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

G. P. Roberts (1), I. Papanikolaou (1,4), P. Cowie (2), A. Michetti (3)

(1) The Research School of Earth Sciences, Birkbeck & University College London, Gower Street, London, WC1E 6BT, UK.(2) Institute of Earth Science, School of GeoSciences, University of Edinburgh, West Mains Road, Edinburgh, EH9 3JW.(3) Universita dell’Insubria, Dipartimento di Scienze, CC.FF.MM., Via Lucini, 3, 22100, Como, Italia.(4) Faculty of Geology, Univ. of Athens, School of Sciences, Faculty of Geology, Panep/poli, 15701 Ilissia, Greece.

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.