

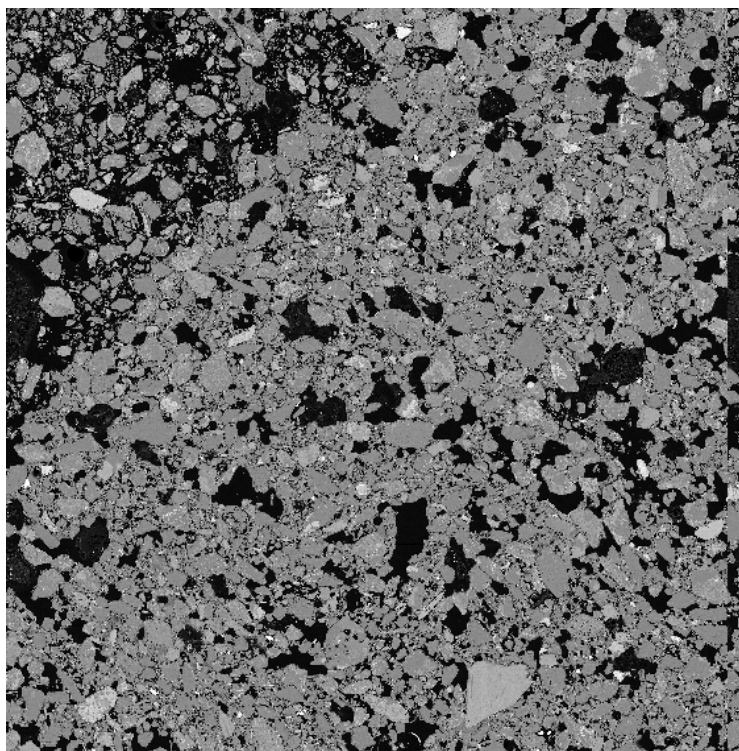
## Fusion of EDS and BSE Image

### 1. Introduction

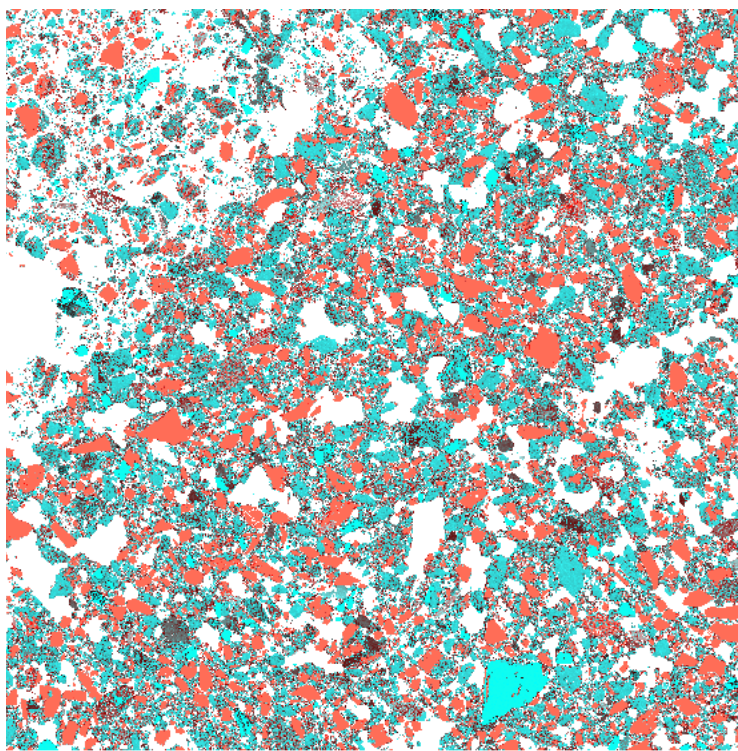
This tutorial is part of the PerGeos Training course, and will detail how to do the so-called fusion between an EDS and a BSE image. Both can have different resolution.

