***Ductile Rheology of the Lithosphere: Lessons from the 1992 Landers, the 1999 Hector Mine and the 2004 Parkfield Earthquakes***

Sylvain Barbot
Scripps Institute of Oceanography
University of California at San Diego

Tuesday 2 December 2008, 11:30 am
4th Floor Faculty Lounge, Hoffman Laboratory, 20 Oxford St
Harvard University

***Abstract:***

The Earth's surface deformation has been increasingly imaged in recent years by application of remote sensing methods such as GPS and synthetic aperture radar (SAR). The increased accuracy of these data offers an opportunity to track subtle changes of the Earth's surface and to constrain rheology of the crust and upper mantle. A simple model explaining interseismic and coseismic deformation is the motion of faults in the seismogenic zone as well as a broad-scale viscous flow in the upper mantle. Improvements in the accuracy and spatiotemporal coverage of geodetic observations allow new insights into a number of long-standing questions, for example: What rheology controls the evolution of slip on a fault plane? What are the interactions between fault creep and mantle flow? Numerous studies have demonstrated that a linear rheology is often inadequate to explain patterns and rates of surface deformation during the postseismic interval of the earthquake cycle. This requires new computational techniques to model the time dependence of three dimensional deformation due to nonlinear rheologies.

We present a new approach to compute displacements due to fault creep and power-law mantle flow. The method is based on analytic solutions to the inhomogeneous Navier's equation in the Fourier domain. We use the Fourier solution to model quasi-static fault creep with rate-and-state friction, nonlinear viscoelastic relaxation in a stratified lower crust and upper mantle as well as static deformation in a half space with heterogeneous elastic moduli. We use SAR data of the 1992 Landers and of the 1999 Hector Mine earthquakes to investigate the heterogeneous mechanical properties of the Earth's crust in the Mojave desert, eastern California. Using continuous GPS measurements of the postseismic deformation following the 2004 Parkfield earthquake, we constrain the effective frictional properties of the Parkfield segment of the San Andreas fault. Finally, using GPS and SAR postseismic data of the Landers and Hector Mine earthquakes we constrain the partition between the localized afterslip and the broader nonlinear viscoelastic relaxation. Our results illustrate the complexity of the crustal rheology, highlighting the heterogeneity of fault frictional properties, the heterogeneity of effective elastic moduli and the role of nonlinear rheology in spatial localization of deformation in the ductile part of the lithosphere.