Estimation of the frictional heat and the amount of wall rock incorporation by thermal fracturing during an earthquake: An example from the pseudotachylyte in Jurassic accretionary complex

*Ayaka Nagate[1], Kohtaro Ujiie[1]

1. University of Tsukuba

Estimation of frictional heat is crucial to evaluate dynamic shear strength and fault behavior during an earthquake. Pseudotachylyte produced by solidification of frictional melt is an unequivocal geological evidence of seismic slip on faults. Here, we estimated frictional heat and amount of wall rock incorporation into coseismic slipping zone during an earthquake, based on microstructural observation and numerical analysis of the pseudotachylyte in the Jurassic accretionary complex. The pseudotachylyte-bearing thrust develops as an out-of-sequence thrust in the coherent chert-clastic sequence, which bounds middle Triassic chert above from early Jurassic siliceous mudstone below. The pseudotachylyte is ~2 mm-thick and sharply separates fractured grey chert above from cataclasite below. The pelagic black carbonaceous mudstone layer is distributed at the stratigraphic equivalent interval of the pseudotachylyte.

The microstructures of the pseudotachylyte are characterized by fault and injection veins, fragments of grey chert and quartz in the dark matrix of illite composition, and irregularly and embayed pseudotachylyte boundaries. The gray chert adjacent to the pseudotachylyte and fragments in the pseudotachylyte consisted of grey chert are intensely cracked, showing jigsaw puzzle-like structure. These microstructural features suggest that thermal erosion, thermal fracturing, and preferential melting of illite occurred during earthquake faulting. Frictional heat, which was estimated from temperature rise, volume fraction of fragments, and pseudotachylyte thickness, is ~7.1 MJ m^{-2}.

The comparison of volume fraction of fragments in the matrix between the pseudotachylyte and the black carbonaceous mudstone layer suggests that half amount of fragments in the pseudotachylyte were derived from wall rocks. The numerical modeling considering temperature rise, heating duration, and thermal properties of gray chert indicates that the temperatures of wall rocks a few millimeters away from the pseudotachylyte boundaries exceed the temperature of a-b transition in quartz (~573 °C) during earthquake faulting. This distance is consistent with spatial distribution of crack density, which shows exponentially decrease away from the pseudotachylyte boundaries. Thus, intensely cracked wall rocks are considered to represent thermal expansion of quartz grains in gray chert, which could contribute to unstable fault slip associated with decrease in stiffness of surrounding rocks.

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