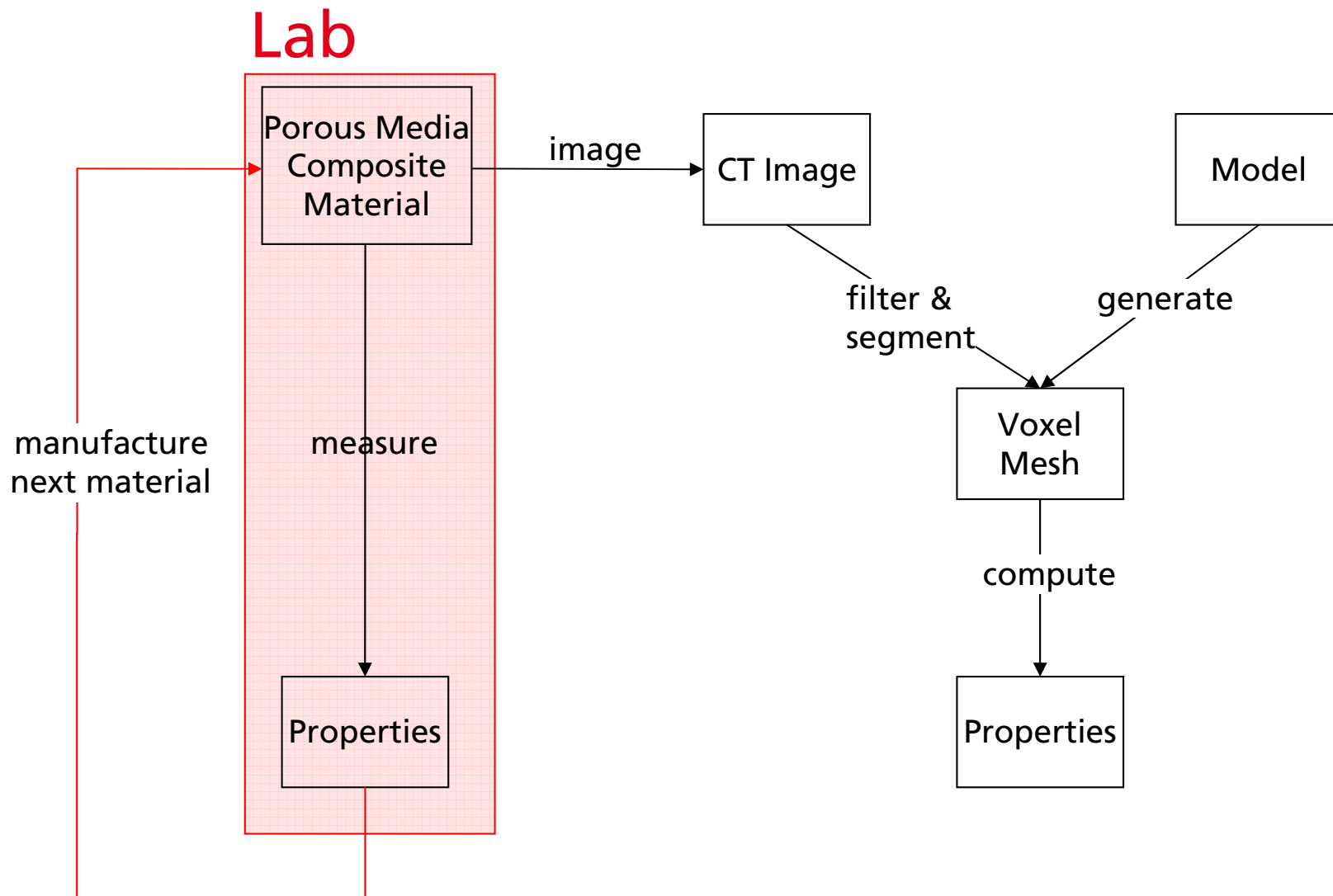# Werkstoffmodellierung und –eigenschafts-berechnung auf Basis von CT-Aufnahmen

Fachtagung Computertomografie, 27.09.2010

Erik Glatt, Jürgen Becker, Stefan Rief und
<u>Andreas Wiegmann</u>

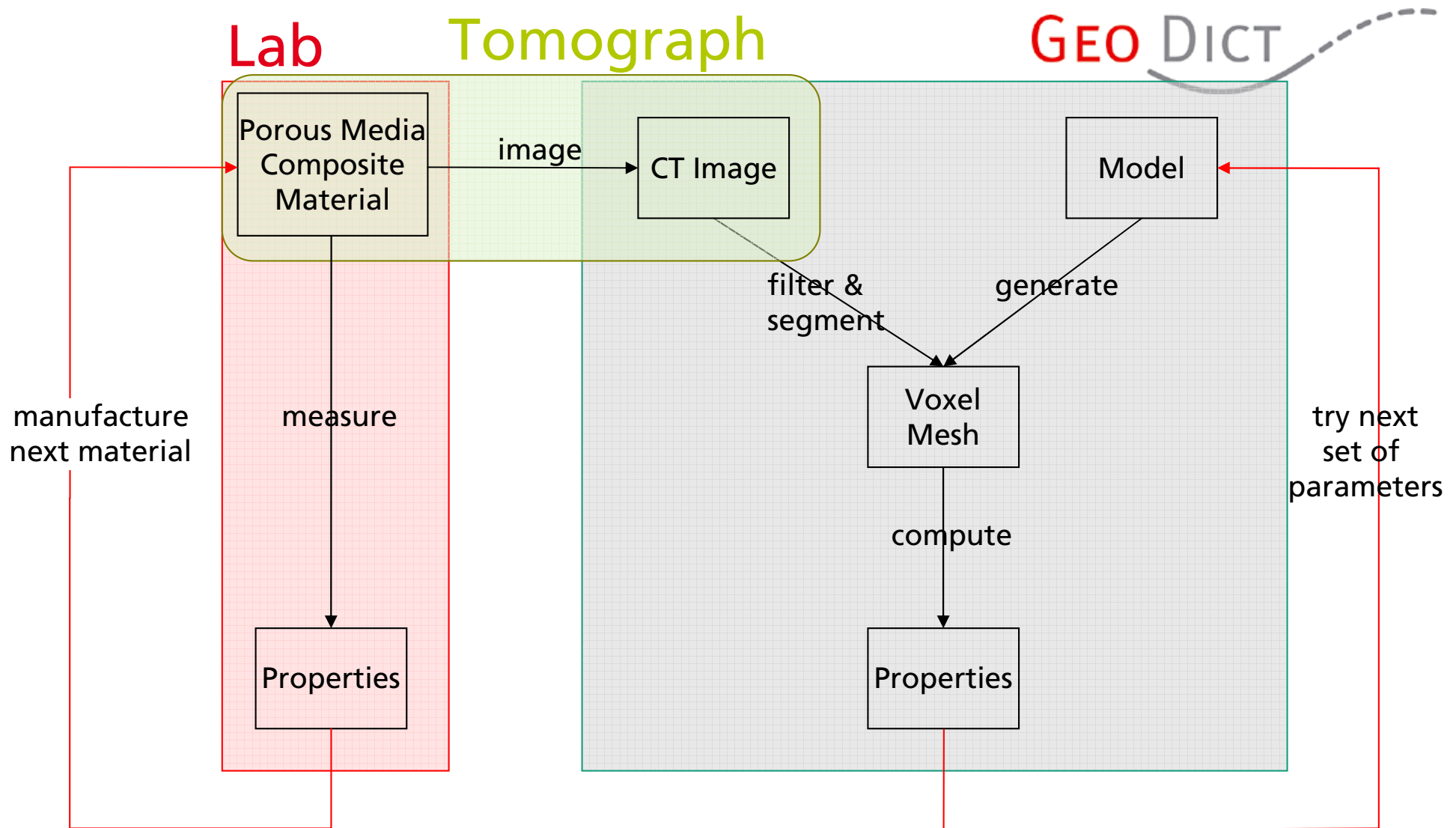Fraunhofer Institut Techno und Wirtschaftsmathematik,

Kaiserslautern

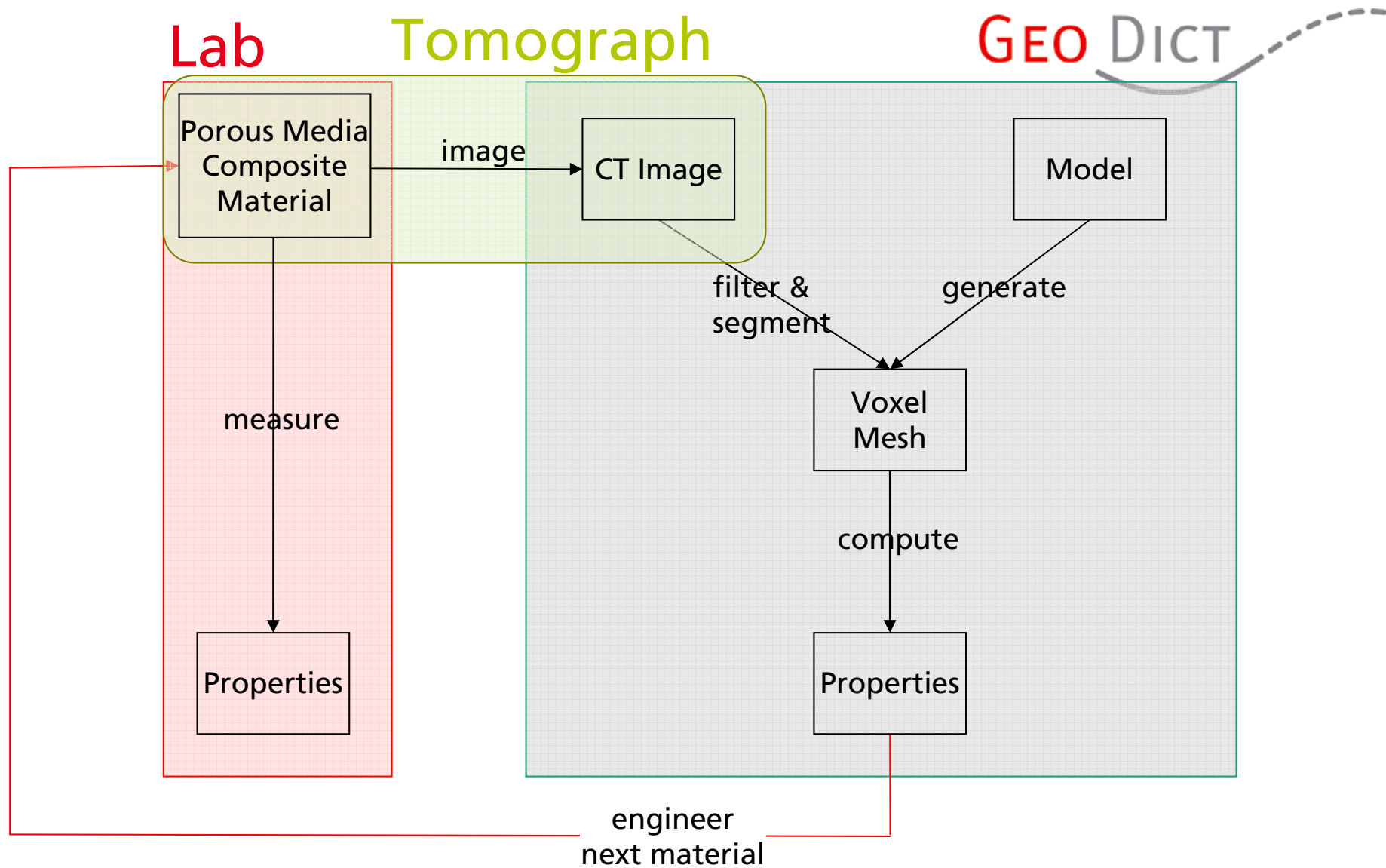# Computer Aided Material Engineering with GeoDict

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Computer Aided Material Engineering with GeoDict

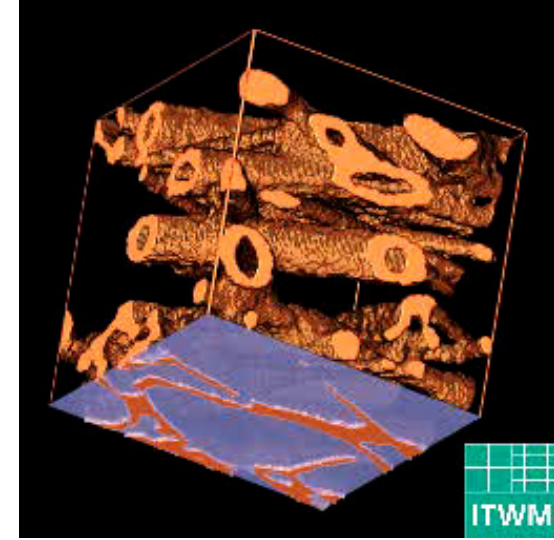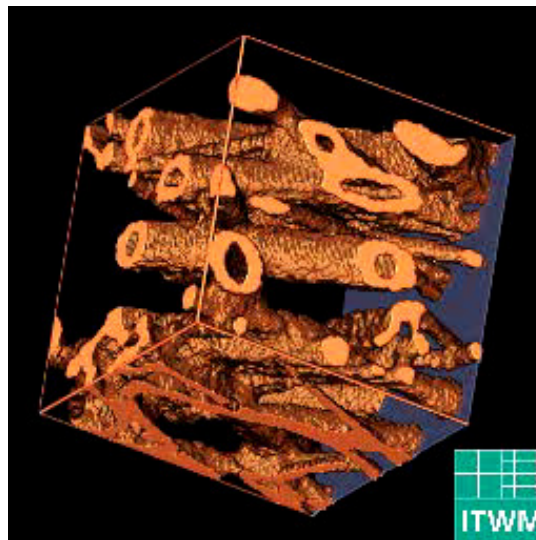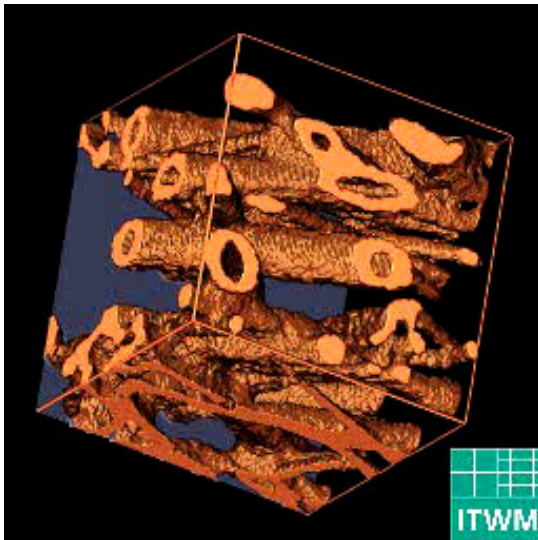# Computer Aided Material Engineering with GeoDict

