Proposed Master Project at NTNU: Fracture propagation during fluid-injection

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Background: Fluid injection operations [1] are regularly done in several field case scenarios like petroleum production, geothermal installation, ground-water exploration and underground CO_2 storage. Normally fluids with high pressure are injected inside porous rocks through the injection wells and sometimes fractures open-up at the well-boundaries. We need better understanding of physical processes that guide fracture propagation in porous media and we also need to develop tools for monitoring fracture propagation. Several lab experiments [2,3] have explored the stress-induced fracturing behavior of number of reservoir rocks during fluid injection scenarios.

Problem formation: We have developed a discrete element model (DEM) simulation code based on invasion percolation and distance dependent stress intensity factor (K) to mimic the stress-induced fracturing of porous rocks. Our simulation code can handle the presence of pre-existing fractures inside the sample. The simulation results agree qualitatively [4] with the experimental observations.

In this Master project, the student will study the stress-induced fracturing with several important inputs like tensile strength distribution, breaking criteria, porosity, sample size, pressure etc. The DEM simulation codes are developed in-house and are available for re-use and further improvement.

Other aspects: Although fractures are mostly seen as "disturbing elements" for the stability of wells and well-operations, in some cases fractures are "intended" -for example, in hydraulic fracturing scenario people create fractures to increase permeability (flow channels) in the porous rocks. Creation of optimal flow channels is also the main goal for geothermal projects to enhance power production and thereby to contribute in the ***Green-energy-sphere***. PoreLab is now developing a research proposal together with Institute of Geophysics, Warsaw on "*Fracturing in ice*". The Master student can be included in this project if he/she likes to pursue a ***research career*** on this topic.

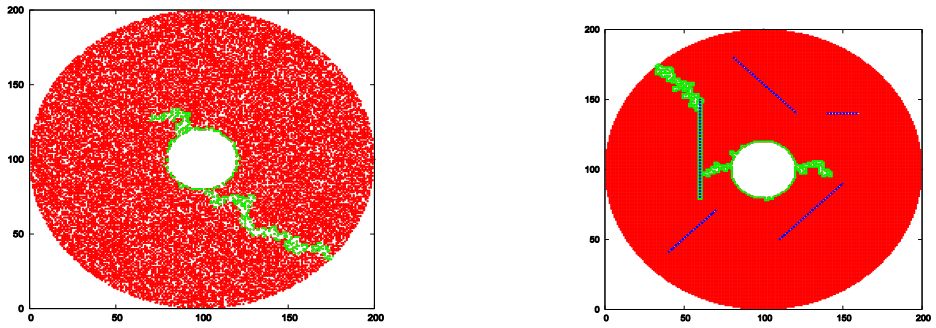

Fig: Fracture propagation in a DEM with no pre-existing fractures (left) and in a DEM with 5 pre-existing fractures (right).

References:

1. E. Fjær, R. M. Holt, P. Horsrud, A. M. Raaen and R. Risnes, *Petrolum Related Rock Mechanics* (Elsevier, 2008). 2. S. Pradhan, A. Stroisz, E. Fjær, J. Stenebråten, H.K. Lund and E. F. Sønstebø, "Stress-induced fracturing of reservoir rocks: Acoustic monitoring and mCT image analysis", Int. J. of Rock Mechanics and Rock Engineering, DOI 10.1007/s00603-015-0853-4 (2015). 3. S. Pradhan, A. Stroisz, E. Fjær, J. Stenebråten, H.K. Lund, E. F. Sønstebø and S. Roy, "Fracturing tests on reservoir rocks: Analysis of AE events and radial strain evolution", ARMA (2014). 4. Invited presentation on *Fracture propagation during fluid injection: Experiment, modeling and monitoring towards field scale applications* at "Fracmeet Conference", IMSc, Chennai, India in March 2019.