



Clustering & Distance to Surface Analysis using **Avizo**

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October 2019

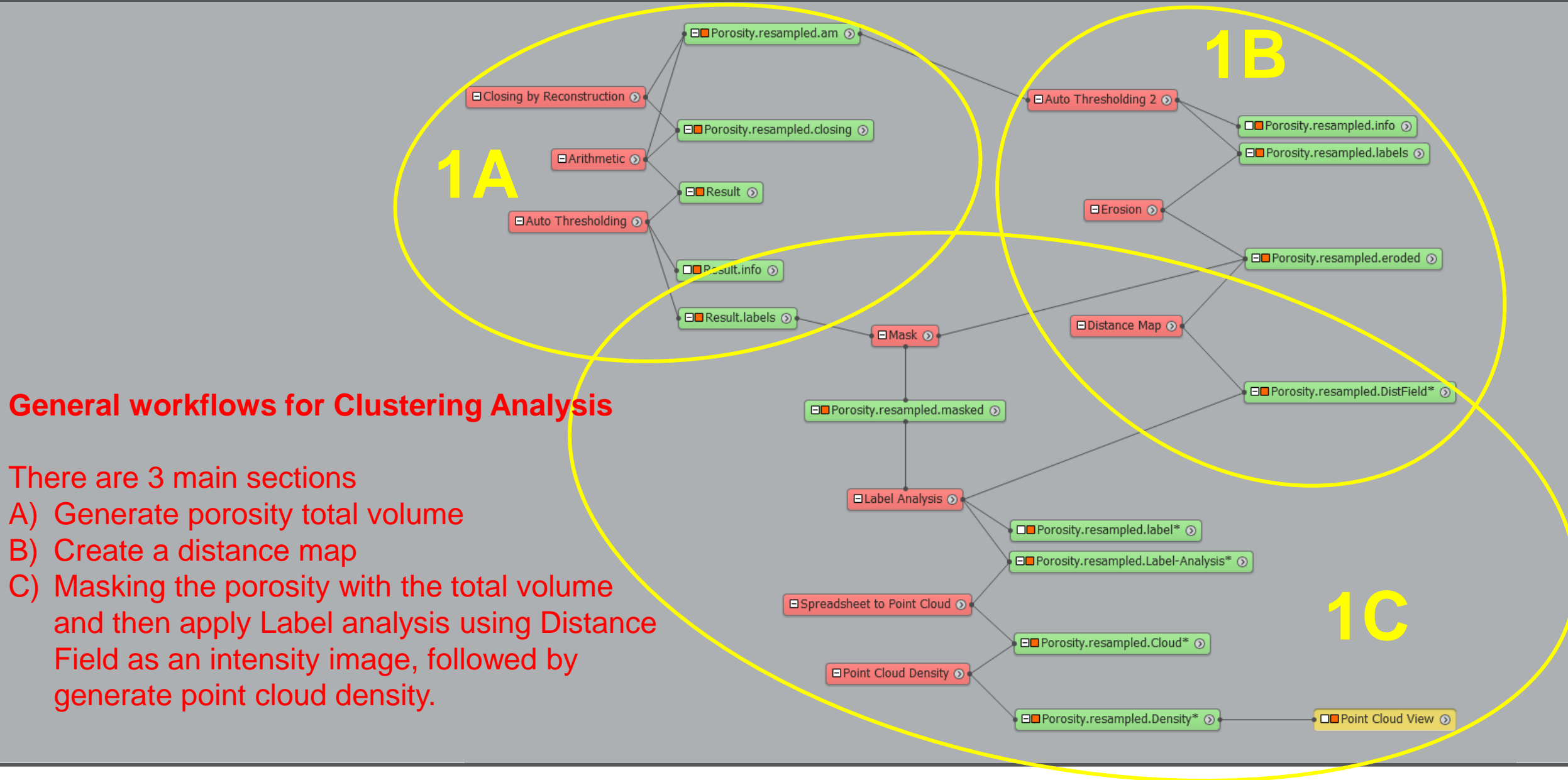
Workflows:

Two independent workflows

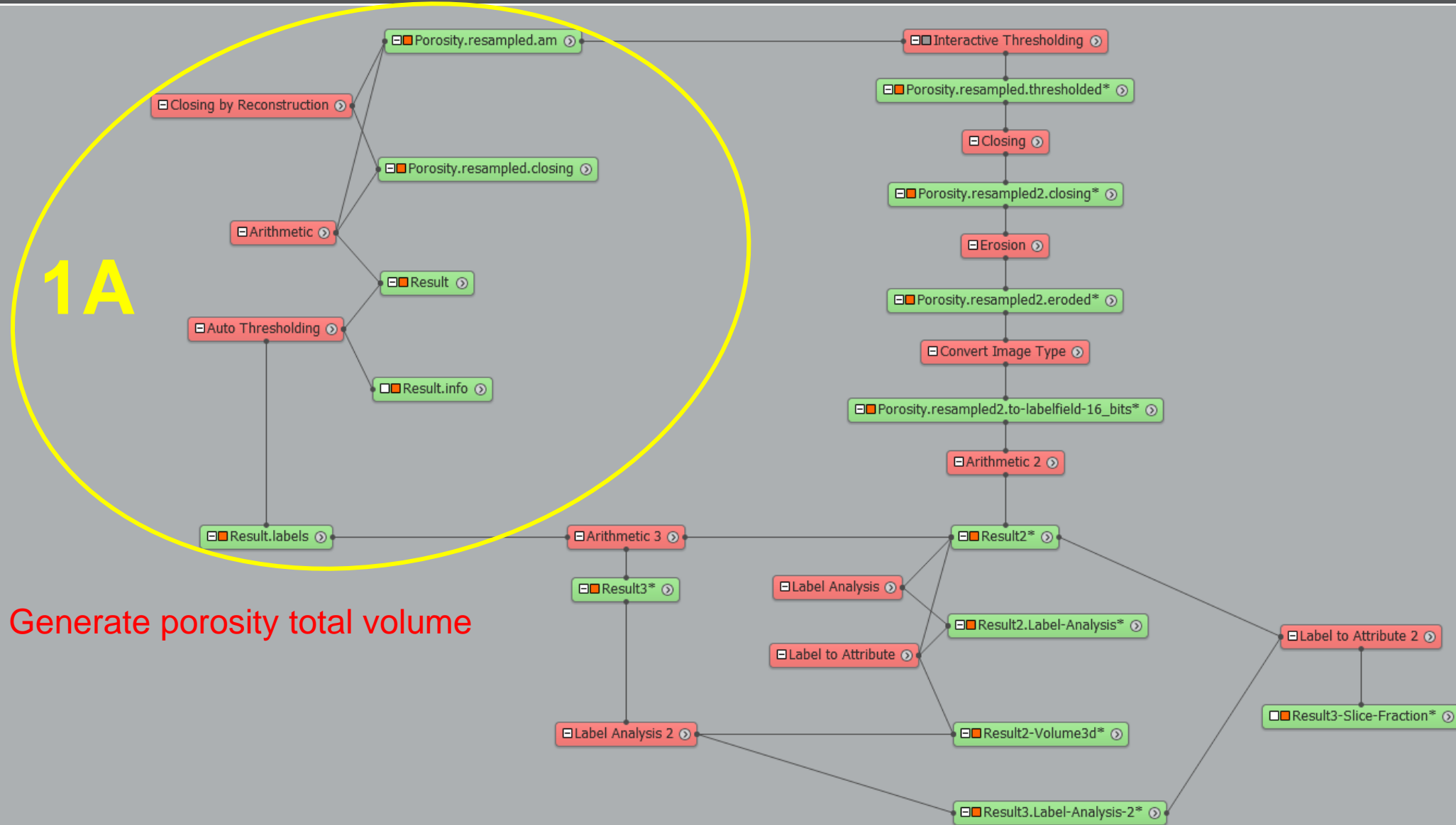
- (1) Clustering
- (2) Distance to Surface

Were generated to analyze porosity distribution and porosity distance to the surface.

Workflows: 1. Clustering



Workflow 1A: Porosity Total Volume

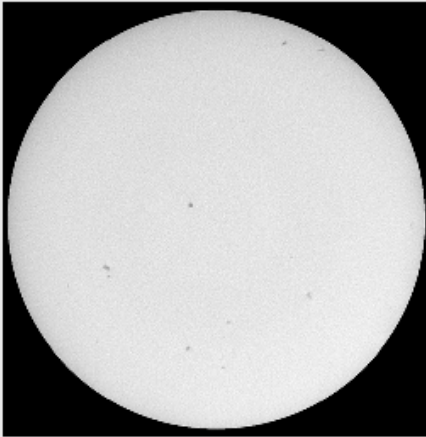
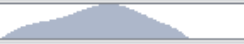


Step 1A.1 : Load the dataset – Porosity.resampled.am

Workflow diagram showing the connection between **Porosity.resampled.am** and **Ortho Slice 2**.

Properties

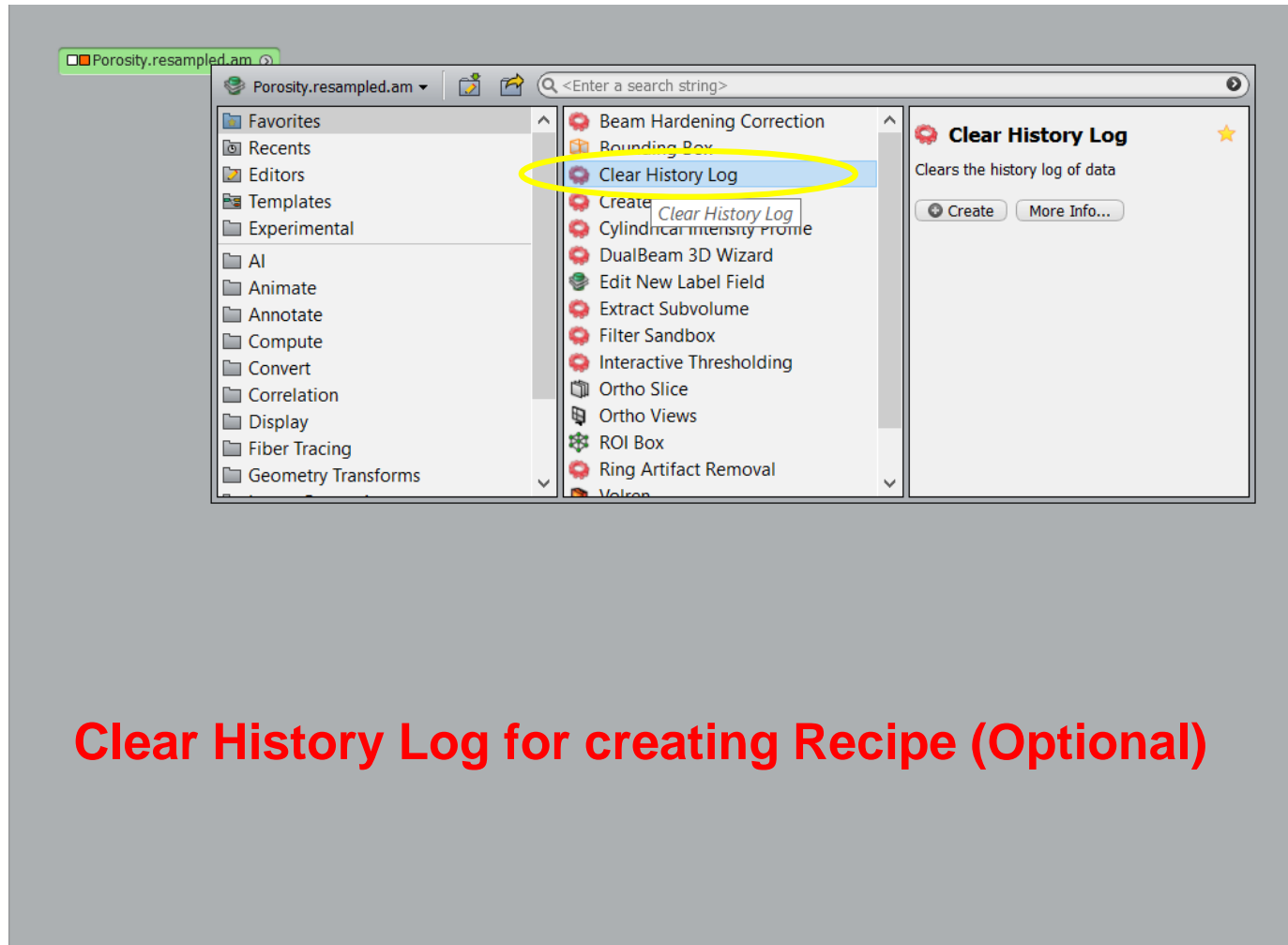
Porosity.resampled.am

Lattice Info:	496 x 507 x 377, uniform coordinates
Data Info:	grayscale, 16-bit unsigned, min-max: 0...58569, window: 26623...65535, intensity ranges: 2
Memory Size:	180.8 MB
Physical Size:	9900, 10120, 7520 [mm] from 5, 5, 199.927 [mm]
Voxel Size:	20 x 20 x 20 [mm]
Preview:	
Master:	NO SOURCE
Histogram:	0  5.857e+04
Shared Colormap:	Edit

- Resample image size if needed
- Attach Ortho Slice to visualize

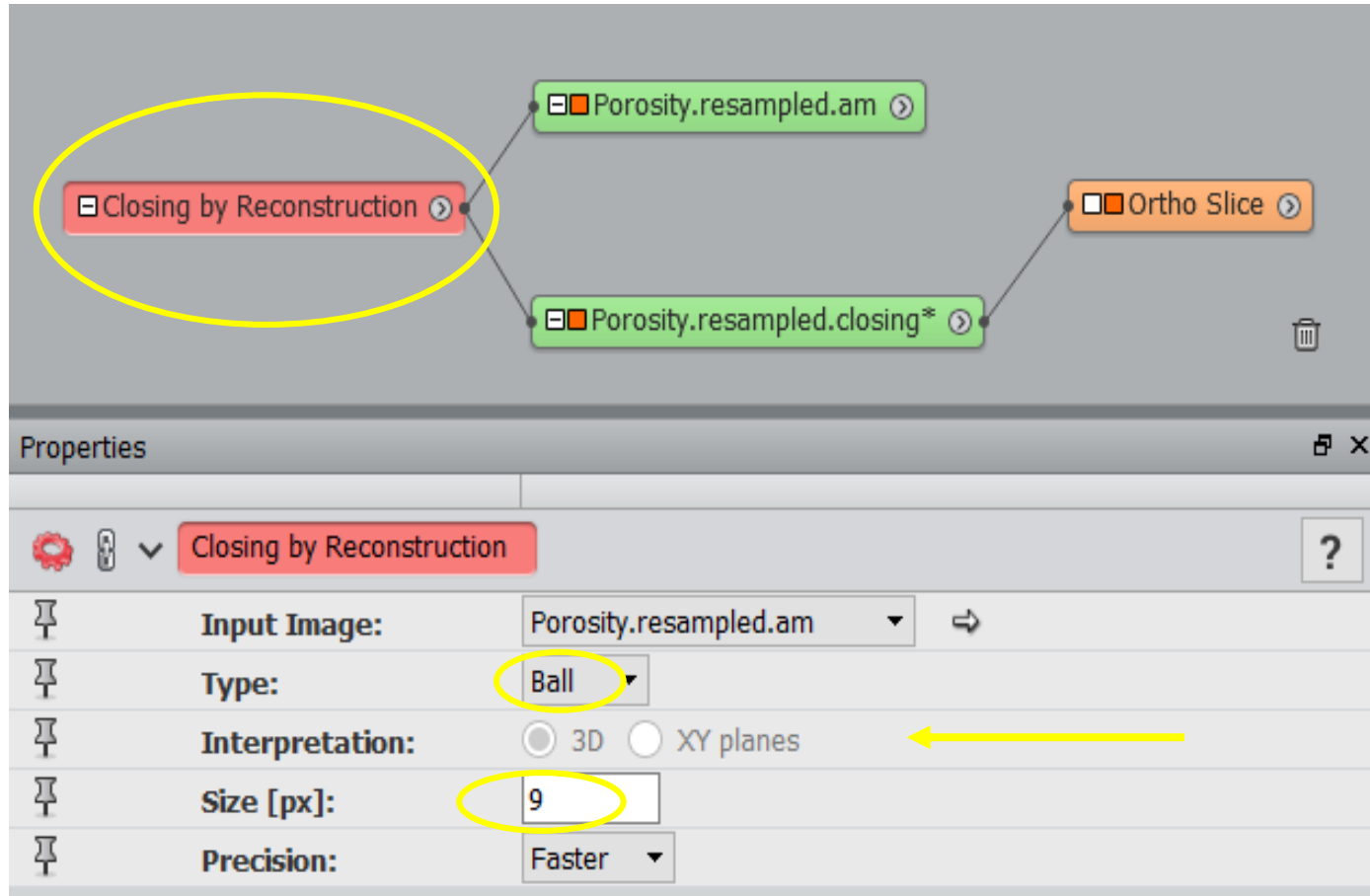


Step 1A.2 : Clear History Log



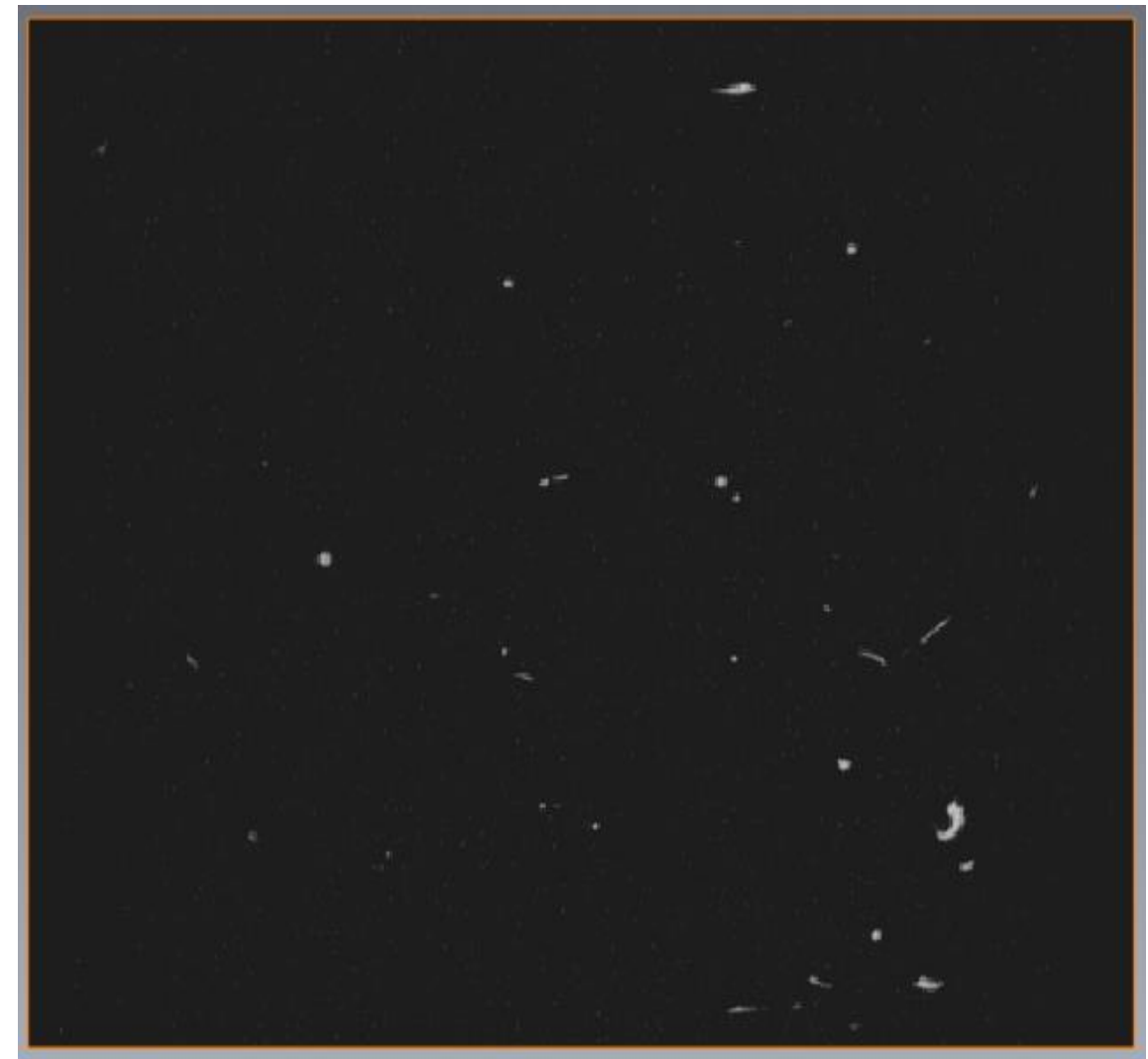
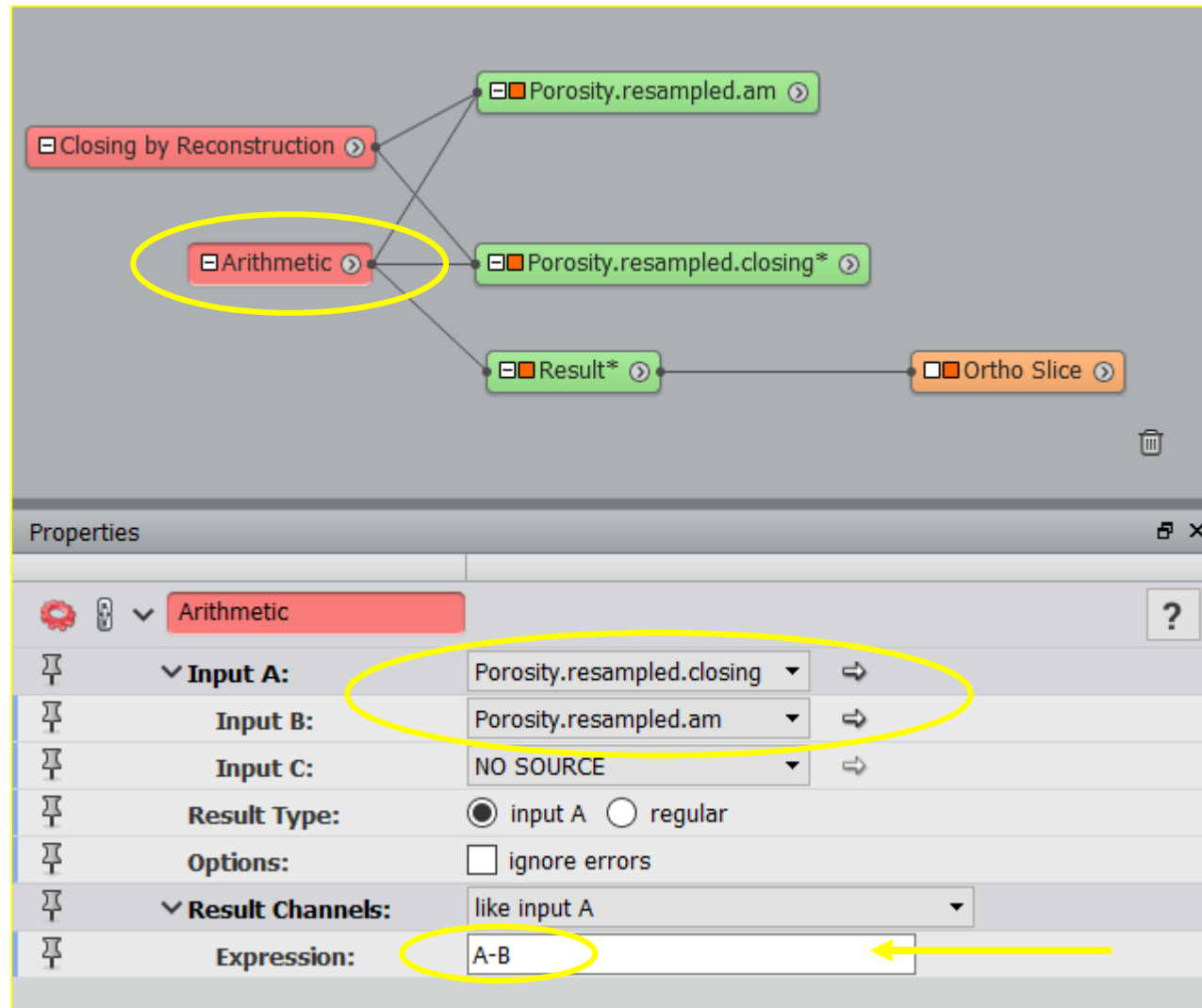
Clear History Log for creating Recipe (Optional)

