A new injection testing method to characterize hydraulic properties of fractured reservoirs using shear-thinning fluids

Project framework

Fractured aquifers are characterized by strongly heterogeneous flow path distributions, whose characteristics strongly constrain our predictive capacities for resource management. Injection test is a common method employed in engineering and research to investigate aquifer hydraulic properties. Injection tests are performed either in single well or interwell configurations and provide insight about fracture transmissivity and network connectivity. But these tests only provide estimates of average hydraulic properties of fractures. In this project, a new injection test method using shear-thinning fluids will be developed. The method aims at providing estimates of the distribution of hydraulic properties, thus significantly improving our exploration capacities of fractured media.

But what is a shear-thinning fluid?

Shear-thinning is a term used in rheology to describe a fluid that displays decreasing viscosity when subject to shear-rate (non-Newtonian properties). Many industrial and engineering applications take the advantage of specific shear-thinning fluids in their process. We commonly find such polymers in the food industry which are used as thickeners to make sauces, yoghurt and to process ice cream. Shear-thinning fluids are also widely used in the oil and geothermal industries. It notably allows a higher efficiency during high pressure pumping and fracking process. Recently, the use of shear-thinning fluid for in-situ remediation purposes is increasing with the objective to enhance the amendment delivery into a contaminated aquifer.

Objectives and methodology

This master project focuses on the development and implementation of a new injection test method using shear-thinning to infer hydraulic properties of fractured reservoirs. Specifically, the student will 1) examine how a shear-thinning fluid injected in the subsurface may select specific thresholds or fracture apertures depending on its rheological behavior through simple modeling exercises; 2) design a field experimental protocol to test the feasibility of the method; and 3) interpret the results and develop inverse model in close collaboration with the main supervisors.

The method will be tested on an experimental site (Mels or Grimsel, to be defined) that was chosen given i) its exceptional logistical support, ii) the large amount of available hydro-geophysical data and iii) the close ongoing collaboration. A first task will consist of designing and developing all technical concerns for the field experiment: i) an optimized injection system will be designed using specific tools available (straddle-packe, pump, mixing system). The protocol will be first tested under laboratory conditions before deployment at the field site and ii) hydraulic and eventually geophysical monitoring set-up will be prepared, for both injection and observation boreholes to constrain hydraulic response induced. In a second task, data acquired during the field experiment will be analyzed. Fracture geometries and preferential flow paths selected by the shear thinning fluid will be analyzed by coupling i) classical injection and tracer test results already available for the site, ii) shear-thinning fluid injections, and if available iii) geophysical monitoring. This set of data will serve as input to the inverse modelling approach.
Training

The student will receive a unique training in techniques used to characterize hydraulic properties of aquifers at the field scale. She/He will also be trained in modeling techniques used to simulate the flow of Newtonian and non-Newtonian fluids in fractures. The student will interact with various researcher at ETH Zurich and UNIL, as well as with numerous international researchers through active collaborations already set up on this topic (University of Rennes, Oregon State University). The student will gain experiences in flow processes in fractured and porous media, important skills for a career development in hydrogeology, petroleum and geothermal research and engineering fields. For more information, please contact Dr. Clément Roques at clement.roques@erdw.ethz.ch, G5, NO building, http://www.clementroques.com/, Co-supervisors: Dr. Maria Klepikova and Dr. Reza Jalali.

![Figure 1: Schematic of the injection test setup using non-Newtonian fluids.](image)

Some references: