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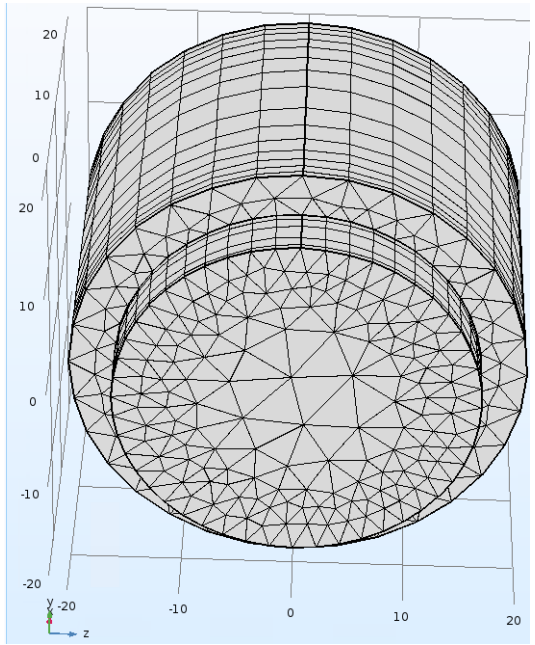
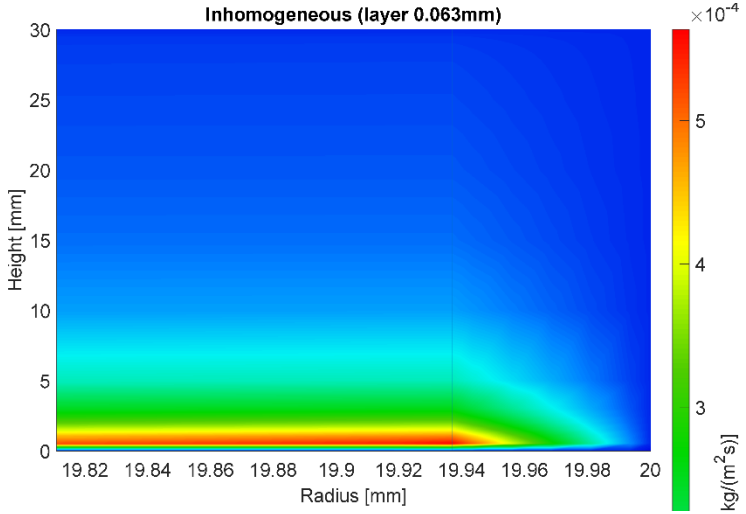
VALIDATION AND CALIBRATION OF GAS FLOW EXPERIMENTS WITH NUMERICAL SIMULATIONS





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and the CoPhyLab Team

Space Research Institute
Austrian Academy of Sciences

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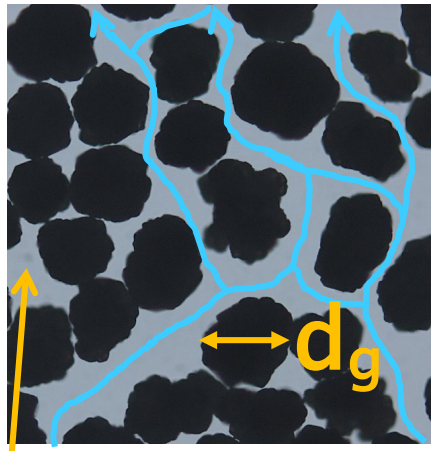
GAS FLOW IN GRANULAR MEDIA