Step 1A.3 : Closing by Reconstruction



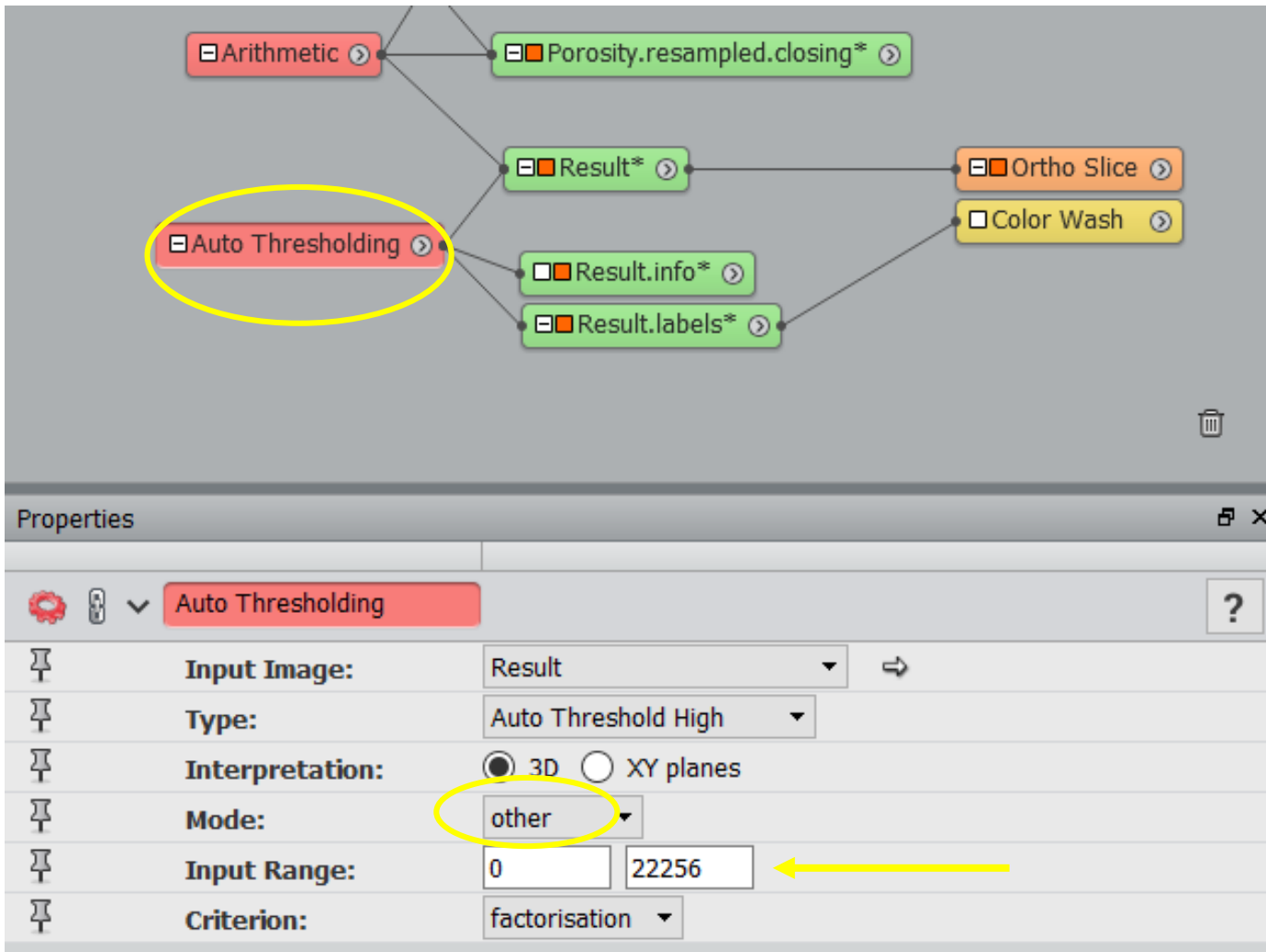
Apply Closing by Reconstruction to Porosity.resampled.am to create background image

Step 1A.4 : Arithmetic



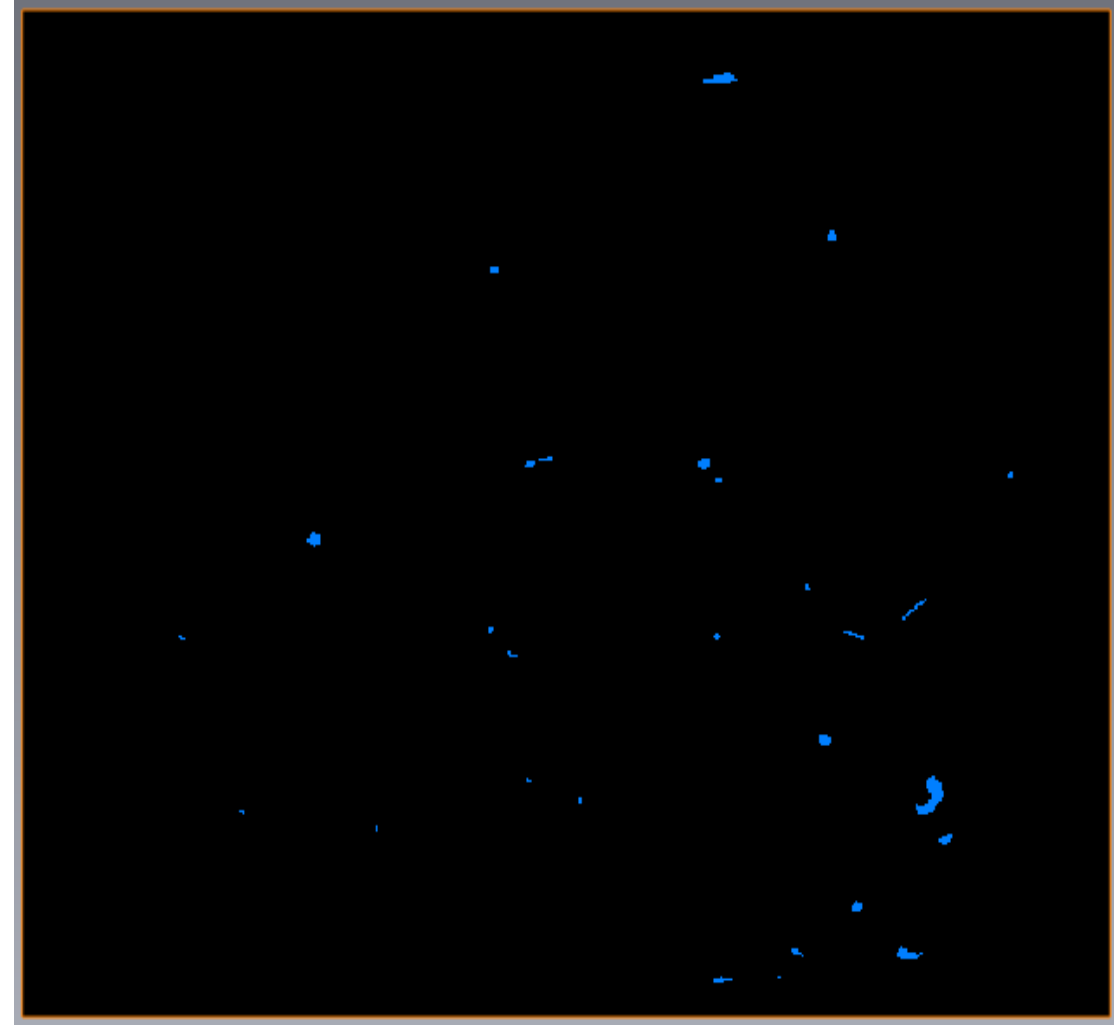
Use Arithmetic to subtract Porosity intensity from the background

Step 1A.5 : Auto Thresholding



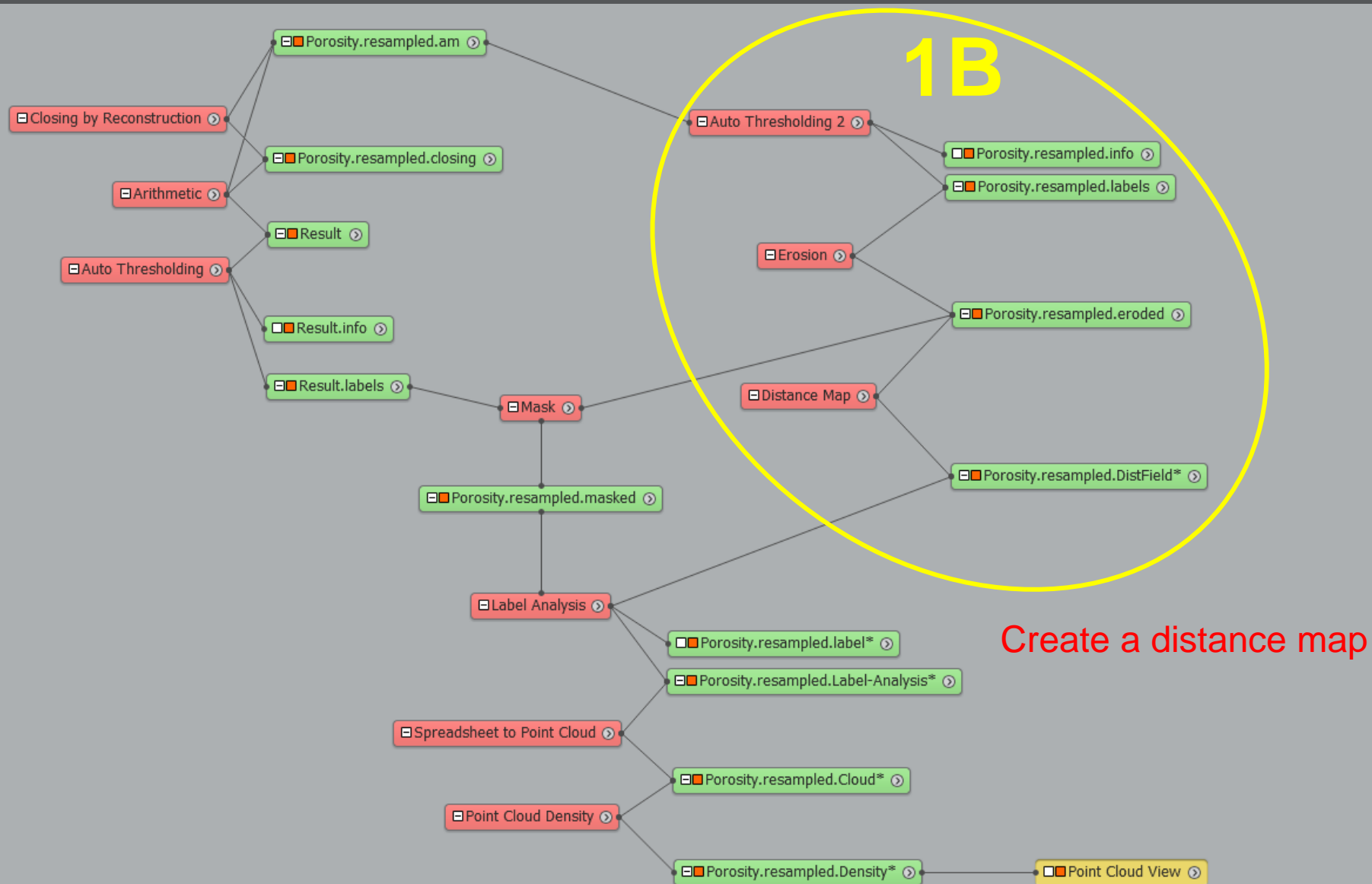
The screenshot displays a workflow graph and the 'Auto Thresholding' node's properties. In the workflow, the 'Auto Thresholding' node is highlighted with a yellow circle. It receives input from 'Arithmetic' and 'Porosity.resampled.closing*'. Its outputs are 'Result*', 'Result.info*', and 'Result.labels*'. 'Result*' is further processed by 'Ortho Slice' and 'Color Wash'. The 'Properties' panel for 'Auto Thresholding' is shown below, with the 'Mode' dropdown set to 'other' and the 'Input Range' set to '0' and '22256', both highlighted with yellow circles and a yellow arrow pointing to the '22256' value.

Auto Thresholding		
Input Image:	Result	
Type:	Auto Threshold High	
Interpretation:	<input checked="" type="radio"/> 3D <input type="radio"/> XY planes	
Mode:	other	
Input Range:	0	22256
Criterion:	factorisation	

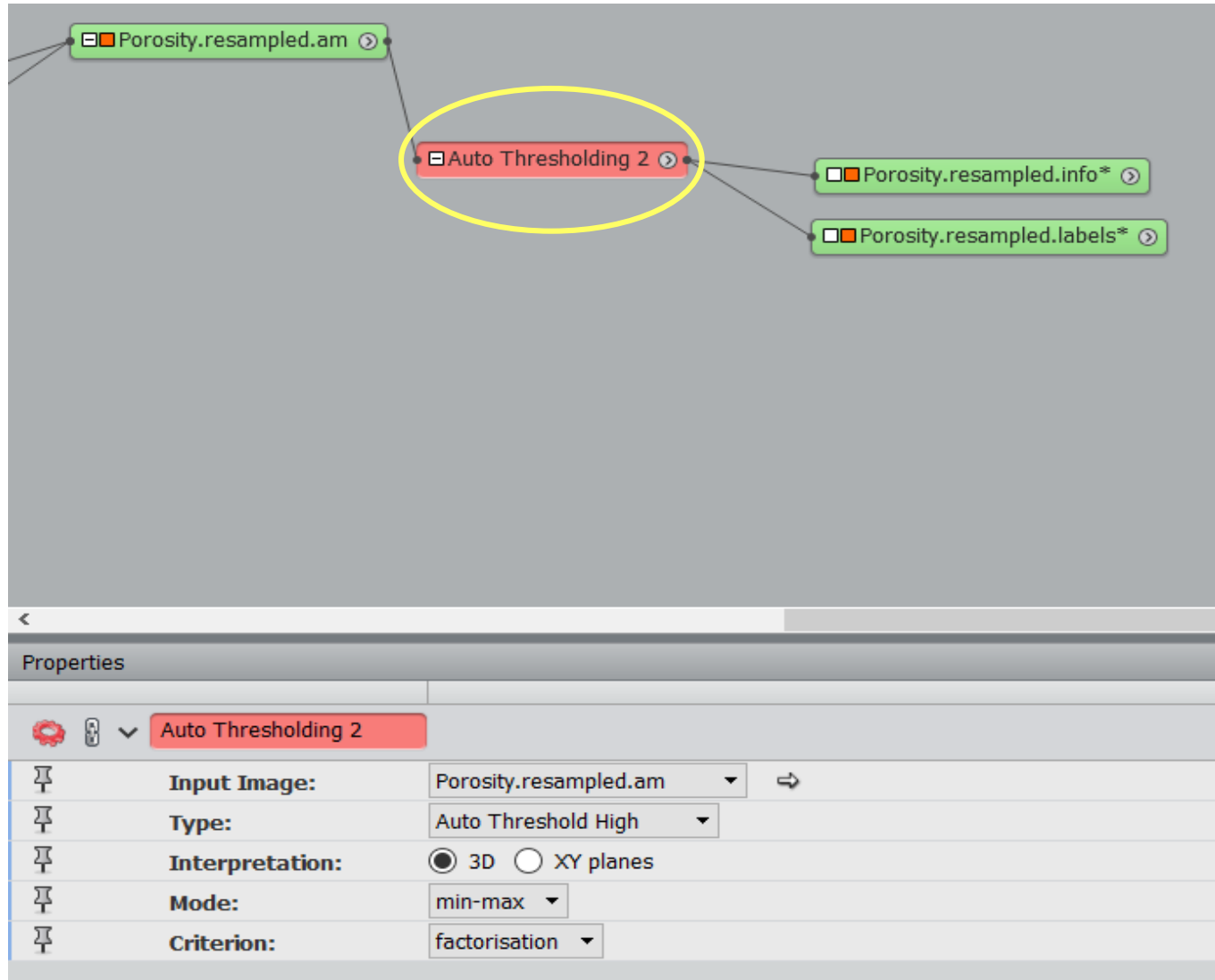


Adjust Input Range in Auto Thresholding to create a binary (label) image of the porosity

