# Werkstoffmodellierung und –eigenschafts-berechnung auf Basis von CT-Aufnahmen

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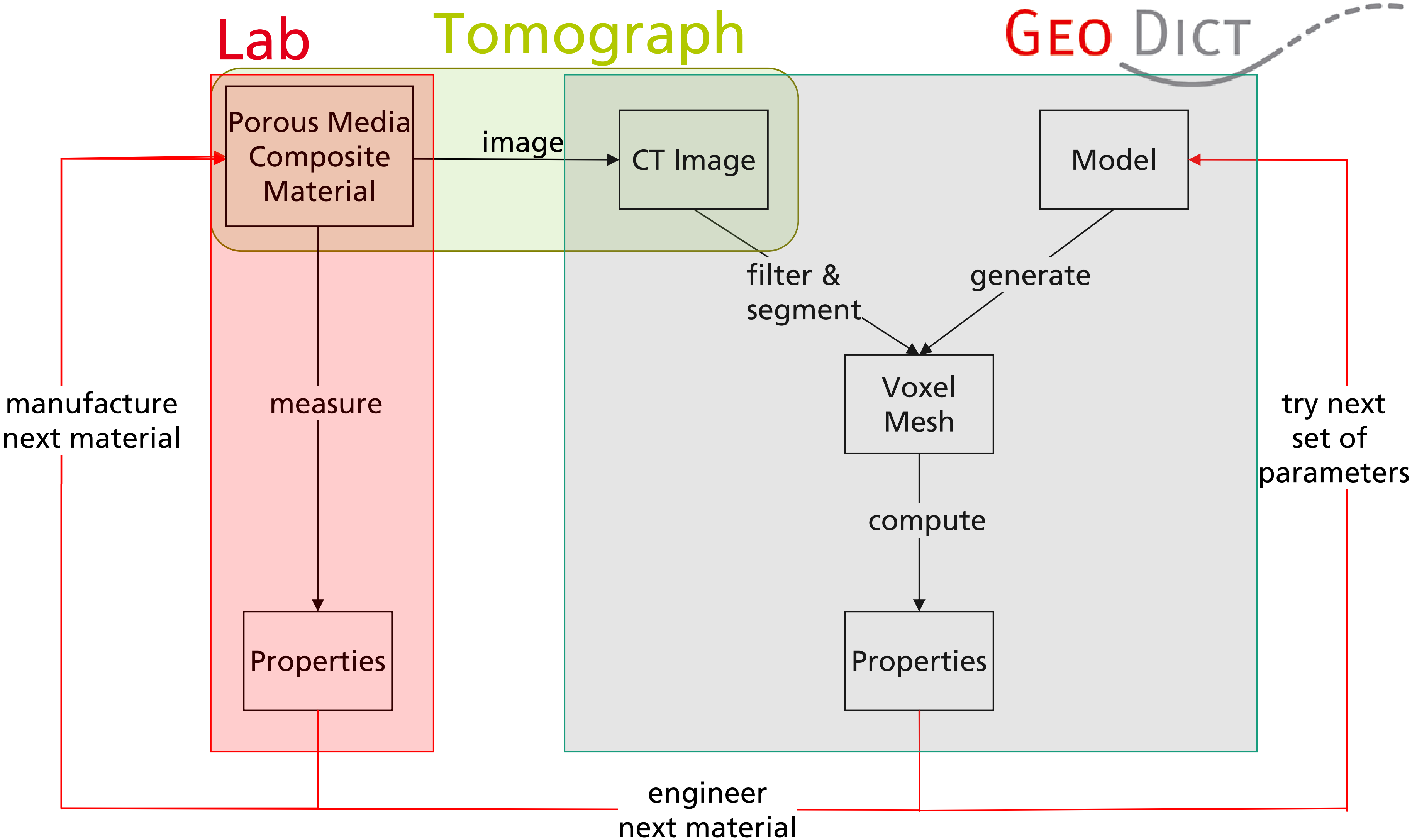
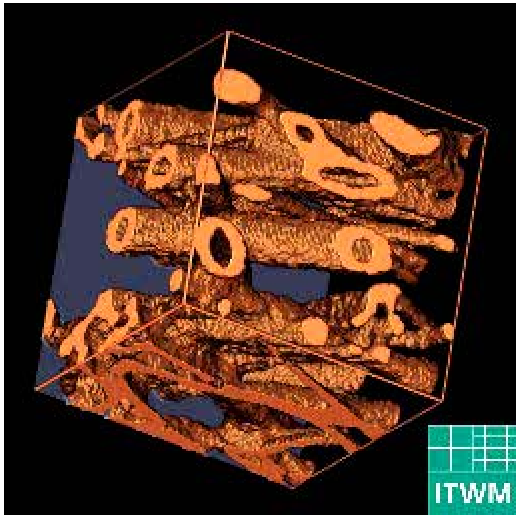
# Computer Aided Material Engineering with GeoDict

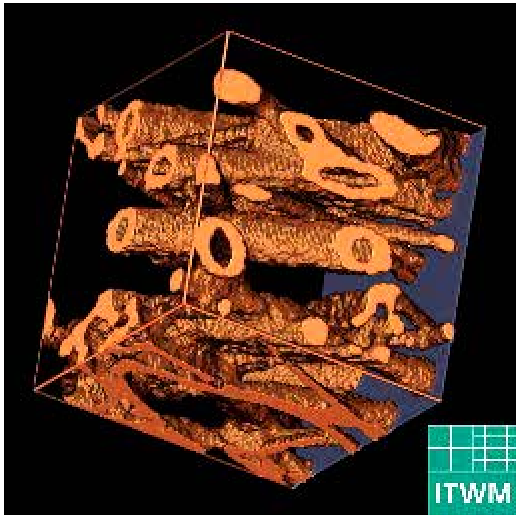


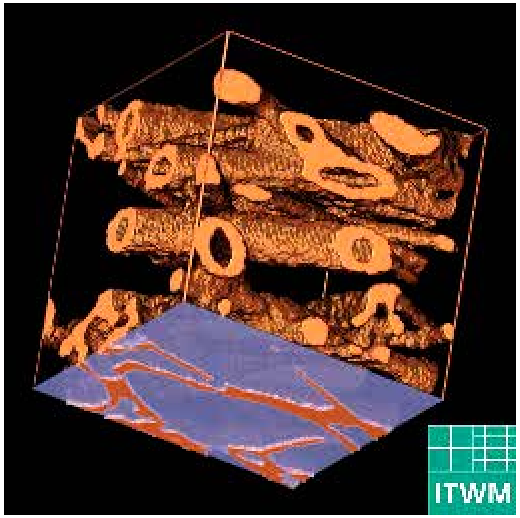
# Computation of permeability

Darcy-Law: $\bar{\mathbf{u}} = \frac{1}{L}\mathbf{K}\cdot\Delta\mathbf{p}$ Generalized: $\vec{\mathbf{u}} = -\kappa\cdot\nabla\mathbf{p}$

