Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SGL43-01 Room:106 Time:May 23 15:30-15:45

Thermal Anomaly and Strength of Atotsugawa Fault, Central Japan, Inferred from Fission-Track Thermochronology

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Fission-track (FT) thermochronology was applied to the Atotsugawa Fault, central Japan, to detect fault related thermal anomaly (Yamada et al., 2009). Six fracture zones are found within an outcrop 20 m long near the portal of the Kamioka Mine prospect tunnel, located on the right bank 1.5 km upstream from the confluence of the Atotsugawa and the Takahara rivers (c. 370 m alt.). Each zone consists of a 1 - 3 cm wide gouge without visible pseudotachylyte, and fractured rocks 10-15 cm wide on its both sides. We collected samples from the gouge and fractured rocks 10 cm apart in each zone, and two reference samples from less fractured rocks. Most of zircon (120 - 150 Ma) and apatite (44 - 60 Ma) ages agree with emplacement ages for the granites that intrude the Hida Belt. A thermal anomaly was identified at one gouge sample that showed an exceptionally younger apatite age (c. 32 +- 3.2 Ma) with a unimodal FT length distribution. This anomaly in such a narrow zone may have been induced by frictional heat at the first fracturing at the apatite age, not by the circulation of hot geofluids within the zone.

Frictional coefficient (*mu*) and the ancient depth of gouge samples (H) are evaluated by the thermal modelling, assuming that the thermal anomaly is cause by a single frictional slip, and that all of the frictional work converts into heat without pore water. The effect of accumulated heat by multiple slips is negligible because the recurrence interval of fault activities is sufficiently long for the thermal diffusion in rocks. FT data and the geometry of sample occurrence give the constraint that the apatite FT age in the gouge was thermally reset although that in the fractured rock 10 cm apart was not. One-dimensional heat transfer model is used to calculate the temporal change in the temperature in and out of the gouge. The model space is composed of a 10 cm wide central slip zone and the 1000 cm wide surrounding zone with a homogeneous temperature distribution at a depth H in the initial stage. Constants of geothermal gradient, rock density, heat capacity, thermal conductivity, and slip rate are given as 30 deg. C/km, 1000 J/kg K, and 3.0 W/m K, and 1 m/s, respectively. Total slip of 5 m long is given by referring to the estimates of Mw 7.0-7.9 for the 1858 Hietsu earthquake along this fault system. The calculation results indicate that the effective heating time is significantly longer than the slip duration, and that samples in the distance to the frictional centre are not necessary heated instantly after the slip. For different combinations of *mu* and H, the maximum temperatures (T_{max0}, T_{max10}) at the centre (D_0) and at 10 cm apart (D_{10}) are different although the time during which the temperature in a specific location is maintained at its maximum is invariant. The effective heating time at D_0 and D_{10} at T_{max0} and T_{max10} are estimated as the order of 100 s and 10000 s, respectively. These estimates and annealing kinetics of zircon and apatite FT give the constraints of $400 < T_{max0} <$ 750 deg. C, and $T_{max10} < 250$ deg. C. To generate the amount of heat for these temperature ranges, *mu* is evaluated as 0.4 - 0.8 for H = 3 km, and > 0.6 for H = 2 km. These rather high estimates of frictional strength are concordant with those measured in laboratory experiments using the gouges taken from the same fault. In the case of pore water exists in the gouge zone, the increase in temperature will be smaller than that calculated above because the pore pressure may decrease the stress on the fault and the frictional heat may be diffused by fluid flow. Therefore, the estimate of *mu* in the dry condition can be regarded as a lower bound.

Yamada, R. et al, 2009, In: Thermochronological Methods: From Paleotemperature Constraints to Landscape Evolution Models, Lisker, F., Ventura, B., Glasmacher, U. A. (Eds.), 331-337, The Geol. Soc., London, 324.

