2D SEM to 3D microCT registration

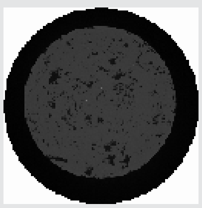
1. Introduction

This tutorial is part of the PerGeos Training course, and will detail how to register a 2D SEM into a 3D microCT scan of the same rock sample.

The Registration module will give better results if the 3D sample is set as the model to register, ie the one to receive a transformation.

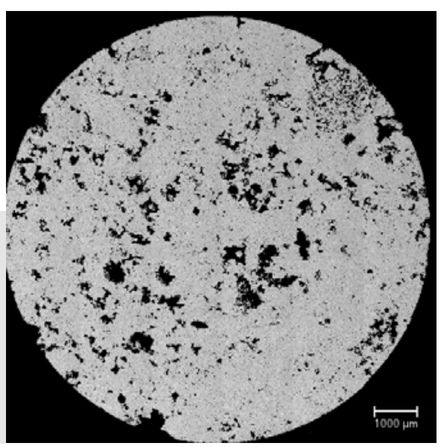
The rock sample is a courtesy of Mustapha Jouiad, MASDAR institute of Science and Technology, Abu Dhabi.

The 3D microCT is a low resolution preview scanned at 20µm.

Data name:	SD1_10mm_20ym.am
Data info:	3D Image, grayscale, 16-bit unsigned
Dimension:	640 x 640 x 1008, uniform coordinates
Physical Size:	12654.3, 12654.3, 19942 [µm] from 0, 0, 0 [µm] Transformed
Voxel size:	19.8033 x 19.8033 x 19.8034 [µm]
Memory size:	787.5 MB
Histogram:	6744 … 6.554e+04
Preview:	

The SEM image resolution is 1.77 µm.

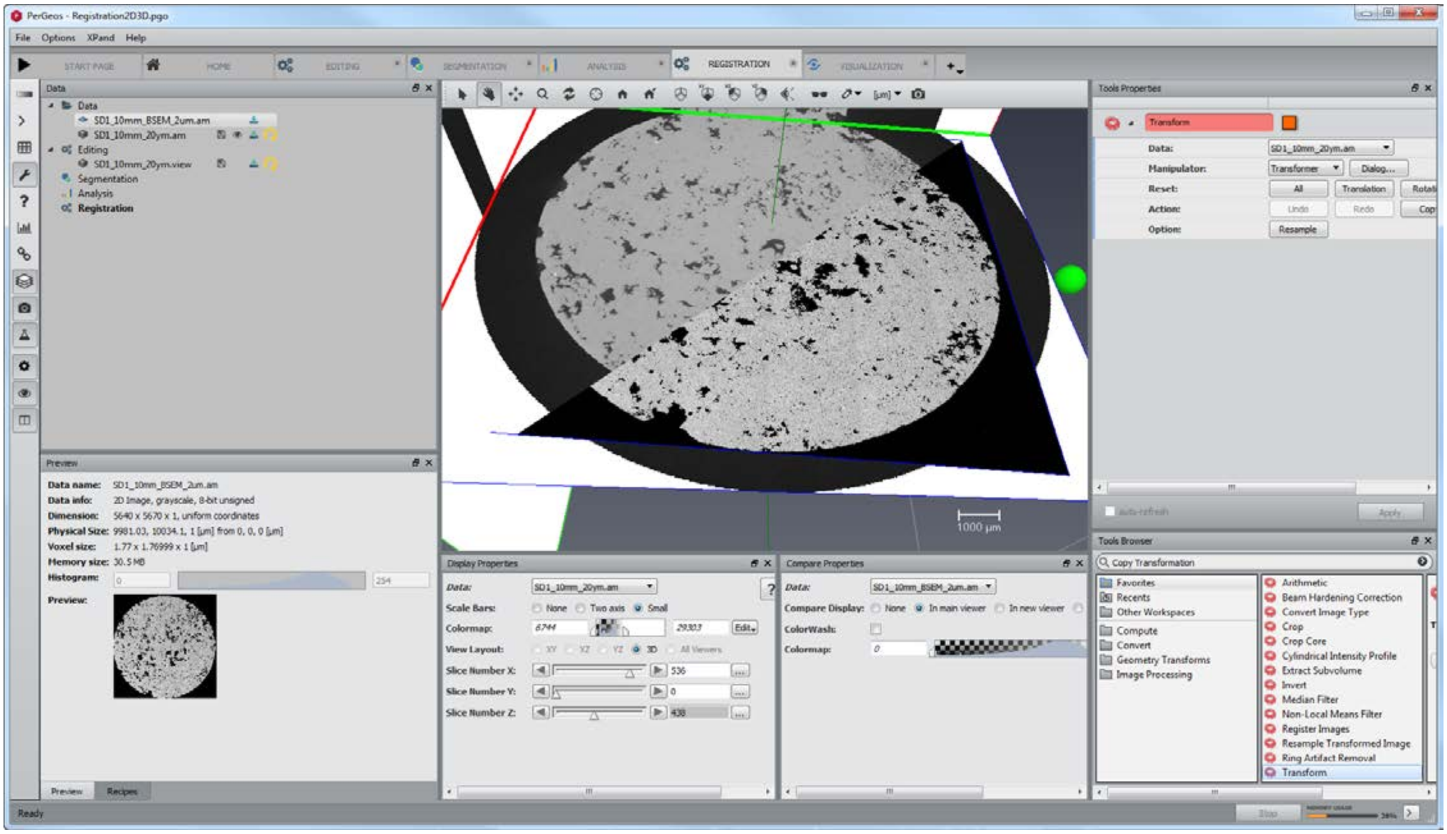
Data name:	SD1_10mm_BSEM_2um.am
Data info:	2D Image, grayscale, 8-bit unsigned
Dimension:	5640 x 5670 x 1, uniform coordinates
Physical Size:	9981.03, 10034.1, 1 [µm] from 0, 0, 0 [µm]
Voxel size:	1.77 x 1.76999 x 1 [µm]
Memory size:	30.5 MB



