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

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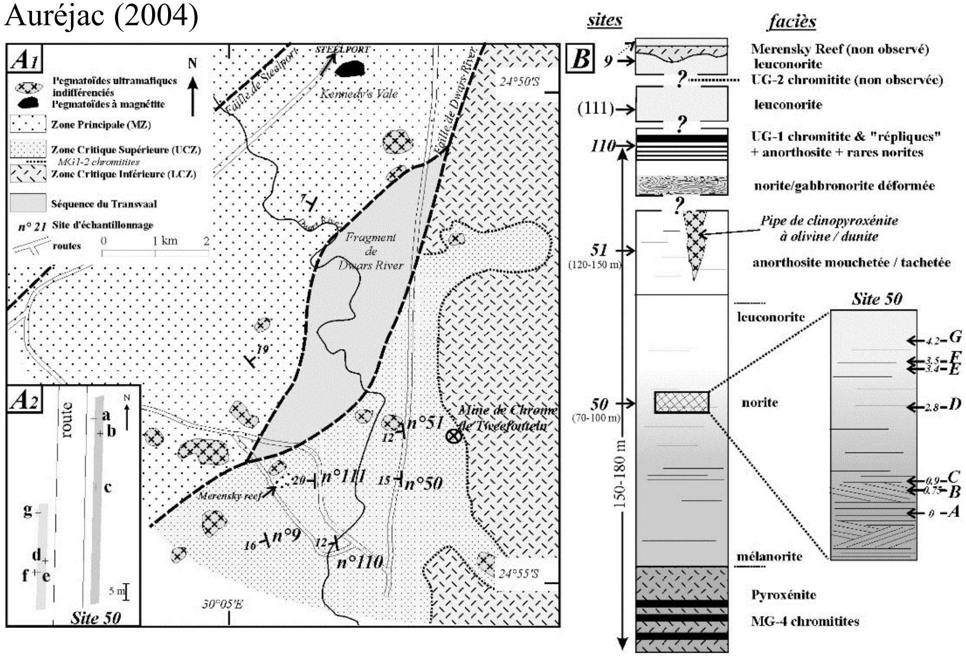
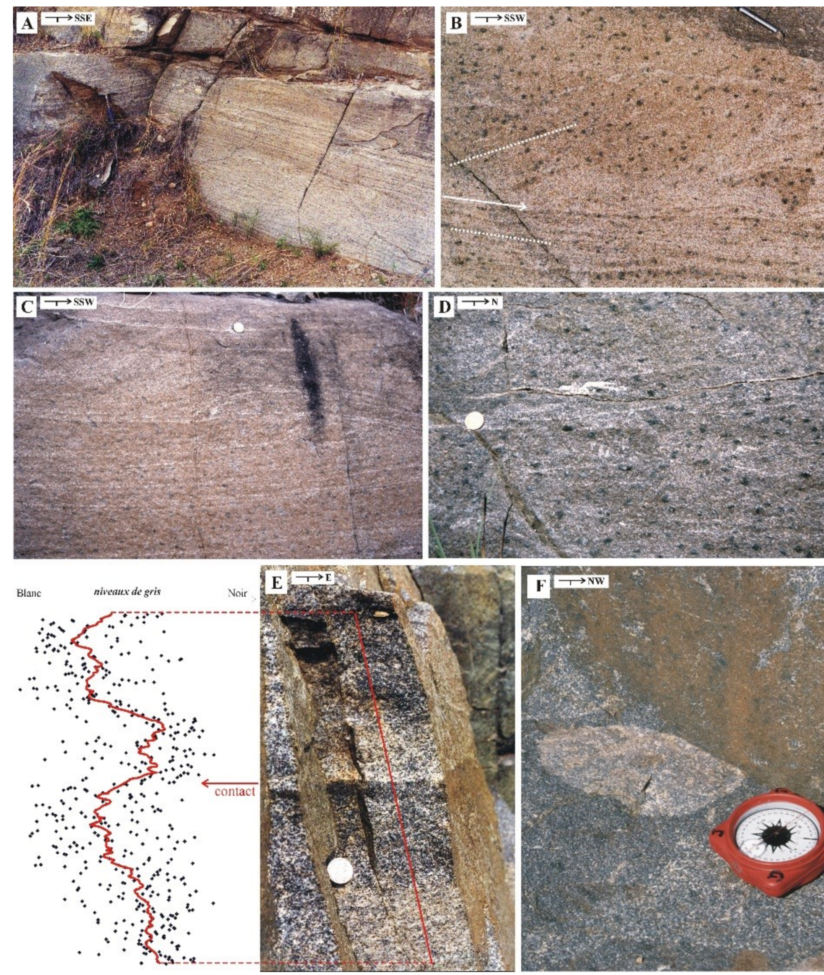
This application uses a set of images of the site 50B from J-B Auréjac (2004) thesis and Auréjac et al. (2003) poster. It is a step by step tutorial of SPO2003 and Ellipsoid2003 programs from 2D images orientation to 3D ellipsoids calculation with useful warning.

Auréjac (2004)



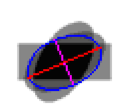
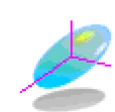
Bushveld East lob Site 50 Auréjac (2004)



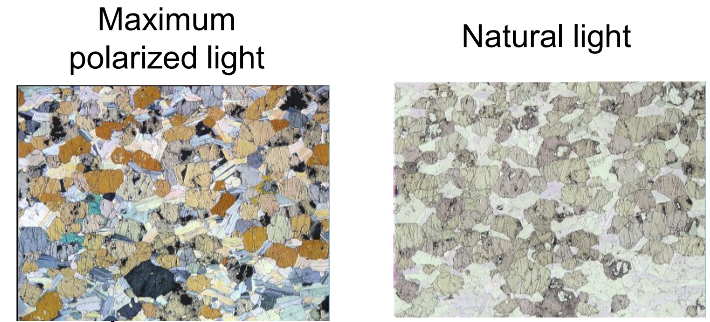
Auréjac, J.-B., 2004. Etude pétrostructurale de gabbros lités de la Zone Critique Supe´rieure, Complexe du Bushveld (Afrique du Sud). Thèse de doctorat, Université Paul Sabatier, Toulouse, France.J.B. Aurejac, P.

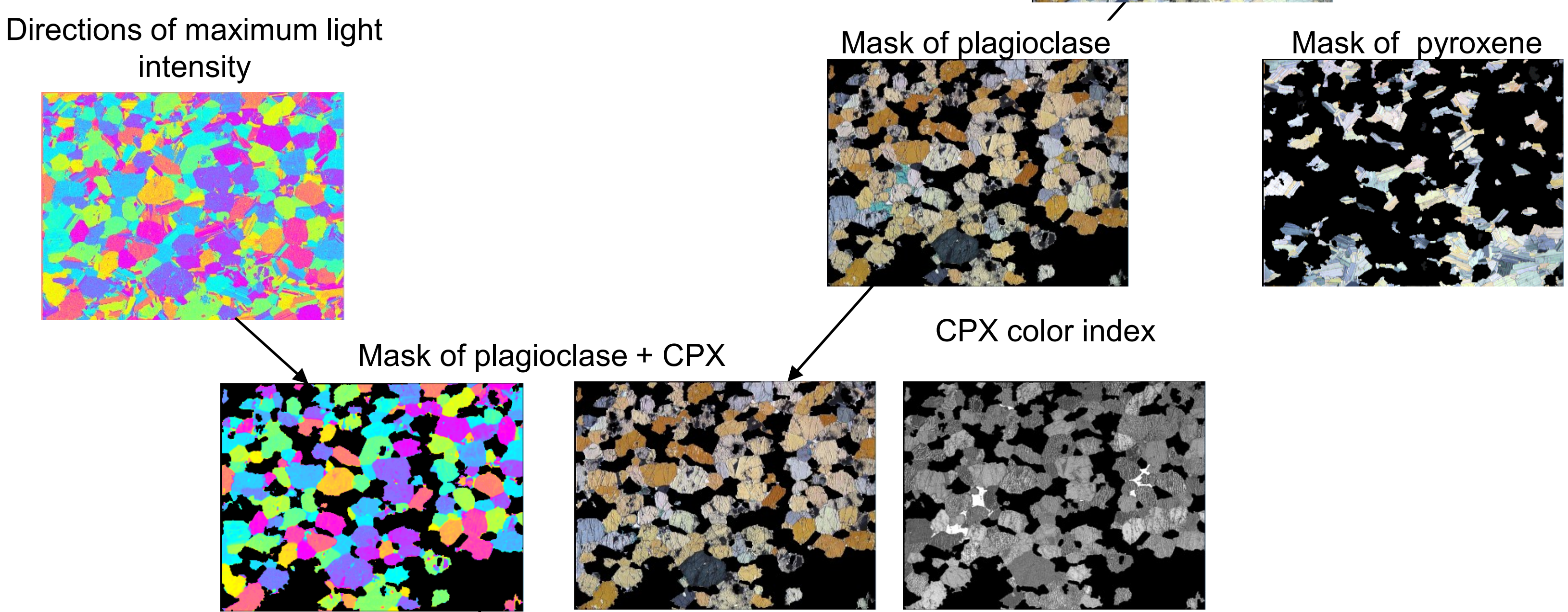
Launeau, J. Girardeau, J.L. Bouchez (2003) "New Textural constraints on the origin of layered igneous cumulates: the Bushveld Complex case". EGS - AGU - EUG Joint Assembly, Nice, France, April 2003

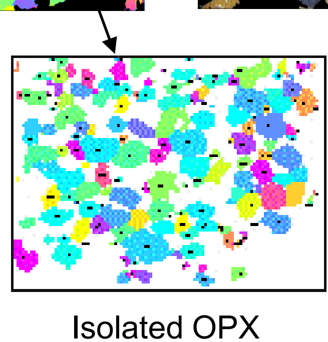
J.B. Auréjac, P. Launeau, J. Girardeau and J.L. Bouchez (2001) "Evidences for a dynamic formation of the layering in the Eastern Upper Critical Zone, Bushveld Complex, South Africa". EUG XI, 8-12 april 2001, Strasbourg.

