Harvard University -- Solid Earth Physics Seminar

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4th Floor Faculty Lounge, Hoffman Laboratory, 20 Oxford St.

Fractal morphology of the roughness of fault surfaces

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The faults at the Earth's surface show complex morphology that is supposed to control earthquake nucleation, propagation, and finally rupture arrest. This morphology, as observed on exhumed slip surfaces, show striations and grooves at all scales due to the coseismic and interseismic damage that accumulates with slip. The roughness of five exhumed faults and a dozen earthquake surface ruptures was measured over a large range of scales: from 50 micrometers to 50 km. All measurements are consistent within the error bars with an anisotropic self-affine geometrical model. A unique geometrical property emerges as the morphology of the slip surfaces shows a straight line covering five decades of length-scales in a log-log plot where axes are fault roughness and spatial length scale. Therefore fault roughness is scale dependent, with a common self-affine behavior described by four parameters: two power-law exponents *H*, constant among all the faults studied and slightly anisotropic ($H_{//} = 0.58 \pm 0.07$ in the slip direction and $H_{\perp} = 0.81 \pm 0.04$ perpendicular to it), and two pre-factors showing a quite large variability. For the largest scales, for which exhumed fault surfaces are not accessible, the 2-D roughness of the surface rupture of ten major continental active faults was characterized, including the surface ruptures of the Izmit and Düzce Mw 7.0 earthquakes that occurred in 1999 on the North Anatolian Fault and for which a fault segment displays supershear rupture. For a range of scales between 200 m and 50 km, all these ruptures show the same self-affine behavior ($H_R = 0.8 \pm 0.1$), extending the analyzed scale ranges to nine decades. This scaling description of scanned fault scarps and rupture traces, both morphology markers of active structures of fault zones, is independent of the geological context and particularly the cumulated slip.