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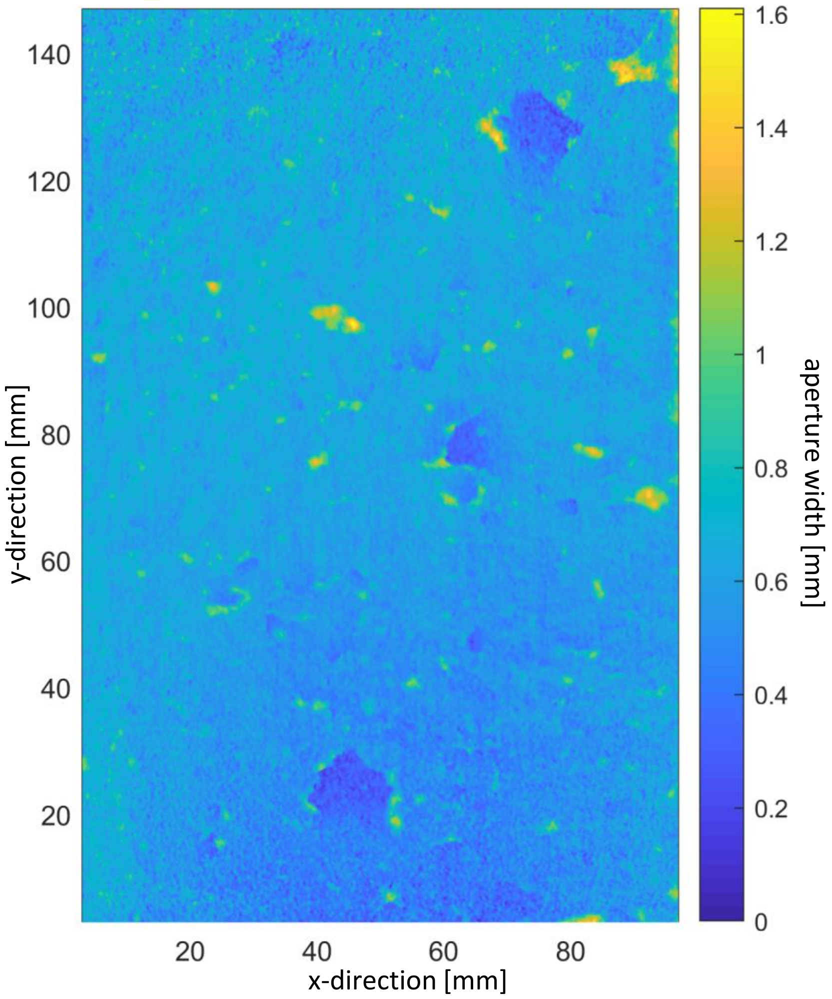
Frank et al. (2020), in Submission



