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Stress evolution following the 1999 Chi-Chi, Taiwan, earthquake: Consequences for afterslip, relaxation, aftershocks, and departures from Omori decay

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We explore how Coulomb stress transfer controls the aftershock distribution, afterslip, and long-term seismicity in a thrust fault system. The 21 September 1999 M_w=7.6 Chi-Chi shock, with a surface-cutting 30°-dipping ramp fault merging into a near-horizontal decollement, is typical of continental thrust systems throughout the world, and so inferences drawn from this uniquely well-recorded event may be widely applicable. In addition, both the coseismic and postseismic deformation were recorded by a dense GPS network spanning the northern half of the rupture. We find that coseismic slip in a ramp-decollement system unloads the upper crust, which is then reloaded by afterslip and viscoelastic relaxation. First, we find that the spatial and depth distribution of aftershocks and their focal mechanisms are consistent with the calculated Coulomb stress changes imparted by the fault rupture. Second, we find that the afterslip largely occurred where the calculated coseismic stress increased on the ramp, decollement and its down-dip extension, subject to the inference that fault friction is very low along the decollement. Third, inclusion of viscoelastic relaxation enhances the fit to the GPS data and aftershock distribution. Thus, we argue that aftershocks and afterslip were at least partially triggered by the coseismic stress increases. The afterslip, asthenospheric relaxation, and large aftershocks altered the crustal stress distribution, which further modified the decay and distribution of aftershocks.