Feedback between fluid and solid dynamics at the tip of a fracture

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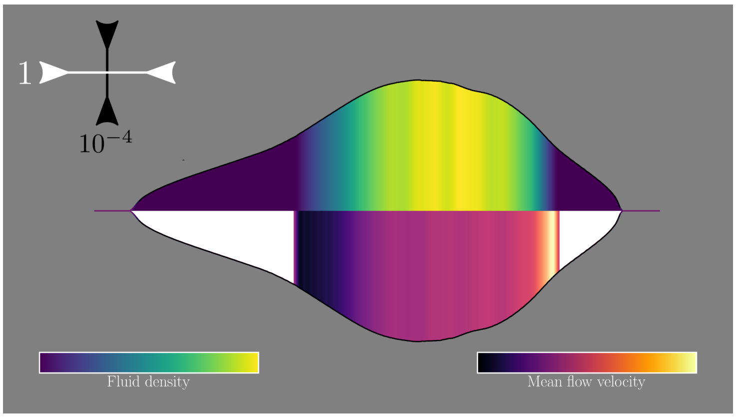
Background: Injection of fluids into underground rock formations is central to a range of energy and environmental applications including geothermal energy and CO_2 sequestration. Such injection may, as an unintended consequence, trigger fractures in the rock, which lead to large and fast increase in porosity in the rock. The rapid expansion of fluid-filled cavities results in large pressure drops and possibly vaporization of the fluid, impacting the propagating rupture. However, an understanding of whether this feedback enhances or impedes fracture propagation is missing.

Project description: In this project, the student will work in a cross-disciplinary research team at the PoreLab Center of Excellence and the Njord Centre to investigate numerically the expansion of a fluid-filled cavity. The student will employ and improve an idealized numerical model that we have already developed, which fully couples solid and fluid dynamics at the tip of a rapidly growing tensile fracture between two solid blocks (see figure below). Using the model, the student will quantify feedback mechanisms between fluid flow and solid deformation. Numerical simulations will be performed using the Norwegian High-Performance Computing (HPC) infrastructure (Sigma2) as well as local computing facilities.

The student will learn theoretical and computational fluid and solid dynamics relevant to sustainable energy and environmental applications (finite volume and boundary integral methods), open-source coding practice, and how to use HPC infrastructure. The student will summarize their work in a report which we may develop together into a publication, and the open-source code will be disseminated in a public Git repository.



Snapshot of dynamic fluid flow simulation showing fluid density (top) and mean velocity (bottom) within a rapidly expanding crack cavity. The white area highlights the formation of a fluid-depleted cavity.

Supervisors: Fabian Barras and Gaute Linga, both early-career researchers at Porelab Center of Excellence and the Njord Centre.

Preferred background of candidate: Physics, mechanics, geoscience or computational science. Basic programming skills (C++ and/or Python) and knowledge of fluid mechanics is required. Some knowledge of solid mechanics and thermodynamics is an advantage.

Number of available projects: 1

Preferred project period: Six week duration beginning in April or May. Reduced hours are possible for an extended duration.

Project work and expected outcomes: Implementation and numerical simulations; some analytical work. The student will write a report summarizing findings on which thermophysical and stress conditions control feedback mechanisms between fluid dynamics and fracture propagation in water-saturated rock, and contribute to a Git repository for the open-source code development.