Title

Hydromechanical modeling of claystones behavior: structural and induced anisotropy, damage/permeability relationship

Thesis topic

The development of numerical modeling tools to predict the short and long-term extension of the damaged zone (EDZ) around underground structures in the framework of thermo-hydro-mechanical couplings is a topic of common interest for INERIS and Andra.

Several models (hydromechanical, damage-viscoplastic and anisotropic elastoplastic) have been developed and used to understand the hydromechanical behavior around structures of the underground laboratory Meuse-Haute Marne (LS-M/HM) from in situ measurements. A comparative investigation of experimental measurements and numerical predictions clearly showed the need to take at least into account the anisotropic behavior of claystones in order to reproduce the observed pore pressure peaks.

The experimental observations show that in addition to the inherent anisotropy present in the claystones, their mechanical behavior strongly depends on the loading direction. Indeed, during loading, the material properties (mechanical, hydraulic and thermal) change in relation to the propagation of microcracks in certain preferred directions. This results in the formation of the EDZ (Excavation Damaged Zone): that is to say, the co-existence of a structural anisotropy of claystones but also an induced anisotropy.

The objective of this thesis is to enrich the knowledge of the rheological behavior of claystones by developing a macroscopic phenomenological model of the hydromechanical response accounting for:

- the structural (transverse isotropy) and induced anisotropy (initiation, propagation and coalescence of microcracks);
- the effect of induced cracking on the evolution of mechanical and transport properties (permeability, porosity ...). Particularly, damage-induced permeability tensor changes will be evaluated.

After a state of the art, an anisotropic elasto(plastic)damage model with hydromechanical coupling will be proposed to reproduce the experimental observations under saturated conditions. This model will be implemented in a finite element code (COMSOL Multiphysics) and validated on the basis of laboratory test simulations under drained and undrained conditions.

The second step will be to reproduce some of the in situ experiments (isothermal and non-isothermal) and "Mine-by test" performed at the LS-M / HM laboratory since 2004, so to evaluate if the predictions are consistent with the current field observations. In particular, the spatiotemporal evolution of convergences, strains, pore pressure and damage parameters will be discussed. Finally, a comprehensive methodology for modeling LS-M/HM structures will be proposed.

This research work will be conducted in collaboration with GeoRessources Laboratory (Multi-scale Hydro-Geomechanics - UMR 7359 - GeoRessources UL) and **Andra**.

Required skills

Solid background in mechanics and / or poromechanics, numerical methods and modelings. Liking and interest in interpretation of laboratory and in situ experiments will be appreciated. Self-motivation and initiative, ability to work in team.

Contacts

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The deadline to submit the applications including the CV, motivation and supporting letters is **15 June 2016.**