The goal of this fusion is to study the grain size distribution and mineral shapes based on the mineralogy information coming from the EDS image, using the high resolution BSE image, since EDS is most of the time of a lower resolution.

The data is courtesy of Dr Stefan Loehr, Macquarie University, Australia



BSE image, resolution : 16624x 16647, 264 MB



EDS image, resolution : 16896 x 16896, 272 MB

## 2. Applying the Fusion EDS – BSE recipe

The fusion EDS-BSE Recipe contains all the needed steps. However, special care should be given to the registration one, since the *Optimizer step* often requires an adjustment.

The screenshot shows a window titled "Recipes" with a dropdown menu set to "Fusion2D EDS-BSE". The window contains a list of steps in a vertical sequence, each with a circular indicator on the left. The steps are:

- Input (master) [Barhill\_BSE]
- Input (model) [Barhill-EDS]
- Segmentation: Label Field Creation
- Module:Auto Thresholding
- Module:Remove Small Holes (highlighted with a filled circle)
- Segmentation: Adding Selection
- Module:Separate Objects (highlighted with a filled circle)
- Register Images:Register (highlighted with a filled circle)
- Module:Resample Transformed Image
- Module:Label Analysis
- Module:Label To Attribute
- Module:Convert Image Type

At the bottom of the window, there are three navigation buttons: a left arrow, a right arrow, and a double right arrow.

### Remove Small Holes

Designed to facilitate the grain separation. Here a value of 40 is used.

Remove Small Holes	
Input Binary Image:	selection
Interpretation:	<input checked="" type="radio"/> 3D <input type="radio"/> XY planes
Size [px]:	40

### Separate Objects

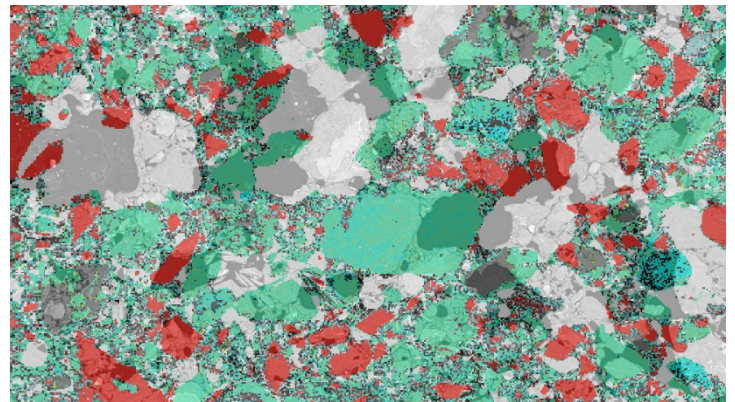
A marker extent of 2 will give good results during the grain separation

Separate Objects	
Input Binary Image:	Barhill_BSE.labels
Method:	Chamfer - Conservative
Interpretation:	<input checked="" type="radio"/> 3D <input type="radio"/> XY planes
Neighborhood:	<input type="radio"/> 6 <input type="radio"/> 18 <input checked="" type="radio"/> 26
Marker Extent:	2
Output Type:	split

### Register Images

The Optimizer initial Step will need to be reduced to around 200  $\mu\text{m}$  since the images are not far from each other.

Register Images		<input checked="" type="checkbox"/> Advanced
Model:	Barhill-EDS	
Reference:	Barhill_BSE	
Transform:	<input checked="" type="checkbox"/> Rigid <input type="checkbox"/> Iso-Scale <input type="checkbox"/> Aniso-Scale <input type="checkbox"/> Shear	
Disable Rotation:	<input type="checkbox"/>	
Register:	<input checked="" type="radio"/> 2D <input type="radio"/> 3D	
Threshold outside:	0.2	
Prealign:	Align centers <input type="checkbox"/> Align principal axes <input type="checkbox"/>	
Metric:	Normalized Mutual Information	
Resampling Options		
Optimizer Options		
Optimizer Type:	Extensive direction Ramp	
Optimizer Step [ $\mu\text{m}$ ]:	initial: 200	final: 0.166667
Gradient Optimizer:	Finest levels: 2	Tolerance: 0.0001
Localizers:	<input type="checkbox"/>	