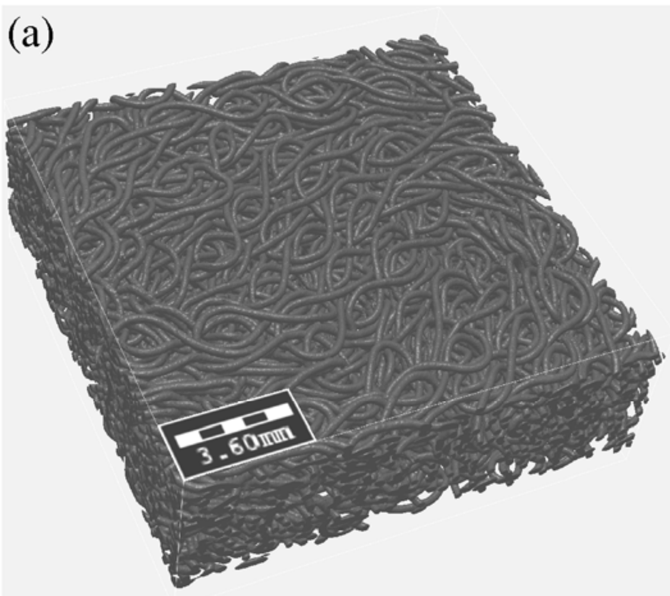
Permeability tensor: $\mathbf{K} = \begin{pmatrix} k_{11} & k_{12} & k_{13} \\ k_{21} & k_{22} & k_{23} \\ k_{32} & k_{32} & k_{33} \end{pmatrix}$ → Find anisotropic material behavior

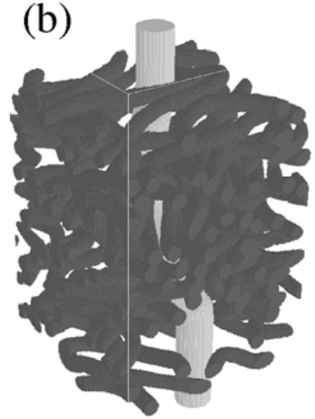


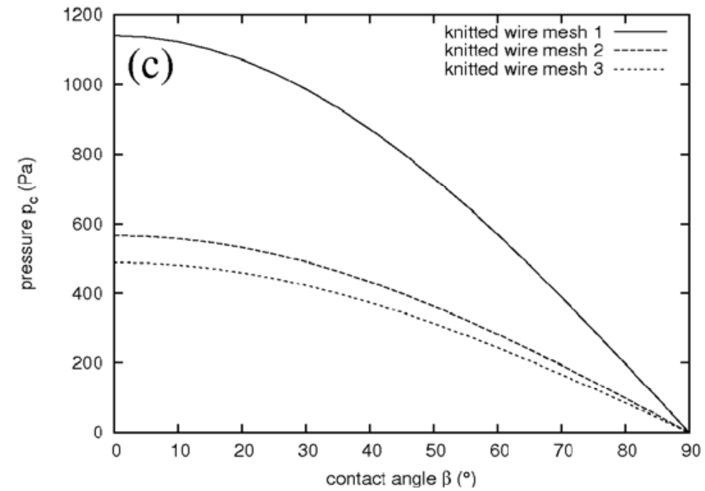



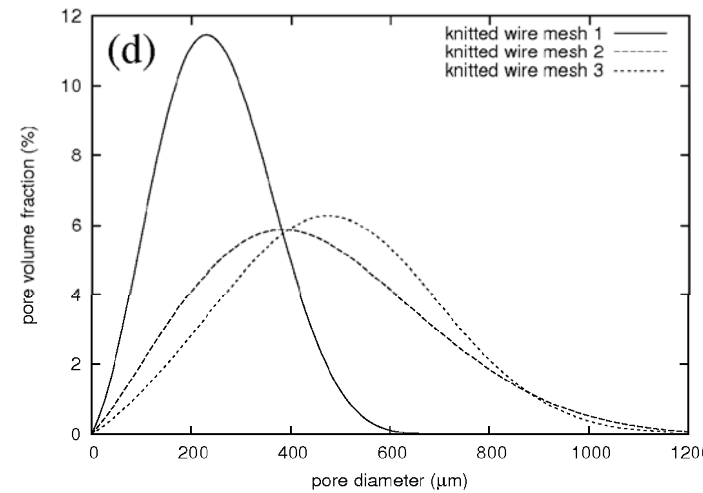



# Knitted Wire Meshes: Geometry-Based Property Analyses




(a): CT-scan of a knitted wire mesh.

(b): Largest through pore.

(c): Bubble point pressure in dependency of the contact angle.

(d): Pore size distribution.

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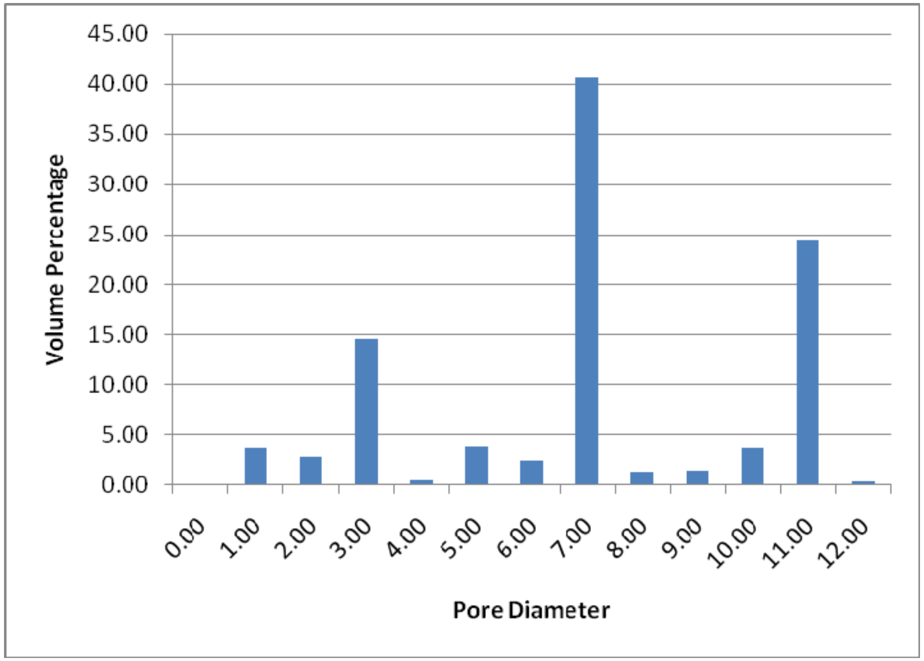
# Use PSD for solids to get fiber diameters







