Postdoctoral Fellowship – INSA Lyon – LaMCoS – ANR project –24 months

Do Rock fault Asperities Melt or Abrade during earthquakes? (DRAMA)

Presentation of the Institute and of the Lab

INSA Lyon (https://www.insa-lyon.fr/) is a generalist engineering school located in Lyon, France. It ranks among the ten best engineering schools in France, and trains about 1,000 engineers each year in topics as diverse as Civil, Mechanical, Electrical, Biochemical, or Environmental Engineering. Our institute also hosts 23 laboratory, 600 permanent researchers of international standing, and about 650 PhD students.

Among these laboratories, the LaMCoS (Laboratory of Contact and Structural Mechanics, https://lamcos.insa-lyon.fr/) carries out research on understanding and controlling the behavior of mechanical structures and systems by studying their interfaces. We innovate to improve understanding of fundamental phenomena to anticipate major societal challenges and respond to technological problems in the fields of Transport, Energy, Health, Biomedicine, Sport and Machine Tools. The lab hosts about 60 permanent researchers and about 100 PhD students. The postdoc will take place in the very dynamic Tribology team, which focuses on the behavior of mechanical interfaces using both numerical and experimental approaches. Among very various mechanical systems, rock faults are one of the hot topics that are studied in the team, with a particular focus on the local phenomena at stake during seismic or aseismic sliding.

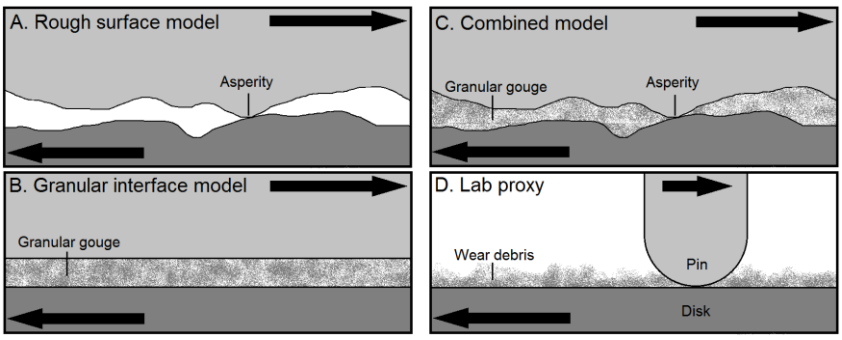

Fig.1. Two opposite representations of seismic faults (A. and B.), a more unified view (C.), and its laboratory proxy (D.)

Scientific context

In order for earthquakes to propagate, the friction force opposing to the relative motion of the two walls of a fault needs to diminish during this motion. Finding the reasons for this weakening is one of the most important challenges of modern earthquakes physics. When it comes to conceptualizing seismic faults, two opposite views are commonly encountered. In the first representation (Fig.1A), seismic faults are seen as the interface between two surfaces of bare rock, with a roughness extending at all scales. In the second representation (Fig.1B), seismic faults are seen as mathematical planes separated by a certain thickness of granular gouge created by abrasive wear of the surfaces during previous slips. The project DRAMA aims to question these two representations and to merge them in a single fault model (fig.1C-D), by installing a dialog between tribology and geomechanics. The concept of asperity is the central question. We will thus investigate the response to shearing and the energy budget of a single asperity during seismic sliding, and their implications on fault weakening.

Research objectives

Two major tools will be developed in this project. The first one is an original experimental apparatus. It consists in a pin-on-disc tribometer with some novel features (Fig.2). Two pieces of rock (a centimetric "pin" with a hemispherical extremity and a large flat "disk") with controlled roughness and geometry will be submitted to frictional sliding. Contact conditions will be similar to those expected for a fault asperity in co-seismic conditions: contact size of 0.1-1 mm, contact normal stress of 10-200 MPa, sliding velocity of 0.1-1 m/s, and sliding distance of 1-10 m. A number of high-sampling-rate sensors (mechanical, thermal, optical, etc.) will be used to constrain the observation of the asperity contact during the simulated seismic events. Complete post-mortem analyses of the wear tracks with optical microscopy, SEM and X-ray tomography will allow to quantify melt and/or cataclasis production and to reconstruct friction scenarios in accordance with the time-series acquired during tests.

