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Stress modeling

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Our long-term goal in this project is to construct a time dependent tensor stress representation for southern California that includes tectonic stress accumulation on faults and both the elastic and viscoelastic effects of historic earthquakes.

In Bob Ge's Ph.D. thesis [1997], we estimated the parameters of a block and fault model using the geometry of the Phase II fault model and slip rates jointly estimated from the geological data in Phase II and the geodetic data of the SCEC Crustal Deformation Velocity Model. From this model we calculated the stress rate using elastic dislocation theory. We tried some alternate formulations of the fault model (just faults; no blocks), and updated the geologic data to that used in the CDMG/USGS hazard model. We found that the stress rate near to faults is extremely sensitive to untestable assumptions, especially segmentation and fault depth, but that away from faults the stress estimates are more robust.

We used the finite element program by Fred Pollitz to evaluate possible triggering of the Hector Mine earthquake by stresses from Landers. Coseismic effects from Landers generally decrease the Coulomb stress on the Hector Mine rupture plane in the region around the Hector hypocenter. However, viscoelastic relaxation in the lower crust transfers stress to the Hector fault plane, so that after eight years the net stress change is an increase in Coulomb stress. If the effective coefficient is 0.4 or less, then the peak in incremental Coulomb stress is near the hypocenter of the Hector event. The results are not very dependent on the assumed displacement of the Landers earthquake, but they do require a fairly low viscosity (10^{20} Pa s) in the lower crust in order for the transient effects to overcome the coseismic stress drop.

To study the systematics of earthquake triggering, we computed the times, distances, and rotation angles between the focal mechanisms of pairs of nearby earthquakes. Most triggered events occur near the fault plane of the triggering earthquake, where the average shear stress on that fault plane should have dropped substantially. To be triggered by Coulomb stress changes, the triggered events must occur on faults oriented at a large angle from the original fault plane, or be caused by random local stress variations. Our statistical studies indicate that the mechanisms of triggered events are very similar to those of their triggers, becoming asymptotically closer as the events are closer in time and space. Thus, many earthquakes are clearly not triggered by stress changes, at least as we presently model them.

Publications resulting from this project:

Kagan, Y.Y., and D. D. Jackson, 1998. Spatial aftershock distribution: Effect of normal stress, *J. Geophys. Res.*, **103**, 24,453 - 24,467, SCEC #426.

Kagan, Y. Y., 2000. Temporal correlations of earthquake focal mechanisms, *Geophys. J. Int.*, **143**, 881-897, SCEC #508.

Abstracts resulting from this project:

Jackson, D. D., and Kagan, Y. Y., 1999. Stress increments and earthquake forecasting, *Eos Trans. AGU*, **80(46)**, Fall AGU Meet. Suppl., p. F1006-1007.

Reports resulting from this project:

David D. Jackson, The uniqueness of stress estimates and implications for earthquake triggering; talk at SCEC Workshop on Earthquake Stress Triggering, Fault Interaction, and Frictional Failure, Carmel, CA, 8-10 June, 1998.