The minerals identification in thin section used the F. Fueten and Goodchild (2001) rotating polarizer stage allowing the identification of orthopyroxene (opx) as summarized in this sketch.

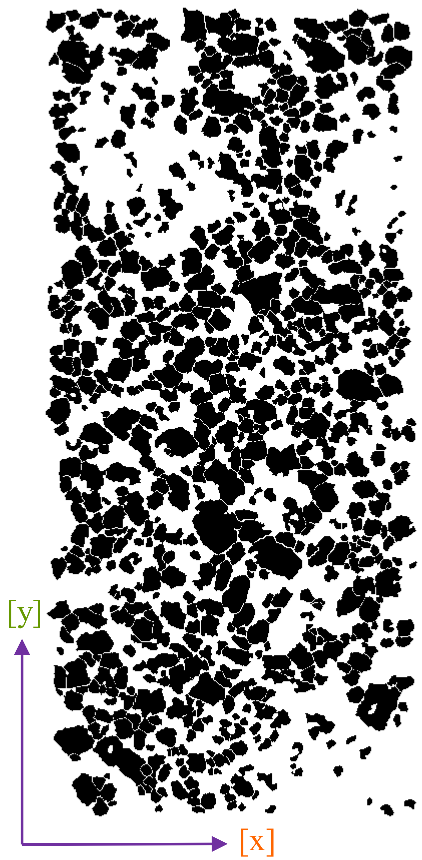




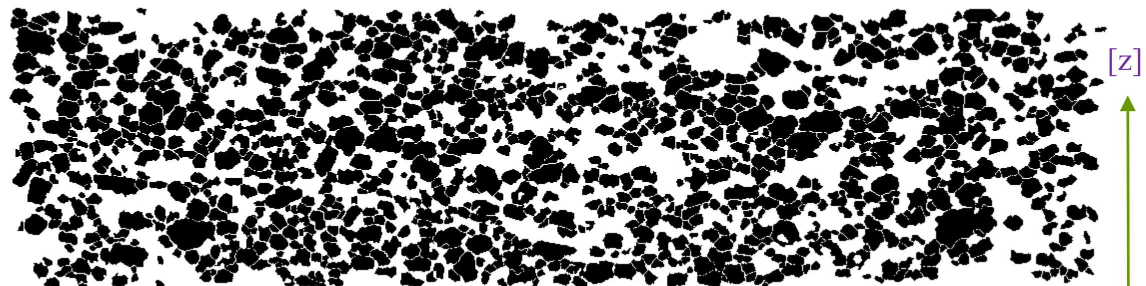


A computer-controlled rotating polarizer stage for the petrographic microscope. Computers & Geosciences, 23, 203–8. *Fueten*, *F.* & *Goodchild*, J.S. (*2001*)

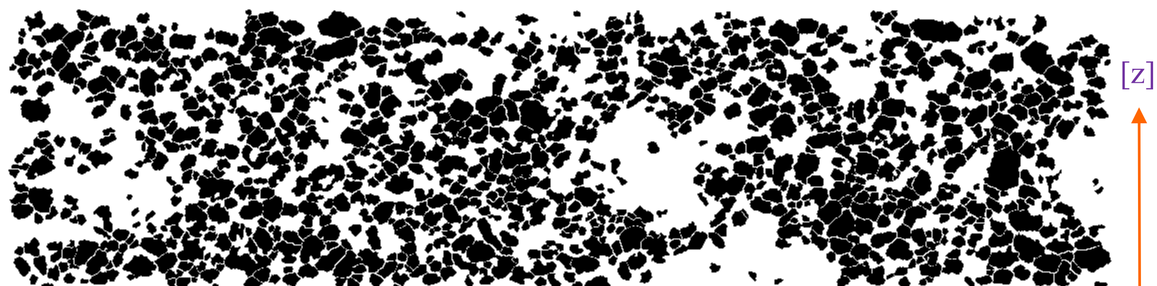
The set of images is composed of 3 perpendicular thin sections taken on the block sample 50B. All orthopyroxene (opx) crystals were classified and segmented by Auréjac (2004). This set of images was reprocessed with the new version of SPO published in 2005 with 9 masks of measurement (see course 6 p 10 and Launeau and Robin (2005)).



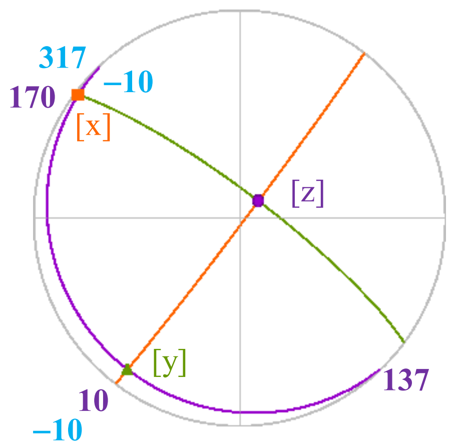
Block sample (xy) relative orientation is 0 / 0



Block sample (xz) relative orientation is 0 / 90



Block sample (yz) relative orientation is 90 / 90

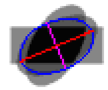


Initial block sample orientation is 0 / 0 / 0

Geographic block sample orientation is **317 / -10 / -10**
137 / 10 / 170

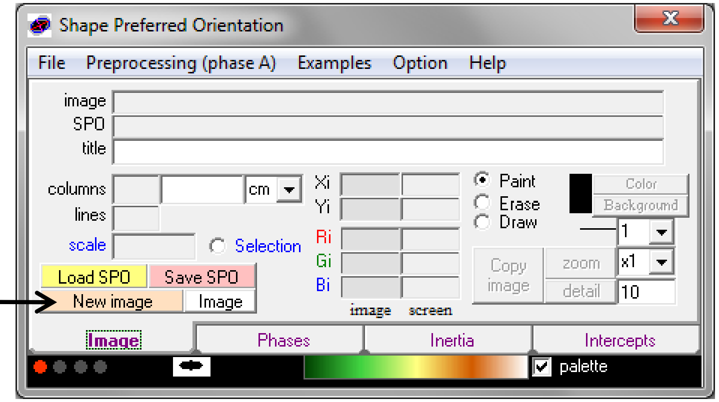
The (xy) top of the block sample was tilted upwards by 10° which is −10° in the NED convention. It is all right here while signs are not forgotten. We will see at the end of this application that orientations will be converted with a warning about the upward negative orientation of [y].

