Université de Neuchâtel
Centre d'hydrogéologie et géothermie

MSc in Hydrogeology and Geothermics
Thesis topic proposal 2023

FRACTURE-NETWORK STATISTICS AND GROUNDWATER FLOW CHANNELING USING DRONE-BASED FRACTURE PHOTOGRAMMETRY

Context and objectives

Alpine catchments play a critical role in sustaining down-gradient streamflow. The hydrology of these catchments is highly dynamic, generally characterized by an annual cycle where groundwater storage and flow through the bedrock play a critical role. In settings underlain by crystalline rocks, groundwater dynamics is controlled by the 3D distribution of fractures. The lack of data regarding the connectivity and properties of the fractured network make the evaluation of relevant hydrogeological properties particularly challenging.

This master project aims at providing quantification into the fracture-network statistics and its impact on groundwater flow channeling. The research will be developed at a alpine catchment observatory located in the canton of Graubünden (Poschiavo). The student will participate in leading an experiment combining drone-based photogrammetry and geophysics. She/He will be trained in advanced catchment-scale field and numerical methods. The goals of this project are to: a) image the geometry of the fracture network on representative outcrops throughout the catchment, b) identify zones with different types of fracturation, and, c) compare the observations with the results obtained from a geomechanical model. In perspective, the model will be used to assess the impact of fracture network statistics on groundwater flow channeling.

Methodology

The student will compile available geological and geophysical data that will be further completed by specific in-situ investigations including: 1) high resolution aerial pictures acquired with UAV instruments, 2) detailed statistical analysis of fracture networks to distinguish zones with different types of fracturation patterns using modern network theories (Davy et al., 2010), and, 3) surface electrical and seismic geophysical investigations to describe the vertical heterogeneity. Data from borehole logging will also be used. The distributions of stress and strain derived from a 3D model will be then compared against geophysical and geotechnical observations in order to produce statistical correlations, for example between strain and fracture statistics such as orientation, length, density, and aperture. This will allow us to build a 3D structural model of the investigated area describing the distribution of mechanical and hydraulic properties. The 3D model will be further used as main constrains for the groundwater model to study the impact of fracture-network on flow channeling. Future publication(s) with the MSc student as co-author are foreseen.

Supervision and collaboration

Supervision by Dr. Clément Roques, Dr. Landon Halloran and Pr. Benoît Valley (UniNE) and Dr. Larissa de Palézieux (ETHZ).

Further information is available from Clément Roques, clement.roques@unine.ch

Figure 1: Picture of one of the main outcrops that will be investigated in this project.