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Macro-scale permeability structure of fault zones in crystalline basement rocks (Poehla-Tellerhaeuser Ore Field, Germany)

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A comprehensive dataset for discrete groundwater inflows to mines in the Poehla-Tellerhaeuser Ore Field and the mining scale fault zones has been compiled from unpublished data recorded by eastern German and Soviet hydrogeologists at the Soviet-German stock company (SDAG) Wismut. This dataset has been analyzed to provide novel insights into the 3D distribution of preferential groundwater pathways and the impacts of faulting on the distribution of hydraulic parameters in crystalline rocks at site scale (Achtziger-Zupančič et al 2016). The sampled 1030 discrete inflows include flow rates ranging from 1.7E-8 to 3.7E-2 m3 sec-1, which were transformed into mesoscale fracture transmissivity values ranging between 3E-13 and 2E-4 m2 sec-1. These mesoscale fracture transmissivities were spatially correlated with fault zones exhibiting trace lengths between 0.3 and 30 km, which were mainly formed during and reactivated several times since Variscan orogeny. The statistical correlations are based on a 3D geological model composed of 14 litho-stratigraphic units and 131 mining scale faults, separated into five main strike directions. These fault zones strongly overlap and cover about 90% of the investigated rock mass volume with a decreasing percentage of overlap in the investigated depth range (0–900 mbgs). 97% of all inflows are located within fault damage zones, and most of the flow occurs within the overlap of multiple fault damage zones. A dimensionless hydraulic model for the distribution of flow Q as a function of the position x within mining scale fault zones has been derived as Q = 1.1e-4.5x (where x decreases from the fault core to the protolith and the exponent varies as a function of fault orientation). 75–95% of the flow occurs within the inner 50% of the damage zone, and mainly NW-SE and NE-SW striking mining scale faults are transmissive. This decrease in flow rate and cumulative flow rate or transmissivity with distance to the fault center might be related to the exponential decrease of mesoscale fracture spacing in fault damage zones. The orientations of these conductive mesoscale fractures within these damage zones show a larger variability than the corresponding mining scale faults.

Repeated deformation within single faults causes increasing cataclasis which in turn increases transmissivity until a certain threshold is reached. Further shearing reduces transmissivity as the usable pore space volume decreases and retrogressive mineral reactions lead to the formation of clay gouge. Our data indicates that this is not restricted to single faults but that this mechanism might be applicable to fault networks. Therefore, the most intensively faulted deposit Haemmerlein is the least transmissive within the Poehla-Tellerhaeuser Ore Field. Also the comparably low average inflow rates within the entire ore field are attributed to the maturity of the fault system.

References:

Achtziger-Zupančič, P., S. Loew, A. Hiller, and G. Mariethoz (2016), 3D fluid flow in fault zones of crystalline basement rocks (Poehla-Tellerhaeuser Ore Field, Ore Mountains, Germany), Geofluids, 16(4), 688-710.