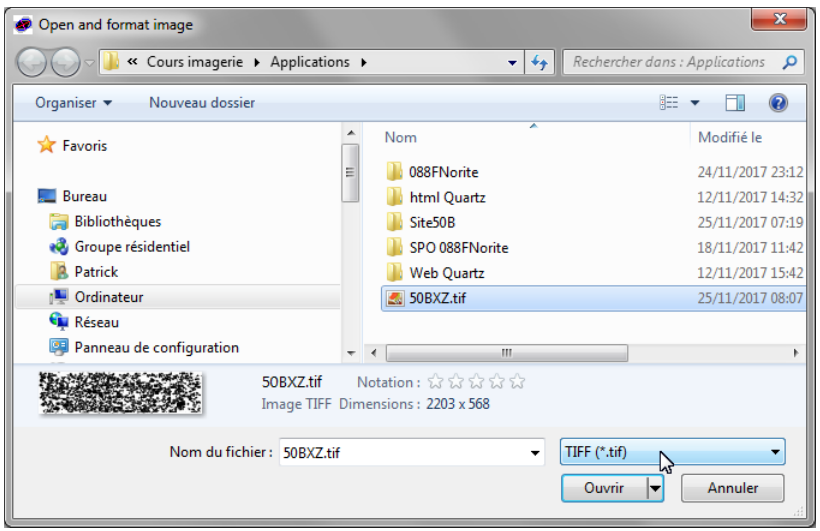
Let now start the program SPO2003

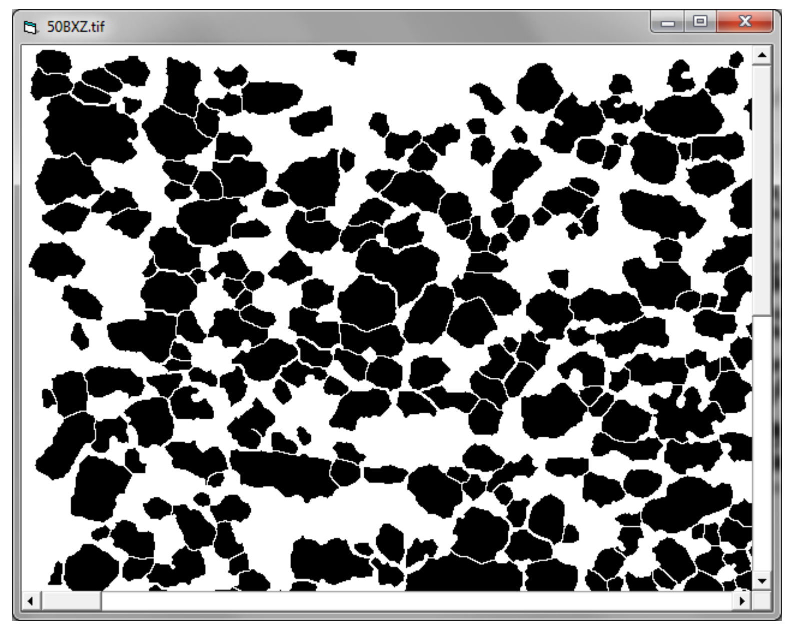


And click on the “New image” button

A standard dialog box appears for the selection of the bitmap image on your system.
By default it starts on bitmap (*.bmp) files, but you may select instead Jpeg (*.jpg), GIF (*.gif) or TIFF (*.tif) files.
After the validation of your file the image appears in a new window.



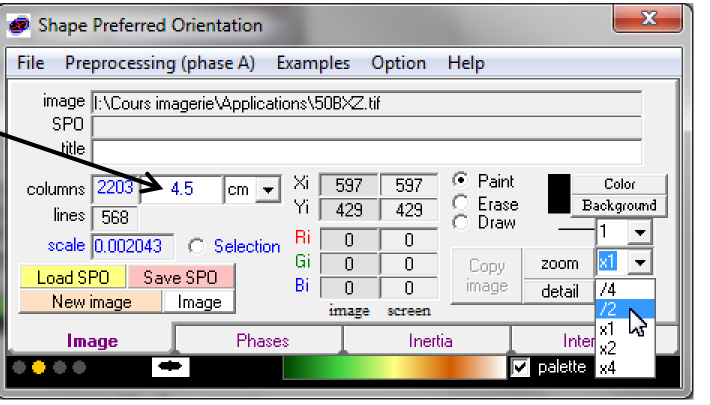


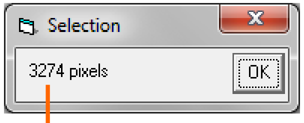


First, type the size of the image width : 4.5 here and click enter to visualize the scale. Select also the unit : cm.

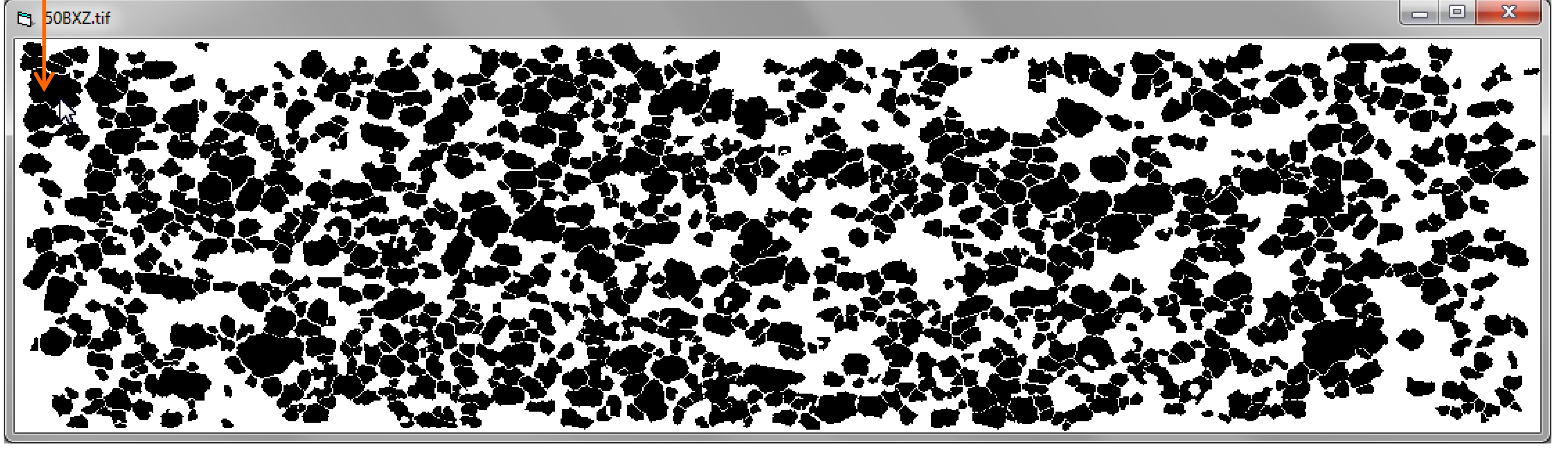
You may zoom back on the image to visualize its full area like in this example with a magnification divided by 2.

Then click on one opx to select its color code. Default is black RGB(0, 0, 0) but any color can be used with the exception of the RGB(255,255,255) white reserved for the background making future impressions or windows metafiles building easier.

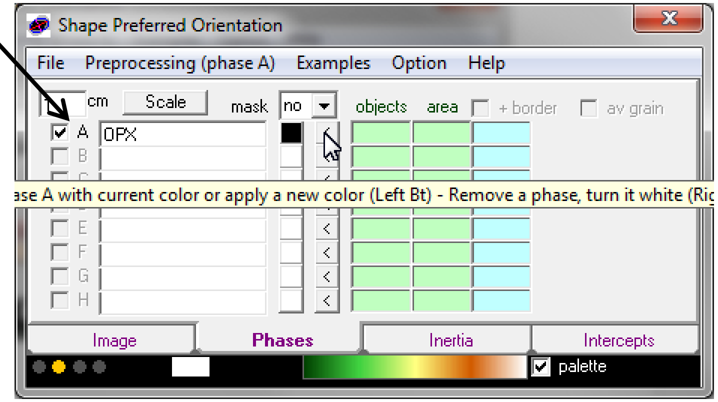


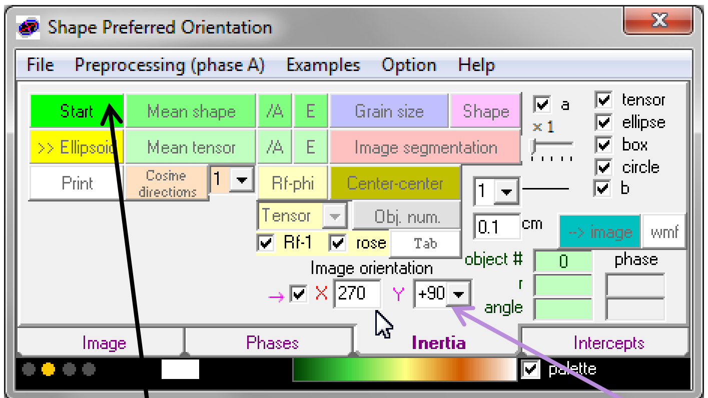


The program automatically looks for all neighboring pixels and a window pop up with their count.



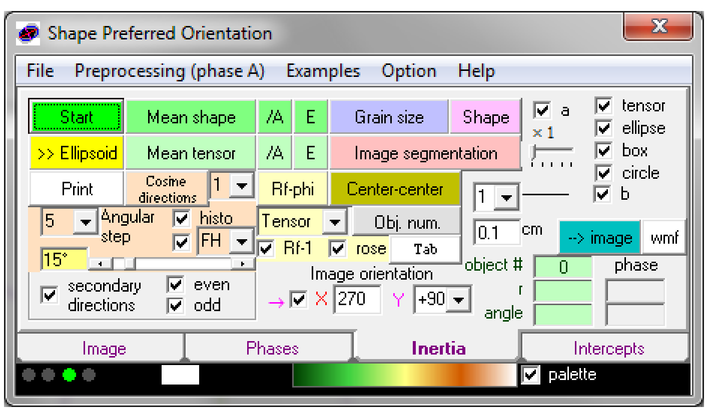
You are now ready to enter the selected color of the phase A
Add eventually a caption: OPX
Click with left button on the < button. A right click on the same button would delete the image phase or class.