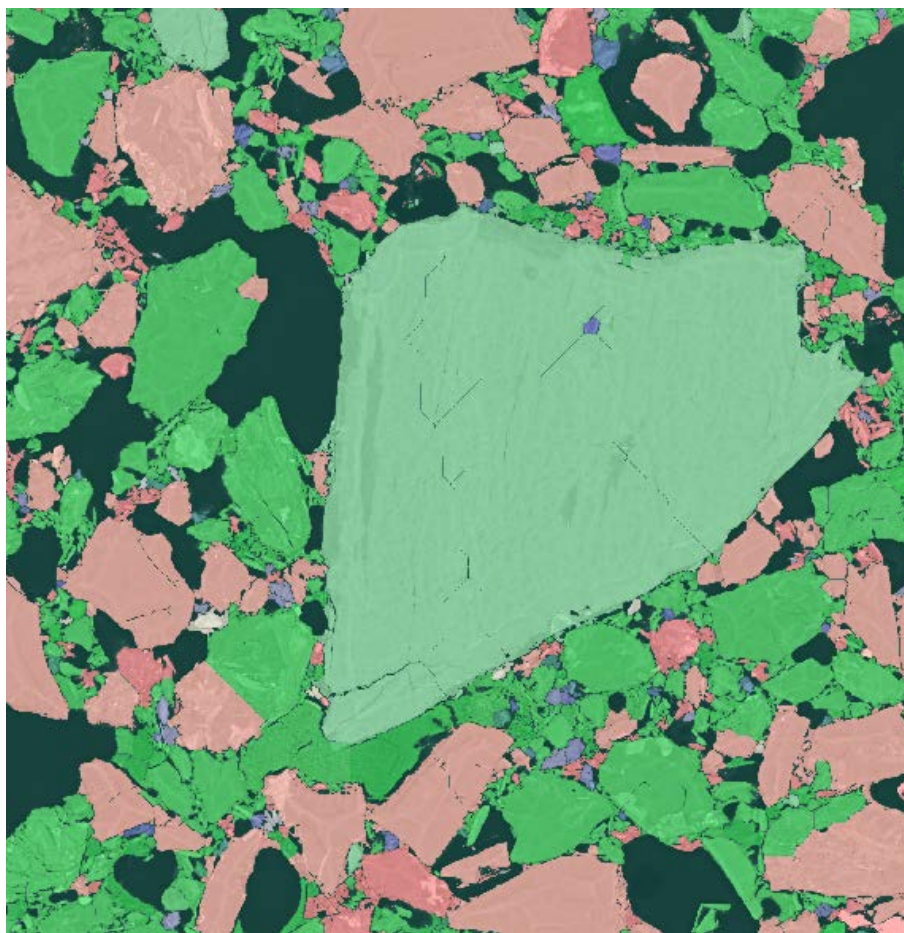


Initial displacement between the images

### 3. Analysis

Now that both images are correctly registered and fused, it is possible to extract statistics and use the mineralogy information from the EDS image.