Workflow 1B: Create Distance Map

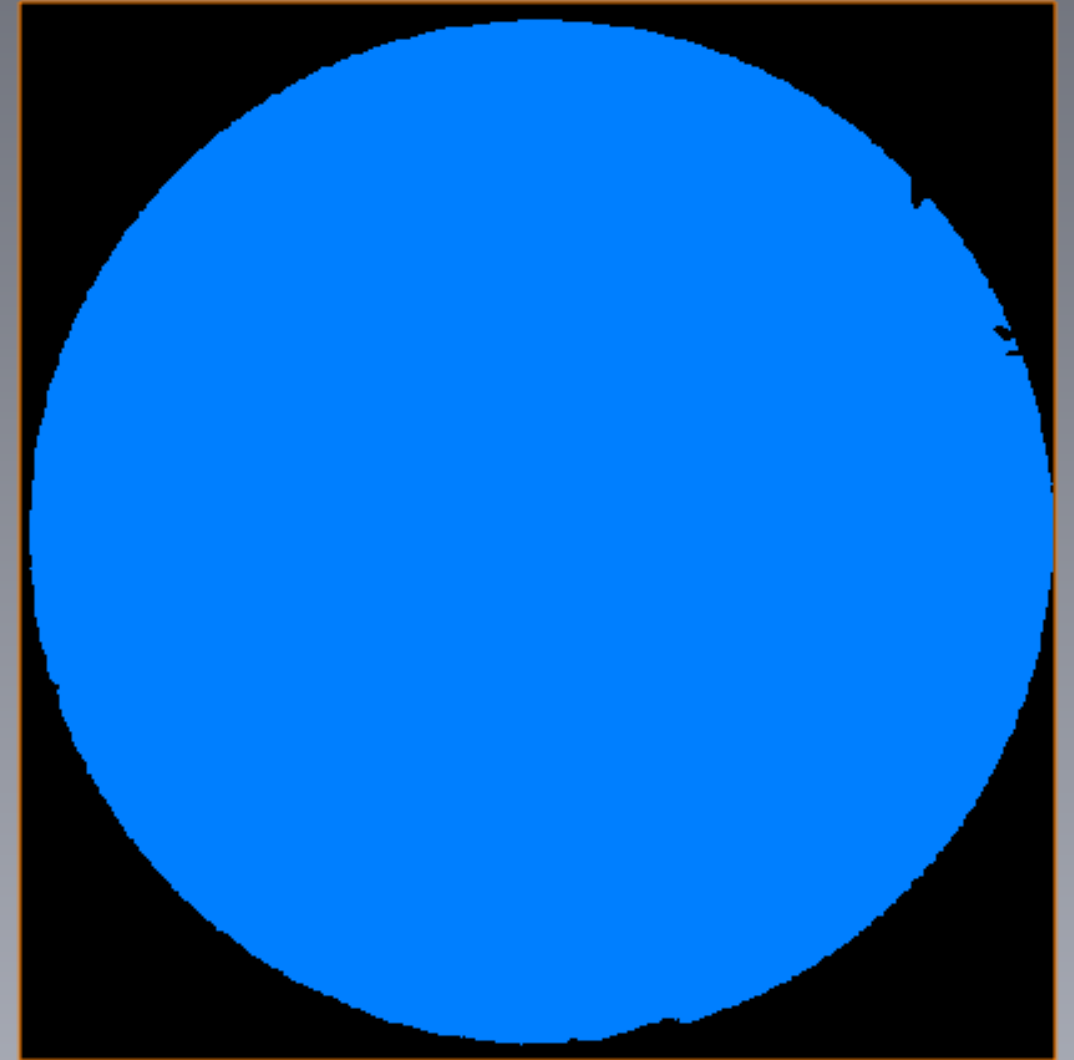


Step 1B.1 : Auto Thresholding



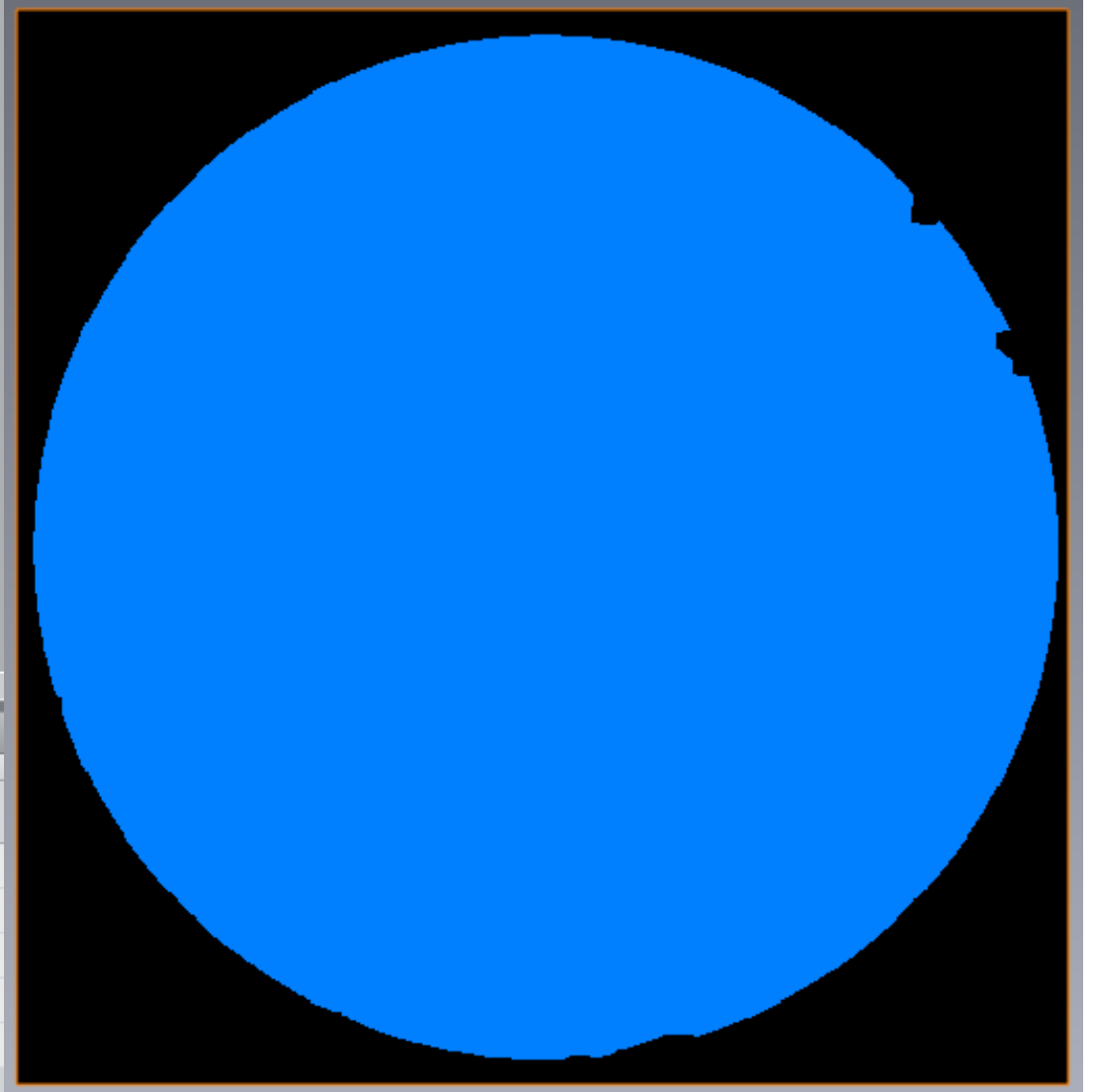
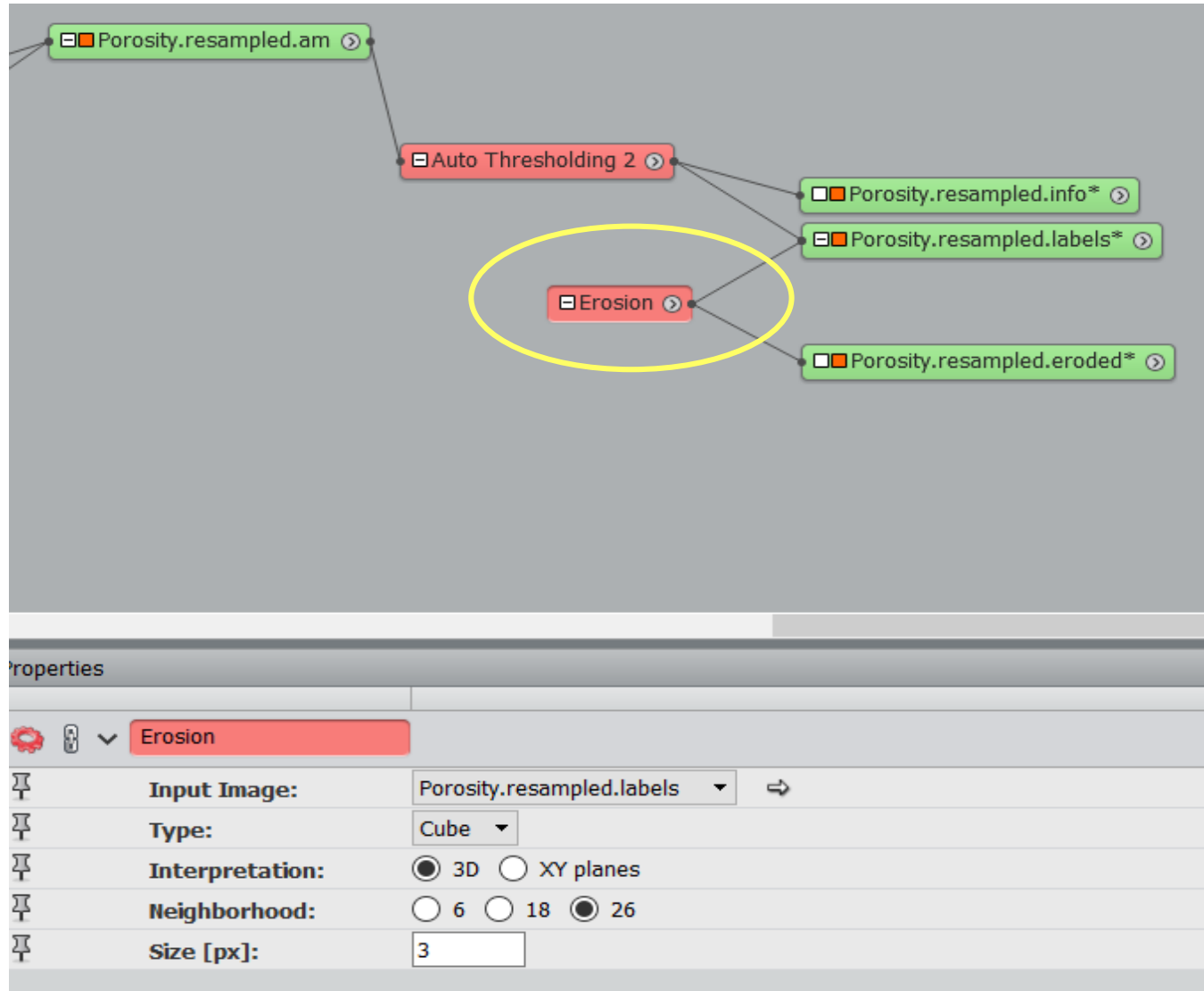
The screenshot displays a software interface for image processing. At the top, a workflow diagram shows a green node labeled 'Porosity.resampled.am' connected to a red node labeled 'Auto Thresholding 2', which is circled in yellow. The 'Auto Thresholding 2' node is further connected to two green nodes: 'Porosity.resampled.info*' and 'Porosity.resampled.labels*'. Below the workflow, a 'Properties' panel for the 'Auto Thresholding 2' node is visible. The properties are as follows:

Property	Value
Input Image:	Porosity.resampled.am
Type:	Auto Threshold High
Interpretation:	<input checked="" type="radio"/> 3D <input type="radio"/> XY planes
Mode:	min-max
Criterion:	factorisation



Apply another Auto Thresholding to obtain total volume in binary (label) image

Step 1B.2 : Erosion



Use Erosion of 3 pixels to shrink volume from the border

Step 1B.3 : Distance Map

The screenshot displays a software interface for image processing. On the left, a workflow diagram shows a sequence of steps: 'Porosity.resampled.am' (green box) leads to 'Auto Thresholding 2' (red box), which then branches into 'Porosity.resampled.info*' (green), 'Porosity.resampled.labels*' (green), and 'Erosion' (red). 'Erosion' leads to 'Porosity.resampled.eroded*' (green), which then branches into 'Distance Map' (red box, circled in yellow) and 'Porosity.resampled.DistField*' (green). Below the workflow, the 'Properties' panel for the 'Distance Map' step is visible, showing settings for Data, Type, Chamfer Weights, and Region.

Distance Map Properties:

- Data:** Porosity.resampled.eroded
- Type:** ☐ Euclid ☒ Chamfer ☐ SingleSeeded
- Chamfer Weights:** ☐ 1-2-3 ☒ 3-4-5 ☐ float
- Region:** Inside

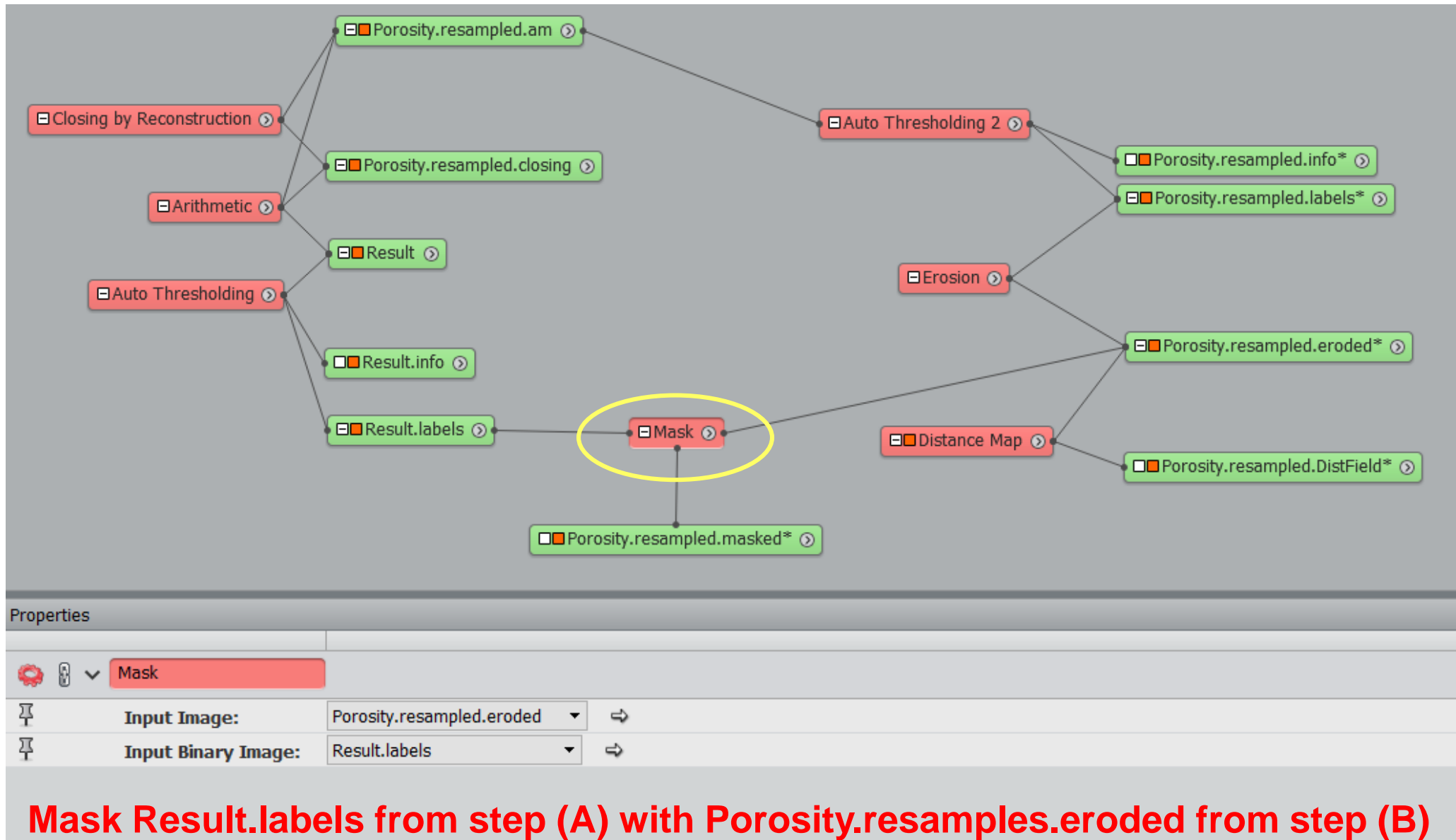
On the right side of the interface, a large visualization shows a grayscale distance map. The map features a bright, circular, radial gradient centered in the middle, fading to black towards the edges, representing the distance field of the selected region.

Apply Distance Map on Porosity.resampled.eroded to generate a distance field

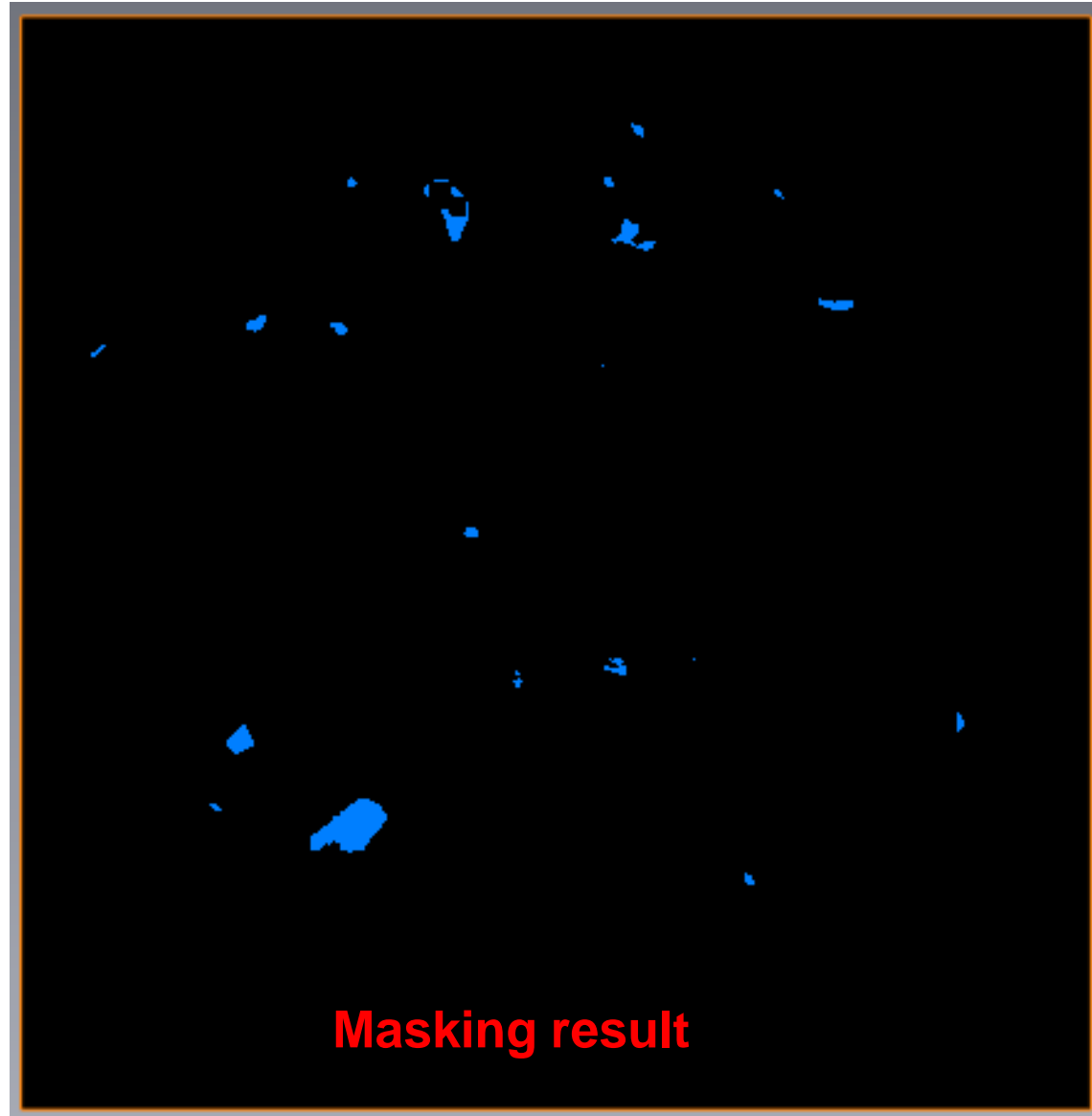
Workflow 1C: Clustering Density



Step 1C.1 : Masking



Step 1C.1 : Masking



Step 1C.2 : Label Analysis

Selection of measure groups

Choose a measure group: NewGroup

Custom measures:

Name	Formula
Slice Fraction	(100 / M

Native measures:

Name	Formula
Mean	Nati
Median	Nati
Minimum	Nati
Stddev	Nati
Volume	Nati
Volume2	Nati

Measures selected in the group:

Name	Formula
Volume3d	Native
BaryCenterX	Native
BaryCenterY	Native
BaryCenterZ	Native
Minimum	Native

OK Cancel Help

Label Analysis

Data: Porosity.resampled.masked

Intensity Image: Porosity.resampled.DistField

Interpretation: ☒ 3D ☐ XY planes

Measures: NewGroup

- Attached Label Analysis with inputs:

Data: Porosity.resampled.Masked

Intensity Image: Porosity.resampled.DistField

- In Measures:, Create a new custom measure - **NewGroup** (1)
containing measures: Volume3d, BaryCenter X, Y, Z and
Minimum (2)

Step 1C.3 : Spreadsheet to Point Cloud

**Covert the table from Label Analysis
into Point Cloud
using Spreadsheet to Point Cloud**

The screenshot displays a software interface with a workflow diagram at the top and a properties panel at the bottom. The workflow diagram shows a red box labeled 'Label Analysis' connected to three green boxes: 'Porosity.resampled.label*', 'Porosity.resampled.Label-Analysis*', and 'Porosity.resampled.Cloud*'. A red box labeled 'Spreadsheet to Point Cloud' is also connected to the 'Porosity.resampled.Label-Analysis*' box and is circled in yellow. The properties panel at the bottom is titled 'Properties' and contains the following settings for the 'Spreadsheet to Point Cloud' node:

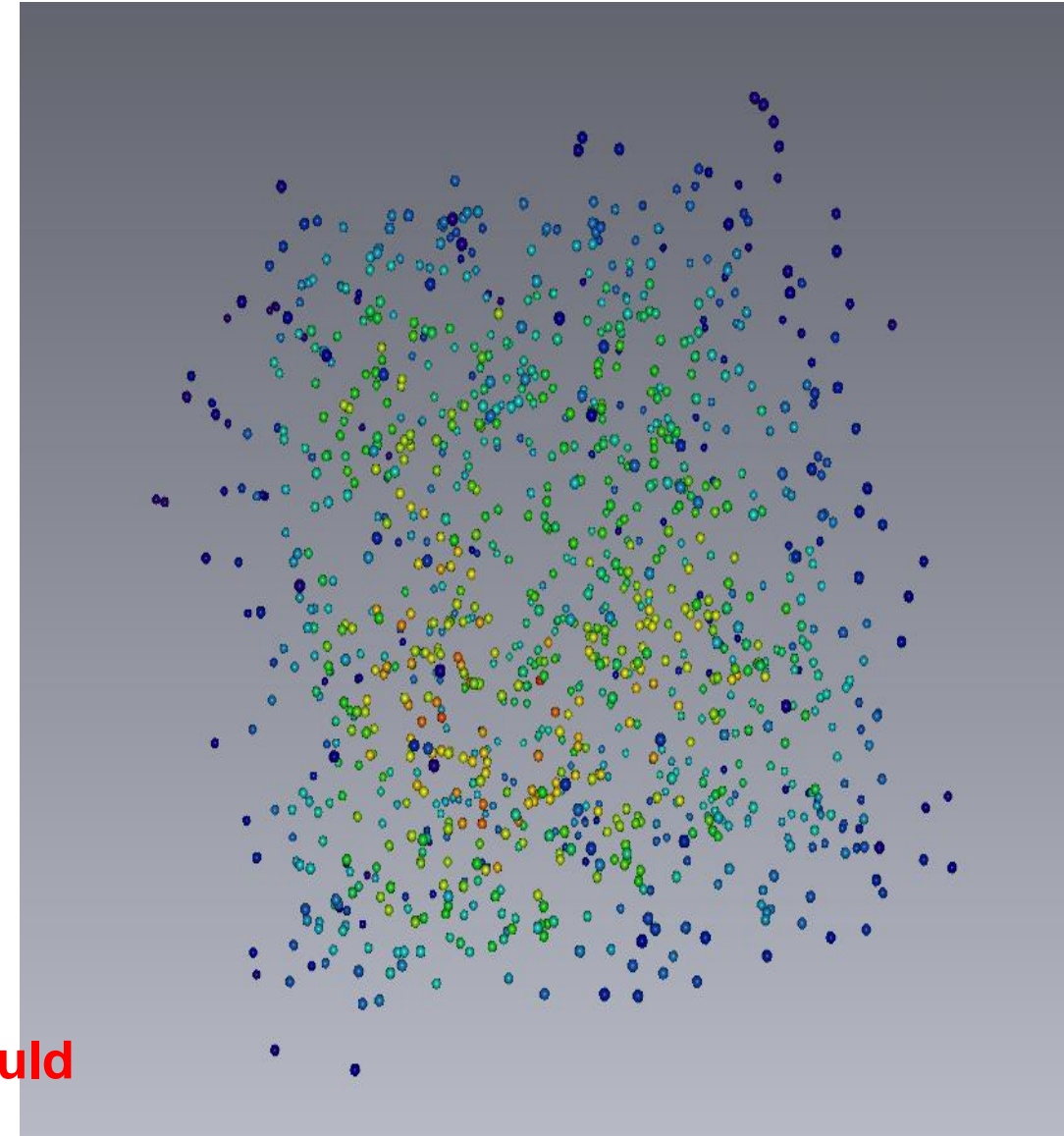
Property	Value
Data:	Porosity.resampled.Label-Analysis
Output:	<input type="checkbox"/> Bounding Boxes <input checked="" type="checkbox"/> Point Cloud
Tensor :	<input checked="" type="radio"/> None <input type="radio"/> Fill Bounding Boxes <input type="radio"/> Distribution
Table:	Porosity.resampled.Label-Analysis
Coordinates:	BaryCenterX BaryCenterY BaryCenterZ

Step 1C.4 : Point Cloud Density

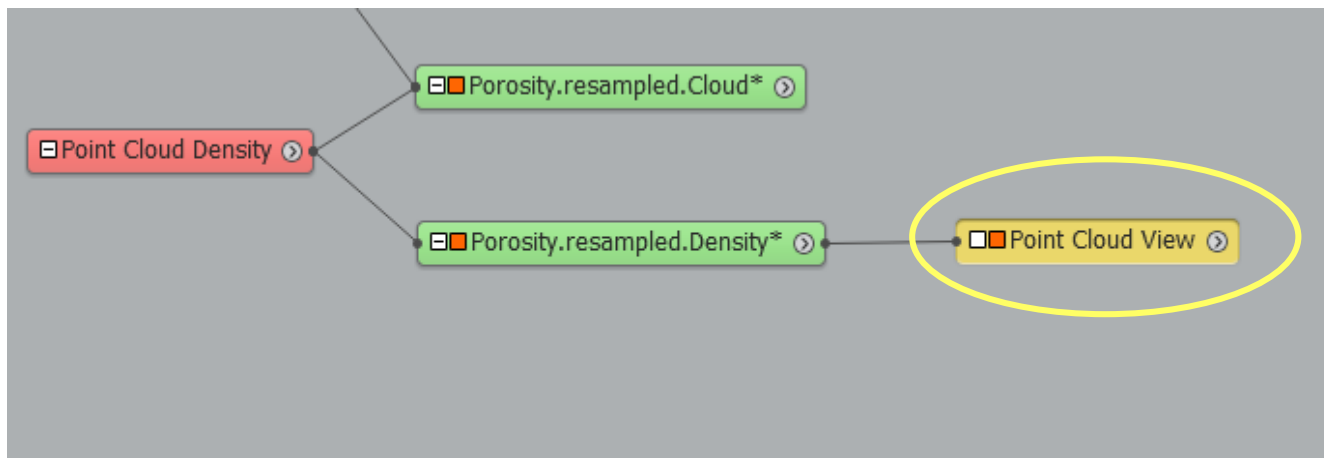
The screenshot displays a software interface with a workflow diagram at the top and a properties panel at the bottom. The workflow diagram shows a sequence of steps: 'Spreadsheet to Point Cloud' (red box), 'Porosity.resampled.Cloud*' (green box), 'Point Cloud Density' (red box, circled in yellow), 'Porosity.resampled.Density*' (green box), and 'Point Cloud View' (yellow box). The 'Point Cloud Density' step is highlighted with a yellow oval. Below the workflow, the 'Properties' panel for 'Point Cloud Density' is visible, showing the following settings:

Point Cloud Density	
Data:	Porosity.resampled.Cloud
Algorithm:	Octree
Radius:	1658.34
Mass:	1.0




Creat Point Cloud Density from Porosity.resampled.Cloud






Step 1C.5 : Point Cloud View




Properties



  **Point Cloud View** 

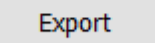
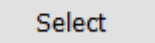
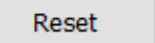
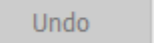
Data: Porosity.resampled.Density 


Colormap: 2.61735e-10  5.02530e-09 


Color: Density [d] 

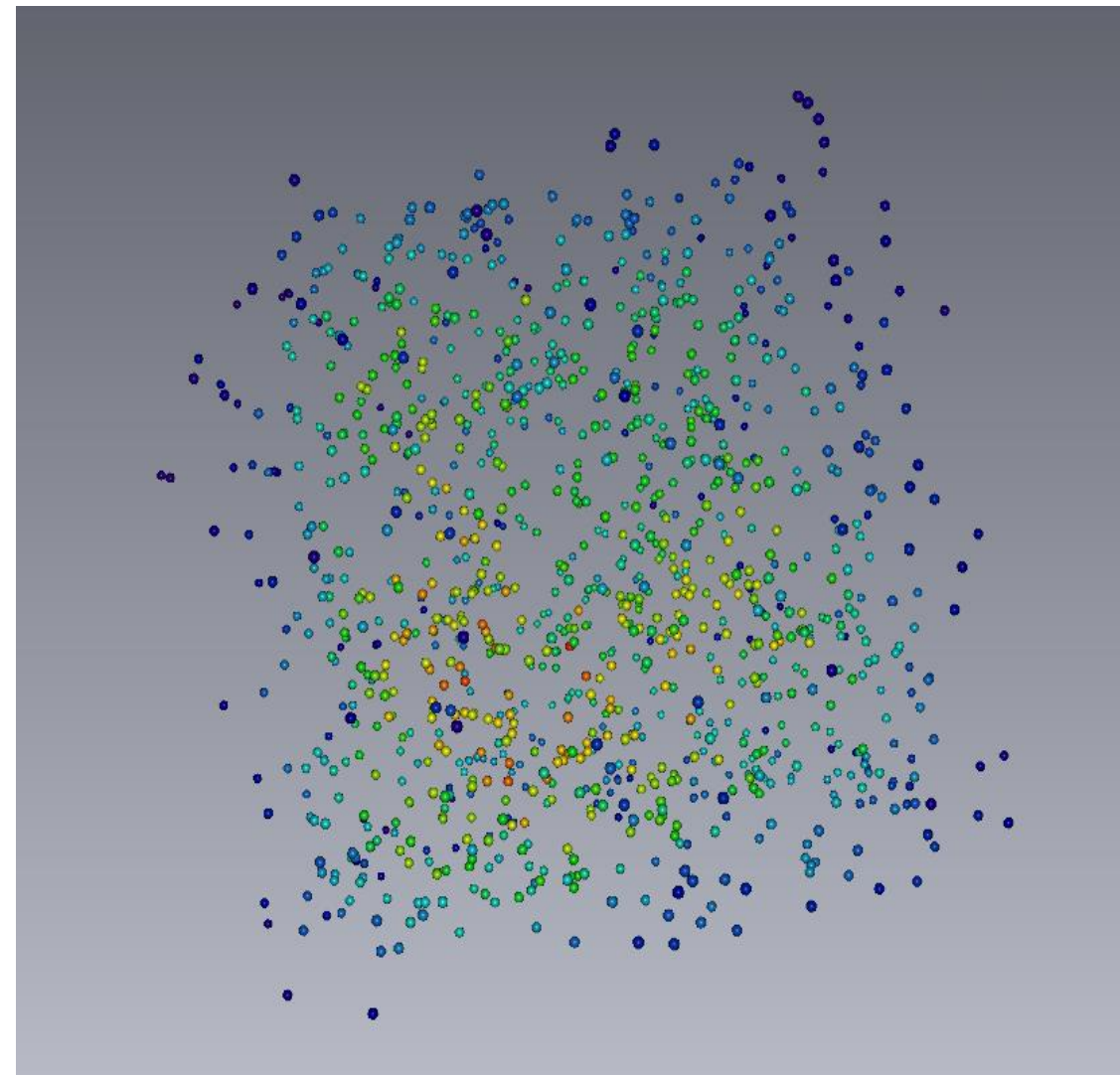
Options: ☒ spheres ☒ opaque ☐ bonds

Sphere Scale:  -0.886525 

Action:    

Filter:  OFF

Scale Spheres:  OFF

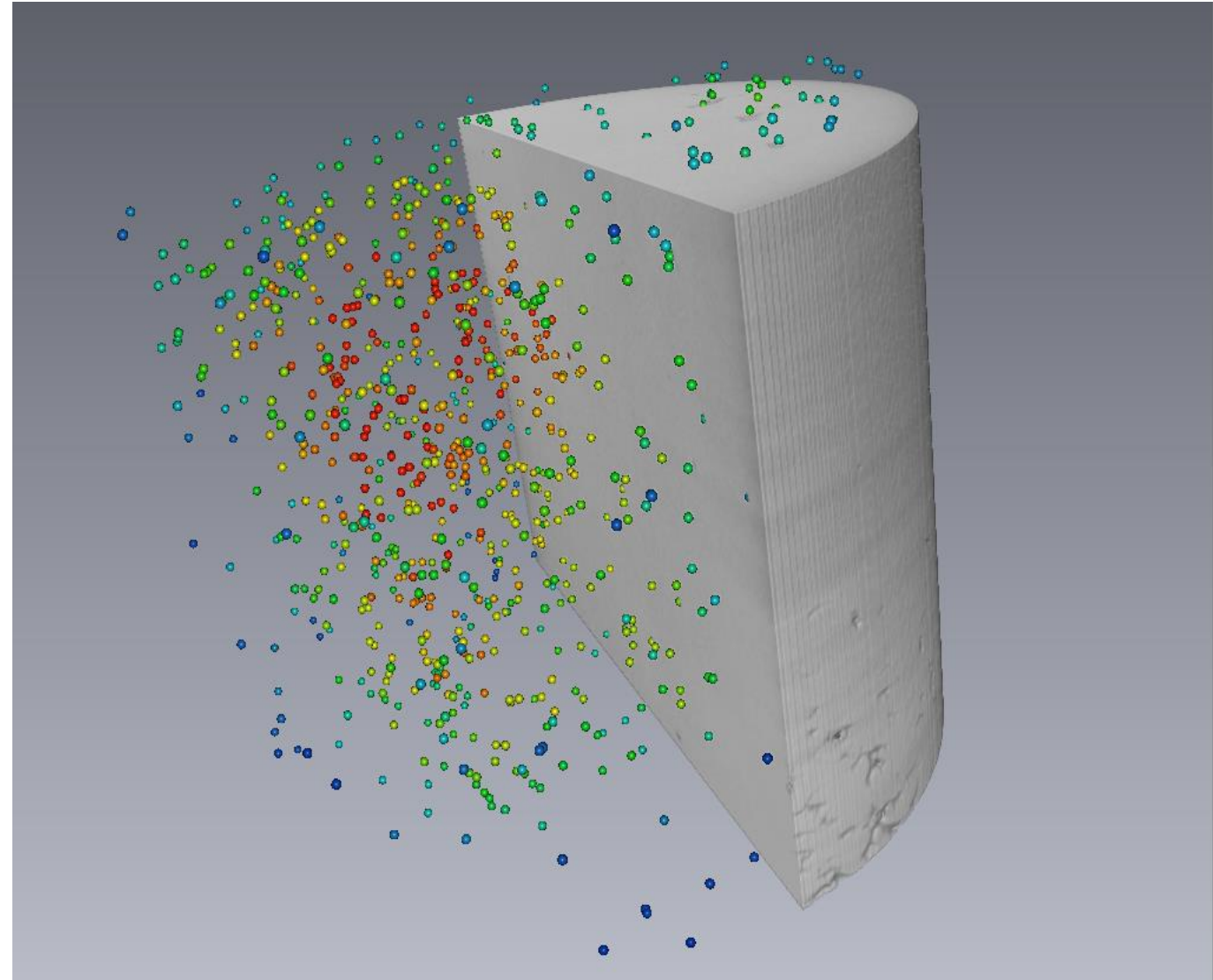
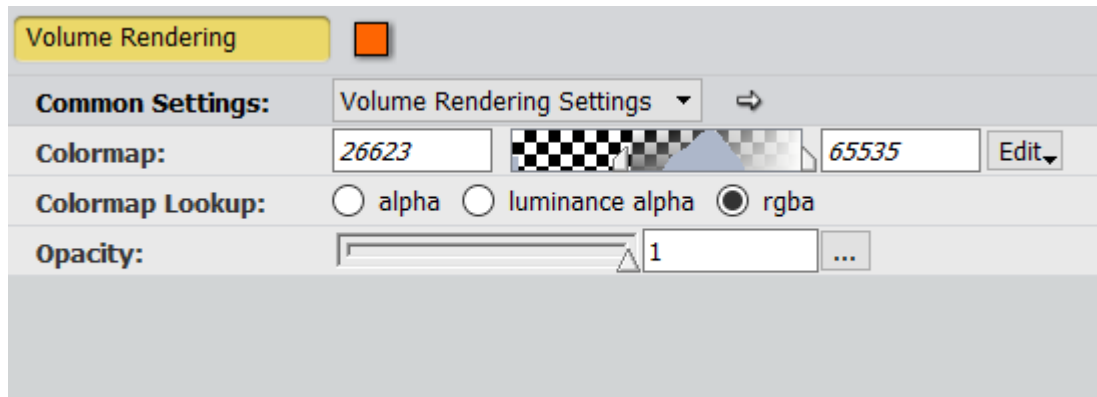
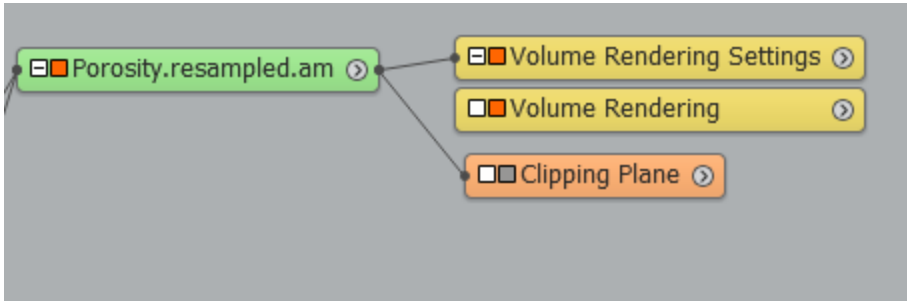


Visualize Point Cloud Density with Point Cloud View

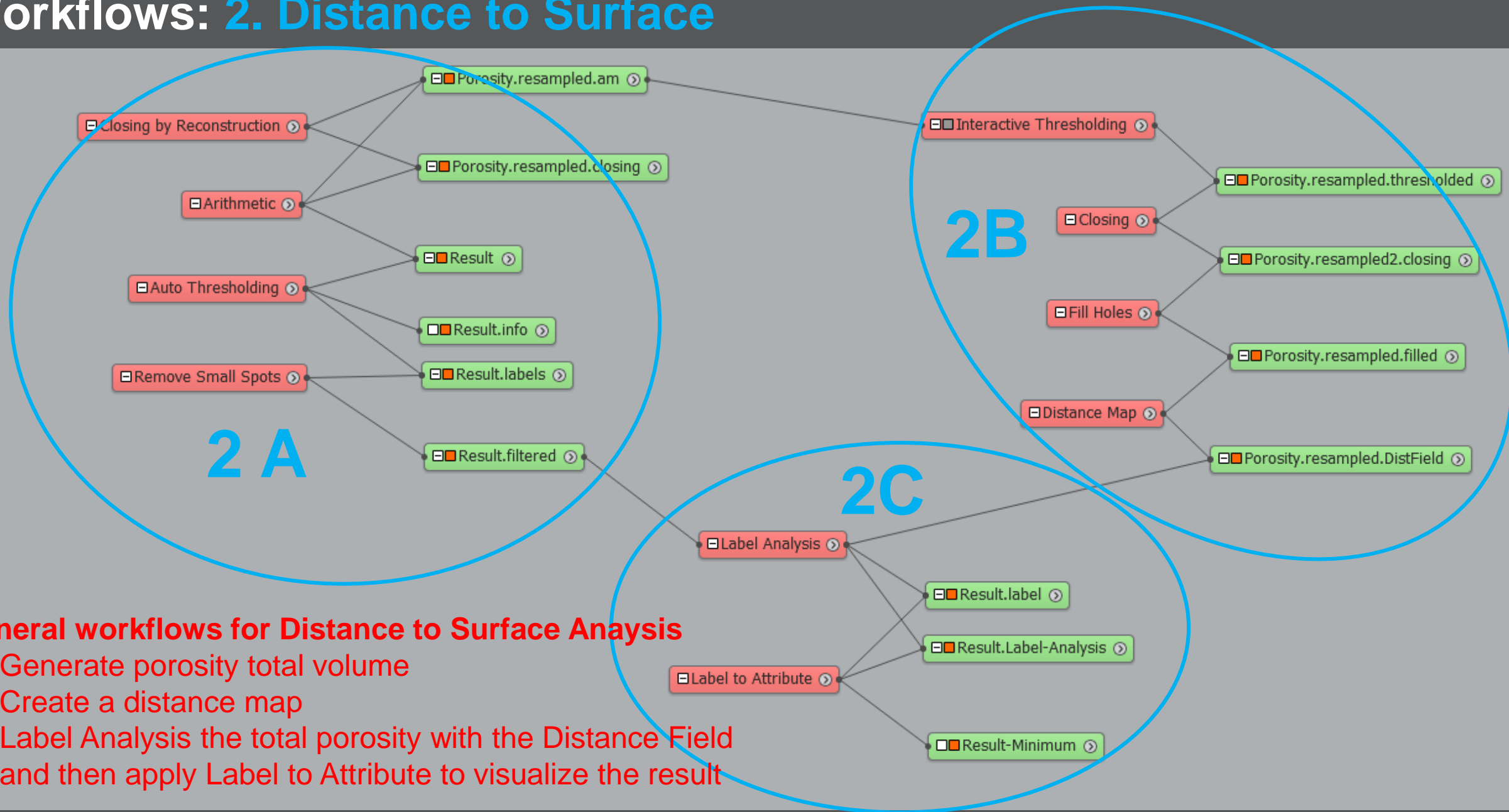
Final Results: 1. Clustering Density

To visualize the cloud results in combination with volume

- Attach Volume Rendering to Porosity.resampled.am
- Set Colormap to VolrenWhite
- Clip the volume using Clipping Plane



