X-ray Computed Tomography (XCT)

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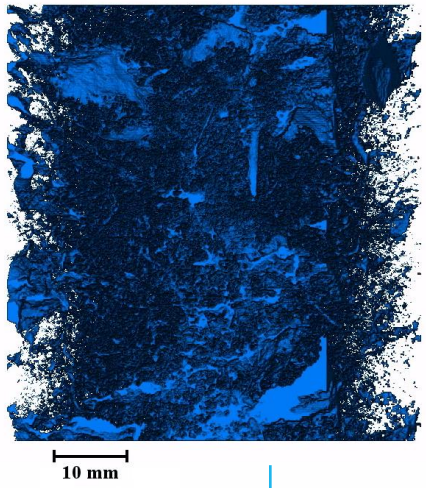
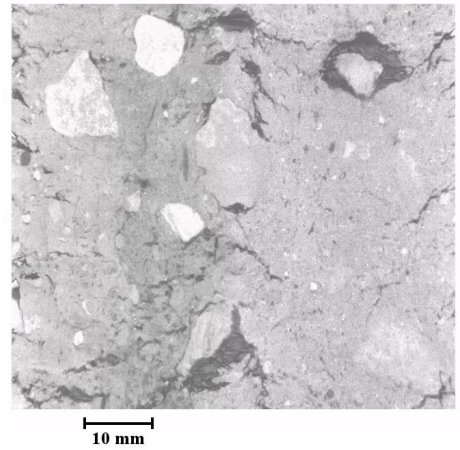
MONet Data types - Images