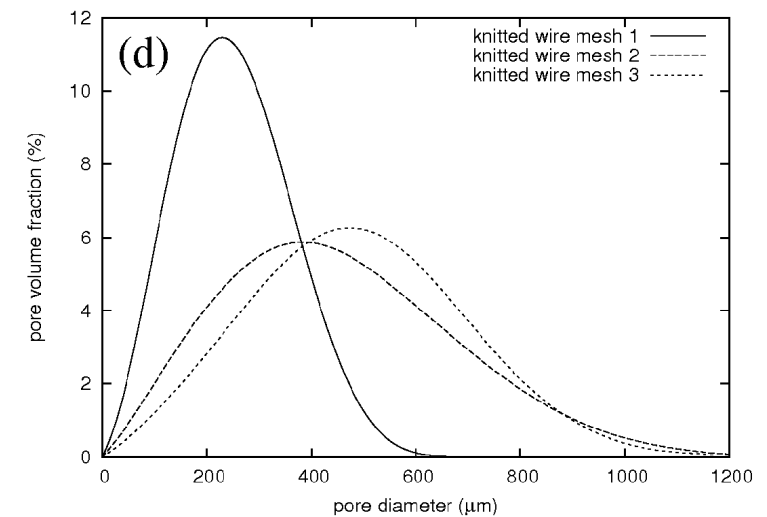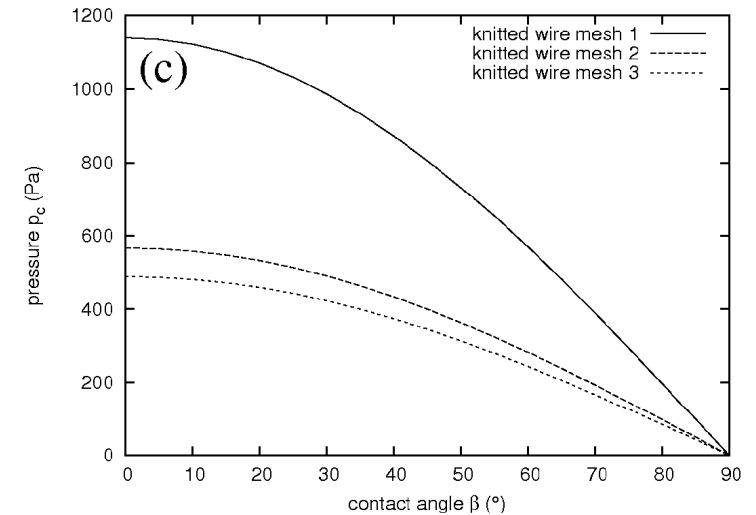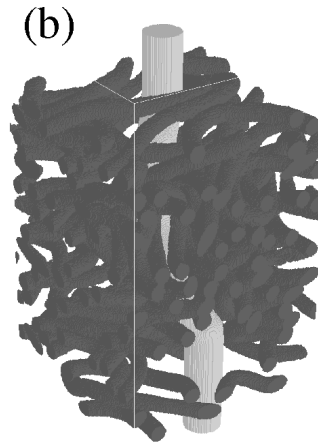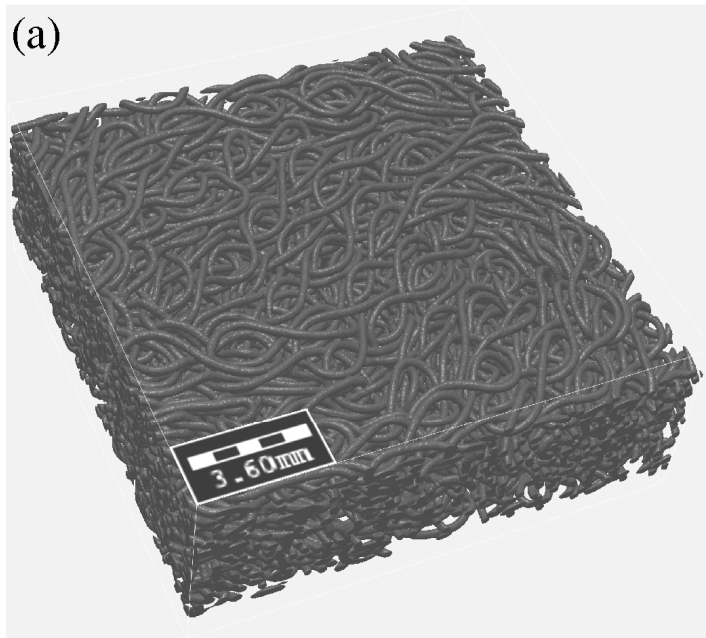# Computer Aided Material Engineering with GeoDict

© Fraunhofer ITWM
5
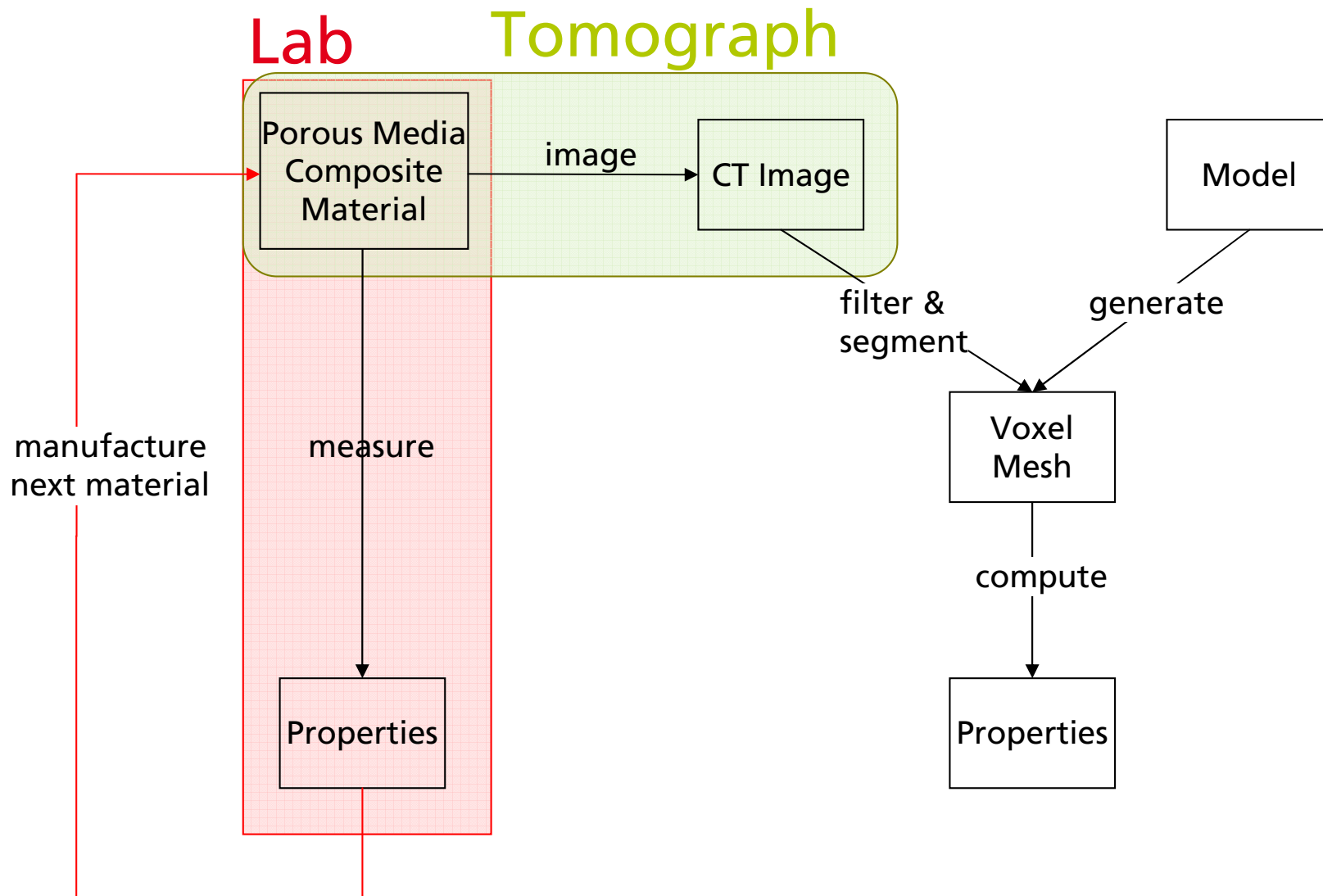
Computation of permeability

Darcy-Law: $\bar{\mathbf{u}} = \dfrac{1}{L}\mathbf{K} \cdot \Delta\mathbf{p}$ 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

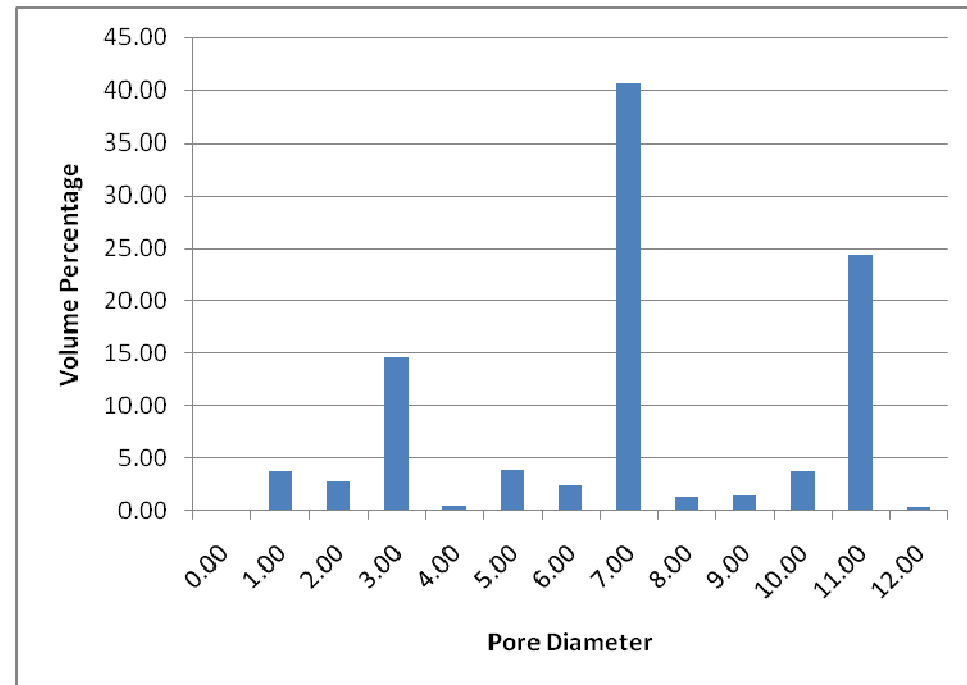# Knitted Wire Meshes: Geometry-Based Property Analyses

(a): CT-scan of a knitted wire mesh.
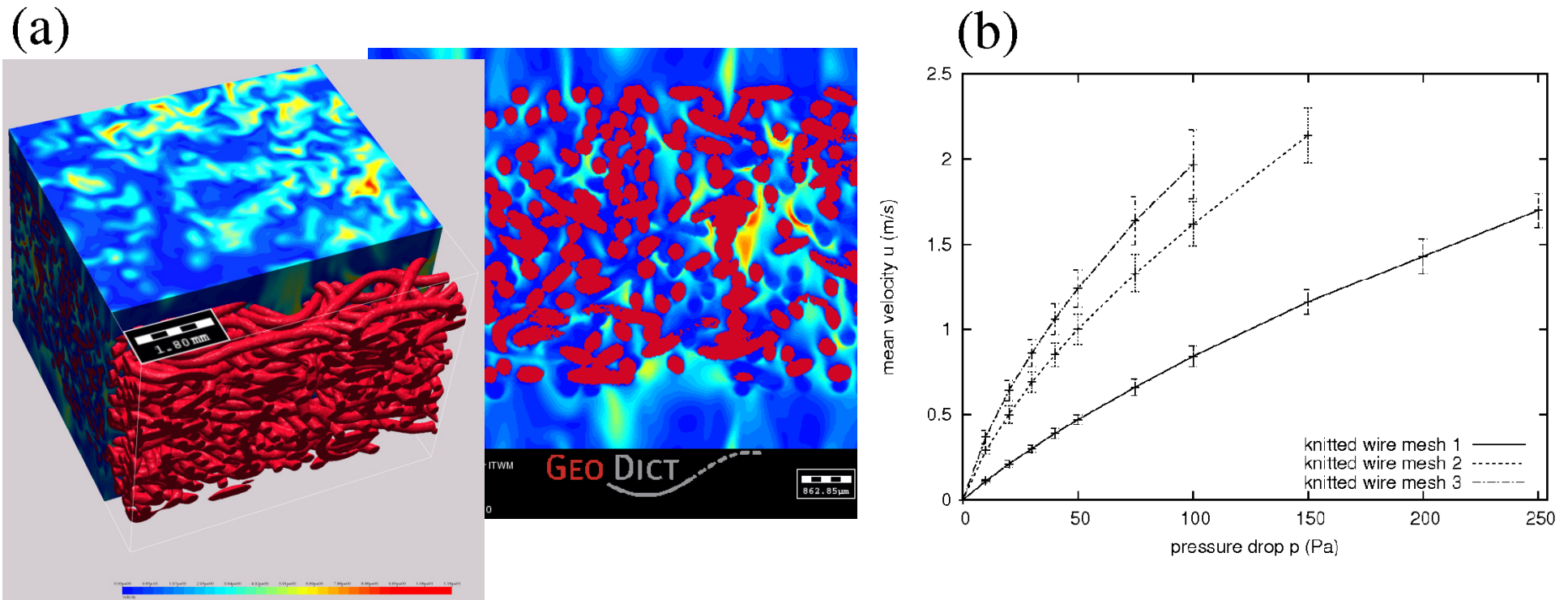
(b): Largest through pore.

