# **Analyze and validate structures with PoroDict and MatDict**

Erik Glatt,
Math2Market GmbH,
erik.glatt@math2market.de



#### **PoroDict**

Characterize the pore space of a structure

Validate geometry models via comparison with CT-images

Validate geometry models via comparison with experiments

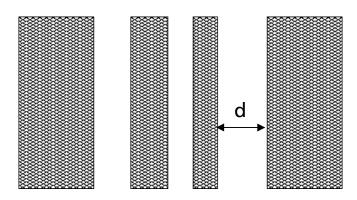
Compare the pore space of different structures (materials)

- Geometric Pore Size Distribution (PSD)
- Pore Size Distribution by Porosimetry
- Percolation Path
- Estimate Surface Area
- Three-Phase Contact Line
- Open and Closed Porosity
- Chord Length Distribution
- Bubble Point
- Euclidean Distance Transform
- Identify Pores (Watershed)

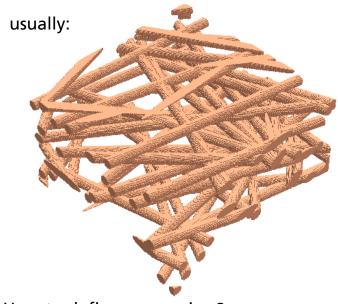


## **Geometric Pore Size Distribution**

#### simple geometry:



Pore sizes well defined and easy to measure



How to define a pore size?

What is measured?



## **Defining Pore Sizes**

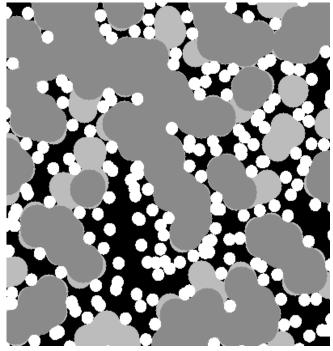
Pore space : X

Opening of radius *r*:

$$O_r(X) = \bigcup_{B_{r,x} \subset X} B_{r,x}$$

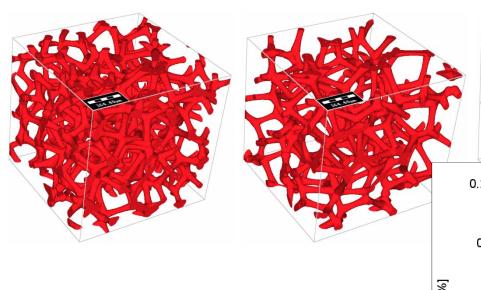
Volume of pores with radius  $r_1 \leq r \leq r_2$  :

$$O_{r_1}(X) - O_{r_2}(X)$$

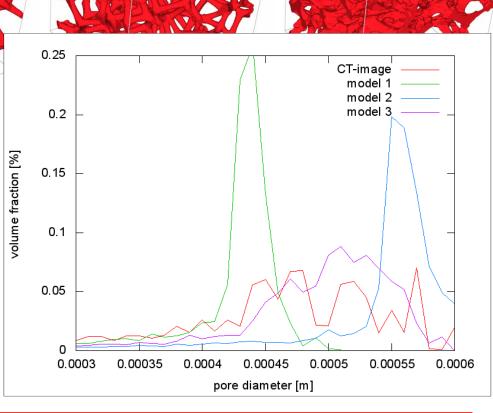


 $\begin{array}{l} \text{dark grey: } r \geq 20 \\ \text{light grey: } 16 \leq r < 20 \end{array}$ 

## Analyze the PSD of a Sponge



Validate the model of a sponge via comparison of the PSD for model and CT-image





## **Identify Pores (Watershed)**

Module: PoroDict (2012R2 Build 11605) Use the watershed algorithm to: Command: WaterShed Domain: 200 x 200 x 200 Voxel: 1 μm Input Map Results Map Results Info Volume Histogram Visualization 5.2e-001 Options Histogram 4.9e-001 4.6e-001 Separate pores 4.3e-001 Equivalent Diameter 3.7e-001 Get a pore size analyzes Relative Count Probability 3.4e-001 3.2e-001 2.9e-001 Give Min. and Max Value 2.6e-001 2.3e-001 2.0e-001 Min. Diameter [m] 0 1.7e-001 1.4e-001 Max. Diameter [m] 2.5e-5 1.1e-001 8.6e-002 5.7e-002 Histogram Bins 20 0.0e+000 5.0e-006 1.0e-005 1.5e-005 2.0e-005 2.5e-005 Update Histogram Equivalent Diameter [m] Load Input Map Store As Text Store As Html Structure **Pores** 



