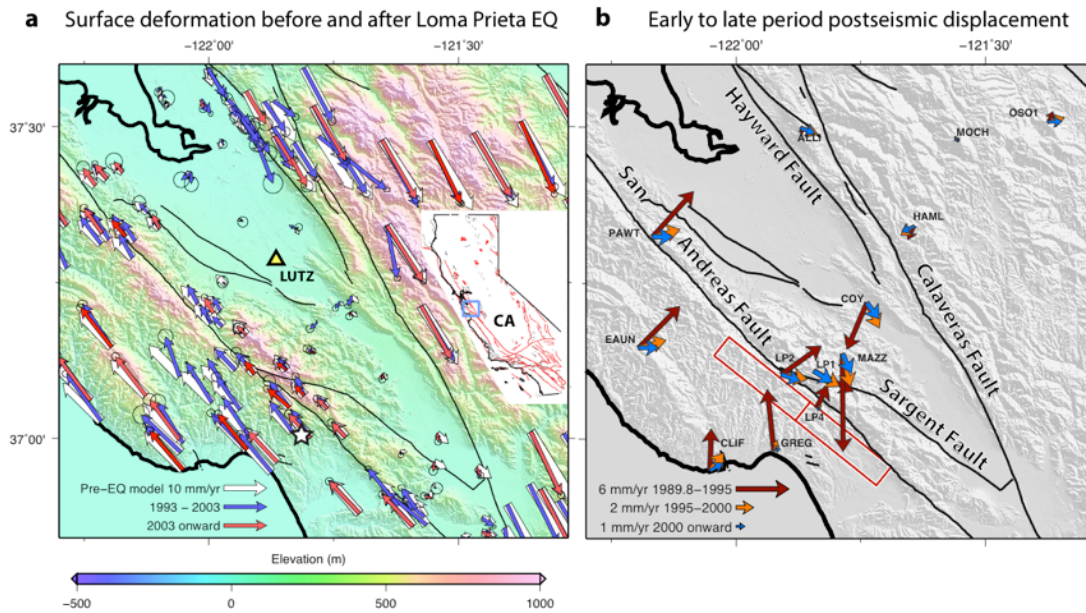


The October 17, 1989 M_w 6.9 Loma Prieta earthquake provides the first opportunity of probing the crustal and upper mantle rheology in the San Francisco Bay Area since the 1906 M_w 7.9 San Francisco earthquake. Here we use geodetic observations including GPS and InSAR to characterize the Loma Prieta earthquake postseismic displacements from 1989 to 2013. Pre-earthquake deformation rates are constrained by nearly 20 years of USGS trilateration measurements and removed from the postseismic measurements prior to the analysis. We observe GPS horizontal displacements at mean rates of 1-4 mm/yr toward the Loma Prieta Mountain until 2000, and ~ 2 mm/yr surface subsidence of the northern Santa Cruz Mountains between 1992 and 2002 shown by InSAR, which is not associated with the seasonal and longer-term hydrological deformation in the adjoining Santa Clara Valley. Previous work indicates afterslip dominated in the early (1989-1994) postseismic period, so we focus on modeling the postseismic viscoelastic relaxation constrained by the geodetic observations after 1994. The best fitting model predicts an elastic 19-km-thick upper crust above an 11-km-thick viscoelastic lower crust with viscosity of $\sim 6 \times 10^{18}$ Pa s, underlain by a viscous upper mantle with viscosity of $\sim 2 \times 10^{19}$ Pa s. The millimeter-scale postseismic deformation does not resolve the viscosity in different layers very well, and the lower crustal deformation may be localized in a narrow shear zone. However, the inferred lithospheric rheology is consistent with previous estimates based on post-1906 San Francisco earthquake measurements along the San Andreas Fault system. The viscoelastic relaxation may also contribute to the enduring increase of aseismic slip and repeating earthquake activity on the San Andreas Fault near San Juan Bautista, which continued for at least a decade after the Loma Prieta event.



Geodetic horizontal measurements in the southern San Francisco Bay Area, shown in the blue box in the map. (a) Surface deformation before and after the Loma Prieta earthquake relative to station LUTZ (yellow triangle). The white arrows are the preseismic secular motion prediction inverted from EDM measurements using 78 dislocations based on *Bürgmann* [1997]; the blue arrows are the BAVU GPS measurements during 1993 - 2003 [*d'Alessio et al.*, 2005]; the red arrows are the USGS velocities from campaign and continuous GPS measurements since 2003. The white star indicates the Loma Prieta earthquake epicenter. **(b)** The Loma Prieta postseismic displacements during 1989 -1995, 1995 - 2000, and 2000 - present. Secular motions have been removed based on *Bürgmann* [1997], and the postseismic displacement is relative to MOCH. The red rectangles are the surface projection of the coseismic fault planes from *Marshall et al.* [1991].