- Motivation:
  - Understand gas flow through (porous) granular media

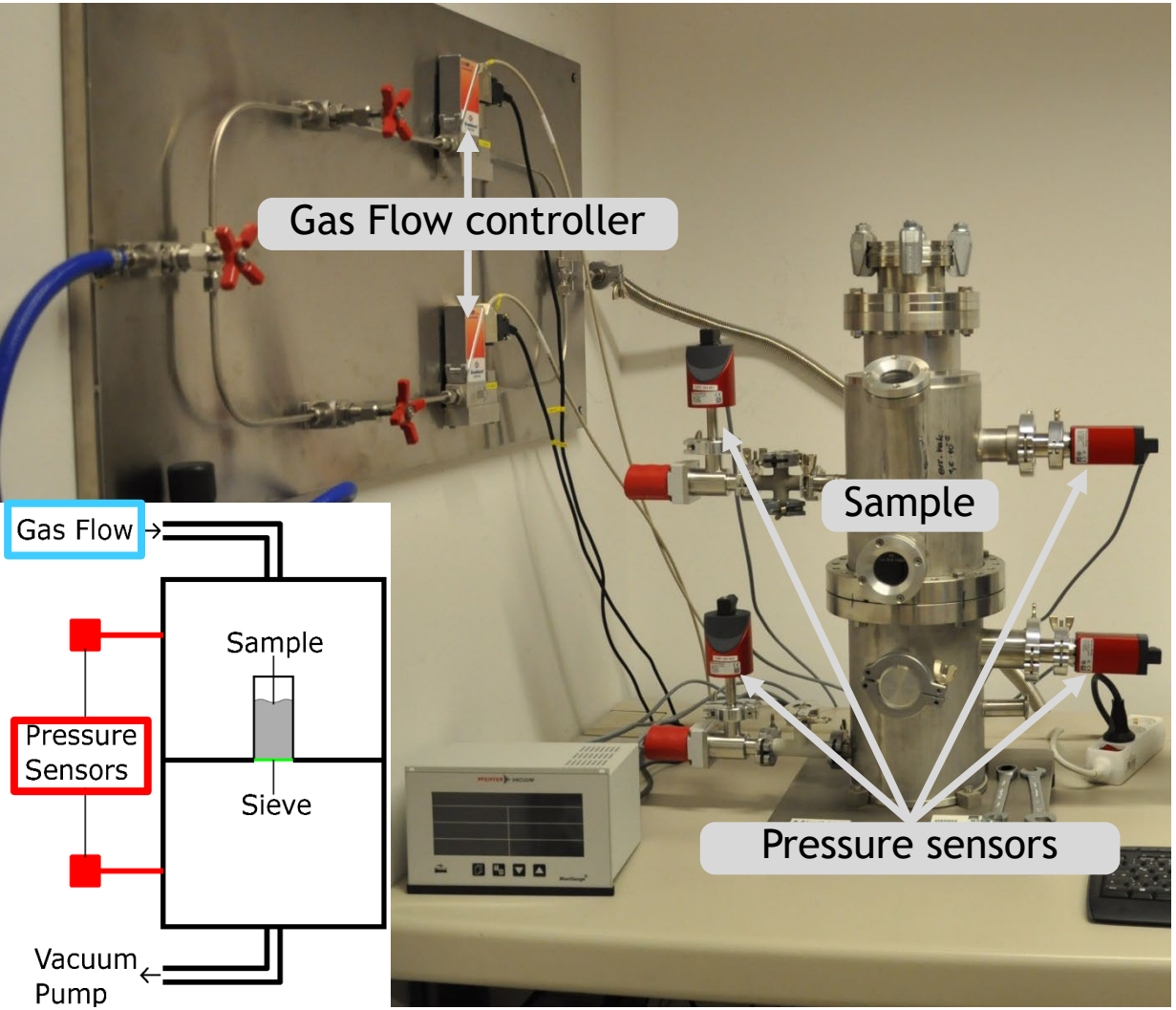
- Aim:
  - Determine material specific parameters
    + functional dependencies (e.g.: average grain diameter d_g, porosity ε…)



