The in-situ stimulation experiment at the Grimsel test site – an overview

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ABSTRACT

The Swiss Energy Strategy 2050 (ES2050) plans to replace nuclear electricity production with an increased utilization of different sources of new renewable energy and sets a target of 7% national electricity supply from Deep Geothermal Energy (DGE) by 2050, corresponding to 4.4 TWh per year and over 500 MWe installed capacity. To reach the ES2050 target, Switzerland will need to install on average 20 MWe per year of additional capacity of electricity production from DGE between 2025 and 2050. A capacity of 20 MWe requires the circulation of over 220 l/s of water at temperatures of 170-190°C, commonly found at 4-6 km depths in Switzerland. As hydrothermal water is scarse and difficult to locate, deep reservoirs will need to be created in hot crystalline basement rock (EGS), safely and at competitive costs.

The ISC project is a decameter in-situ experiment that is currently performed at the Grimsel Test Site (GTS) at a depth of approximately 480m and within crystalline rock. The ISC experiment includes controlled fault slip and hydraulic fracturing experiments at an intermediate scale (i.e.~20*20*20m), which allows high resolution monitoring of the evolution of pore pressure in the stimulated fault zone and the surrounding rock matrix, fault dislocations including shear and dilation, and micro-seismicity in an exceptionally well characterized structural setting.

From 2015 to 2017 we performed an intense characterization and preparation phase that included:

1) Stress measurements using various methods such as hydraulic fracturing, overcoring and hydraulic jacking,

2) Geological characterization using borehole logging, tunnel mapping, Ground Penetration Radar and active seismic measurements,

3) Pre-stimulation hydraulic characterization,

4) Tracer tests using dyes, salt and DNA nanoparticles.

5) installation of monitoring equipment including FBG fibre optics sensors and distributed fibre optics for strain measurements, distributed fibre optics temperature measurements, tiltmeters, micro-seismic surface and borehole sensors, pore pressure sensors and surface extensometers.

In February 2017 we performed a series of fault-slip experiments (i.e. 6 experiments) on interconnected faults adjacent to two injection boreholes. During the test we used one injection borehole to inject water at high pressures (rates up to 35 l/min) and the second injection boreholes to monitor the pressure propagation.

Subsequent to the fault-slip experiments we performed an intense phase of post-stimulation hydraulic characterization. In Mai 2017 we performed a series of five hydraulic fracturing tests within test intervals that were free of natural fractures. Two injection fluids were used: pure water and a Xanthan-Salt-Water mixture with a viscosity of 30-40cp and an electric conductivity of 1800-2000 μS/m.