

## Applications with tutorials

01 - Intercepts processing in grey levels of Adamello Batholith images

02 - SPO basic processing of classified images

03 - SPO processing of one classified norite of the Bushveld

04 - Intercepts processing in greyscale and classified images of Rooi Rand dykes

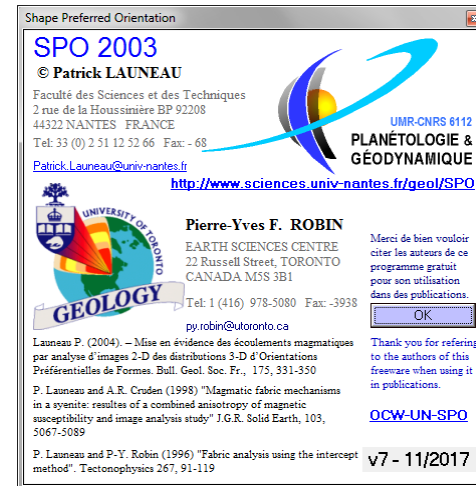
05 - Intercepts processing in grey levels of faults and lineaments

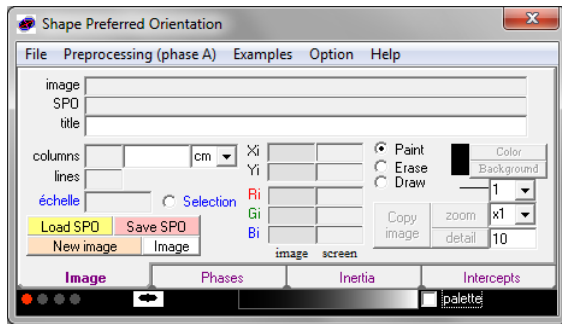


Pr. Patrick Launeau  
[patrick.launeau@univ-nantes.fr](mailto:patrick.launeau@univ-nantes.fr)

## How to start with SPO2003

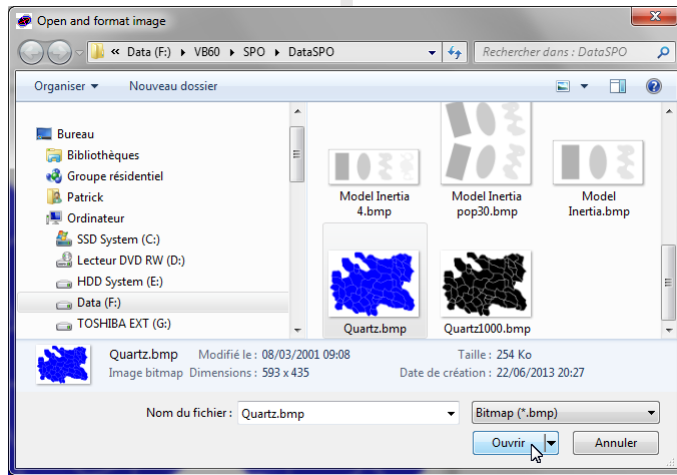
- 1 Load an image
- 2 Phase selection
- 3 Inertia tensor
- 4 Save your work
- 5 How to define a new phase
- 6 Phase selection
- 7 Intercepts of objects
- 8 Center to center analysis



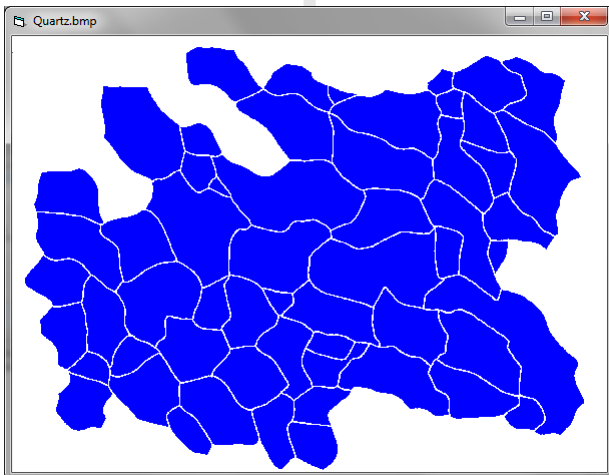


1 Load an image

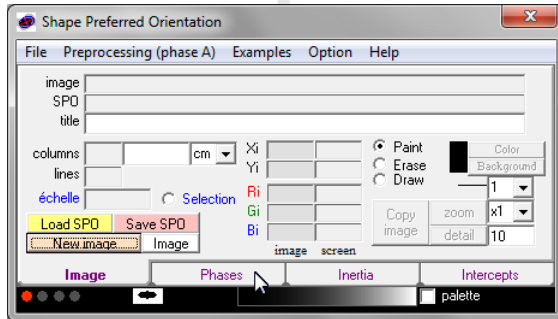
Click on **New image**



and select your image

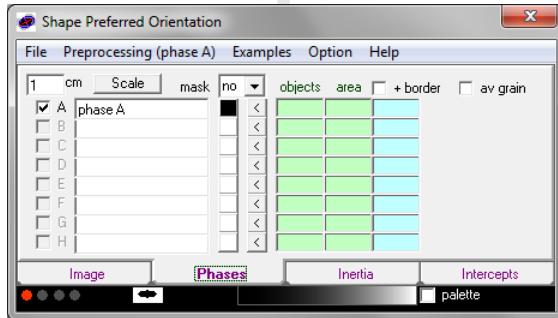


In this example quartz grains are blue

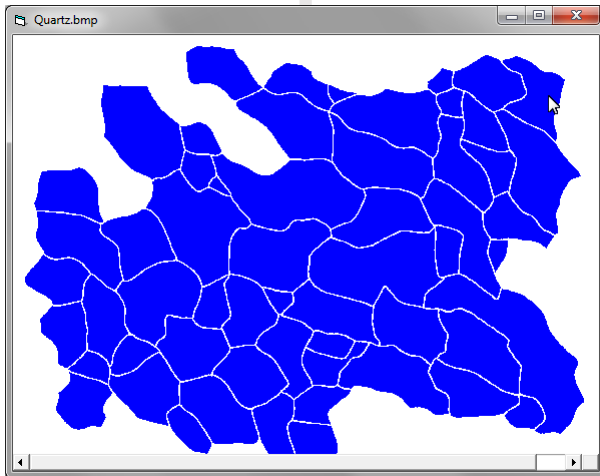


2 Phase selection

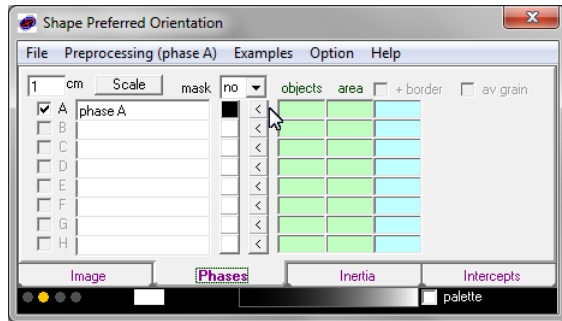
Click on tab **Phases**



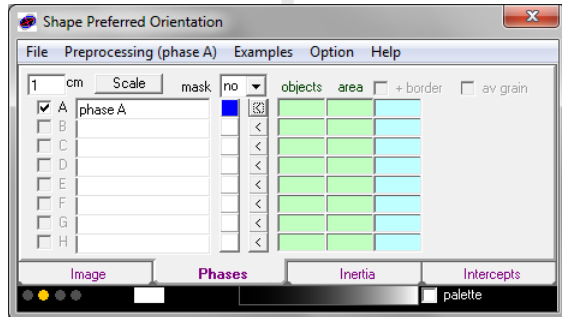
The default color is black, the background is always white (default paper color)



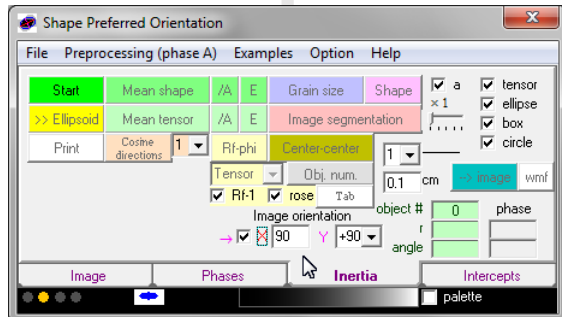
Click (with left button) on one grain to select the color (a window displays the number of pixels in the grain selected)



The color selection appears at the bottom of the window (see blue ellipse). Click with the left button on < in the line A to set the phase A color to blue.



