Fission track thermochronology of an ancient seismogenic zone in the Shimanto accretionary complex, southwest Japan

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The fission track (FT) method is useful for thermal history analysis because FTs in minerals are thermally annealed by heating at relatively low temperatures. In this study, FT thermochronologic analysis was performed on zircons separated from an ancient seismogenic zone in the Shimanto accretionary complex. To better understand the mechanism of trench-type earthquakes, it is essential to constrain the temperatures of the seismogenic zone in the subduction zone. The Shimanto accretionary complex is one of most studied ancient complexes currently exposed on land. It consists of unmetamorphosed to low-grade metamorphosed coherent turbidites and melanges, with estimated maximum burial depths of about 10 to 15 km and maximum temperatures of about 200 to 300 degree C. Because the temperatures of seismogenic zone is suggested generally to be about 150 to 300 degree C in the subduction zone, it is likely that the ancient seismogenic zone is located somewhere within the Shimanto accretionary complex. Furthermore, the FT analysis is particularly effective for tackling the problem because sufficient amount of zircons are included in the sandstones of the Shimanto accretionary complex.

Samples were collected from the surrounding area of the boundary fault between the Okitsu Melange and Nonokawa Formation. It is suggested that this fault was once located in the seismogenic zone, owing to the occurrence of pseudotachylyte therein which was formed by the frictional melting of a host rock. In this area, no thermal effect was found by previous zircon FT analysis [Hasebe et al.,1997,JGR,102,7659]. We carried out more detailed zircon FT analysis on 39 sandstone samples collected along a traverse orthogonal to the fault.

For zircons from the footwall of the boundary fault, i.e., the Okitsu Melange, the observed mean FT lengths are indistinguishable from the reference mean length determined previously on unannealed spontaneous tracks in zircon age standards [Hasebe et al.,1994.,Chem.Geol.,112,169]. The zircon FT ages are consistent with the previous data [Hasebe et al.,1997]. In contrast, in the hanging wall of the fault, i.e., the Nonokawa Formation, zircon FTs show reduced mean lengths and ages not only for samples nearby the fault, but also for samples less than about 3 km away orthogonal to the fault.

Two FT length distribution patterns are found for partially annealed samples in the hanging wall area. One is a unimodal length distribution having a peak around 7-9 microns, with no long FTs. The other is a bimodal length distribution having peaks around 10-11 microns and 5-6 microns, where the short FT component is dominant over the long one. These types of distributions are interpreted either by residence within the zircon partial annealing zone (ZPAZ; 210-310 degree C for a heating duration of 10 million years, after Tagami and Shimada [1996,JGR,101,8245] with adjustment of heating duration) for an extended period of time after the initial cooling of sandstone to the ZPAZ, or by the secondary heating up to ZPAZ after the initial cooling below the ZPAZ. The present results are more likely interpreted by the latter model because the degree of FT annealing shows significant, irregular variation within the hanging wall area less than about 3 km away orthogonal to the fault. More FT length and age analysis is in progress to make clear this interpretation.

It is thus likely that the thermal anomaly around the fault extends widely toward the hanging wall. In addition, the paleotemperature was not uniform throughout the zone of thermal anomaly. A similar trend was found by the zircon FT analysis of Nojima fault borehole samples [Murakami et al.,2002,GRL,2002gl015679]. It is also suggested that the heat was transferred or dispersed via fluids widespread in the hanging wall, judging from the concentration of veins nearby the fault.