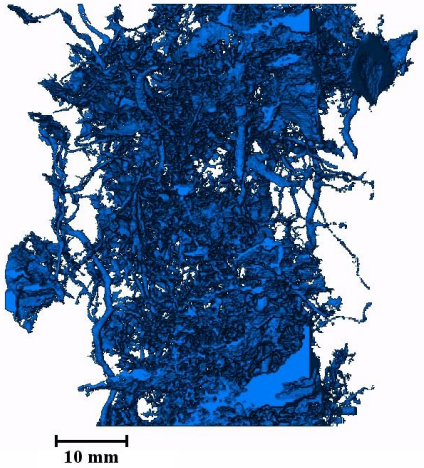
Whole Core



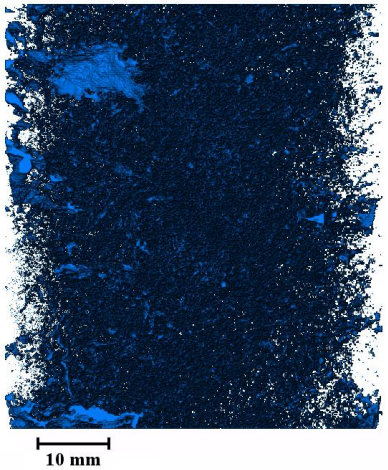
Pores



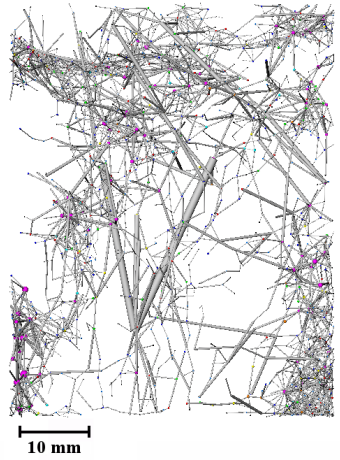
Raw image



Connected Pores

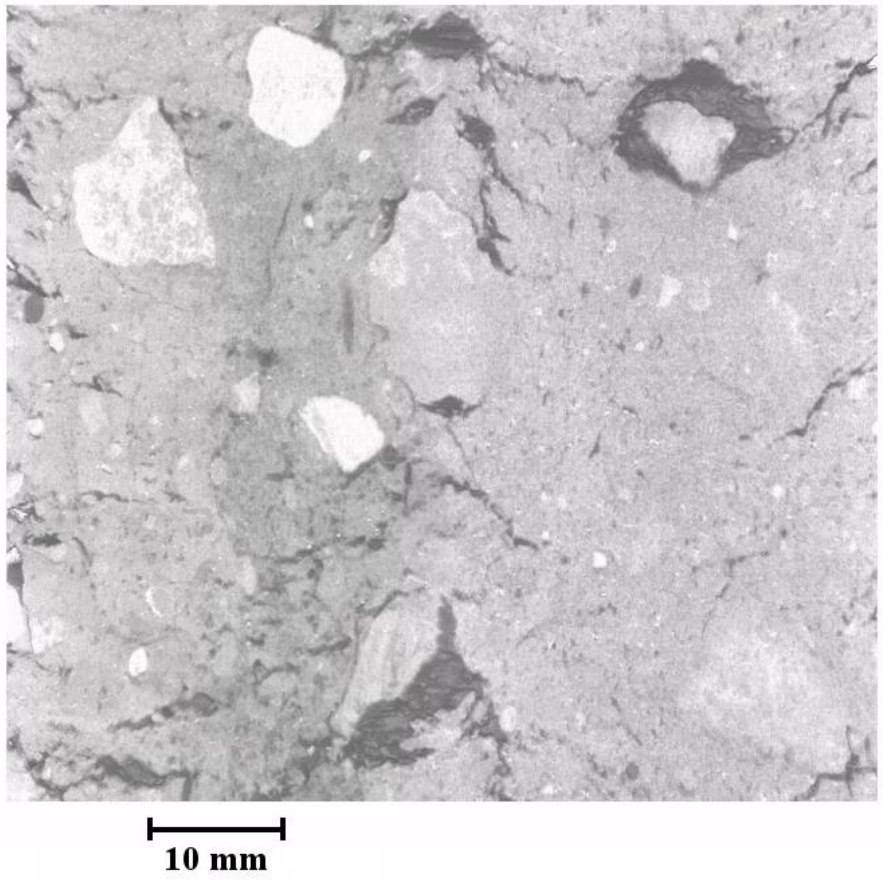


Unconnected Pores



Pore Network Model

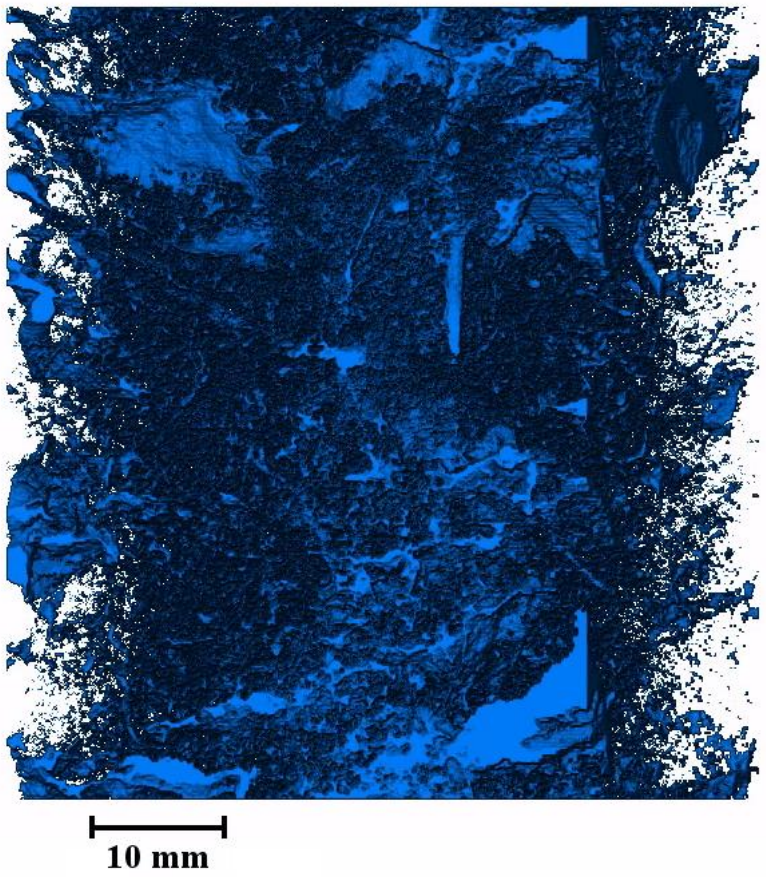
Imaging - RAW



Grey scale image based on density

- Fresh scan, unaltered
- Cropped
  - 1240 x 1200 x 1575 voxels (actual size 47.28mm x 45.76mm x 60.0456mm)
- Shade based on density
  - White = increased density
  - Black = decreased density