Eventually change the caption

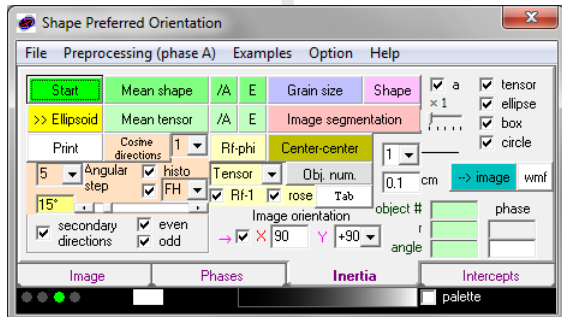


## 3 Inertia tensor

Click on tab Inertia

The image orientation can be reset.

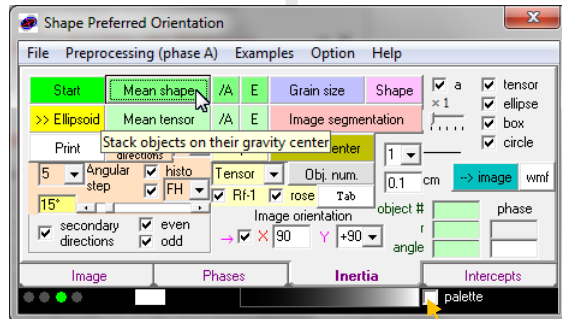
By default X is up at 0 degree and Y is on the right at +90 degrees. In this case X is at 90 degrees and Y at X+90.



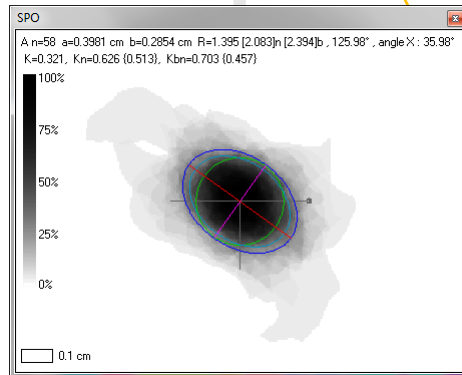
Click on Start to run the calculation

The bottom green light means that inertia tensor have been calculated on the current image.

It turn orange when changing any part of the image (delete one grain, draw new boundary...).

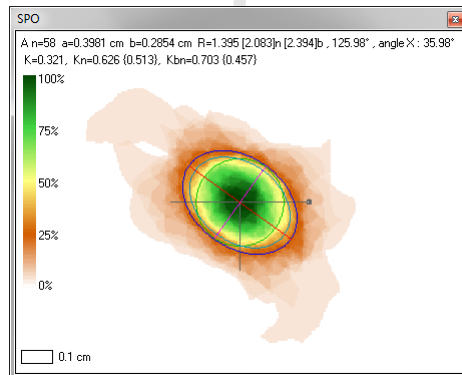


Click on **mean shape** to display the mean SPO.



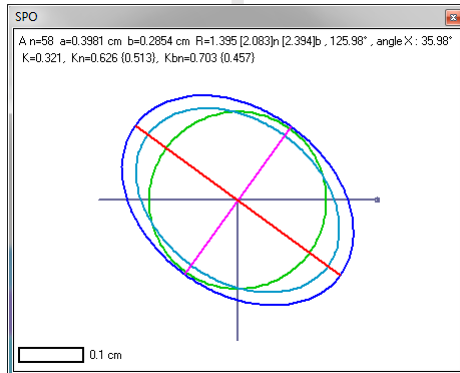
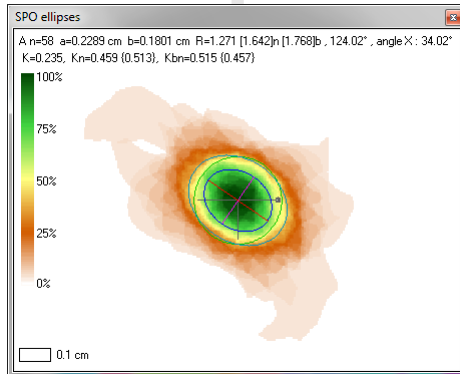
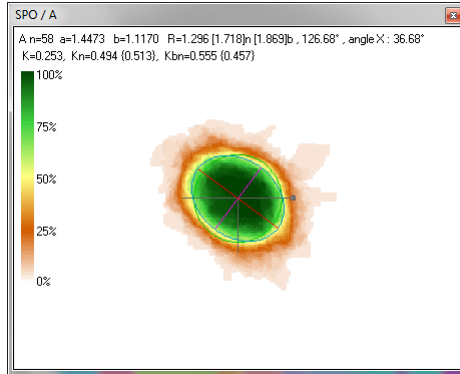
It appears in grey level density of pixels stacking all the grains on the top of each other with the same gravity center.

A click on color palette display it with a color code.



In this example one phase is analyzed:  
Phase A number of grain  $n = 58$   
length of the inertia tensor ellipse  $a = 0.3981$  cm  
width of the same ellipse  $b = 0.2854$  cm  
and the shape ratio  $sr = a/b = 1.395$   
the orientation  $\alpha$  of  $a$  is (in degrees):  $125.98$   
The rake  $\psi$  from X to the long axis  $\alpha$  is  $35.98$

SPO



Click on **/A**.

By clicking on /A you divide each grain by its area and stack the resulting shapes on each other.

Therefore, all the grains have the same weight.

a is a relative length: 1.4473 with no dimension

b is a relative length: 1.1170

the shape ratio sr is given by a/b: 1.296 and the orientation of a is: 126.68 degrees

Click on **E**.

E replace each grain tensor by its ellipse inverse matrix prior its stacking. It therefore has an inverse size weight.

a is a relative length: 0.2289

b is a relative length: 0.1801

the shape ratio sr is given by a/b: 1.271 and the orientation of a is: 124.02 degrees

Click on **mean tensor** for a display without pixel density

In this example one phase A is analyzed:

number of grain n = 58

length of the inertia tensor ellipse a = 0.3981 cm

width of the same ellipse b = 0.2854 cm

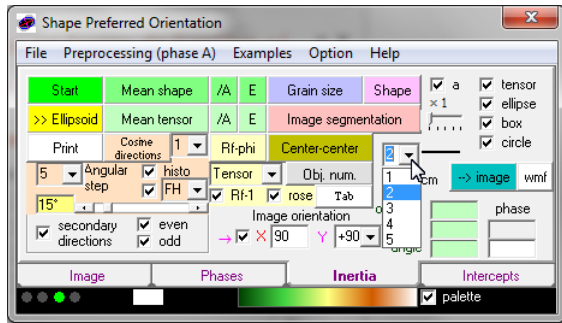
and the shape ratio  $sr = a/b = 1.395$

the orientation  $\alpha$  of a is (in degrees): 125.98

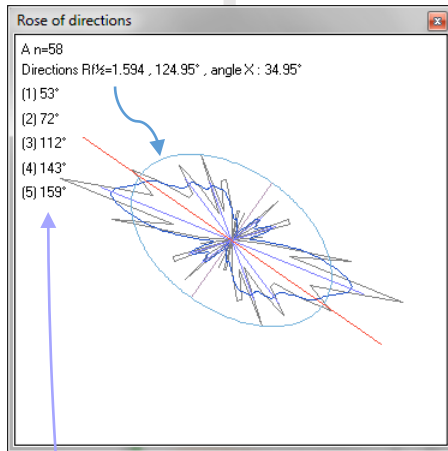
the rake  $\psi$  from X (angle X:) to the long axis  $\alpha$  is 35.98

**Inertia tensor ellipse**, **ellipse of the same surface**, **circle of the same surface**.

# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

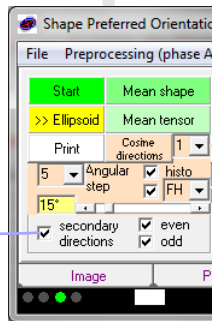


This example show how to plot a graph with line thickness of 2 pixels.



