Fault coupling controls fine-scale fault structure and kinematics along the San Andreas Fault

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Abstract

The central San Andreas Fault (CSAF) exhibits diverse modes of seismic and aseismic deformation along a highly localized fault zone. Although the main fault trace appears as a simple planar fault, small earthquakes exhibit highly complex fault geometry and slip motions. Here, we investigate the focal mechanisms, seismicity, and repeating earthquakes from 1984 to 2015 along a 6-km-wide 170-km-long segment of the CSAF to investigate both the main fault coupling and the spatiotemporal variations of surrounding small earthquakes. We propose a simple mechanical model of a freely slipping shallow seismogenic layer with several locked patches driven by inter-seismic slip at 34mm/yr beneath the seismogenic layer. The simulated fault creep rate, creep direction, and surface deformation are consistent with those estimated from recurrence rate of repeating earthquakes, slip directions of repeating earthquake focal mechanisms, and the surface creep observed from INSAR data. The modeled off-fault stress field also shows high correlation with the variation of focal mechanism properties of M>=1 earthquakes around the fault. The results suggest that the variation of fault coupling along the CSAF play a primary role in the seismic and aseismic deformation patterns both on-fault and off-fault. The highly coupled patches along the CSAF indicated by the model show large slip deficits that could potentially be compensated by moderate-sized earthquakes or by accelerated afterslip following large earthquakes on adjacent fault segments.