The Aar Massif experienced a 20 Ma long exhumation history. Owing to a slab roll back mechanism and delamination in the lower crust, the deepest parts exhumed by a strong buoyant component from ancient depths of up to 20 km to their today’s position. Associated deformation structures, mainly steeply oriented reverse faults, dissect the entire massif, defining nowadays important mechanical anisotropies, which are relevant for a variety of geological and hydrodynamic processes. Their description requires a quantification of the 3D structural pattern, identification of major flow paths for both recharging cold meteoric and discharging hot hydrothermal fluids as well identification of fluid pathway preserving/generating processes. For the structural 3D characterization of fault patterns a combined approach of remote sensing based fault identification and field verification by mapping and measurements provide a suitable database. Thanks to the substantial variations in topography of the Aar Massif, fault planes can be projected to depth, the associated uncertainties can be evaluated and tested against subsurface occurrences in the numerous underground galleries. As major outcome an overall validated structural 3D model of the central Aar Massif will be presented.

Such structural 3D models provide the great opportunity for hydrodynamic investigations. A detailed study was performed in the case of NAGRA’s Grimsel Test Site, where a high-resolution 3D fault plane model was linked to water inflow points in the gallery. Fault intersections and fault planes with high slip tendencies can explain about 90% of the observed inflow situations. Although localized at the meter scale, owing to the dense fault network, meteoric water can infiltrate pervasively throughout the entire Aar Massif along the pre-existing fault planes recharging the underground water reservoirs. Vertical tube-like channels provide major pathways in the case of the subvertical large-scale dextral strike-slip faults of the Grimsel pass shear zone in the south of the Aar Massif. Inside these upwelling zones of hot hydrothermal water, cockade structures have been detected in zones of high porosities. The cockade structures therefore serve as paleoseismic archives. Including theoretical considerations on the size of the cockades and the dimensions of cockade zones, information on the extension of the involved fluid volume, the lateral extend of the seismically active structure as well as the magnitude of the seismic energy release can be gained. The data show the importance episodic seismic fracturing for the preservation of such upwelling zones over geological time scales. In this sense the presented project provides new knowledge on fundamental and applied aspects of geophysics, rock mechanics and structural geology/tectonics.

Guests are very welcome!