PO

**Cosine direction** displays the rose of direction, a polar histogram (grey line) of the long axis directions. The default angular step (class interval) is  $5^\circ$ . A Gaussian filter is also available with a factor  $k$  (default is 60; orange line). Secondary directions can also be shown with blue lines. They can highlight sub-fabrics. The mean direction is given by the Harvey and Laxton (80) method.  $r$  is the intensity of preferred orientation ***Rf***.



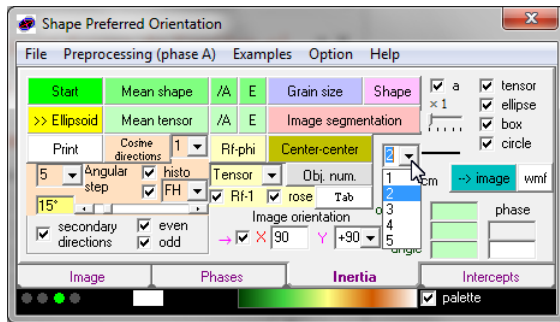
Cosine direction 1: unweighted or weighted by  $D$ : object mean diameter,  $a$ : ellipse long axis,  $r$ : shape ratio,  $a'$ : box long axis or  $r'$ : shape ratio  
Class angular step of histogram :  $5^\circ$  in this example

Robin and Jowett (1985) Gaussian filter angle  $\beta$  Gaussian of histogram FH or calculated from the individual orientations FC

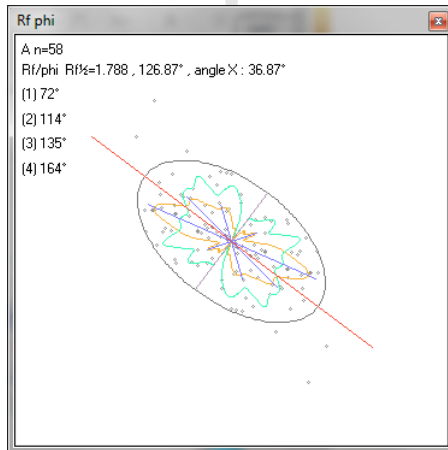
Angular value of  $\beta$  :  $15^\circ$  in this example. Increase with scroll bar.



## Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017



This example show how to plot a graph with line thickness of 2 pixels.

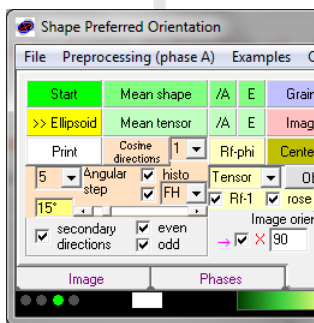


Rose **Rf-phi** (Dunnet, 1969) displays a polar diagram of the shape ratio - 1, so isotropic grains are 0.

The fabric is given by a method similar to the eigenvector (grey ellipse and red line).

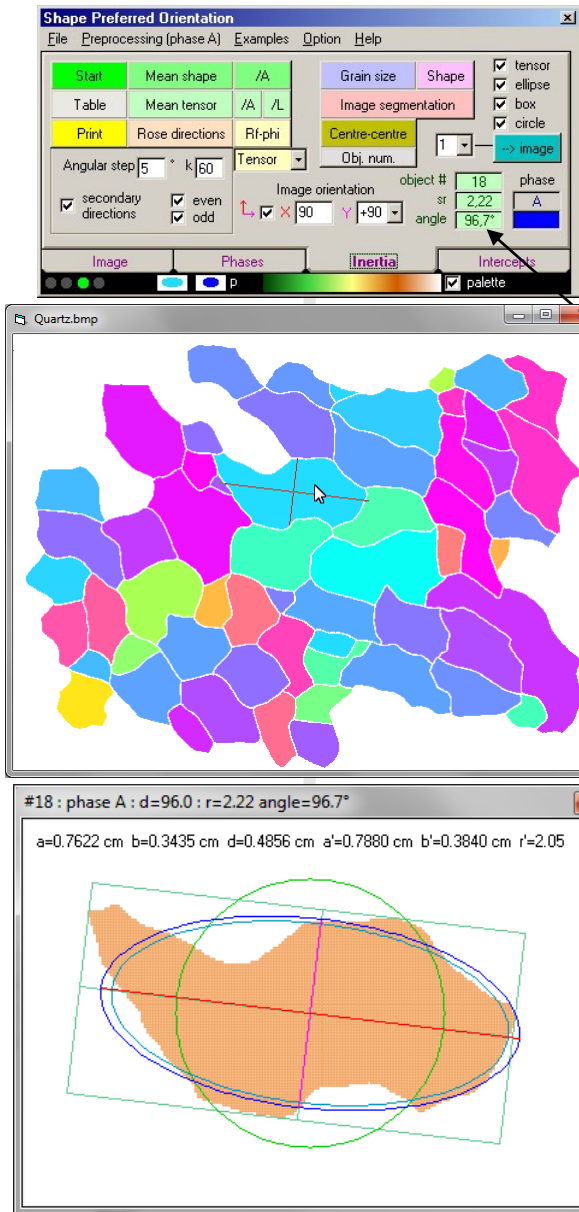
A Gaussian filter is also available and adjustable with k (orange line).

Sub-fabrics can also be shown on the graphic (blue line).



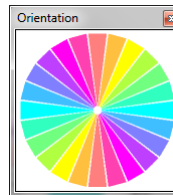
Rf (Dunnet, 1969) calculated from tensor ellipse or box shape ratio with

Rf-1 if checked, idem for rose



By default, the button Start displays the grains with a color code proportional to the orientation.

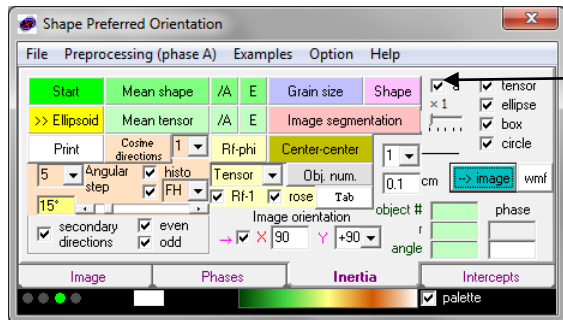
While moving the mouse arrow on the image, 2 lines indicate the orientation of a and b of the current grain. At the same time, its object number, shape ratio (sr) and angle (of a) appears next to the phase id is also shown with its color (phase A blue in this example).



click with right button to copy le scale

By clicking on the grain in the image, the following window pop up. In the window title one can find the object number and diameter d in pixel. You can also read the shape ratio and the orientation of the object. The window contains the length a and b of the inertia tensor (blue), d the diameter of the circle scaled to the object area (green). It also displays the size a' and b' of the box surrounding the object which shape ratio is given by r'.

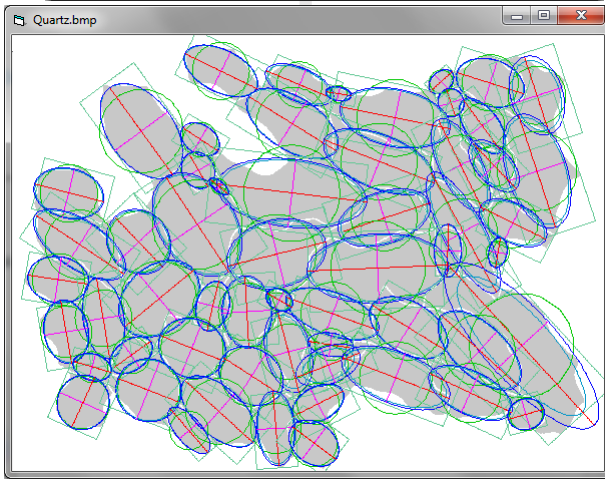
# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017



You can change the length of the **long axis a**  
**short axis b**

Click on **-> image** to plot all optional tensor, ellipse, box and circle on each object.