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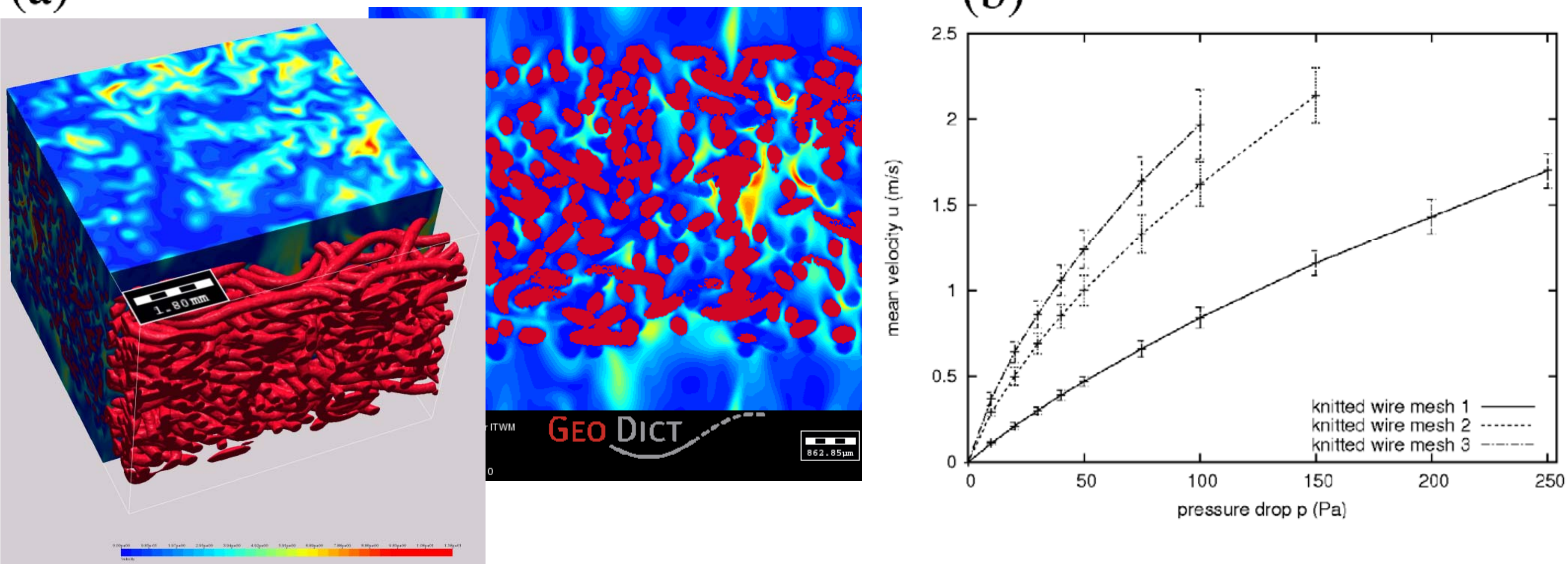
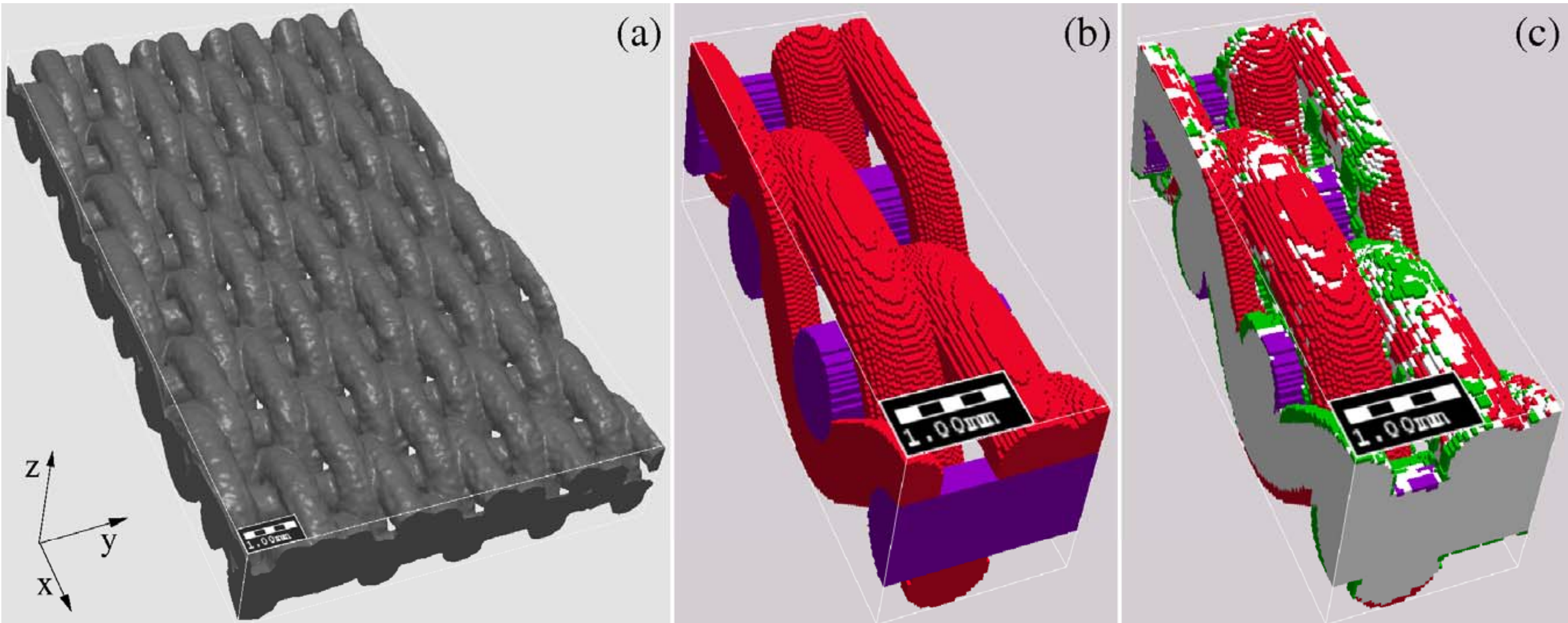
# Knitted Wire Meshes:
# Partial-Differential-Equation-Based Property Analysis

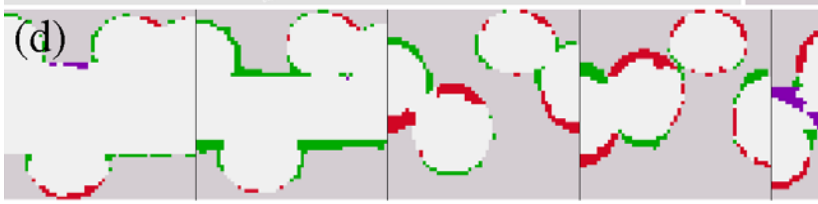
(a) (b)




(a): Magnitude of velocity in a CT-scan of a knitted wire mesh.
(b): Mean velocity as function of pressure drop for three knitted wire meshes.

# Woven Metal Wire Meshes: Geometric Validation



(a): CT of a twill Dutch-weave. (b): Geome
(c)-(d): Geometric validation.

Microscopy Courtesy M. Knefel, Gebr. Kufferath AG.