- Model:
  - Diffusion law with pressure dependent coefficient

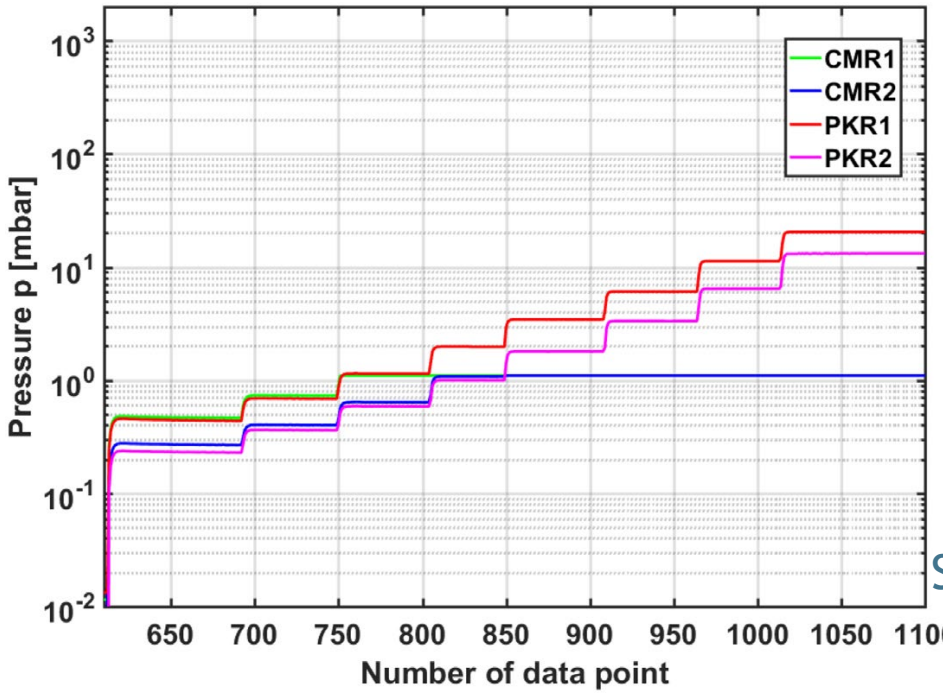
$$J = -\frac{1}{RT}\left(D_K + \frac{pB}{\mu}\right)\nabla p$$

