Hydraulic Characterization of Bedretto Underground Laboratory (BULGG) by Analyzing Thermal Anomalies

Introduction: Permeable fractures/faults construct the hydraulic backbone in most geological structures, especially in hard rocks. Such permeable features, however, may be associated with a high level of anisotropy/heterogeneity, which can significantly influence the fluid flow pattern. There exist several approaches to characterize the anisotropy/heterogeneity of the fracture/faults using their mechanical-, hydraulic-, chemical- and thermal-signatures, amongst which, thermal analysis will be the focus of the current study. The permeable fractures often manifest with thermal contrast to the surrounding rock volume (see Fig. 1), which is attributed to complex hydrogeological properties of the system. In addition, the thermal anomaly itself might not be uniformly distributed over the entire fracture/fault surface. This is usually evident, for example, from thermal images of the fracture/fault intersections in tunnel excavations (see Fig. 2).

Research Goals: This study aims to improve our understanding of heterogeneity/anisotropy of the fracture/fault systems in Bedretto Underground Laboratory for Geosciences and Geoenergies (BULGG) (Ma et al. 2022) through the acquisition of high-resolution Infra-Red (IR) images to map the temperature of the tunnel walls, focusing where large fault/fractures intersect the tunnel. The potential correlation between the observed thermal anomalies and the available information including the geometry of the structures, chemical content, level of tunnel overburden and stress state will be investigated. The results of this study are expected to shed light on dominant transmissivity direction at different parts of the Bedretto tunnel.

Research Methods: For this purpose, the student will use an IR camera to image the temperature of the discharging fluid from fractures/faults with considerable outflow from the tunnel wall, in particular from the first 3 km of Bedretto tunnel. The IR thermal imaging camera will be used for this purpose to detect the thermal anomalies above 0.1˚C between the flowing fluid and the surrounding rock (see Fig. 2). The temperature data from the tunnel wall will first be compared to direct fluid temperature measurements from an existing dataset. The observations will next be compared with complementary data to find potential correlations, in particular with directionality of the thermal anomaly over the tunnel surface outcrop, outflow rate, rock overburn above the structure, chemical properties of the flowing water, etc.

Requirements: The student will spend approximately one to two weeks, in total (cumulatively) at BULGG to observe/measure/collect required data. The student also needs to have strong analytical skills, attention to details and in particular to be interested in field works.

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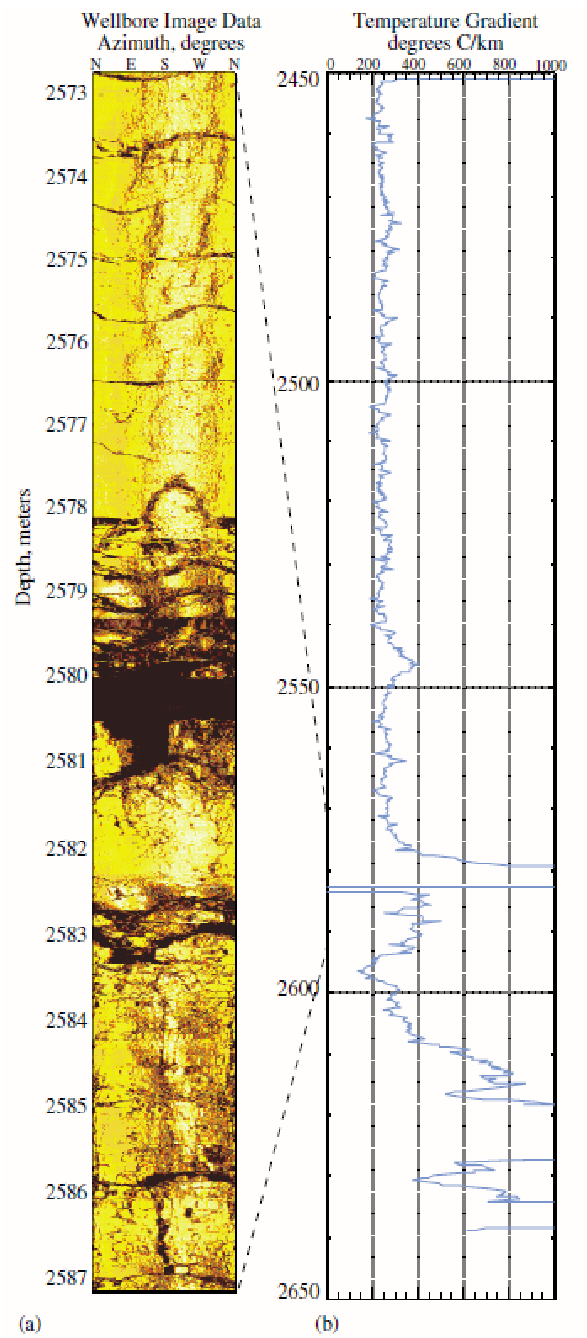

Figure 1: a) borehole tele-viewer and b) temperature log from the same interval in a borehole (Barton and Moos 1997).

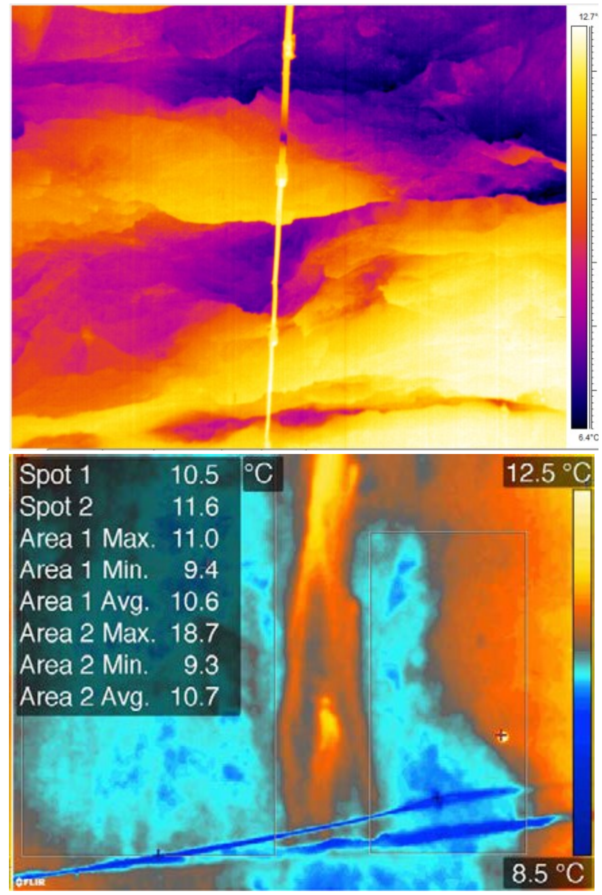

Figure 2: The thermal images of tunnel sections at (top): Bedretto tunnel , and (bottom): the Äspö HRL (Neretnieks et al. 2018).

Reference:

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