Hydrothermal ore deposits at on- and off-axial sites of backarc spreading in the southern Mariana Trough

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In the southern Mariana Trough, the arc front is considered to be located close to the backarc spreading center. Four active hydrothermal fields have been located around 13N spreading axis. Snail site (12_57.2'N, 143_37.2'E, depth = 2880 m) and Y site (12_57.6'N, 143_36.7'E, depth = 2830 m) are located on the crest of the backarc-spreading ridge (on-axis). Pika site (12_55.1'N, 143_38.9'E, depth = 2830 m) is on the top of an off-axial volcano 5 km far from the spreading axis and Archaean site (12_56.35'N, 143_38.0'E, depth = 2990 m) lies on flank of the spreading ridge that is about 2 km far from the axis. Linear alignment of the hydrothermal activities at Snail, Archaean and Pika sites, which is almost perpendicular to the arc front, may be related to a structural lineament. During dive programs TN167A in 2004 using ROV ROPOS (CSSF) & R/V Thomas G. Thompson, and YK03-09 in 2003 and YK05-09 in 2005 using submersible SHINKAI6500 (JAMSTEC) & R/V Yokosuka, we extensively collected sulfide and sulfate ore samples. In addition, sulfide samples were provided by a shallow drilling conducted in 2004 using BMS (Kakegawa et al., 2008).

Mineralogy of the ore samples showed some diversity reflecting intensity of the hydrothermal activities and the tectonic setting. Hydrothermal activities at Pika and Archaean sites were associated with vigorous venting of high temperature fluid and large mound formation of sulfide ore deposits. The sulfides were composed from pyrite, marcasite, sphalerite, and lesser amount of chalcopyrite. Barite occurred only in the outermost part of chimney structures, while chalcopyrite is found only at the inner part. Massive sulfide rubbles were predominated by cryptocrystalline pyrite and marcasite. In the drill core samples, only pyrite was identified. On the other hand, activities at Snail and Y sites were represented by moderate to low temperature fluid shimmering. As mineral assemblage of sulfides, marcasite, sphaleraite and pyrite were common. Chalcopyrite was found rarely, while galena was sometimes identified as minor occurrence. Sometimes, the outermost zone was composed of fine-grained barite with little sulfides.

These sulfides showed different sulfur isotopic compositions according to location; from +6.8 to 8.4 per mill at Snail site, from +6.0 to 7.4 per mill at Y site, from +3.6 to 6.9 per mill at Archaean site, and from +0.8 to 3.5 per mill at Pika site. While so called mantle sulfur range was found at the off-axis sites, ^{34}S-rich signature was found at the on-axis sites. This trend is seemingly discordant with the tectonic setting, however, accordance with previous petrologic studies which suggest involvement of subducted material into a magma beneath the spreading center. Occurrence of galena (PbS) is also attributed to involvement of incompatible elements into the magma.

In a preliminary study, we dated the ore samples using disequilibrium of isotopes in the U and Th decay chains. Active chimney samples from Archaean and Pika sites yielded ages less than 2 years according to disequilibrium between ^{228}Th and ^{228}Ra. The inactive chimney and massive sulfide rubbles collected from Archaean site were determined as 35-120 years, which was similar to the result of the massive sulfide from Pika site. Age of the drilled sulfide samples was estimated as longer than 35 years. Sulfide deposition up to 5 meters thick was considered as rapid relative to 1600 years (half-life of ^{226}Ra), on assuming that no Th (the parent of ^{226}Ra) had not been included during the precipitation. The inactive chimney sample collected from Y site also yielded an age of 35-120 years, whereas the crustal sulfide samples from Snail site yielded ages around 10 years according to disequilibrium between ^{228}Th and ^{228}Ra.