Simulation numérique de fracturation hydraulique à l'échelle mésoscopique à l'aide d'un modèle lattice

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Characterizing the path of the hydraulic fracture in a heterogeneous medium and the change of the transport properties of this medium is one of the challenges of current research on hydraulic fracturing.
A 2D lattice hydro-mechanical model is used to describe hydraulic fracturing. Coupling is achieved with a staggered scheme that comprises two dual lattices, one for the mechanical problem and another one for fluid flow. In the mechanical problem [1], natural joints are added. They are represented by introducing elements with a Mohr-Coulomb behavior. In the fluid problem, Poiseuille flow is considered in each lattice element. A local permeability, which depends on the viscosity of the fluid and on the lattice geometry (opening between two solid parallel planes), is introduced. Macroscopically, it yields a Darcy-type equation in the case of a homogeneous material. The action of fluid pressure on the solid skeleton is represented using Biot's theory. The effect of cracks on fluid flow is captured by increasing the local permeability according to the increase of relative displacements in the dual mechanical lattice element. This increase results from the non-linear response of the skeleton.
First, we present the propagation of fracture restricted to the mechanical case. The influence of a natural joint crossed by the fracture is analyzed with the help of a parametric study. Then, the hydro-mechanical coupling is introduced. Results concerning characteristic length and hydraulic fracture behavior are discussed. The size of the area concerned by the change of transport properties, the stimulated reservoir volume, with respect to permeability, is analyzed. This parameter is important in order to evaluate the efficiency of the stimulation by hydraulic fracture in the context of tight hydrocarbon reservoirs.

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References

[1] Peter Grassl, David Grégoire, Laura Rojas Solano, and Gilles Pijaudier-Cabot. Meso-scale modelling of the size effect on the fracture process zone of concrete. International Journal of Solids and Structures, 49(13):1818–1827, 2012.