Click on **wmf** to export all drawing to a windows metafile

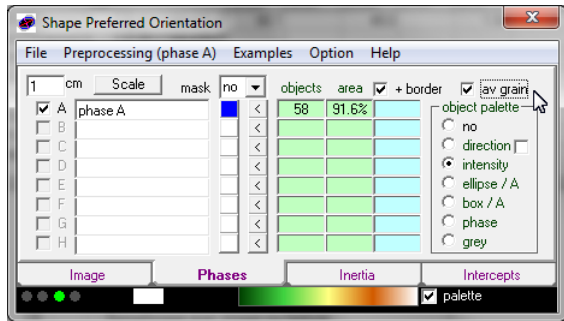


Inertia tensor ellipse, ellipse of the same surface, circle of the same surface and bounding box

Click on **Tab** to display the table of the results and export it with Copy (or cm with a conversion in cm)

Copy	cm	xc	yc	s	d	angle°	a/b	a	b	ellipse/s	Cleft	Ctop	Cwidth	Cheight	radian	xx	xy	yy	a'max	a'min	b'max	b'min	a/b'	code	box/s
mean object				2686	58.48	126.0	1.39	78.70	56.42						2.19878038459296	155.966187554929	40.2810793501623	132.811198649507	80.1		49.0		1.64		81.03
mean obj /A						126.7	1.30	11.02	8.51						2.21095832160721	155.966187554929	40.2810793501623	132.811198649507							
1		207.1	35.4	2527	56.72	116.2	1.88	79.54	42.36	4.72	172	10	77	55	2.02852018233733	340.125818367801	112.315454977811	167.456850737011	39.24	-44.50	25.34	-23.84	1.70	0	62.97
2		475.9	47.2	2455	55.91	107.5	1.50	69.72	46.49	3.69	438	19	74	57	1.8769872507245	288.491322999324	48.5024691286331	150.4001304126	37.24	-37.19	25.84	-26.39	1.42	0	58.36
3		522.5	59.8	2603	57.57	162.0	1.57	81.20	51.88	27.11	488	20	63	86	2.82795860245826	191.436995847901	71.5647569096741	388.873670543858	44.29	-49.18	31.55	-35.47	1.39	0	140.67
4		285.5	49.1	1636	45.64	113.0	2.17	72.67	33.54	17.03	250	27	70	48	1.97211158527251	290.447033733658	93.4092201146573	109.958778940824	31.89	-38.74	19.09	-18.09	1.90	0	60.52
5		427.1	46.0	426	23.29	48.0	1.45	28.51	19.70	3.55	413	32	26	27	0.837582753452302	38.9064779915802	-13.1912208776918	36.1429224801075	14.21	-15.33	9.55	-11.59	1.40	0	46.60
6		127.7	95.4	5453	83.32	143.8	1.64	107.13	65.37	0.86	87	49	84	95	2.51064359446172	423.723741104359	214.460484471456	560.598035682211	59.41	-52.63	34.36	-33.47	1.65	0	39.38

# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017



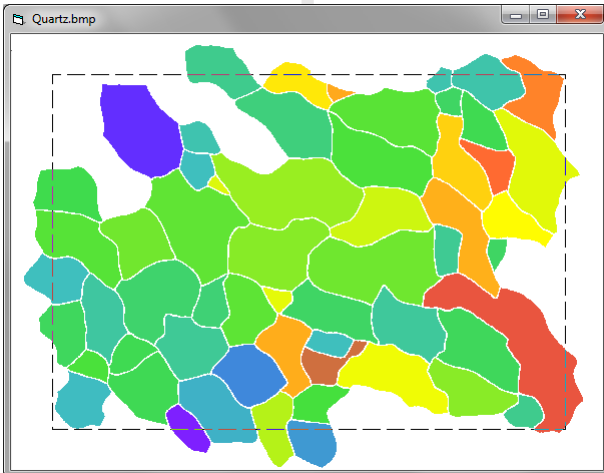
Note the number of objects and the percentage of surface area of the phase A.

The **+** **border** checkbox fill the space between objects.

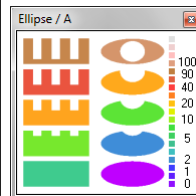
The **av grain** checkbox define a margin proportional to half the object mean size for cutting bias correction.

Both option unchecked would give a modal fraction of 60.4%

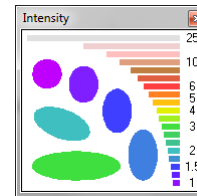
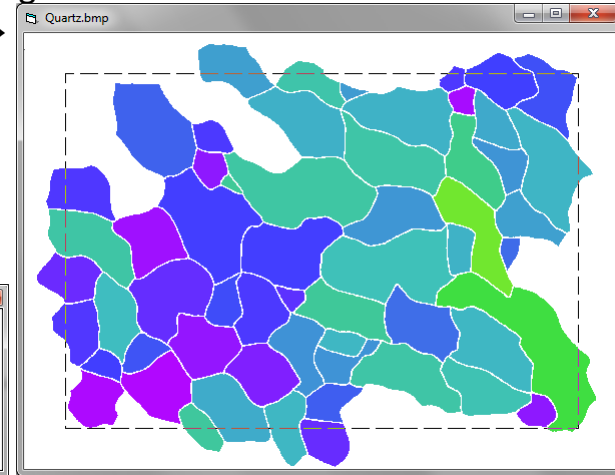
Click on **intensity** for →



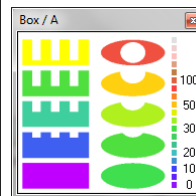
Click on **ellipse / A** to analyze the deviation of each object to the ellipse.



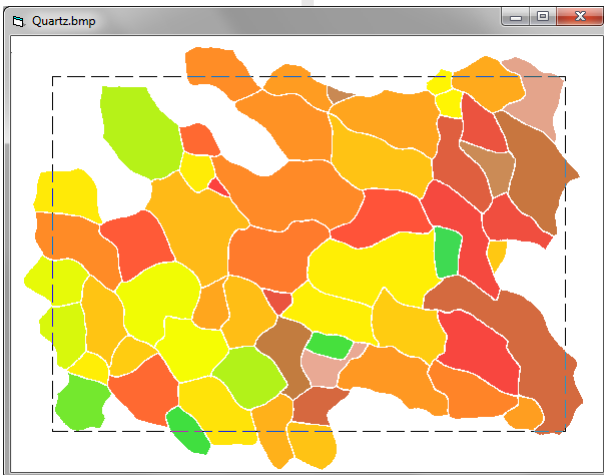
click with right button to copy the scale



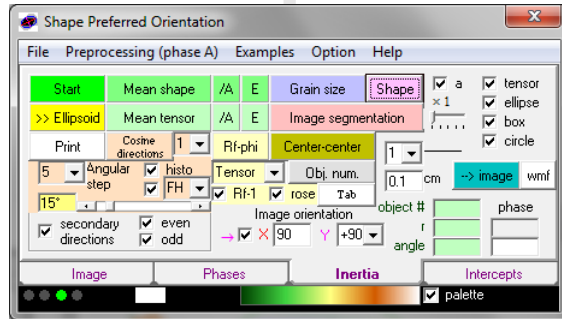
Click on **box / A** to analyze the deviation of each object to its bounding box.