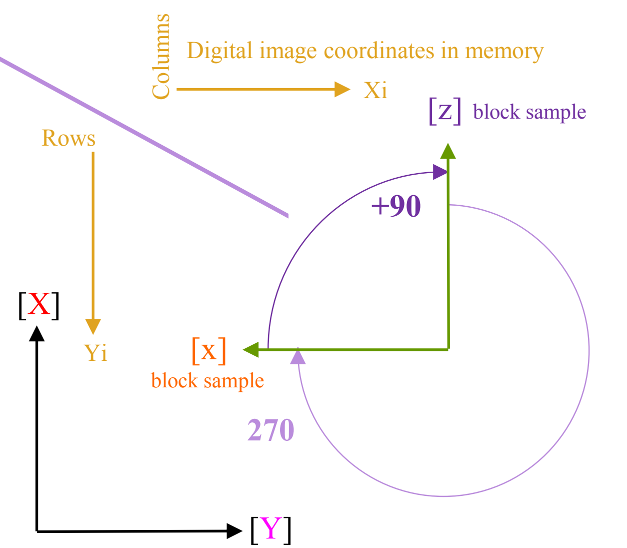




Select tab Inertia and enter the image internal orientation.

You can now click on Stat button.
This activates the other buttons allowing different processing.



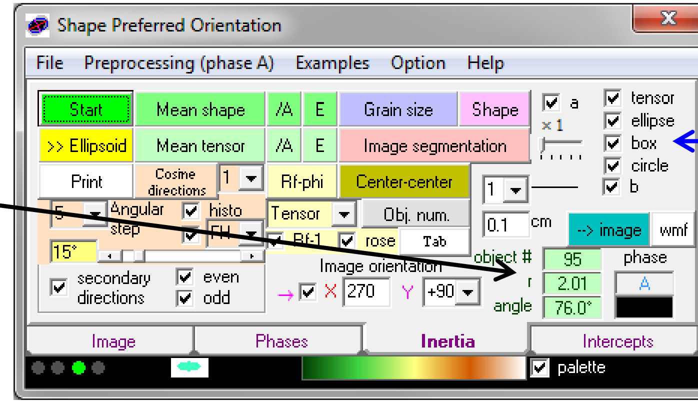


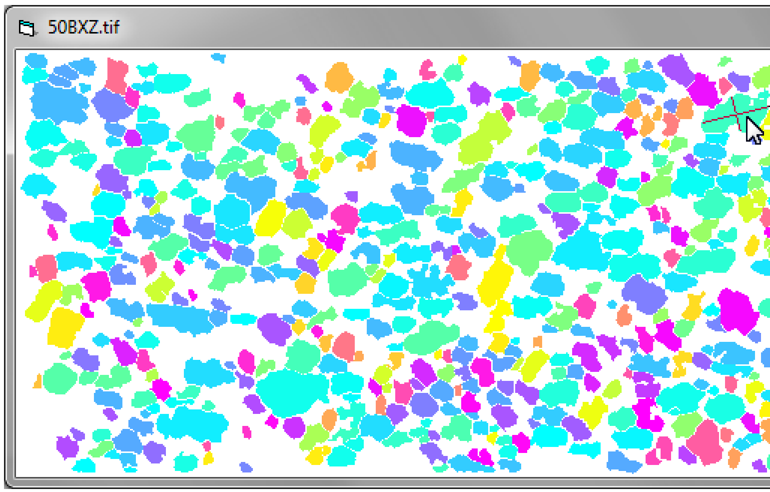
Warning about orientations

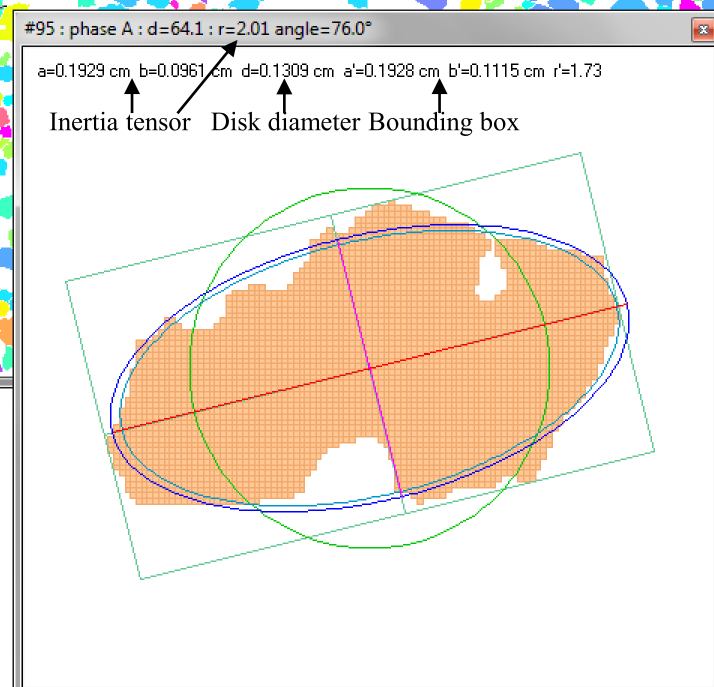
Default internal image orientation 0 / 0 / 0 compatible with NED

Each opx crystal now has a color code of orientation. Moving the mouse pointer on it allows to visualize object number #, shape ratio r, default image orientation angle, phase/class letter and associated color here

A click on one object pop up a new window focused on that object with results display.



