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Permeability of intact and fractured rocks in Krafla geothermal reservoir, Iceland

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The magmatic-hydrothermal system at Krafla Volcano, North-East Iceland, has been the source of an important geothermal fluids, exploited by Landsvirkjun National Power since 1977 to generate electricity (∼60 MW). In the last decade, the energy was extracted from fluids of moderate temperature (200-300°C), but in order to satisfy the demand for sustainable, environmentally-safe energy, Landsvirkjun is aiming to source fluids in the super high-enthalpy hydrothermal system (400°-600°C and <220 bar). In relation to this, IDDP-1 was drilled in 2009. Drilling was terminated at a depth of 2100m when the drill string penetrated rhyolite magma. The rock around this rhyolite magma body shows great potential for production, as its temperatures are very high and it is located at shallow depth. Here, we present the results of mechanical and permeability tests carried out on the main lithologies forming the geothermal reservoir rock.

During a field survey in fall 2015, and through information gathered from previous drilling exercises, five main rock types were identified and sampled to carry out this study: that is, basalts (10% to 60% porosity), hyaloclastites (35% to 45% porosity), obsidians (0,25% to 5% porosity), ignimbrites (13% to 18% porosity), and intrusive felsites and microgabbros (10% to 16% porosity). The only rock type not found in outcrops on the surface is the felsite and microgabbros which are thought to be directly above the rhyolite magma (∼80m thick). The reason they can be found on the surface is that during the Mývatns-fires, an explosion creating the Víti crater and scattered these rocks around the area.

For all these lithologies, the porosity was determined using helium pycnometry. On-going permeability measurements are made using a classic hydrostatic cell. To simulate the stress conditions extant in the hydrothermal field, we performed permeability measurements at a range of confining pressure (1 to 100 MPa), using a pore pressure differential of 0.5 – 1.5 MPa (at an average pore pressure of 1.25 MPa). We present the results of permeability-porosity relationships for each rock as a function of confining pressure and discuss the permeability of the fluid reservoir as a function of effective pressure (i.e. = confining pressure – pore pressure) to constrain fluid flow during different pressurisation events.

Complementary Brazilian tests were also performed to induce a fracture in the samples and the permeability of these fractured rocks will be measured to describe the role of macrofractures in controlling fluid flow. Permeability measurements at high temperature (up to ∼500 C) will be performed on selected rocks. The aim of these experiments will be to discover the relative role of the various lithologies on the permeability of the reservoir, which will inform us how to improve the geothermal productivity of the proposed deep well through thermo-mechanical stimulations.