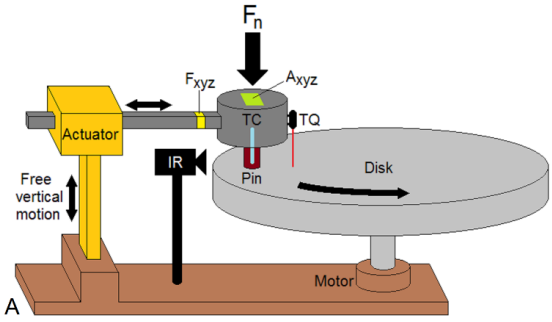

Fig.2. Sketch of the experimental device

The second tool will be an ambitious numerical clone of the experimental device (Fig. 3). It will be implemented in the simulation code MELODY, and will build on recent (and more than promising) results obtained in (i) the simulation of partial melting within co-seismically sheared granular gouges and (ii) the simulation of rock degradation and gouge emission in sliding rock faults. The simulations will reproduce the pin-on-disk sliding contact and allow the asperity to spontaneously evolve towards abrasion, melting, or both. They will involve a coupling between the Discrete-Element Method (DEM) for the bulk degradable rock and the granular gouge, the Multibody Meshfree Approach for the molten gouge, and a heat creation and diffusion scheme in order to trigger and control melting.

The project is founded by the french ANR (Agence Nationale de la Recherche). The postdoctoral researcher is expected to work mostly on the experiments (finalizing the design of the apparatus and of its instrumentation system, running the first tests, analysing the initial and the worn samples, processing experimental data), but may also run simulations if particularly interested in this aspect of the project.

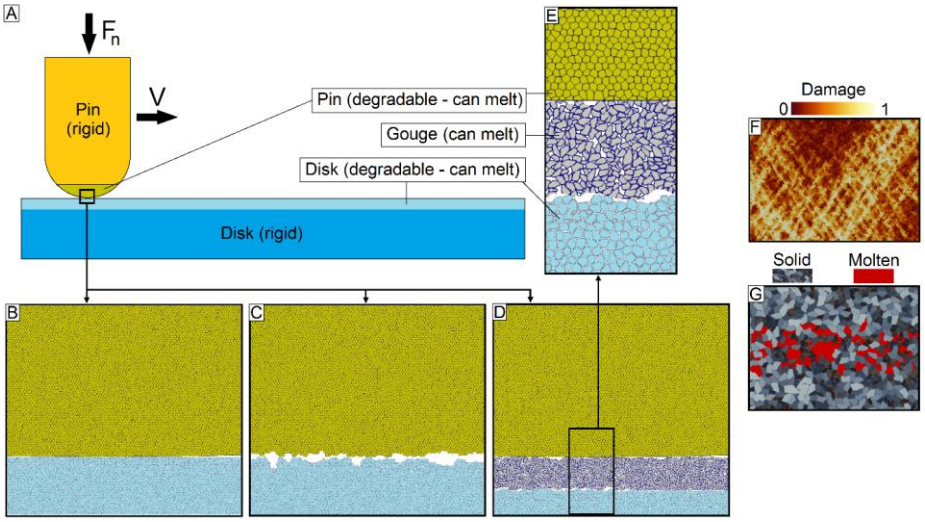

Fig.3. A. Sketch of a typical simulation, with different possible initial conditions (B., C., and D.); E. Zoom on discrete gouge and degradable pin and disk surfaces; F. Example of simulated damage patterns in discretized brittle rock [13]; G. Example of partially molten gouge with the fluid phase approximated by very soft incompressible grains [12]

Associated researchers

The principal investigator is Guilhem Mollon (http://guilhem.mollon.free.fr), he will be supervising the postdoctoral researcher in collaboration with a number of internal and external scientific partners. Aurélien Saulot (Prof.), Lionel Lafarge (Mechanical design engineer) and Amandine Ferrieux-Pâquet (Instrumentation engineer), from the LaMCoS, will help for the daily work. And Alexandre Schubnel, Stefan Nielsen, Cino Viggiani and Edward Andò, from national and international institutions, will contribute on various scientific aspects of the project.

Fig.4. Views of Lyon

Requested training and experience

The recruited postdoctoral fellow will hold a PhD in one of these disciplines: Rock Mechanics, Fault Mechanics, Tribology, Surface and Friction Science, Mechanical Engineering, or Granular Physics. He/She will be experienced in lab work, especially on the experimental side, and in experimental data processing. He/she will also have a minimum track record in scientific publications, and an interest in seismic fault mechanics. French or English speakers will be preferred.

Location, duration, starting date, salary

The work will mostly take place at the LaMCoS, in Lyon-Villeurbanne, on the La Doua Campus (https://goo.gl/maps/MGMimAttGJAcBTiD6), close to the gorgeous "Parc de la Tête d'Or" and about 20 minutes from Lyon City Center by public transportation (Fig. 4). Several research trips might be needed to Paris, Durham, Grenoble, or Lausanne. The Fellowship is for 24 months, starting around September 2022. Monthly salary is ~2000-2200 €.

Procedure and contact

You are welcome to send your application (including extensive CV, list of work and publications, a short letter expressing your experience, connections and interest in this topic, and references contacts) to the following email address: guilhem.mollon@insa-lyon.fr. Applications will be closed by the end of the summer 2022, or earlier if the perfect candidate is recruited before.