GAS FLOW EXPERIMENT



$$J = -\frac{1}{RT}\left(D_K + \frac{pB}{\mu}\right)\nabla p$$

- Viscous permeability B
- Knudsen diffusion coefficient D_K



Schweighart+ 2021

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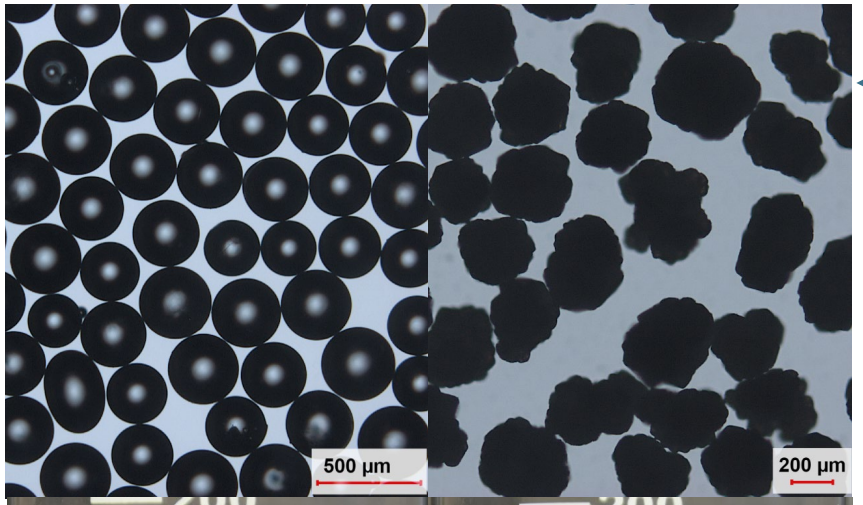
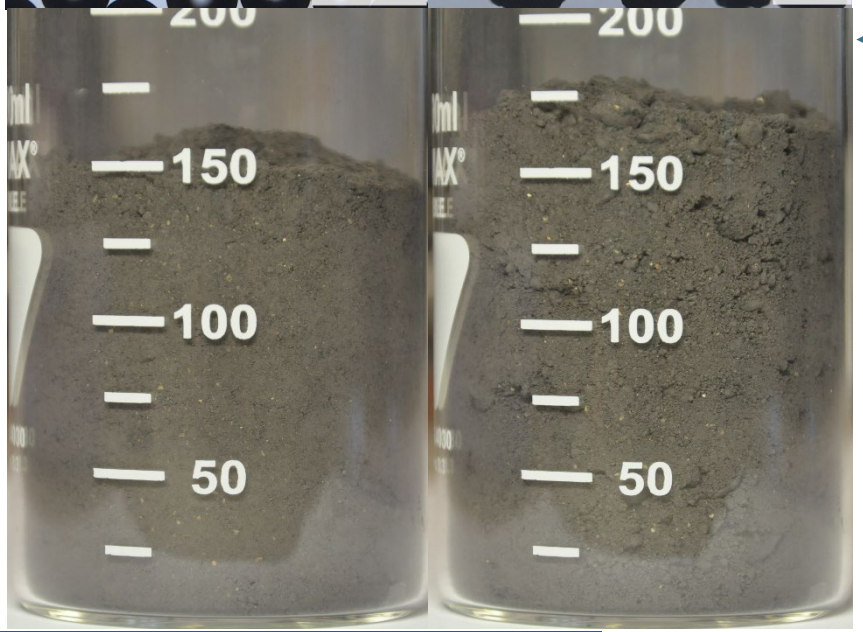
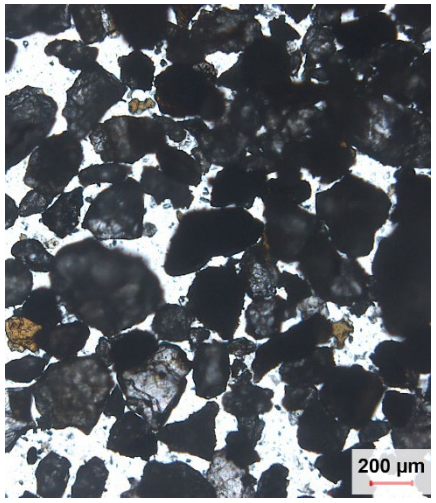
SAMPLES

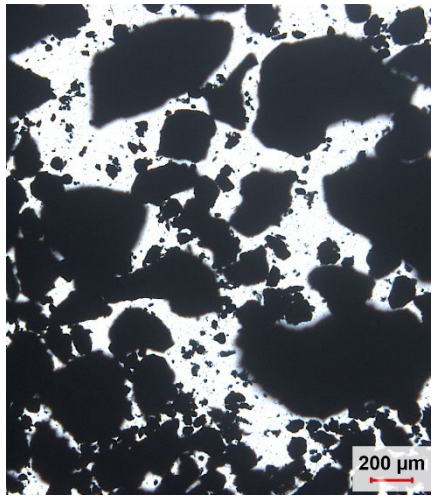


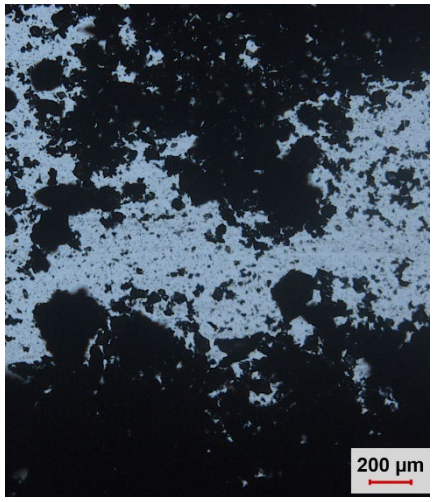
- Glass Beads (GB)
  - 11 size groups, 45 µm to 4.3 mm



