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Constraints on frictional strength and pore pressure excess for a weak San Andreas: The Rice-style model revisited

S. Tembe (1), D. Lockner (2), T.-f. Wong (1)

(1) Department of Geosciences, State University of New York at Stony Brook, USA, (2) U. S. Geological Survey, Menlo Park, California, USA

Elevated pore fluid pressure confined to the fault zone has long been hypothesized as the cause of weakening in the San Andreas fault. One conceptual model of this is the *Rice* [1992] model, where pore pressure in the fault core could rise as needed, reducing the effective normal stress and therefore the fault strength. The adjoining crust is considered to be relatively strong, with limiting stresses comparable to those required to induce thrust faulting in a rock mass with Byerlee frictional strength. In this scenario a pronounced pore pressure excess can be generated and maintained within the fault gouge that would allow frictional sliding to occur at a low shear stress level, with a local stress state in the strike-slip regime and maximum principal stress oriented almost normal to the fault plane. In light of recent findings of weak clays, serpentine and talc phases in drill core and cuttings samples obtained from the SAFOD scientific borehole, we extend the *Rice* [1992] model to include an intrinsically weak fault zone. Values for the fault zone friction coefficient μ_f were obtained from published and newly acquired data from friction experiments conducted in the saw-cut configuration at hydrothermal conditions (compatible with 0-15 km depth) on three materials: illite-bearing fault gouge from SAFOD ST1 3067 m MD core at, the serpentine mineral-chrysotile, and talc. Using only experimental values for μ_f and a directional constraint $\psi = 20^\circ$(corresponding to $\sigma_{H\,\max}$ making a 70˚ angle to the fault) in the model, the fluid pressures involved range from sub-hydrostatic up to 3 times σ_V and are sensitive to the relative magnitudes of the principle stresses. Incorporating a weak fault zone into the model resulted in pore pressure and stress magnitudes less than that predicted

using the original *Rice* [1992] model. Alternatively, when the shear stress constraint of $\overline{\tau} <$20 MPa (inferred from the long-term heat flow signature of the San Andreas) and allowing$\sigma_h \sim \sigma_V$ (based on estimates of stress magnitudes at SAFOD), the model predicts $\psi <$5° and $\mu_f \approx$0.05.