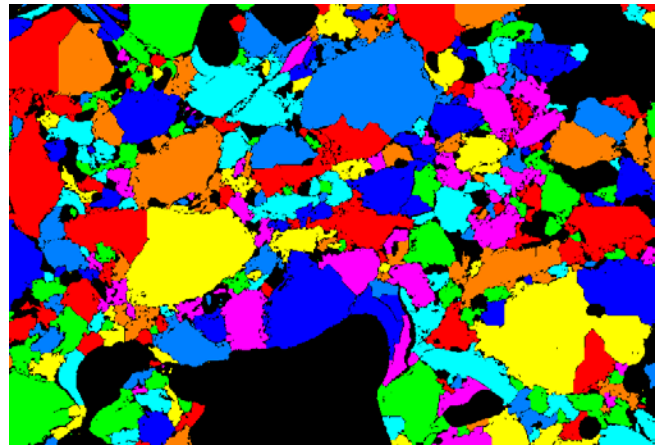
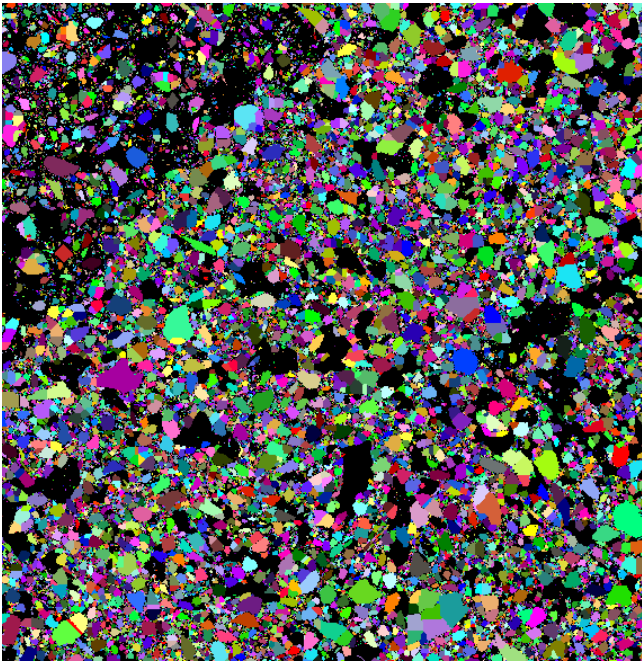
*Note : PerGeos 2.0 will come with a dedicated import function for Nanomin, the EDS analyzer from the MAPS Mineralogy software. This import function will allow the user to directly retrieve mineral names and colors in PerGeos.*



Each of the identified grain has received the most representative mineral

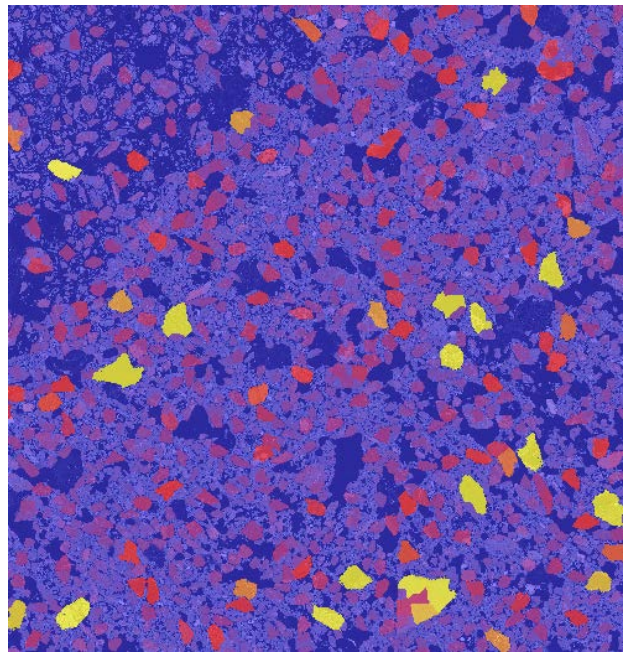
Grain size distribution

A **Label analysis** on the resulting image will give around 64300 different grains



