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Slip-rates, normal fault evolution and seismic hazards, central Italy

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The rate at which a fault slips fundamentally determines the seismic hazard because average earthquake recurrence intervals tend to decrease as slip rates increase. Slip-rates on different faults within a growing fault system are not distributed randomly in space and time, because slip-rates must produce evolving fault geometries that (a) maintain the scaling relationship between fault length and displacement, and (b) accommodate the regional strain-rate. Thus, seismic hazard is not distributed randomly in space and time, and can thus be determined through study of the spatial and temporal variations in slip-rates.

Two alternate methods for constraining seismic hazards using slip-rates are discussed. First, if strains measured either geodetically or using velocity fields derived from fault slip-rates exceed that implied by seismic moment summations for a given time period, then the excess strain may be released during impending earthquakes. The post 12-18 ka velocity field for extension in central Italy derived from observations of striated fault scarps imply strain rates (0.078 $\pm$0.02 ppm/yr, or 0.052 $\pm$0.01 ppm/yr across a distance of 63.6 km) that are broadly comparable with those from GPS/triangulation and historical seismicity (0.10-0.06 ppm/yr). However, spatial gradients in the 12-18 ka strain field of 0.04 $\pm$0.01 or 0.06 $\pm$0.01 ppm/yr over a distance of only c. 7 km along strike, indicate that the spatial resolution provided by geodetic and seismicity data are not yet high enough to assess the seismic hazard for specific faults. However, a second method, which uses the post 12-18 ka slip-rates to calculate and map the

expected numbers of shaking events with $>0.5g$ horizontal acceleration, replicates the post 1349 A.D shaking record from medieval towns. This reinforces our point that seismic hazard assessment requires that fault slip-rates are well-characterised over long timescales (multi-seismic cycles), underlining the need for understanding of the evolution of fault arrays through time.