フィッション・トラック　ニュースレター　第18号　19-21　2005年

野島断層のFT熱年代学研究

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Fission-track thermochronology of the Nojima fault zone

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Quantitative assessment of heat generation and transfer associated with a fault motion is critically important to constrain the thermal budget of orogeny as well as to estimate the shear stress that controls the energy budget of earthquakes. These thermal signatures also provide a tool for constraining the ages of faults. In the present contribution, we summarize our recent results of the zircon fission-track (FT) thermochronologic analysis of the Nojima fault, which was activated during the 1995 Kobe earthquake (Hyogoken-Nanbu earthquake; M7.2) (Tagami et al., 2001; Murakami et al., 2002; Murakami and Tagami, 2004). Rock samples were collected from the University Group 500 m (UG-500) borehole, Geological Survey of Japan 750 m (GSJ-750) borehole, the fault trench at Hirabayashi, and nearby outcrops. In the two boreholes that penetrate the fault at depth, zircon FTs were partially annealed in the samples neaby the fault (Figures 1 and 2). The age of onset of cooling from the zircon partial annealing zone (ZPAZ) was estimated by the inverse modeling of FT data using the Monte Trax program; i.e., 2.5 Ma within 3 m (in the hanging wall only) from the fault plane in the UG-500, and 35 Ma within 25 m from the fault in the GSJ-750. On the basis of one-dimensional heat conduction modeling as well as the general positive correlation between the FT annealing and deformation/alteration of borehole rocks, those cooling ages in both boreholes probably represent ancient thermal overprints by heat dispersion or transfer via fluids in the fault zone. Calculation of in-situ heat dispersion indicates the resulted temperature increase of 1 degree C, if the frictional heat is homogeneously and instantaneously dispersed via fluids to a 3 m-wide zone. Because such a small temperature increase does not advance significantly the zircon FT annealing, it is likely that the thermal overprints were caused by migration of hot fluids along the fault zone from deep crustal interior. For the fault trench samples, zircon FTs of the 2 – 10 mm thick pseudotachylyte layer were totally annealed and subsequently cooled through ZPAZ at 56 Ma, which is interpreted as the time of (final stage) of pseudotachylyte formation (Figure 3). It is suggested, therefore, that the present Nojima fault was formed in the Middle Quaternary by reactivating an ancient fault initiated at 56 Ma at mid-crustal depth.

References

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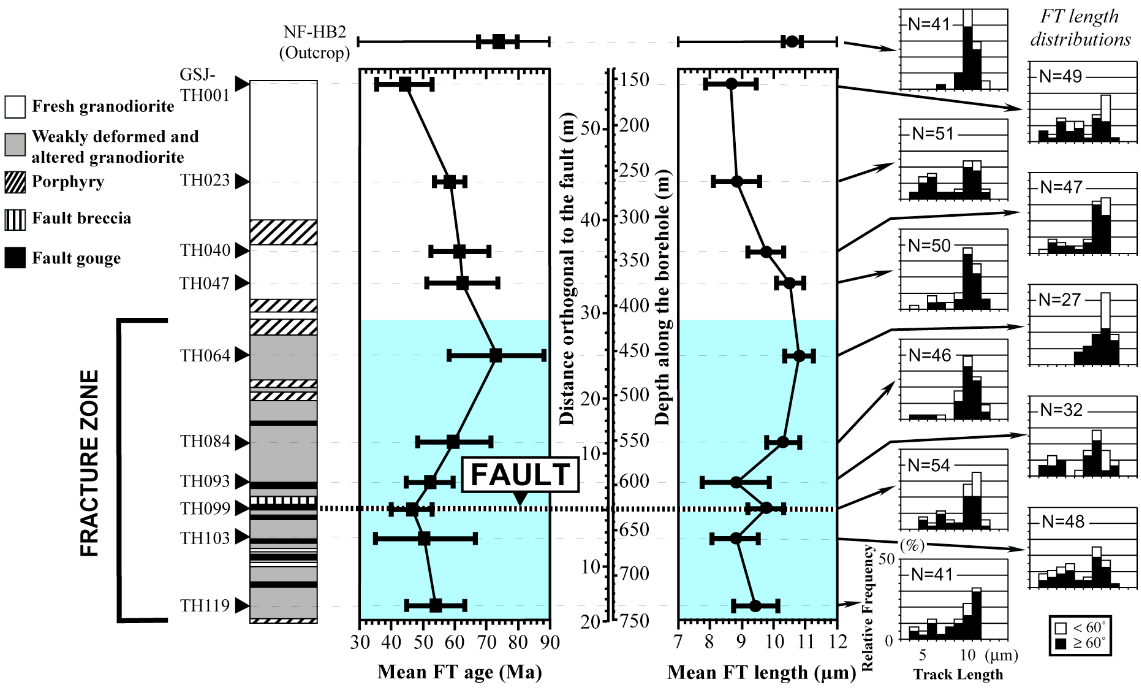

Figure 1. Zircon FT length and age versus distance to the fault in the GSJ 750 borehole. Zircons from the outcrop are characterized by mean lengths of ~10 – 11 μm and unimodal length distributions, showing no signs of appreciable reduction of FT length. In contrast, those from adjacent to the fault at depth show significantly reduced means of ~6 – 8 μm and distributions having two components of long and short tracks. Error bars are ±2 SE. Note that the track-length distribution is shown in a histogram with different patterns for tracks marking azimuth angles greater (solid column) and less (open column) than 60° to the crystallographic c-axis, because track lengths in zircon depend on etching and annealing properties which show an angular variation. Also shown are the distribution of fault rocks (Tanaka et al., 1999) and sample localities (Murakami et al., 2002).

