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The evolution of hillslope strength following large earthquakes

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Earthquake-induced landslides play an important role in the evolution of mountain landscapes. Earthquake ground shaking triggers near-instantaneous landsliding, but has also been shown to weaken hillslopes, preconditioning them for failure during subsequent seismicity and/or precipitation events. The temporal evolution of hillslope strength during and following primary seismicity, and if and how this ultimately results in failure, is poorly constrained due to the rarity of high-magnitude earthquakes and limited availability of suitable field datasets. We present results obtained from novel geotechnical laboratory tests to better constrain the mechanisms that control strength evolution in Earth materials of differing rheology. We consider how the strength of hillslope materials responds to ground-shaking events of different magnitude and if and how this persists to influence landslide activity during interseismic periods. We demonstrate the role of stress path and stress history, strain rate and foreshock and aftershock sequences in controlling the evolution of hillslope strength and stability. Critically, we show how hillslopes can be strengthened rather than weakened in some settings, challenging conventional assumptions. On the basis of our laboratory data, we consider the implications for earthquake-induced geomorphic perturbations in mountain landscapes over multiple timescales and in different seismogenic settings.