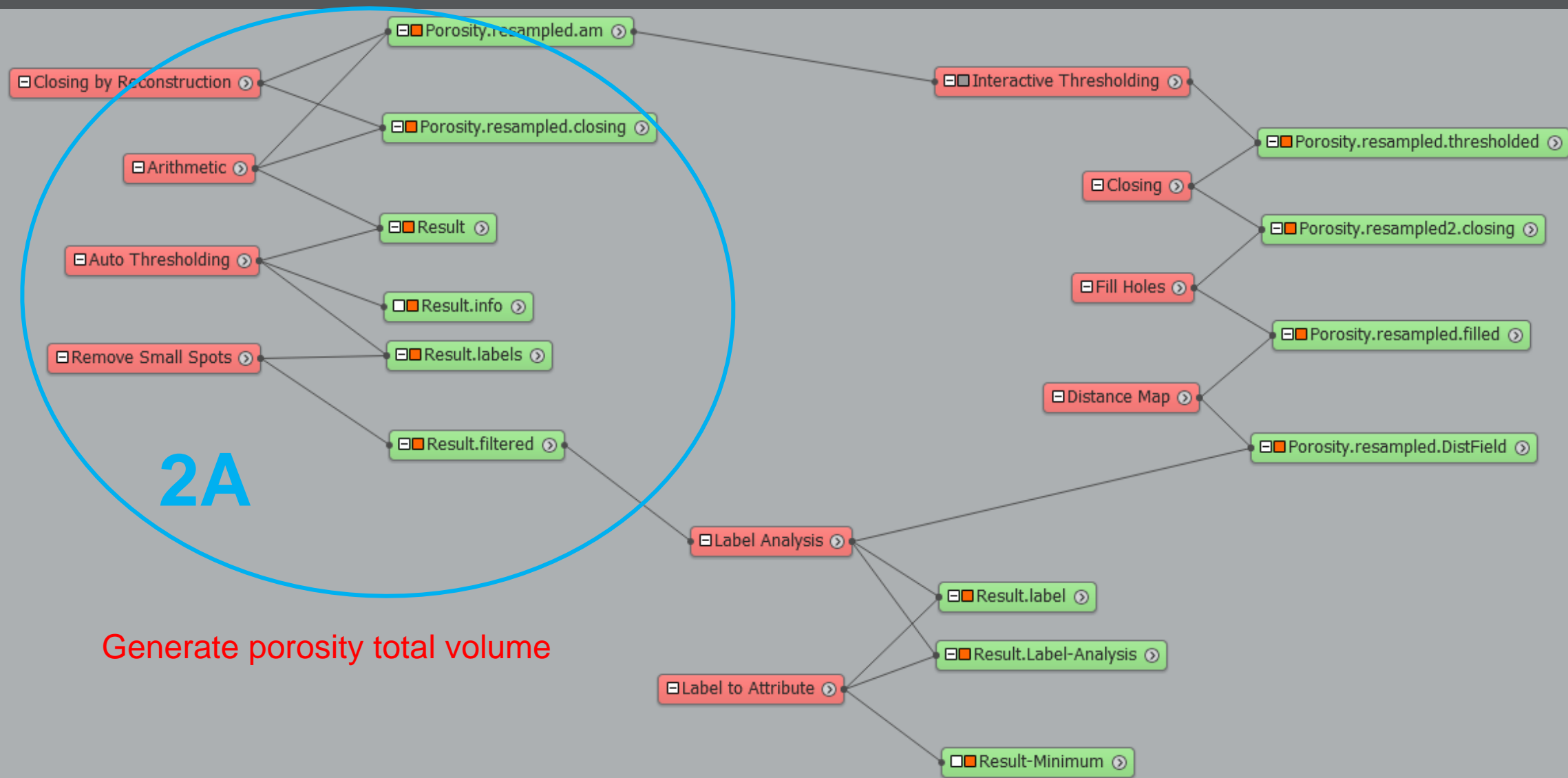
Workflows: 2. Distance to Surface



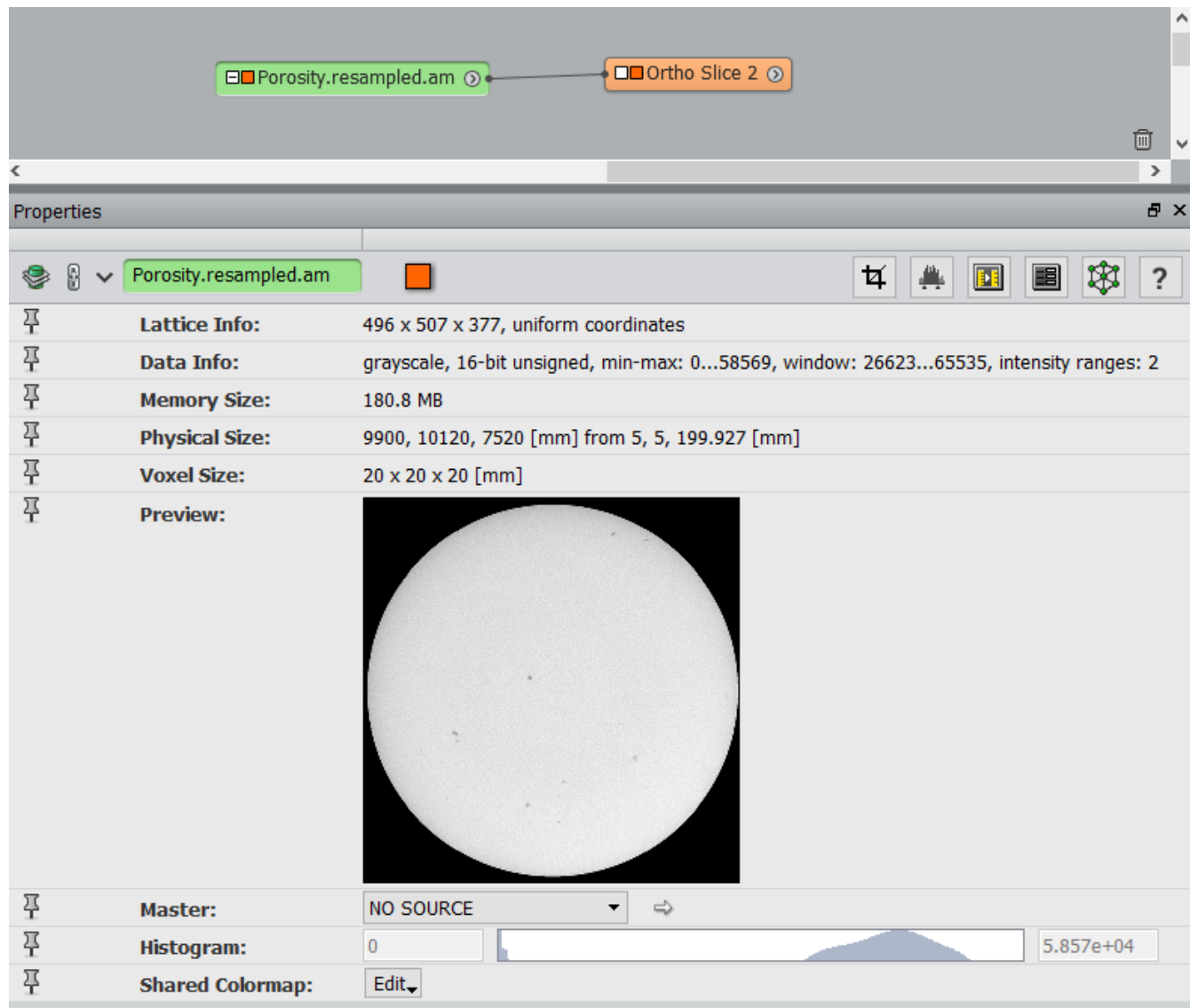
General workflows for Distance to Surface Analysis

- A) Generate porosity total volume
- B) Create a distance map
- C) Label Analysis the total porosity with the Distance Field and then apply Label to Attribute to visualize the result

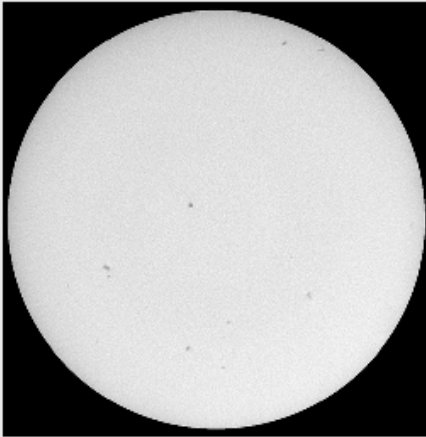
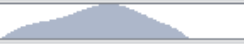
Workflow 2A: Porosity Volume



Step 2A.1 : Load data



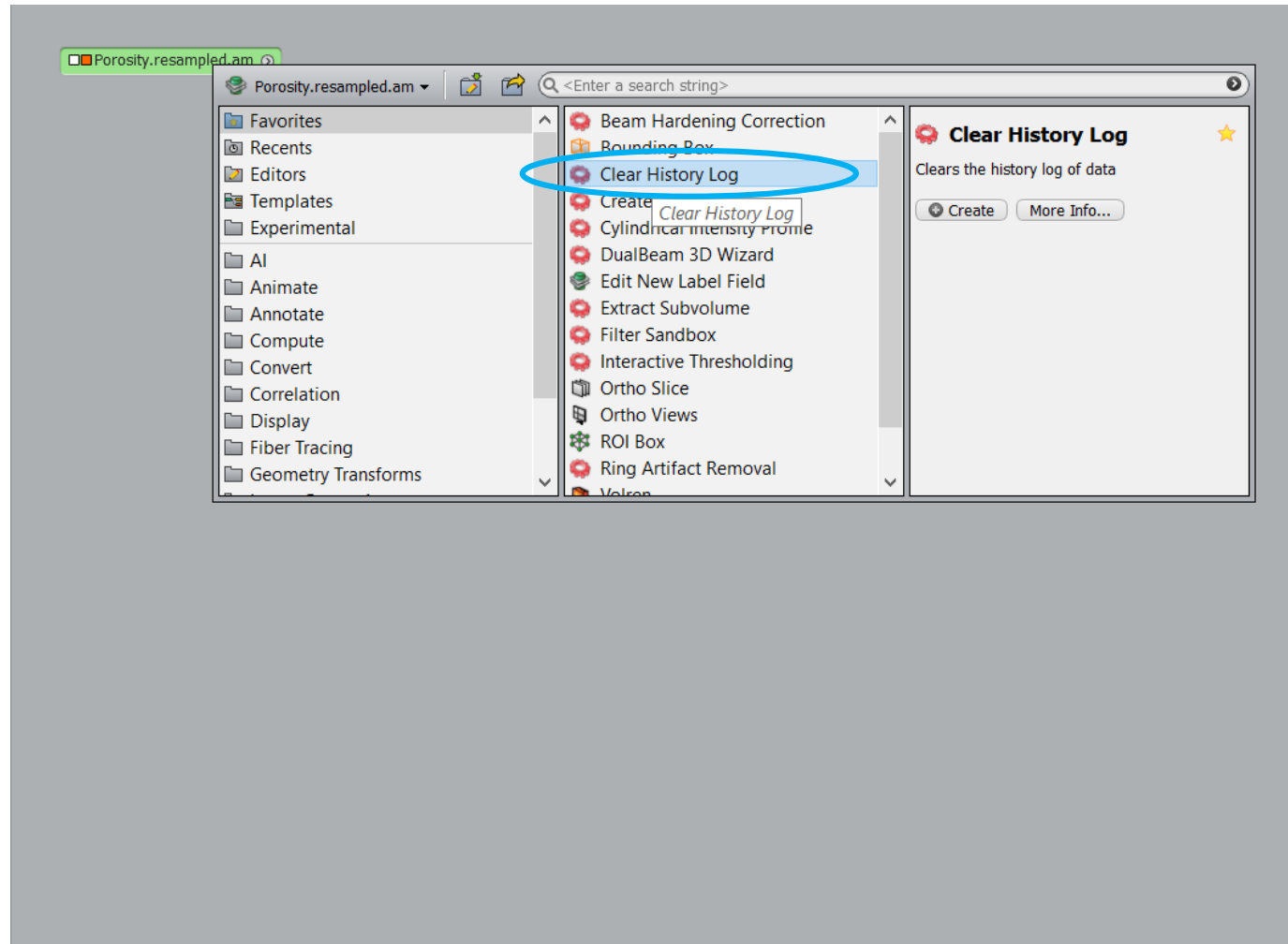
The screenshot shows the 'Properties' panel for a file named 'Porosity.resampled.am'. The panel displays various metadata and a preview image.

Property	Value
Lattice Info:	496 x 507 x 377, uniform coordinates
Data Info:	grayscale, 16-bit unsigned, min-max: 0...58569, window: 26623...65535, intensity ranges: 2
Memory Size:	180.8 MB
Physical Size:	9900, 10120, 7520 [mm] from 5, 5, 199.927 [mm]
Voxel Size:	20 x 20 x 20 [mm]
Preview:	
Master:	NO SOURCE
Histogram:	0  5.857e+04
Shared Colormap:	Edit

- Resample image size if needed
- Attach Ortho Slice to visualize

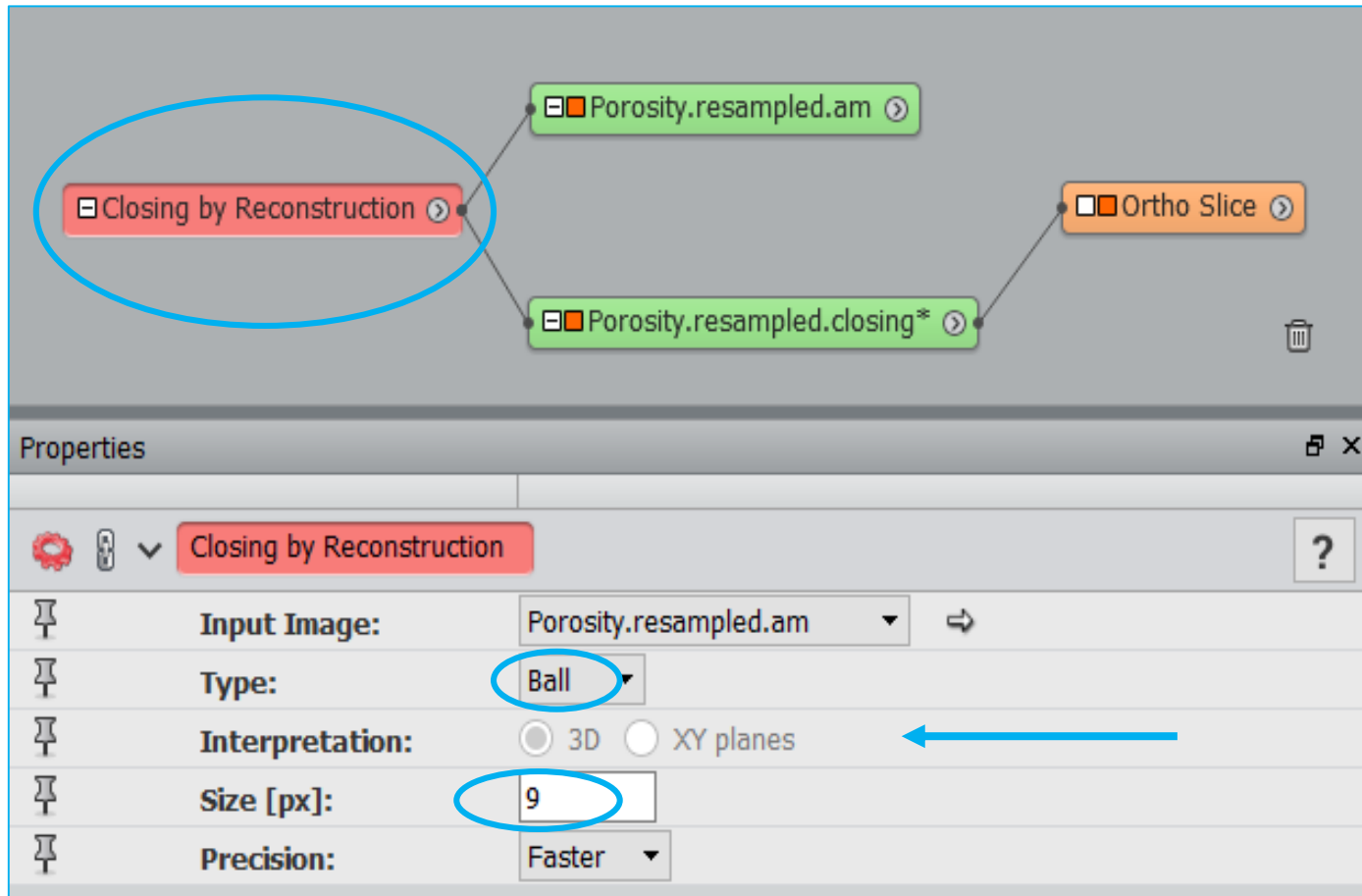


Step 2A.2 : Clear History Log



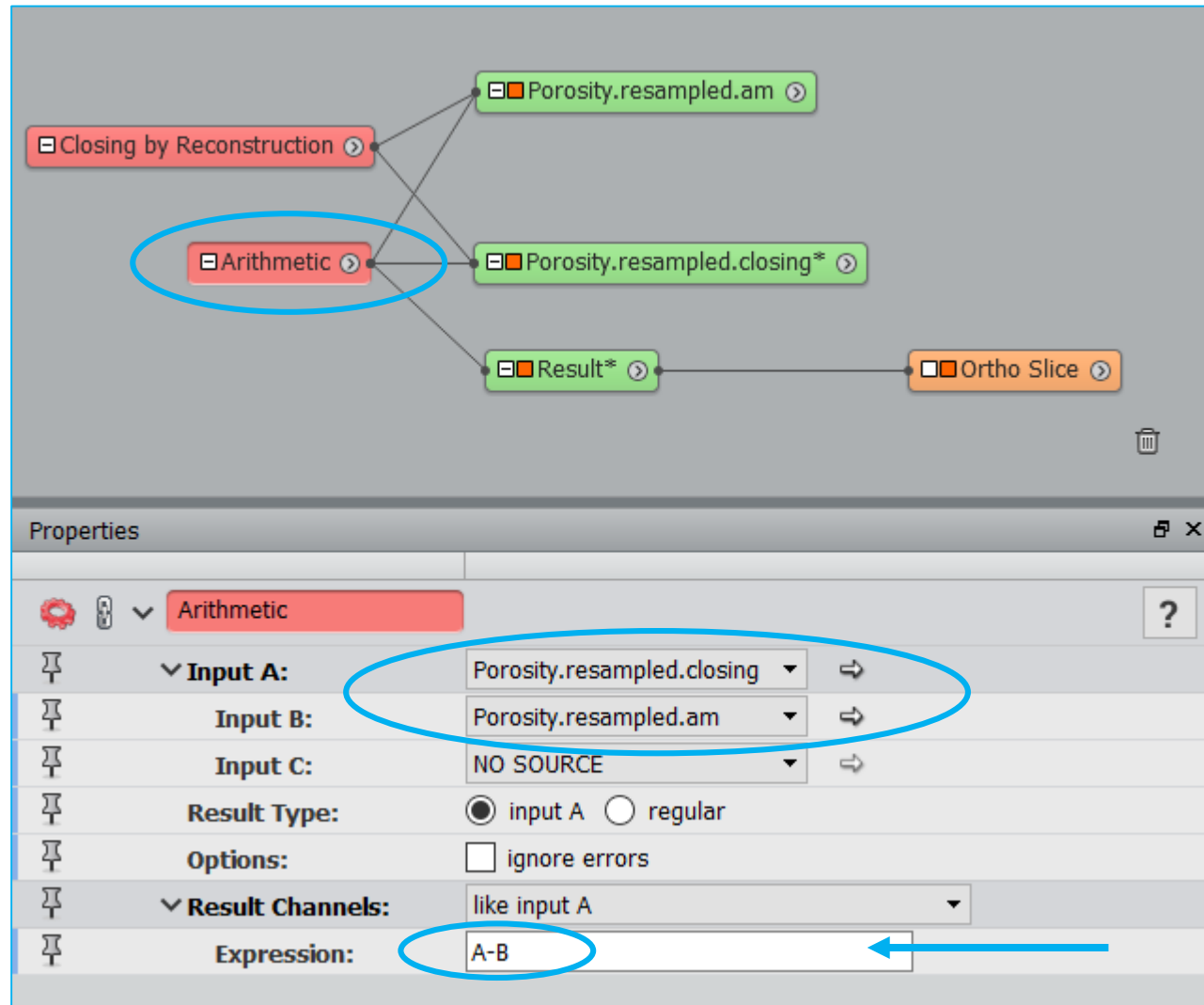
Clear History Log for creating Recipe (Optional)

Step 2A.3 : Closing by Reconstruction



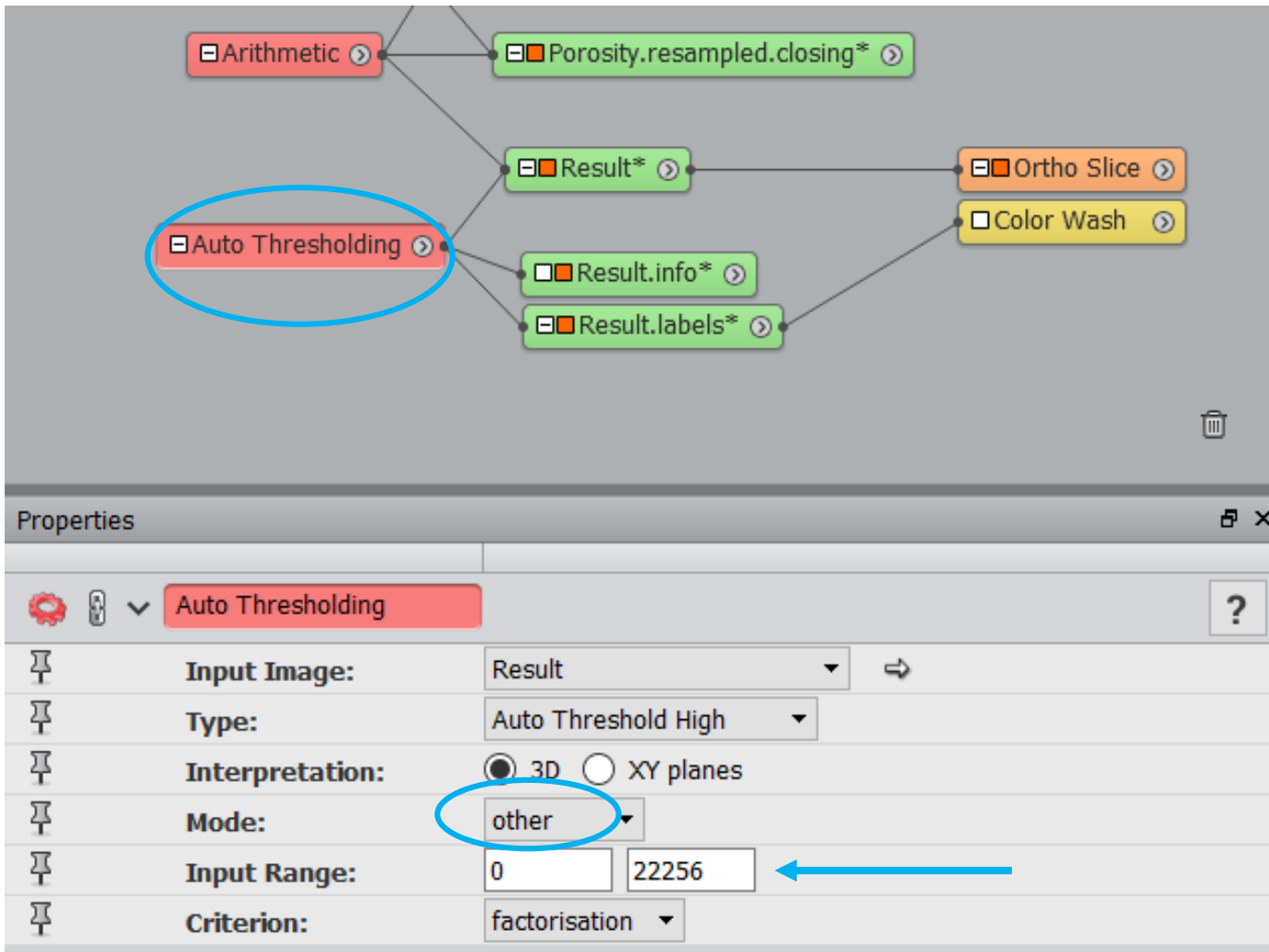
Apply Closing by Reconstruction to Porosity.resampled.am to create background image

