AOGS 2005

A Combined Thermal Pressurization and High-Velocity Behavior of Nojima Fault Gouge to Infer Slip-Weakening of a Fault

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Thermal pressurization has long been suggested as a weakening mechanism of a fault during seismogenic fault motion. Internal and permeability structures of Nojima fault zones were determined at an outcrop at Funaki and at Hirabayashi trench site. Permeability was measured with a deformation and fluid flow gas apparatus at Kyoto University, using a constant flow rate method and a pore pressure oscillation method with nitrogen gas as pore fluid. Permeability structure of Nojima fault zone is characterized by very impermeable fault gouge with permeability of 10^{-20} to 10^{-18} m^2 at pressures and by permeable fault breccia and fractured host rocks with permeability of 10^{-17} to 10^{-14} m^2. Measured porosities of fault gouge and fault breccia are 30 % and 20 % at pressures, respectively. These measured values of hydraulic parameters were then used to calculate thermal pressurization processes numerically. Results clearly exhibit that thermal pressurization processes markedly reduces fault strength with slip-weakening distance, *Dc*, of the same order as those determined seismological analyses. Thus thermal pressurization can be a very effective weakening mechanism of a fault at high slip rates.

Thermal pressurization analysis was conducted incorporating with measured slip-weakening of Nojima fault gouge in order to see which of thermal pressurization or high-velocity weakening of gouge is more important. Strength reduction becomes insensitive to slip-weakening curves when permeability is below about 10^{-18} m^2, so that thermal pressurization dictates fault weakening. When permeability is greater than 10^{-16} m^2, both transport and slip-weakening properties of a fault affect the gross slip-weakening behavior. Thus, mechanical behavior of a fault at high slip rates must be predicted by combining the two properties. Present work elucidated nearly equal significance of those two processes and has striking impact in understanding dynamic fault motion during large earthquakes. Such a combined analyses are needed not only to infer mechanical property of a fault, but also to estimate temperature rise in a fault zone.