Subject offered for a contract starting october 2016

SUBJECT TITTLE: "*EARTHQUAKE RUPTURE SPEED, FROM SLOW TO SUPERSHEAR*"

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Host lab/ Team :
ENS- Laboratoire de Géologie de l'ENS- UMR 8538

Financing: ERC grant REALISM (Reproducing Earthquakes in the Laboratory: Imaging, Speed and Mineralogy)

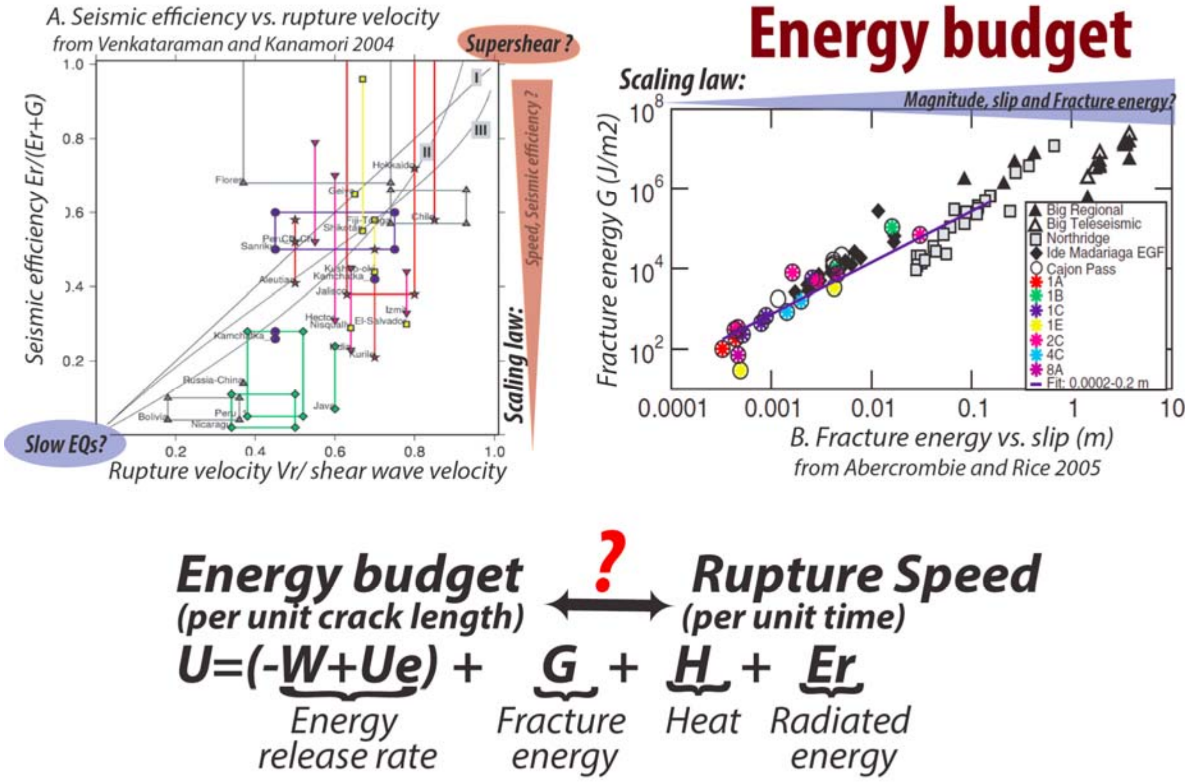
For more information go to http://ed560.ipgp.fr, section: Offres de these (PhD offer), You must apply on the Doctoral School website

It is often assumed that rapid ruptures can cause more damage than slow ones, and hence the reason why we need to study and understand what controls the rupture speed. From a theoretical point of view, if the earthquake rupture propagates infinitely slowly, i.e. quasi-statically, all the elastic energy available is dissipated locally into heat and fracture energy). On the other hand, if it propagates at seismic wave velocities (3-6 km/s in the Earth's crust and much higher at deeper levels), most of the energy is converted into seismic waves.

Up to this day, the earthquake energy budget cannot be fully constrained from seismological data, neither locally, or even as a spatial average along the fault. Attempts were made to measure seismic efficiency, that is how much of the elastic energy is radiated by seismic waves, and of earthquake fracture energy, that is the energy dissipated locally for the fracture to further propagate. Both in the laboratory and in the field, fracture energy was observed to scale with the earthquake magnitude size and the amount of slip. Seismological inversions of rupture speed (excluding supershear or slow earthquakes) have shown an apparent scaling of seismic efficiency with rupture velocity. Given the uncertainties on the rupture speed, this scaling needs to be confirmed, but up to this day, the radiated energy has never been measured in the laboratory. Finally, because of the impossibility to access the stress and strain conditions at depth, the heat terms and energy release rate are not well constrained, so that in the end, our understanding of the earthquake energy budget is still very incomplete.

Our objectives are to:

1- Reproduce a complete spectrum of rupture speeds, from slow to supershear;
2- Measure independently the energy release rate (stress and strain at the onset of rupture), the fracture energy (including on and off-fault damage terms), the heat produced, the radiated energy (including that radiated by damage) and the rupture speed;
3- And then, for the first time, fully constrain the earthquake thermodynamic energy budget in the laboratory, at in-situ PT conditions.



The earthquake energy budget consists of 4 non-independent terms: the energy release rate (by unit crack length) is the energy driving rupture propagation; the fracture energy G is the energy dissipated locally into fresh fracture surfaces; Heat is the energy dissipated locally into heat by frictional - or viscous/plastic – processes. Finally, the radiated energy is the energy radiated by seismic waves. These terms depend on the rupture and sliding velocities, the amount of slip, the strain rate and the stress drop. In case mineral transformation play a role, mineral latent heat and volume change should also be taken into account.

- *Methodology:* Given the uncertainties on the stress and strain conditions at depth and on the rupture speed, and the impossibility to access the heat term, our understanding of the earthquake energy budget is still far from complete. Our rationale is to study rupture processes in rock samples that can exhibit increasing plasticity (marble or shales for instance). Heat maps of the surface will be produced using a newly developed carbon matter thermometer deposited directly onto the fracture surface, while the radiative terms will be independently evaluated from far-field accelerograms and slip-functions.

This PhD. project is fully funded via an ERC consolidator grant starting Oct. 1st 2016. In total, three PhD students, two post-doctorates and one research engineer will also be hired over the course of the project. The candidate is expected to work and collaborate within a team.

Knowledge and Skills (not essentially required, but desirable)

- Familiarity with rock physics rock mechanics technology and methods
- Ability to communicate effectively, both orally and in writing, with a wide range of people
- Familiarity with data processing and signal analysis using Matlab/Python
- Commitment to high quality scientific research.
- Motivation to carry out and publish scientific research and to develop a scientific career.
- Ability to work collaboratively as part of a team.