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

(d): Pore size distribution.
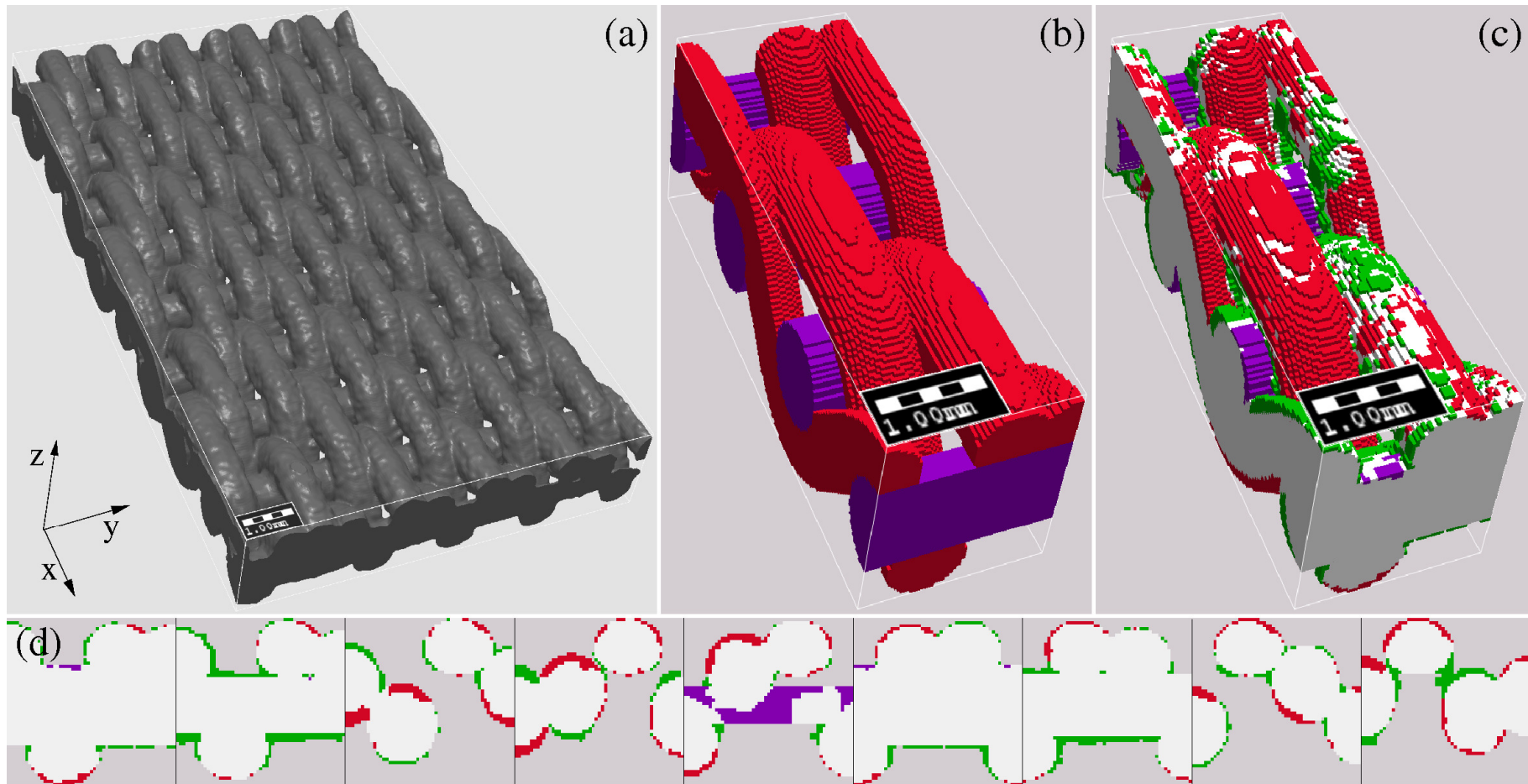
Use PSD for solids to get fiber diameters

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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.

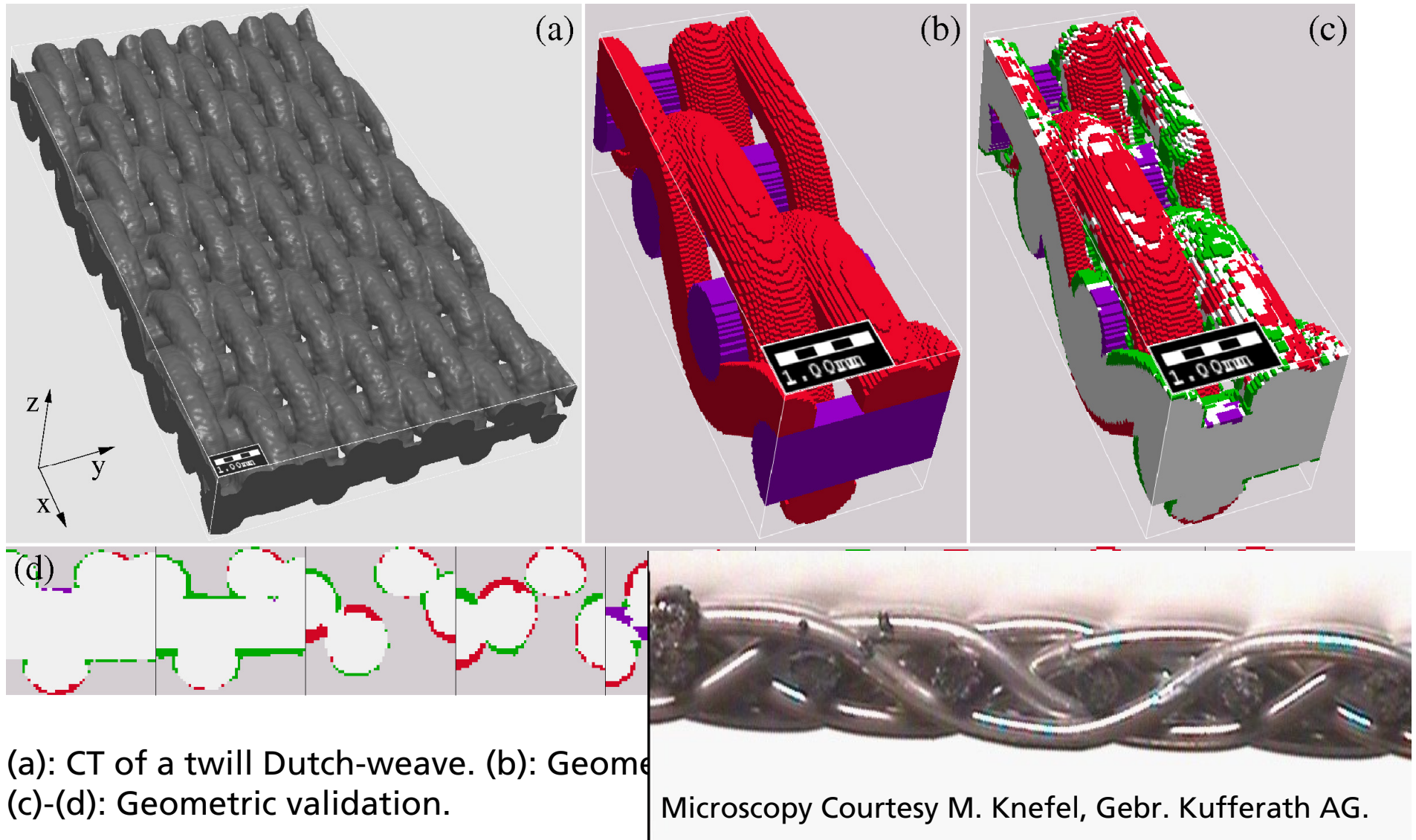# Woven Metal Wire Meshes: Geometric Validation

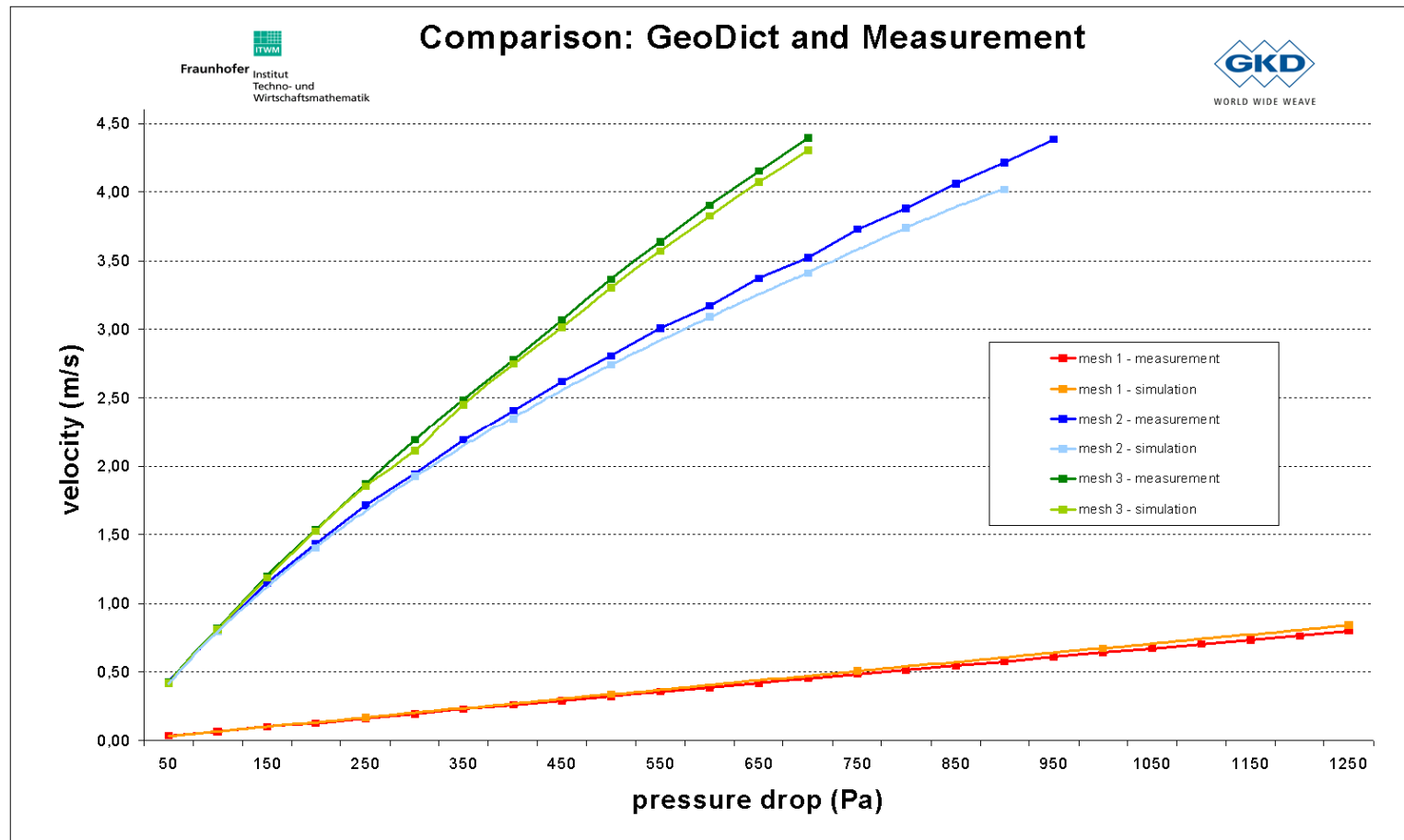(a): CT of a twill Dutch-weave. (b): Geometry model.
(c)-(d): Geometric validation.

Microscopy Courtesy M. Knefel, Gebr. Kufferath AG.

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.