2. Pre-align the 2 samples

Using a Transform object applied on the 3D sample, approximatively place it over the SEM slice.

The 3d sample's Z slice 438 can be used as a reference.

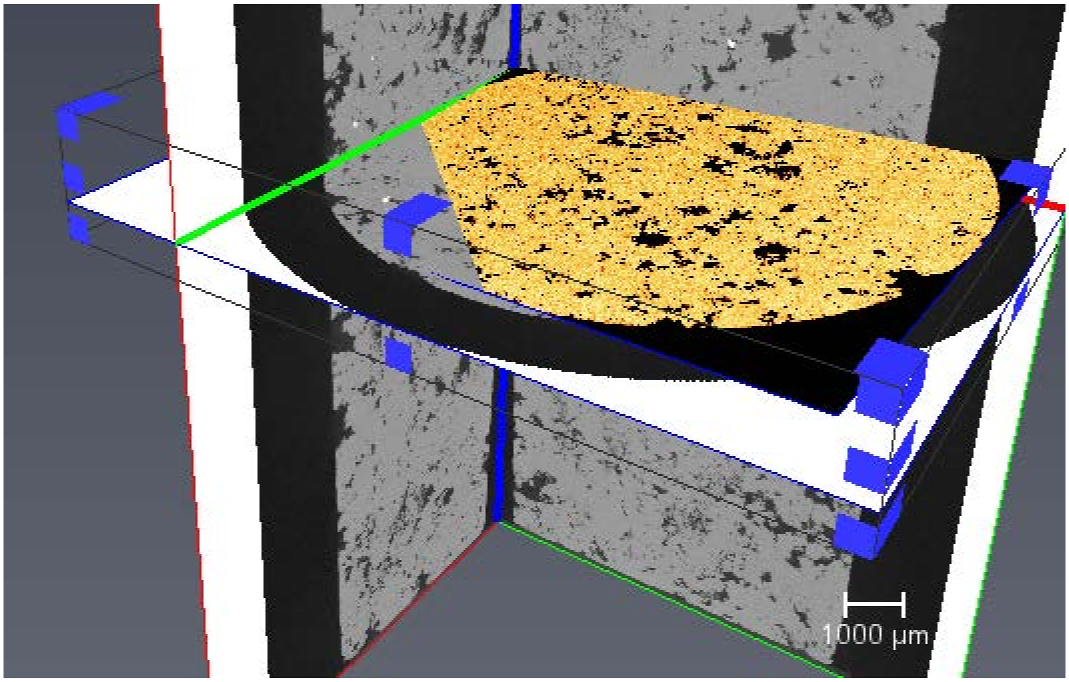


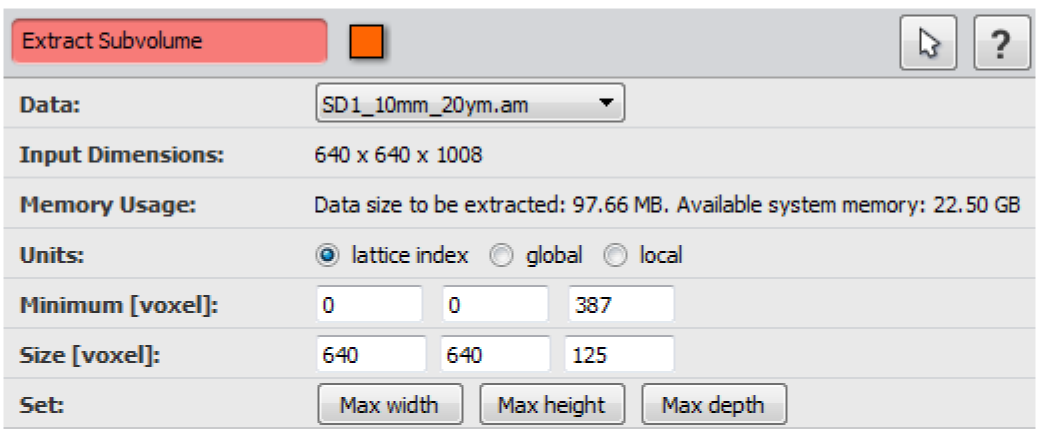
Note : It is highly recommended to transform only one sample, since a resampling step is often needed after a data has been transformed.

3. Extract a subset of the 3D sample

In order to maximize the registration precision and lower the computation time, it is