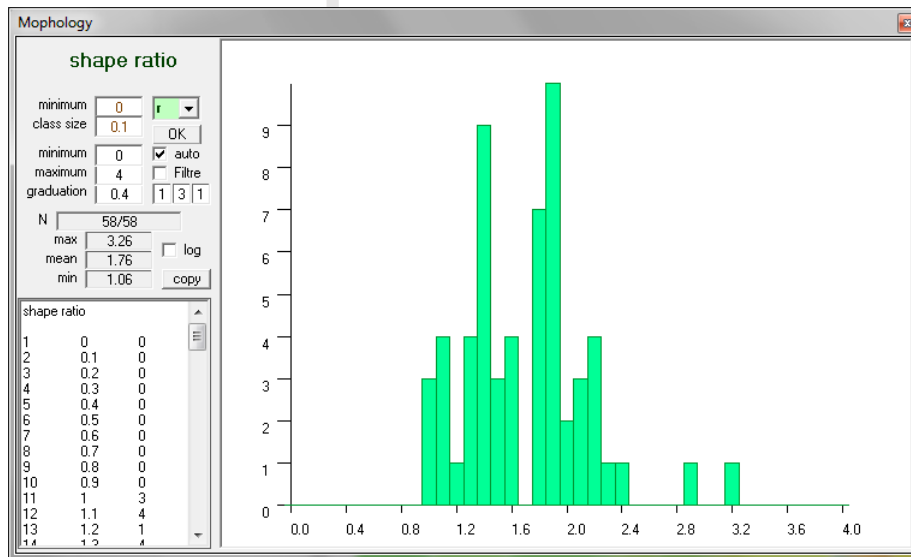
click with right button to copy the scale

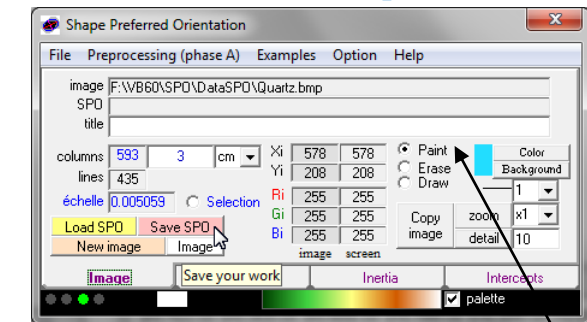


# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017



One can also analyze the grain's shape ratio distribution with the button Shape

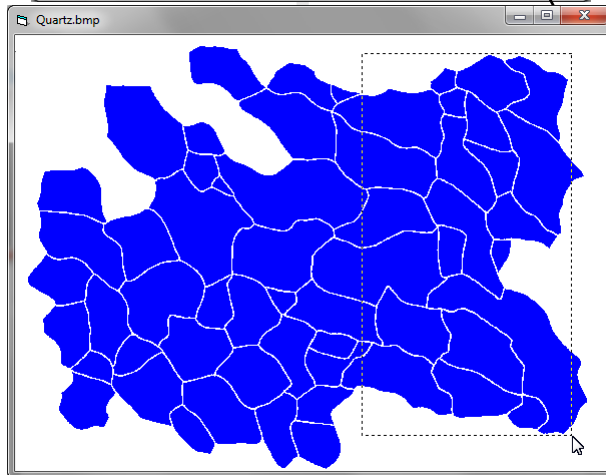




#### 4 Save your work

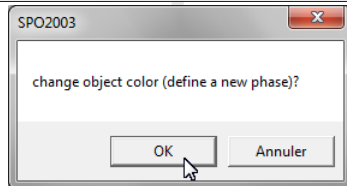
Write title and set the image width in cm  
(for example 3 cm / 593 pixels = 0.005059 cm/pxl)

Save your work in a **Save SPO** file and loaded it again with **Load SPO**.

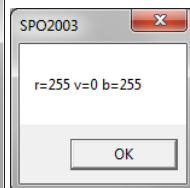
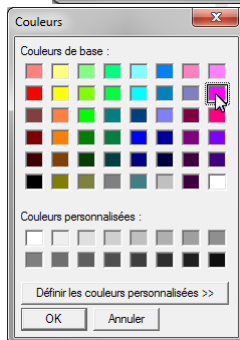


#### 5 How to define a new phase

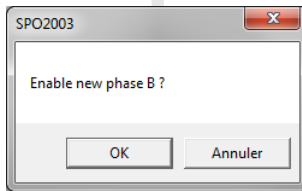
While the tab **Image** is active and while the check box **Paint** is on, press the mouse left button and drag the mouse on the image as shown.



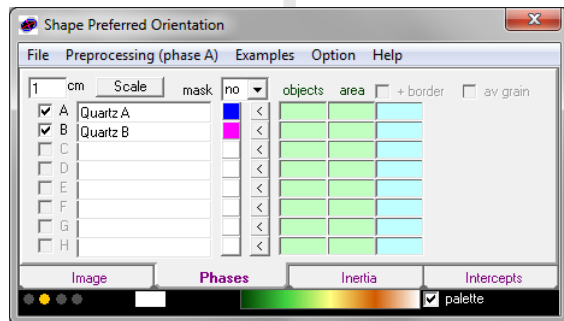
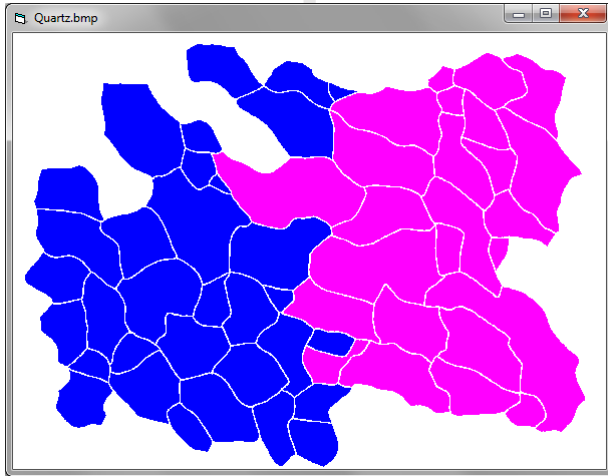
release the left button and click on OK



select the color and press OK two times

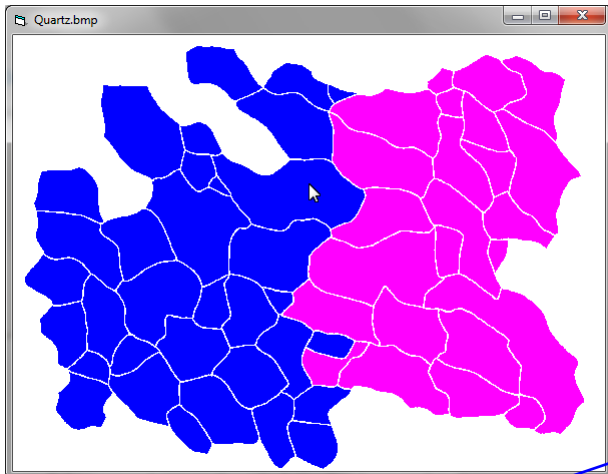


press OK to define a new phase

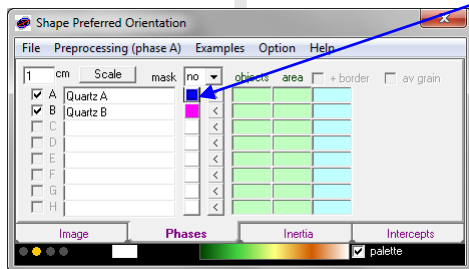


and name it as shown here

The light is orange because the image change and the inertia tensor calculation should be run again.

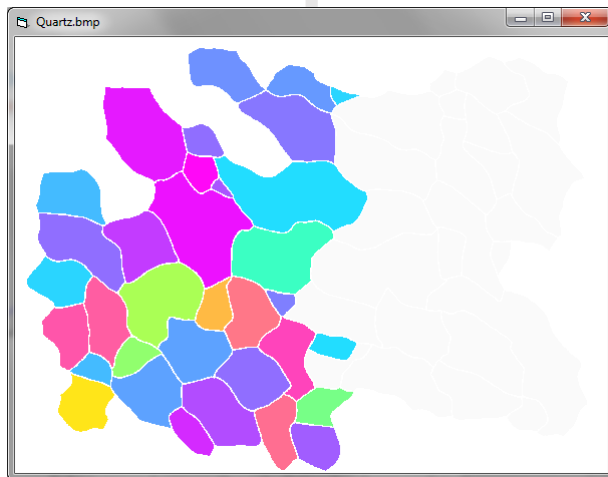


You may also change the color of one grain. For example, select the color of Quartz A with a left click on the (blue button) and click on the grain with the right button of the mouse to paint it in blue as shown here