# Woven Metal Wire Meshes: Measurement and Simulation

Velocity dependent pressure drop: Comparison between measurements and simulations on corresponding geometry models.
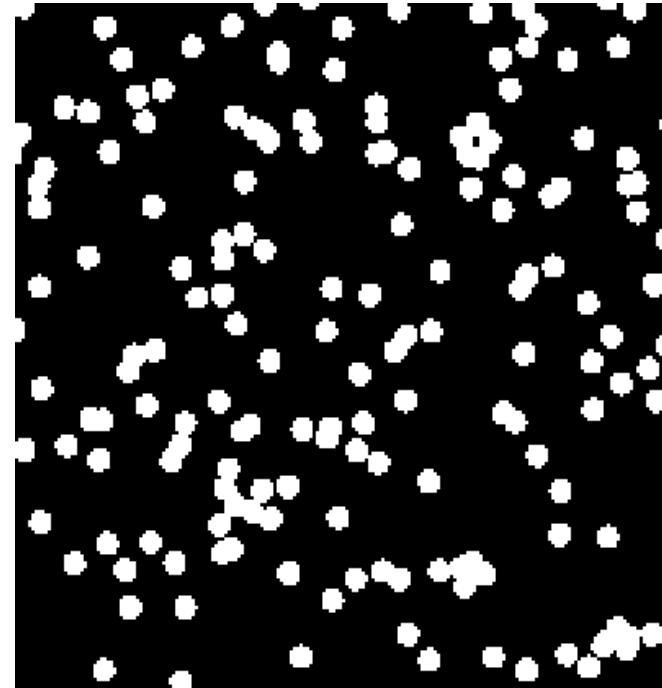
Model: Curved Fibers with inder

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
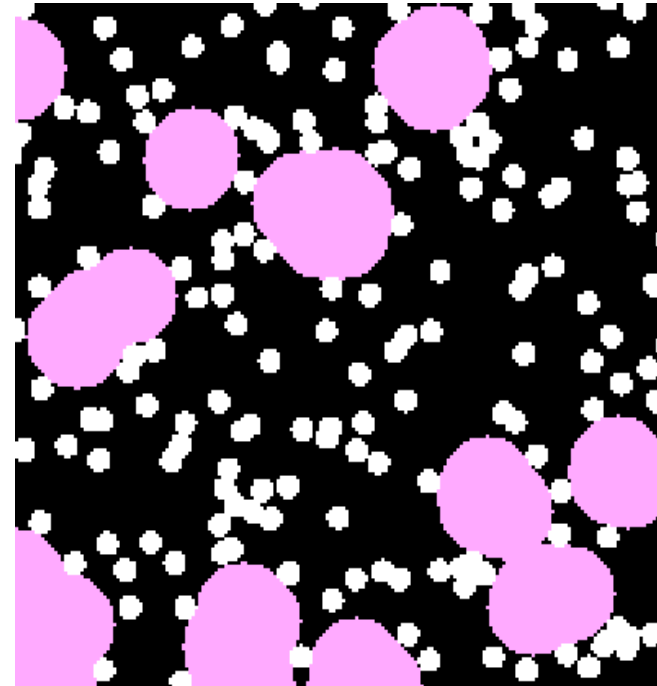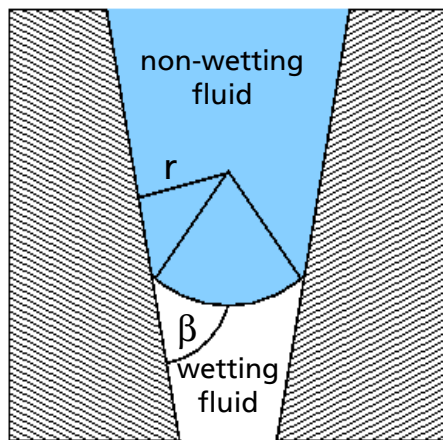- add binder
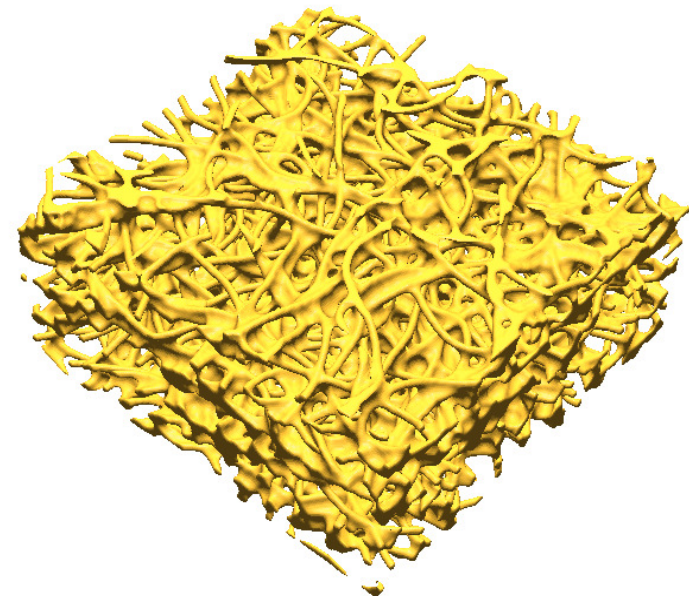
Relative Permeability

Two-step approach:

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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 $p_c \geq \frac{2\sigma}{r} \cos \beta$

non-wetting fluid

r

β
wetting fluid

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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 Stokes equation on the remaining pore space to determine wetting phase (=air) permebility
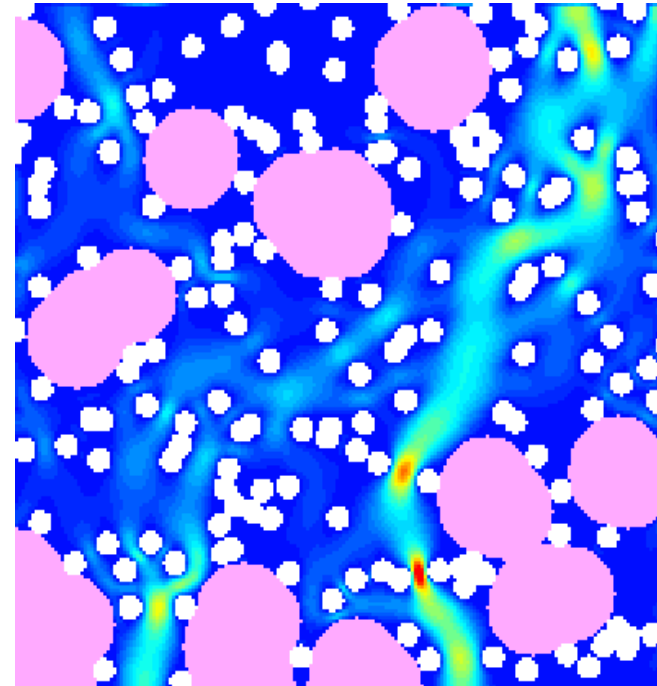
Simulated mercury Distribution at Bubble Point in tomography
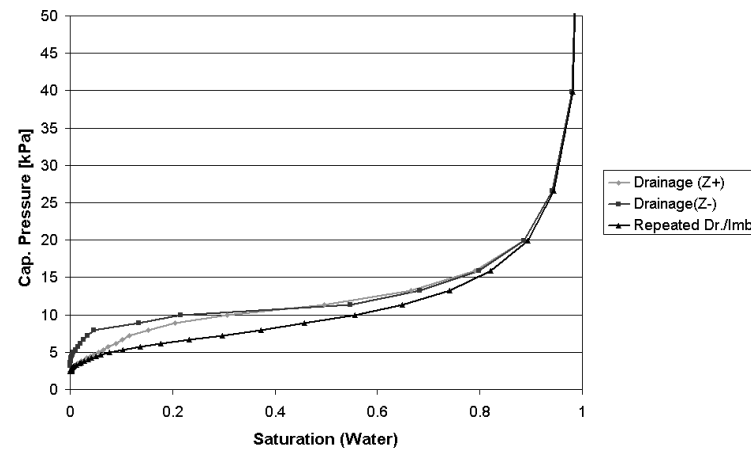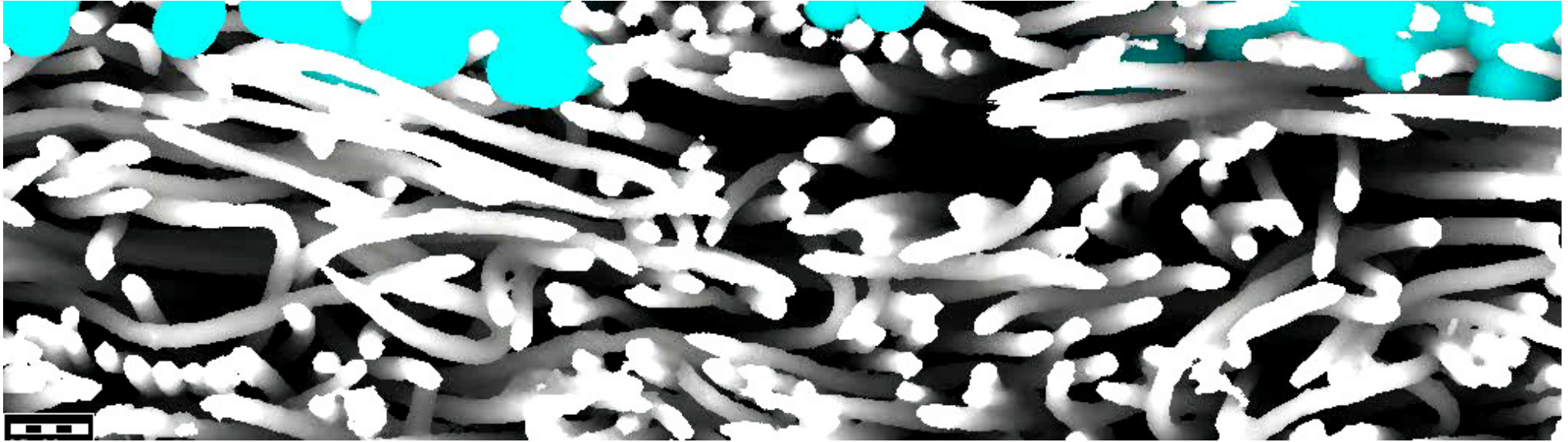
pc= 10.6 kPa
(r=10.5 μm)

Comparison of two compression models

uncompressed

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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
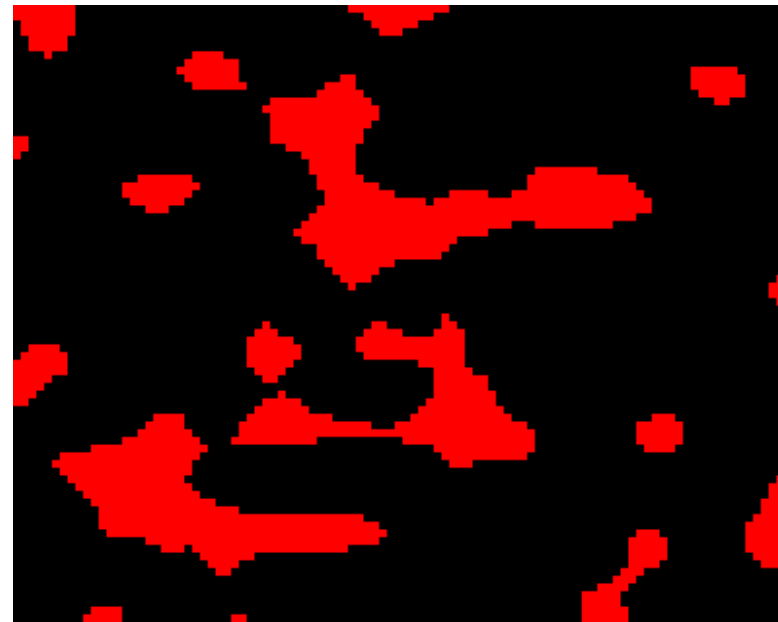
compressed (20%, red. model)
computation time: 0.25 s

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Comparison of two compression models

uncompressed

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

Fraunhofer
ITWM

Comparison of two compression models
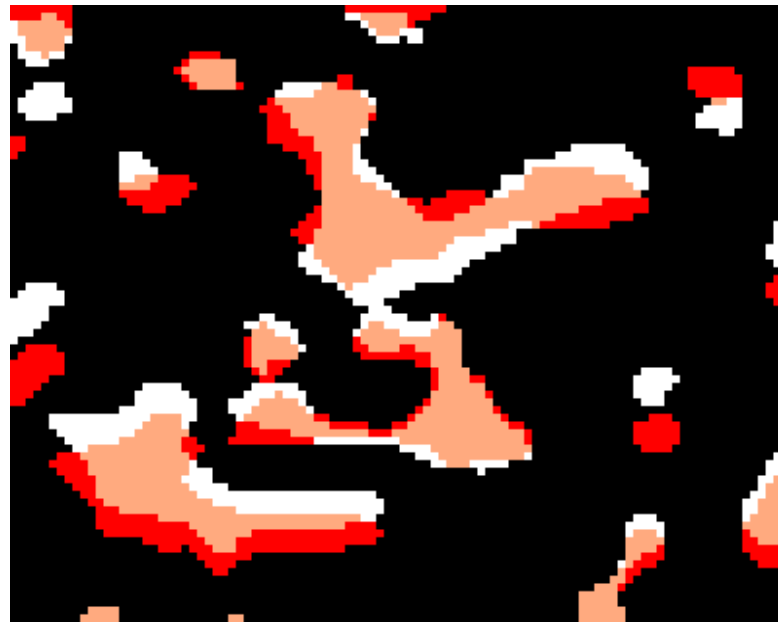
uncompressed

compressed (20%, comparison)

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Compression Effect on Permeability