- Analogues
  - Asteroid
  - Quartz sand
  - Martian
  - Lunar







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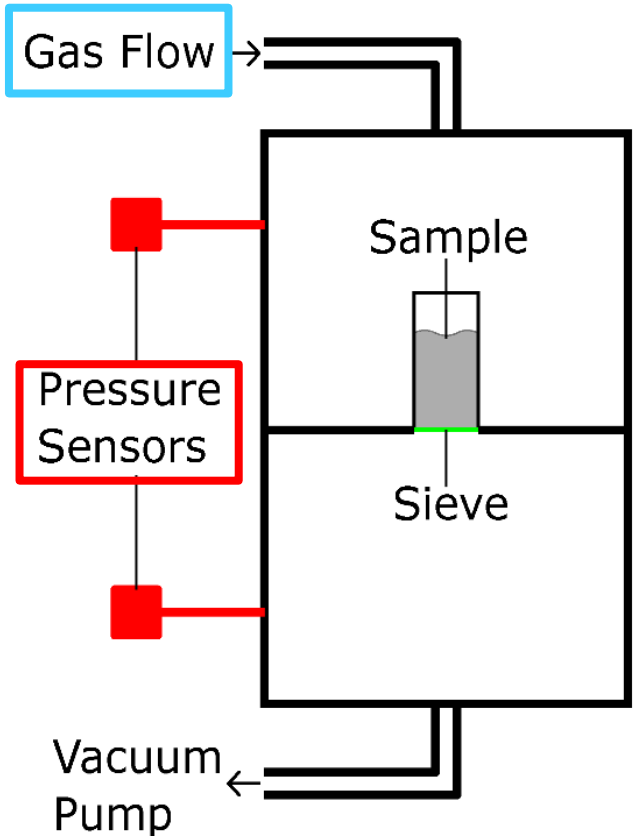
FEM SIMULATIONS

- Model baseline:
  - Stationary and transient studies
  - Boundary conditions matching experiment

$$\frac{\partial}{\partial t} = 0$$

- Input:
  - B, D_K, ε, downstream equilibrium pressure (stationary studies)
- Output:
  - Steady-state and transient pressure distribution in sample
- Comparison:
  - Equilibrium pressure upstream and downstream of sample



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INITIAL RESULTS

Larger deviations:

d < 250 µm

→ grain angularity

(Measurement results of Schweighart+ 2021)