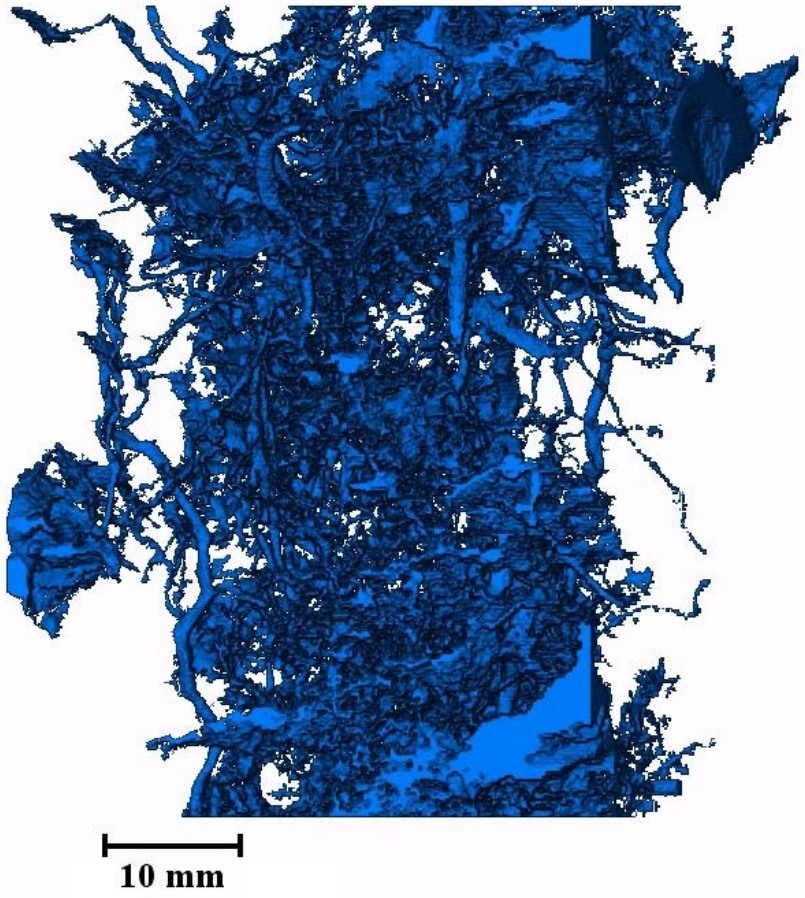
Imaging - Pores



Isolated Pores

- Binary image
- Size and shape analysis
- Base for further data analysis

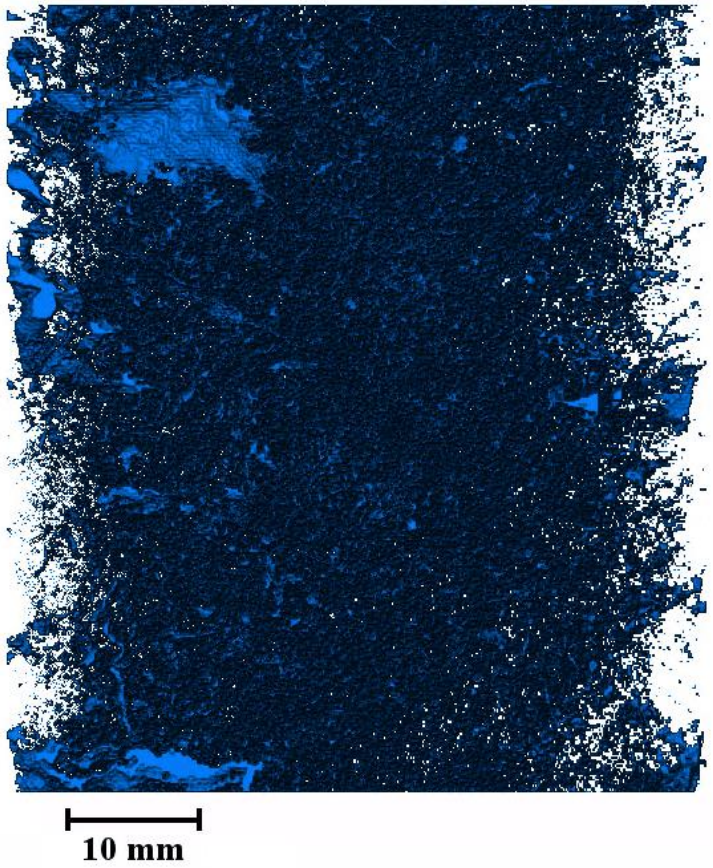
Imaging – Pores: Connected



Isolated Pores

- Binary image
- Connectivity based on axis (X, Y, & Z)
- Size and shape analysis
- Used to calculate flow rates

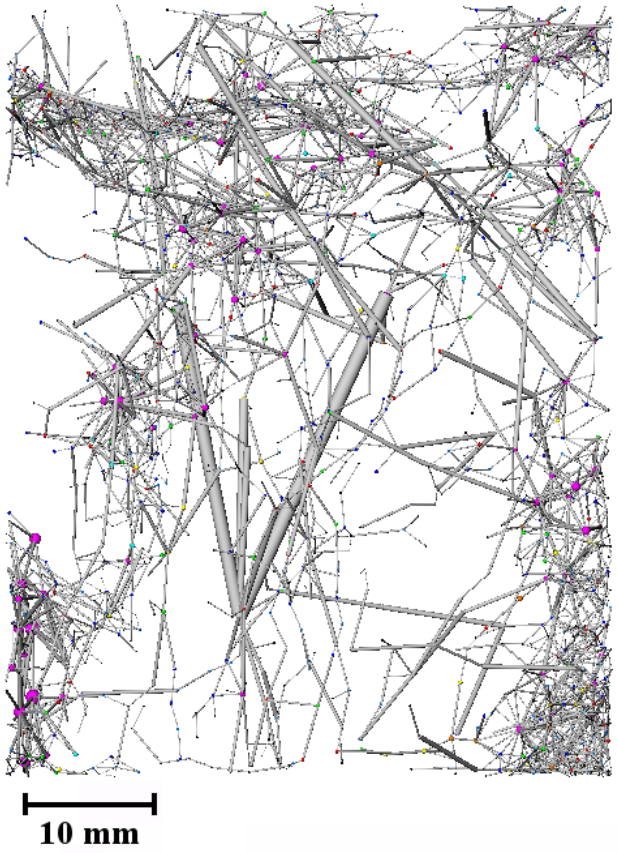
Imaging – Pores: Unconnected



Unconnected Pores

- Binary image
- No connectivity on any axis
- “Islands”

