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PhD in computational mechanics - modeling of fluid-driven fracture propagation

Successful production of electricity from deep geothermal resources relies on a proper engineering of the permeability of initially 'tight' geothermal reservoirs. This is achieved via hydraulic stimulation. Such an operation consists in the injection of fluid in the reservoir from deep boreholes in order to re-activate pre-existing fractures and/or create new fracture surfaces. The aim is to ultimately increase the thermal heat flux that can be brought back to the geothermal power plant on surface via a flow loop between two or more wells. This hydraulic stimulation technique is similar to the one used in the oil and gas industry. Numerical models are necessary to design and optimize these stimulation operations in order to achieve a proper increase of the reservoir permeability [1, 2].

This thesis will focus on theoretical and numerical modeling of propagation of fluid-driven fractures in three dimensions, with an emphasis on mixed mode propagation as well as the effect of interaction between multiple fractures [3]. Comparisons of theoretical predictions with laboratory experiments will be performed throughout this work (see e.g. [4] for examples). This PhD falls within a larger research project on the modeling of fluid driven fractures propagation at EPFL combining theoretical, experimental and field investigations.

This thesis requires a strong background in continuum mechanics (both solid and fluid) and its computational aspects. The candidate must have a strong interest in i) the mechanics and physics of fracture propagation as well as the mechanics of fluid-infiltrated porous media, and ii) numerical methods for non-linear problems in mechanics. Preliminary experience of scientific programming (and the will to learn) as well as knowledge of programming languages (e.g. C++, python, Fortran etc.) is mandatory.

Interested students should contact Prof. Brice Lecampion (including resume and transcripts), prior to submiting an application to EPFL doctoral school in mechanics (see `phd.epfl.ch/edme` for more details about the mechanics doctoral program at EPFL and the application process). This thesis can start in Q2 or Q3 2018.

References

[1] E. Detournay. Mechanics of hydraulic fractures. *Annual Review of Fluid Mechanics*, 48:311–339, 2016.

[2] B. Lecampion, A. P. Bunger, and X. Zhang. Numerical methods for hydraulic fracture propagation: A review of recent trends. *Journal of Natural Gas Science and Engineering*, 49:66–83, 2018.

[3] B. Lecampion and J. Desroches. Simultaneous initiation and growth of multiple radial hydraulic fractures from a horizontal wellbore. *Journal of the Mechanics and Physics of Solids*, 82:235–258, 2015.

[4] B. Lecampion, J. Desroches, R. G. Jeffrey, and A. P. Bunger. Experiments versus theory for the initiation and propagation of radial hydraulic fractures in low permeability materials. *Journal of Geophysical Research: Solid Earth*, 122, 2017.