Step 2A.4 : Arithmetic



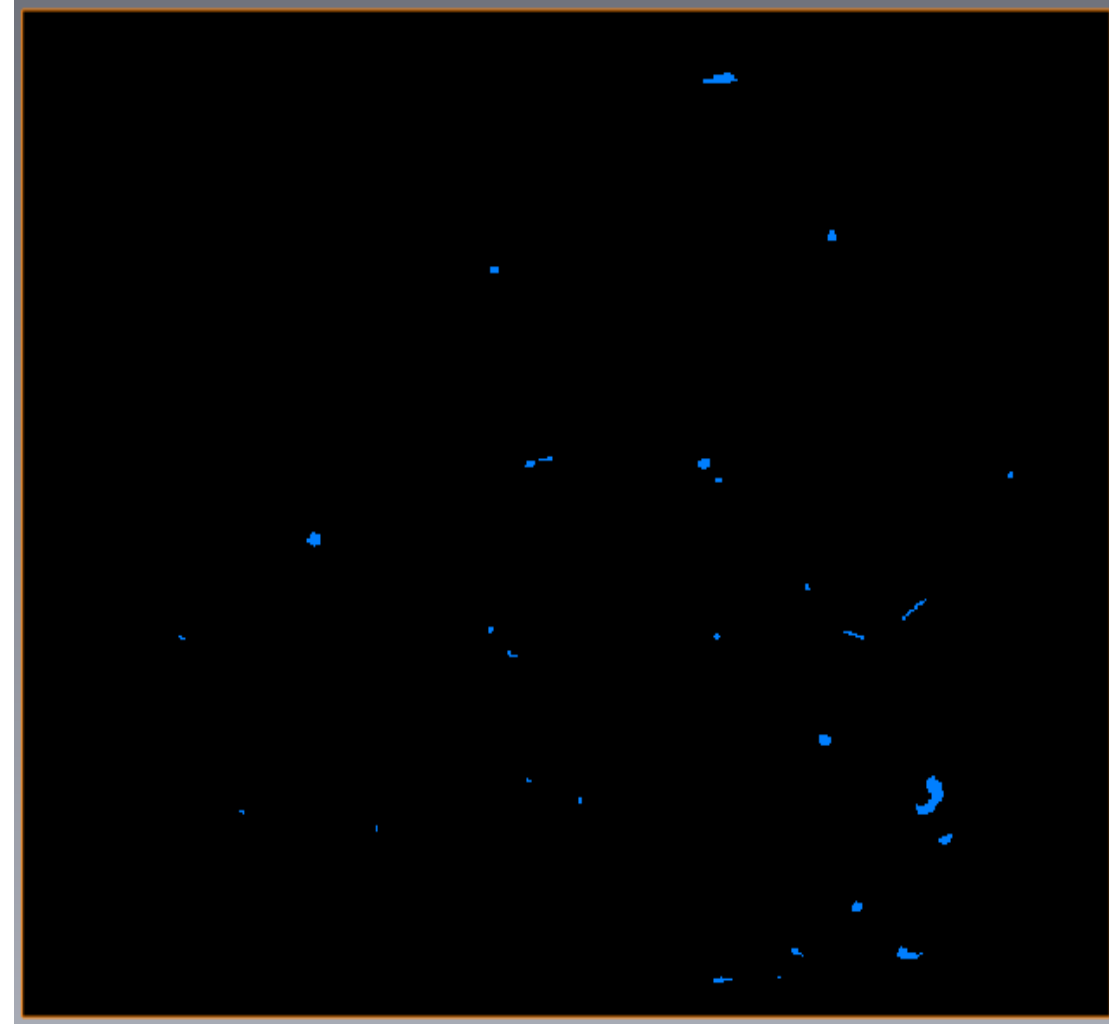
Use Arithmetic to subtract Porosity intensity from the background

Step 2A.5 : Auto Thresholding



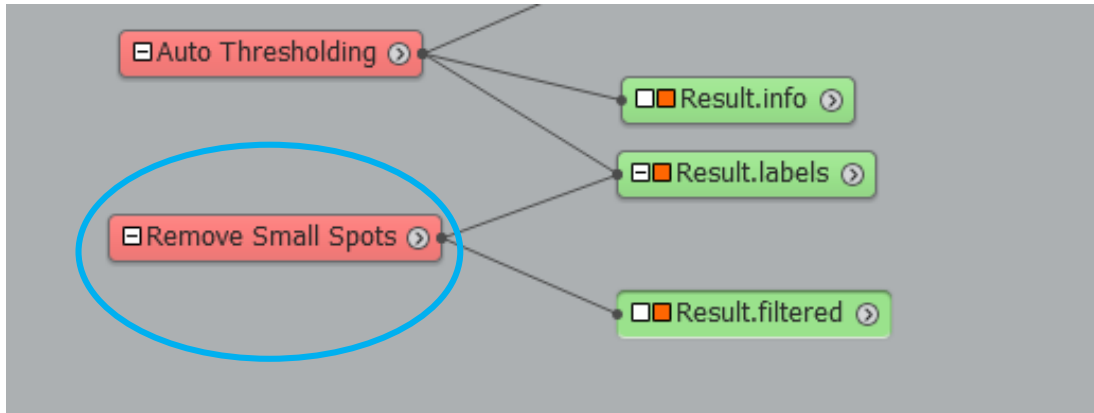
The screenshot displays a workflow graph and the 'Auto Thresholding' node's properties. In the workflow, the 'Auto Thresholding' node is highlighted with a blue circle. It receives input from 'Arithmetic' and 'Porosity.resampled.closing*'. Its outputs are 'Result*', 'Result.info*', and 'Result.labels*', which then feed into 'Ortho Slice' and 'Color Wash'. The 'Properties' panel for 'Auto Thresholding' is shown below, with the 'Mode' dropdown set to 'other' and the 'Input Range' set to 0 to 22256, indicated by a blue arrow.

Auto Thresholding		
Input Image:	Result	
Type:	Auto Threshold High	
Interpretation:	<input checked="" type="radio"/> 3D <input type="radio"/> XY planes	
Mode:	other	
Input Range:	0 22256	
Criterion:	factorisation	



Adjust Input Range in Auto Thresholding to create a binary image of the porosity

Step 2A.6 : Remove Small Spots



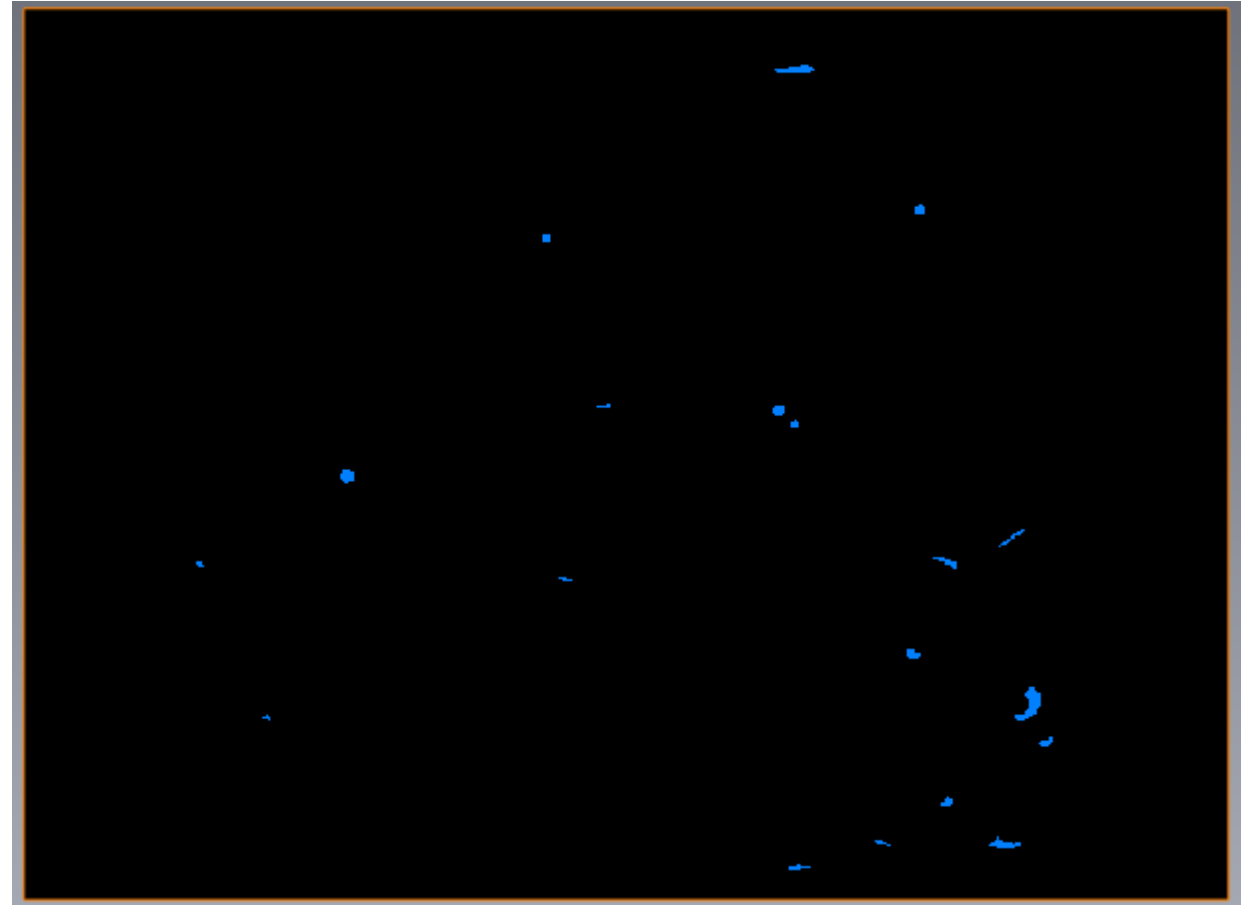
Properties

Remove Small Spots

Input Image: Result.labels

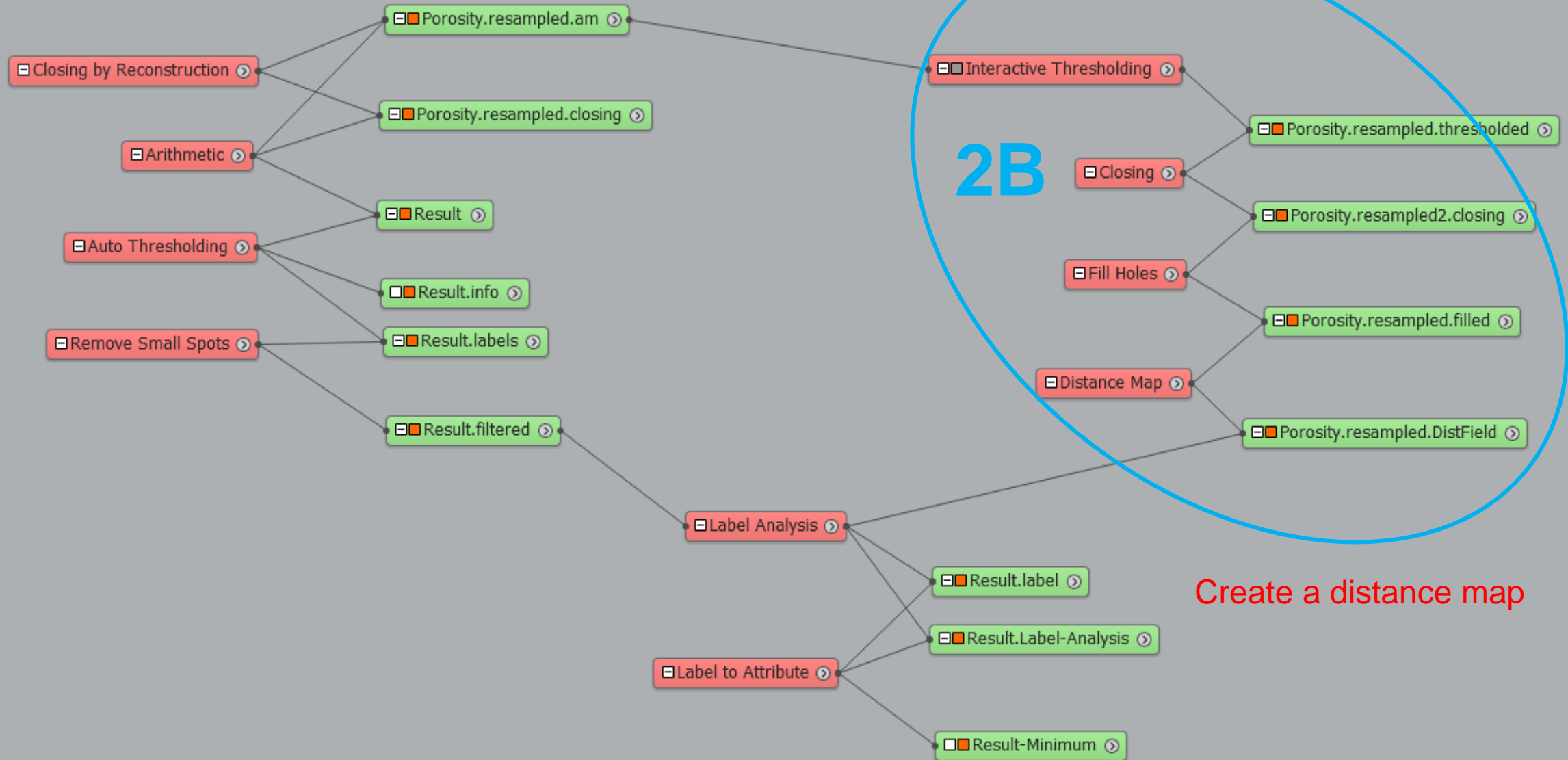
Interpretation: ☒ 3D ☐ XY planes

Size [px]: 25

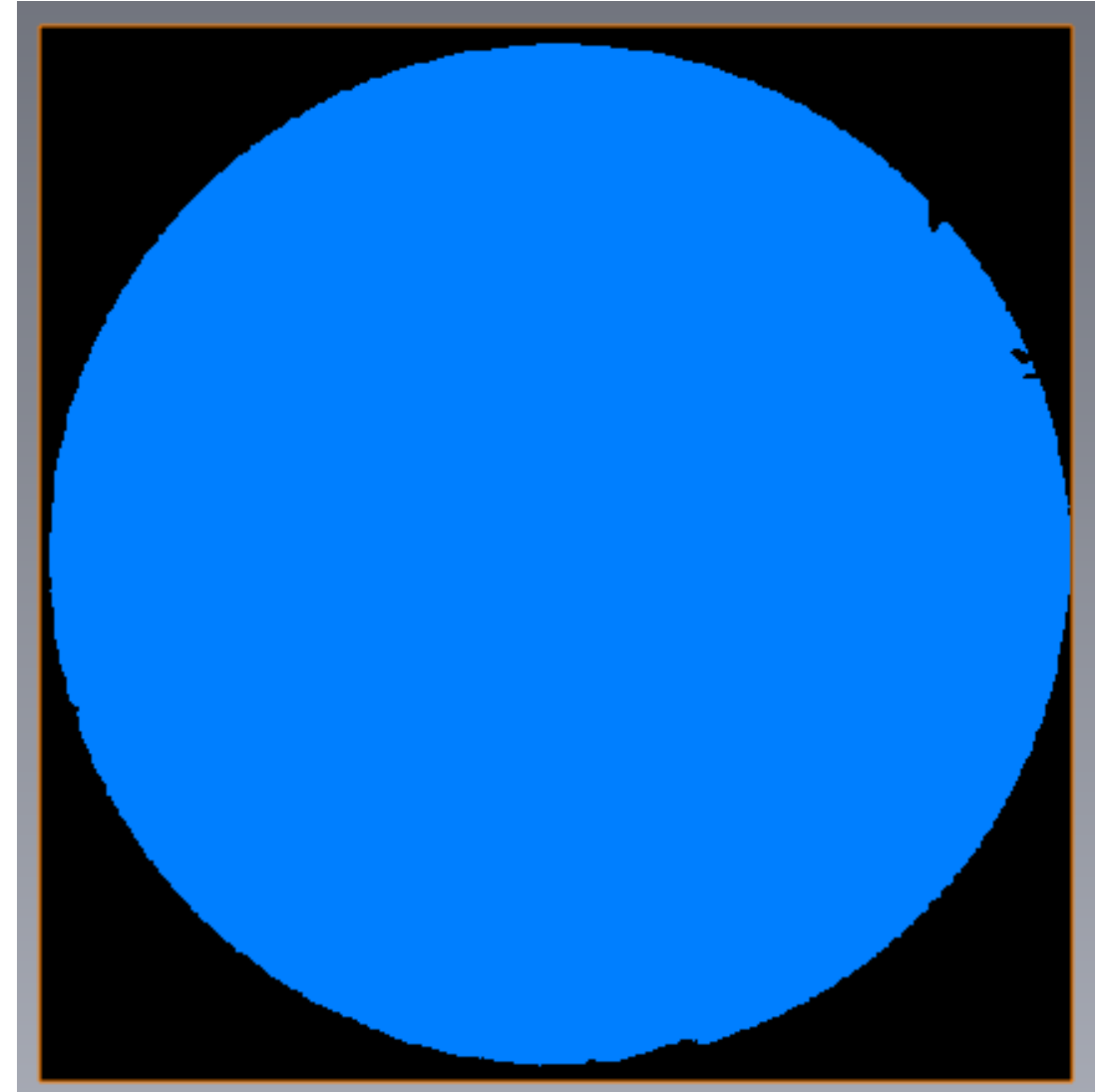
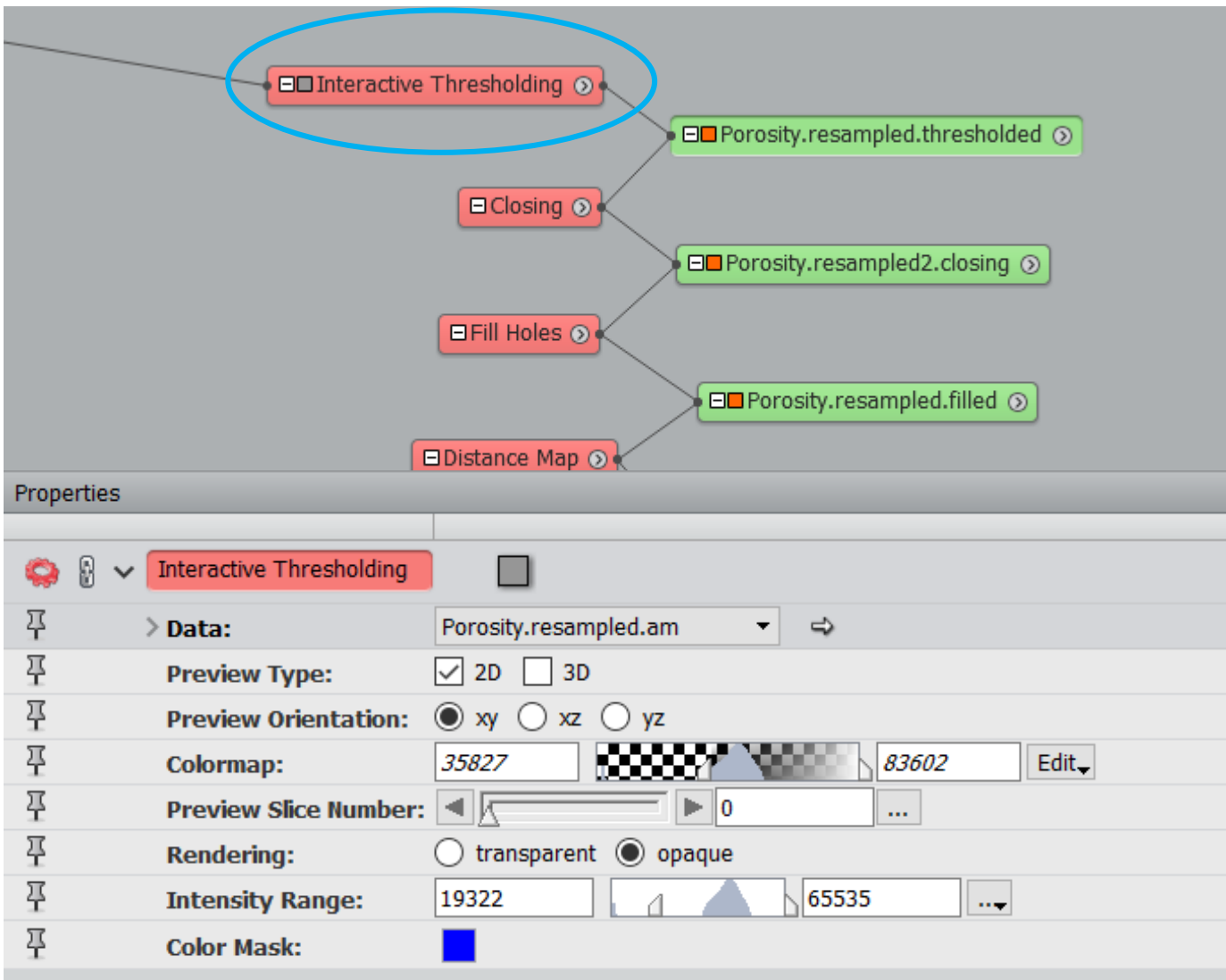


Remove Small Spots (Pixel size = 25)