Keywords: Thermochronology, Fault strength, Frictional heat, FT, Atotsugawa Fault

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SGL43-02 Room:106 Time:May 23 15:45-16:00

Experimental study for argon release and possibility of rejuvinated age after frictional heating granite

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Isotope ratios of noble gas in certain minerals are believed to be modified easily by their ambient reservoirs when the minerals reach higher temperatures than their closure temperature. The thermal history of a rock or a geologic event, even a fault movement, can therefore be determined quantitatively by applying radiometric dating methods to a set of different minerals. However, neither traditional K-Ar nor Ar-Ar dating methods can be applied easily to faulted rocks because, in the case of faulting, it is difficult to prove that the temperature of an event was greater than the closure temperatures of minerals.

Frictional heating experiments performed on fine grain homogeneous gabbros with high temperatures induced by frictional heating using a high-velocity friction apparatus were used to test whether rapid fault movement can rejuvenate the argon isotope ratio of fault rocks by the Argon released. The temperature on the artificial fault plane is flashing and above the closure temperature of the K-Ar system, as expected from the calculated cooling age. The anticipated rapid equilibration of volatiles during the frictional heating of rocks implies that the Argon isotope composition/ratio was released to an atmospheric value during this experiment.

Privious result of gabbroid analysis, we could observed that the reset was occurred only frictional plane, and we setted that second fuse enviroment (stable melted and pseudotachylyte was made) at the time. Rejuvenation and/or apparent increases in the K-Ar ages were only observed in a narrow, 3-mm-wide zone around the fault plane that appears thermally altered and mechanically fractured in thin sections.

In this study, for the granite friction experiment, the Argon gas released timing is faster, which called ”first fuse” (Hirose et al., 2005) in the time. The granitoid, which is composed upper crust, include the potassium rather gabbroid, which composed lower crust, because the radiogenic Ar is more abundant in the nature. After granite friction experiment, Argon and other gases released by the sample were collected in a small aluminum tube in a nitrogen atmosphere before and after the frictional heating granite experiment, also. Therefore, we could not observe glass and glassy material after granite experiment, but the argon gas released at ”first fuse” stage. We report that the measured noble gas isotopes in an Aji granite sample analysis, compared with gabbroid analysis.

Keywords: K-Ar age, Ar isotope, frictional heating, granit, gabbro

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SGL43-03 Room:106 Time:May 23 16:00-16:15

The method and issues of ESR dating of hydrothermal barite

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At an initial stage of studies of sea floor hydrothermal activities, their changes with time was not an issue. However, it has become important since it was found that such sea floor hydrothermal activities support the biological communities. We have been making progress in developing dating method using ESR (electron spin resonance) signals in barite contained in hydrothermal sulfides.

Kasuya et al. (1991) first pointed out that barite is possibly suitable mineral for ESR dating. Okumura et al. (2010) first practically applied this method to barite in sulfide made by sea floor hydrothermal activities, however, the work investigated neither if the properties of the signals are appropriate for dating nor the method for appropriate dose rate estimation. Subsequently, Toyoda et al. (2011) and Sato et al. (2011) studied these topics but they are still insufficient. Currently, most critical issue of ESR dating of sea floor hydrothermal barite is appropriate dose rate estimation.

The dose rate estimation for barite is quite different from that for other minerals, which are

(1) Ra and its daughter elements are the source of natural radiation, but not U or Th.

(2) Radiation from other minerals is negligible.

(3) Internal alpha particles give significant contribution to dose rate (40-60 %)

(4) Shape of the sulfide deposits (chimneys) have to be considered in estimating gamma ray dose.

The first two items are easy to be taken into account. For the third, Toyoda et al. (submitted) determined the alpha effectiveness, which is the ratio of formation efficiency of the signal by a unit dose of alpha particles to that of gamma rays. However, the variation of dose response is so large that re-examination is necessary. For the last item, this shape correction is necessary when the radius of the chimney is less than 20 cm or when the sample is taken from the position other than its center. We will report how we can make this correction in the presentation. Results of actual gamma ray measurements revealed that the contribution of dose to barite from the radioactive nuclei in sea water with hydrothermal activities is negligible. White and Rood (2001) found that Rn escapes from barite but we found that it is not the case.

