Grains analysis of a 40GB sandstone sample

Introduction

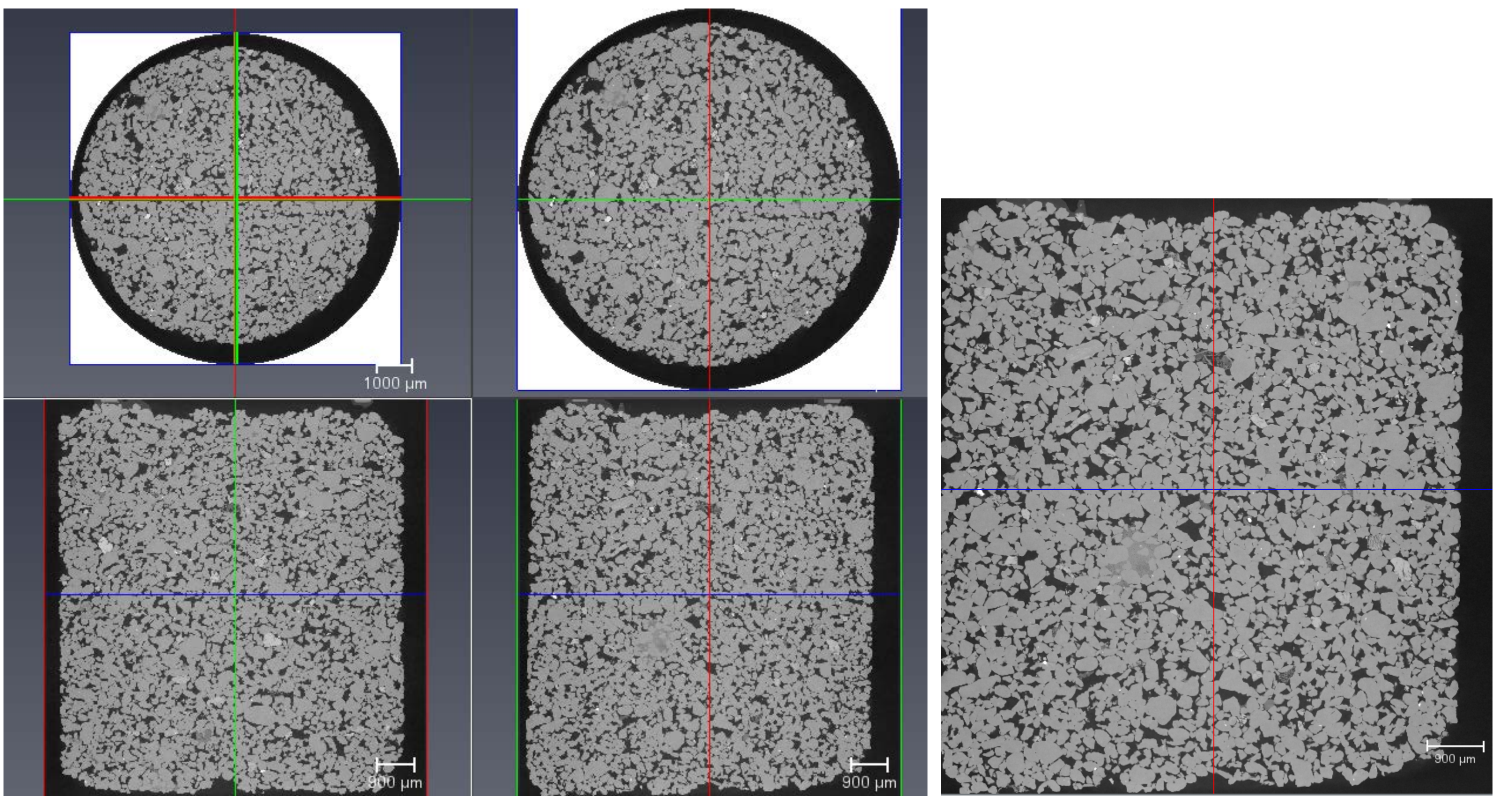
This tutorial is part of the PerGeos Training course, and will detail how to separate the grains of a sandstone sample acquired with a Heliscan microCT.

Thanks to the helical reconstruction, the Heliscan microCT is able to scan tall samples with a very high fidelity, no spatial distortion and a high SNR.