recommended to extract a subset of the 3D sample before applying the registration module.

Apply an *Extract SubVolume* module to the 3D sample, so that the SEM slice is entirely contained inside.





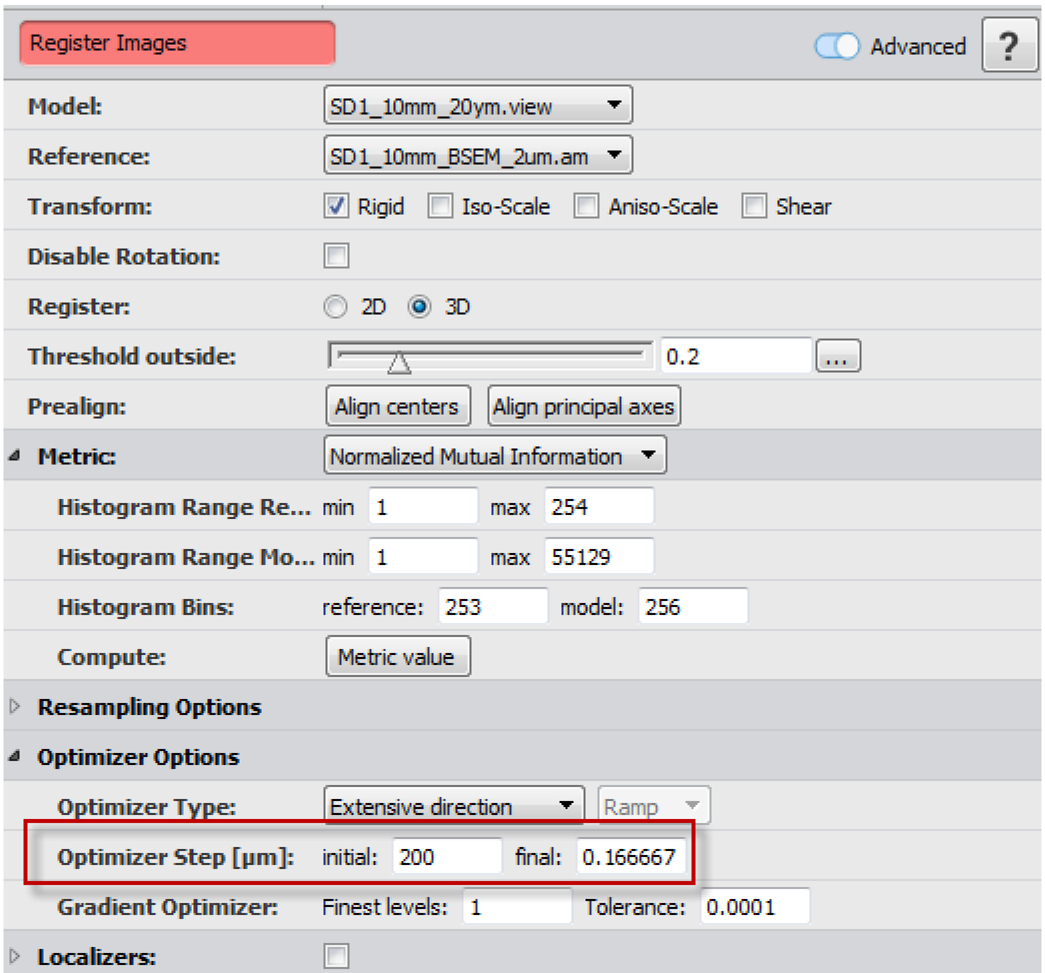
Extract Subvolume	
Data:	SD1_10mm_20ym.am
Input Dimensions:	640 x 640 x 1008
Memory Usage:	Data size to be extracted: 97.66 MB. Available system memory: 22.50 GB
Units:	lattice index / global / local
Minimum [voxel]:	0 0 387
Size [voxel]:	640 640 125
Set:	Max width / Max height / Max depth