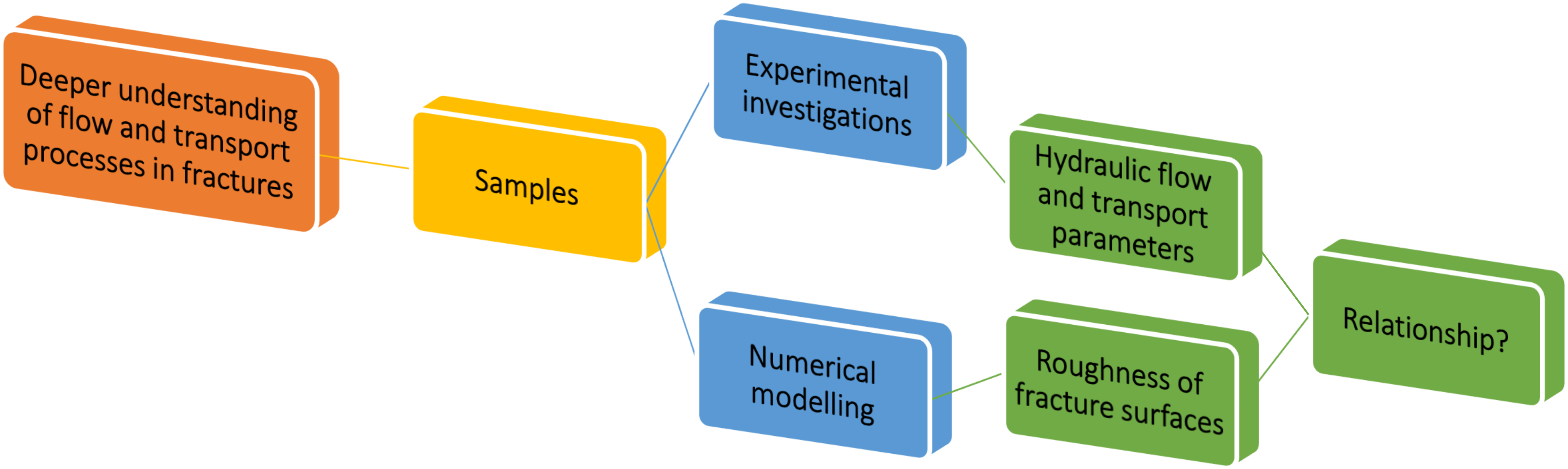

RUHR-UNIVERSITÄT BOCHUM

# 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 → Samples → Methods → Results



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Samples

# 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**

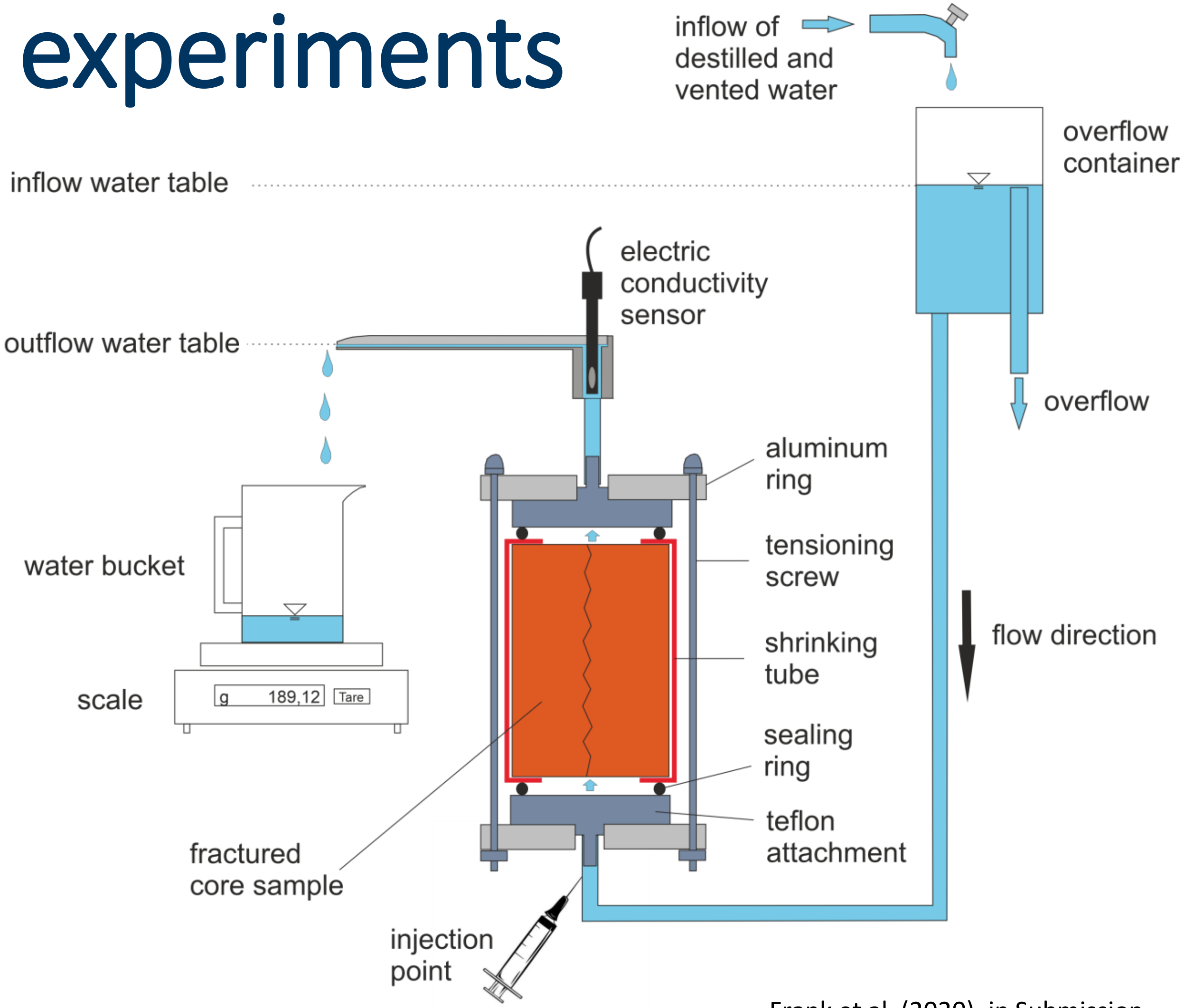
- Remlingen (Würzburg), Thüngersheimer Anticline
- Triassic, red colored
- Diameter 100 mm, Length 150 mm
- Porosity: 13.1 ± 0,1 % (Schuster, 2017)
  12.9 % ± 0,3 % (Frank et al. 2020)
- Composition: 62 % Quartz
  18 % Feldspar
  18 % Phyllosilicate