1. Overview of the sandstone sample

This large data set (40GB .lda file allowing real time visualization, cf PerGeos Tech highlight on Large Data Management) is a 1cm tall Berea sandstone subplug acquired with the Heliscan microCT at a resolution of 3.5 µm.

Data name:	sandstone.lda
Data info:	3D Image, grayscale, 16-bit unsigned
Dimension:	2600 x 2600 x 3080, uniform coordinates
Physical Size:	9250, 9250, 10960 [µm] from -1.299e+06, -1.299e+06, -1.554e+06 [µm]
Voxel size:	3.55906 x 3.55906 x 3.5596 [µm]
Memory size:	39712.5 MB



2. Definition of the binarization recipe

The aim of the recipe will be to segment and separate the grains in order to be able to output properties such as number of grains, size, aspect ratio, etc.

Due the very high resolution and high SNR, no denoising filter is needed.

In order to apply the computation on a standard PC, a slab processing will be executed, since the in-memory computation would take approx. 160 GB.

The recipe contains:

- The grains **segmentation** step using a *Marker Based Watershed* and a black *TopHat*
- The grains **separation** step using *Separate objects* on a Chamfer Distance map with a marker extent set to 1

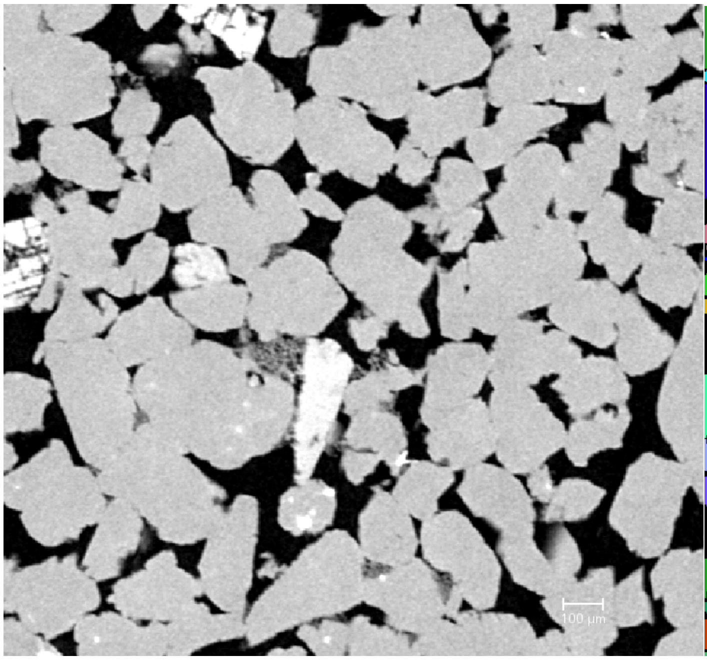


Figure 1 Zoom on slice 1589 : greyscale grains