Note: the transformation applied during step 1 is kept in the extracted subset

4. Set registration parameters

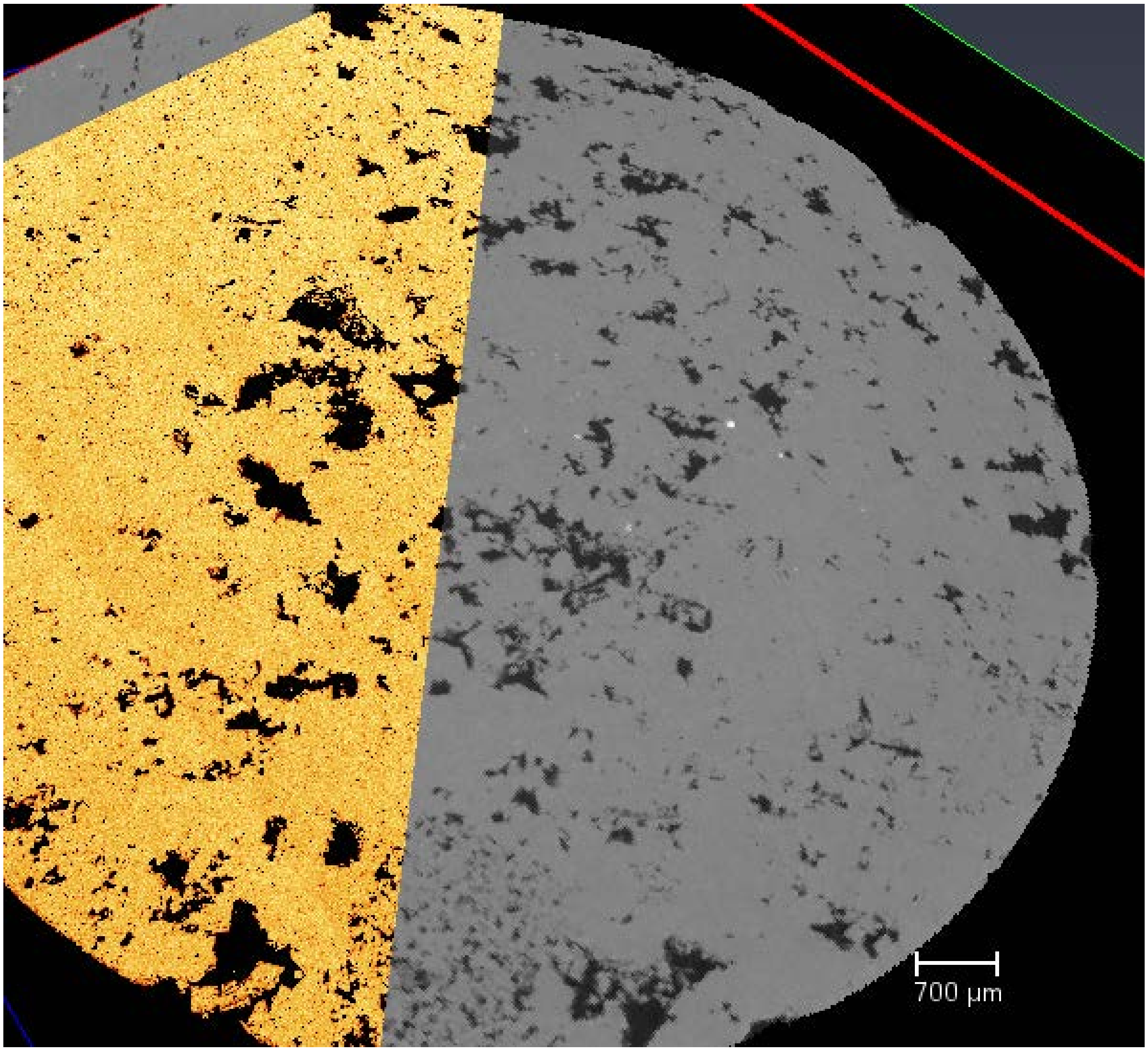
As the model, set the 3D subsample containing the transformation, since the registration process will lead to a transformation (a modification of the existing one).
The reference is the SEM image. As the acquisition modalities and histograms are different, we will use the *Normalized Mutual Information* metric.