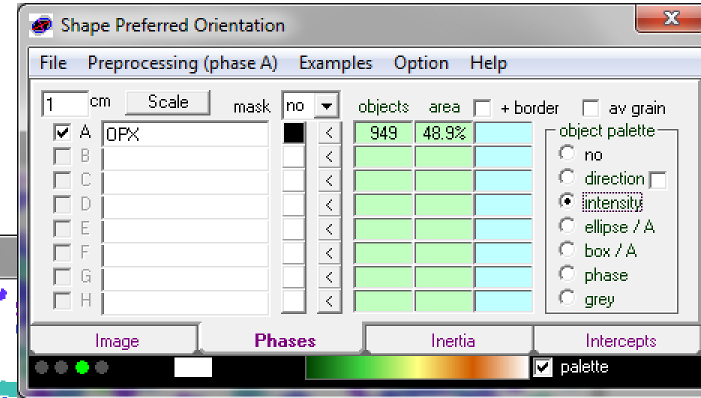


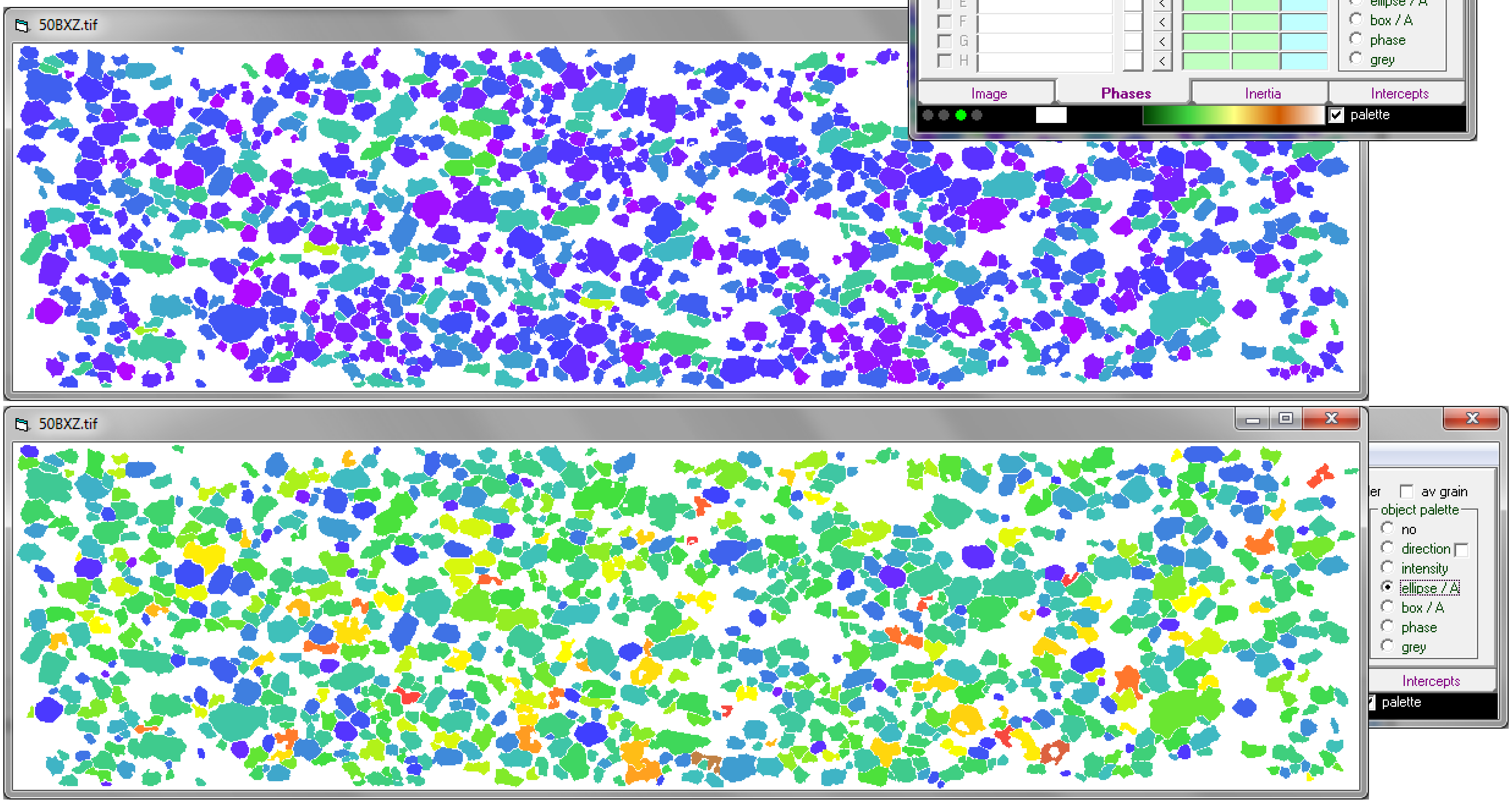


Inertia tensor ellipse,
Ellipse of the same surface,
Bounding box,
Circle of the same surface,
Short axis B, and
Long axis A are selectable.

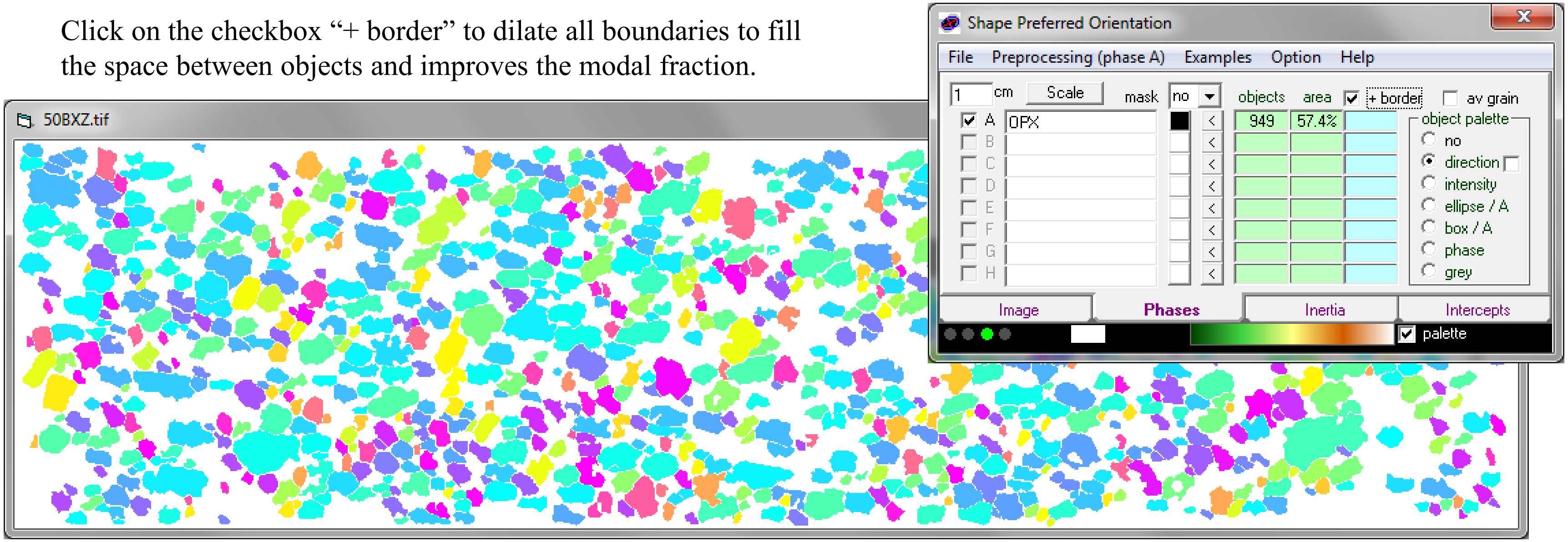
Click on tab “Phases” to change the color code.

All cut objects have been erased for inertia tensor calculation so modal fraction are biased by missing areas. The thickness of the boundaries between objects also biases that modal fraction.

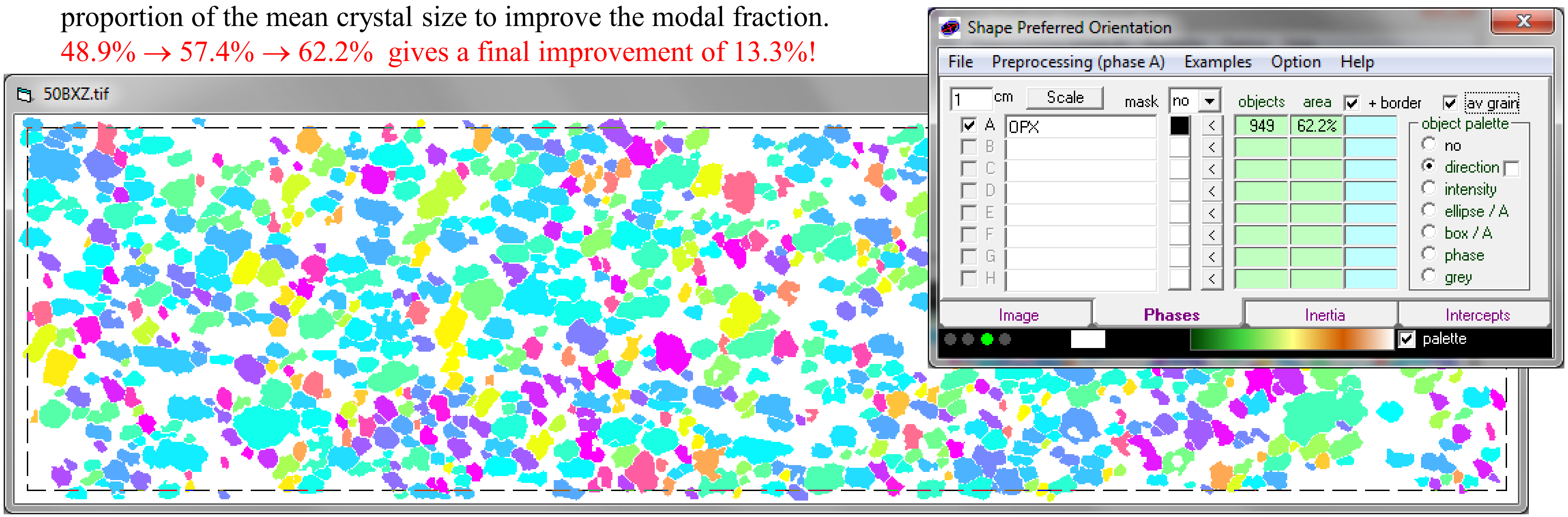




Click on the checkbox “+ border” to dilate all boundaries to fill the space between objects and improves the modal fraction.

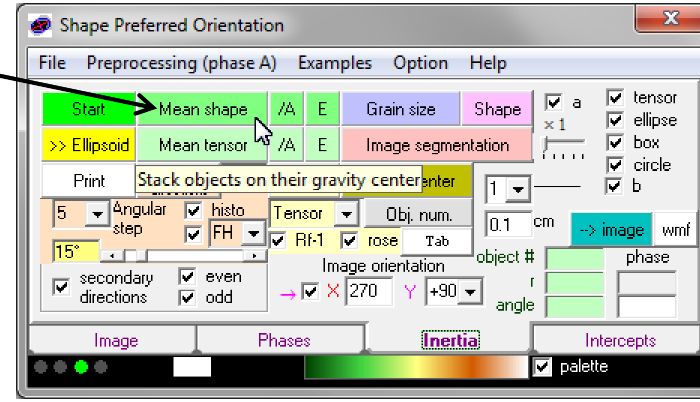


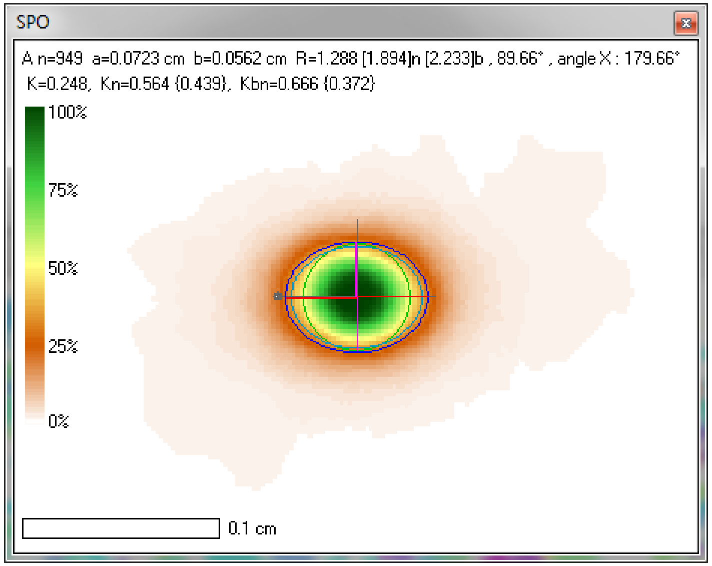
Click on the checkbox “+ av grain” for the correction of the area in proportion of the mean crystal size to improve the modal fraction.
48.9% → 57.4% → 62.2% gives a final improvement of 13.3%!



