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Dynamic damage of rocks : from single fracturing to pulverization

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Can we recognize from inspection of the damaged zone of the fault the size of previous earthquakes this fault experienced? To do so, we have to understand the dynamic behavior of rocks.

Using Split Hopkinson Pressure Bars experiments, loading with known stress and strain history can be applied at strain rate as large as 1000/s. We used this device on granitic rocks from the damage zone of the San Andreas Fault. The samples are a proxy of the initial state of the natural pulverized rocks: damaged but not yet pulverized. If we load them at strain rate larger than 150/s, we could reproduce fragmentation similar to the pulverized outcrop of Lake Hughes, on the Mojave segment of the San Andreas Fault (Doan and Gary, 2009). Below this strain rate, the samples failed by simple fracturing. We could therefore put constraints on the preexisting earthquakes that occurred on this part of San Andreas Fault.

How are these conclusions affected by change lithology? How are they affected by their initial damage? We review in this presentation the experiments we did on less damaged granite and limestone.

We first tested intact specimen of the Tarn Granite. This rock has the same composition and grain size than the San Andreas Fault, but is less fractured. We found a similar transition as for the San Andreas Fault samples: beyond a critical strain rate value, the samples failed not with a few fracture, but with an intense fracturing. We found no intermediate state between these two extreme states. The strain rate threshold value is about 250/s, higher than for the damage San Andreas Fault samples. The intact granite has also higher strength. This is in accordance with the statistical theory of Hild et al. (2003).

However, carbonate rocks display a different damaging behavior. Contrary to granite, limestone experience progressive pulverization. Although there is a slight strain rate control, we found that the microfracture intensity is controlled by strain. Beyond 2%, there is an intense fracturing. The fracture network is different than for the granite: it displays a hierarchical pattern reflecting incremental damage pattern.

Numerical simulations by Shenoy and Kim (2003) suggest an explanation for such a behavior. They did numerical simulations of fragmentation with a heterogeneous distribution of stress in a otherwise homogeneous medium. If the stress heterogeneity is large, the grain size of the fragments decreases progressively with strain rate. In the other case, grain size decreases abruptly beyond a critical strain rate. Understanding of the fragmentation of rocks requires an understanding of the statistical physics of fracture interaction.

References:

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