Since we have a 2D image as the reference, the Optimizer step parameter is reduced and set to 200µm.
All the other ones are left with the default values



5. Register the samples

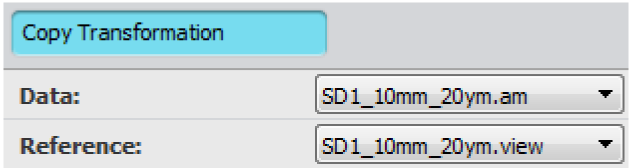
When pressing the Apply button, the best transformation to apply to the 3D subsample in order to minimize the error according to the metric is computed.



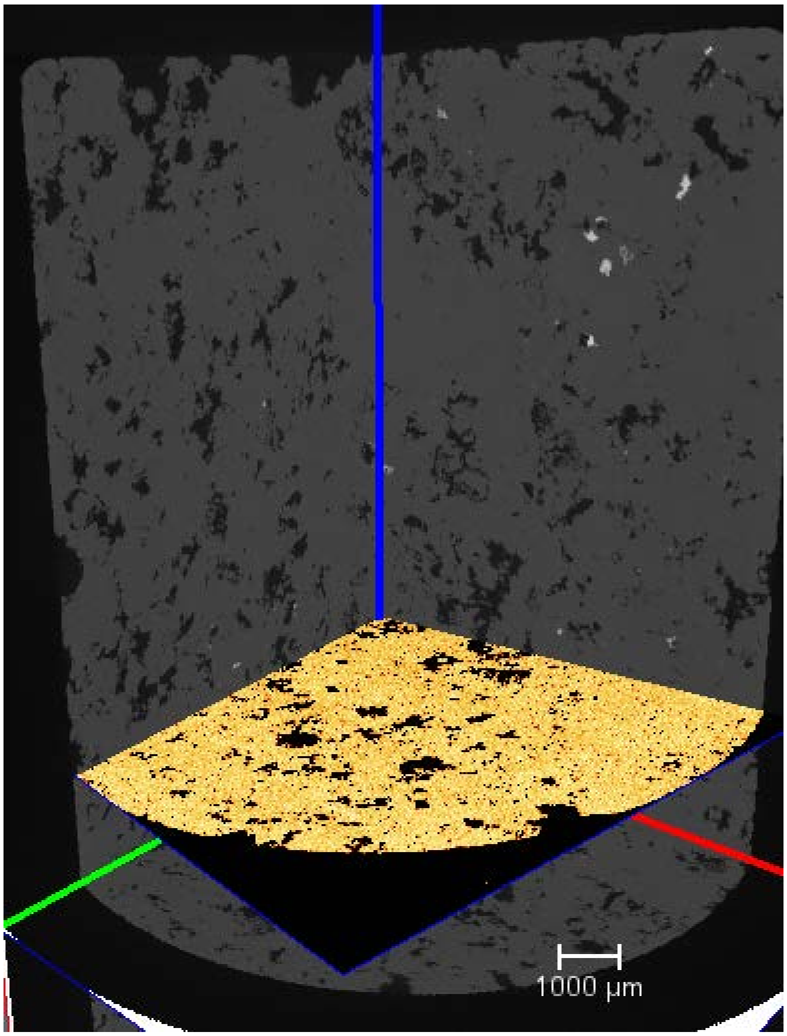
SEM image sample (left) registered to 3D sample (right)