Imaging – Pore Network Model View

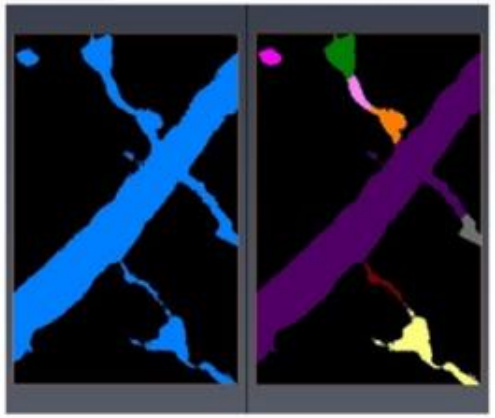


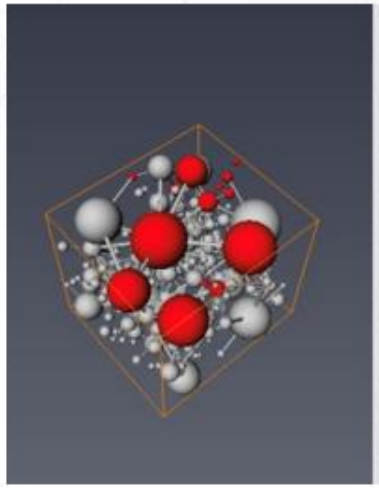
Pore Network Model

- Computer generated image based on flow rate calculations.
  - **Scale**: Volume
  - **Coloring**: Equatorial radius
  - **Throat scale**: Channel Length

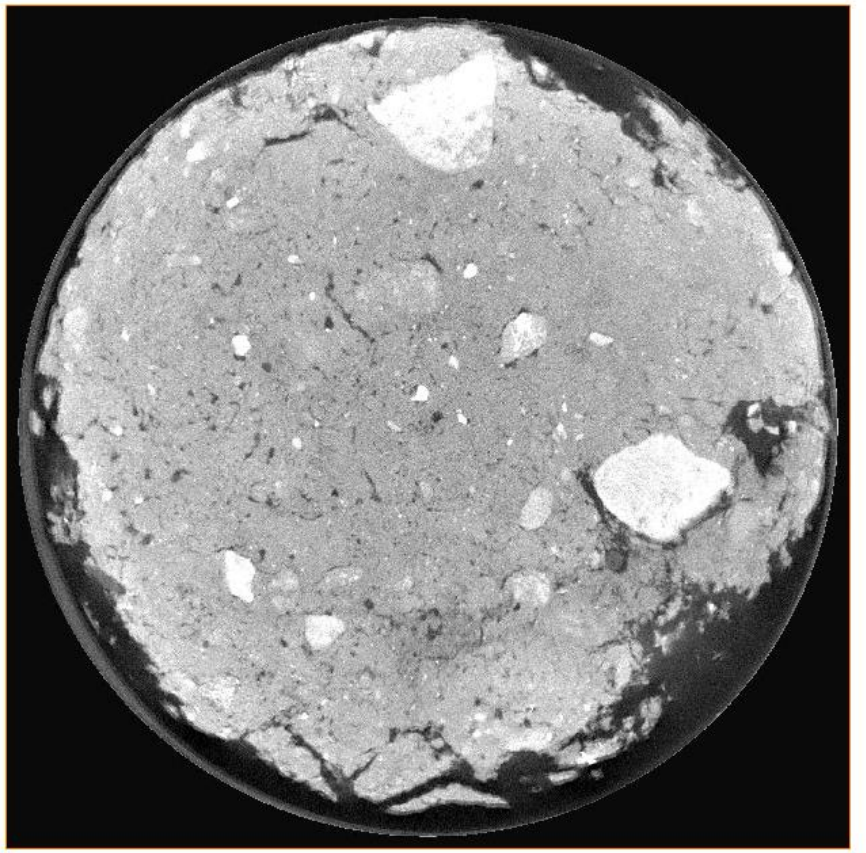
Image Thresholding

- Image Thresholding
- Based on grey scale values
- Binarizes image, creates an ‘object’
- Analyzes fundamentals of the porosity