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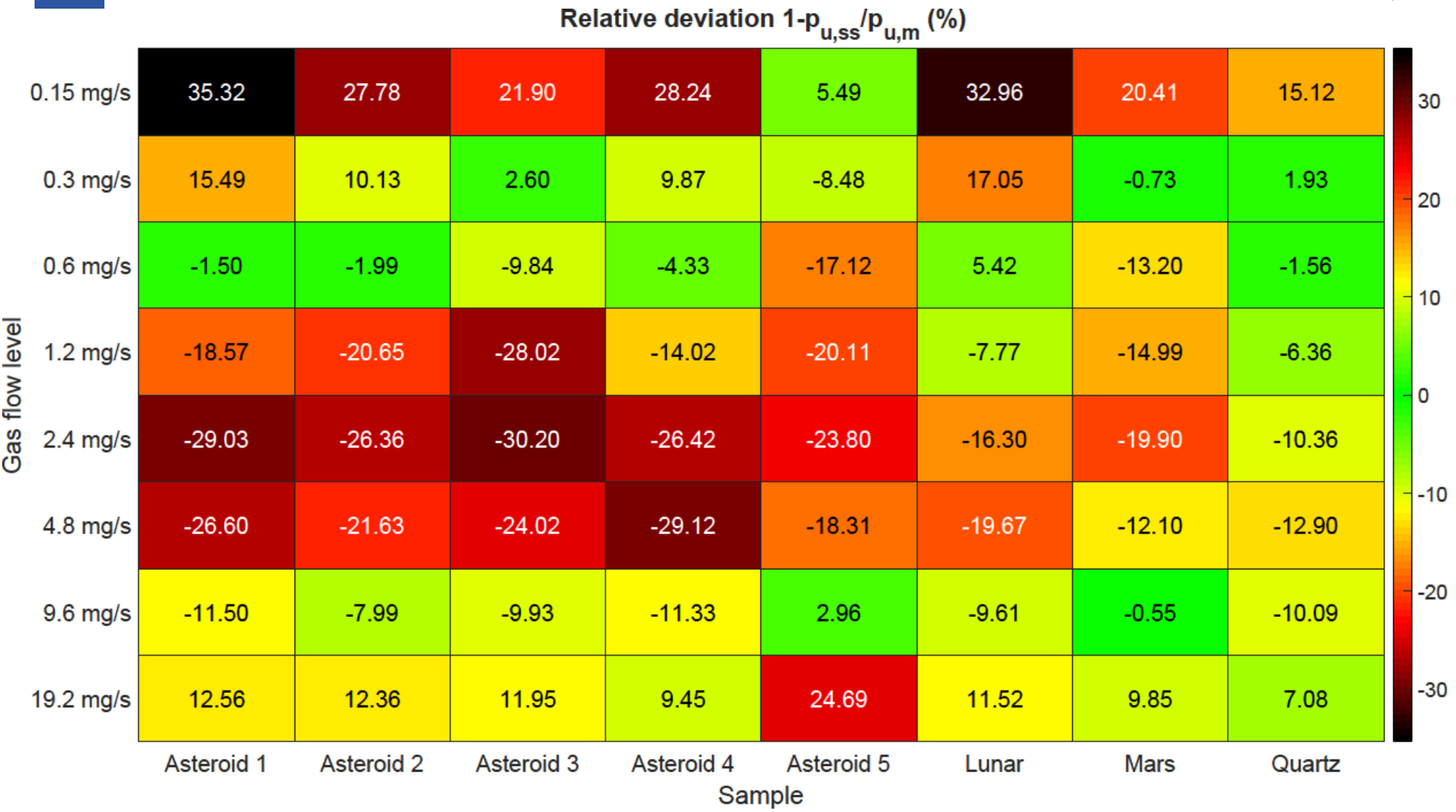
INITIAL RESULTS



Large deviations:

No clear pattern

→ polydisperse, angular grains

(Measurement results of Schweighart+ 2021)

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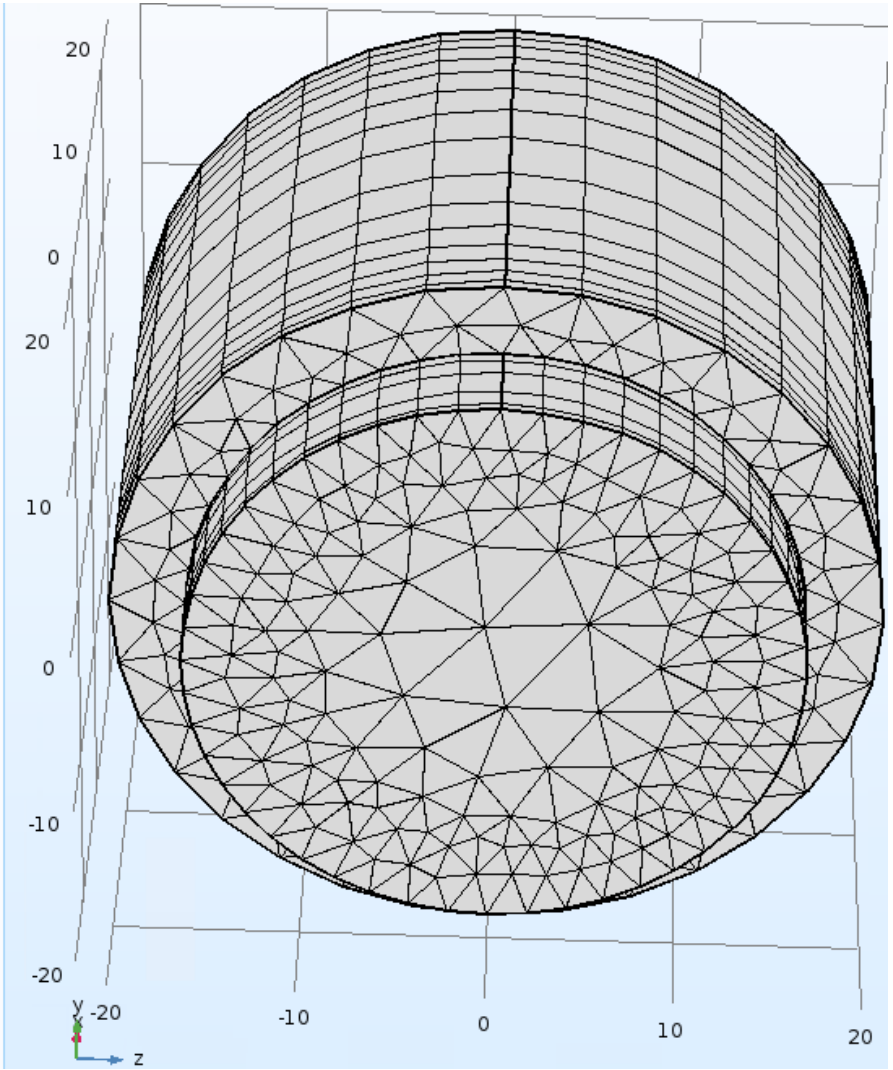
ANALYSIS OF ERROR SOURCES

