Investigating surface morphology and transport parameters of single fractures

Sascha Frank, Thomas Heinze, Mona Ribbers, Stefan Wohnlich

EGU 2020 - Online | 4 - 8 May 2020 | Session HS8.1.2
Aim

Deeper understanding of flow and transport processes in fractures

Samples

Experimental investigations

Hydraulic flow and transport parameters

Numerical modelling

Roughness of fracture surfaces

Results

Relationship?
Sandstone cores

**Flechtinger Sandstone**
- Bebertal, Flechtinger mountain hoist (Sachsen-Anhalt)
- Permian, red-brown colored
- Diameter 100 mm, Length 150 mm
- Porosity: 5.8 – 12.5 % (Zang, 2007; Blöcher et al., 2014)
  9.6 % ± 0.1 % (Frank et al., 2020)
- Composition: 63-64 % Quartz
  20-24 % Feldspar
  12 % Phyllosilicate
  (Analyzed by Krakow Rohstoffe GmbH)

**Remlinger Sandstone**
- Remlingen (Würzburg), Thüngersheimer Anticline
- Triassic, red colored
- Diameter 100 mm, Length 150 mm
- Porosity: 13.1 ± 0.1 % (Schuster, 2017)
  12.9 % ± 0.3 % (Frank et al. 2020)
- Composition: 62 % Quartz
  18 % Feldspar
  18 % Phyllosilicate
  (Analyzed by Krakow Rohstoffe GmbH)
Experimental investigations

Darcy and tracer experiments

- Injection: 1 ml of a 2 molar NaCl solution
- Measuring electric conductivity
- Analysis of 30 breakthrough curves (BTC)
  - Calculating flow and transport parameters
    - Aperture width
    - Velocity
    - Dispersion coefficient

Frank et al. (2020), in Submission
Numerical Modelling - JRC

- High resolution 3D-Laser scans of both fracture surfaces of each core
- Defining coordinate system
- Interpolating a closed surface based on a regular grid from the recorded data
- Calculating longitudinal and transversal joint roughness coefficient (JRC) for n points along x/y-direction
  ➢ Calculating mean JRC

Vertical heights relative to a reference plane

Frank et al. (2020), in Submission
Numerical Modelling - BTC

- Using different methods to reproduce measured BTC's
  - Advection-dispersion-equation fit (ADE)
  - Moment analysis
  - Continuous time random walk fit (CTRW)

- Compare results from all methods with JRC
  - Aperture width
  - Velocity
  - Dispersivity
  - Dispersion coefficient

Frank et al. (2020), in Submission
Fracture aperture width / Permeability (Cubic law):
- Flechtinger: 120 µm – 140 µm / 1.2 – 1.7 ∙ 10⁻⁹ m²
- Remlinger: 70 µm – 100 µm / 4.4 – 8.8 ∙ 10⁻¹⁰ m²

Velocity: comparable results from ADE and Moment analysis, underestimated with CTRW fit

Dispersion coefficient: for some samples overestimated with moment analysis

Dispersivity: comparable results from all methods, for some samples overestimated with CTRW fit

More reliable results from ADE fit and Moment analysis
Results JRC

- Joint roughness coefficient:
  - Flechtinger: 13.3 – 14.1 (Exception 11.8)
  - Remlinger: 11.2 – 12.8

✓ Higher JRC for Flechtinger cores accompanying with higher aperture widths
  - One exception for Fle_7_100_S1, which is in range of Remlinger cores, but was as well optically more homogenous and isotropic like Remlinger cores.

Frank et al. (2020), in Submission
Conclusion

✓ No additional dispersion effect due to surface roughness found as suspected by phenomenological models
  ➢ Dispersivity is very similar for all JRC values over all samples
  ➢ Velocity is most influenced by aperture width and Dispersion coefficient by velocity

✓ Surface roughness may have an influence, but the range we have measured is too small

Frank et al. (2020), in Submission
Thank you for your attention
Literature