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Acoustic investigation of rupture nucleation in the Laboratory

Alexandre Schubnel, Nicolas Brantut, Audrey Ougier-Simonin, Mathilde Adeliner, Jerome Fortin, and Yves Gueguen

ENS Paris - CNRS, Laboratoire de Geologie, Paris, France (aschubnel@geologie.ens.fr)

Triaxial compression experiments were performed on several materials (Glass, Granite, Basalt, Sandstone, Marble and Gypsum) at confining pressures ranging from 10 to 100MPa, and from room temperature to 70 degrees C. During each of these experiments, acoustic waves radiated from damage accumulation and fast crack propagation were continuously monitored thanks to a fast acoustic recorder, which enables to obtain continuous acoustogram of rupture nucleation and propagation, without the limitations of former trigger systems. In our experiments, rupture does not need to be slowed down, and the transition from quasi-static nucleation to dynamic propagation has now been systematically investigated.Comparing each material, three main observation can be drawn :

- First, the amount of damage accumulation before the dynamic rupture propagation varies from material to material, and also depends on the pressure and temperature conditions. For instance, glass, granites and sandstones are typically materials where the nucleation involves a large amount of cracking prior to rupture. In contrast, rupture in basalt at low confinement is not preceded by any damage accumulation. Finally, pre-rupture damage accumulation can also be purely aseismic, which is the case of marble for instance.

- Second, the brittle-ductile transition does not exactly overlaps the aseismic-seismic transition, at least in the conditions at which we performed our experiments. For example, marble deforms plastically beyond 50MPa, and although the deformation is ductile, a large amount of crack accumulates in the rock, which tends to make it unstable. In the same way, acoustic emissions decrease in gypsum with increasing pressure and temperatures.

- Finally, the time during which rupture propagates depends largely on the rheology. For instance, and in the case of ductile failures such as in marble, dislocation and twin accumulation is such that cracks propagation steps are small and/or slow, and thus the radiated energy release rate remains small at early stages of rupture and increases with rupture speed.

Put together, our observations clearly highlight the dependence of the radiated acoustic (and microseismic?) energy during rupture nucleation and early stages of crack propagation not only on the rupture propagation speed and the slip velocity but most importantly on the rock's lithology and rheology.