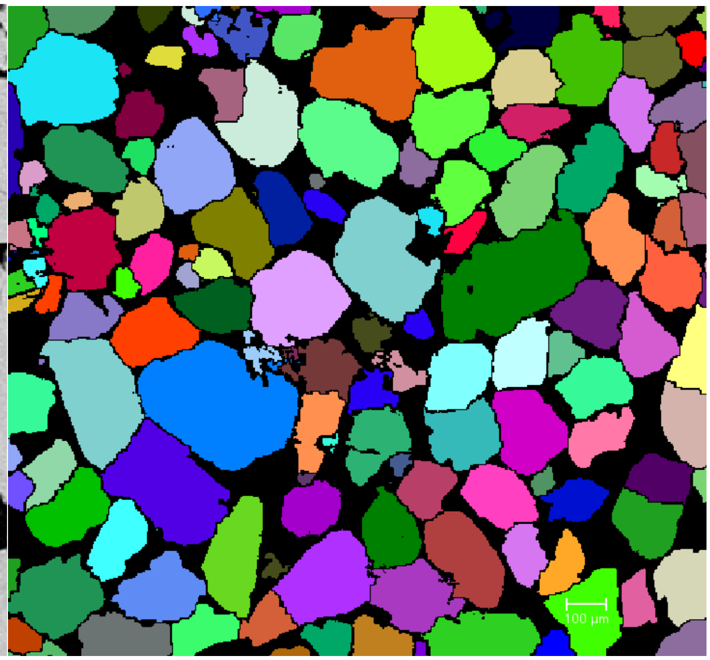
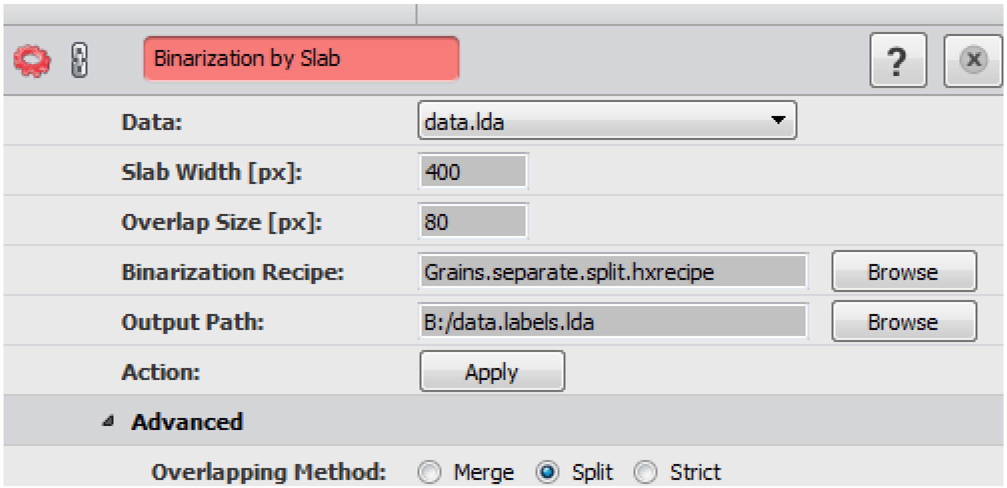


Figure 2 Zoom on slice 1589 : separated grains

3. Apply the processing by slabs



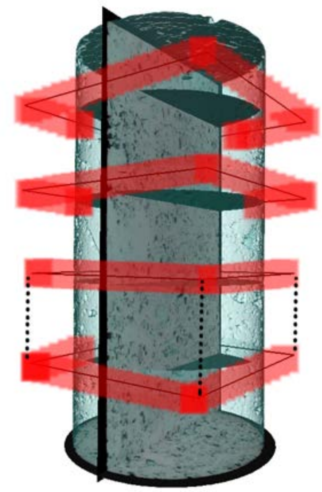


Figure 3 slab processing illustration

Having only 32GB RAM on the workstation, the slab width has been set to 400 slices (approx. 5GB). That way, the slab processing should not use more than 25GB of RAM.

The overlap between the slabs is set to be higher than the maximum size of the grains, because a grain might be separated by the slab separation plane. During the slab processing, the overlap is added to the top and bottom of the current slab, to let the segmentation and separation step take information outside of the current slab.

A manual measure of the grains indicates a maximum size of approx. 50 pixels. A value of 80 pixels for the overlap size is then a safe number.

The “Separate Objects” step of the recipe needs to output a binary data (to be solved in further PerGeos version by the use of a slab mechanism with label data output). A *Labeling by slab* is then needed after the Binarization.

Finally, the Overlapping Method is set to *Split*, because if a grain is split by a slab, the overlapping split grains information must be kept in the merged result.