6. Copy the transformation to the original sample

Using *Copy Transformation*, copy the transformation of the 3D subsample to the original 3D sample



The SEM and the 3D sample are now correctly registered



7. Extraction in the 3D sample of the corresponding 2D slice

Now that both samples are registered, let's compare the 3D sample and the 2D image by extracting a microCT slice at the location of the SEM image.

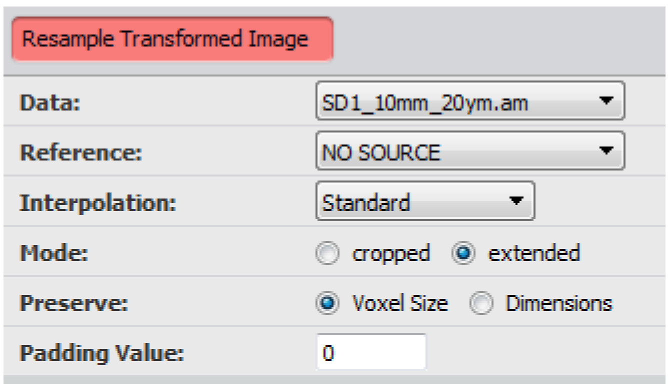
Further analysis not details here could include comparison of the pore space between the SEM and the microCT to see if the microCT pore space segmentation is accurate, if the resolution is high enough, etc.

Since the SEM is not perfectly axis aligned due to cutting precisions of the rock sample, the corresponding 3D slice will be tilted.

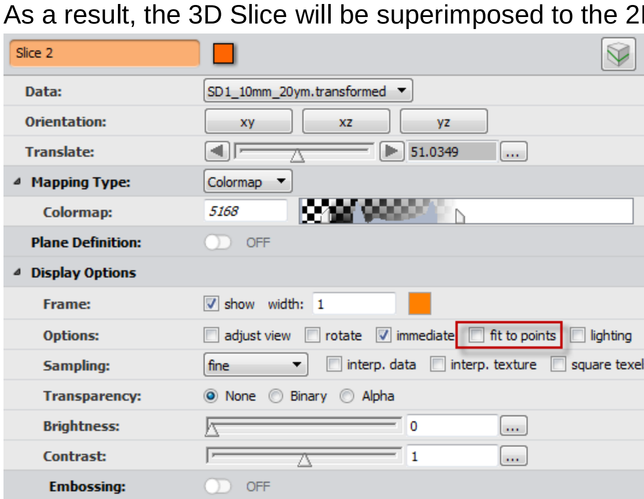
Waiting for a proper module in a latter PerGeos version, we will use the *Fit To Points* mechanism of the *Slice* object.

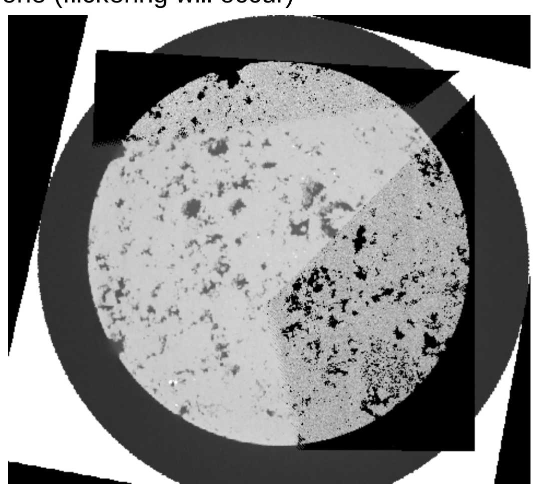
Note: since Fit To Points doesn't support transformations, we will apply the transformation to the data first.