(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 break through curves (BTC)
  - ➢ Calculating flow and transport parameters
    - – Aperture width
    - – Velocity
    - – Dispersion coefficient

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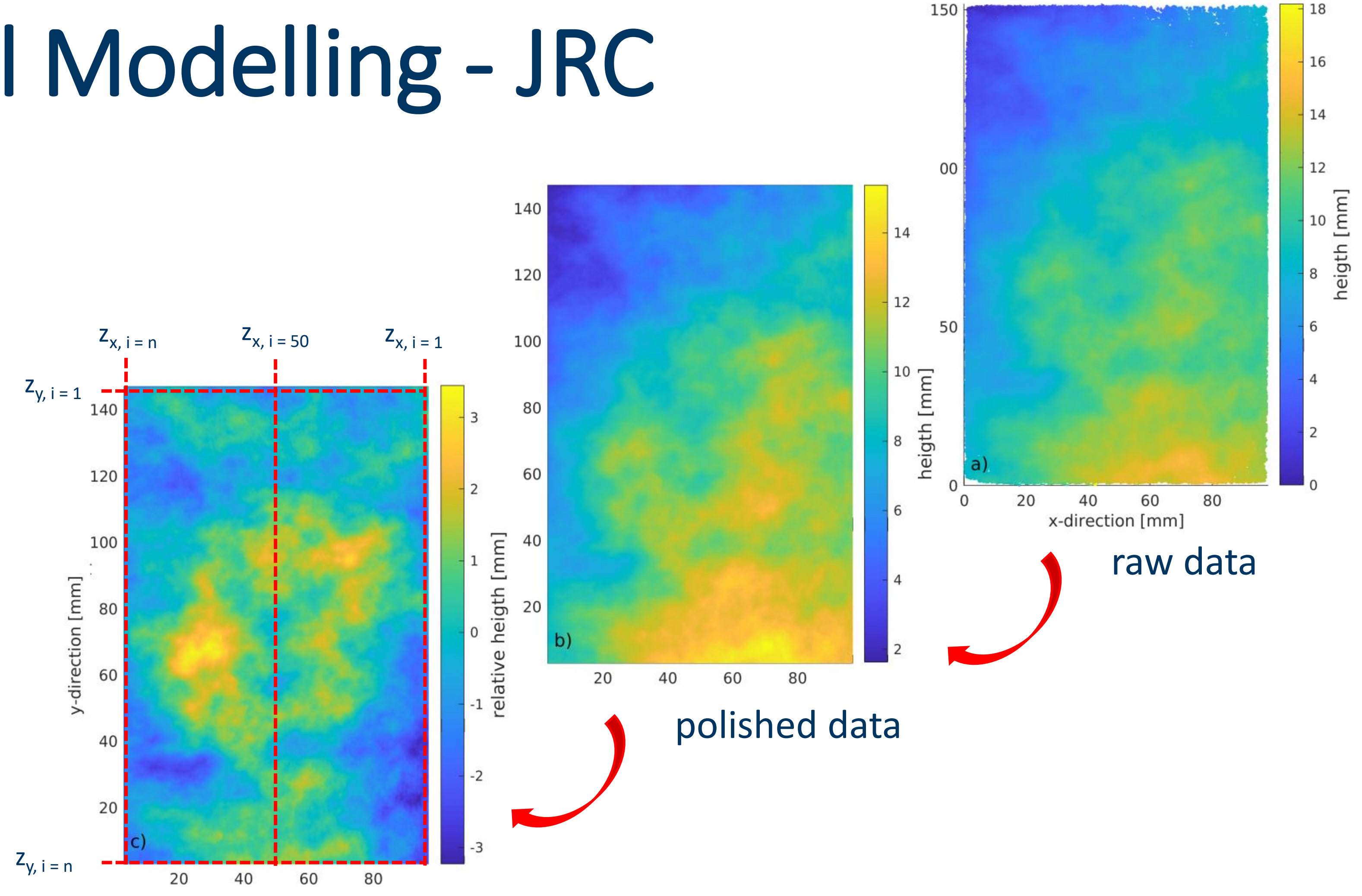
Numerical modelling

