12 months Postdoctoral position in collaboration between Inria and IFPEN, Nice, France.

Non matching discretizations of mixed dimensional poromechanical models with frictional contact at matrix fault interfaces, application to fault reactivation assessment in CO2 storages.

The simulation of coupled poromechanical processes in fractured/faulted porous media plays a key role in many geoscience applications. This results from the ubiquity of fractures or faults in geology and from their strong impact on the fluid flow and mechanical behavior of the rocks. This is in particular the case of CO2 geological storage assessment for which the risk of CO2 leakage through reactivated faults as a result of injection must be carefully investigated.

The discretization of such models is quite challenging due to the geometrical and geological complexity of the media, combined with the highly constrated scales and physical properties and to the strong nonlinearities involved in such coupled processes. An efficient modelling approach amounts to represent the fractures or faults as interfaces coupled with the surrounding porous rock called the matrix. This reduction of dimension is achieved by averaging the equations and unknowns in the fracture width and by imposing ad hoc transmission conditions at interfaces, leading to so-called mixed-dimensional models.

This project follows, on the one hand, the PhD thesis of Julien Coulet at IFPEN dealing with Virtual Element Methods (VEM) on polytopal meshes for poromechanical models [3] (without taking faults into accounts), and, on the other hand, the researches on mixed-dimensional poromechanical models in fractured/faulted porous media conducted in the Inria project team Coffee in collaboration with Jerome Droniou from Melbourne (`https://math.unice.fr/~massonr/HDTHM/HDTHM.html`) [1]

The objective is to extend these researches targetting the simulation of fault reactivation in CO2 geological storages. The model should account for the coupling between the mechanical deformation of the matrix, the mechanical behavior of faults (with contact, friction and slip), as well as the fluid flow in the porous matrix and along the faults.

The discretization will take into account the geometrical constraints of such geological models. It will be based on polytopal meshes non-matching at matrix fault interfaces. We will focus on VEM methods for the mechanics in order to exploit their robustness and flexibility in terms of meshes and order of approximation. A key point of this work is to integrate an efficient discretization of the contact mechanics at matrice fault interfaces. It could be based on a mixed method with vectorial Lagrange multipliers [4, 1], or on a consistent Nitsche penalization of the contact conditions [2]. The discretization of the mixed-dimensional flow model will be based on an Hybrid Finite Volume scheme adapted to polytopal and non-matching meshes.

Applicant background: Applicant should have a PhD in applied mathematics related to the discretization of partial differential equations and scientific computing. She/he should be experienced with a scientific programming language such as Fortran, C or C++ and be interested in applications and team working.

Framework : The postdoctoral project is part of a collaboration between IFPEN and l'Université Côte d'Azur (laboratoire de Mathématiques J.A. Dieudonné (LJAD) and joint LJAD-Inria project team Coffee).

Location : The position will be held at LJAD on the Campus of Valrose in Nice with periodic meetings at IFPEN in Rueil Malmaison.

Duration and starting date: the duration is for 1 year and the starting date before the end of 2022.

Salary: About 2150 Euros net/month.

Application : Send application with CV, letter of motivation, and references to
roland.masson@univ-cotedazur.fr,
isabelle.faille@ifpen.fr,
guillaume.enchery@ifpen.fr

References

[1] F. Bonaldi, J. Droniou, R. Masson, and A. Pasteau. Energy-stable discretization of two-phase flows in deformable porous media with frictional contact at matrix–fracture interfaces. *Journal of Computational Physics*, 2022.

[2] F. Chouly, M. Fabre, P. Hild, R. Mlika, J. Pousin, and Y. Renard. An overview of recent results on nitsche's method for contact problems. In Stéphane P. A. Bordas, Erik Burman, Mats G. Larson, and Maxim A. Olshanskii, editors, *Geometrically Unfitted Finite Element Methods and Applications*, pages 93–141, Cham, 2017. Springer International Publishing.

[3] J. Coulet, I. Faille, G. Vivette, and F. Nataf. A fully coupled scheme using virtual element method and finite volume for poroelasticity. *Computational Geosciences*, 2019.

[4] B. Wohlmuth. Variationally consistent discretization schemes and numerical algorithms for contact problems. *Acta Numerica*, 20:569–734, 2011.