#### **MatDict**

Characterize the material phases of a structure

Validate geometry models via comparison with CT-images

Validate geometry models via comparison with experiments

Compare the material phases of different structures

- Connected Components
- 1D Statistics
- 2D Statistics
- Analyze Objects

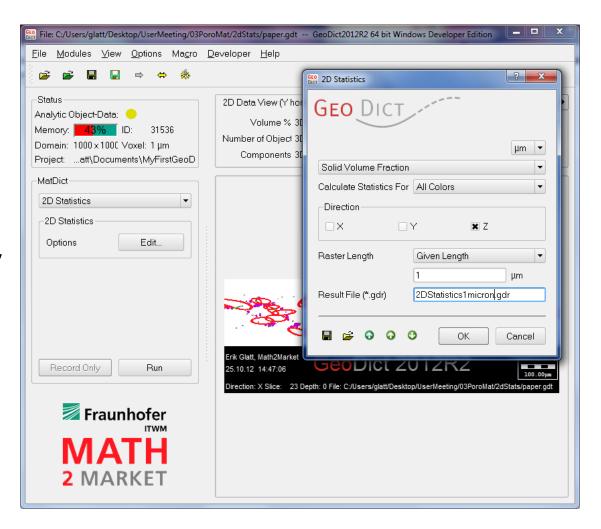


## **2D Statistics**

Calculate the SVF along rays in x-, y- or z-direction

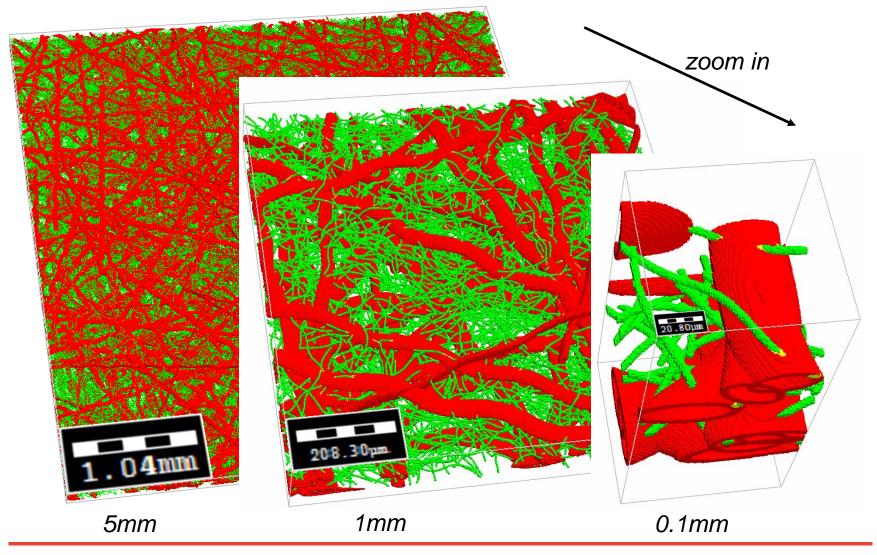
#### **Example:**

Use the 2D statistics to study the heterogeneity of a paper sheet





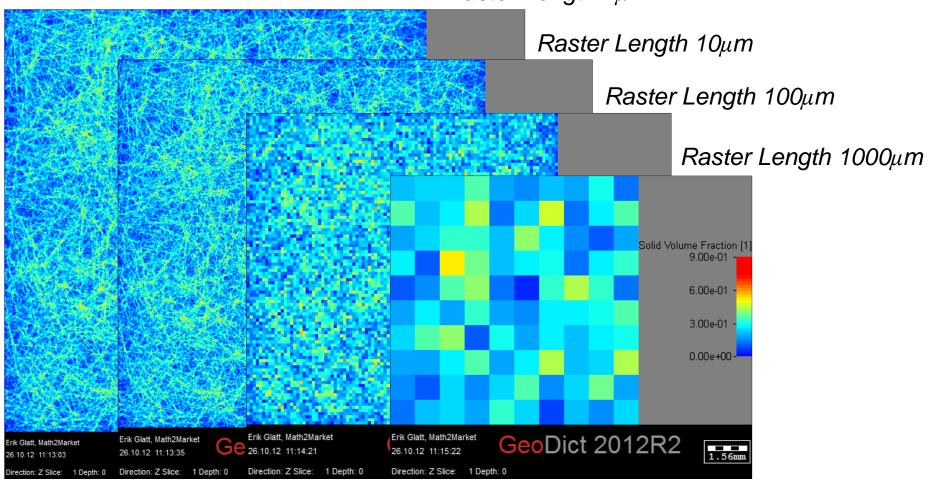
# Heterogeneity of a Paper Sheet 1





## Heterogeneity of a Paper Sheet 2

Raster Length 2μm

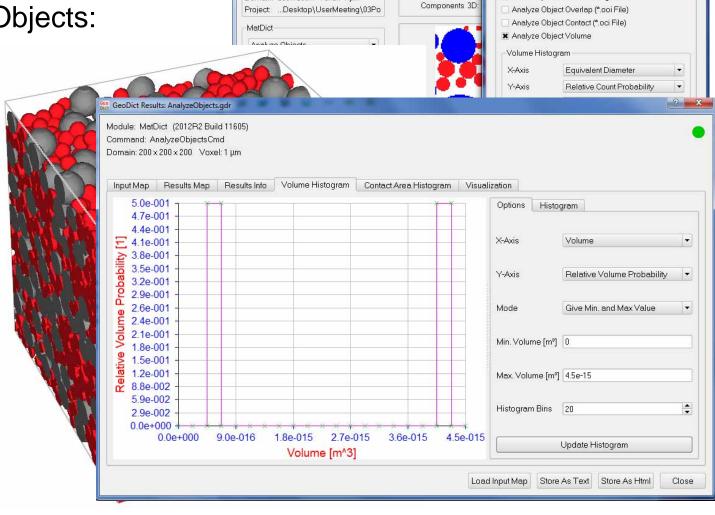




# **Analyze Objects**

Analyze Gad-Objects:

- Volumes
- Contacts
- Overlaps



-- GeoDict2012R2 64 bit Windows Developer Edition

Analytic Object-Data:

Domain: 200 x 200 x Voxel: 1 µm

File Modules View Options Magro Developer Help

Analyze Objects

2D Data View (Y horizo

Number of Object 3D:

Volume % 3D:

GEO DICT

Object Data Analyze Options

Analyze All Colors ▼ IIIII

Write Object Orientation to \*gof File



#### Conclusions

PoroDict and MatDict are powerful tools to analyze and validate the geometry of material models and CT-images.

#### **Examples:**

- validation of a sponge model via comparison of the PSD
- Study the heterogeneity of paper with the 2D statistics

## **Outlook**

Planed new features:

- Skeletonization algorithm
- Fiber property estimation (diameters,..)
- 3D Statistics