• calculated for 0%, 10%, 20%, 30% compression
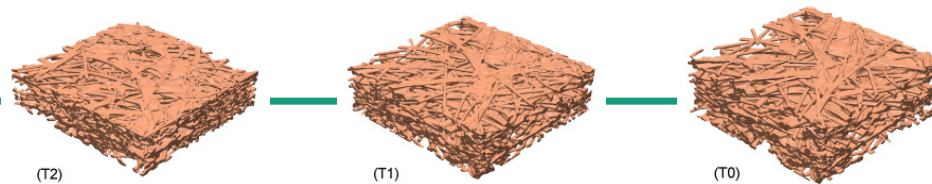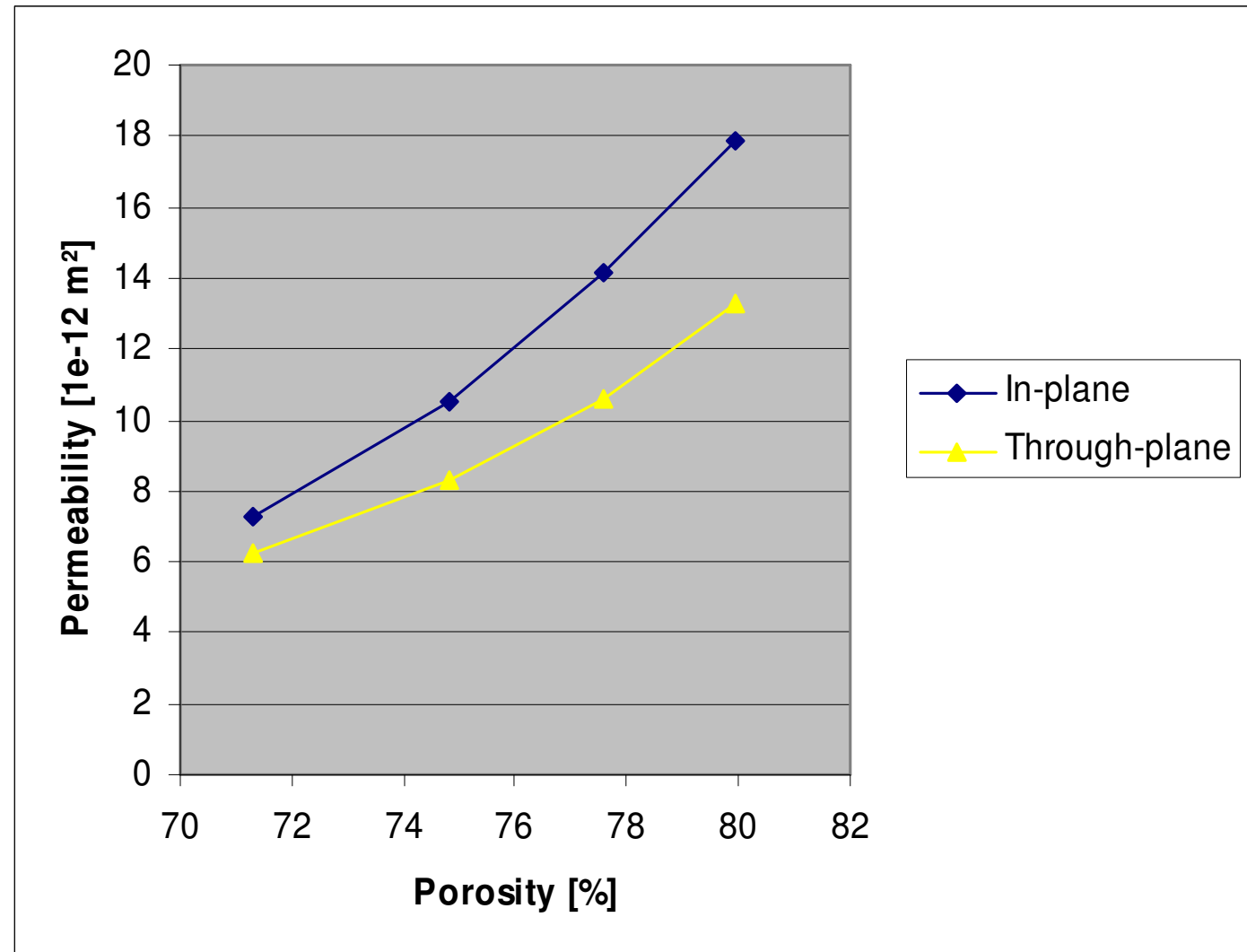
Compression Effect on Relative Permeability
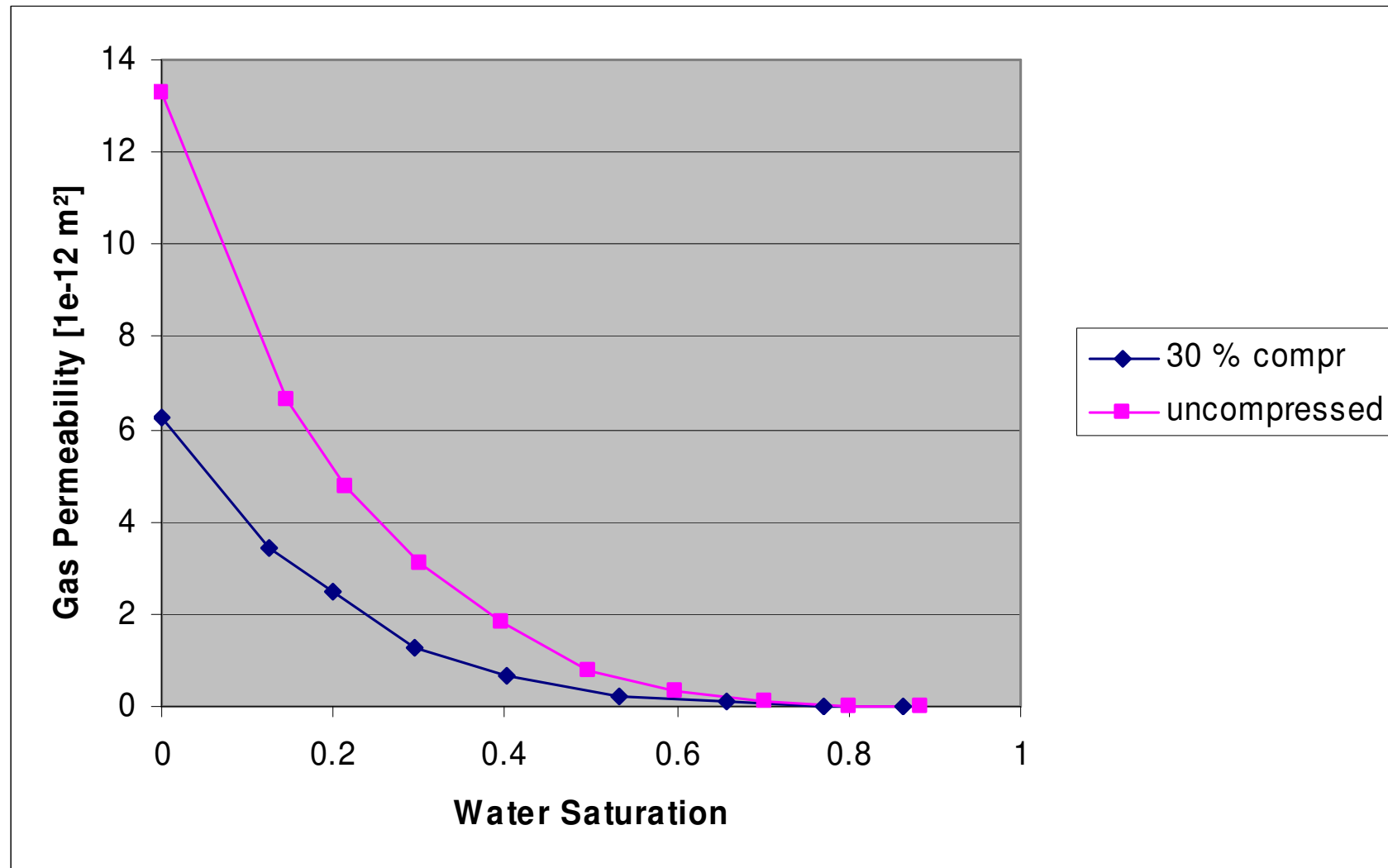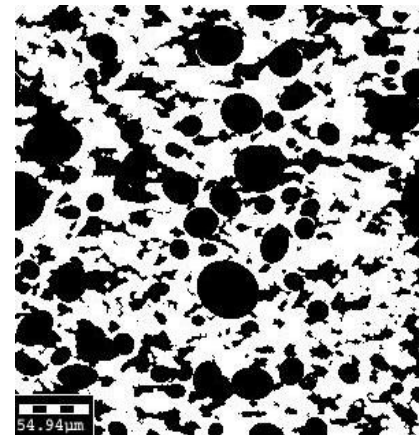
Tomography and Models of felts