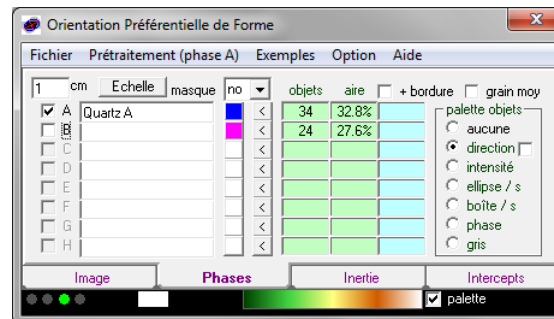


## 6 Phase selection

When 2 phases are defined, you can visualize one or both by using the selections as shown bellow



light is green because the calculation has been updated





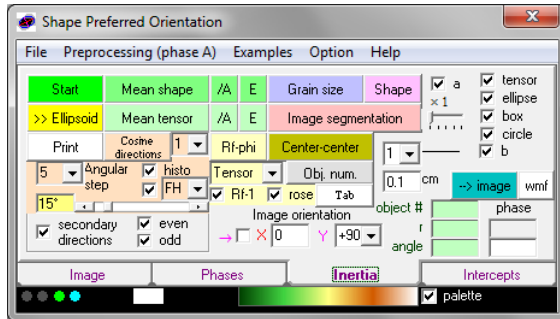
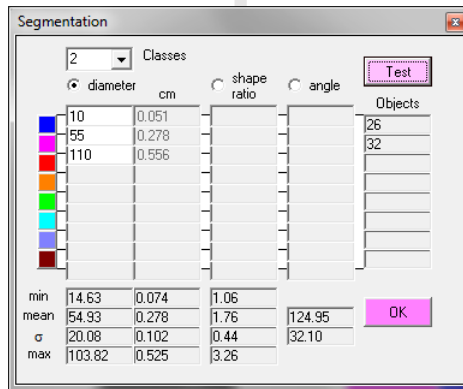


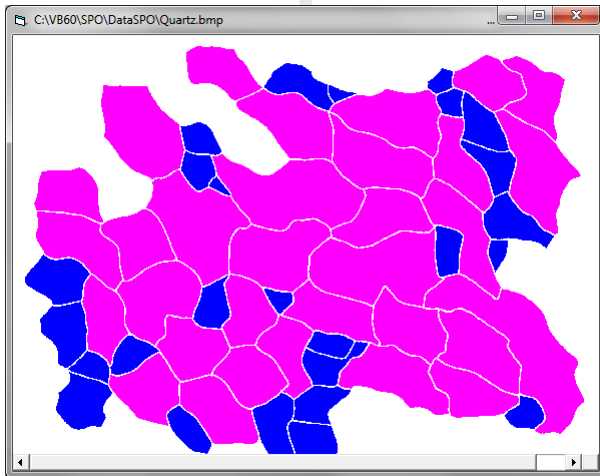
Image segmentation can also be used to divide the objects in sub-populations.



In this example objects are separated in 2 classes of diameters :

1. Blue from the minimum value to the mean value
2. Magenta from mean value to the maximum value

Click on Test to visualize the segmentation before its validation by a click on OK



The selection is possible on diameter, shape ratio or angle.

## 7 Intercepts

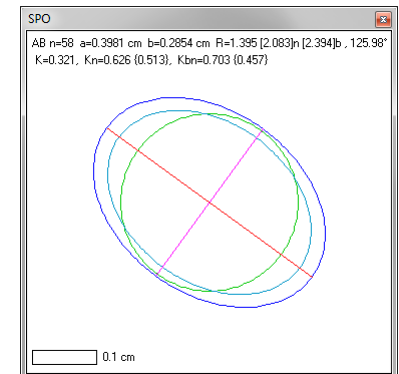
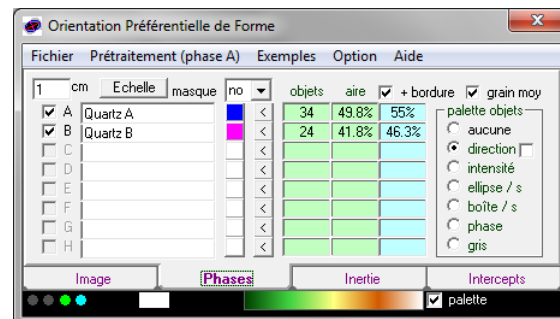
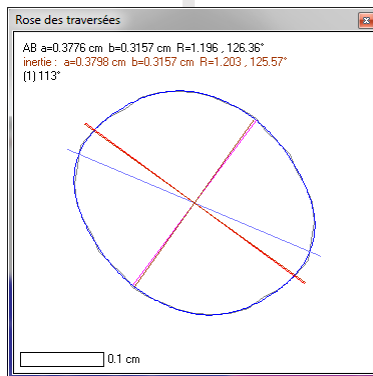
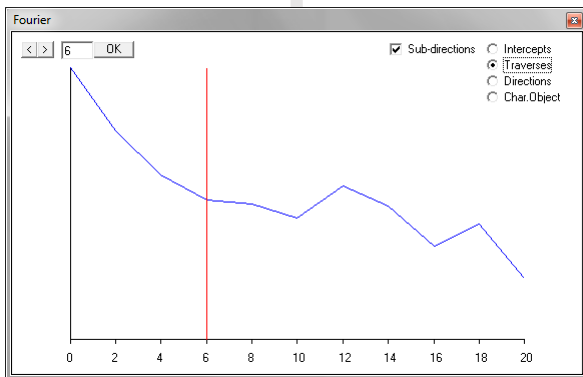
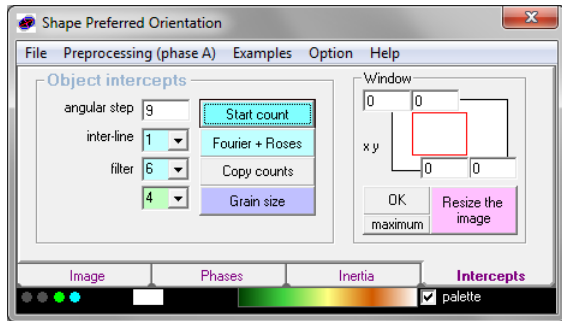
Calculation after inertia : each grain has a specific code (ranging from 0 to 16000), thus there is no minimum distance between grains. The minimum distance is given by the size of the filter (it is  $6/2=3$  pixels in the following example).

You may change the angular step as presented below and click on **Start count**.

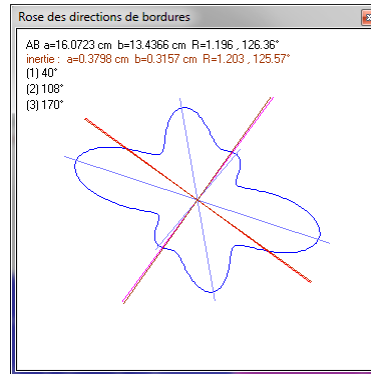
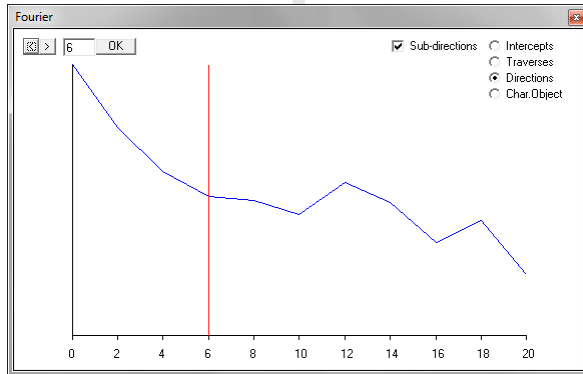
The green light means that the grains have been identified during the inertia calculation. A cyan light appears at the end of the intercepts calculation.

The power spectrum windows of the Fourier series automatically pop-up at the end of the calculation. You may increase the harmonic number with button >.

The inertia tensor results printed in violet in the rose of traverses is calculated on intercepts and should not confused with the main inertia tensor analysis on object surface areas.

