

Transformation of ore minerals and their geochemical signatures in submarine hydrothermal ore deposits in Izena Hole, Okinawa Trough

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It is important for exploration and development of submarine hydrothermal ore deposits to understand zoning of ore bodies and their mineral assemblages, particularly with depth from the seafloor. Transformation of ore minerals via dissolution and re-precipitation may cause such a zoning corresponding to the evolution of a hydrothermal system because geochemical conditions may then vary with the depth from the seafloor. In this study, we aimed (1) to clarify the mineral assemblage changes with increasing depth of a mound sulfide deposit by microscopic observations and SEM-EDS analyses, (2) to understand geochemical evolution of hydrothermal fluids based on Fe contents in sphalerite determined by EPMA, and (3) to understand the formation processes of Fe sulfides by analyzing Fe isotopic composition of the bulk samples with MC-ICP-MS. The samples used for the analyses were obtained from Site C9027, which drilled up to 72.5 meter below seafloor (mbsf) through a mound sulfide deposit in Hakurei site, Izena Hole, middle Okinawa Trough during the CK16-05 cruise operated from November to December, 2016 under the SIP program.

Results of microscopic observations show that sphalerite and galena are comparatively dominant with minor occurrence of pyrrhotite and anglesite in the samples at shallow depths. In contrast, samples from middle and deep depths are more abundant on pyrite and chalcopyrite, and pyrite, respectively. The texture that pyrrhotite was dissolved and replaced by pyrite or marcasite was observed in the samples in the depth of 0.05 – 44.0 mbsf. The Fe content in sphalerite tends to decrease with increasing depth, and also change within single sphalerite grain. These results suggest that hydrothermal fluid geochemistry such as fugacity of S₂ and O₂, and temperature changes for the depth and time. The $\delta^{56}\text{Fe}$ values ($\delta^{56}\text{Fe}$ (‰) = 1000 * [(⁵⁶Fe/⁵⁴Fe)_{sample} / (⁵⁶Fe/⁵⁴Fe)_{IRMM-014} - 1]) of the bulk samples range from -0.62 to +0.11‰, which tends to increase toward the deeper part. This indicates that Fe sulfides at shallow depths was formed by non-equilibrium precipitation with a rapid cooling, which caused a kinetic isotope effect. In contrast, those at deeper depths were likely formed near the equilibrium conditions.

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