# 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

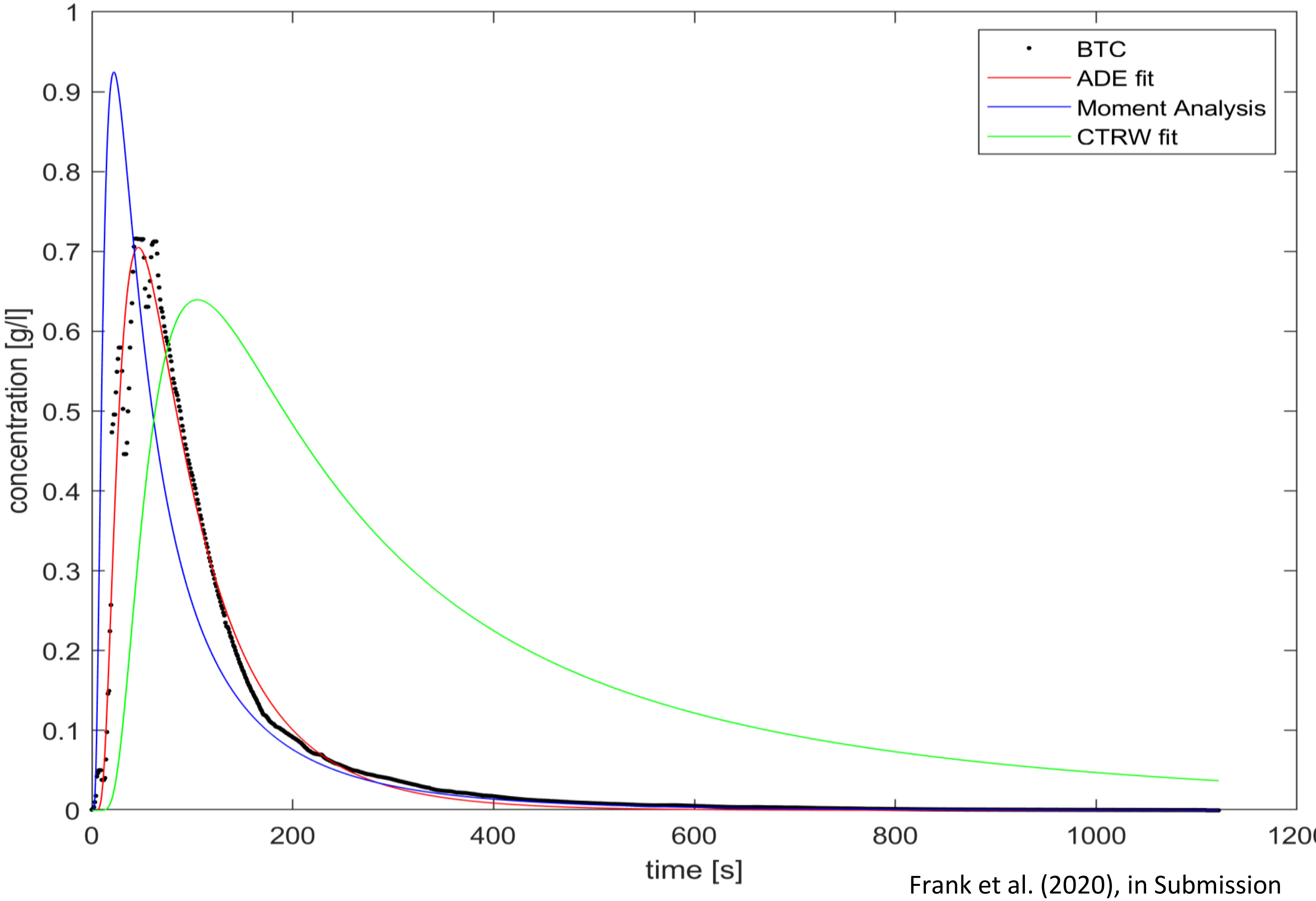
Frank et al. (2020), in Submission

Numerical modelling

# 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

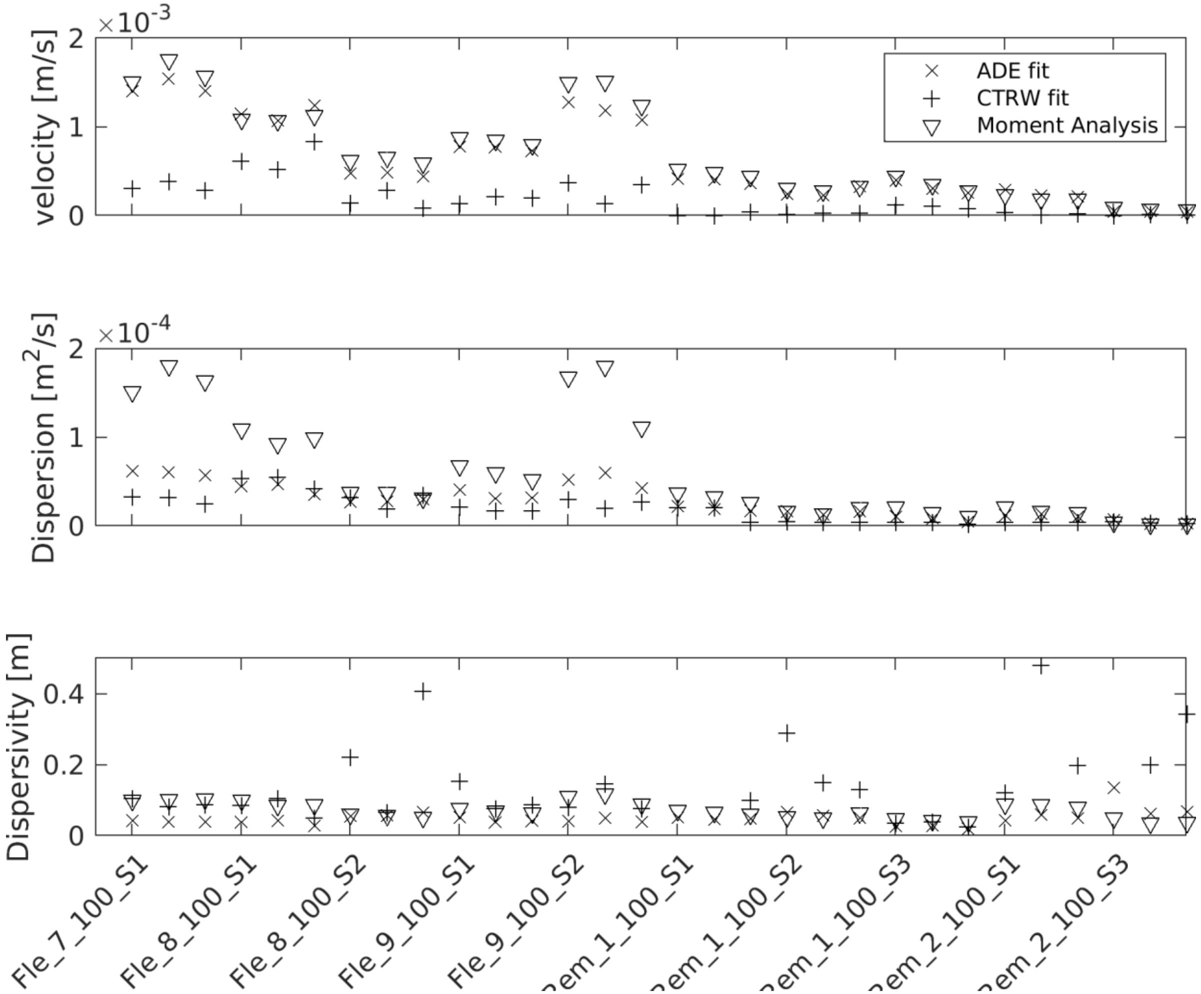