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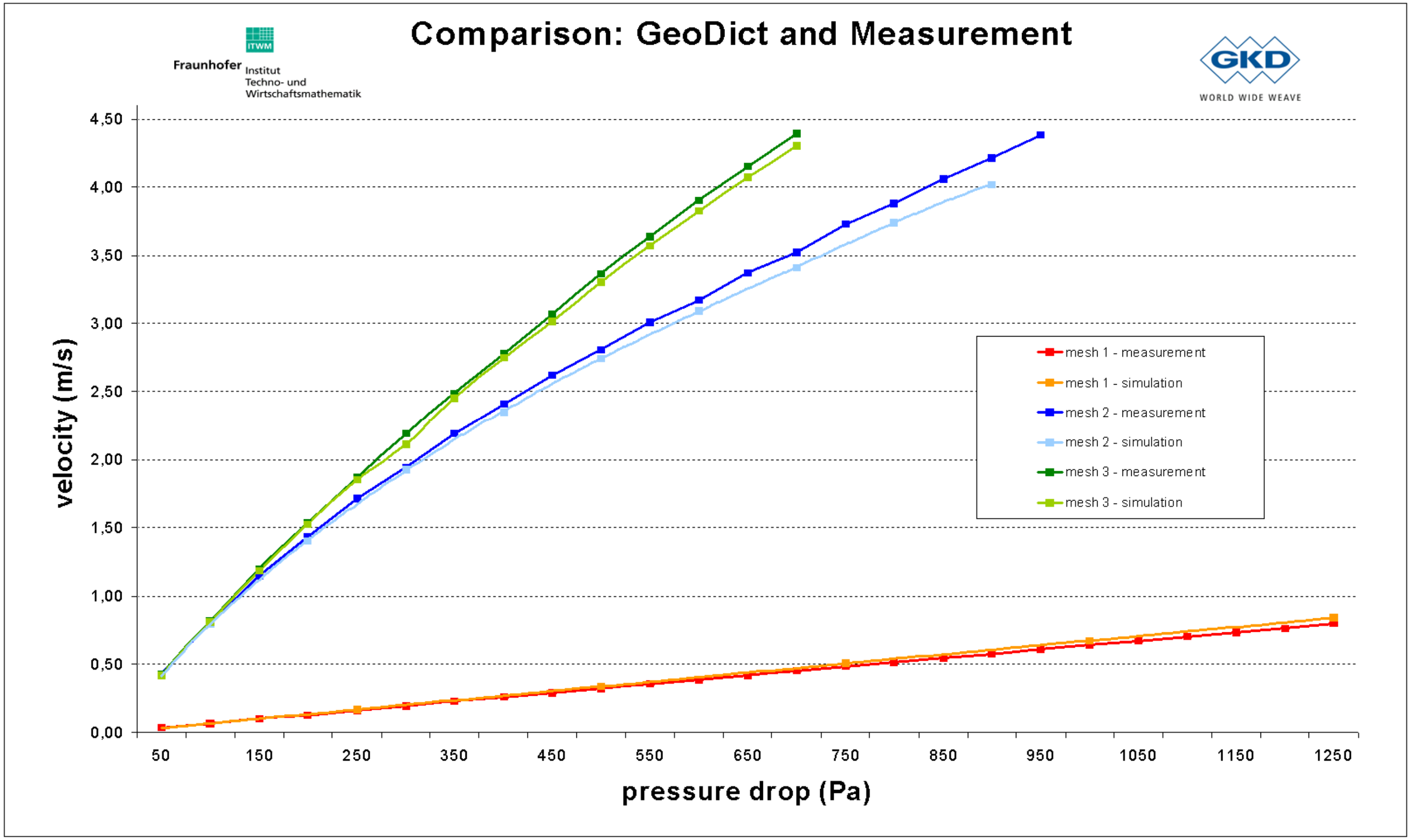
# Woven Metal Wire Meshes: Measurement and Simulation

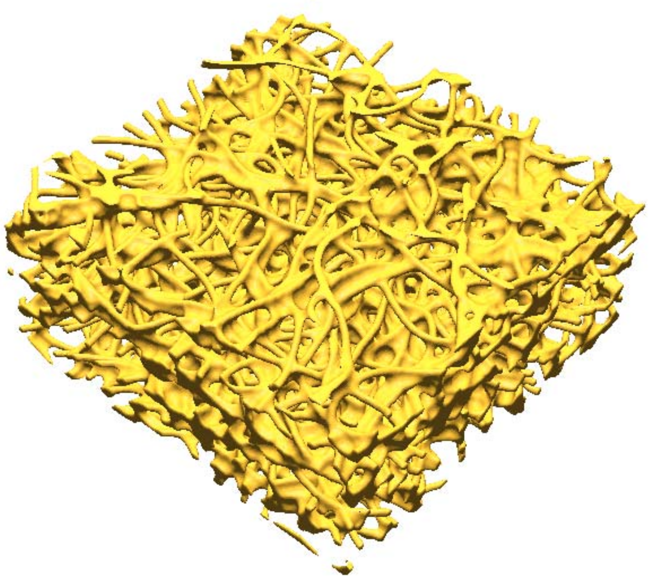



Velocity dependent pressure drop: Comparison between measurements and simulations on corresponding geometry models.

# Model: Curved Fibers with inder

Process:

- fibers consist of straight segments
- start with one segment, then add segments
- direction of added segment:
    - direction of prev.  segment + random disturbance
    - direction of first segment + random disturbance
    - keep current curvature + random disturbance
- add binder



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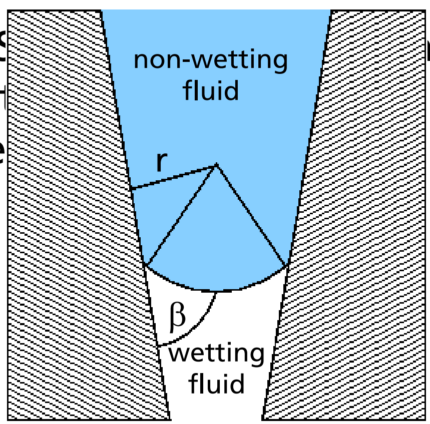
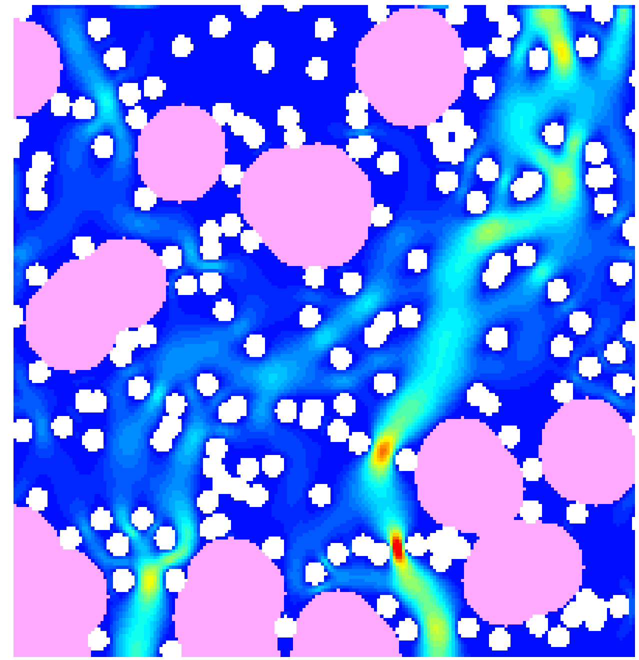
# Relative Permeability

Two-step approach:

1. Use pore morphology method (Hilpert, 2001) to determine distribution of air and water phase.
   - Idea: a pore is filled with the non-wetting fluid (=water), if $p_c \geq \frac{2\sigma}{r} \cos \beta$

