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PhD in computational mechanics - multiscale 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. Numerical models are necessary in order to design and optimize these injection operations.

This thesis will focus on the multiscale aspects of the propagation of fluid-driven fracture in brittle porous media. More specifically, the presence of natural fractures at all scales as well as rock heterogeneities has the tendency to increase the apparent fracture energy required to propagate these fractures (so-called heterogeneity toughening in fracture mechanics, see e.g. [1, 2, 3] among others for examples in 'dry' loading mechanics for different materials). The goal of this PhD is to develop numerical models - in combination with theoretical approaches - to better understand how these toughening mechanisms develop in the case of fluid-driven fracture where fluid-solid interactions are strong (e.g. [4, 5]). Comparisons of theoretical predictions with field observations and laboratory experiments will be performed throughout this work.

This PhD falls within a research project on the modeling of fluid driven fractures propagation. It requires 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) and knowledge of programming languages (i.e. C++, python etc.) is a plus.

Interested student should contact Prof. Brice Lecampion, and submit in parallel an application to EPFL doctoral school in mechanics (see `phd.epfl.ch/edme` for more details about the mechanics PhD program at EPFL and the application process). This thesis can start in Q2 or Q3 2017.

References

[1] M. Ortiz. Microcrack coalescence and macroscopic crack growth initiation in brittle solids. *International Journal of Solids and Structures*, 24(3):231–250, 1988.

[2] D Vashishth, JC Behiri, and W Bonfield. Crack growth resistance in cortical bone: concept of microcrack toughening. *Journal of biomechanics*, 30(8):763–769, 1997.

[3] Bernd Wetzel, Patrick Rosso, Frank Haupert, and Klaus Friedrich. Epoxy nanocomposites–fracture and toughening mechanisms. *Engineering fracture mechanics*, 73(16):2375–2398, 2006.

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

[5] B. Lecampion and E. Detournay. An implicit algorithm for the propagation of a hydraulic fracture with a fluid lag. *Comp. Meth. Appl. Mech. Engng.*, 196:4863–4880, 2007.