Hydraulic flow and transport parameters

# Results F&T

- 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



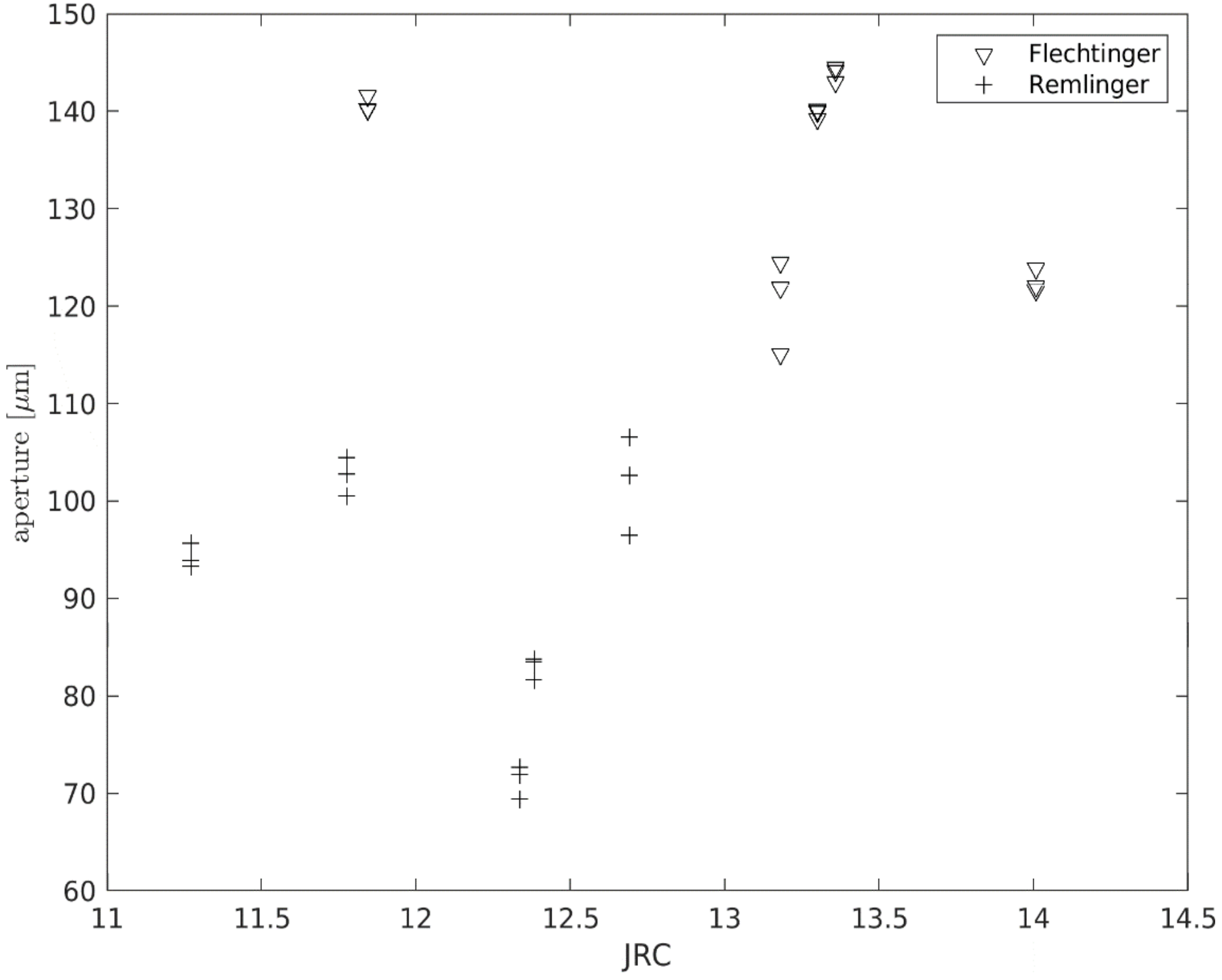

Frank et al. (2020), in Submission

Roughness of fracture surfaces

