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Infrared monitoring of hydrothermal echanges occurring in a fracture

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We aim to characterize the heat exchange that occurs when water flows through a fracture at a different temperature from that of the surrounding rock. This happens during many man-made or natural processes. For instance, injection of water in the context of geothermal power plants or sudden mechanical movements (e.g. rockfalls, landslides, earthquakes) that transport water.

It is presently challenging to estimate the heat transfer and temperature inside a fractured medium where water is flowing, despite various numerical models which have been proposed [Neuville et al, 2010, 2013; Kolditz et Clauser, 1998; Heuer, 1991]. The difficulties arise from the complexity of the fracture network, the fracture topography, as well as complex hydraulic flow (e.g. recirculation) and heat exchanges. As a consequence, various hypotheses were made in the models. More experimental data are required in order to calibrate these models, validate or refute the hypotheses. Our work aims to provide temperature data at the fracture scale, in an experiment where the pressure gradient an fracture topography are controlled, with slow hydraulic flow. This required to develop a setup from scratch.

An infrared camera and thermistors are used to monitor the temperature in space and time. Water is injected through a partly natural rough fracture with impermeable walls. The bottom part of the fracture is a larvikite stone with a rough surface (presumably this surface was obtained from mode I fracturing), and the top part is a layer which is transparent in the infrared range. As a consequence the infrared camera is expected to measure the temperature at the interface between this transparent layer and the water. The topography of the surface of the rock was reconstituted using a photogrammetry software [MicMac, IGN], and compared to measurements made with a mechanical profiler. Using this geometry we carefully localize the temperature observations (infrared camera and thermistors) and correlate the temperature variations with the topography.

Preliminary comparisons with simulations from a coupled lattice Boltzmann method that solves both the complete Navier-Stokes and advection-diffusion equations in three-dimensions are also presented.

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MicMac, IGN: sofware developed by the French Institut Géographique National (IGN)

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