Report on a 2013 Workshop on Ductile Rheology of the Southern California Lithosphere: Constraints from Deformation Modeling, Rock Mechanics, and Field Observations

A workshop was held May 1-2, 2013 in Menlo Park, California to investigate properties and processes of ductile lithosphere deformation (see Figure 1). This workshop provided overviews of the newest results from lab, field and geodetic modeling disciplines relevant to better understanding earthquake processes in southern California. A principal goal of the workshop was to bring together niche experts in tectonic geodesy, laboratory rock mechanics, and field observations of ductile rocks to gain better interdisciplinary understanding of the stress transfer process between brittle-elastic upper crust and ductile lithosphere in southern California. Principal outcomes of the meeting were (1) a greatly improved understanding of the relation between the lab- derived transient and steady state flow laws, their relation to field examples of crustal flow, and their application to modeling surface crustal deformation; (2) near unanimous agreement that relatively narrow ductile shear zones exist beneath active faults in the seismogenic crust; and (3) a goal of mapping of the southern California ductile lithosphere using results of seismic imaging and anisotropy to constrain rock type and flow, combined with laboratory inferences of appropriate ductile flow laws at relevant pressure, temperature and state conditions

Simplified viscous flow laws (e.g. Maxwell, Burgers body) have been used in the past to model earthquake cycle deformation and lake unloading and provide adequate fits to Earth's surface deformation. However, these models are non unique. Furthermore, there is some disagreement between upper mantle effective viscosities estimated by the two methods in western Nevada that may be real and needs to be investigated. It was also agreed that lab- and field-supported power flow laws should increasingly supersede idealized laws and, where possible, use new models of transient creep such as those discussed at the workshop. In this way modelers can better understand whether these more realistic laws produce diagnostic features in the surface deformation field not explained by the older simplified laws.

Ductile shear zones are ubiquitously observed in the roots of upper crustal faults and are produced in laboratory simulations of ductile deformation. The width of these zones, their variation with depth and the reduction in effective viscosity are not well constrained, but observations and models of metamorphic core complexes suggest differential stresses of 100-200 MPa right below the brittle/ductile transition and a variety of possible strain weakening mechanisms.

Longer-term research priorities for improving fundamental understanding of deformation, stress state and fault slip rates in southern California were also identified. These include: (1) new observations and modeling of earthquake cycle deformation, focusing especially on better constraining the duration and spatial distribution of post-seismic deformation, which may contaminate the presumed steady-state velocity field (CGM, Community Geodetic Model) and bias fault slip rate estimates; (2) Use of ductile flow laws and better mappings of the heterogeneity of lithospheric ductile rheology to better constrain differential stresses on southern California faults and the blocks surrounding them (SCEC's Community Stress Model, CSM).

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The workshop had 30 attendees and was funded by SCEC and the USGS. A complete report can be accessed at the workshop website: http://www.scec.org/workshops/2013/rheology/index.html

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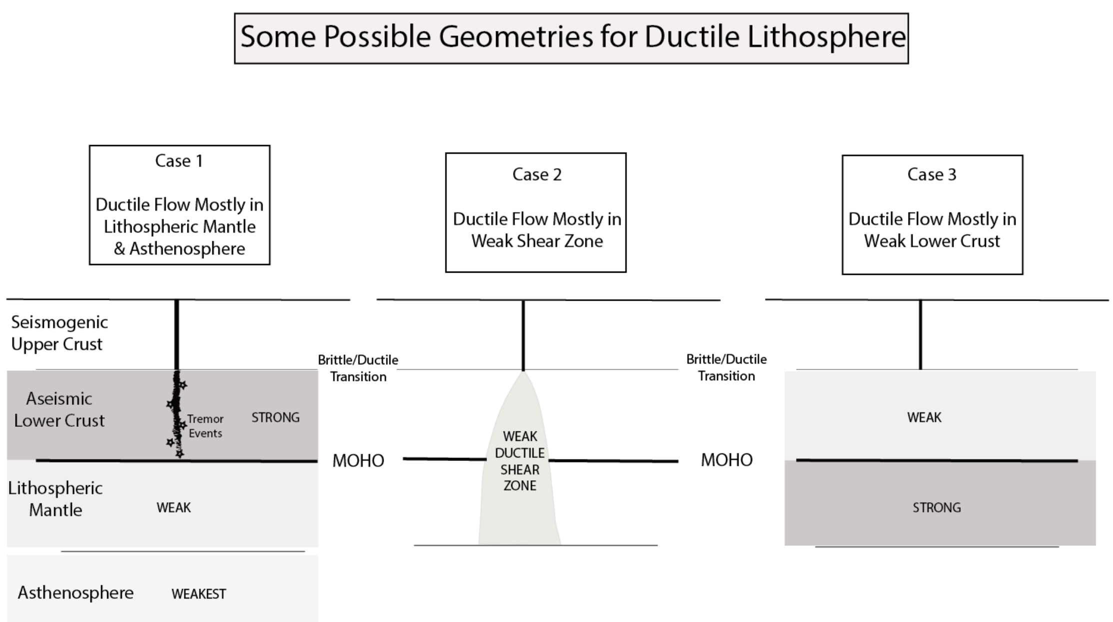

Figure 1