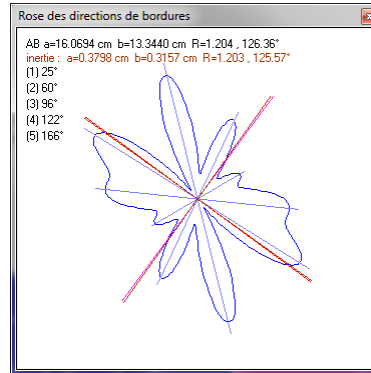
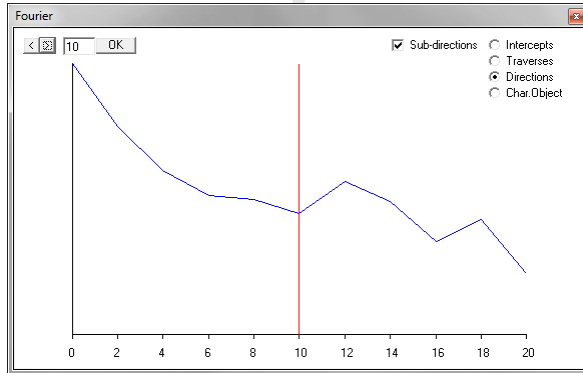


# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

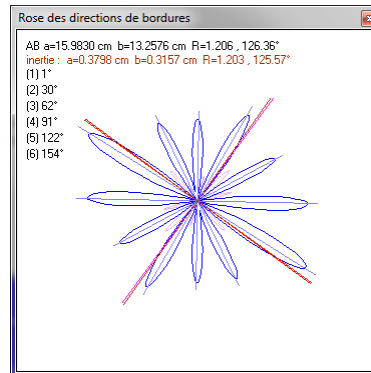
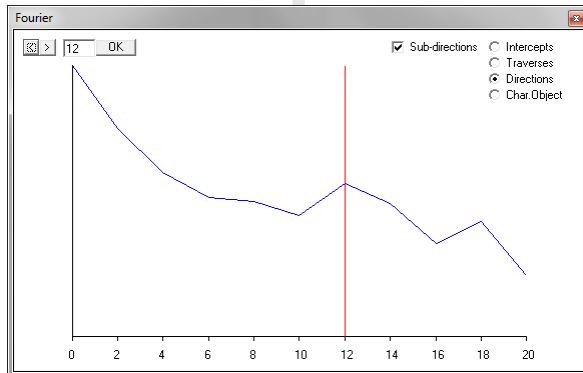


You may increase the harmonic number or number of Fourier component with the button >

The rose of direction is available

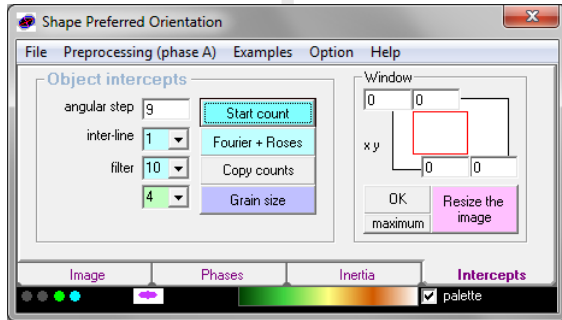


The sum of the Fourier components up to 10 gives the optimal display

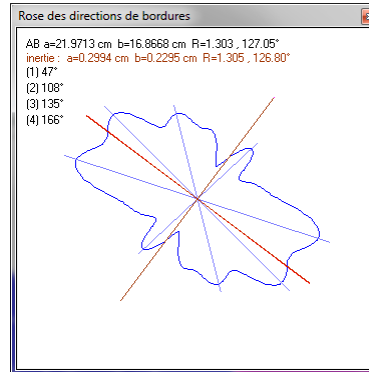
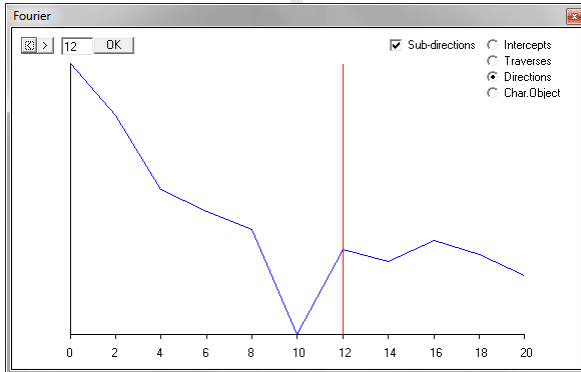


The high component 12 is quite noisy when using an intercepts counting filter of 6 pixels

# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

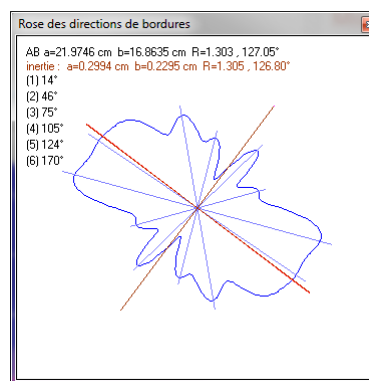
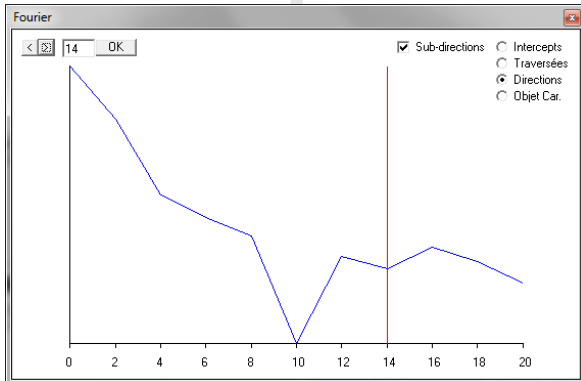


The use of a larger filter of 10 pixels reduce the noise

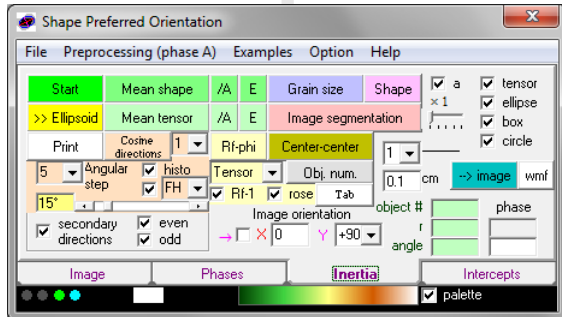


You may decrease the number of Fourier components with the button <

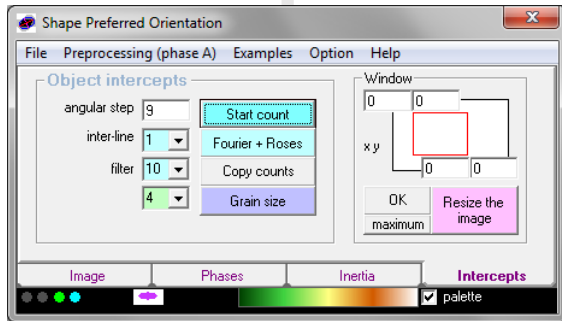
The Fourier component 12 is OK with a filter of 10 pixels



But the Fourier component 14 optimizes the rose of directions.



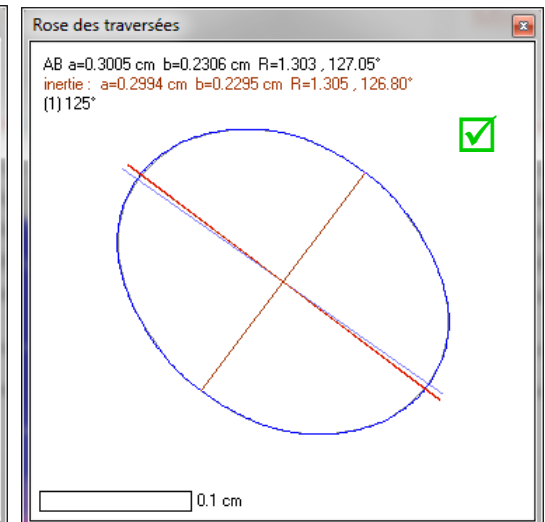
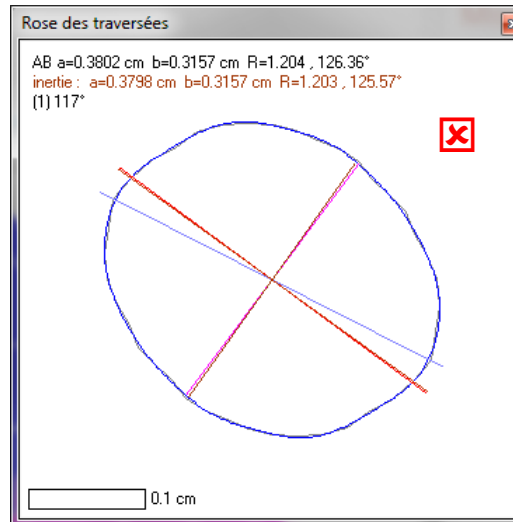
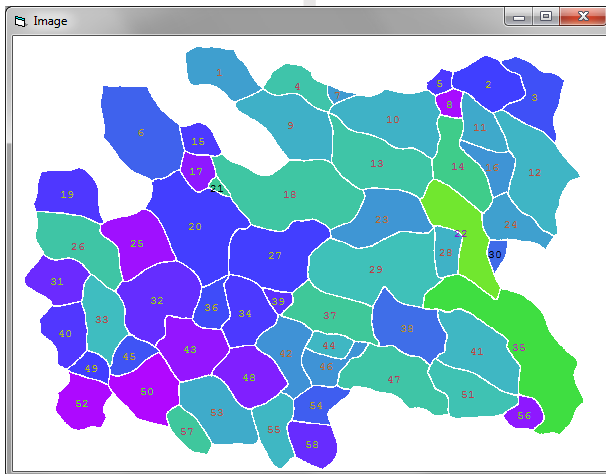
Click on Obj. num. to print the order number of each object in its gravity center

