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ESR dating of barite in sea-floor hydrothermal sulfide deposits

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The temporal change of submarine hydrothermal activities has been an important issue in the aspect of the evolution of hydrothermal systems which is related with ore formation (Urabe, 1995) and biological systems sustained by the chemical species arising from hydrothermal activities (Macdonald et al., 1980). Dating methods using disequilibrium between radioisotopes such as U-Th method (e.g. You and Bickle, 1998), 226Ra-210Pb and 228Ra-228Th method (e.g. Noguchi et al., 2011) have been employed for such studies.

Okumura et al., (2010) made the first practical application of ESR (electron spin resonance) dating technique to a sample of submarine hydrothermal barite to obtain preliminary ages, while Kasuya et al. (1991) first pointed out that barite can be used for ESR dating. Toyoda et al. (2011) determined the optimum ESR condition while Sato et al. (2011) confirmed that the signal is thermally stable enough for an age range of several thousand years. Takamasa et al. (in press) obtained U-Th and ESR ages which are roughly consistent with each other.

The samples were taken by NT11-20 and NT12-06 research cruises operated by JAMSTEC. Barite (BaSO4) was extracted from hydrothermal chimney samples (HPD#1331G01,HPD#1331G03, and HPD#1333G06) taken from two site at Okinawa Trough. Blocks of sulfide deposits were cut into pieces, and about 2.0g was crushed. The samples were soaked in 12M hydrochloric acid, left for approximately 24 hours. Then, 13M nitric acid was added. Finally, after rinsing in distilled water, the sample was filtered and dried. Impurities were removed by handpicking. An X-ray diffraction study was made to confirm that the grains are pure barite. After gamma-ray irradiation at Takasaki Advanced Radiation Research Institute, Japan Atomic Energy Agency, they were measured at room temperature with an ESR spectrometer (JES-PX2300) with a microwave power of 1mW, and the magnetic field modulation amplitude of 0.1mT. The bulk Ra concentration was measured by the low background pure Ge gamma ray spectrometer. Assuming that Ra is populated only in barite, the dose rate was calculated with the alpha effectiveness of 0.043 (Toyoda et al., 2012), where the decay of Ra (a half life of 1600 years) was also taken into account.

The ages of the pieces of HPD#1331G01 (Hatoma Knoll) were obtained to be 2600 to 4000 years, where outer pieces tend to be older. The ages of HPD#1331G03 are older to a direction, from 2.2 ka to 10 ka (Hatoma Knoll). HPD#1331G06 (Yoron Knoll) showed much younger ages around 100 years where they are older to a direction.

The results, the ages of the Hatoma Knoll is older than the Hatoma Knoll, are consistent with the landscape observation from the submarine vehicle, which gave such impression such as by number of dead chimneys and amount of sediments on the sulfide deposits, and with the diversity of the creatures inhabiting in the area.

Keywords: barite, hydrothermal activities, electron spin resonance, dating