What controls the duration of aftershocks, and why it matters for probabilistic seismic hazard assessment

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Is seismicity in slowly deforming regions such as the central U.S., Australia, and inner Honshu composed largely of aftershocks of past mainshocks, or is the rate of earthquakes steady and so indicative of future earthquake potential? While aftershock productivity grows with mainshock magnitude, aftershock duration—the time until the aftershock rate decays to the pre-mainshock rate—may not. Basham and Adams [1983] and Ebel et al. [2000] proposed that intraplate seismicity in Eastern North America could be aftershocks of mainshocks that struck hundreds of years beforehand, a view consonant with rate/state friction [Dieterich, 1994], in which aftershock duration varies inversely with fault stressing rate. Most tests of the Dieterich relationship use inconsistent duration estimates and ambiguous proxies for the stressing rate, such as mainshock frequency. Here, we estimate aftershock durations of the 2011 M=9 Tohoku-oki rupture at twelve sites up to 250 km from the source, as well the as near-fault aftershocks of eight large Japanese mainshocks, sampling faults slipping 0.01 to 80 mm/yr. We find that aftershock sequences lasted a month on the fastest-slipping faults and are projected to persist for >200 years on the slowest. If slip rate or background seismicity rate are roughly proportional to stressing rate, this supports Dieterich and Ebel's hypotheses. Thus, the hazard associated with aftershocks may depend on local tectonic conditions rather than the mainshock magnitude, and that aftershock sequences can masquerade as background seismicity, misguiding and inflating hazard assessments in some intraplate regions.

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