Thermal processes of seismogenic zones inferred from thermal history analysis of fault rocks using the fission-track method

Takahiro Tagami[1]; Masaki Murakami[2]; Tomoya Sato[1]

[1] Earth and Planetary Sci., Kyoto Univ.; [2] Academy of Sciences of the Czech Republic

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 first 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. 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. 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.

In addition, we also measured 25 ages and length distributions of fission tracks in zircons separated from sandstones in and around an ancient seismogenic zone found in the Shimanto accretionary complex, southwest Japan. The observed FTs showed significantly reduced mean lengths and ages for samples within 10-20 m away orthogonal to the fault on the hanging-wall side. This suggests that the heating up to the zircon partial annealing zone (220-350 degree C) occurred by a thermal event along the fault after the deposition that locally perturbed the geothermal structure (30 degree C/km). The ancient thermal anomaly probably represents heat transfer via fluids from deep crustal interior because calcite layers and deformed/altered biotite and plagioclase are observed widespread in the thin sections of samples within the heating zone.

References

Tagami, T., Hasebe, N., Kamohara, H. and Takemura, K., 2001. Thermal anomaly around Nojima fault as detected by the fission-track analysis of Ogura 500M borehole samples. The Island Arc, 10, 457-464.

Murakami, M., Tagami, T. and Hasebe, N., 2002. Ancient thermal anomaly of an active fault system: Zircon fission-track evidence of Nojima GSJ 750m borehole samples. Geophys. Res. Lett., 29, doi: 10.1029/2002GL015679.

Murakami, M. and Tagami, T., 2004. Dating pseudotachylyte of the Nojima fault using the zircon fission-track method. Geophys. Res. Lett., 31, doi: 10.1029/2004GL020211.