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# Permeability of Icelandic deep geothermal reservoirs: insight from HP and HT measurements

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Although the Icelandic geothermal system has been intensively investigated over the years, targeting increasingly deeper reservoirs (e.g. under supercritical conditions) requires a good knowledge of the behaviour of physical properties of the host rock types at high temperatures and pressures. In particular permeability, which is the key parameter controlling the dynamics of such unconventional reservoir, is poorly known under these conditions. Up to this date, there is only very limited data available on this topic, especially for magmatic rocks, which is attributed to the difficulty to access these extreme conditions in the presence of pore fluids.

Three types of rocks, representative of the lithology are investigated: dolerite, basalt and hyaloclastite. These rocks experienced a high degree of alteration with actinolite, epidote +/- chlorite and talc, representing high temperature conditions (>350°C).

We used an internally heated pressure vessel (the Paterson Press) to perform permeability measurements at high temperature and pressure. The effective pressure varied up to 120 MPa while the temperature varied up to 800°C. Inert Argon gas was used as the pore fluid to avoid fluid/rocks interaction. Due to the wide range in permeability, we combined different methods of measurements (steady-state, harmonic, pulse and numerical methods) in order to maintain the accuracy of the permeability measurements.

We observed a significant decrease of permeability with effective pressure for the micro-fissural samples (dolerites) when compared to the generally inter-granular hyaloclastites. The decrease is about 1 to 2 orders of magnitude for the dolerites, ranging from about 1 $\mu$Darcy to 0.01 $\mu$Darcy, while the effective pressure increases from 10 to 120 MPa, respectively. We related this rapid decrease of permeability to the closure of micro-cracks at low effective pressures. This effect has hysteresis as it is not reversible when the effective pressure is re-decreased. On the other hand, effective pressure seems to have little effect on the permeability of hyaloclastites. The logarithm of the varies linearly with the effective pressure.

At high temperature, permeability generally decreases with increasing temperature. However, some samples (dolerites) displayed a reproductive increase by about two orders of magnitude from 0.01 $\mu$Darcy to 1 $\mu$Darcy between 200°C and 300°C. This increase is related to thermal cracking. At 500°C, we also observed a time-dependent behaviour for some hyaloclastites, showing a decrease of permeability over a time span of one hour, while the other samples showed very little temperature-dependance. Important changes in microstructures, such a pore collapse, fracture sealing, or thermal cracking, are invoked by microscopic observations to explain such behaviours. Permeability is highly variable from one rock type to another making interpretation difficult.

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