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Fault roughness evolution at seismogenic depths

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Fault surface roughness is a principal factor influencing fault mechanics, and particularly seismic rupture initiation, propagation, and arrest. In a complex feedback, roughness at a certain stage (i.e. at a certain accumulated net slip) is also a result of surface refinement processes that involve different kinds of generalized wear mechanisms. Here we investigate the roughness of slip surfaces from the seismogenic strike-slip Gole Larghe Fault Zone, exhumed from ca. 10 km depth. The fault zone is hosted in granodiorites of the Adamello batholith (Italian Alps) and exploited pre-existing joints. Individual seismogenic slip surfaces show cataclasites and beautifully preserved pseudotachylytes of variable thickness. In addition to classical structural parameters (net slip, fault rocks thickness, etc.), we determined the morphology of fault traces over almost five orders of magnitude using terrestrial laser-scanning and photogrammetry. Fourier power spectrum analysis of the fault traces revealed a self-affine behavior with Hurst exponents H = 0.6 - 0.8. Roughness of pre-existing joints is isotropic with H = 0.8. Roughness of faults at small scale (1 m to 1 mm) shows a clear genetic relationship with the roughness of precursor joints, and an evolution evidenced by anisotropy in the Hurst exponent, which ranges between H = 0.6 parallel to slip and H = 0.8 at a high angle to slip. Roughness of faults at scales larger than net slip (> 1 - 10 m) is not anisotropic and less evolved than at smaller scales. These observations are consistent with an evolution of roughness, due to generalized wear processes, that takes place only at scales smaller or comparable to the observed net slip. Based on these data, a revised model for wear along seismogenic faults will be presented.