2. Solve S … e remaining pore
   space t … phase (=air)
   perme …





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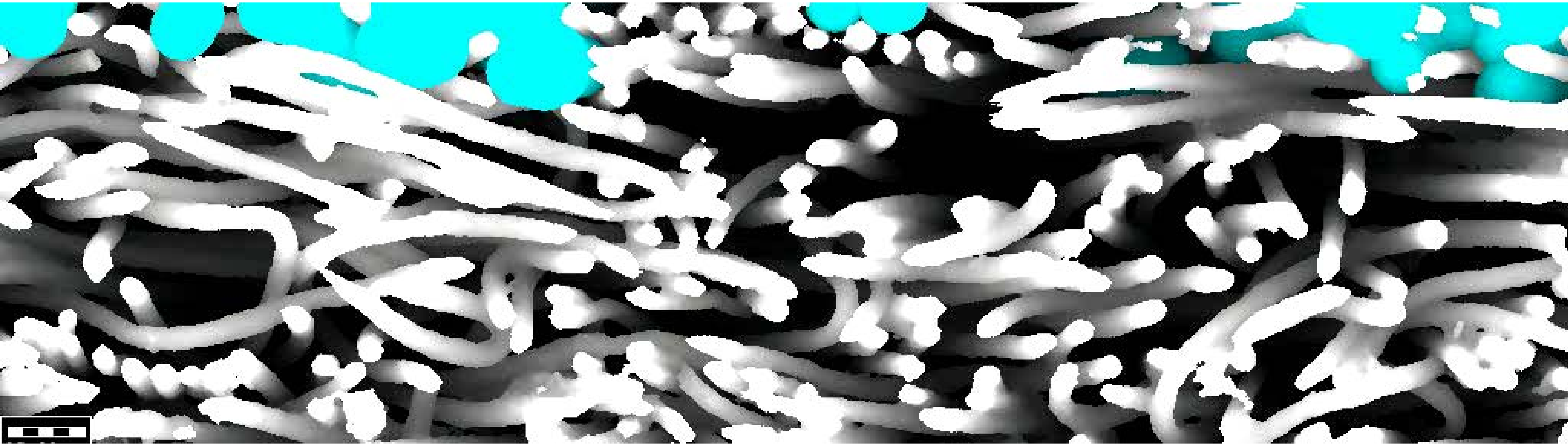
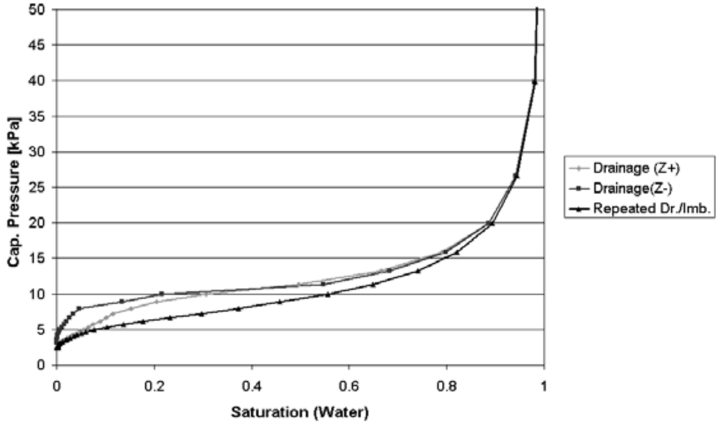
# Simulated mercury Distribution at Bubble Point in tomography






pc= 10.6 kPa
(r=10.5 μm)

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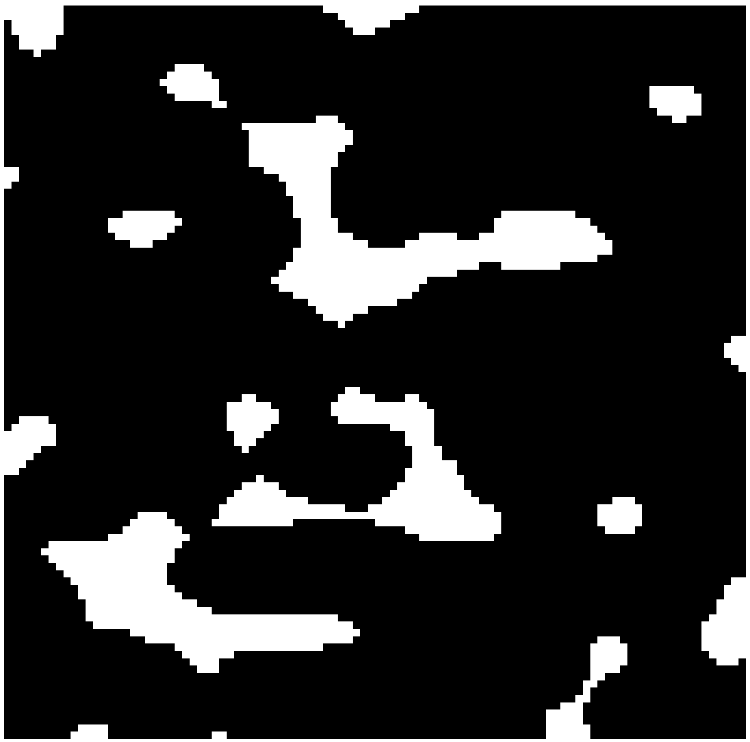
# Comparison of two compression models

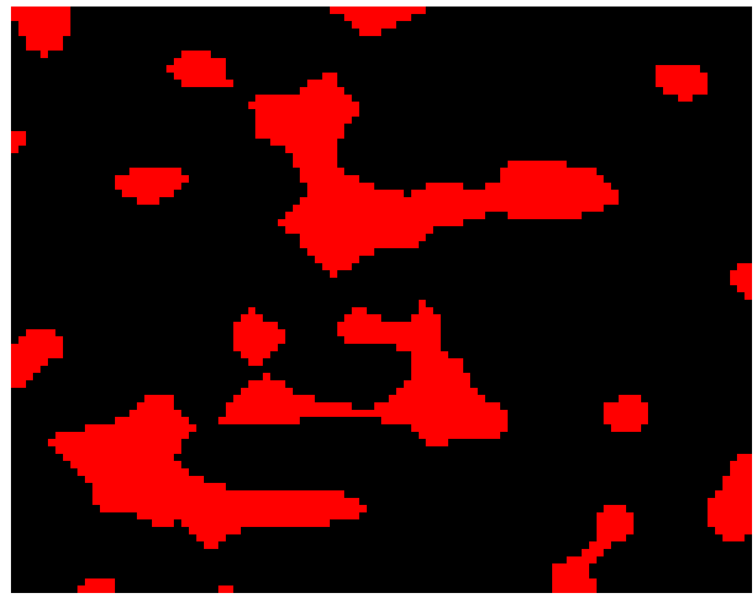
Geometric Algorithm:

*(Schulz, Becker, Wiegmann, Mukherjee, Wang, J. Electrochem Soc. 154, 2007)*

- compression in z-direction
- handles each z-column separately
- mass is kept by shifting solid blocks
- No knowledge about applied forces