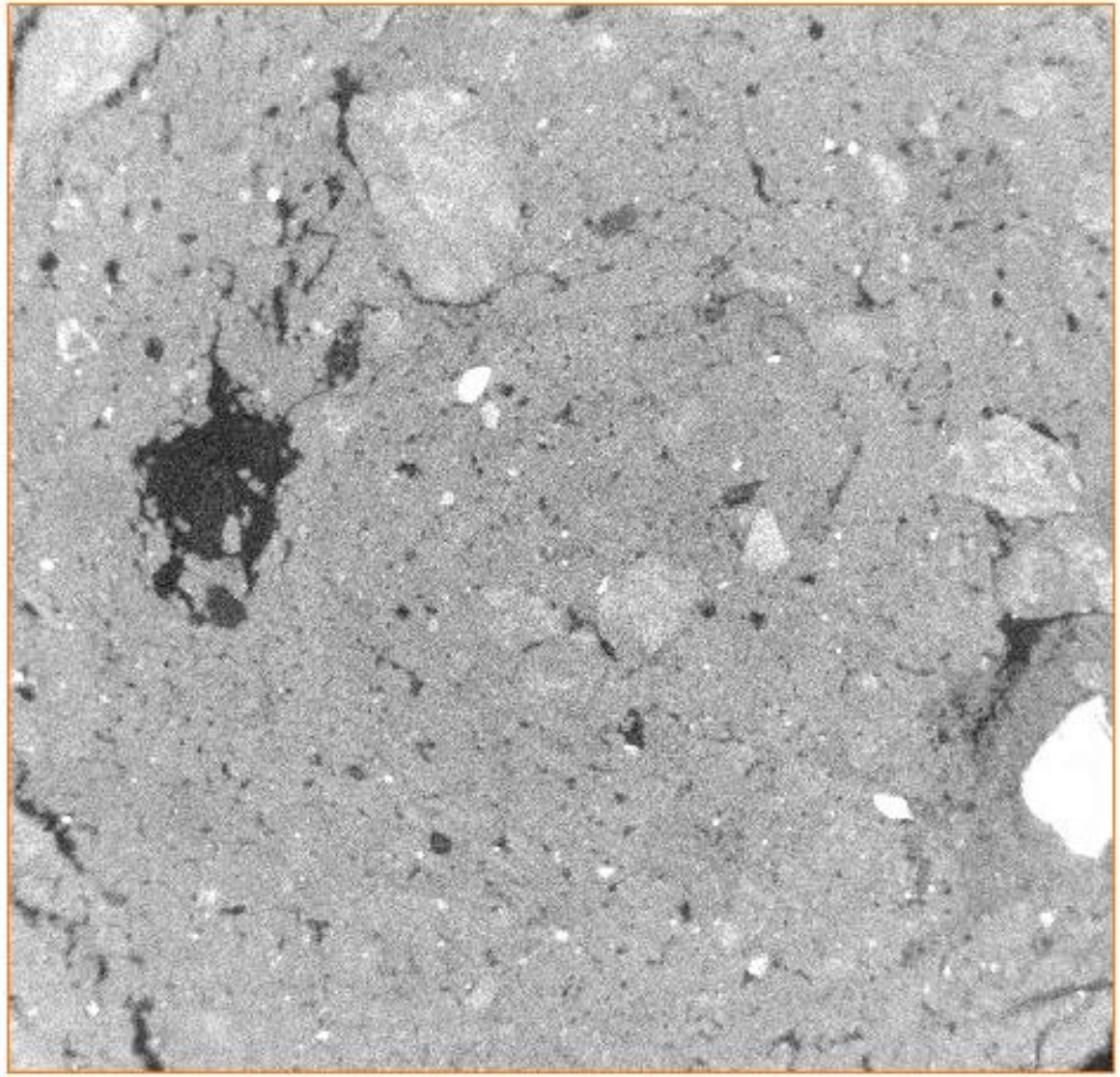
	Pore ID	Volume	Area	EqRadius
1	0	0.0780605	1.22915	0.265123
2	1	0.361577	3.40463	0.441947
3	2	0.138114	1.8833	0.320664
4	3	0.0014512	0.0638127	0.0702467
5	4	0.0467395	0.150073	0.105894
6	5	0.0012162	0.0690542	0.0662717
7	6	0.327738	2.95732	0.378834
8	7	0.0113686	0.86959	0.147231
9	8	0.510571	4.56064	0.504253
10	9	0.0055935	0.147367	0.106802
11	10	0.392412	3.24608	0.454169
12	11	0.0018743	0.110051	0.078119
13	12	0.703128	4.66303	0.551656
14	13	0.0256269	0.617245	0.204125
15	14	0.0012724	0.0578862	0.0672227
16	15	0.0149633	0.353941	0.149738
17	16	0.000535062	0.0344628	0.0503623



Example; Pore thresholding from low to high, and high to low

Thresholding Pore spaces

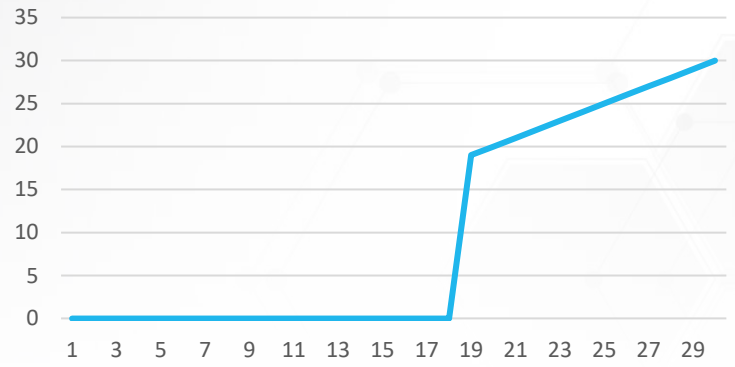
- Thresholding from minimum in the direction of maximum until darker slots are selected.
- Potential for machine learning “Deep Learning”
- Slightly Over-selecting is a good thing.