Arbitrary colors represent adjacent grains

	Area (µm <sup>2</sup> )	BaryCenterX (µm)	BaryCenterY (µm)	Mean	index
19	13851	1407.27	84.008	1	19
20	40	1452.75	2.375	1	20
21	457	1486.25	13.0438	1	21
22	3	1502	0	1	22
23	6	1560	0.5	1	23
24	848	1614.73	8.61203	1	24
25	7	1653.29	0.428571	1	25
26	3	1679.33	0.666667	1	26
27	1399	1703.41	26.8628	1	27
28	58	1742.29	1.24138	1	28
29	605	1835.27	7.03802	1	29
30	45205	1949.22	99.4957	1	30
31	1	2093	0	1	31
32	2134	2095.21	36.4461	1	32
33	369	2126.42	11.065	1	33
34	300	2204.23	5.63	1	34
35	35	2241.2	2.68571	1	35
36	329	2328.72	5.68997	1	36

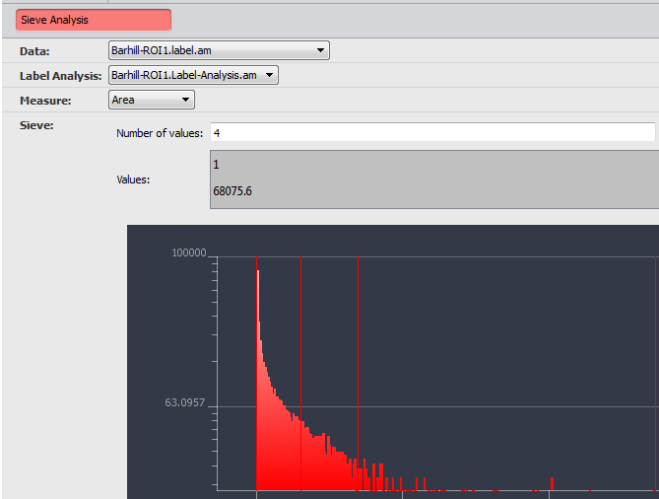
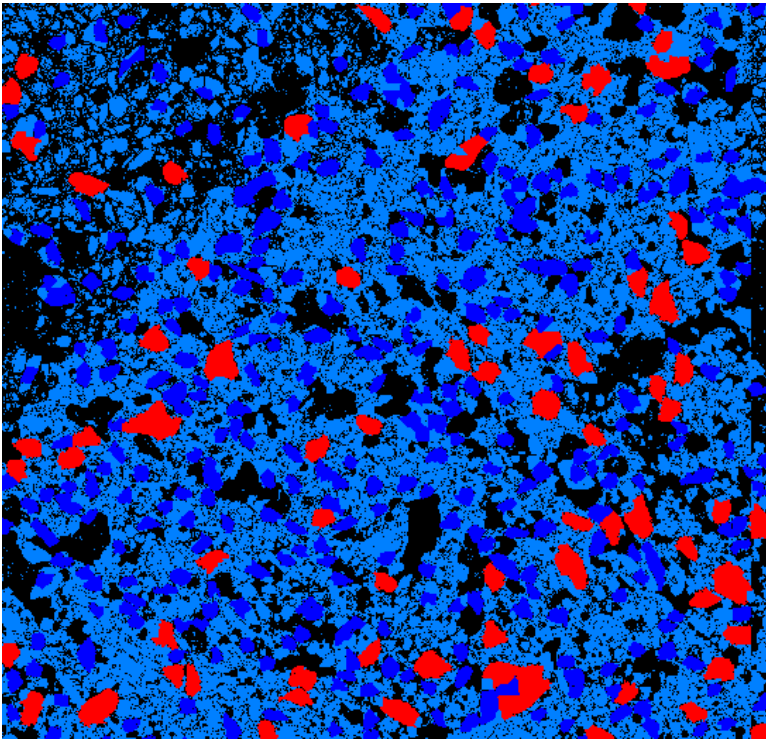


Colors represent grain size

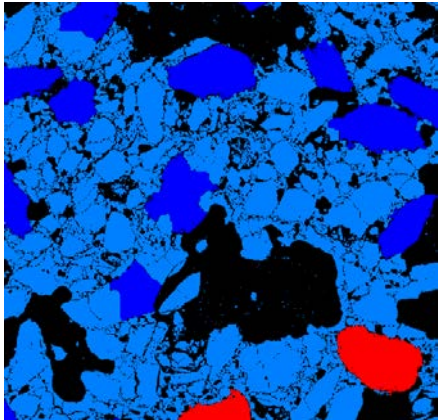
Grain Size Distribution

Grain size classification

A **Sieve analysis** on the resulting label image will segregate the different grains into 3 classes.