Note: more than 165000 grains were found after the separation step

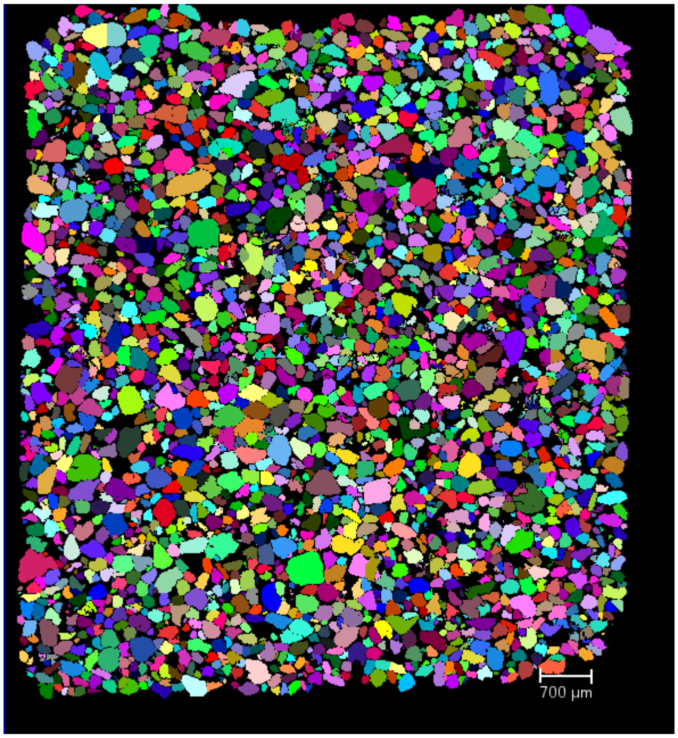


Figure 4 separated grains on slice Y 1324

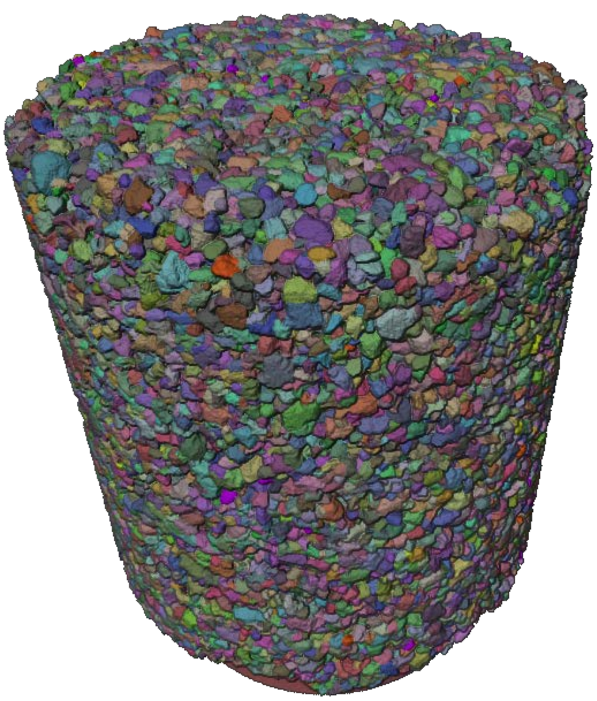


Figure 5 grains in 3D

4. Grain analysis

The analysis of the grains is computed in-memory, ie for the whole 40GB dataset.

Using Label analysis, the different grains are analyzed and the following parameters are computed:

- Volume
- Equivalent diameter
- Sphericity

Tables

data.labels.labels.Label-Analysis

	Volume3d (mm^3)	Shape_VA3d	EqDiameter (mm)	index
Mean	0.00213683	1.92406	0.0997375	82924
Min	4.50892e-08	0.239733	0.00441595	1
Max	0.229071	71.6928	0.759143	165848
Median	0.00126148	2.05076	0.100223	82924
Variance	1.73469e-05	3.13556	0.00886352	2.29218e+09
Kurtosis	154.11	121.677	-0.670645	-1.19979
Skewness	7.33456	6.05287	0.53052	-8.33814e-05

	Volume3d (mm^3)	Shape_VA3d	EqDiameter (mm)	index
127454	0.00936493	3.72626	0.261518	127454
134606	0.00936466	3.6046	0.261516	134606
70732	0.00936376	2.54716	0.261507	70732
137498	0.00936344	3.31514	0.261504	137498
124309	0.00936312	2.24999	0.261501	124309
117788	0.00936294	2.53818	0.2615	117788
164390	0.0093629	1.91469	0.261499	164390
72504	0.00936263	5.63137	0.261497	72504
26655	0.00936155	2.34904	0.261487	26655
124122	0.00936123	2.28869	0.261484	124122
45104	0.00935983	1.63688	0.261471	45104
54964	0.00935834	3.04017	0.261457	54964
9707	0.00935798	3.27774	0.261454	9707
126981	0.00935771	7.52134	0.261451	126981
10815	0.00935546	1.85869	0.26143	10815
6044	0.00935514	3.1095	0.261427	6044
126256	0.00935487	2.76681	0.261425	126256
159764	0.00935366	1.96389	0.261413	159764
129425	0.00935357	2.2394	0.261412	129425

Figure 6 grains analysis

The standard suite of processing, gathering a filtering and sieving of the analyzed grains, is of course available.