Geophysical Research Abstracts
Vol. 19, EGU2017-3535, 2017
EGU General Assembly 2017

Linking fault pattern with groundwater flow in crystalline rocks at the Grimsel Test Site (Switzerland)

Raphael Schneeberger (1), Alfons Berger (1), Urs K. Mäder (1), H. Niklaus Waber (1), Florian Kober (2), and Marco Herwegh (1)

(1) University of Bern, Institute of Geological Sciences, Tectonics, Bern, Switzerland (raphael.schneeberger@geo.unibe.ch), (2) Nagra, Wettingen, Switzerland

Water flow across crystalline bedrock is of major interest for deep-seated geothermal energy projects as well as for underground disposal of radioactive waste. In crystalline rocks enhanced fluid flow is related to zones of increased permeability, i.e. to fractures that are associated to fault zones. The flow regime around the Grimsel Test Site (GTS, Central Aar massif) was assessed by establishing a 3D fault zone pattern on a local scale in the GTS underground facility (deca-meter scale) and on a regional scale at the surface (km-scale). The study reveals the existence of a dense fault zone network consisting of several km long and few tens of cm to meter wide, sub-vertically oriented major faults that are connected by tens to hundreds of meters long minor bridging faults. This geometrical information was used as input for the generation of a 3D fault zone network model. The faults originate from ductile shear zones that were reactivated as brittle faults under retrograde conditions during exhumation. Embrittlement and associated dilatancy along the faults provide the pathways for today's groundwater flow. Detection of the actual 3D flow paths is, however, challenging since flow seem to be not planar but rather tube-like. Two strategies are applied to constrain the 3D geometry of the flow tubes: (i) Characterization of the groundwater infiltrating into the GTS (location, yield, hydraulic head, and chemical composition) and (ii) stress modelling on the base of the 3D structural model to unravel potential domains of enhanced fluid flow such as fault plane intersections and domains of dilatancy.

At the Grimsel Test Site, hydraulic and structural data demonstrate that the groundwater flow is head-driven from the surface towards the GTS located some 450 m below the surface. The residence time of the groundwater in this surface-near section is >60 years as evidenced by absence of detectable tritium. However, hydraulic heads obtained from interval pressure measurements within boreholes are variable and do not correspond to the overburden above the interval. Underground mapping revealed close spatial relation between water inflow points and faults, major water inflows occur in strongly deformed areas of the GTS. Furthermore, persistent differences in the groundwater chemical composition between infiltration points indicate that connectivity between different water flow paths is poor. Different findings indicate complex flow path geometries. However, domains of enhanced dilatancy and domains with increased number of fault intersections correlate with areas in the underground with 'high' water inflow.