Micromechanical modeling of geomaterials by considering the microstructural anisotropy

- **Doctoral school**: Science and Engineering for "Ressources, Processes, Products and Environment" (RP2E)
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- **Fellowship** : 1684,93 Euros per month ; **Starting date and duration**: October 1st, 2018, 36 months
- **Candidate** : Highly motivated by research in theoretical and numerical modeling, he (she) has a good background in mathematics and mechanics of materials. An experience in finite element method is welcome. He (she) appreciates working in a team. He (she) is autonomous and has initiative. He (she) writes and speaks English fluently.
- **Deadline for application** : April 30th 2018

Context and objective:

One of the most important subjects in mechanics of materials is to describe the macroscopic behaviors by considering the evolution of the complex microstructures. It is especially for the porous composite geomaterials (e.g. marl and argilite rocks) relating to the propagation of the microcracks and the growth of the microvoids which enormously affect their damage process. In the region "Grand Est" of France, due to their low permeability, these rocks are usually presented as the materials that construct the natural and engineering structures for the underground storage (e.g. the storage of the radioactive waste, etc.). In this thesis, we will particularly focus on the application of the micromechanical modeling that is going be developed to this class of materials. The objective is hence principally to study the mechanical behaviors of the micro-cracks by taking into account the microstructural anisotropy and by applying the analytical and numerical homogenization techniques to the damage analysis of these geomaterials.

In the first part of the work, we are interested in the microporoelastic modeling in order to estimate the effective properties of the studied geomaterials with an anisotropic complex microstructure. This microstructure will be represented by a Representative Elementary Volume (RVE) generated by the RSA approach (Random Sequential Adsorption [1]) with various forms of micro-voids and micro-inclusions that corresponds to the recent work in "Multiscale HydroGeomechanics" team of Laboratory Georessources (e.g. microtomographical observations [2]). Different studies will be realized by adopting the numerical homogenization (i.e. method based on full field simulations) and compared with the theoretical results that were/will be obtained through the analytical homogenization (i.e. method based on mean field derivations). It is actually important, for the next modeling of micro-cracks induced damage, to focus on the case of RVE with the oblate spheroidal voids which is particularly corresponding to the nature form of micro-voids near the penny shaped cracks of argilites.

Moreover, the macroscopic behavior of the studied geomaterials is strongly affected by the damage induced by the propagation of micro-cracks and the growth of the micro-voids. The damage process generally introduces the deterioration of the mechanical properties that induces an softening precursor of various types of instabilities such as the strains localization. In the second part of this work, we are therefore interested in the study of the material damage, in particular concentrate on the initiation and propagation of the micro-cracks in the microstructure. A Phase field method [3,4] will be developed specifically based on the theories of damage micromechanics [5]. The approach combining the numerical homogenization and the phase field theory allows to obtain diverse reference results permitting to assess those obtained from the analytical homogenization.

References:

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[2]: *K. Kalo. Caractérisation microstructurale et modélisation micromécanique de roches poreuses oolithiques. Thèse de doctorat, Université de Lorraine,2017.*

[3]: *Francfort and Marigo, Revisiting brittle fracture as an energy minimization problem. J. Mech. Phys. Solids, 1998, 46(8), 1319-42.*

[4]: *C. Miehe, F. Welschinger, M. Hofacker. Thermodynamically consistent phase-field models of fracture: Variational principles and multi-field FE implementations. Int. J. Numer. Meth. Eng. 2010, 83, 1273-1311*

[5]: *L. Dormieux and D. Kondo. Micromechanics of Fracture and Damage, Wiley, 2016.*