Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SGL39-P01 Room:Convention Hall Time:May 24 18:15-19:30

Observation of alpha recoil tracks in zircon: An attempt

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The decay of heavy nuclrei leaves damage in crystal; fission tracks (FT) or alpha recoil tracks (ART). ART is smaller in size compare to FT, thus only applied to layered silicates. If ART can be ovserved in zircon, which in general has higher uranium concentration than layered silicate, we can date samples whose ages are in order of thousand years old or older.

When zircon with high track density (e.g., $>$30 tracks/10^{-6}cm^2) was observed, many small pits with the depth less than 20 nm were found together with fission tracks. Fission tracks show deeper depths of ˜50nm when the sample was readily etched and can be reasonably distinguished from other topographic lows. In the observation of young zircons collected from modern volcanic product, dynamic range of surface topography is less than 5 nm after the etching of 10 hrs. Many surface shallow etch pits with the depth of ˜20 nm found in old zircons do not exit. Occasionally a hole with the depth of ca. 10 nm was found on the smooth surface. Because these zircons are from modern volcano and existence of a fission track is less plausible, these countable holes may be alpha recoil tracks. The depth of these holes is concordant with the shallow pits found in old zircon. Therefore, these shallow pits may also be alpha recoil tracks.

To see the behavior of shallow pits in old zircon, zircon was annealed at 600 degrees C or 1000 degrees C and observed. The surface topography have not changed much and 10˜15nm pits were still preserved in the sample after 600 degrees C annealing. After 1000 degrees C annealing, the surface topography become a little flat, and as smooth as modern zircon.

Keywords: radiation damage, atomic force microscope, alpha recoil track, fission track, zircon

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Attempts to date slip event of crush zones associated with plastic deformations of biotite based on FT thermochronology

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Timings of fault slips are generally constrained by dating displaced geomorphic markers, e.g., terrace surfaces, alluvial deposits, and artificial structures. However, these markers are not always available. Therefore, direct dating of fault materials have been also attempted to determine ages of faulting events; for instance, detecting chronological anomalies derived from frictional heating or crushing (e.g., Ikeya et al., 1982, Science; Murakami and Tagami, 2004, GRL; Yamada et al., 2013, JAES; Ganzawa et al., 2013, JGSJ) and dating hydrothermal veins or clay minerals formed after faulting (e.g., Zwingmann et al., 2004, JSG; Watanabe et al., 2008, Geochem .J.; Siebel et al., 2009, IJES; Yamasaki et al., 2013, Chem. Geol.) were performed (Tagami, 2012, Tectonophys.). However, definitive procedures to determine faulting ages based on such geochronological methods have not been established because thermogenesis and mass transport along fault zones are not simple. More fundamental and case studies are desirable to improve these methods.

We introduce an attempt to date a crush zone associated with plastic deformation of biotite on the basis of fission-track thermochronology. The crash zone is observed in granitic basement rocks and is distributed in the Monju prototype fast breeder reactor site, northwestern part of the Tsuruga peninsula, southwest Japan. The original topography and covering layers were excavated and removed during the construction of the Monju. Crush zones observed in the site are generally shorter than several tens meters and the width is less than several centimeters, producing net-work structures associated with ductile deformations. Along the crush zones, plastically deformed biotite grains are generally observed, which implies the crush zones were slipped under the temperature higher than 150-250 deg. C (e.g., Lin et al., 1999, Tectonophys.; Passchier & Trouw, 2005, " Microtectonics 2nd ed"). The Tsuruga body of the Kōjaku Granite, host rock of the crush zones, intruded at the end of the Cretaceous, cooled down to the ambient temperature within a few million years, and has been free from regional scale secondary heating (Sueoka et al., submitting). By contrast, local heating, such as basaltic intrusions at ˜19 Ma, may have occurred around the crush zones. In this study, we are performing fission-track thermochronometric studies for the crush zones, aiming to determine the timing of fault slips occurred at >150-250 deg. C. Although it is generally known that apatite fission-tracks are annealed at 90-120 deg. C for 10^6-10^7 years, even shorter-term heating, e.g., for several hours to several years of heating, can anneal apatite fission-tracks at >200 deg. C (e.g., Laslett et al., 1987, Chem. Geol.). This temperature range agrees with the temperature at which biotite is plastically deformed. In this presentation, we are going to report the preliminary results of fission-track analyses.