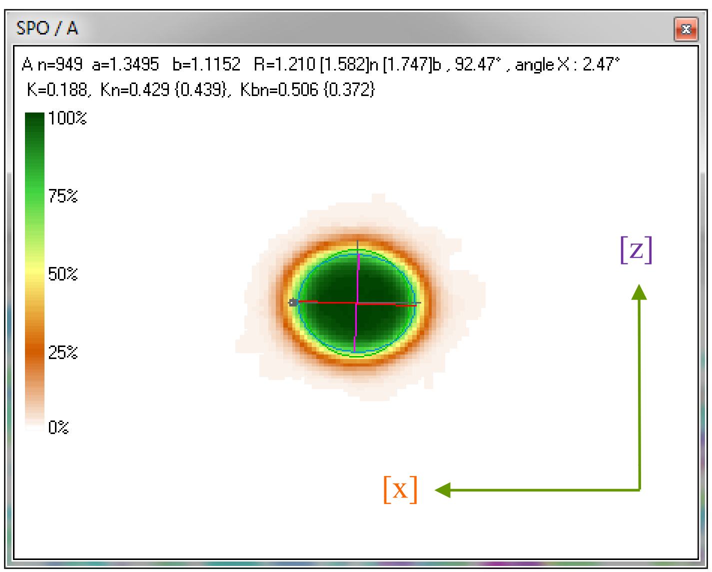
Dash line = mask of unbiased modal fraction calculation

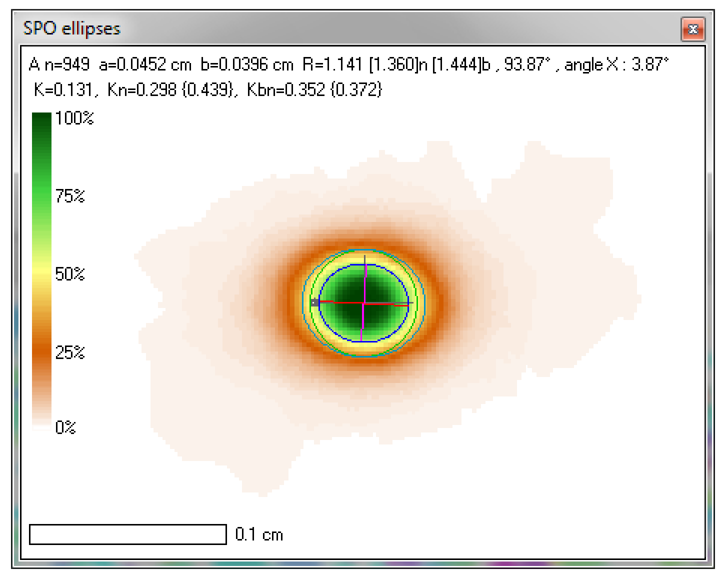
Go back to Inertia and click on "Mean shape" to visualize it.





One click on button "/ A" calculates the mean shape of crystals weighted to their surface area giving results without scale (left below) and one click on button "E" replaces each inertia tensor by its corresponding inverse shape matrix for the calculation of mean shapes proportional to the smaller crystals (right below).



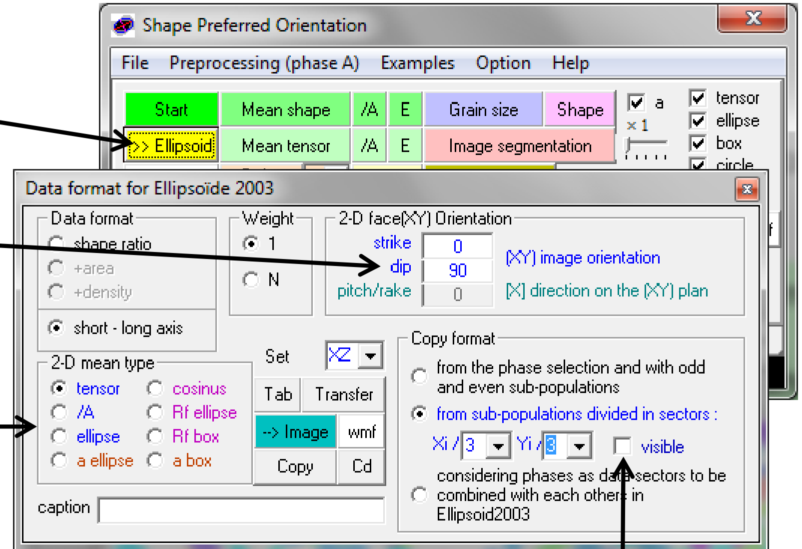


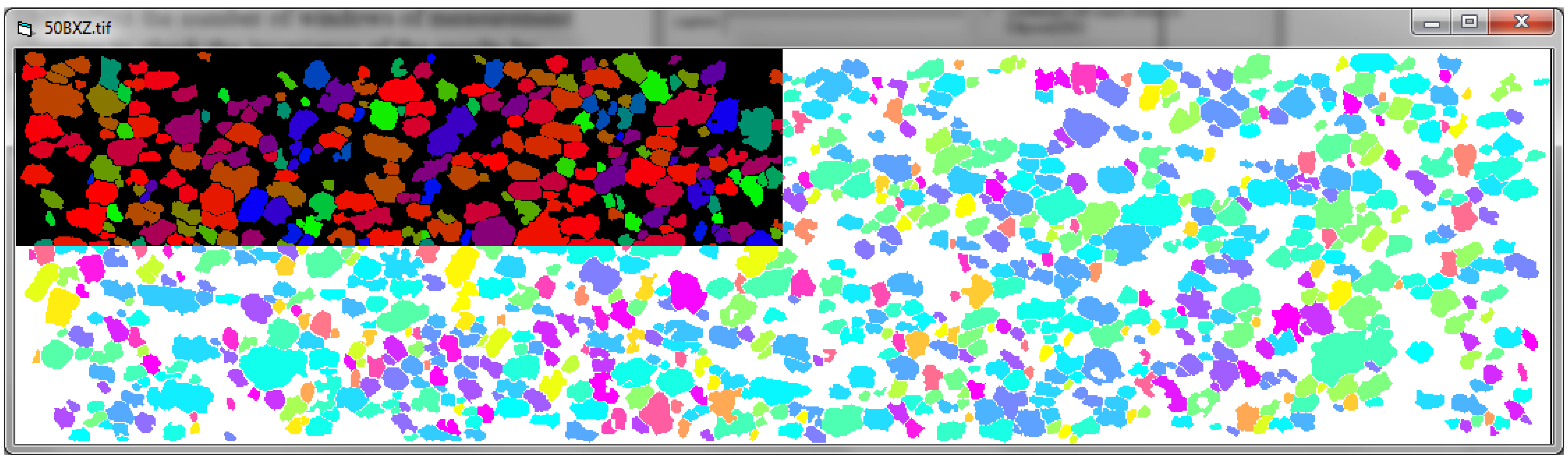
Click on “>> Ellipsoid” button to pop up the window of exportation of the data to Ellipsoid.

Enter the initial relative orientation of the block sample section which is 0 / 90 for (XZ). The rake comes from the internal orientation of the image.

By default the exportation concerns short and long axis of mean shapes which can be calculated from inertia tensor to bounding box by a click on its corresponding checkbox.

