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Effects of physical aging degradation on OSL properties of quartz

OSADA, Akira[1*] ; YAMANAKA, Chihiro[1] ; TAKADA, Masashi[2]

[1]Department of Earth and Space Science, Osaka University, [2]Department of History, Sociology and Geography, Faculty of Letters, Nara Women's University

Optically stimulated luminescence (OSL) using radiation-induced centers has been used for the dating of Quaternary samples. Although the principle is quite similar to that of ESR dating, clear difference exists between them. In OSL dating, luminescence centers easily bleached by light are investigated. Therefore, OSL is used to determine buried ages of samples after resetting OSL signal by exposure to the sunlight. In ESR dating, on the other hand, radiation centers with unpaired electrons are considered. For the ESR centers, usual light bleaching does not affect much but thermal annealing at several hundreds degree in Celsius affects to the centers in spite of higher stimulating energy of photon than temperature.

Usually, intensity of OSL from a natural sample shows sample-dependence between particles or aliquots. Therefore, a signal regenerating method for the same sample is widely used, which means repeated OSL measurements to the same sample with giving a different dose of γ or β irradiation. Such sample dependence would be attributed to the imperceptible difference of impurities or defects of crystals, but are not fully understood. It is known that quartz from old sediment or from a geological fault shows an intense OSL and specifically shows a quick response for weaker stimulating light known as 'the fast component' of OSL. However, quartz from igneous rocks does not show such fast component OSL[1]. Considering these facts, we can assume weathering of materials causes such enhancement of OSL sensitivity.

In this study, we have performed mechanical crushing and α-irradiation on quartz of reagent grade in order to simulate the effects of weathering on the OSL properties. Quartz powder with the grain size of 149-250 μm obtained after the ball-mill operation of 0.5 to 2 hours were used for OSL measurements. Also, α-irradiation at 1.3, 5.5, and 63kGy for powdered quartz was performed at the energy of 1.8MeV. OSL was measured with Risø TL/OSL reader DA-20 at β-irradiation of 50 Gy.

Also, we have performed annealing on quartz samples from Ayers Rock and Thar Desert for the purpose of knowing OSL characteristic of natural samples that are sensitive, and reagent quartz doped 0.01mol% lithium in addition to the above reagent samples. These samples were annealed 300∼800 ℃ for an hour in steps of 100 ℃.

As a result, the OSL intensity increased with the crushing time. It is considerable that mechanical crushing leads the precursors of OSL centers, although we did not observe the fast component of OSL through this experiment. It is interesting that the α-irradiated quartz samples indicated crucially higher intensity. Considering the range of α-particles, defects near the surface of sample should contribute to the increase of the OSL Intensity.

Reagent samples that annealed from 500 ℃ to 800 ℃ showed an increase of OSL intensity up to ten times of non-annealed samples, and the trend is more remarkable for ball-milled and α-ray irradiated samples. However, the reagent sample doped with lithium showed a decrease of OSL intensity. The Ayers Rock sample didn't showed any clear change of OSL intensity, but Thar-Desert sample showed twenty times of increase of OSL intensity. In addition, we have observed five times of increase for natural samples in the fraction of the fast component to the total intensity. These results indicate that the electrons that are detrapped by annealing are strongly related to OSL mechanism, and the thermal stability is different among the centers related to the fast component, the slow component and the centers that quench OSL.

Reference

[1]Tokuyasu K., Tanaka K., Tsukamoto S., and Murray A., 'The characteristics of OSL signal from quartz grains extracted from modern sediments in Japan', Geochronometria 2010, vol.37, pp13-19.

Keywords: Luminescence dating, Optically Stimulated Luminescence, Quartz