Hydraulic Stimulation of Crystalline Rock – Grimsel Test Site

Mohammadreza Jalali*, Joseph Doetsch*, Valentin Gischig*, Hannes Krietsch*, & Florian Amann*

*Swiss Competence Center for Energy Research – Supply of Electricity (SCCER-SoE), ETH Zürich, Sonneggstrasse 5, CH-8092 Zürich (jalalim@ethz.ch)

A decameter-scale In-situ Stimulation and Circulation (ISC) experiment has been initiated at the Grimsel Test Site (GTS, Figure 1) to study and address a wide-range of research questions related to the stimulation and production phases of a geothermal reservoir. The main objectives in this context consist of the physical understanding of permeability enhancement during hydraulic stimulation, related induced seismicity, and evaluation of the generated heat exchanger efficiency.

Figure 1. Grimsel Test Site (GTS) is located in the Swiss Alps in the central part of Switzerland. ISC experiment is conducted in the south part of the GTS in a low fracture density Grimsel granodiorite. Three main intersecting sub-vertical ductile shear-zones exist in the stimulated volume.

The hydraulic stimulation part of the ISC experiment, which is the focus of this study, is split into three phases, i.e. pre-stimulation (phase I), stimulation (phase II) and post-stimulation (phase III) (Figure 2). Each phase includes planning and
performing intensive geological, geophysical, hydrogeological, geomechanical and seismological field investigations followed by data analysis that guides design of the subsequent phase.

Figure 2. Workflow of the stimulation part of the ISC experiment

Phase I of the ISC experiment started in August 2015 to evaluate detailed characteristics of the target rock volume. Geophysical borehole logging, geophysical imaging (GPR and active seismic), hydraulic testing (packer tests, heat, solute, dye and DNA-tracer tests) and stress measurement have been performed to optimize the location of monitoring boreholes, improve anticipation of the experiment outcome and add more constraints on input parameters, boundary conditions and geometry for numerical models. In addition, three stress measurement boreholes, two injection boreholes and ten additional boreholes dedicated to pressure, temperature, strain, GPR, and active and passive seismic monitoring were drilled and characterized. After completion of all the monitoring boreholes, hydraulic stimulation using step-rate and pressure injection scenarios in various stimulation intervals in two dedicated injection boreholes will be carried out. Seismic activity, pressure propagation, strain and tilt measurements are carried out simultaneously during the hydraulic stimulation phase. The stimulation phase is followed by post-stimulation phase which mostly contains geophysical (e.g. borehole geophysical) and hydraulic characterization of the stimulated volume. This allows to analyze the stimulation induced changes in faults and rock mass controlling the fluid flow and heat exchanger properties, which define the stimulation efficiency.

The ISC experiment is designed such that stimulation processes, i.e. shear dilatancy, seismic and aseismic slip front propagation, and the resulting enhancement of the fracture conductivity, are recorded in a unique interdisciplinary dataset. The data will include information on THM coupled processes and induced seismicity that could not be obtained from stimulation experiments in deep reservoirs typically targeted for EGS. This dataset also allows us to address the objectives as well as validation and verification of the existing THM and induced seismicity models.