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Monitoring thermal processes in low-permeability fractured media using fibre-optics distributed temperature sensing (FO-DTS)

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Fibre-optics distributed temperature sensing (FO-DTS) systems constitute arguably one of the main significant advances in the development of modern monitoring techniques in field hydrogeology, both for shallow (e.g. quantification of surface water-groundwater interactions) and deeper applications (borehole temperature monitoring). Deployment of FO-DTS monitoring systems in boreholes has notably allowed further promoting the use of temperature as a tracer to improve the characterization of heterogeneous media, with a strong focus on permeable environments such as shallow unconsolidated aquifers and/or highly-fractured rocks, generally found close to ground surface. However, applying this technology to low-permeability media, as in the case of intact rock mass intersected by isolated, discrete fractures still remains a challenge, perhaps explaining the limited number of field results reported in the scientific literature to date. Yet, understanding the transport, storage and exchange of heat in deep, low-permeability crystalline rocks is critical to many scientific and engineering research topics and applications, including for example deep geothermal energy (DGE).

In the present contribution, we describe the use and application of FO-DTS monitoring to a broad range of processes, varying from the propagation and persistence of thermal anomalies (both natural and induced) to the monitoring of the curing of epoxy resin and cement grouts along the annular space of boreholes designed for monitoring discrete, packed-off zones. All data provided herein has been collected as part of a multi-disciplinary research program on hydraulic stimulation and deep geothermal energy carried out at the Grimsel Test Site (GTS), an underground rock laboratory located in the Aar massif, in the Swiss Alps. Through these examples, we illustrate the importance of understanding the spatial and temporal variations of local thermal regimes when planning to monitoring boreholes temperatures (whether to determine geothermal field, characterize in situ thermal properties of the rock mass, conduct thermal tracer tests or characterize the heat-exchange efficiency between rock mass and fluid-filled fractures). Collected temperature transient are furthermore interpreted with simple numerical models in order to characterize hydrogeological properties of the media.