Thermal pressurization analysis for Iida-Matsukawa Fault based on its permeability structure

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Sibson (1973) proposed a concept of thermal pressurization in which pore pressure build-up due to frictional heating dramatically weakens a fault during seismogenic fault motion. Lachenbruch (1980) and Mase and Smith (1987) proposed theories to analyze such a combined thermal and hydrological processes. However, limited fluid-transport data on natural faults, particularly those on storage capacity, have left the analyses of thermal pressurization within natural faults incomplete. Only recently, Wibberley (2002) and Noda et al. (2003) measured permeability and storage capacity for fault zones of Median Tectonic Line and Hanaore Fault and showed that thermal pressurization can dramatically weakens faults with slip-weakening distance, Dc, on the same order as that determined in a seismological technique. But such studies are quite few now, so that the present study extended similar analyses to Iida-Matsukawa fault in Nagano Prefecture, central Japan.

Iida-Matsukawa Fault extends in NW-SE direction and is located in the southern part of Nagano Prefecture, central Japan. The fault zone at an outcrop in Suzugataira area in the west of Iida City is about 10 meters in width. Fault gouge occurring along the fault core is 5-10 mm wide. The fault zone consists of cataclasite, foliated cataclasite, foliated fault breccia and fractured granite. Lin (1996) reported crushed rocks with injection features which are somewhat similar to pseudotachylytes suggested that they formed fluidization and injection of gouges. This fluidization hypothesis will be critically examined here based on a thermal pressurization analysis.

Permeability and storage capacity have been measured with an intra-vessel deformation and fluid flow apparatus and with a high-pressure deformation and fluid flow gas apparatus at Kyoto University, using an oscillating pore pressure method and a constant flow rate method. Nitrogen was used as pore and confining fluid. Permeability of fault rocks in Iida-Matsukawa Fault is 10^(-14)-10^(-18) m^2, and permeability of rocks on the northern side is lower by 2 or 3 orders of magnitude than that on the southern side.

One-dimensional finite-difference analysis of thermal pressurization process was performed based on Lachenbruch's (1980) theory and incorporating the measured permeability structure of the Iida-Matsukawa fault. The results indicates that thermal pressurization process is not so effective for this fault as a weakening mechanism at the initiation of earthquake since the built-up pore pressure due to frictional heating dissipates into surrounding foliated fault breccia zone rather easily. The analysis also shows temperature increase in the deformation zone by more than several hundreds of Centigrade, suggesting that unknown weakening mechanisms become operative. Pseudotachylyte-like rocks of crush origin with injection features, reported by Lin (1996) for this fault, are likely to have formed as shock-induced rupture veins as in the case of mine-induced faults in South Africa.