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Coseismic and inter-seismic strength changes due to frictional heating and diffusion of slip zone pore fluids in a seismogenic fault zone

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The recent acquisition of permeability and structural data from fault zones allow us to quantitatively examine the hydromechanical response of a fault to rapid shear heating during an earthquake. A combined field and laboratory study using an excellent exposure of the Median Tectonic Line fault zone in Japan has revealed a central slip zone (approximately 10 cm wide) of very fine-grained low permeability clay gouge (log k(m2) = -20 to -21 parallel to foliation at effective pressures of 80 - 180 MPa). This zone is interpreted as the most recent seismogenic slip zone, and is laterally continuous across most of the outcrop. Evidence of previous slip zones such as oblique narrow shear zones either bifurcating from the central slip zone or being truncated attest to a complexity in previous rupture behaviour.

Numerical modeling of a saturated granular gouge slip zone suggests that increased fluid pressure by frictional heating will not be dissipated on the time scale of an earthquake provided that the new rupture remains in the low permeability central slip zone. This suggests that thermal pressurization is likely to be an important slip weakening mechanism on the short time scale. However, on a longer timescale, the post-slip decay of this elevated fluid pressure may control a regain in strength (healing), depending on the interplay between diffusion of frictional heat, with consequent thermal contraction of the fluid-filled pores, and diffusion of the elevated fluid pressure. Such post-slip decay of fluid pressure is likely to be on a much smaller time scale than mechanisms generating interseismic pore fluid pressure rises by chemical fluid-rock interactions such as pressure solution creep.