EGU2020-5229
https://doi.org/10.5194/egusphere-egu2020-5229
EGU General Assembly 2020

Investigating surface morphology and transport parameters of single fractures

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In order to obtain a deeper understanding of flow and transport processes in fractures, experimental investigations and numerical modelling have been carried out focusing on the effects of fracture surface morphology. To determine a possible relationship between the roughness of fracture surfaces and hydraulic and transport parameters, two different types of sandstones has been investigated. The sandstones were a coarse-grained, inhomogeneous and strongly anisotropic Flechtinger sandstone (Bebertal, Germany) and a fine-grained, rather homogeneous, isotropic Remlinger sandstone (Würzburg, Germany).

The sandstones were first cored with a diameter of 100 mm and a height of 150 mm and split into individual fissures. The resulting fracture surfaces were scanned using a 3D scan and surface images were generated. These surface images were used to determine the Joint Roughness Coefficient (JRC) and other measures of roughness. The roughness has been characterized along 1D profiles in each direction. Mean values and spread have been calculated for each surface. The fracture surfaces are self-affine so that little variation along both surfaces has been determined. Both sandstone halves were then joined together and the reassembled fractured rock core was examined experimentally. Darcy and tracer tests were carried out for the investigations and hydraulic (permeability, fracture opening width) and transport parameters (flow velocity, dispersivity, dispersion coefficient) were derived from the results and compared with each other and with the surface roughness. For the Darcy experiments, the cores were clamped in a specially designed Darcy cell and calculations were done based on equations for the cubic law. The transport parameters were determined using a salt tracer and by evaluating the breakthrough curves, recorded by measuring the electrical conductivity, with the moment analysis.

First results show a very clear separation between Remlinger and Flechtinger sandstone. Thus, the finer-grained Remlinger cores show lower JRC than the coarser-grained Flechtinger, as expected. Further, the Flechtinger cores have larger aperture opening widths than the Remlinger cores. First comparisons show a tendency to higher dispersivity with higher JRC, and thus with the Flechtinger than in the case of the Remlinger cores. Though, in-depth analysis reveals that the JRC alone might not be sufficient to characterize transport processes along fractures, as anisotropy, as well as roughness variability along the fracture surface can influence flow and transport. Numerical modeling of flow paths across the fracture surface are used to relate experimental results with the flow pattern across the rough surface.