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Study of aperture fields in fractures

Project Framework: Understanding fluid flow in the subsurface is crucial for geothermal, oil- and gas reservoirs, as well as CO_2 sequestration sites and nuclear waste storage. In all aforementioned cases, fluid flow in the subsurface is strongly dominated by flow through fractures. This is especially true in impermeable host rocks, such as granite. Fracture permeability is influenced by many factors, among them the aperture magnitude (i.e. fracture opening – distance between two fracture surfaces), but also the degree of connectivity of large aperture regions within fractures. Additionally, aperture fields can display anisotropic features, which favor a certain flow direction. In a subsurface system, the relation between mechanical, thermal and chemical on the fracure can further alter the aperture field. Aperture fields are therefore a crucial part to understand flow mechanisms in the subsurface, from reservoir productivity to contaminant transport.

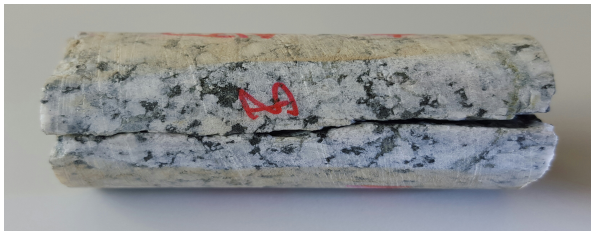
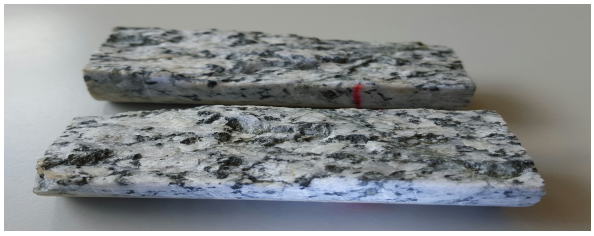
a)  b) 

Figure 1: Examples of fractures in small-scale granodiorite specimen for the laboratory scale.

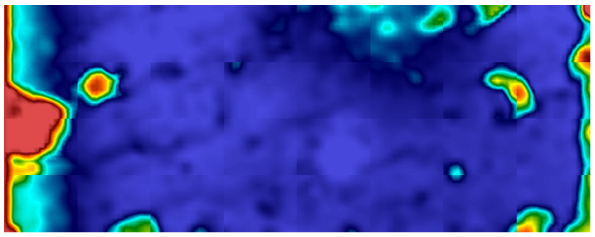
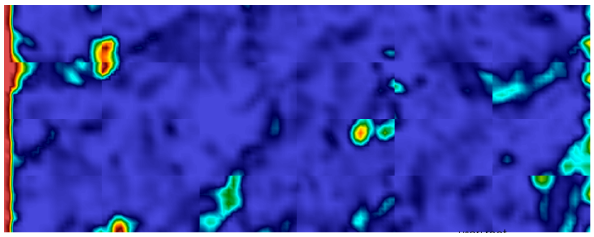
a)  b) 

Figure 2: Fracture aperture fields of specimen 1 (a) and 2 (b) with colorbar ranging from blue (small aperture) to red (high aperture).

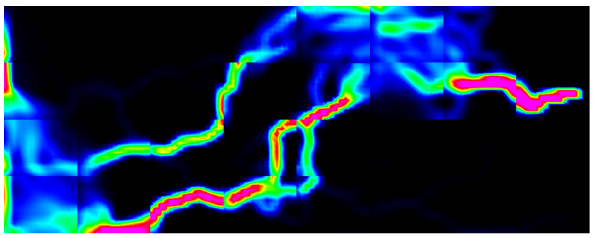
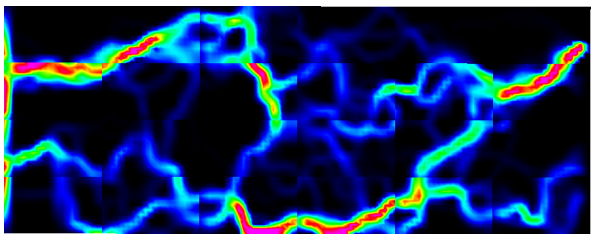
a)  b) 

Figure 3: Flow rates from the right to the left of specimens 1 (a) and 2 (b). the colors indicate flow rate magnitude from low (black) to hihg (pink).

MSc Thesis Project Goals: This project will investigate which properties in a fracture are most crucial for large flow rates and how to quantify them. A number of stochastic approaches exist, which characterize aperture

regions in a fracture. Bottlenecks, for example, with a small aperture can hinder flow through specific flow paths despite large apertures along the remaining flow paths. Data sets of a large number of fractures and aperture fields in granitic rock already exist and will serve as a starting point for the investigation. Potentially, different rock types could also be sampled to extend the data set and study key differences in aperture fields across rock types. Performing numerical simulations of fluid flow through heterogeneous fractures could also be utilized to better understanding of channeling in aperture flow.

Master Thesis Tasks:

- Familiarize yourself with different aperture fields (fracture scale and type).
- Evaluate several key properties which characterize aperture conductivity.
- Implement analytical and numerical methods, which quantify aperture properties.
- Optional: Utilize numerical simulations to investigate flow processes in aperture fields.
- Optional: Collect additional fracture material with corresponding aperture fields to study key differences between granitic fractures and other rocks.

Required Student Skills: We are looking for a student with a background in engineering or natural sciences. A background in geology or rock mechanics is not necessary. The successful candidate should have solid computer skills and an interest to work with provided software, as well as develop small functionalities.

Supervision:

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