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Omori's Law and Fluid-driven Aftershocks

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The underlying physical mechanism driving aftershocks of large earthquakes has remained elusive since Omori first empirically observed in 1894 that aftershocks decay as approximately 1/t. To date, only the rate-state formulation of friction and damage models predict Omori's Law, but no physical model exists that can match both the spatial and temporal evolution of real aftershock sequences from tectonic events. Using a simple numerical model of non-linear diffusion and a step-wise increase in permeability at the onset of slip, I show that the spatial and temporal evolution of aftershocks map the propagation of a pressure pulse emanating from over-pressured regions generated either by co-seismic thermal pressurization or trapped fluid sources at depth. Model and data show excellent correlations in both space and time for more than twelve thousand well-located aftershocks from the 1992 Joshua Tree (M6.1), the 1992 Landers (M7.3), the 1994 Northridge (M6.7), and the 1999 Hector Mine (M7.1) earthquakes. Omori's Law emerges naturally through the permeability, exponentially increasing with reducing effective stress, and exponentially decreasing with time to mimic post-seismic precipitation processes that reseal the permeable network. The Omori fitting parameters A, B, and p collapse to a single parameter that defines the healing rate of the co-and post-seismically generated permeable network.