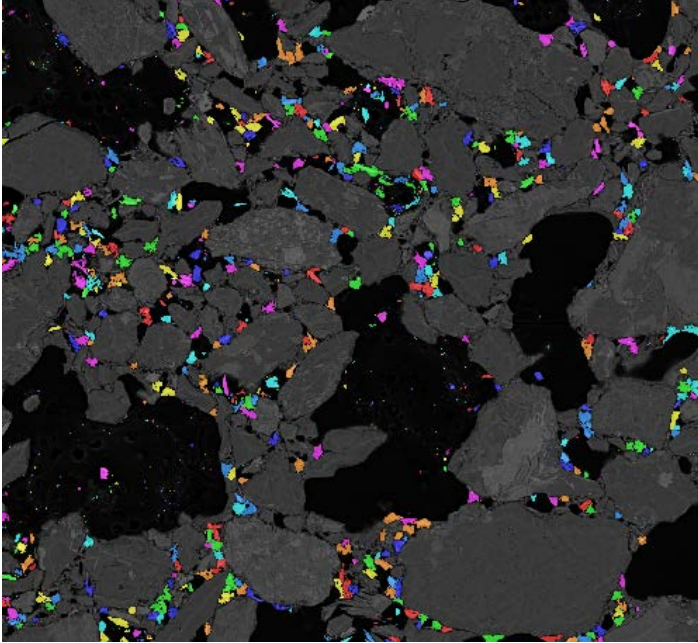


Classification into 3 different classes

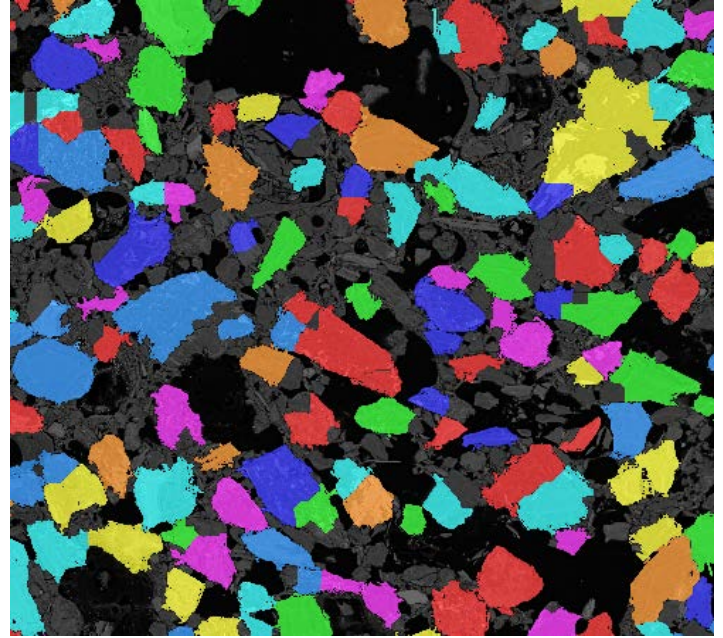


Shape factors

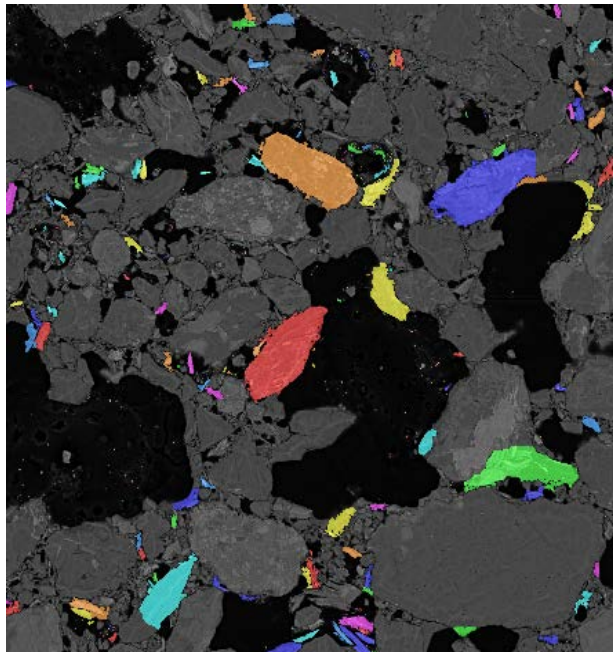
An **Analysis Filter** on the resulting label