- Experiment geometry:
  - d=40 → d=36 mm: error of Δp≈ 4-7 %
  - d=40 → d=32 mm: error of Δp≈ 10-18%



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ANALYSIS OF ERROR SOURCES

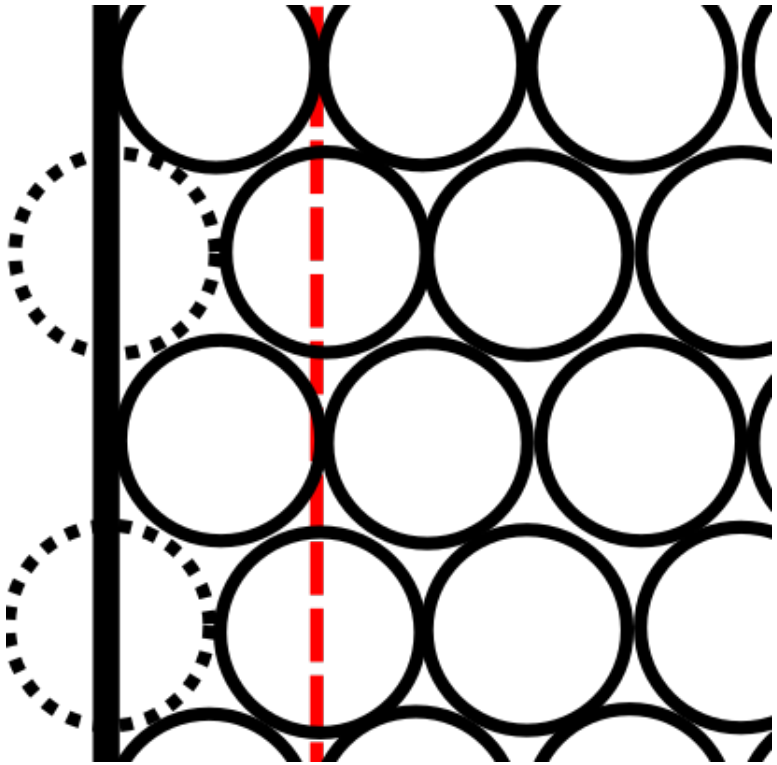
- Packing properties:
  - Boundary layer with higher ε (35%→54%)
  - Error of Δp:
    - >50% for largest beads
    - <10 % for medium beads
    - <5 % for smallest beads

$$D_K \sim \frac{\varepsilon^2}{1-\varepsilon}$$

Asaeda+ 1974

$$B \sim \frac{\varepsilon^3}{(1-\varepsilon)^2}$$

Kozeny-Carman model (Pinto+ 2009)