- Apply resample Transformed Image on the 3D sample

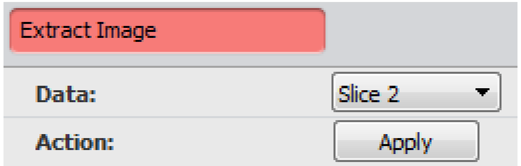


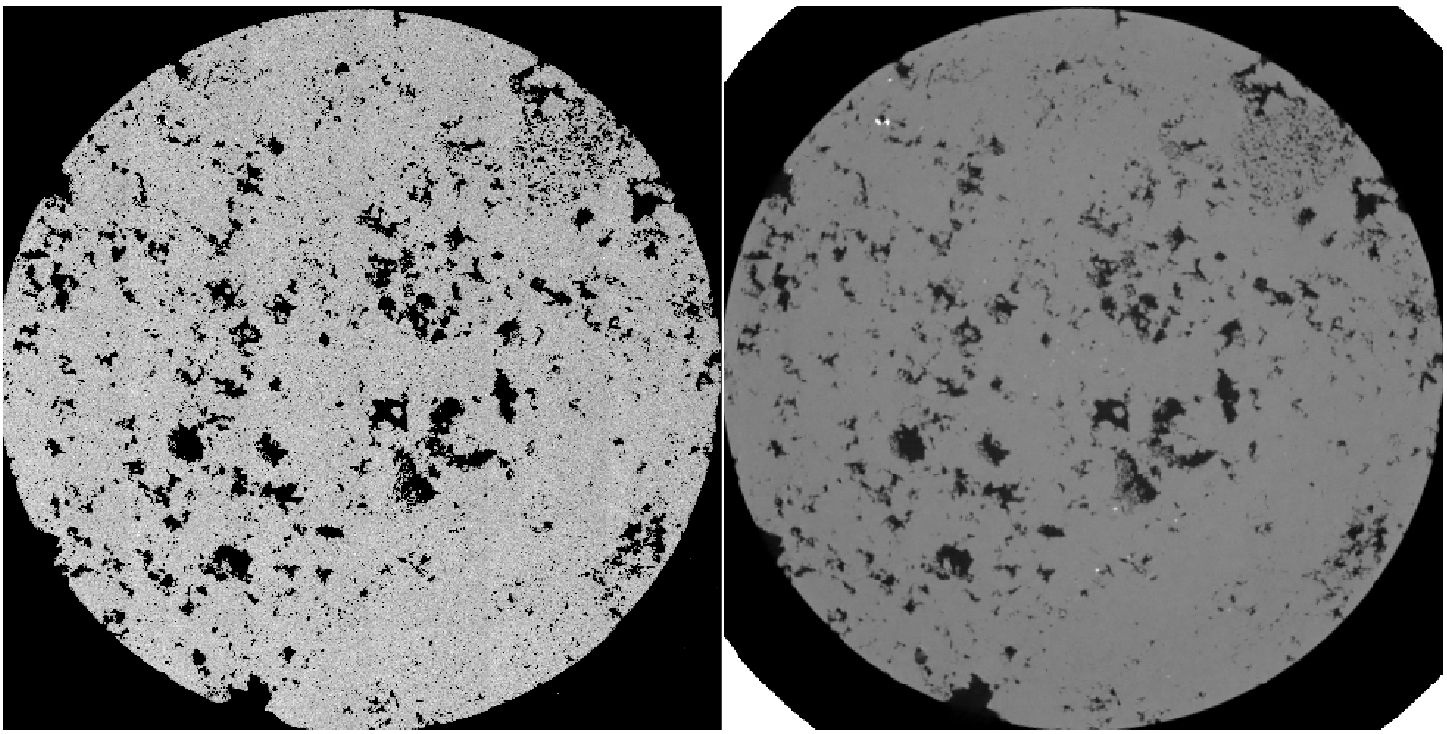
- In the Explore Workspace, create a slice object connected to the transformed data, and another one connected to the 2D image.
  In the Display options, activate the Fit to Points mechanism, and click 3 times in the viewer on the 2D slice.
  As a result, the 3D Slice will be superimposed to the 2D one (flickering will occur)





Applying an Extract Image to the Slice will effectively extract a new image data from the Slice





SEM slice on the left, corresponding 3D microCT slice on the right