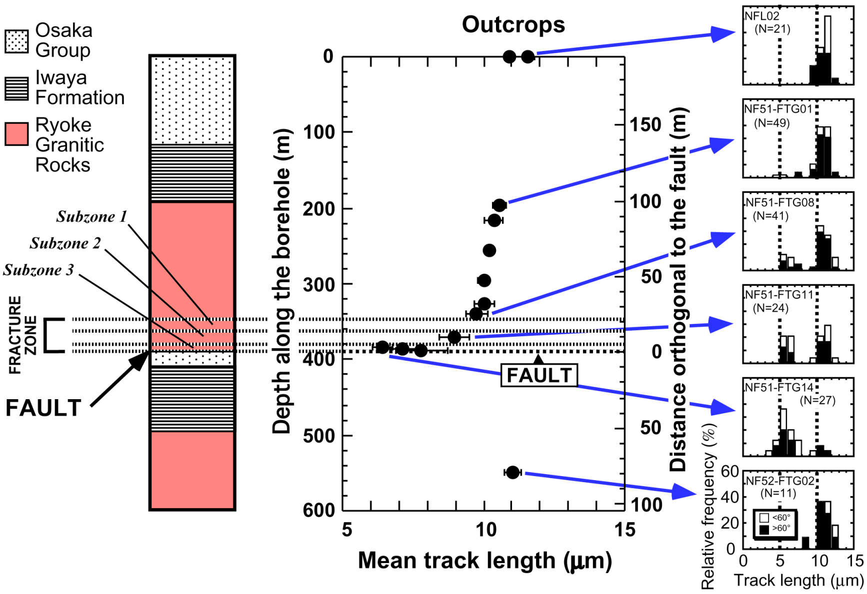

Figure 2.　Zircon mean FT length versus distance to the fault in the UG 500 borehole, with track length histograms of representative samples.　Zircons from localities >30 m away from the fault plane as well as those from outcrops are characterized by the mean lengths of ~10 – 11 μm and unimodal distributions with negative skewness, showing no signs of appreciable reduction of FT length.　In contrast, those from adjacent to the fault at depth show significantly reduced means of ~6 – 8 μm and distributions having a dominant peak around 6 – 7 μm with rather positive skewness.　Error bars are ±1 SE.　Also shown is the lithology of the borehole section (Murata et al., 2001), along with the three subzones within the fracture zone that represent dominant fault rock types (Tanaka et al., 2001); subzone 1 = non- to weakly deformed and altered rocks, subzone 2 = weakly deformed and altered rocks, subzone 3 = fault breccia and fault gouge.

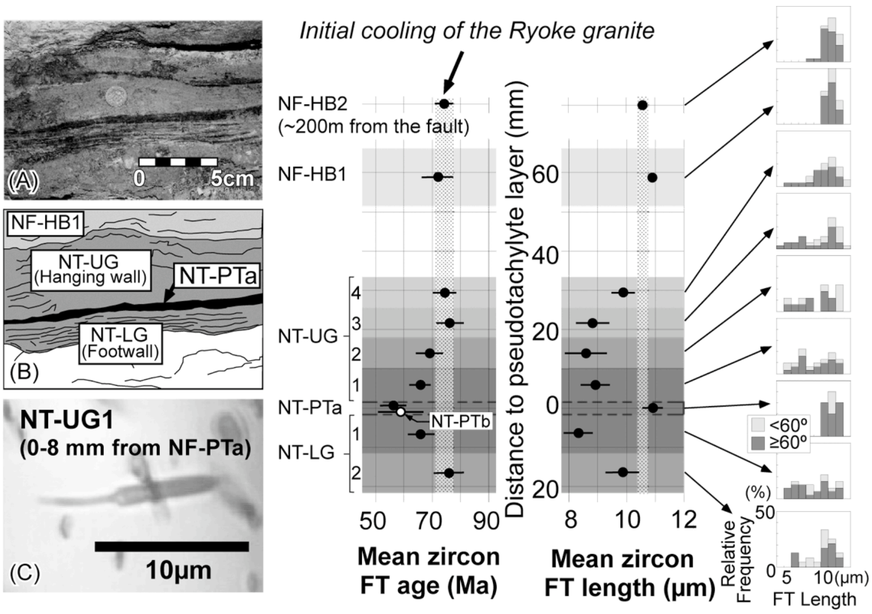

Figure 3.　The photograph (A) and sketch (B) of a sampled fault rock section in the Hirabayashi trench, with a plot of mean age, mean length and length distributions of zircon fission tracks measured.　NT-PTb is also plotted (open circle).　The blue boxes represent the mean age and length of NF-HB2 (the Ryoke host rock sample).　The sample from the pseudotachylyte layer (NT-PTa) has an age significantly younger than that of initial cooling of the Ryoke host rock sample (NF-HB1 and 2).　The photograph (C) is "syringe-shaped" tracks found in NT-UG1, which shows the evidence of partial annealing.　Error bars are ±1 SE.　After Murakami and Tagami (2004).