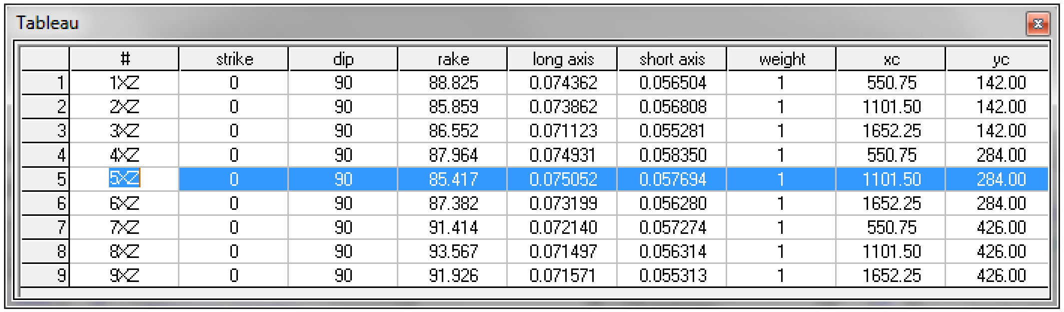
Then select the number of windows of measurement allowing to evaluate the invariance of the results with translation. A cut of 3 × 3 windows gives a total of 9 windows of measurement which can be visualized by a click on visible checkbox.



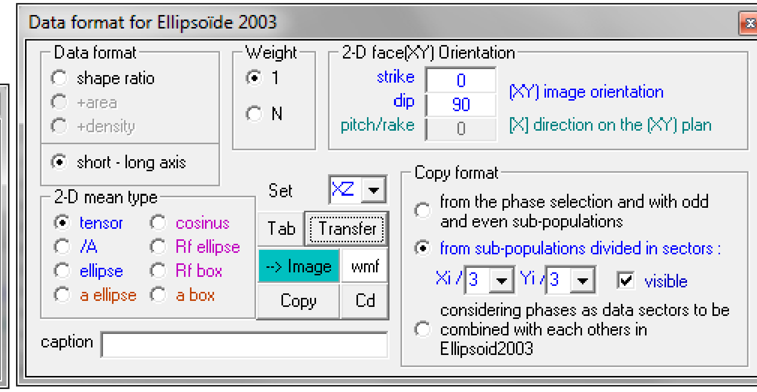


All windows of measurement overlap 50% with their neighbors.

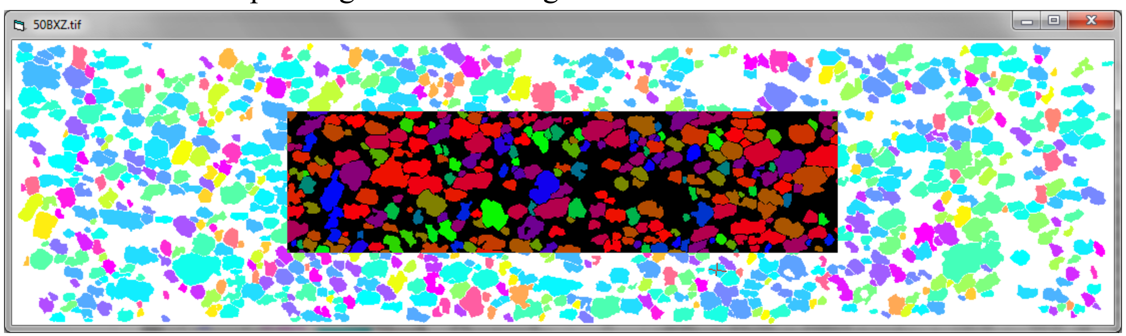
Click now on “Tab” button to pop up the table and on “Transfer” button to send the data into it.



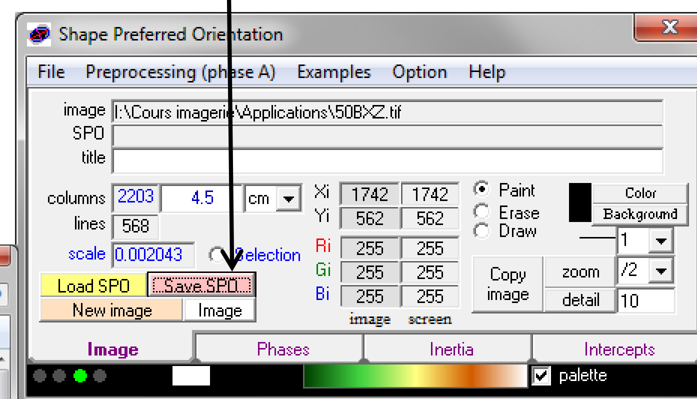
	#	strike	dip	rake	long axis	short axis	weight	xc	yc
1	1XZ	0	90	88.825	0.074362	0.056504	1	550.75	142.00
2	2XZ	0	90	85.859	0.073862	0.056808	1	1101.50	142.00
3	3XZ	0	90	86.552	0.071123	0.055281	1	1652.25	142.00
4	4XZ	0	90	87.964	0.074931	0.058350	1	550.75	284.00
5	5XZ	0	90	85.417	0.075052	0.057694	1	1101.50	284.00
6	6XZ	0	90	87.382	0.073199	0.056280	1	1652.25	284.00
7	7XZ	0	90	91.414	0.072140	0.057274	1	550.75	426.00
8	8XZ	0	90	93.567	0.071497	0.056314	1	1101.50	426.00
9	9XZ	0	90	91.926	0.071571	0.055313	1	1652.25	426.00



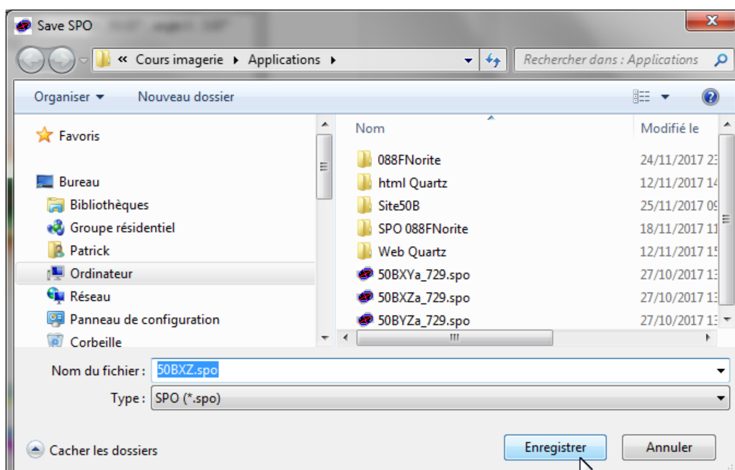
While “visible” is checked click on any table row to highlight the position of the corresponding area with a negative window.



It is recommended to save its work before continuing with the next step. The file saved contain the image, all calculations and all orientations.



Uncheck “visible” to hide the negative window

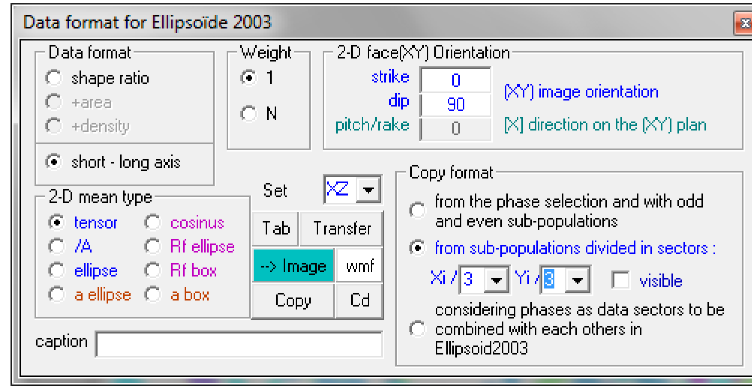


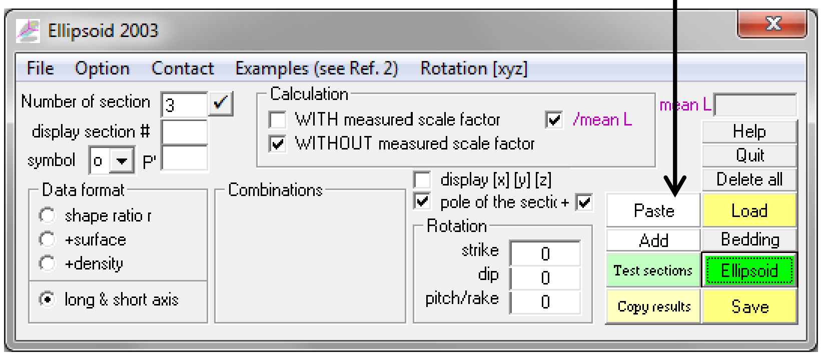
It is also recommended to save all SPO file (xy), (xz) and (yz) prior 2D exportation towards the 3D Ellipsoid program.

