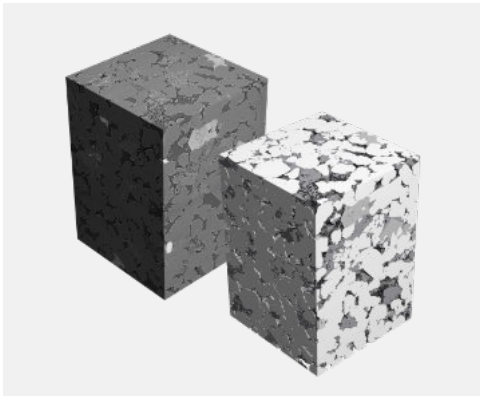# GeoDict

The Digital Material Laboratory

Digital two-phase flow under consideration of the entire hysteresis

- The calculation of the capillary pressure curve is an important task to be solved when determining the properties of a reservoir

- The hysteresis cycle maps the following processes:

  - **Primary Drainage (forced):**
    Water is displaced by oil

  - **Imbibition (spontaneous+forced):**
    Oil is displaced by water based on the preceding fluid distribution

  - **Secondary Drainage (spontaneous+forced):**
    Water is displaced by oil based on the preceding fluid distribution

MATH
2 MARKET

1 — Import and segmentation

Import a µCT scan of a rock sample:

- Use advanced GeoDict image processing tools to improve the scan's quality
- Segment the scan into 4 phases via
  - Manual thresholding
  - Automatic thresholding (OTSU, k-Means)
  - Multiphase thresholding via watershed algorithm
  - AI-based segmentation

**Result**: **Digital twin of the rock sample**

2 — Property Analysis
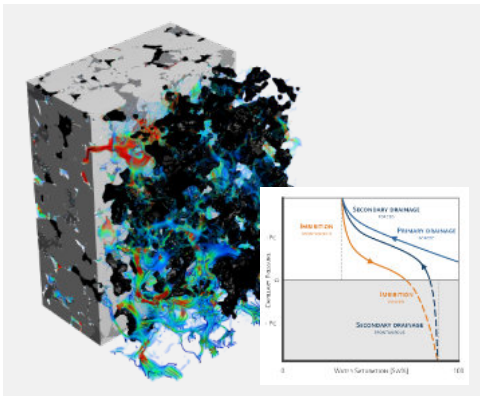
- The entire contact angle range (water-wet, neutrally-wet, oil-wet, mixed-wet) of the simulated fluids is mapped according to the individual wetting properties of the rock
- Extensive automation of individual workflows is possible:
  - Fluid properties
  - Wetting conditions
  - Contact angle
  - Interfacial tensions
  - Flow direction

Result: **Statistical description of rock properties**

3 — Calculation of the relative permeability of large structures under mixed-wet conditions
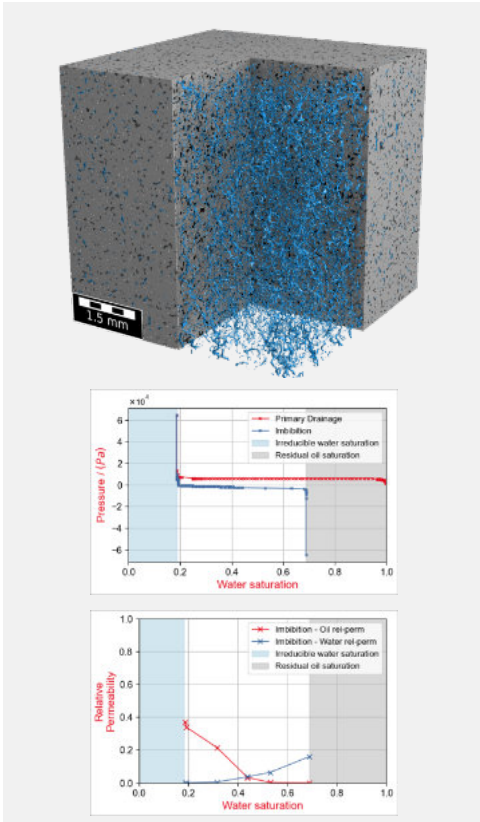
- When determining the rock properties, the saturation distribution of the phases is calculated for each pressure step
- Digital sandstone sample (1500x1500x1500 voxels) with a resolution of 3.7 µm
- Contact angle (to the mineral surfaces):
  - Water-wet CA: 40°
  - Oil-wet CA: 140°
- Results of the capillary pressure curve calculation:
  - Irreducible Water saturation: 19 %
  - Residual Oil saturation: 31 %
- Used computer resources:
  - Duration: ~3.8 days
  - RAM: ~195 GB
  - Parallelization: 32 Cores
  - Software: GeoDict 2022 (Linux)

Mattila et al., 2016: A prospect for computing in porous material research: very large fluid flow simulations, Journal of Computational Science, 15, pp. 62-76,
https://doi.org/10.1016/j.jocs.2015.11.013

G. Burmester, F. Zekiri, H. Jurcic, P. Arnold, H. Ott., Integration and Upscaling of Multi-Phase Fluid Flow Properties in Clastic Reservoirs, 83rd EAGE Annual Conference & Exhibition, Conference Proceedings, pages 1-5, 2022
https://doi.org/10.3997/2214-4609.202210939

Result: **The relative permeability can be determined ~100 times faster than using conventional laboratory methods!**

MATH 2 MARKET