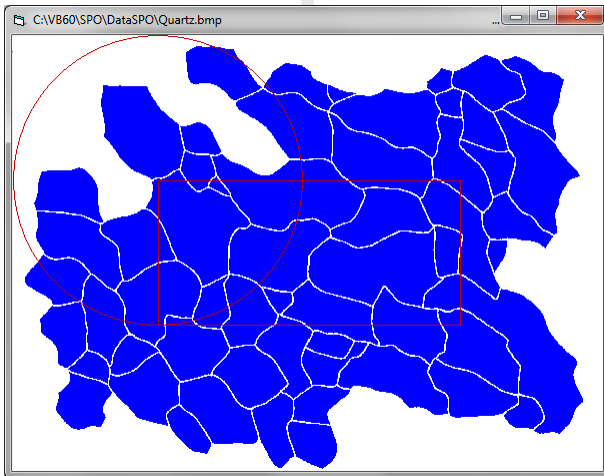
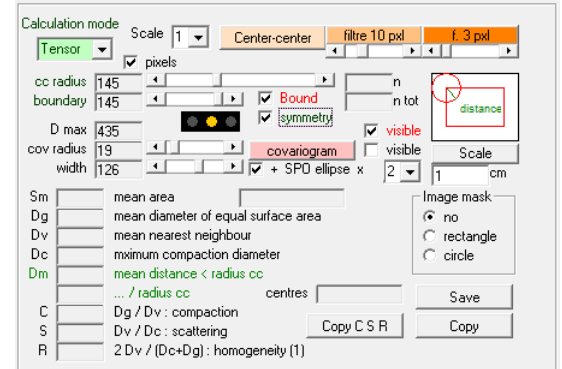
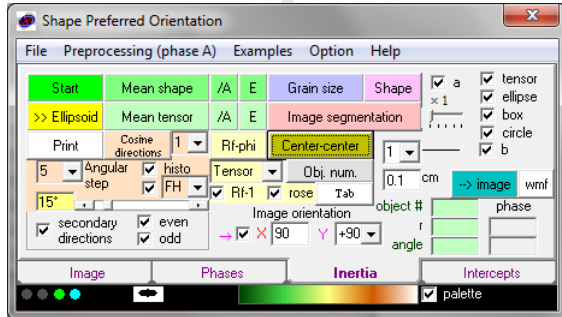


The last version of intercepts method of SPO2003 considers that each object is on an independent plane. So there is no more spatial resolution limit of detection between objects close to each other. **Its is then recommended to use the best intercepts counting filter (see also course 2 p. 10).**

Intercepts filter of 6 pixels

Intercepts filter of 10 pixels





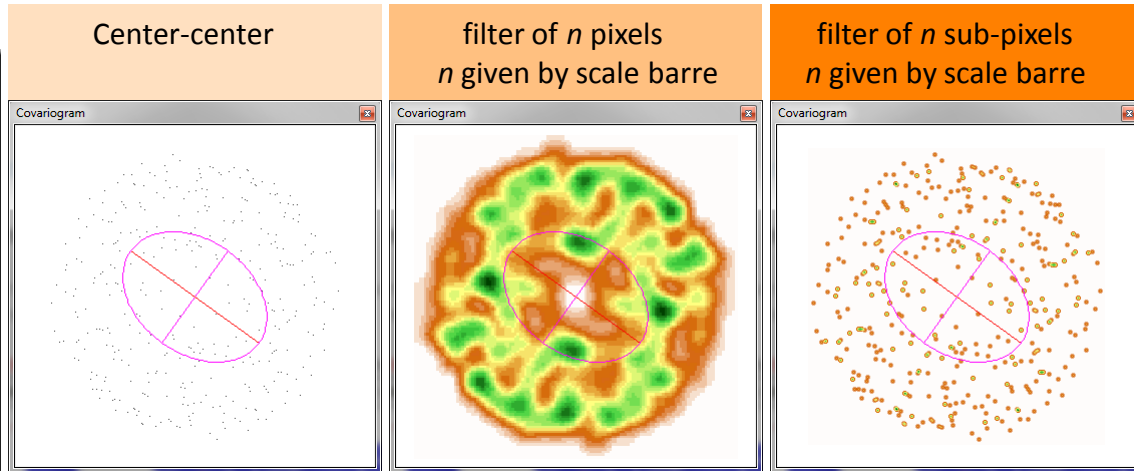
## 8 Center to center analysis

Center to center and Fry diagram works only with the inertia tensor method

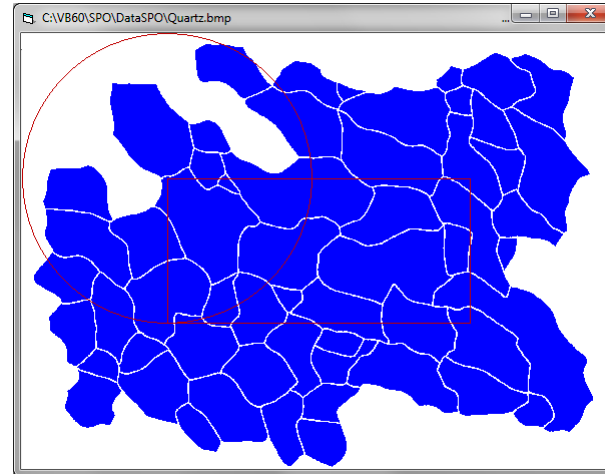
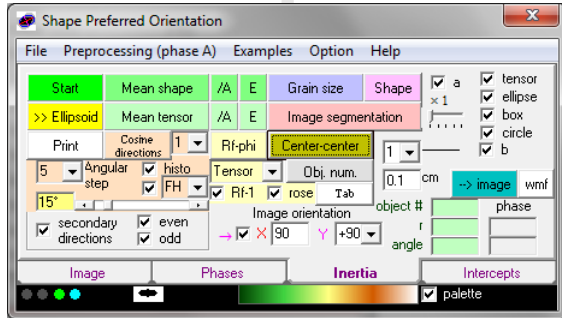
Check **Bound** to automatically adjust the size of the area of first centers and the radius of the disk of second center search.  
Check symmetry to invers the selection between first and second center.

Different smoothing filter are available to facilitate the analysis of objects spatial distribution.

Check + SPD ellipse x 2 to print it in magenta on the diagram.



# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017



Click on covariogram for the calculation of compaction, scattering and homogeneity parameters.

Calculation mode

Tensor Scale 1 Center-center filtre 10 pxl f. 3 pxl

pixels

cc radius 145 boundary 145  Bound 12 n  distance

D max 435  symmetry 58 n tot

cov radius 19  covariogram  visible Scale

width 126  + SPO ellipse x 2 1 cm

Sm 3480.3 mean area

Dg 61.1 mean diameter of equal surface area

Dv 41.1 mean nearest neighbour

Dc 68.3 mximum compaction diameter

Dm 100.7 mean distance < radius cc

0.694 ... / radius cc centres 452 Save

C 1.487 Dg / Dv : compaction Copy C S R Copy

S 0.602 Dv / Dc : scattering

R 0.635 2 Dv / (Dc+Dg) : homogeneity (1)

Image mask

no

rectangle

circle