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Up-scaling of the fracture toughness in heterogeneous media

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The fracture toughness is an important parameter which controls the rupture of rocks or other geological materials under stress. Estimation of fracture toughness are generally obtained through indirect measurements and often fail to describe its fluctuations over different scales although these variations are present in heterogeneous material such as rocks. Here we present a series of mode I experiments on two welded plexiglass (P.M.M.A.) plates. Surfaces of the two plates were previously sandblasted in order to introduce defects. Loading of the bottom plate caused the initiation and the propagation of a crack at the interface between the two plates. We tracked the progression of the rupture front with a camera taking advantage of the optical contrast between the ruptured and the un-ruptured part of the sample. The displacement of the loading point and the force applied to the bottom plate are also continuously monitored. This original experimental setup provides us the possibility to estimate the stress intensity factor during the crack propagation from the position of the rupture front. These results are compared with the ones predicted by the Linear Elastic Fracture Mechanics (L.E.F.M.). The mean position of the crack front first provides us a large-scale estimate of the fracture toughness. We also deduced an estimate of the fracture toughness heterogeneity by looking at the variation of the front position around its mean position. These fluctuations of the fracture toughness are compared with a numerical model in order to test the physical mechanism responsible for global toughness variations, i.e. how the local toughness fluctuations are upscaled. We finally determine the entire map of local toughness values through which the crack propagates during the fracture of our heterogeneous medium.