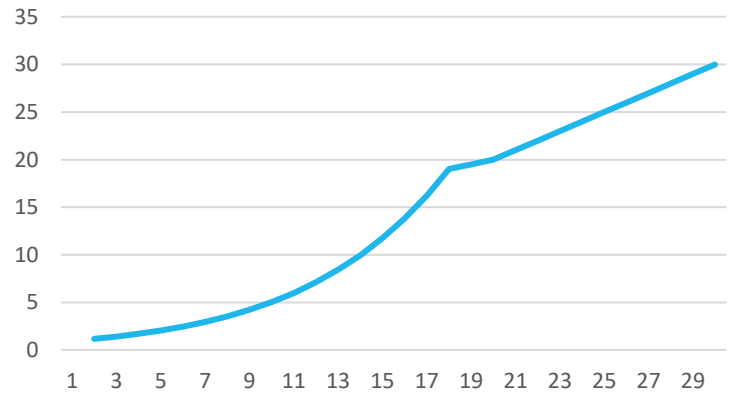
Thresholding Pore spaces (cont.)

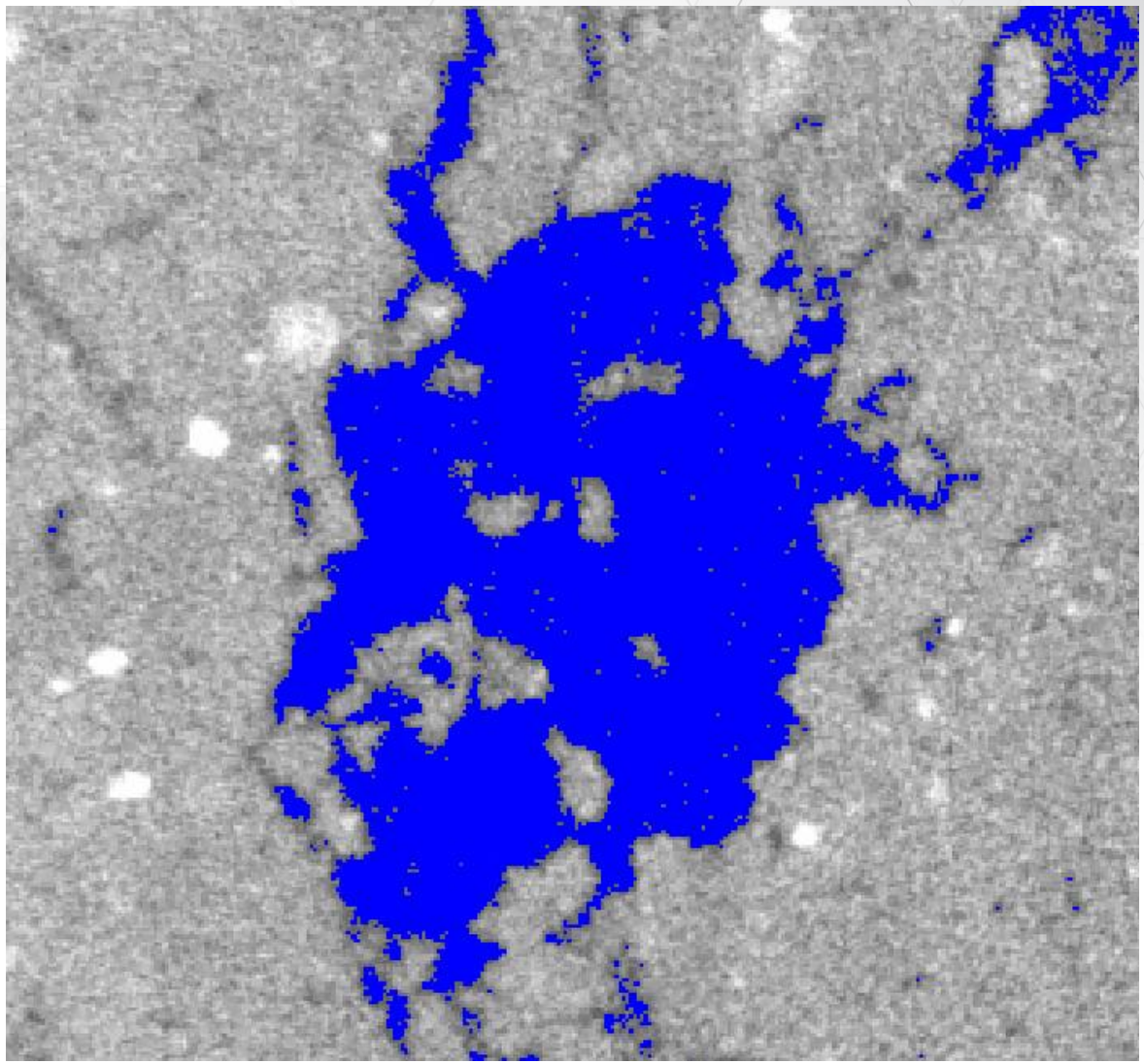
- Reasoning: The AI in Avizo creates a “blending” type gradient.
- Example:

From this



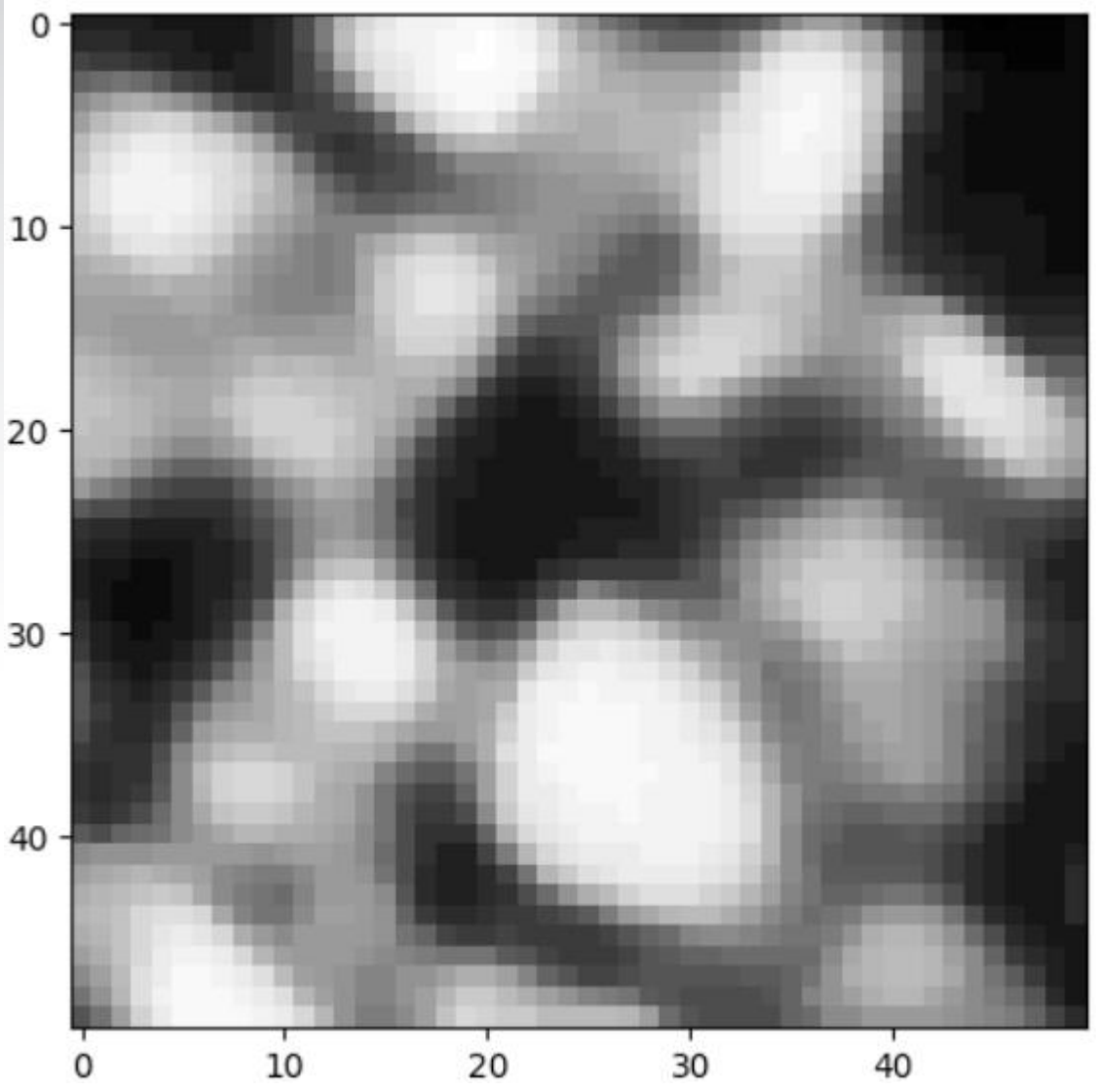
To this



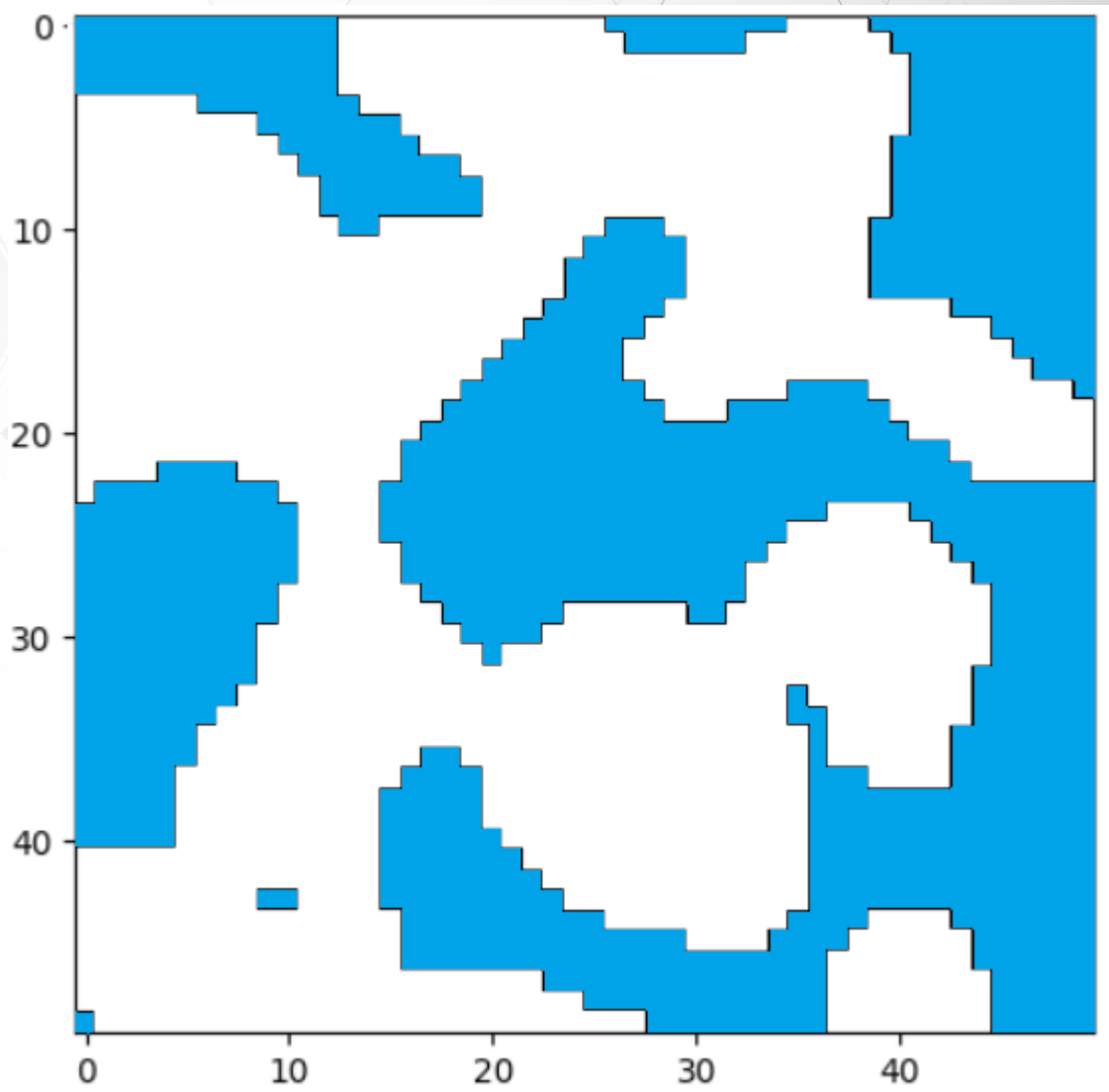


Thresholding slightly over

Thresholding Pore spaces (cont.)



Grey Scale



Binary Image

MONet Data types - Numerical

- Scan information
- Pore size
- Pore volume fraction
- Pore connectivity
- Wet Bulk density
- Permeability
- Flow rate
- Tortuosity

	A	B	C	D	E	F	G	H	I	J	K
1	Voxel	0.0381						Volume (mm3)	Area (mm2)	Diameter(mm)	Area Fraction
2	1241	1201	1576	Sizes X Y Z			Label analysis				
3	47.2821	45.7581	60.0456	Actual Size			Mean	0.046367593	0.255852073	0.071305692	3.56E-07
4							Min	5.55E-05	4.37E-03	0.047327433	4.26E-10
5							Max	44530.97656	218199.4375	43.97655869	3.42E-01
6	Pores	0.347915					Median	8.24E-05	8.09E-03	0.059617709	6.39E-10
7	(Pores.measure, Volume fraction)						Variance	2034.26709	48847.53125	0.004137394	1.20E-07
8							Kurtosis	974543.1875	974521.375	212036.0938	974543.1875
9	Pores.Axis.Connectivity	0.341549					Skewness	987.1895142	987.1730957	316.0162964	987.1895752
10	(Pores(2).measure Volume Fraction)		98.17024273								
11											
12											
13	Wet Bulk Density	1.51451									
14	(Solid.analysis)										
15											
16	PNM in Z										
17	k [µm^2]	k [d]	TotalFlowRatePerSec	Tortuosity							
18	2.51E-05	2.54E-05	2.39E+02	1.811437462							
19											
20	PNM in Y										
21	k [µm^2]	k [d]	TotalFlowRatePerSec	Tortuosity							
22	1.43E-01	1.44E-01	2.33E+06	1.649198089							
23											
24	PNM in X										
25	k [µm^2]	k [d]	TotalFlowRatePerSec	Tortuosity							
26	1.20E-02	1.21E-02	1.84E+05	1.63792351							