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Interplay of seismic and aseismic deformation during brittle creep crack propagation

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Observations of temporal and spatial correlations between slow slip earthquakes and tectonic tremor activity suggest a physical relation between them. Recent hypotheses suggest that tectonic tremors are bursts of seismic energy due to the rupturing of small asperities within slow slipping regions. Here we present laboratory results of a unique experimental setting aimed at understanding the coupling between seismic and aseismic slip on creeping faults. We performed mode I crack propagation experiments on glass bead blasted and annealed 2D interfaces of transparent material (PMMA) where fracture fronts were confined to the 2D weakness plane of the heterogeneous interface. We monitored acoustic emissions (AE) with piezo-electric sensors surrounding the crack front line. We also optically monitored the rupture front line with up to 1000 frames per second. The experimental loading conditions produce quasistatic front propagation at slow average speeds. Image processing reveals de-pinning along the front that we characterize as intermittent opening during slow front propagation. Localization of acoustic emission suggest that they are associated with front moves and that events are distributed along a wide range of amplitude. The intermittent dynamics of the crack propagation, and the large scale distribution of both seismic and aseismic deformations suggest that the front move is controlled by elastic interactions due to local disorders within the material both in the creeping and brittle regimes. Using the analogy between mode I and shear modes fractures, our results translate into intermittent slip on faults linked to clustering of seismic activity produced by the breakage of asperities embedded in creeping regions.