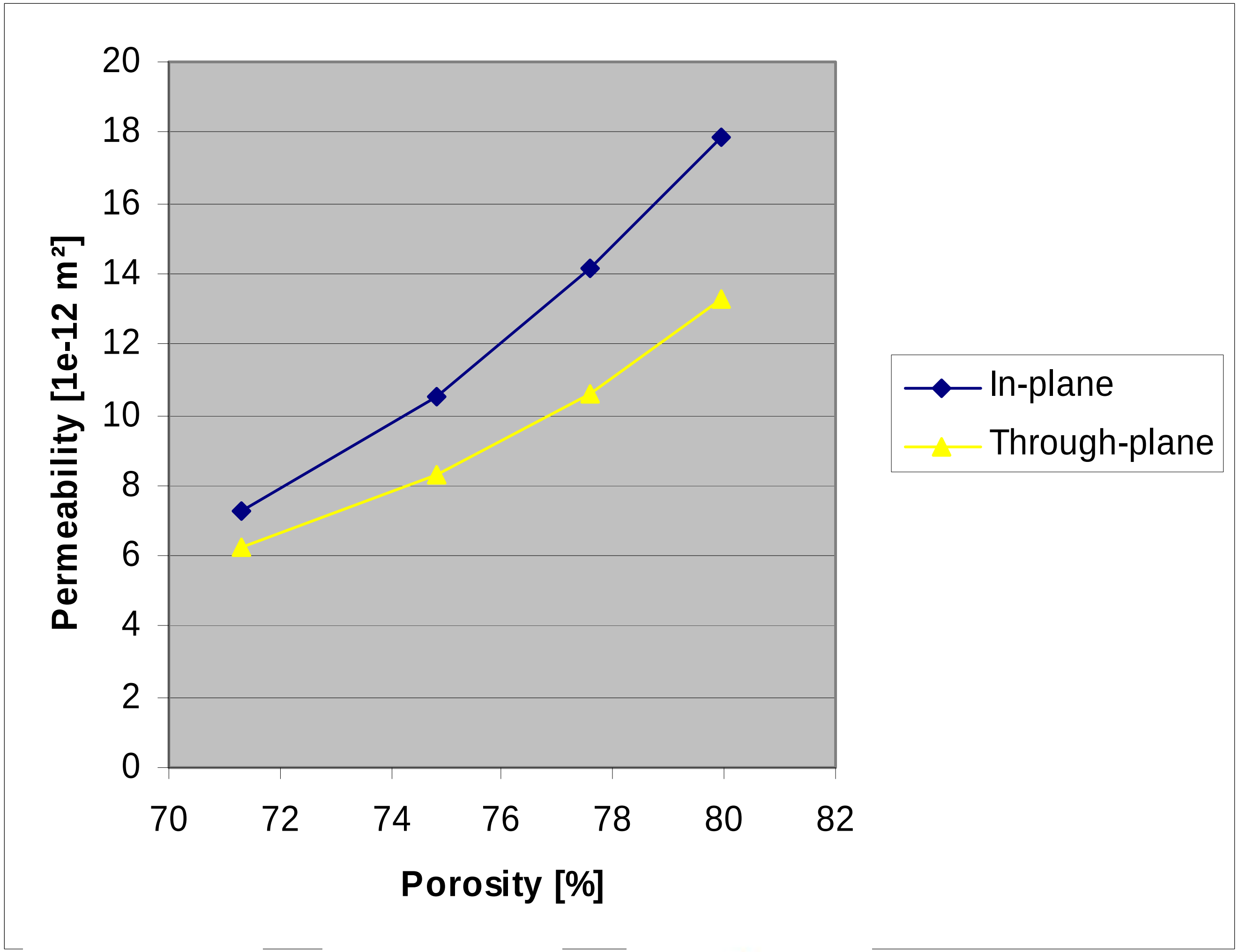
uncompressed

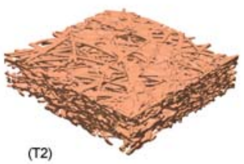


**compressed (20%, FE model)**
**computation time: 5 days**
**computation time: 0.25 s**

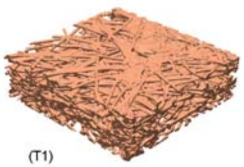
# Compression Effect on Permeability

• calculated for 0%, 10%, 20%, 30% compression

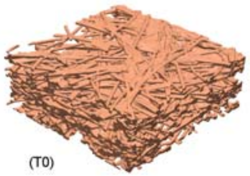


(T2)



(T1)



(T0)

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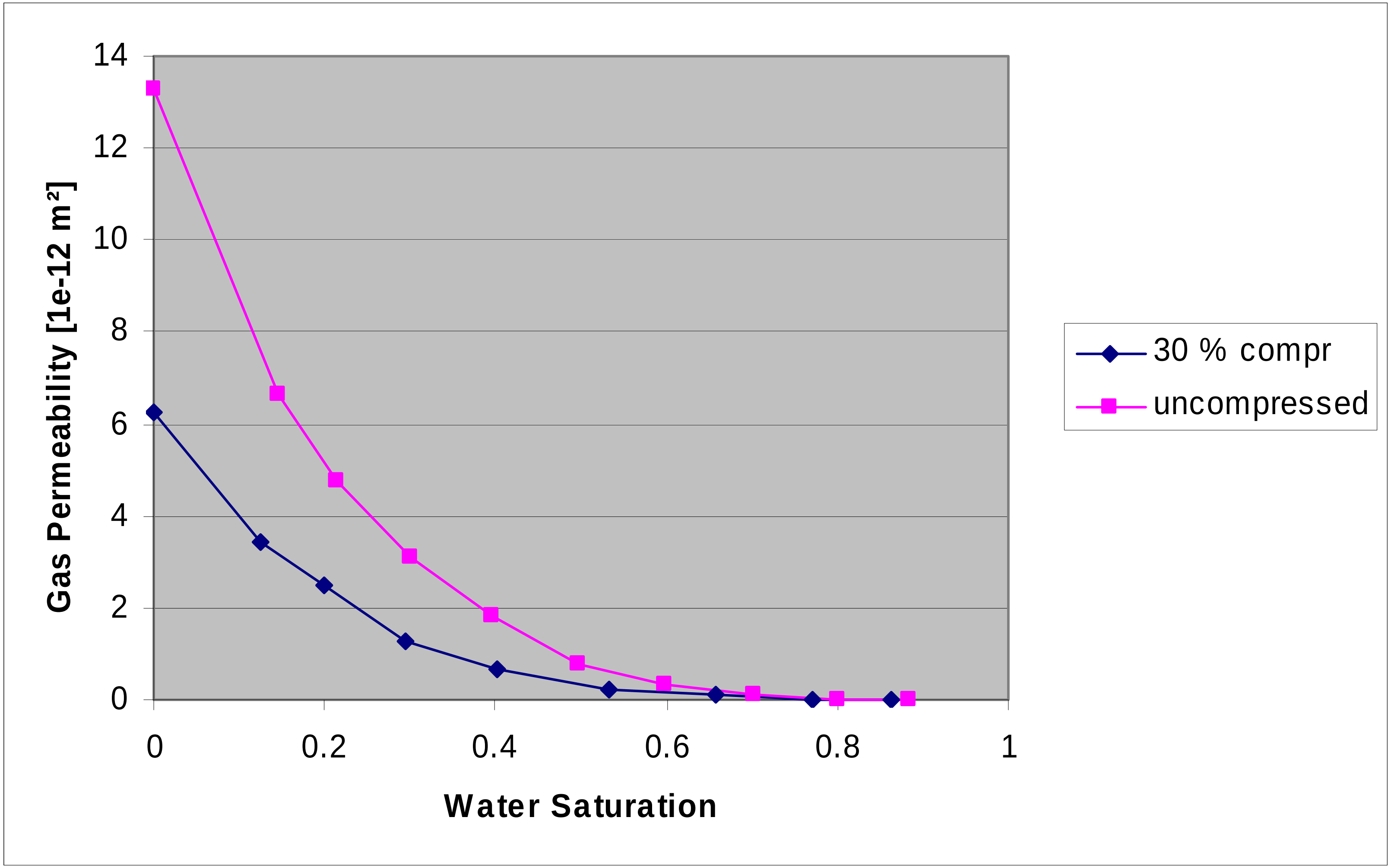
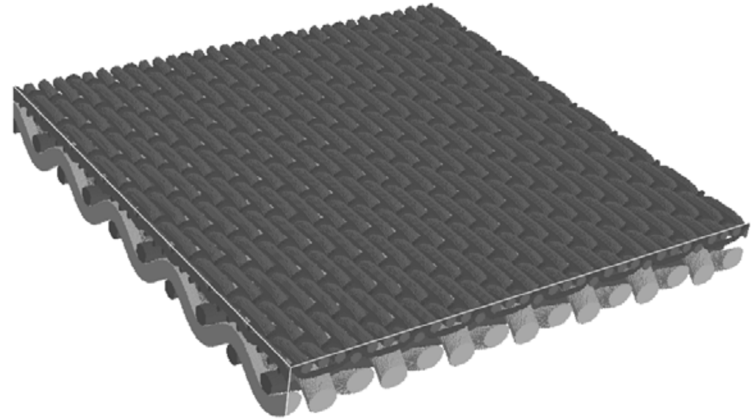
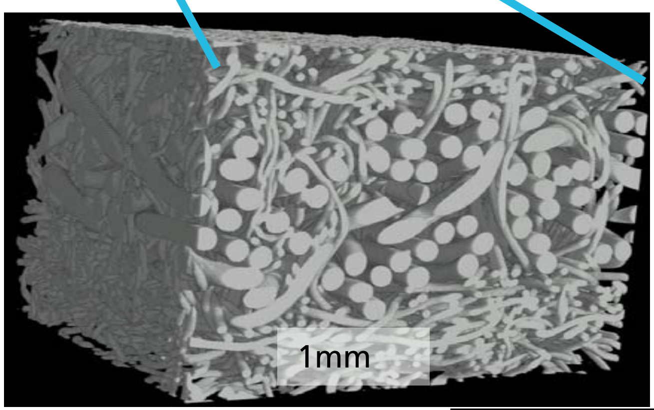
# Compression Effect on Relative Permeability



