

## **PhD position: Clay thermodynamic and friction properties: Which influence on earthquakes?**

Institute of Earth Sciences of Orléans (ISTO), University of Orléans, France

### **Context:**

Plate boundary fault zones exhibit a wide range of dynamic behaviours, from aseismic slip to mega-earthquakes. So far, there is no consensus on a model describing the processes controlling these fault behaviours. A possible answer might lie in the properties of smectite, a swelling clay mineral that form the core of many of the fault zones and that is able to adsorb significant amounts of water in-between nanometric interlayers. Despite their potential importance, the thermodynamics of hydration/dehydration reactions in smectite and the connections between these reactions and the fault deformations remain poorly known. These fundamental questions are the heart of the ANR project SMEC funding this Ph.D. position.

The objectives of the SMEC project are: 1) to decipher the thermodynamics of hydration/dehydration in smectite, as a function of the conditions of confining pressure, fluid pressure, and temperature, 2) to link hydration to the mechanical behaviour, and 3) to upscale this coupling between hydration and mechanics to the scale of faults in the perspective of applying it to address large-scale natural examples. These questions will be addressed using a combination of laboratory experiments and numerical simulations from the clay mineral layer to the plate boundary fault.

### **Objective:**

Within the framework of SMEC, the objectives of the present Ph.D. project are twofold. The first goal is to constrain experimentally the conditions of dehydration/hydration in smectite. Experiments of dehydration/hydration reactions will be carried out at ISTO, using a semi-transparent, high-pressure and high temperature vessel at ISTO equipped with in situ XRD monitoring. XRD patterns will be modelled in terms of water layer distribution in smectite interlayer space. The role of the different parameters ( $P_{\text{fluid}}-P_{\text{solid}}-T$  conditions, nature of interlayer cation) on the reactions will be assessed. The details of dehydration/hydration reactions will be analysed on the basis of complementary Synchrotron experiments using the same experimental setup.

In a second part, the Ph.D. project will focus on the effect of such hydration/dehydration reactions on smectite mechanical properties. Friction experiments will be designed and carried out in the Paterson rig to analyse the mechanical properties of smectite aggregates. Steady-state friction coefficient, as well as rate-dependence, will be estimated as a function of interlayer water, interlayer cation, temperature and confining/pore pressure. Second, the role of dehydration reactions occurring during deformation to trigger slip instabilities, will also be explored.

These experimental results will then be used as inputs to develop theoretical and numerical approaches of smectite thermodynamics and mechanical properties (not handled in the present position but in other parts of the overall SMEC project).

### **Ph.D. supervision and scientific environment:**

The present Ph.D. project will be supervised by Hugues Raimbourg (Professor, ISTO, Orléans), Eric Ferrage (Directeur de Recherche CNRS, IC2MP, Poitiers), Marianne Conin (Associate Professor, GéoRessources, Nancy), and Benoît Dubacq (Chargé de Recherche CNRS, ISTEP, Paris). The experiments will be carried out in close collaboration with Rémi Champallier and Benjamin Langérome (Research engineers, ISTO, Orléans). The starting date is planned in 2024. The position is funded for 3 years.

The project will be hosted in the Institute of Earth Sciences of Orléans (<https://www.isto-orleans.fr/en/home/>) at the University of Orléans (<http://www.univ-orleans.fr/en>). SMEC project, encompassing the present Ph.D. position, involves a consortium of 7 labs and the recruitment of 3 Ph.D. positions. Regular trainings and scientific discussions between the 3 Ph.D. positions and the scientific partners of SMEC will be organized.

### Requirements and application procedure:

We are looking for a highly motivated student with a strong interest in deformation processes and mineral reactions. The applicant should hold a Master degree (or equivalent) in Earth Sciences or Mechanics.

Enquiries regarding the specifics of the project should be directed to Hugues Raimbourg: [hugues.raimbourg@univ-orleans.fr](mailto:hugues.raimbourg@univ-orleans.fr).

The application should include a full CV, transcripts of academic degrees, a statement of research interests and the contact information of two potential referees. The application should be submitted to [hugues.raimbourg@univ-orleans.fr](mailto:hugues.raimbourg@univ-orleans.fr) as a single pdf. Applications will be possible from the **1<sup>st</sup> of March 2024**.