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Up-scaling of the fracture energy in heterogeneous media during brittle creep experiments

Olivier Lengliné (1), Jean Schmittbuhl (1), Jean Elkhoury (2), Jean-Paul Ampuero (2), Renaud Toussaint (1), and Knut Jorgen Maloy (3)

(1) Université de Strasbourg, IPGS, Strasbourg, France (lengline@unistra.fr), (2) Seismological Laboratory, Caltech, USA, (3) Department of Physics, University of Oslo, Norway

The fracture energy (G_c) of an heterogeneous material is mainly controlled by the fluctuations of its local strength. However relating these microscopic variations to a global criterion defining the condition of crack propagation inside the material is not straightforward. The front dynamics at large scale in the creep regime is shown to correspond to a roughly constant value of G (energy release rate). It is also found to be well described by an Arrhenius law. It is not yet clear how this evolution law is influenced by disorders over the crack interface. Such influence has strong implications on many geological processes as the brittle-ductile transition and the nucleation process of earthquakes. Here we present a series of mode I experiments on two heterogeneous welded plexi-glass plates where we measure G_c over a wide range of scales. Material heterogeneities are generated by glass-beads blasting of the 2D surfaces prior to welding. Ruptures are confined to the 2D interface between the two plates and propagation is initiated upon loading. We track the progression of a slow rupture front line with optical imaging taking advantage of the optical contrast between ruptured and un-ruptured parts of the sample. We also continuously monitor the displacement and the applied force at the loading point. This unique experimental setting provides the possibility to estimate G_c during rupture under quasi-static rupture propagation conditions. We obtain the large-scale estimate of G from the elastic energy flux due to the quasi-static nature of the rupture propagation. Variation in the front position around its mean provides an estimate of the heterogeneity in G_c at the smallest resolvable scale. We show that the macroscopic estimates of fracture energy is not a simple average of the microscopic fracture energy at local sites. The microscopic distributions of fracture energy are systematically shifted to higher values compared to macroscopic estimates.