# Tomography and Models of felts

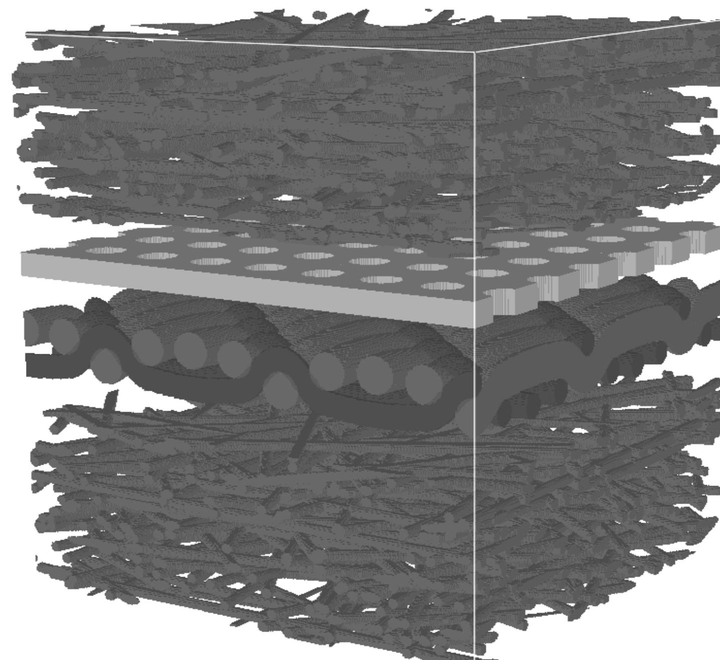



Papiermaschine




Tomographie

Forming fabric and dewatering felt





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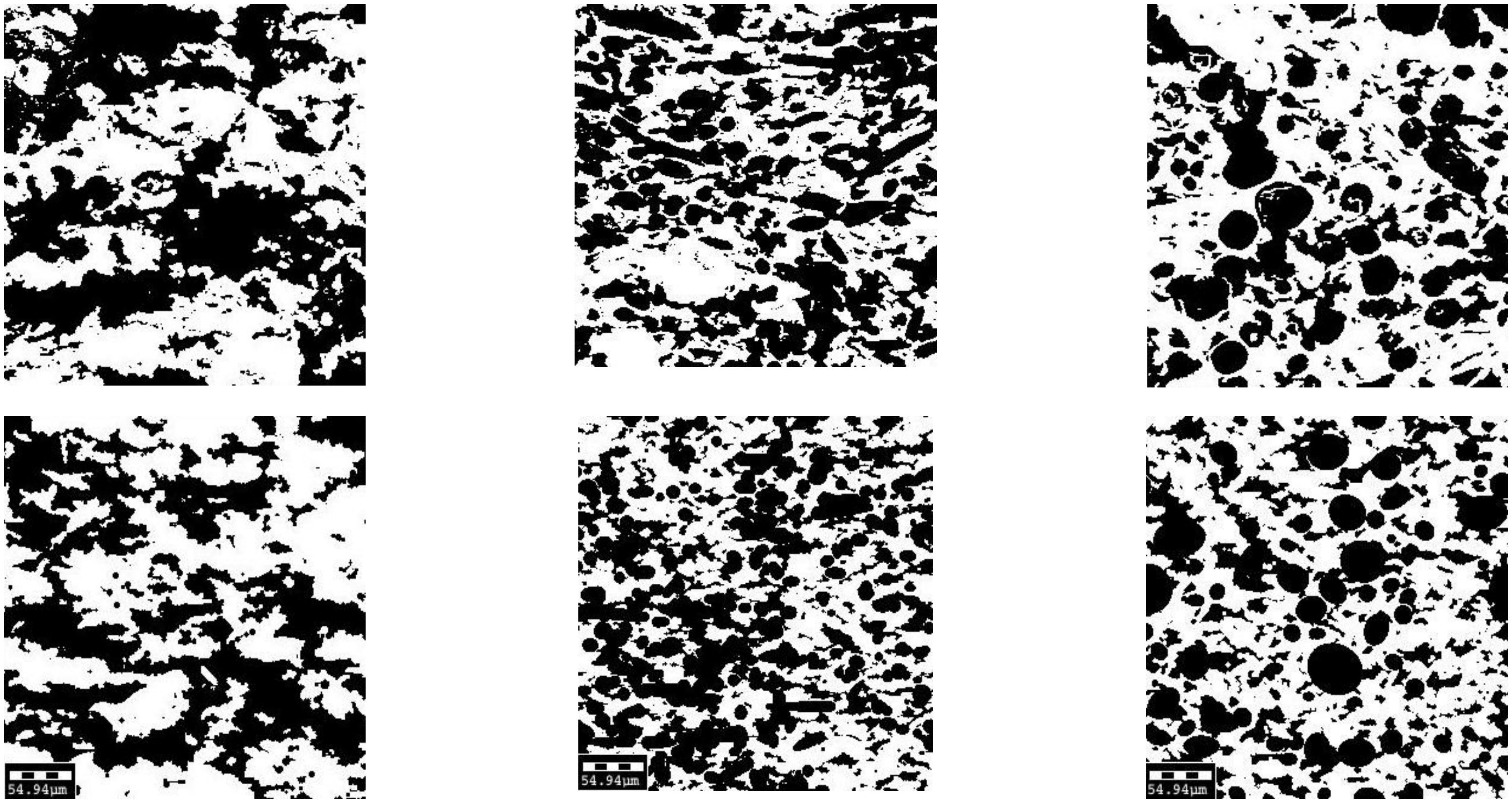
# Binarized SEM (top) and virtual sintered ceramics (bottom)