Workflow 2B: Create Distance Map

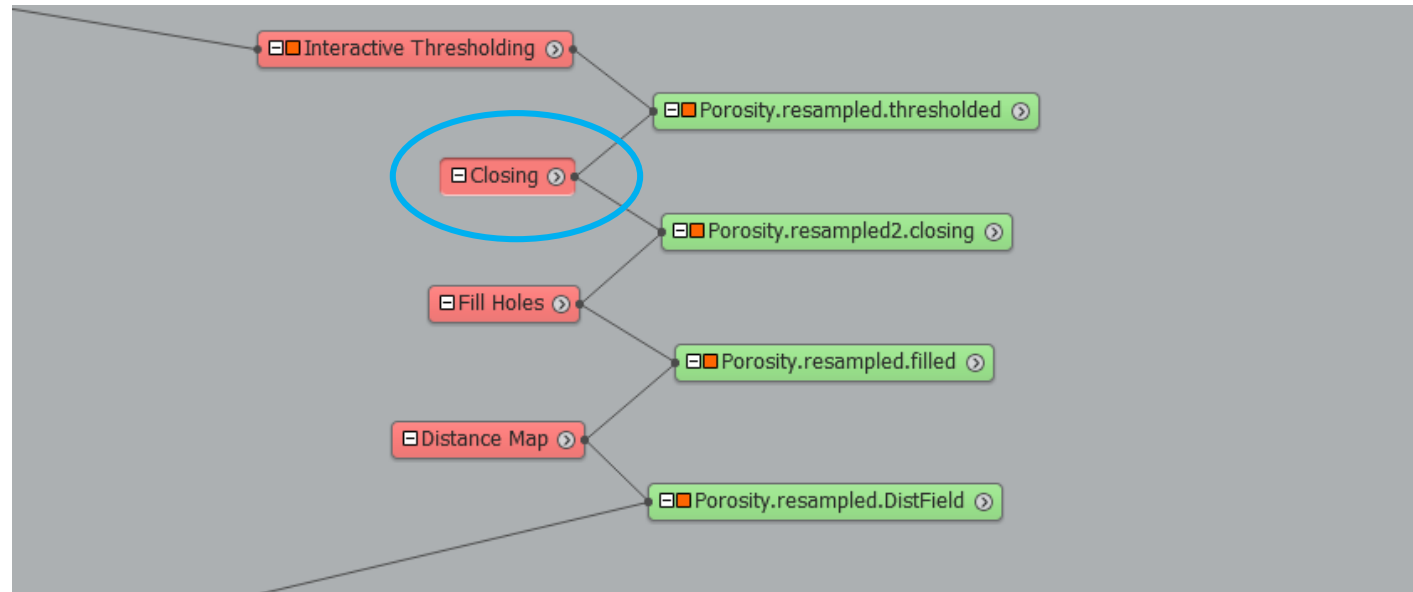


Step 2B.1 : Interactive Thresholding



Apply Interactive Thresholding to obtain total volume in binary image

Step 2B.2 : Closing



properties

Closing

Input Image: Porosity.resampled.thresholded

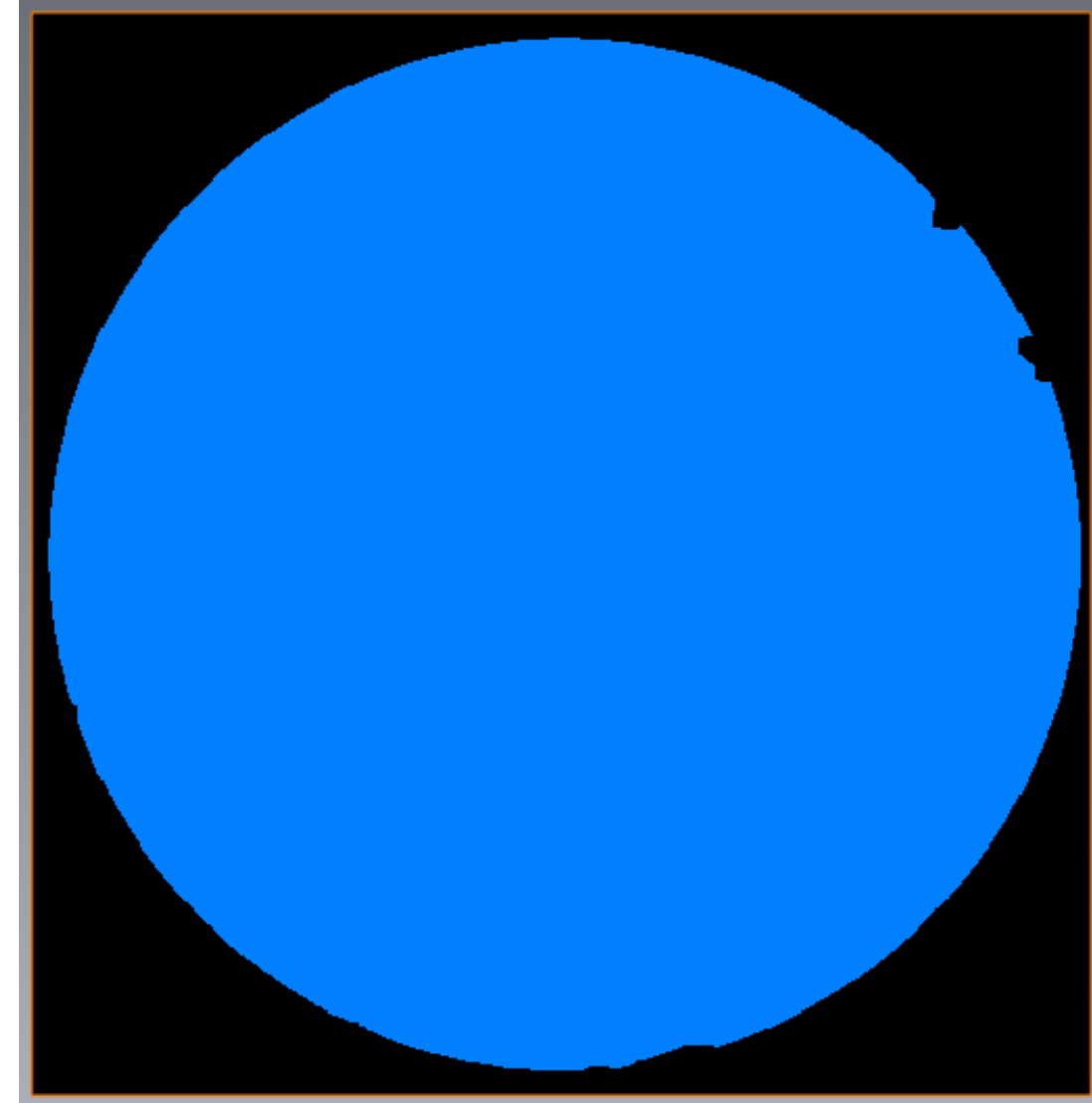
Type: Cube

Interpretation: ☒ 3D ☐ XY planes

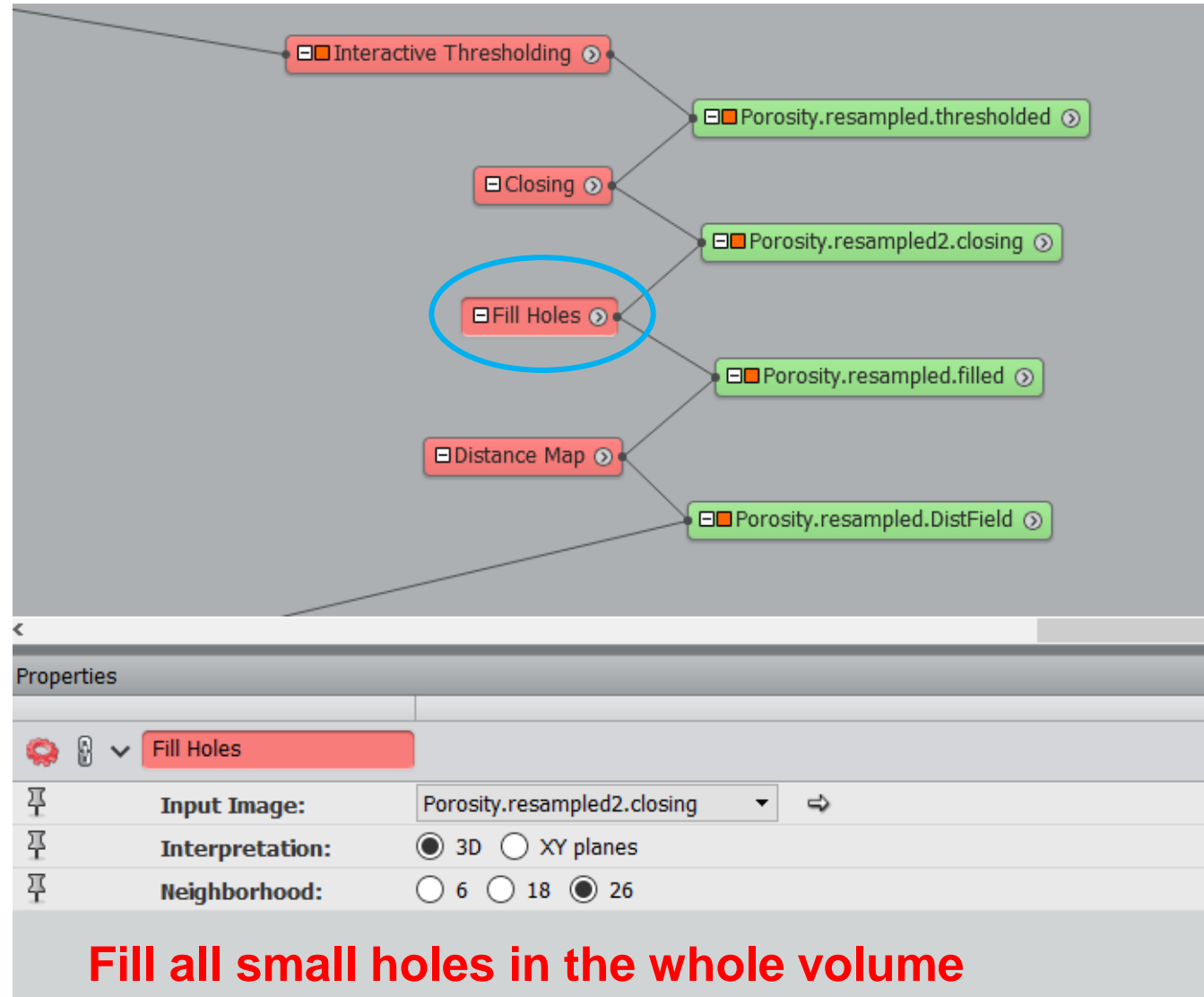
Neighborhood: ☐ 6 ☐ 18 ☒ 26

Size [px]: 3

Closing (Size = 3 Pixels) to Close all small hole volumes



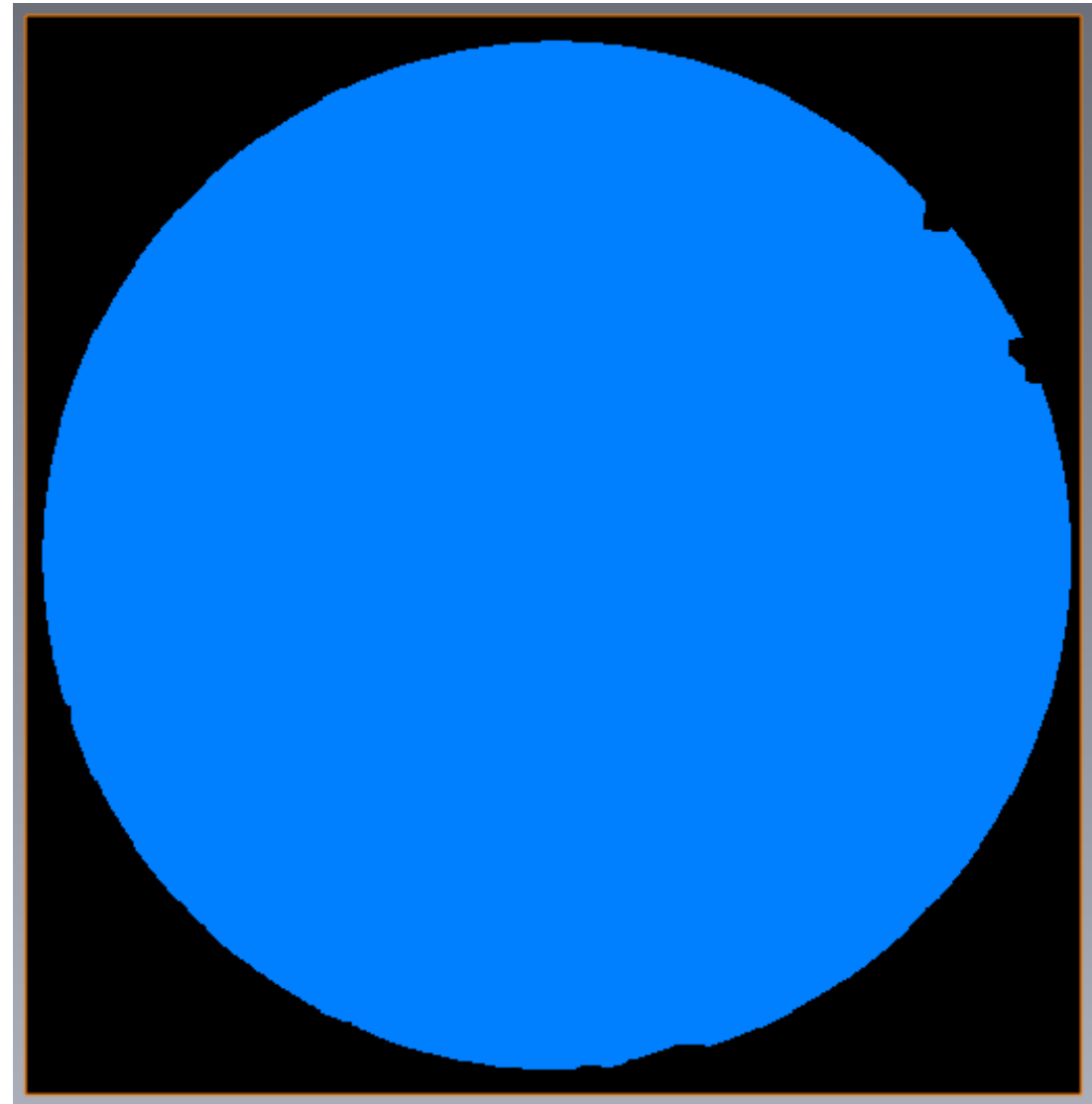
Step 2B.3 : Fill Holes



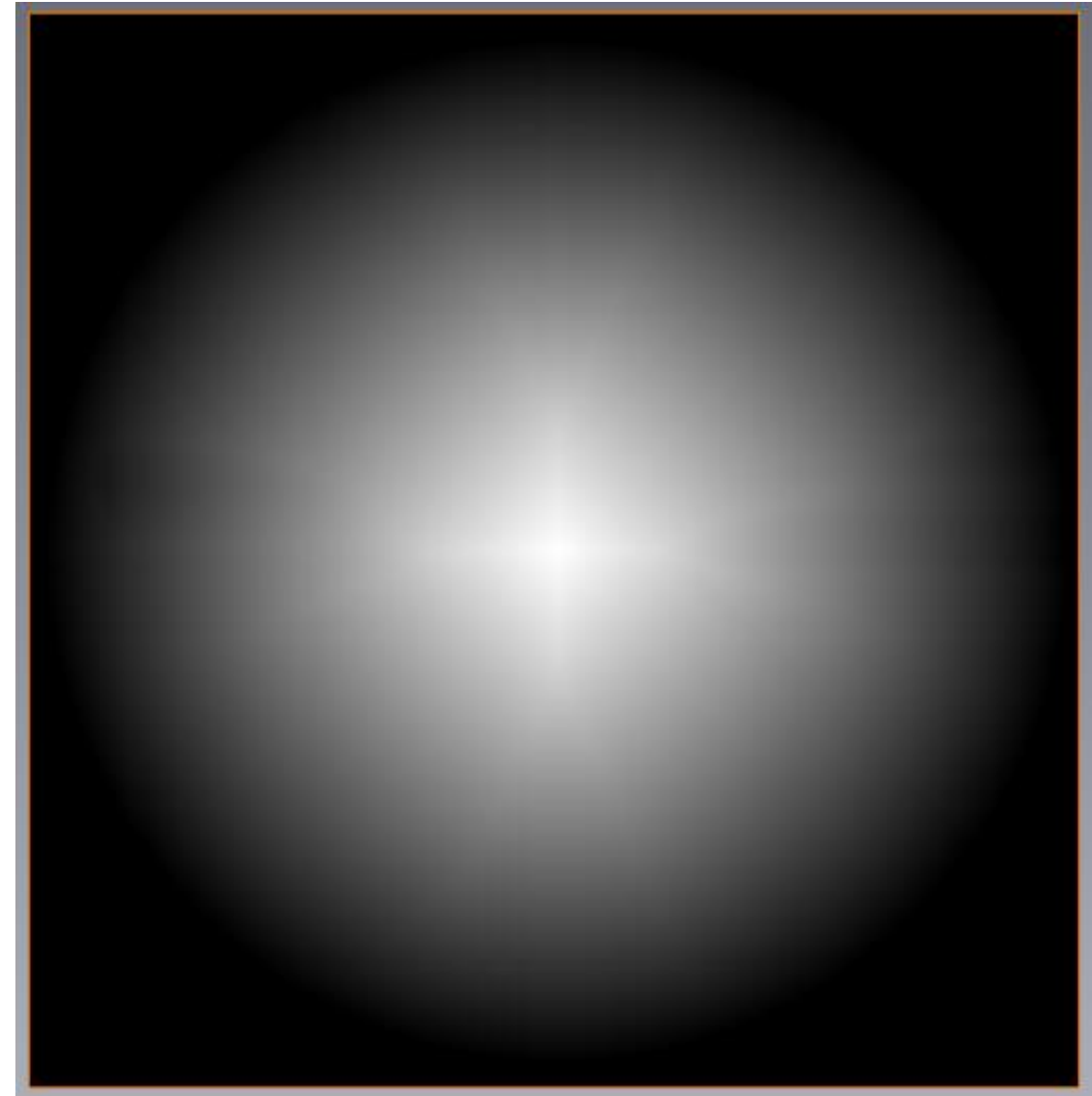
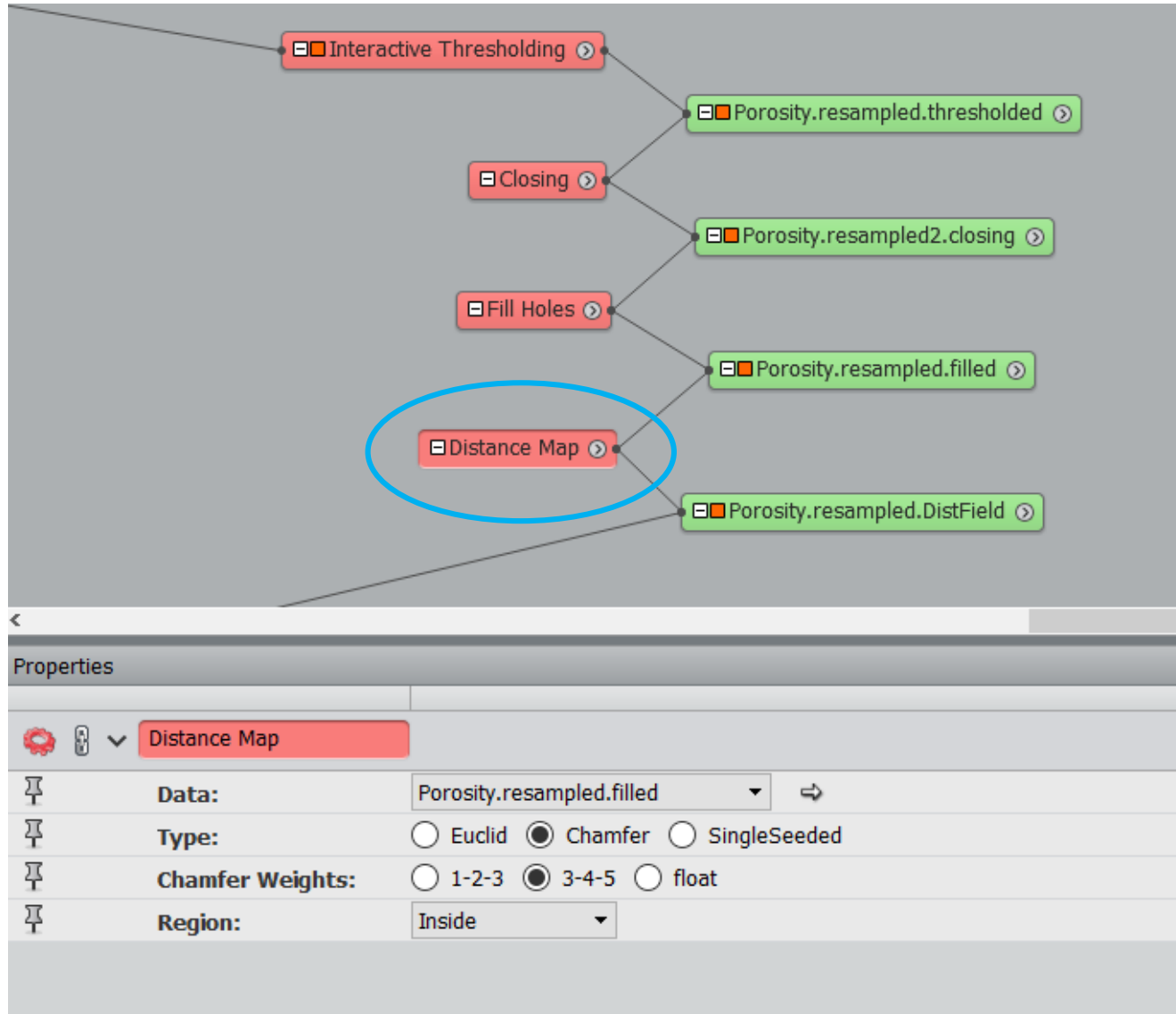
The screenshot displays a workflow diagram with several steps: 'Interactive Thresholding', 'Closing', 'Fill Holes' (highlighted with a blue circle), and 'Distance Map'. Each step has a corresponding output node: 'Porosity.resampled.thresholded', 'Porosity.resampled2.closing', 'Porosity.resampled.filled', and 'Porosity.resampled.DistField'. Below the workflow, the 'Properties' panel for the 'Fill Holes' step is visible, showing the following settings:

- Input Image:** Porosity.resampled2.closing
- Interpretation:** 3D (selected), XY planes
- Neighborhood:** 6, 18, 26 (selected)