10m

Papiermaschine

1mm
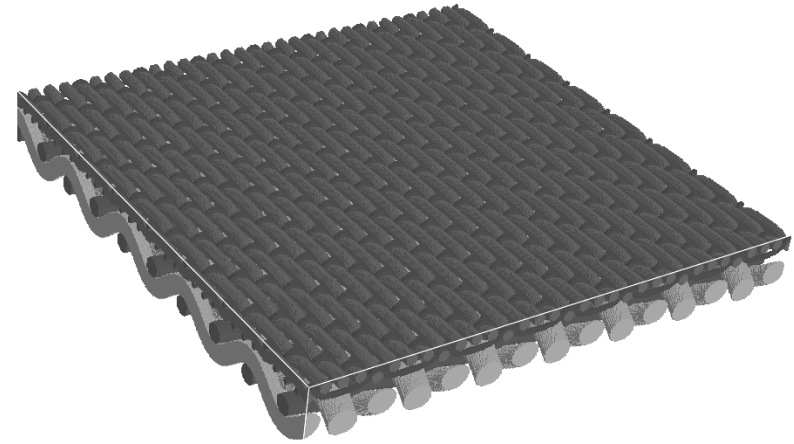
Tomographie

Forming fabric and dewatering felt

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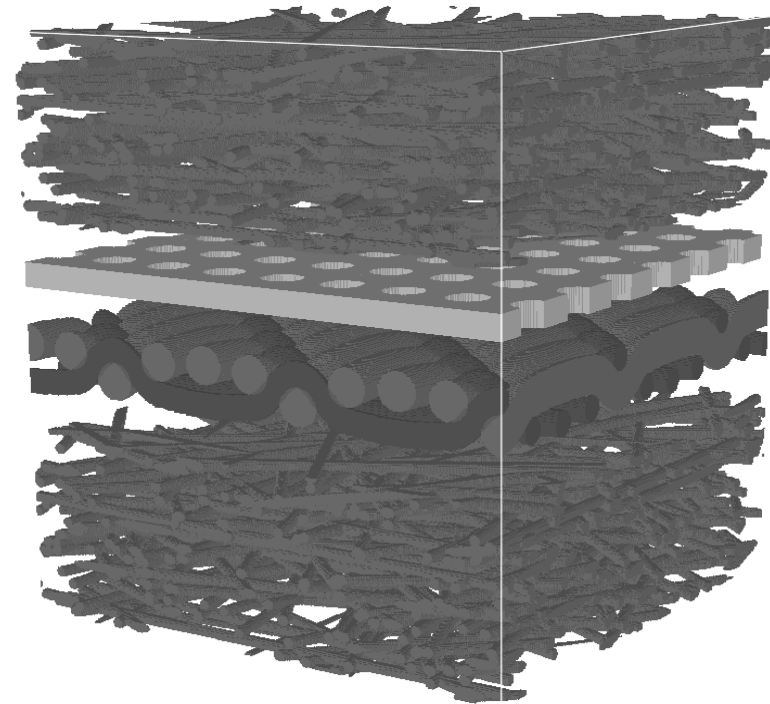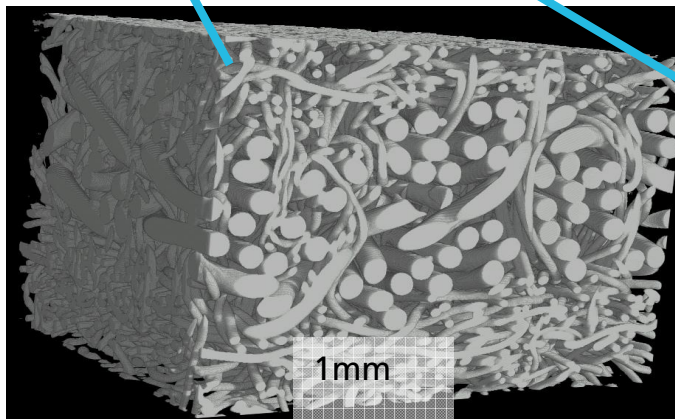
Binarized SEM (top) and virtual sintered ceramics (bottom)
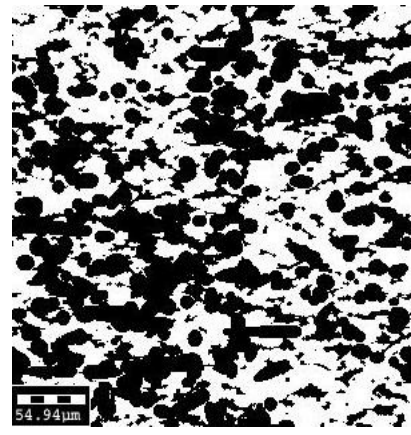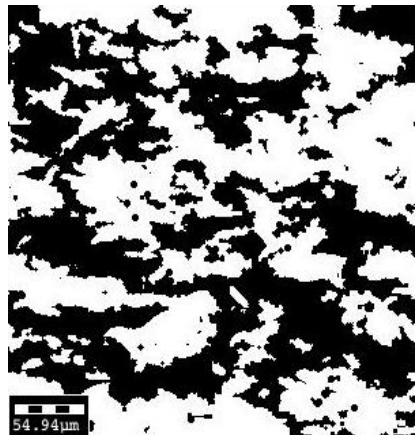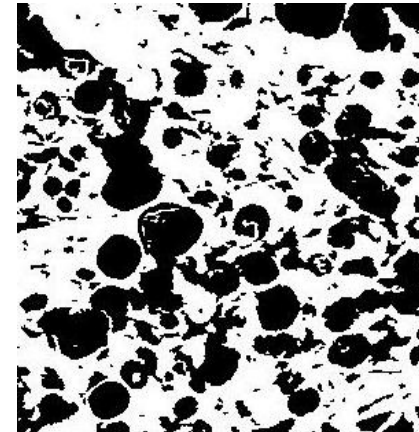
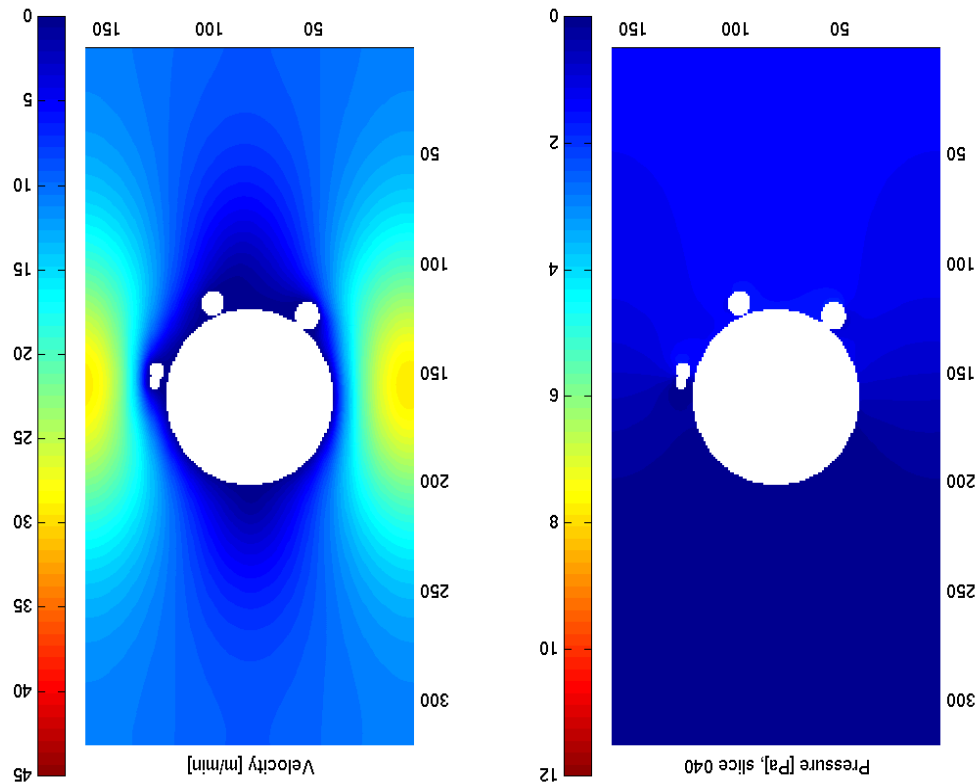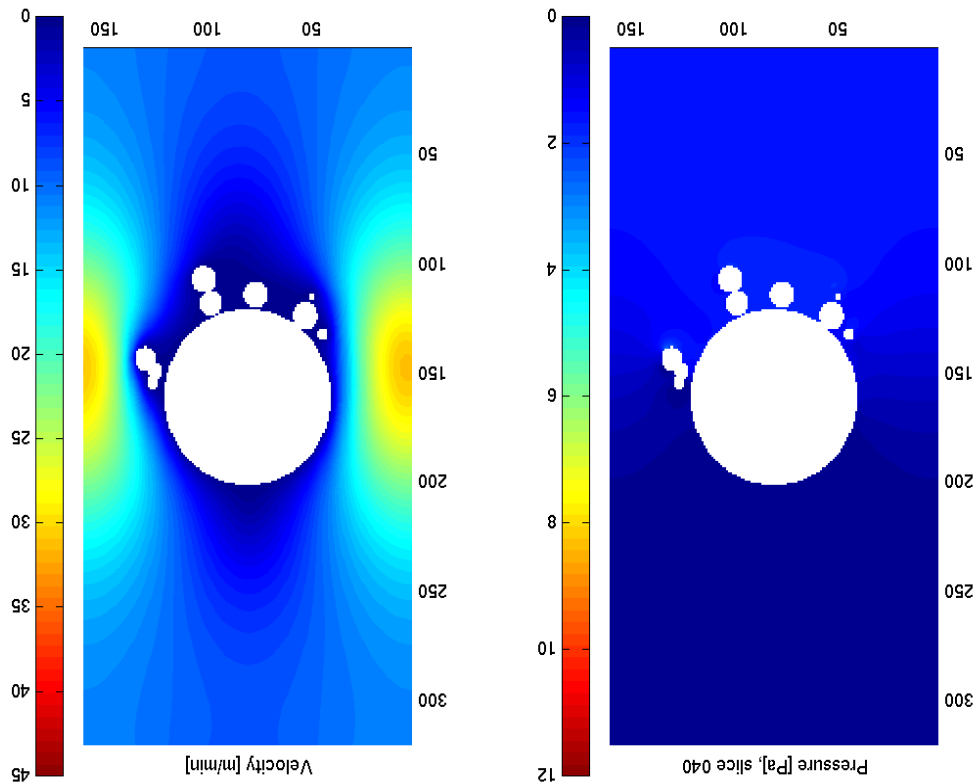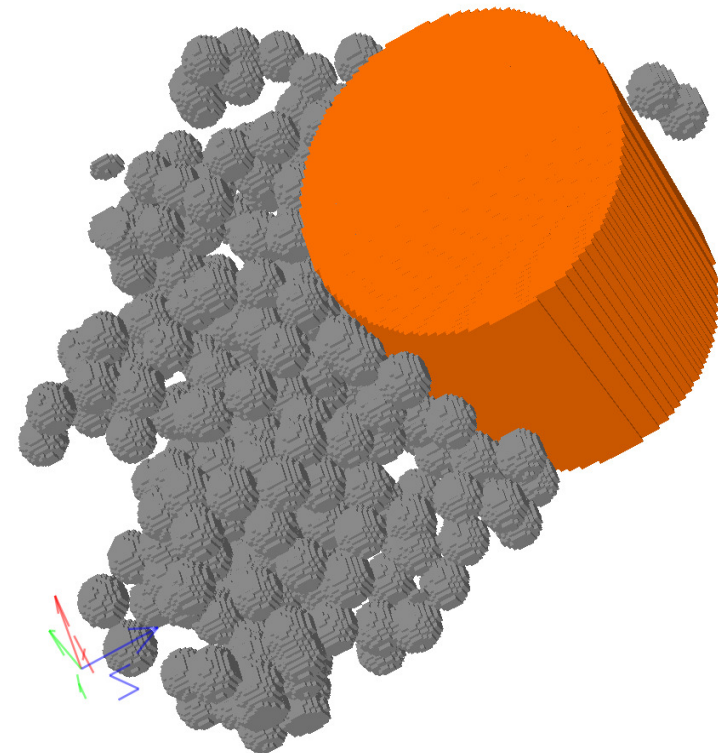# Computed vs measured porosities and permeabilities

Pressure and Velocity in Clogging Simulation

Filtration is multiple physics!

