Master internship

Mechanics of swelling clay faults: granular approach

Supervisor: L. Brochard (Laboratoire Navier, École des Ponts/Univ. Gustave Eiffel/CNRS)

Context

Plate boundary fault zones exhibit a wide range of dynamic behaviors, from aseismic slip to mega-earthquakes. So far, there is no consensus on a model describing the processes controlling these fault behaviors. 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 minerals. Despite their potential importance, the thermodynamics of hydration/dehydration reactions in smectite and the connections between these reactions and the fault deformations, is not yet known. These fundamental questions are the heart of the ANR project SMEC of which this internship is part.

Objective

The modeling of part of the SMEC project propose to combine molecular simulations, granular modeling and micromechanics in order to relate the hydration/dehydration reactions of smectites to the mechanical behavior of faults zones. The proposed internship will focus on the granular modeling part and will build on a recent granular model of clays[1], coarse-grained from the molecular scale, that is able to capture both hydration and mechanics at the scale of the clay matrix (µm). While the mechanics at the nanoscale has little to do with the macroscopic behavior, the mechanics at the matrix scale already exhibits most features of usual clay mechanics (plasticity, logarithmic response to compression, thermal compaction). Yet, the interplay between hydration and the shearing response, at the heart of fault stability, is poorly known, and will be the first objective of this internship. Particular attention will be paid to investigate the hydration states representative of fault conditions, and especially conditions likely to trigger instabilities by dehydration.

Practical information and applications

This internship will be located at Navier laboratory (Champs-sur-Marne, Paris region) for 5-6 months, under the supervision of Laurent Brochard (multiscale team), starting in February or March 2024. A Ph.D. at Navier Laboratory that can start in fall 2024 is planned in the continuity of this internship, funded by CNRS within the scope of the ANR SMEC. The applicants must be enrolled in a Master of Science (last year) or equivalent in the field of (geo)-mechanics and/or physics of materials (or close subject), with a special taste for numerical work and modeling. They must be able to communicate fluently in English, both written and spoken. The interested applicants are invited to apply by email by sending a CV, a motivation letter and their transcripts to L. Brochard (laurent.brochard@enpc.fr).

[1] Asadi, F., Zhu, H.-X., Vandamme, M., Roux, J.-N., & Brochard, L. (2022). A meso-scale model of clay matrix: the role of hydration transitions in geomechanical behavior. Soft Matter, 18(41), 7931-7948.

6 et 8 avenue Blaise Pascal – Cité Descartes – Champs-sur-Marne-F-77455 MARNE-LA-VALLÉE CEDEX 2
email: laurent.brochard@enpc.fr