image will segregate the different classes depending on their size or length.



Area < 3000  $\mu\text{m}^2$



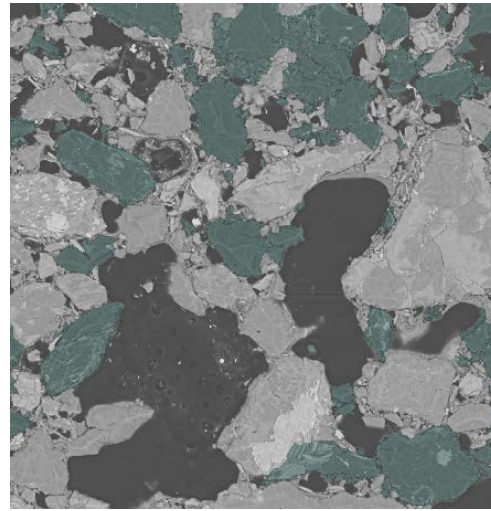
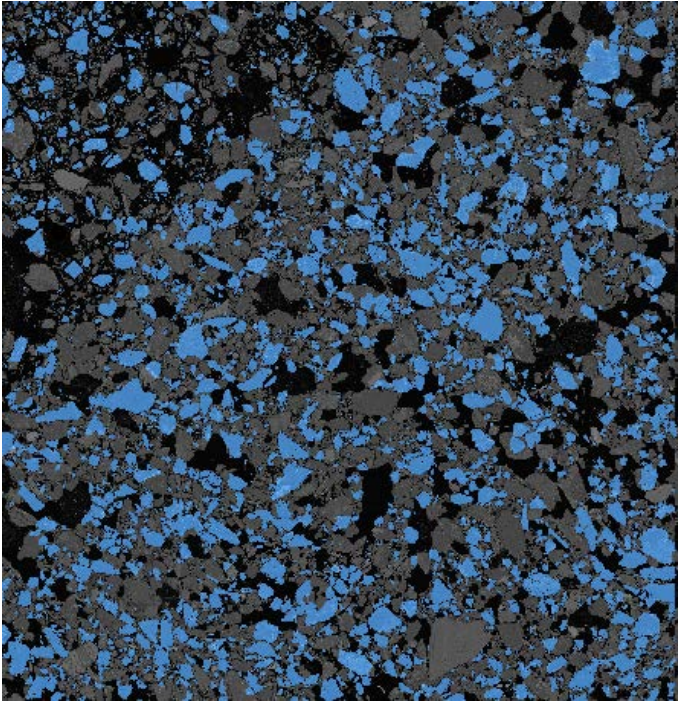
Area > 20000  $\mu\text{m}^2$