The ESR ages of barite are roughly consistent with U-Th ages but much older than 226Ra-210Pb ages. Results of our ^{226}Ra-^{210}Pb age estimates will also be presented.

Keywords: ESR, dating, barite, sea floor hydrothermal activity, natural radiation

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SGL43-04 Room:106 Time:May 23 16:15-16:30

Thermoluminescence Dating of Calcite Veins in the Zambales Ophiolite, Luzon, Philippines

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A Deep geological repository of radioactive wastes from nuclear reactors is composed of several barriers including cement and bentonite. High alkaline groundwater might be produced through the alternation of the cement, thus the stability of bentonite during the interaction with high alkaline groundwater is one of the important issues to be studied as bentonite plays an important role to prevent an outflow of the contaminated groundwater to the environment owing to its cation exchange and swelling properties.

To understand bentonite-alkaline groundwater reaction with the geological timescale, it is useful to investigate a similar phenomenon occurred in nature. There is an ophiolite suites covered with bentonite layer in Luzon, Philippines. High alkaline groundwater originated probably from the serpentinization of mafic rocks has been circulating along cracks in a rock and bentonite layers. To determine the timescale of fluid-bentonite interaction, calcite precipitated from high alkaline groundwater was dated using thermoluminescence (TL) dating method.

First, TL color of calcite samples was investigated, and they emit red TL. Paleodose was measured using this red TL and SARA(single-aliquot regeneration and added dose) method was applied to evaluate sensitivity change of calcite occurred through repeated heating of samples.

In annual dose measurement, we measured radioactive element concentrations of calcite and a surrounding mafic sample using XRF, EPMA, LA-ICP-MS analyses. Cosmic ray contributions to annual dose was calculated by an equation of Prescott (1994).

To know the annual dose of a heterogeneous sample, detailed three-dimensional rock distributions around the sample is necessary. Unfortunately, the analyzed sample was very small in size, therefore we do not know accurate distribution of surrounding rock facies. By assuming the ratio of calcite and the surrounding mafic rock, the age of calcite was calculated.

As a result, the order of calcite age is ˜10 ka (younger than 100 ka and older than 20 ka). For accurate dating, it will be necessary to consider errors in added dose, exact distribution of rock which contributes the annual dose, and development of a method to estimate an annual dose for a heterogeneous sample.

This study is a part of a project to develop an integrated natural analogue programme in the 2011 fiscal year in Japan, which was funded by Agency for Natural Resouces and Energy of the Ministry of Economy, Trade and Industry , Japan.

Keywords: Thermoluminecsence dating, calcite vein

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SGL43-05 Room:106 Time:May 23 16:30-16:45

Re-Os geochronology of the Hitachi VMS deposit, Ibaraki Prefecture: The oldest sulfide deposit in the Japanese Island

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We applied the Re-Os isotope dating method to the Fudotaki and Fujimi sulfide ores from the Hitachi Deposit in the Ibaraki Prefecture. The Re-Os isochron of the Fudotaki sulfides yielded ca. 540 Ma which is the oldest age among the all other metal deposits in the Japanese Island. This isochron exhibited excellent linearity and the Re-Os age of the Fudotaki sulfides is much older than a timing of contact metamorphism by the Irishiken Granites (Late Cretaceous). Thus, we interpreted this Re-Os age as a primary depositional age of the Fudotaki sulfides on a paleo-seafloor. On the other hand, the Re and Os isotope compositions of the Fujimi Deposit showed no correlation in the 187Re/188Os vs. 187Os/188Os space. The Fujimi sulfides underwent higher grade metamorphism than that of the Fudotaki sulfides up to epidote-amphibolite facies or granulite facies, and the Re-Os isotope system of the sulfide ores was disturbed by metamorphism. Since the Hitachi Deposit is a syn-genetic sulfide deposit, the eruption age of the wallrock (basic volcanic rock) is also estimated to be ca. 540 Ma. This Re-Os age obtained here will be an important age constraint to clarify the geological history of the Japanese Island.

Keywords: Re-Os age, VMS deposit, Hitachi Mine, Fudotaki Deposit, Hitachi metamorphic belt, Japanese Island