Pressure and Velocity in Clogging Simulation
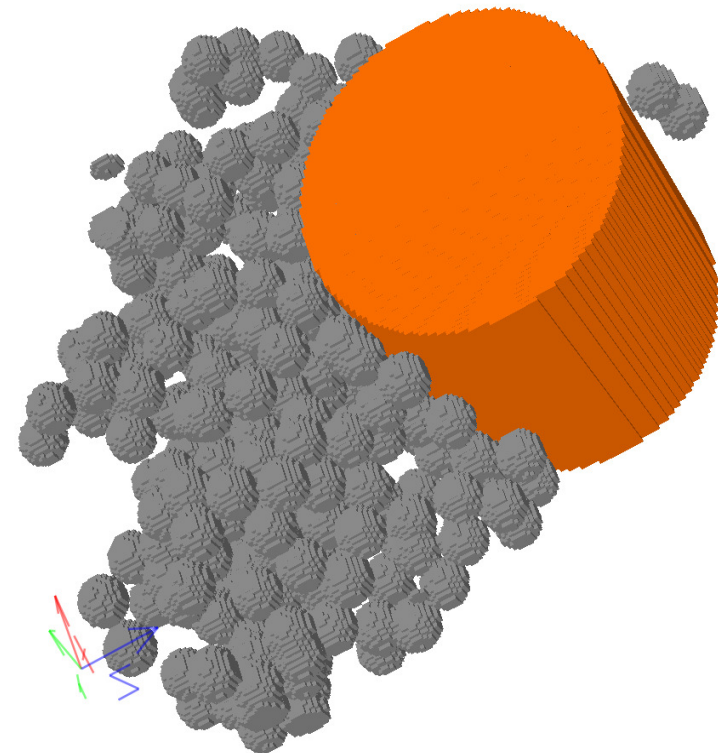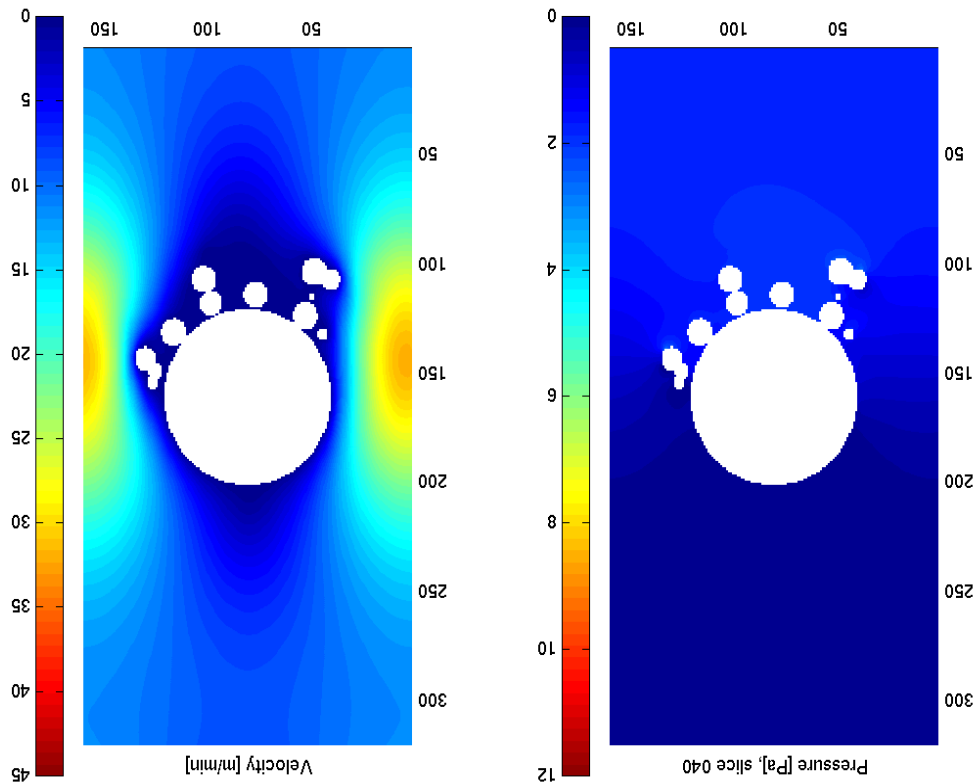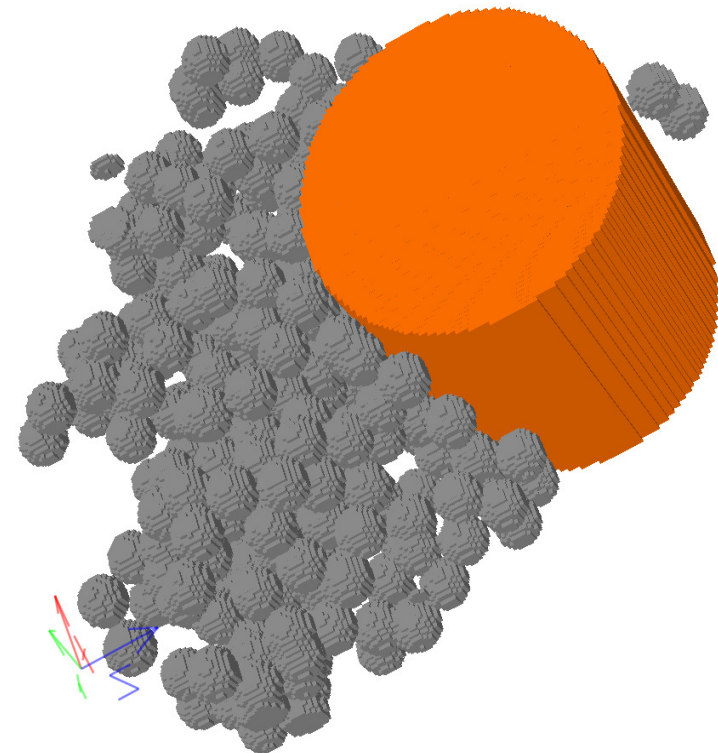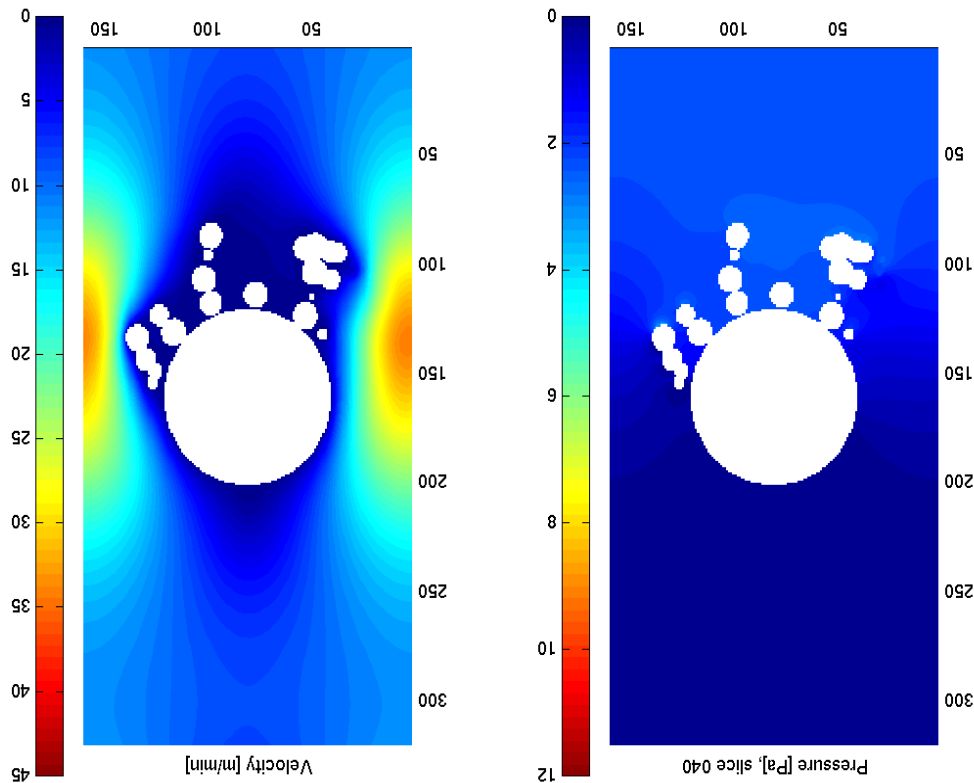
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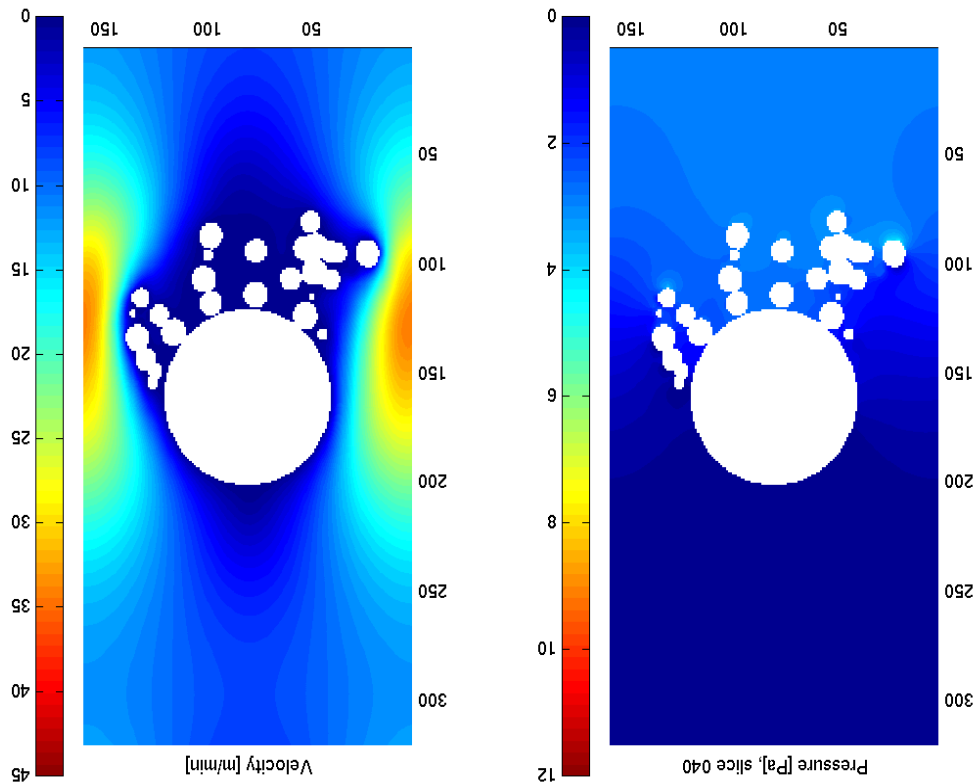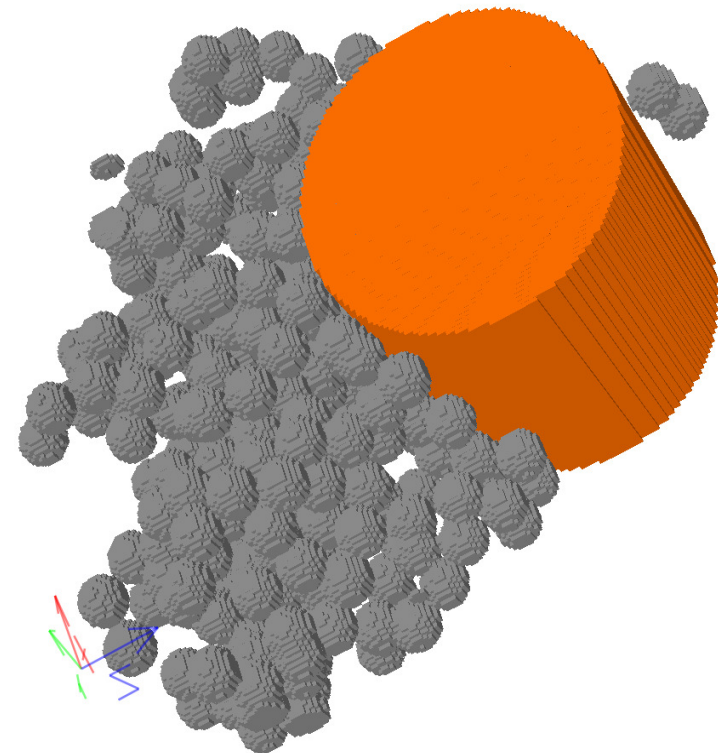
Pressure and Velocity in Clogging Simulation
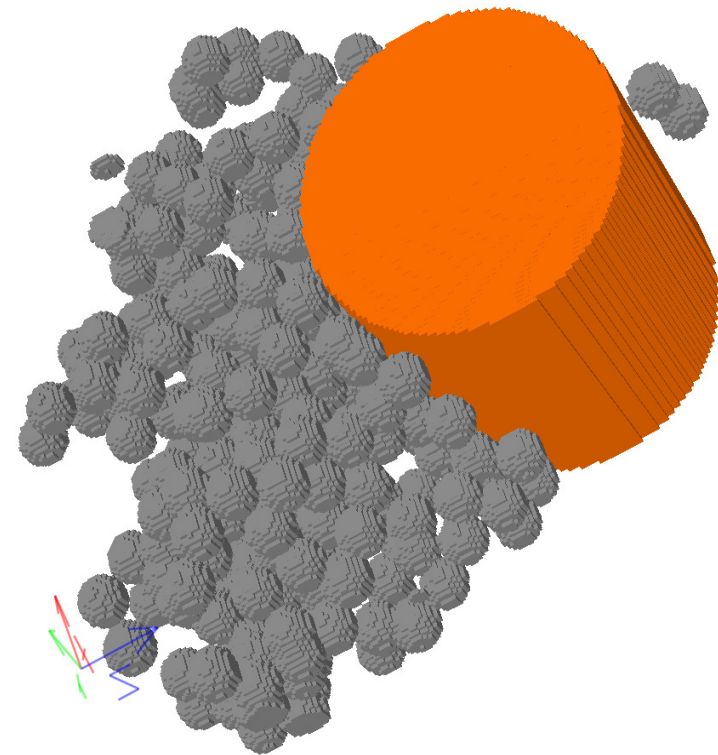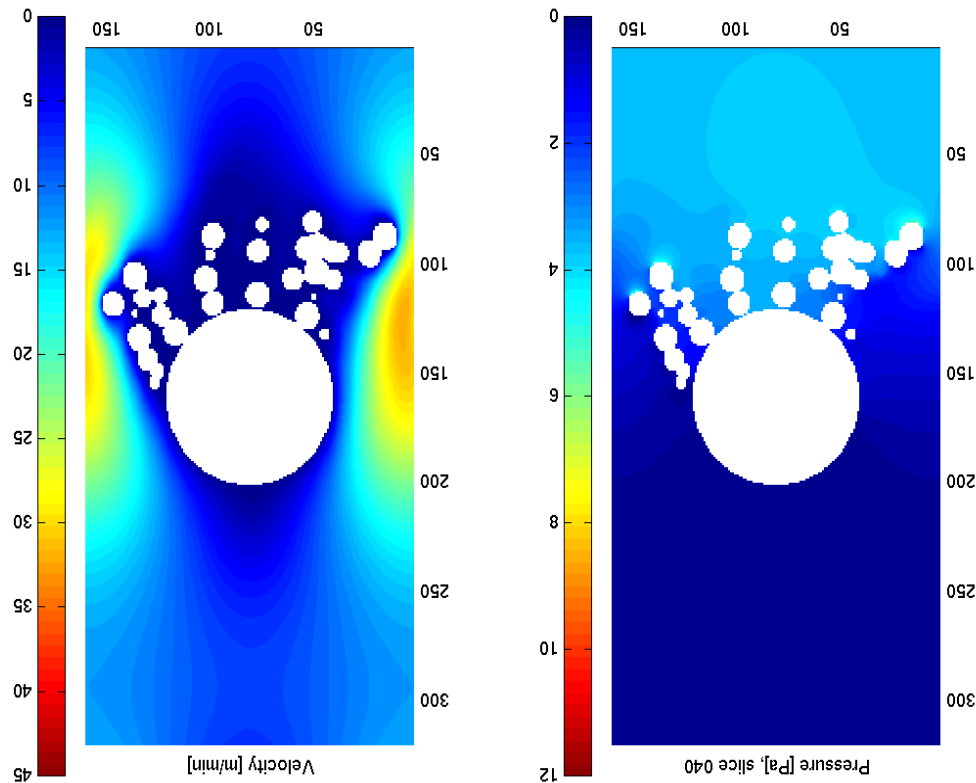
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Pressure and Velocity in Clogging Simulation
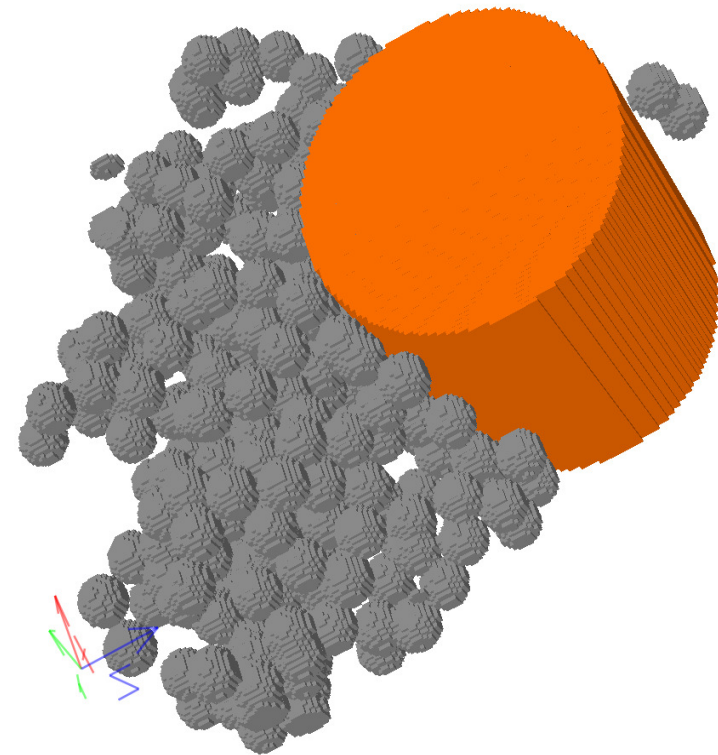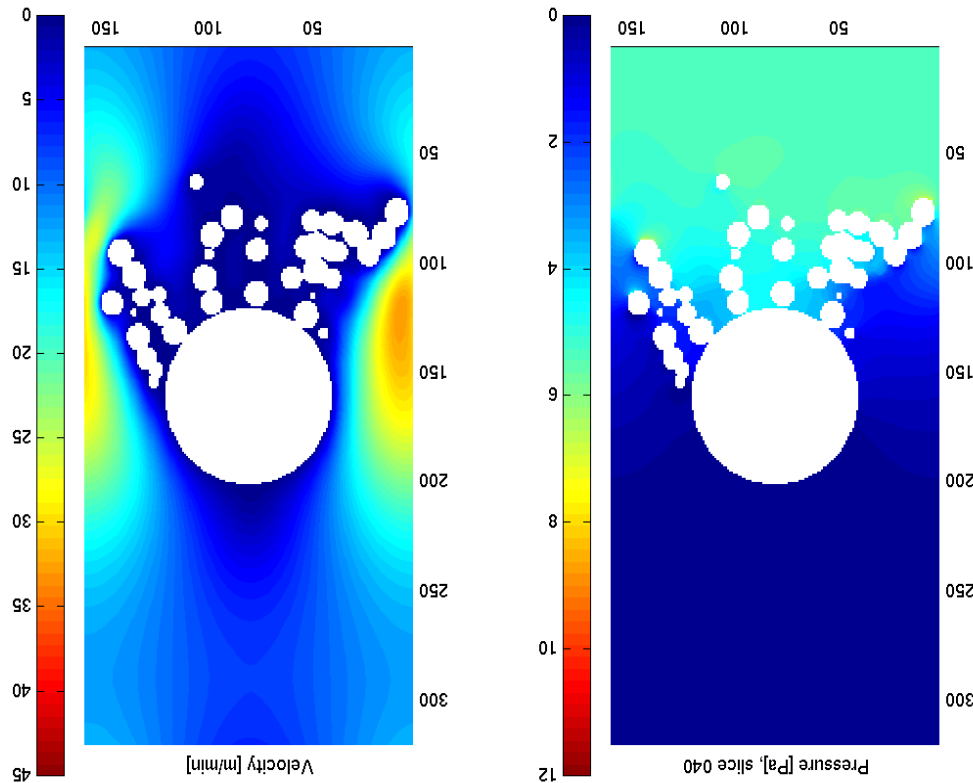
Filtration is multiple physics!

