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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.

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