# 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

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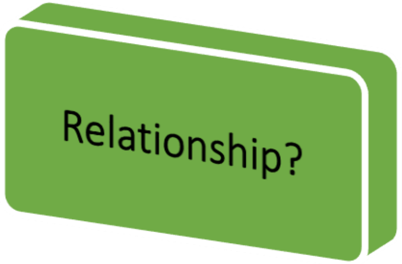
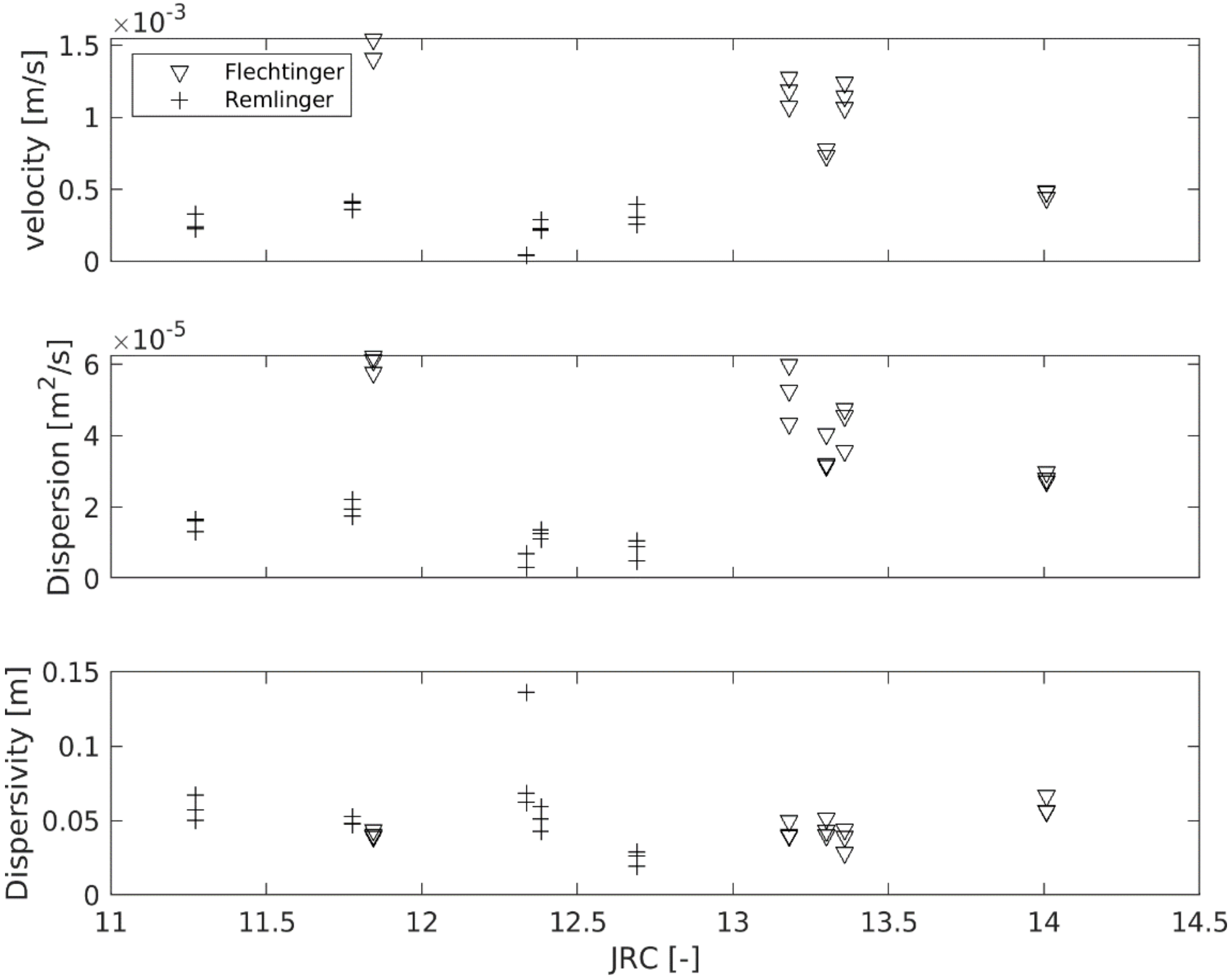



# Conclusion

- ✓ 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

Frank, S., Heinze, T., Ribbers, M., Wohnlich S. (2020): Experimental study on the effect of roughness on transport properties of single fractures. In submission in: Journal of Contaminant Hydrology - Elsevier. Submitted on April 14, 2020