École des Ponts ParisTech

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IFSTTAR

Navier

PhD position in Geomechanics

Numerical modelling of the hydromechanical behaviour of multiphase fractured porous media: Analysis of fracture propagation conditions

Hydraulic fracturing of rocks which is the phenomenon of fracture propagation under fluid phase forces, is a technique used in petroleum engineering and geothermal energy and a also risk studied for geological storage projects, in particular, of crabon dioxide.
In the framework of linear fracture mechanics, the crack propagation is modelled by using the concepts of fracture toughness and stress intensity factors. In porous materials the effective stress concept has been shown to be efficient for modelling the mechanical behaviour of the solid frame, especially for elastic-plastic deformation. However, the application of this concept to crack propagation merits a deep examination. In a porous material under non uniform pressure, the pressure field gradient is, as well as the stress field, singular at the crack-tip. The sharp variation of the pressure in the neighbourhood of the crack and the possible interactions between different fluid phases raise the difficulty of defining a relevant effective stress at the crack tip. Hydraulic fracturing in porous rocks constitutes yet an open problem despite of numerous works devoted to this topic (Bjerrum et al. 1972, Jaworski et al. 1981, de Pater et al. 1994). A relevant concept of effective stress for crack propagation in the context of multiphase porous materials requires specific research work. Progress on this issue can be done through the numerical modelling of pore pressure and stress fields in the vicinity of a crack tip under multiphase flow in a porous material.

The PHD thesis research work consists first in a deep theoretical investigation of the conditions of fracture propagation in a porous material. The case of a monophasic material will be first considered and then extended to the case of multiphase material. A model for crack propagation in porous materials will then be developed based on theoretical considerations and numerical simulation results of stress and pressure fields around a fracture tip The model will then be implemented in a Finite Elements code and applied to the study of fracture propagation risks in CO2 storage projects in depleted oil reservoirs.

The PHD thesis will be achieved in the framework of the ANR project SEED-FISIC, at Laboratoire Navier, Ecole des Ponts ParisTech, supervised by Ahmad Pouya.

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