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Postseismic deformation following the 2008 Mw 7.9 Wenchuan earthquake: Implications for heterogeneous fault behavior and lower crustal rheology

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Postseismic deformation following large earthquakes can reveal fault behavior and lithospheric rheology, which are essential for understanding seismogenic mechanisms and seismic hazards. Geodetic observations with good spatial coverage may allow identifying distinct processes of postseismic deformation, as our study reveals for one of the most damaging earthquakes that occurred in the Asian highlands. In this study, GPS displacements from the first 7 years following the 2008 Mw 7.9 Wenchuan earthquake, Sichuan region, are used to study the relevant mechanisms of postseismic deformation. Separated models of afterslip and viscoelastic relaxation and a combined model are built to explain observed postseismic displacements. In contrast to previous studies, which assumed afterslip and viscoelastic relaxation were independent, we include the viscoelastic relaxation effect induced by time-dependent afterslip in the combined model. Modeling results suggest that the middle- to far-field postseismic deformation is mainly induced by lower crustal viscoelastic relaxation, whereas the near-field displacement is caused by stress-driven aseismic afterslip. The seismic moment released by afterslip is up to 25% of that released by the coseismic rupture. Negligible aseismic afterslip is observed in the seismic gap between the Wenchuan and Lushan earthquakes, indicating the locking state of the fault within this segment. The effective lower crustal viscosity of the eastern Tibetan Plateau is found much less than that of the adjacent Sichuan Basin. The low viscosity finding is consistent with previous observations of low seismic velocity and high electrical conductivity in this region, all of which support the model of ductile lower crustal flow beneath the Tibetan Plateau.