Keywords: fission-track thermochronology, dating of crush zones, plastic deformation of biotite, Kojaku Granite

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SGL39-P03 Room:Convention Hall Time:May 24 18:15-19:30

Effects of physical aging degradation on OSL properties of quartz

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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

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High precision and high sensitive stable isotopic analysis by using original CF/DI-IRMS system for IsoPrime100

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The stable carbon and oxygen isotopic compositions (δ^{13}C and δ^{18}O) of calcium carbonate, especially biogenic calcite, are used for environmental analysis (e.g. reconstruction of paleo-seawater temperature). The measurement of δ^{13}C and δ^{18}O of calcium carbonate is performed based on the comparison between the δ^{13}C and δ^{18}O of international standard calcite. Through the analysis, the isotopic values of samples should be determined precisely in order to compare and discuss with the analytical results reported in previous studies. In this study, we have developed a sample preparation system for IRMS (isotope ratio mass spectrometer) for high precision and high sensitive analysis. As a result, analytical results of NBS-19 (international standard calcite) using the developed system with dual-inlet IsoPrime100 (IRMS) showed δ^{13}C= +1.95 +/-0.026 ‰ and δ^{18}O= -2.20 +/-0.056 ‰ in long-term external analytical precision (n=36). Moreover, we found that short-term external precision (within a day) for this system have achieved around +/-0.01 ‰. By using the developed system with continuous-flow IsoPrime100 (IRMS), we can determine δ^{13}C and δ^{18}O of calcite and seawater (as low as 0.1 microgram of $CaCO_3$; 1 nmol of CO_2) with standard deviations of +/-0.1 ‰.

Keywords: High precision, stable isotopic analysis, carbon and oxygen isotope, carbonate, development

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High-resolution stable isotopic analysis of CaCO3 to clarify the life history recorded in fish otolith

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Japanese sardine is one of the important fish resources in Japan because they are utilized in our food, and used as fish meal. To keep these natural fish resources, we need to understand the life cycle of fishes. In recent years, previous studies reported that the stable isotopic records in otolith of fish reflect the ecology of their live. In this study, we analyze the stable isotopic composition of otolith of Japanese sardine in high resolution (=microscale: <100micrometer) to detect the environmental changes recorded in each growth stage of otolith. To realize the high-resolution microscale-analysis, we employed Geomill326 to mill otolith in microscale, and the microscale isotopic analytical system (MICAL3c) to determine isotopic compositions of small amounts of milled samples. As a result, we found that the stable isotopic composition in the center of otolith has different isotopic value with the outer edge of otolith. Especially, the seawater temperature calculated from stable oxygen isotope ratio in the outer edge of otolith is comparable with the water temperature at the time they captured. In addition, we successfully detect the life history of fish for each growth stages in high resolution. This demonstrated work is the first collaboration between Geomill326 and MICAL3c.

Keywords: otolith, stable isotope, microscale analysis, high resolution, environmental proxy, carbonate

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An attempt to obtain earthquake-related events from stalactite

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Dripstones in limestone cave such as stalactites and stalagmites showing colored banding are thought to record some kind of change in the process of their growth. In many cases, dripstones have been studied for the purpose of revealing paleoenvironmental change. Their growth is directly affected by groundwater recharge passing through cracks. The open states of the cracks are easily modified by tectonic deformation such as earthquake. Growing dripstones, therefore, record not only paleoenvironmental change, but possibly also tectonic event. Here we try to detect an event caused by tectonic deformation by analyzing stalactite having banding texture.

We got stalactites from Kuzuu district in Tochigi prefecture and stalagmites from Ishigaki Island in Okinawa prefecture. We observed banding texture under microscope, analyzed chemical composition by ICP-MS and EPMA and carried out radioactive carbon dating.

The result shows that Si, Al, Mg and Fe are concentrated on dark bands, which implies emplacement of clay minerals on the surface of the Kuzuu stalactite and Ishigaki stalagmite. The AMS^{14}C dating result displays that carbonate of Kuzuu stalactite grew from 37,000 to 33,000 (^{14}C age). We recognized a growth rate anomaly around the middle of the stalactite. In this presentation we discuss possible environmental factor and tectonic event to form banding textures on Kuzuu stalactite and Ishigaki stalagmite.

Keywords: stalactite, stalagmite