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Stress Evolution and Earthquake Triggering in Southern California

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This report summarizes results already published by Deng et al., (1999).

Major earthquakes are followed by aftershocks that occur at decreasing rates for months or even years. To maintain a high level of aftershock activity long after a major earthquake, several mechanisms could be involved in the postseismic process. Laboratory experiments suggest that both the frictional strength of a loaded fault [Dieterich, 1994] and the strength of fault zone materials [Scholz, 1968] could change with time. It has also been proposed that the reequilibration of pore fluid pressure could change the normal stress and contribute to the generation of aftershocks [Nur and Booker, 1972].

Another important but overlooked mechanism is the time-dependent shear stress loading in the source region. Geodetic data can potentially constrain this kind of stress loading following large earthquakes. Typically, broad-scale postseismic deformation has been attributed to viscoelastic relaxation below the seismogenic zone [e.g., Thatcher and Rundle, 1984]. The relaxation of the deviatoric stress in the lower part of the crust can transfer stress up to the upper crust and trigger aftershocks in the long term [e.g., Freed and Lin, 1998]. Postseismic deformation data can constrain this gradual loading process which may be responsible for the time-dependent triggering of aftershocks.

The M 6.7 Northridge, California, earthquake is a key event for helping us to understand this problem. As part of this study, Deng et al. [1999] combine the extensive seismic and geodetic measurements with a realistic computer model of viscoelastic processes to explain the temporal decay and spatial patterns of aftershocks.

Following the M 6.7 Northridge earthquake, significant postseismic displacements were resolved with GPS. Using a three-dimensional viscoelastic model, we suggest that this deformation is mainly driven by viscous flow in the lower crust. Such flow can transfer stress to the upper crust and load the rupture zone of the main shock at a decaying rate. Most aftershocks within the rupture zone, especially those that occurred after the first several weeks of the main shock, may have been triggered by continuous stress loading from viscous flow. The long-term decay time of aftershocks (about 2 years) approximately matches the decay of viscoelastic loading, and thus is controlled by the viscosity of the lower crust. Our model provides a physical interpretation of the observed correlation between aftershock decay rate and surface heat flow.

Deng, J., K. Hudnut, M. Gurnis, H. and E. Hauksson, Stress loading from viscous flow in the lower crust and triggering of aftershocks following the 1994 Northridge, California, Earthquake, *Geoph. Res. Lett.*, 26, 3209-3212, 1999