ESR dating of barite of marine hydrothermal vents

Shin Toyoda[1]; Gouta Kikuchi[1]; Junichiro Ishibashi[2]; Ryohei Suzuki[3]

[1] Dept. Appl. Phys., Okayama Univ. Sci.; [2] Earth & Planet. Sci., Kyushu Univ.; [3] Earth and Planetary Sci., Graduate School of Sci., Kyushu Univ.

At the beginning of the discovery of the hydrothermal systems in the sea, their timescales were not of interest. The timescale became one of the issues when some huge hydrothermal plumes were found as well as volcanic activities at the sea bottom and sudden changes of the hydrothermal activities. The long term change of the hydrothermal activities also became of interest in the aspect of ore formations. However, no systematic geochronological studies of the hydrothermal system at the sea bottom are possible so far due to lack of the methods to cover all the age ranges of interest. Recently, water flows below the sea bottom related with the hydrothermal activities have been subjects of the scientific studies to investigate not only the transfer of the elements from the magma to the sea water but also the biological systems sustained by the chemical species in those water flows. Barite ($BaSO_4$) is one of the minerals possibly useful for such long term geochronological investigations as it is stable in the sea water.

It was pointed out by Kasuya et al. (1991) that barite is possibly one of the minerals useful for electron spin resonance (ESR) dating. However, no practical dating studies have been done so far. In the present paper, we used barite hand picked from portion taken at the basal part of a hydrothermal chimney at the Tiger mound in Yonaguni Knoll IV hydrothermal vent field. The sample was taken at the time of the dive, YK04-05 by Shinkai 6500 performed by JAMSTEC. The details of the sample such as occurrence are reported by Suzuki et al. (2008). The hand picked mineral grains were examined by X-ray diffraction to see no peaks were observed other than those of barite.

ESR measurements were done at room temperature by JEOL PX-2300 at Okayama University of Science with a microwave power of 1 mW, the modulation frequency of 100 kHz, and modulation amplitude of 0.1 mT. A signal was observed with g values close to those reported by Kasuya et al. (1991) to be due to SO3-. The signal intensity was enhanced by gamma ray irradiation so that the accumulated natural dose of 441 Gy was obtained by extrapolating the saturating exponential curve to the zero ordinate, fitted to the dose response of the signal intensities. The concentrations of uranium, thorium and potassium (K_2O) were obtained to be 3860 ppm, 91 ppm, and 0.24 %, respectively, by the low background pure germanium gamma ray spectrometry. The natural dose rate was calculated from those concentrations assuming that the sample was on the sea floor, therefore, a geometry factor of 0.5 was multiplied to the gamma ray dose rate. The age of the sample was obtained to be 260 years old by dividing the accumulated dose by the dose rate of 1680 mGy/y.

Barite was shown by the present study to be a useful mineral for dating underwater geothermal activities. However, there are many issues for this method to be established, such as detailed identification of the ESR signal, the geological validity of the obtained age, occurrence of the mineral and the chimney in the order of cm to mm for the precise determination of the dose rate, the efficiency of the defect formation by the alpha particles (0.1 was assumed in the present study).

References

Kasuya, M., Kato, M., and Ikeya, M. (1991) ESR signals of natural barite ($BaSO_4$) crystals: Possible application to geochronology. Essays in Geology, Professor Hisao Nakagawa Commemorative Volume, 95-98.

Suzuki, R., Ishibashi, J., Nakaseama, M., Konnno, U., Tsunogai, U., Gena, K., and Chiba, H. (2008) Diverse Range of mineralization induced by phase separation of hydrothermal fluid: case study of the Yonaguni Knoll IV hydrothermal field in the Okinawa Trough back-arc basin, Resource Geology, 58, 267-288.