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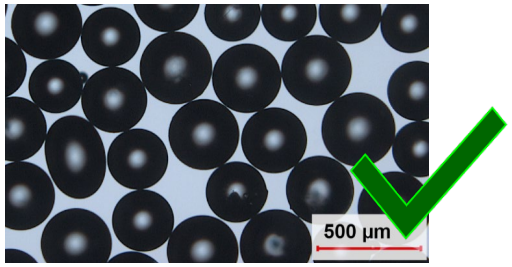
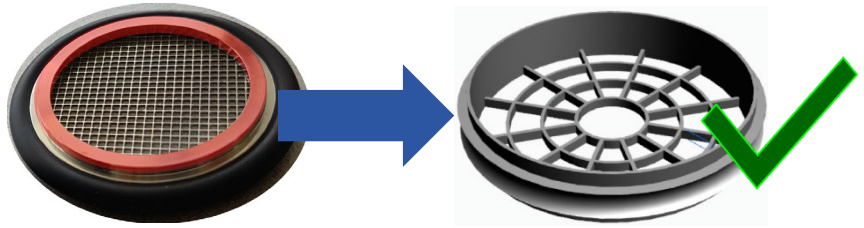
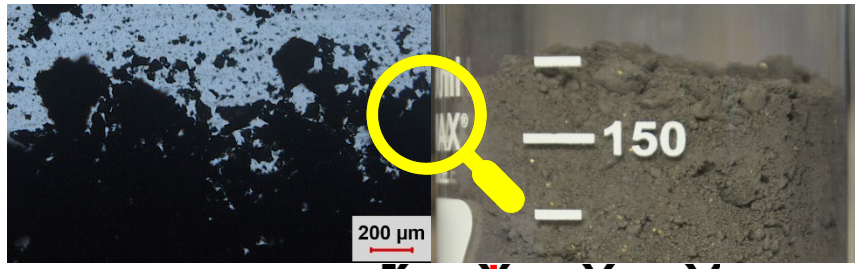
SUMMARY AND OUTLOOK

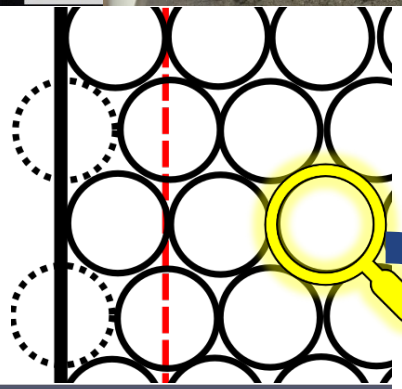
- Applicability of model:

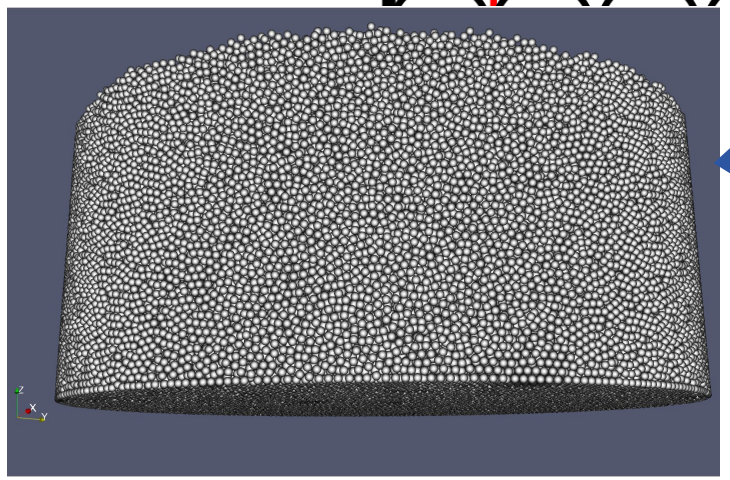


- Error sources:









- Alternative simulation methods
  - DEM → for virtual samples
  - Particle codes for gas flow

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ACKNOWLEDGEMENTS

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