Heating and Weakening of Shear Zones in Earthquake and Landslide Mechanics

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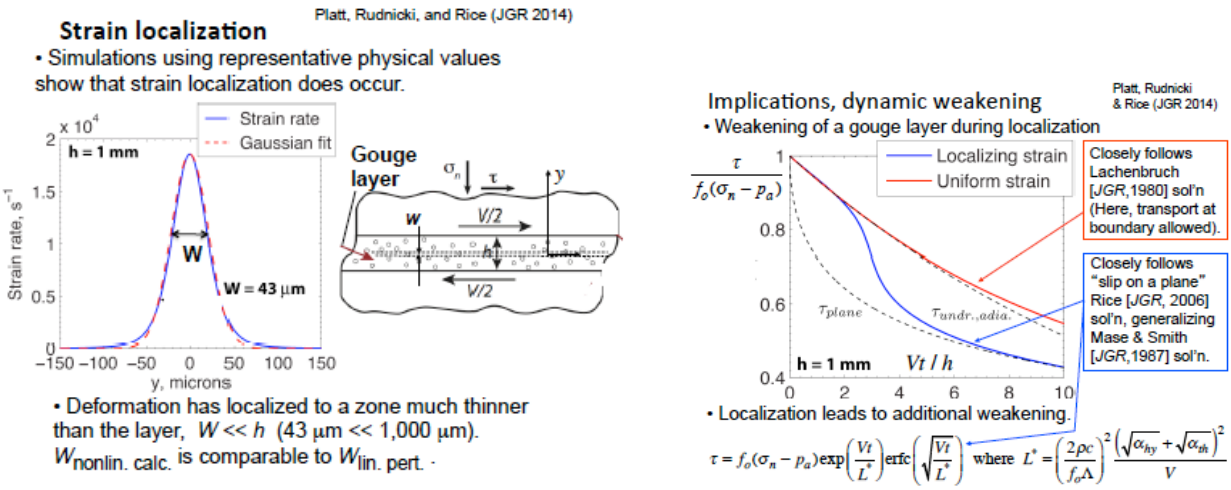
Field and borehole observations of active earthquake fault zones show that shear is often highly localized to principal deforming zones of order 10s of microns to a few mm wide. Landslides in relatively homogeneous soils, especially clays, or in layered strata can likewise exhibit extremely narrow shear zones. Those two domains of study, landslide and earthquake mechanics, reached a stage of relative maturity with, it seems, very little communication of researchers in one field about developments in the other and vice versa, but with a great exception being the late Ioannis Vardoulakis who co-organized, with Y. Hatzor and J. Sulem, the unifying Batsheva de Rothschild conference of 2009 on "Shear Physics at the Meso-scale in Earthquake and Landslide Mechanics". The lecture will follow those pioneers to address narrow shear zone development as a thermo-hydro-mechanical localization process in wet granular media. In it, highly elevated pore pressure is a predicted and lab-verified consequence of rapid straining, which enables intense shear localization. That pressurization can develop in fluid which pre-exists in the gouge as groundwater, or in volatile phases emerging at high pressure from thermal decomposition reactions in hydrated silicates (clays, serpentines) or carbonates. The concepts show howshear zone materials with high static friction coefficients, ~0.6 to 0.8, can nevertheless undergo strongly localized shear at effective dynamic friction coefficients of order 0.1, thus fitting observational constraints, e.g., in the earthquake case, of producing negligible surface heat out-flow and rarely creating extensive melt. This is collaborative research with Nicolas Brantut (Univ. Col. Lond), John D. Platt (Smithsonian Inst. Sci.) and John W. Rudnicki (Northwestern Univ).



References

[1] J. R. Rice, *Heating and weakening of faults during earthquake slip*, J. Geophys. Res. B **111**, doi:10.1029/2005JB004006 (2006).

[2] J. R. Rice, J. W. Rudnicki, J. D. Platt, *Stability and localization of rapid shear in fluid-saturated fault gouge, 1. Linearized stability analysis*, J. Geophys. Res. B **119**, doi:10.1002/2013JB010710 (2014).

[3] J. D. Platt , J. W. Rudnicki, and J. R. Rice, *Stability and localization of rapid shear in fluid-saturated fault gouge, 2. Localized zone width and strength evolution*", J. Geophys. Res. B **119**, doi:10.1002/2013JB010711 (2014).

[4] J. D. Platt, N. Brantut, and J. R. Rice, *Strain localization driven by thermal decomposition during seismic shear*, J. Geophys. Res. B **120**, doi: 10.1002/2014JB011493, (2015).