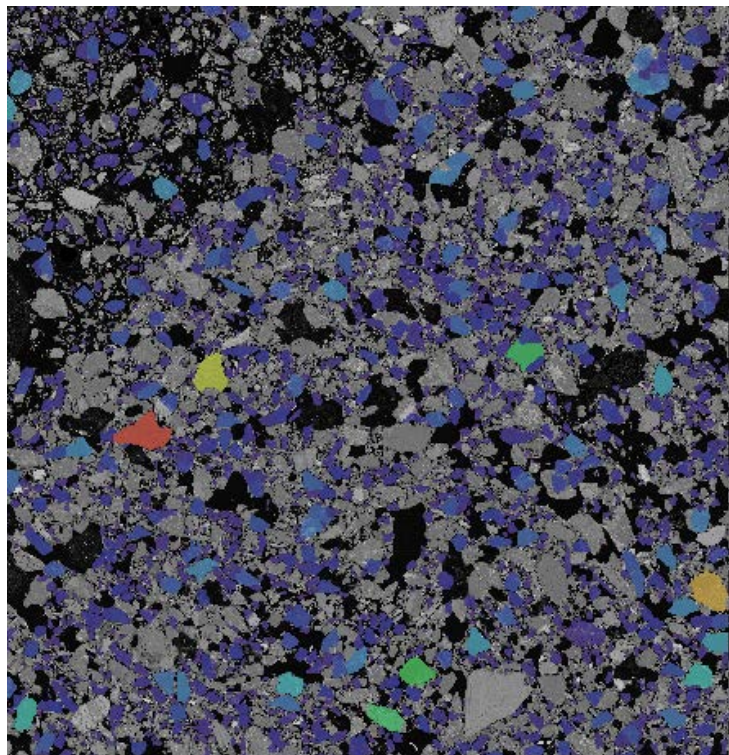
Elongated grains

Mineral -grain association

All grains corresponding to one mineral can easily be extracted with an **Arithmetic** module ( A == mineral ID)



Quartz ( Mineral 234 )



Quartz size distribution ( colors represent grain size)

	Area (µm <sup>2</sup> )	BaryCenterX (µm)	BaryCenterY (µm)	Mean	index
Mean	16045	8176.74	8615.34	1	2057.5
Min	1	4.55625	3.27027	1	1
Max	605058	16197	16641.3	1	4114
Median	5265.32	8088.55	8725.07	1	2057
Variance	1.00531e+09	2.05902e+07	2.33903e+07	0	1.41042e+06
Kurtosis	65.2607	-1.14297	-1.22124	--	-1.2
Skewness	6.00149	0.0109276	-0.0484146	--	-7.74554e-06
					.....
	Area (µm <sup>2</sup> )	BaryCenterX (µm)	BaryCenterY (µm)	Mean	index
1	1072	8.81716	25.7108	1	1
2	1524	520.602	8.67257	1	2
3	20240	623.012	72.0465	1	3
4	28541	841.053	62.3455	1	4
5	700	1088.83	8.63429	1	5
6	20634	1237.04	59.5671	1	6
7	3137	3006.28	30.8145	1	7
8	185	3365.88	3.27027	1	8
9	588	3793.05	7.82483	1	9
10	100069	4774.33	132.186	1	10
11	7265	4887.28	30.6742	1	11
12	16901	6376.79	48.9914	1	12
13	2745	6495.69	19.259	1	13
14	4329	7248.88	25.5223	1	14
15	4154	8016.34	28.766	1	15
16	19065	10271	57.7197	1	16
17	11600	10426.9	50.1147	1	17
18	51761	11199.5	99.9806	1	18
19	3104	11447.7	18.1372	1	19
20	159623	11657.1	229.749	1	20
21	29051	12195.6	81.9789	1	21
22	34779	12428.6	119.456	1	22
23	4707	14658.5	29.3973	1	23
24	14487	14760.2	53.2116	1	24
25	3521	15081.3	12.4198	1	25
26	1152	15571.9	14.2691	1	26
27	33576	15735.2	65.485	1	27