Fill all small holes in the whole volume

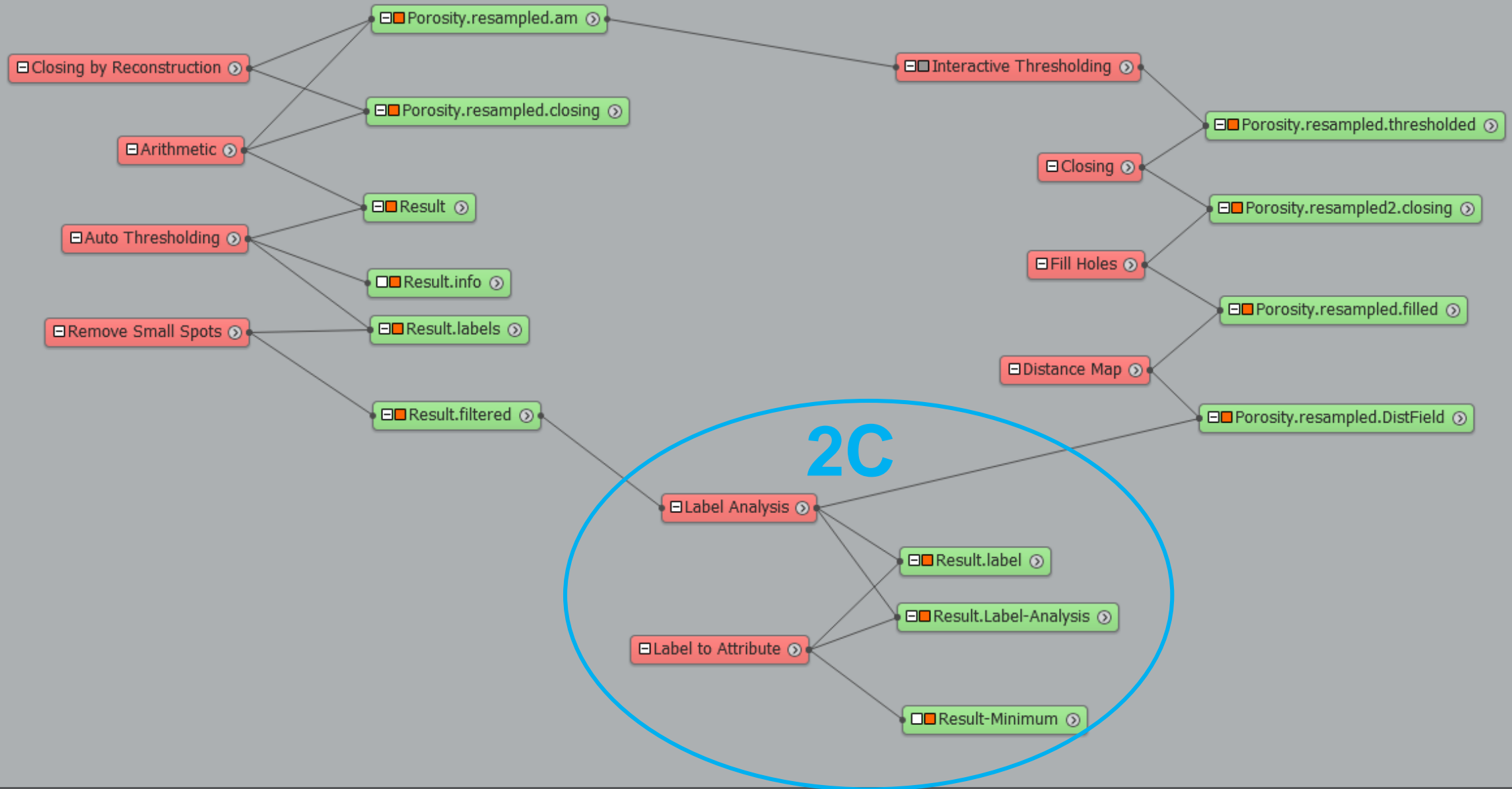


Step 2B.4 : Distance Map



Apply Distance Map on Porosity.resampled.filled to generate a distance field

Workflows 2C: Label Analysis



Step 2C.1 : Label Analysis

Selection of measure groups

Choose a measure group: **Distance**

Custom measures:

Name	Formula
Slice Fraction	(100/ Maximum)

Native measures:

Name	Formula
Median	Native
Minimum	Native
Stddev	Native
Volume	Native
Volume2	Native
Intercent	

Measures selected in the group:

Name	Formula
Minimum	Native

Properties

Label Analysis

Data: Result.filtered

Intensity Image: Porosity.resampled.DistField

Interpretation: ☒ 3D ☐ XY planes

Measures: **Distance**

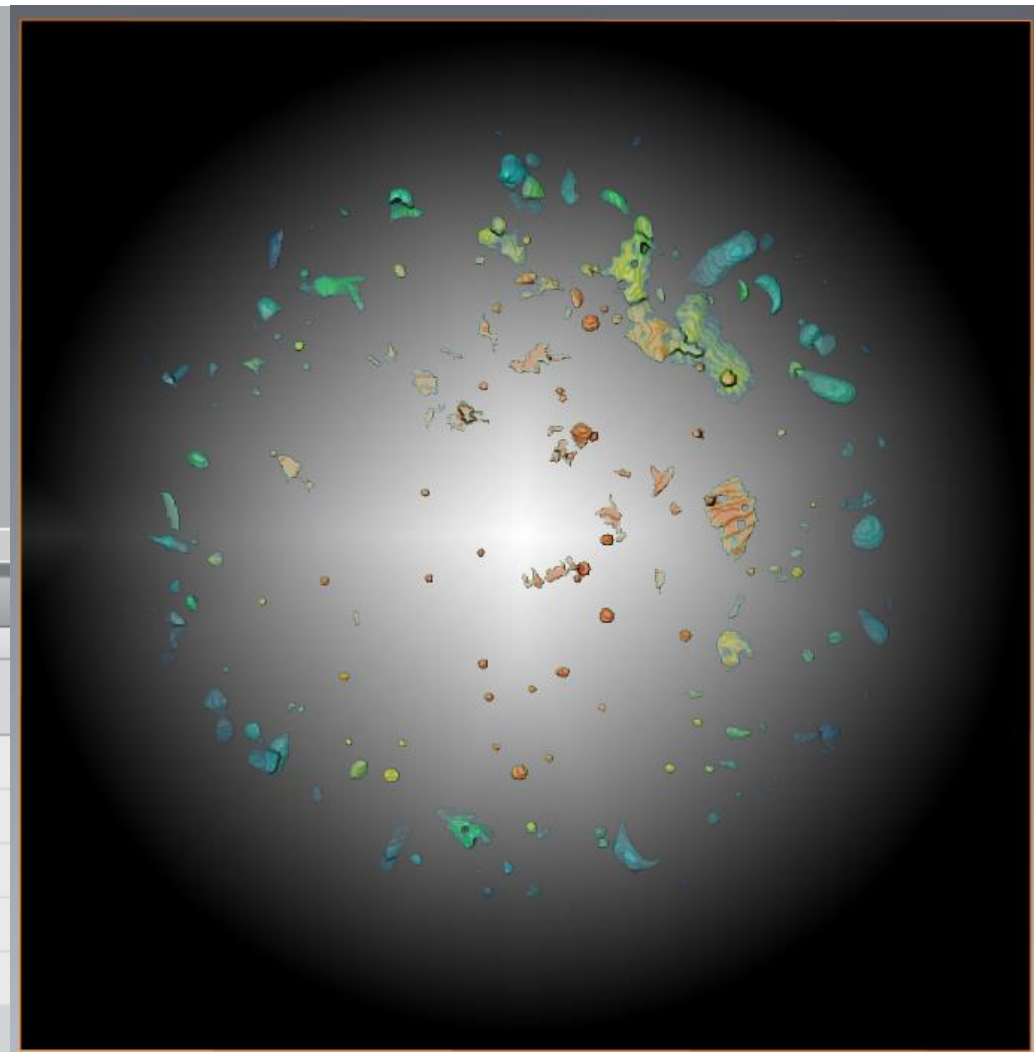
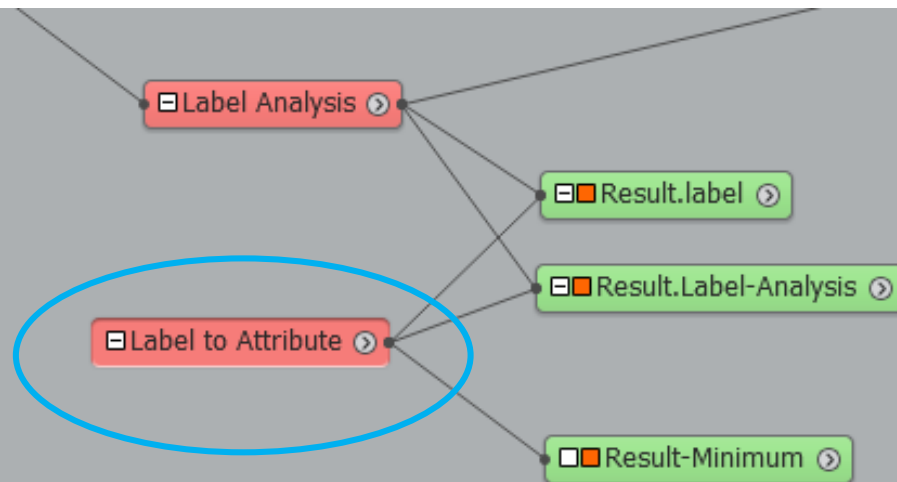
- Attached Label Analysis with inputs:

Data: Result.filtered

Intensity Image: Porosity.resampled.DistField

- In Measures:, Create a new custom measure - **Distance** (1)
containing measure: Minimum (2)

Step 2C.2 : Label to Attribute



Properties

Label to Attribute

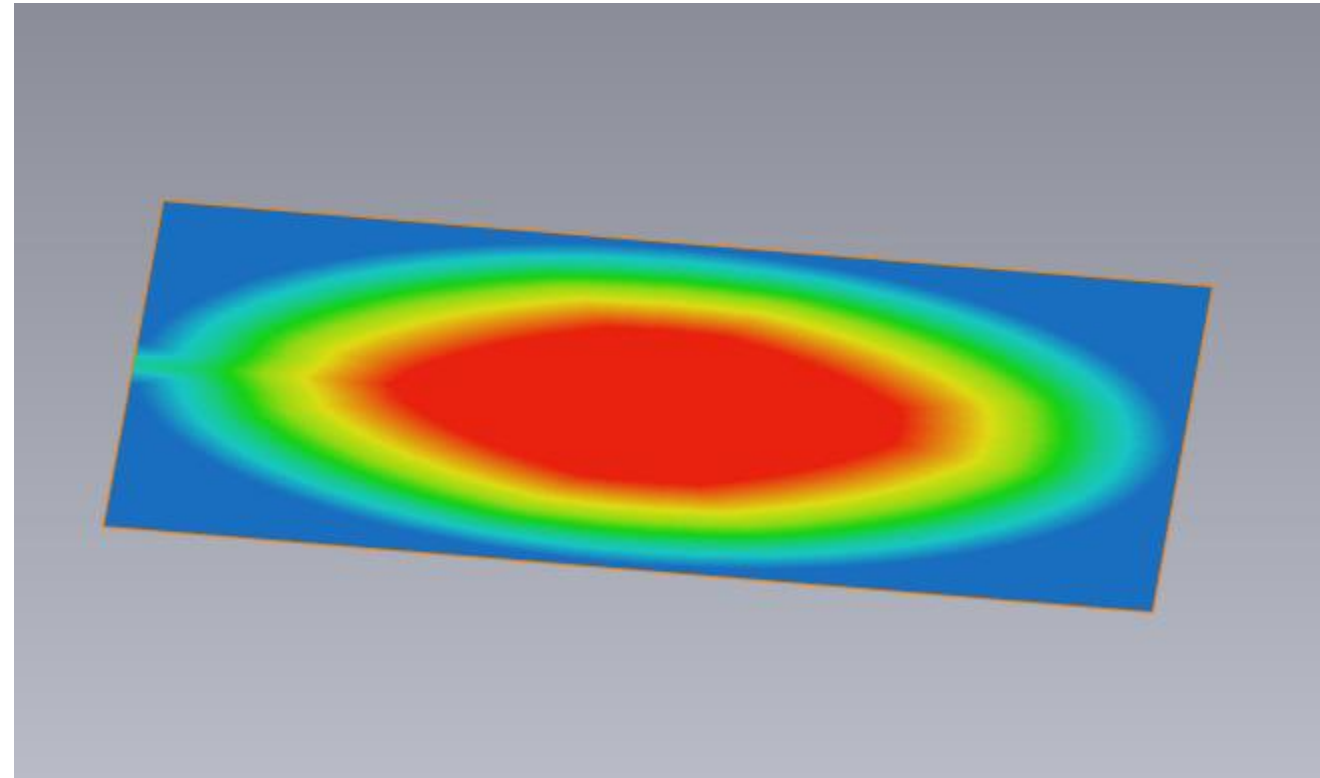
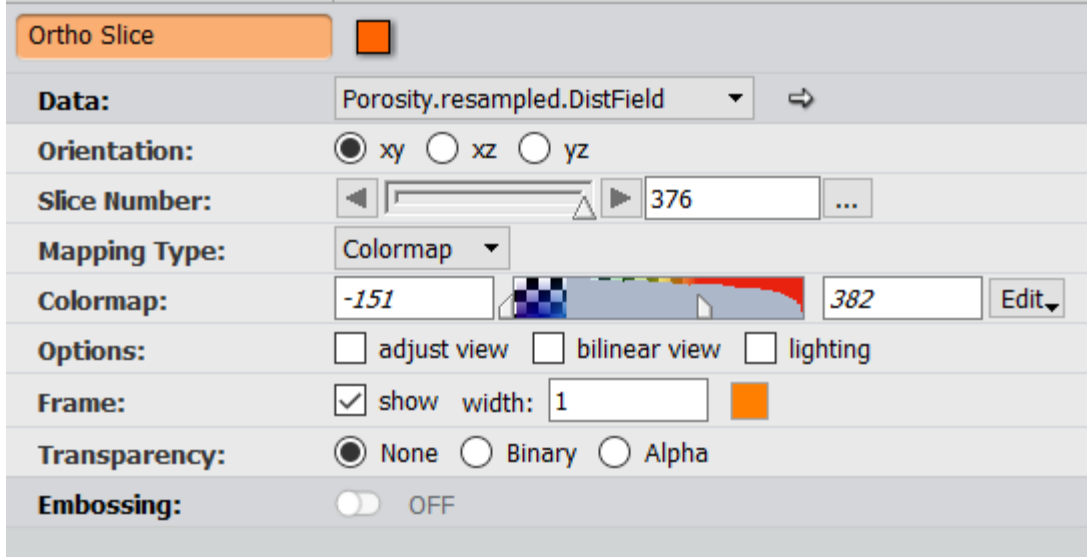
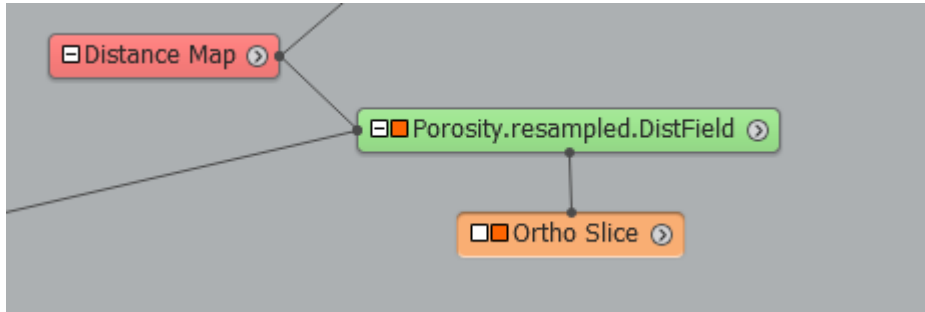
Data:	Result.Label-Analysis	⇒
Label Image:	Result.label	⇒
Attribute:	Minimum	
Labels Column:	index	
Padding Value:	<input type="checkbox"/> Auto	0

Apply Label to Attribute with Data: = Result.Label-Analysis and Label Image: = Result.label

Final Results: 2. Distance to Surface

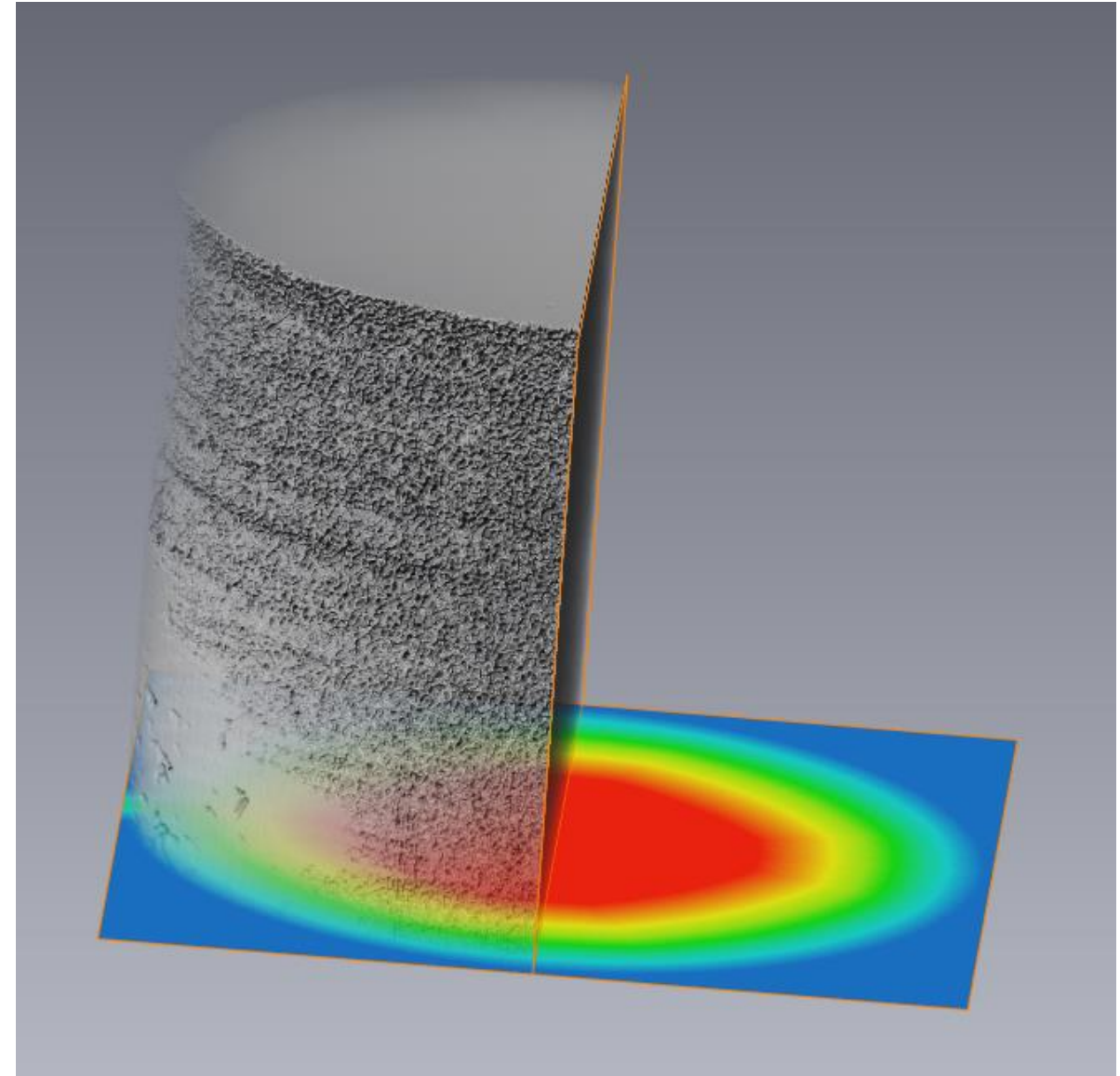
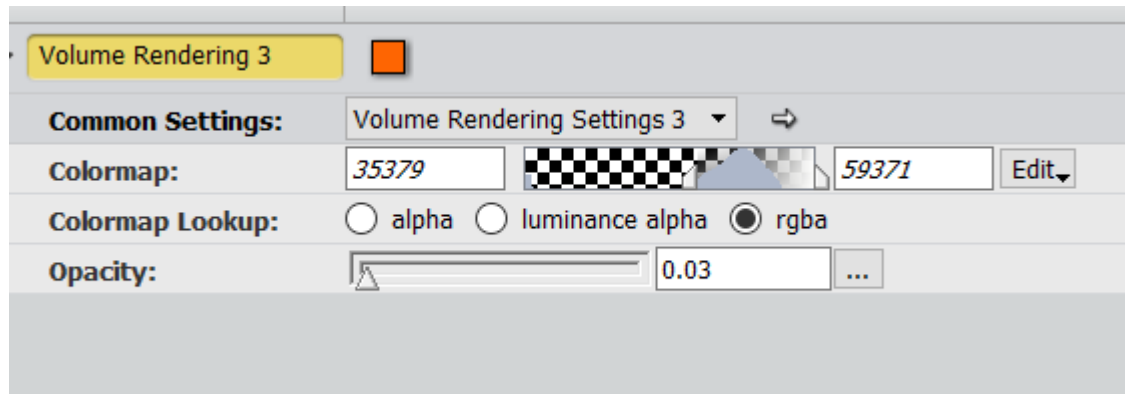
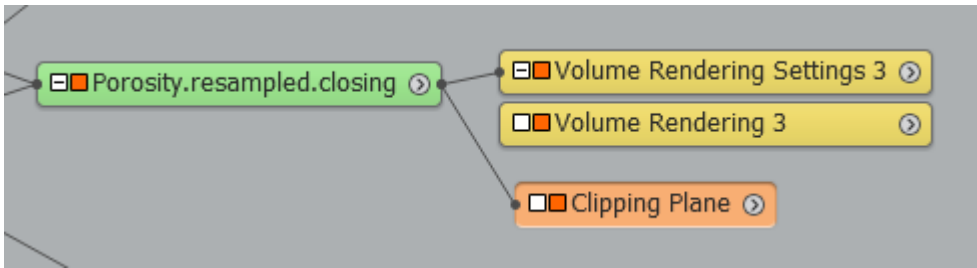
To visualize all the results in combination

- Attach Ortho Slice to Porosity.resampled.DistField
- Set Colormap to Physics



Results: 2. Distance to Surface

- Attach Volume Rendering to Porosity.resampled.closing
- Set Colormap to VolrenWhite
- Clip the volume using Clipping Plane



Results: 2. Distance to Surface

- Attach Volume Rendering to Result-Minimum
- Set Colormap to Physics

