}\text{S}/^{36}\text{S}$) of pore water sulfate extracted from core samples and mineralized sulfide at the Iheya North hydrothermal system in the Okinawa drilled by CHIKYU, 2009 (IODP Leg 331). Based on pore water chemistry and temperature profile, the subseafloor environment is divided into Unit-1, -2 and -3 from top to bottom. In the Unit-1, fresh seawater is circulated, whereas in Unit-3, hot hydrothermal fluid ($>300^\circ\text{C}$) is stored below anhydrite cap rock. The Unit-2 is a mixing zone between the hydrothermal fluid and seawater. We found that the $\delta^{34}\text{S}$ value of sulfate in the Unit-2 was higher than those expected by simple mixing between seawater sulfate and the hydrothermal component. The observed ^{34}S -enrichment and decreased sulfate concentration suggest sulfate reduction took place in this hydrothermal system. Based on our model calculation, apparent isotope effect $\epsilon_{34\text{e}}$ is estimated to be -32.2 permil. The large fractionations together with slight D^{33}S enrichment and D^{36}S depletion all suggest that the sulfate reduction is not thermochemical process but microbial reduction with high reaction rate. Our numerical simulation indicates that the sulfate is reduced probably within the recharge zone of seawater before mixing with high temperature fluid. Additionally, we estimate the contribution of microbial sulfate reduction from mineralized sulfide. In spite of sulfide dominantly deposited from hydrothermal fluid, deep (>16 m) sulfide sulfur shows characteristic isotopic composition suggesting incorporation of microbial sulfide, roughly $\sim 50\%$. Consequently, rapid seawater circulation in the Iheya North hydrothermal system may support active microbial sulfate reduction below the seafloor.