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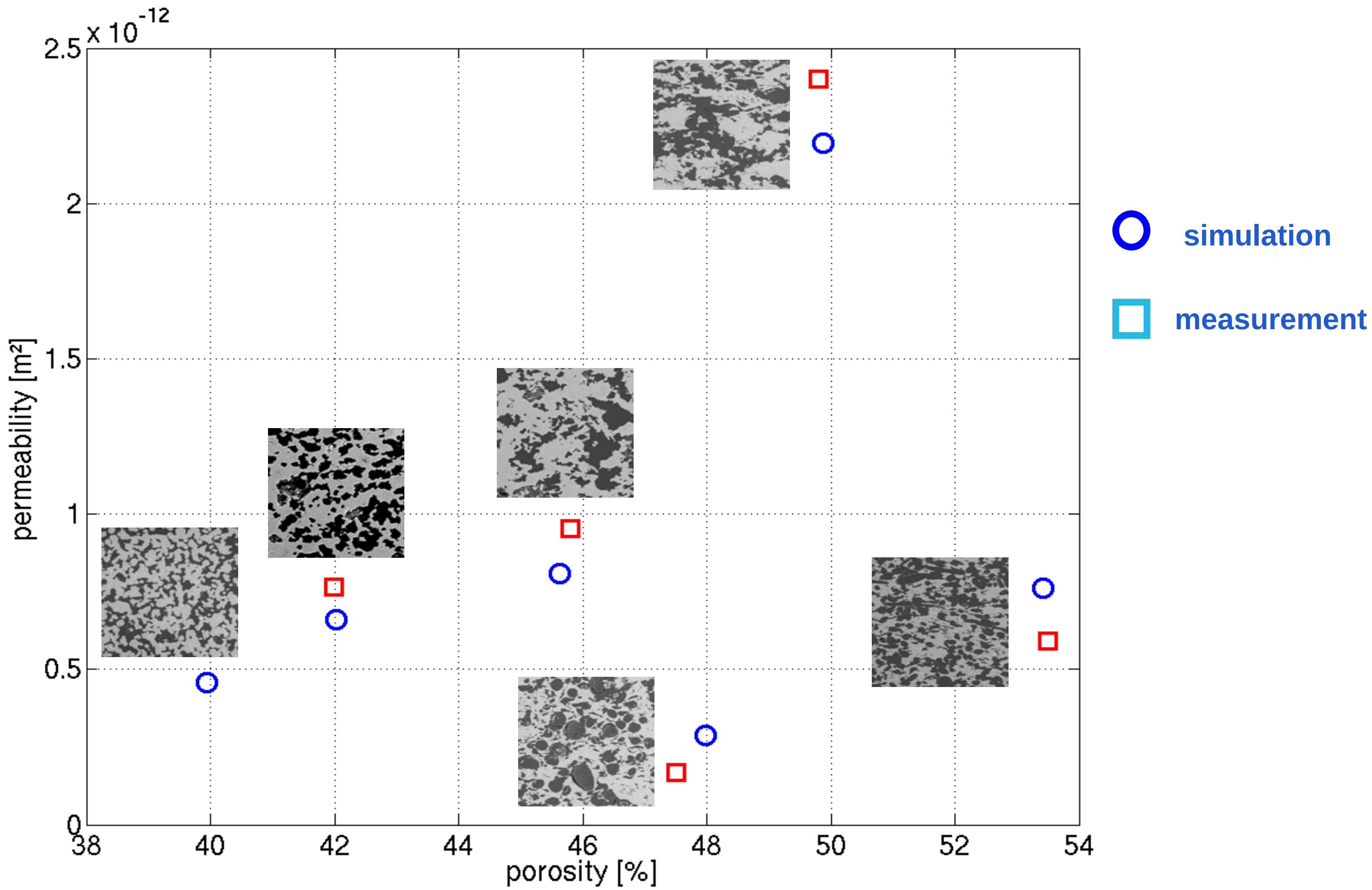
# Computed vs measured porosities and permeabilities







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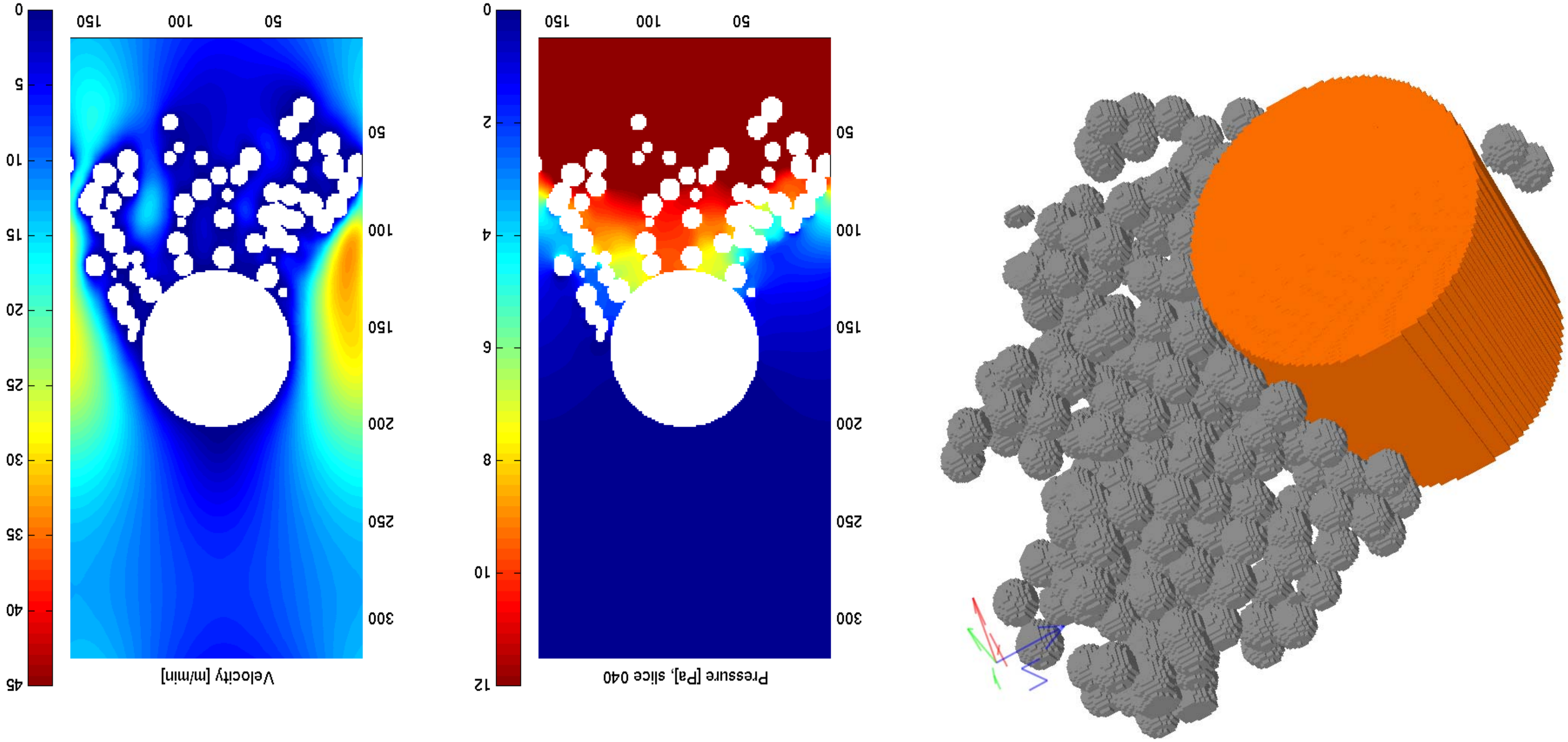
# Pressure and Velocity in Clogging Simulation

Filtration is multiple physics!







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Geometry and property predictor

www.geodict.com

Thank You !