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U-Th dating of sulfide minerals from a hydrothermal vent -comparisons with other dating methods-

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The time scale for hydrothermal activity is an important factor controlling the size of hydrothermal ore deposits and the evolution of chemosynthesis-based communities in a submarine hydrothermal system. Radioactive isotopes with short half lives such as ^{210}Pb have been mainly used for dating of sulfide minerals in seafloor hydrothermal systems. Lalou et al. (1985) obtained young ^{210}Pb-Pb ages (<100a) for sulfide minerals from axial ridge of East Pacific Rise (12°N 50') where the spreading rate is large. However, they could not detect ^{230}Th for the minerals with alpha spectroscopy. ^{234}U-^{230}Th ages were successfully obtained for sulfide minerals from TAG area on the slow spreading mid-Atlantic Ridge using a thermal ionization mass spectrometry (TIMS). We applied ^{234}U-^{230}Th radioactive disequilibrium dating to sulfide minerals from a sulfide crust collected in South Mariana Trough where spreading is fast with the use of MC-ICP-MS. We also compared the ^{234}U-^{230}Th ages of sulfide minerals with ESR and ^{226}Ra-^{210}Pb ages of barite from the same sulfide crust. A slice of the crust which was further cut into 13 pieces were used this study.

^{234}U-^{230}Th and ESR methods yielded age of 0.27 ~ 2.2 ka. Two ages are consistent in most of samples. The crust also showed continuous ^{234}U-^{230}Th ages which suggest continuous growth. Noguchi et al. (2011) applied ^{226}Ra-^{210}Pb dating to barite from the same crust and reported young (30-40 years) ages. The different ages of ^{226}Ra-^{210}Pb system may have been caused from continuous growth of the sulfide crust. Here we assume a volumetrically continuous growth model of a sulfide crust to examine the behaviors of ^{234}U-^{230}Th and ^{226}Ra-^{210}Pb pairs. When each part of the sulfide crust precipitates, it contains ^{234}U and ^{226}Ra but no ^{230}Th and ^{210}Pb. The precipitated part is kept as a closed system. After the continuous growth for 2,000 a, the crust with a mean age of 1,000 a is sampled for analysis. If all part of the sulfide crust mixed thoroughly, ^{234}U-^{230}Th system yields 997 a, while ^{226}Ra-^{210}Pb system yields 84.9 a. The result of the calculation demonstrates that ages based on a shorter-lived radioactive isotope are biased by younger material addition. The discordant ages found between the ^{234}U-^{230}Th and ESR ages obtained in this study and ^{226}Ra-^{210}Pb ages reported by Noguchi et al. (2011) could be caused by continuous growth of the sulfide crust. The similar disconcordant ages were reported for opals precipitated from ground water (Neymark et al., 2000).

Our results demonstrated that sulfide deposits of a $>$ 10 cm thickness can record the evolutional history of hydrothermal activity of $>$ 1 ka. The application of MC-ICP-MS allowed improved geochronological resolution of U-Th disequilibrium ages and has lowered the required sample amount to less than 2 g.

Keywords: hydrothermal vent, U-Th radioactive disequilibrium dating, ESR dating, inconsistent age