Sx-004 Room: C311 Time: June 7 14:15-14:30

Ancient thermal anomaly around Nojima Fault detected by fission track analysis of zircon

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To detect frictional heat owing to activation of earthquake faults is of importance in resolving a long-standing state-stress problem. This study presents zircon fission-track (FT) data from Nojima Fault, which was reactivated during the 1995 Kobe earthquake. Samples were collected from Cretaceous Granitic Rocks and Osaka Group sediments, using the GSJ 750 m, NIED 1800 m, UG 500 m borehole and trenching investigation at Hirabayashi. As a result, shortened FTs are observed from samples above nearby the fault in three borehole and trench samples. The secondary cooling below the ZPAZ in boreholes can be explained by heat transfer via fluids from the deep interior of crust. The cooling in pseudotachylyte can be explained by the frictional heating of fault motion.

To detect frictional heat owing to the activation of earthquake faults is of primary importance in resolving a long-standing state-stress problem. This study presents zircon fission-track (FT) data from Nojima Fault, which was reactivated during the 1995 Kobe earthquake. Samples were collected from Cretaceous granitic rocks and Osaka Group sediments, using the GSJ 750 m, NIED 1800 m, UG 500 m borehole and trenching investigation at Hirabayashi. As a result, shortened FTs are observed from samples above nearby the fault in three borehole and trench samples. In GSJ 750 m and UG 500 m boreholes, the zone where the secondary cooling through the ZPAZ (partial annealing zone for zircon) is detected ranges ~4 m above the fault. In pseudotachylyte collected during trenching, the zone of secondary cooling through the ZPAZ is considered to range 2 mm across the fault.

What is a main cause of the secondary cooling through the ZPAZ? We consider four models; (a) thermal anomaly along the fault, (a-1) heat transfer via fluids from the deep interior of crust or (a-2) the frictional heating of fault motion, in which case the mean track length (the age) shows local reduction around the fault, (b) local uplift of the fossil ZPAZ by the thrust motion of the fault, in which case the downward gradual reduction in the mean length (the age) may repeatedly in the section, and (c) local uplift of the fossil ZPAZ by the squeeze from the depth, in which case the mean track length (the age) shows local plateau-reduction around the fault. In the case of model (b), the width of a high paleotemperature region is as narrow as <~4 m in distance orthogonal to the fault, which is equal to <~25 m in vertical direction above the fault. Hence, the region cannot be explained by the fossil PAZ under subnormal island-arc geothermal conditions. In the case of model (c), if young-age rocks were squeezed from the depth, all the track length distribution of finally cooled rocks at the same time should have the same shape. In GSJ and NIED borehole at Hirabayashi, the track length distributions of finally cooled rocks at 40 Ma seem to be different. Thus this model is not applicable to the case of two boreholes at Hirabayashi. However, we cannot judge the trench and UG 500 m samples because there is no FT length data in the trench sample and few FT age data in 500 m borehole. More detail FT data are necessary to judge these samples. Then we consider the two cases of model (a). In the case of model (a-1), deformed and altered zone is well matched with the finally cooled zone below the ZPAZ. For example, in UG 500 m borehole, the Osaka Group below the fault were hardly deformed and altered, while the granitic rocks above the fault were deformed and altered. In the case of boreholes, if hot fluids lie easily along the fault gouge, tracks in zircon will be shortened along the fault. In the case of model (a-2), assuming the temperature of heating 1600-2500'C and the duration of heating 1 second as frictional heating, the section of ZPAZ ranges 0-1 mm from the center of the fault. In pseudotachylyte, the final cooling below the ZPAZ can be explained by (a-2) the frictional heating of fault motion.

The secondary cooling through the ZPAZ in boreholes can be explained by model (a-1) heat transfer via fluids from the deep interior of crust. The cooling in pseudotachylyte can be explained by model (a-2) the frictional heating of fault motion.