EGU22-11543
https://doi.org/10.5194/egusphere-egu22-11543
EGU General Assembly 2022

2D & 3D numerical modeling of fluid-driven frictional crack growth for geothermal hydraulic stimulation

Brice Lecampion, **Alexis Sáez**, and Regina Fakhretdinova
Geo-Energy Lab, EPFL, Switzerland (brice.lecampion@epfl.ch)

Hydraulic stimulation of deep geothermal reservoirs is necessary in order to establish economical flow rates between the injector and producer wells. Previous field experience in deep crystalline reservoirs have highlighted the importance to stimulate the well by zones in order to create several fractures along the well instead of carrying out a single large stimulation which typically results in the reactivation of only a few fractures along the open-hole section – thus resulting in poor reservoir coverage and low flow transmissivity. Localized hydraulic stimulation can be performed via packer-systems, and although different in their details, share similarities with stimulation operations performed in unconventional oil and gas reservoirs. The main differences are that i) propping agents are not typically used in crystalline geothermal reservoirs, ii) the injection pressure often remains lower than the minimum in-situ stress and iii) the long-term increase of permeability relies on the self-propping effect associated with the shear dilatant behaviour of pre-existing fractures. The type of fractures propagated during hydraulic stimulation thus exhibit both shear and tensile modes of deformation (different than the purely tensile hydraulic fractures).

Physics-based models are necessary in order to design the injection sequence and are typically used in conjunction with uncertainty analysis. We report our developments of two and three-dimensional numerical models for the hydraulic stimulation of pre-existing fractures accounting for both shear and opening modes of deformation. The fracture behavior is modelled via a non-associated Mohr-Coulomb frictional elasto-plastic law with possible weakening/hardening of friction and dilatancy with slip, while the host rock is assumed linearly elastic. The fluid flow behaviour of the fracture accounts for opening and the associated permeability / storativity changes (with the possibility to use different type of permeability law). We solve in a fully coupled manner the resulting non-linear moving boundary hydromechanical problem.

We present several verification tests for the growth of a frictional shear crack growth in the plane of a pre-existing frature under the injection of fluid at constant rate in both 2D and 3D. Especially, we compare our numerical results with recent analytical solutions for the case of constant friction and constant hydraulic properties of the pre-existing fracture. We then discuss several examples combining shear dilatancy and its effect on flow properties as well as the possible tensile opening of the pre-existing stimulated fracture. Accuracy, robustness and numerical performance – critical for the use of the solver for engineering design - will be discussed as well as future improvements.

This work is sponsored by Geo-Energie Suisse A.G. and the Swiss Federal Office of Energy.