Pressure and Velocity in Clogging Simulation

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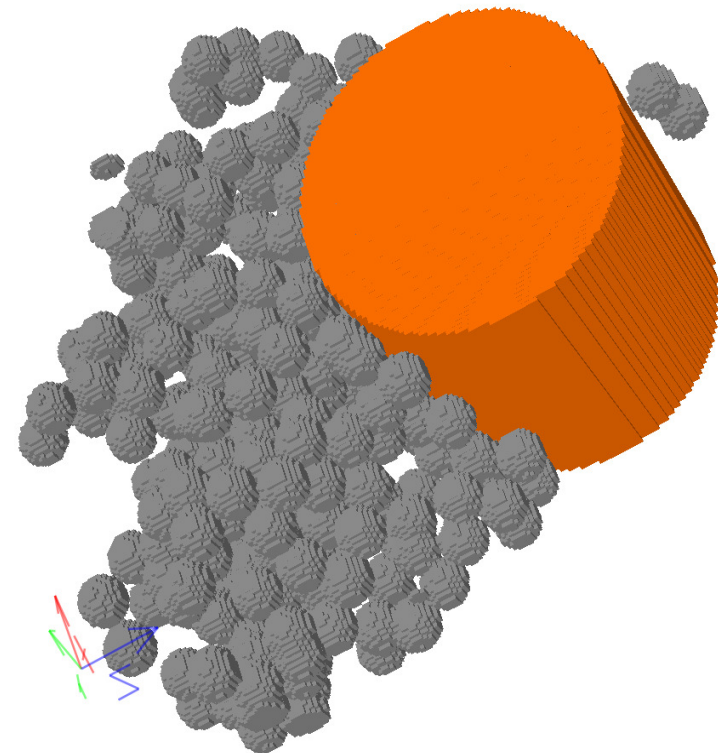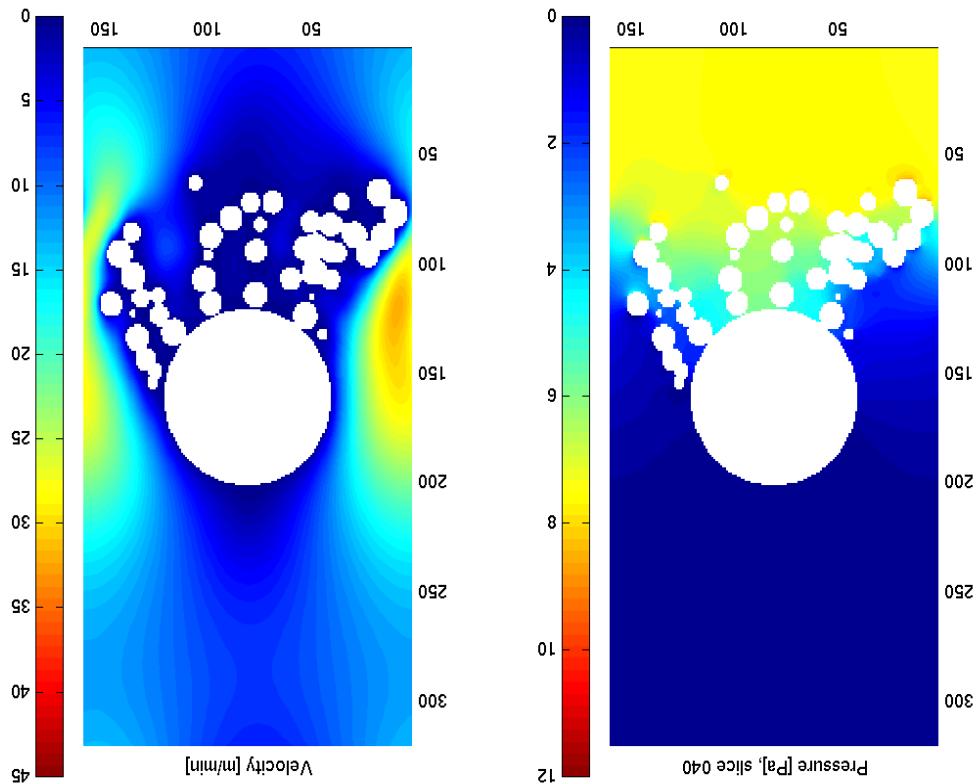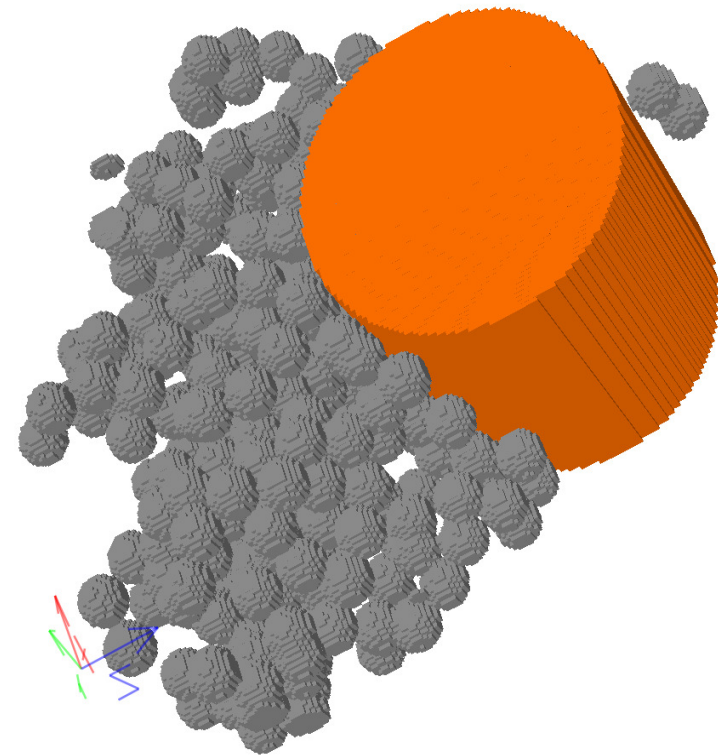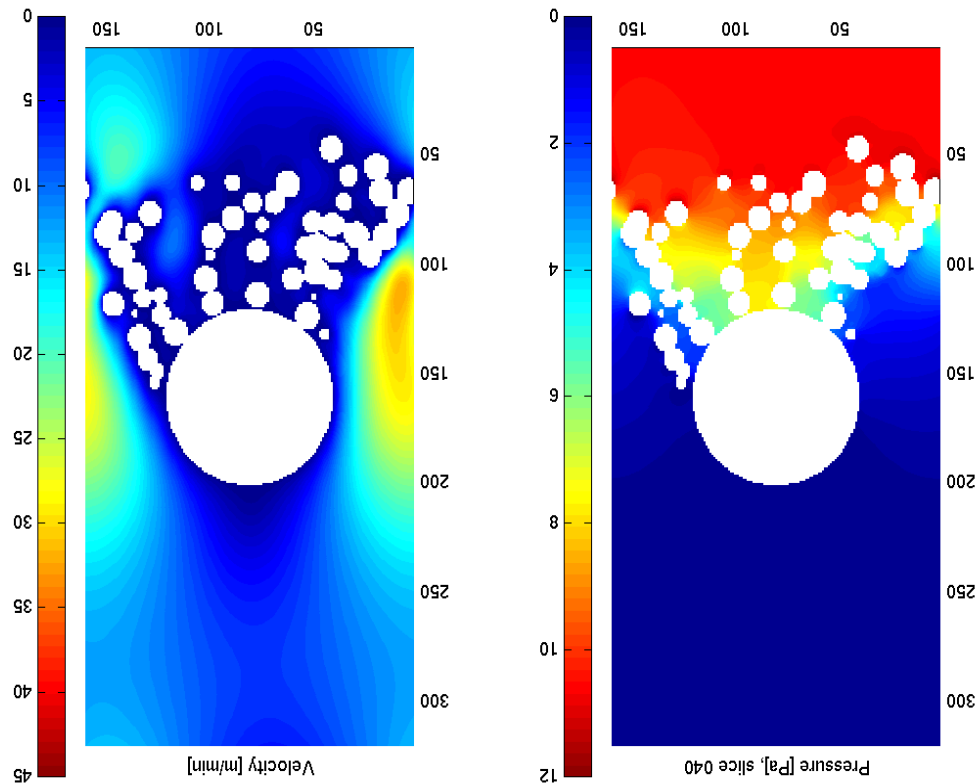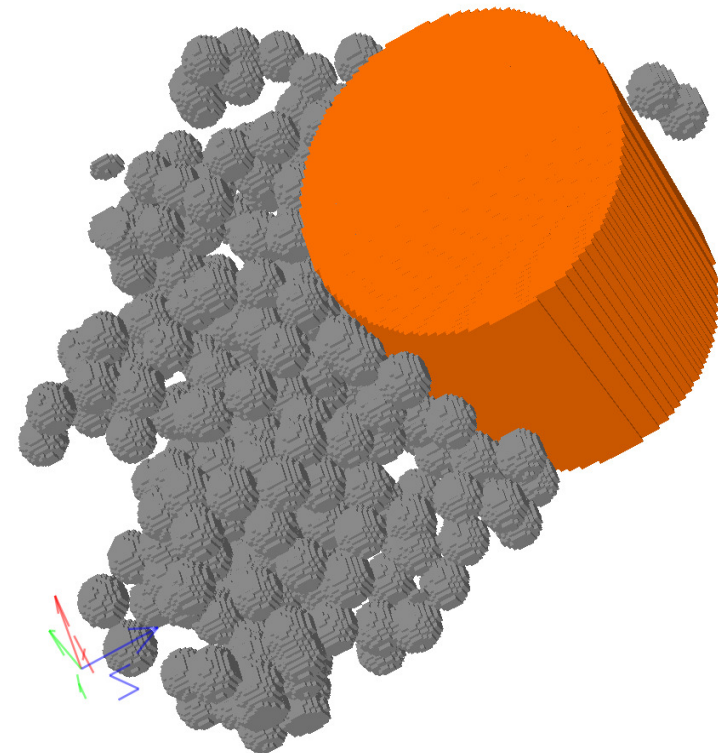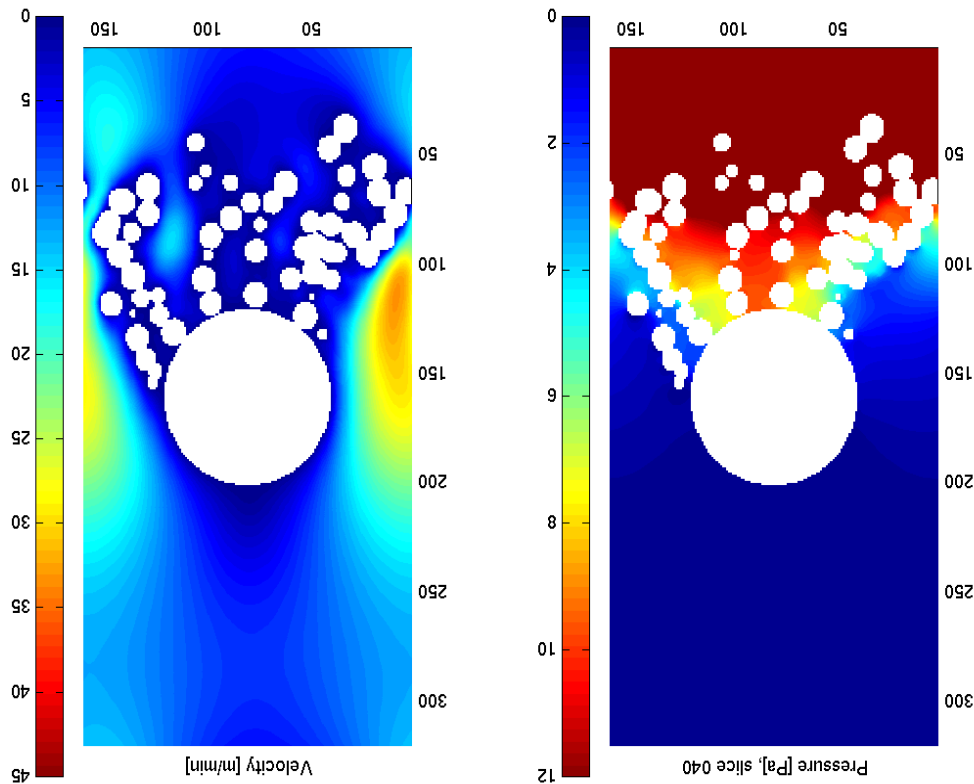
Filtration is multiple physics!

Pressure and Velocity in Clogging Simulation

Filtration is multiple physics!

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Pressure and Velocity in Clogging Simulation

Filtration is multiple physics!

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Geometry and
property pre**dict**or

www.geodict.com

Thank You !

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