An attempt to generate physically-based DFN for coupled hydro-mechanical simulation

Dominique Bruel, MINES ParisTech, PSL Research University, Centre de Geosciences, 35 rue St Honoré, 77300 Fontainebleau, France

This research forms part of a more general program dedicated to geothermal energy for electricity production in hot fractured and faulted rocks and is dedicated to fracture network modeling. Past experiences in coupling hydromechanical processes such as fluid pressurization up to levels that trigger shear rupture along discontinuities have shown the limitation of using simple point process stochastic DFN realizations. Because they often exhibit non realistic topologies, they are not fully appropriate to discuss physical processes [1,2]. Part of the fractures in a preexisting network is likely to propagate under many pressure and stress conditions. This process results into fracture linkage, which contributes to permeability enhancement but might be responsible of unwanted seismicity [3]. The proposed approach aims at reproducing a fracture network developing in an extensional context by capturing some pattern inherited from mechanical processes [4,5,6]. As in [5], it combines a 3D stochastic sequential point process generation of disc shaped flaws with a predetermined orientation, and rules for simulating their growth until arrest is prescribed. Fractures are growing in their plane, as discs and each disc, with an updated radius, is sequentially tested against all the other elements. New flaws can be incorporated. Arrest is obtained under different circumstances, but mainly because of a distance or exclusion criterion met with two different neighboring fractures [5,7]. This distance criterion can be a contact condition or can reflect a mechanical interaction depending of the stress shadow context. The local geometrical configuration at the arrest can also be associated with the generation of an additional relay fracture. The numerical simulation stops when a prescribed fracture density is met. The first results show the crucial role of these elements of smaller size that control the connectivity. An important aspect of the generation process is that the pseudo-mechanical status of each element is saved at each stage. Moreover the stress regime applying on the relay structures is reflecting the local stress conditions, more precisely the stress state prevailing on "mother" fracture tips, and not only the stress state at large, as demonstrated by detailed FE numerical simulation [7,8]. The work in progress seeks to identify a proxy taking into account an effective stress change issuing from subsequent hydraulic simulations within a fracture network. This will be associated with an update of the arrest rules and possibly with the apparition of new connections within a given network.

Acknowledgements :

The author wish to thank the French Agency for the Environment and Energy Management (ADEME) and the French public funds Investments for the future (label IA) which support this research project through the ongoing program GEOTREF [2015-2019], handled by a consortium headed by TERANOV and KIDOVA (https://geotref.com/fr/)

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Short abstract:

In this paper, we seek to reproduce the development of fractures in an extensional context by capturing some pattern inherited from mechanical processes. The approach combines a 3D stochastic point process generation of disc shaped flaws with a predetermined orientation, and rules for simulating their growth until arrest is prescribed. The pseudo-mechanical status of each element, with regard to neighboring elements is continuously saved, thus allowing further interactions in case a sudden effective stress change is superimposed.