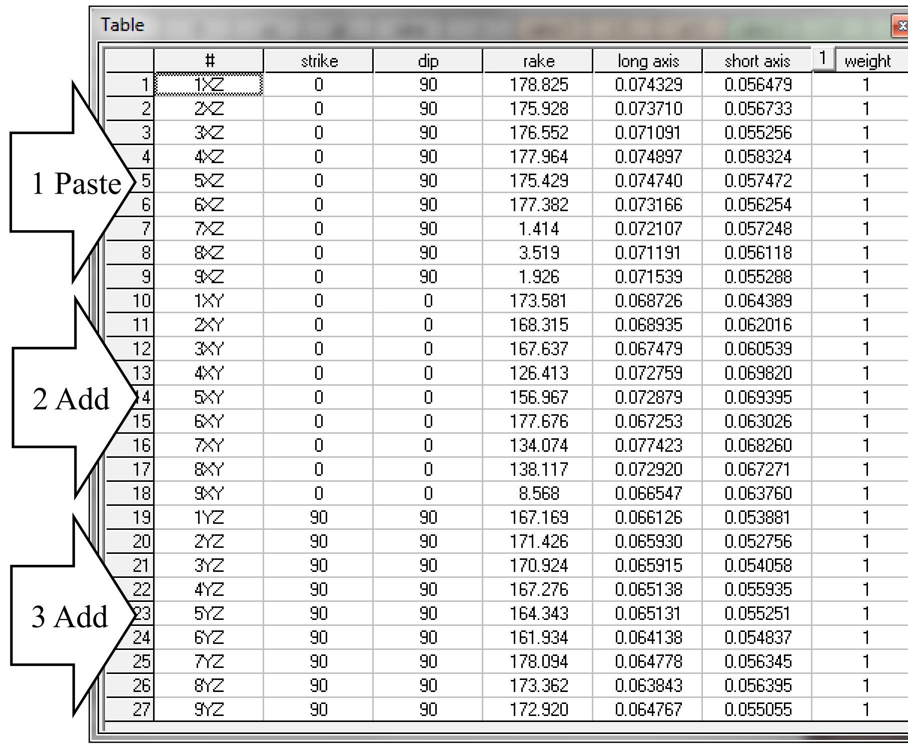
While the Table is visible click on “Copy”.

Open Ellipsoid (or select it if it is already open) and click on “Paste” for the first file.

Then click on “Add” for the two other sections. The ellipsoid calculation require a minimum of 3 sections roughly perpendicular to each other.

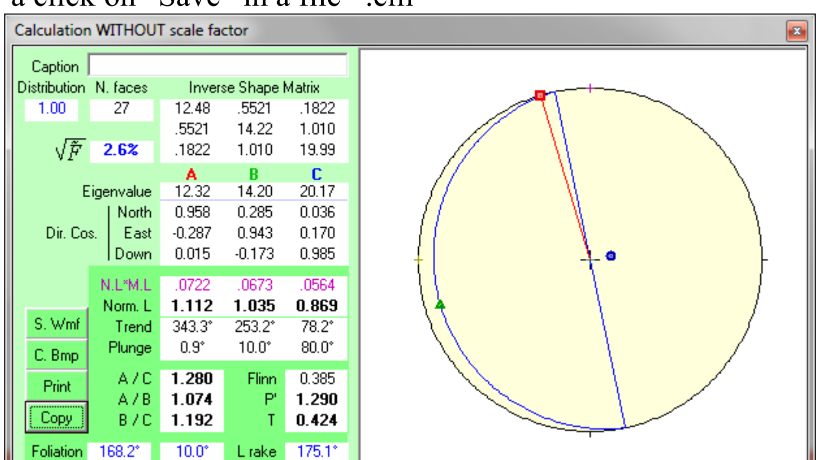






	#	strike	dip	rake	long axis	short axis	1	weight
1	1XZ	0	90	178.825	0.074329	0.056479		1
2	2XZ	0	90	175.928	0.073710	0.056733		1
3	3XZ	0	90	176.552	0.071091	0.055256		1
4	4XZ	0	90	177.964	0.074897	0.058324		1
5	5XZ	0	90	175.429	0.074740	0.057472		1
6	6XZ	0	90	177.382	0.073166	0.056254		1
7	7XZ	0	90	1.414	0.072107	0.057248		1
8	8XZ	0	90	3.519	0.071191	0.056118		1
9	9XZ	0	90	1.926	0.071539	0.055288		1
10	1XY	0	0	173.581	0.068726	0.064389		1
11	2XY	0	0	168.315	0.068935	0.062016		1
12	3XY	0	0	167.637	0.067479	0.060539		1
13	4XY	0	0	126.413	0.072759	0.069820		1
14	5XY	0	0	156.967	0.072879	0.069395		1
15	6XY	0	0	177.676	0.067253	0.063026		1
16	7XY	0	0	134.074	0.077423	0.068260		1
17	8XY	0	0	138.117	0.072920	0.067271		1
18	9XY	0	0	8.568	0.066547	0.063760		1
19	1YZ	90	90	167.169	0.066126	0.053881		1
20	2YZ	90	90	171.426	0.065930	0.052756		1
21	3YZ	90	90	170.924	0.065915	0.054058		1
22	4YZ	90	90	167.276	0.065138	0.055935		1
23	5YZ	90	90	164.343	0.065131	0.055251		1
24	6YZ	90	90	161.934	0.064138	0.054837		1
25	7YZ	90	90	178.094	0.064778	0.056345		1
26	8YZ	90	90	173.362	0.063843	0.056395		1
27	9YZ	90	90	172.920	0.064767	0.055055		1

You must click at least one time on “Ellipsoid” (which pop up the window below) to calculate it and save your work by a click on “Save” in a file *.elli



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

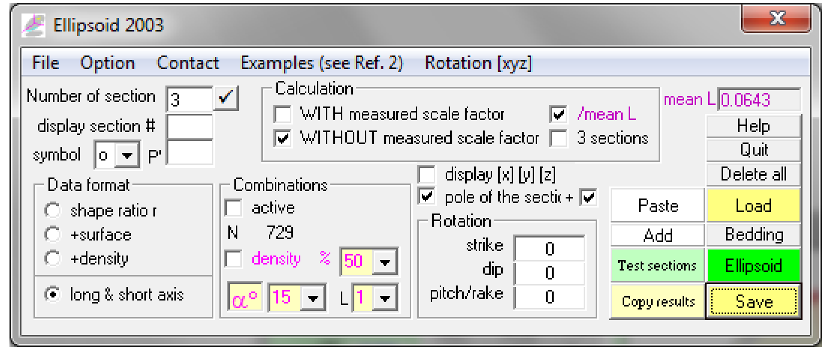
The use of internal 0 / 0, 0 / 90 and 90 / 90 block sample section's orientation the program automatically selects the right combination of section.

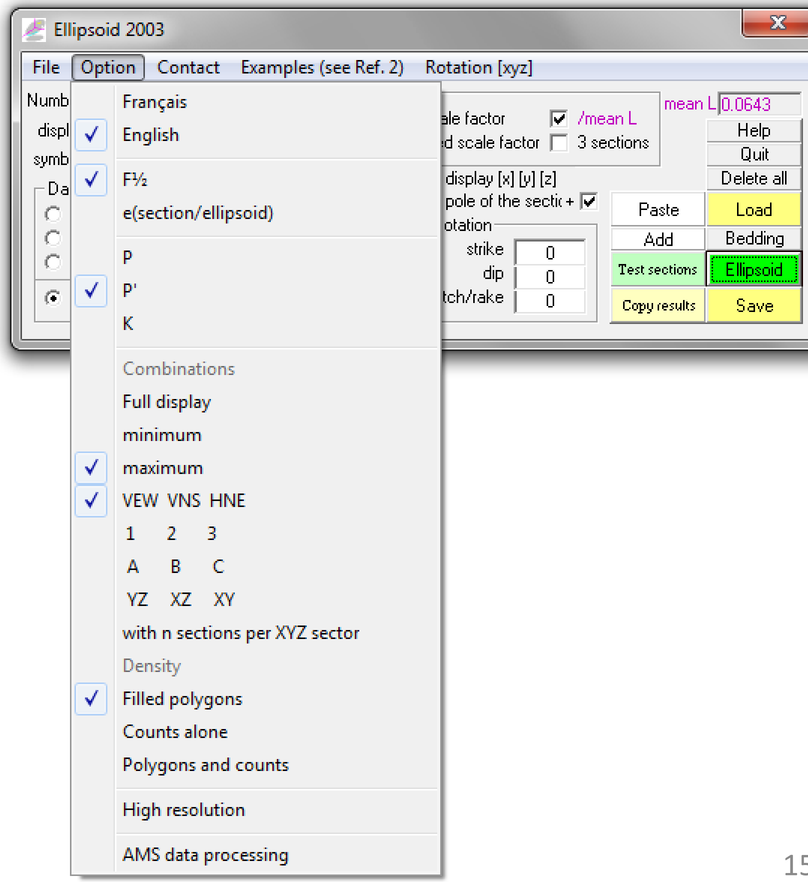
If the frame "Combinations" is empty use "Option" menue to select the right code of section family 1 2 3 or A B C or YZ XZ XY. For instance in this example one could select YZ XZ XY.

The "Test sections" button run a routine checking the compatibility of the sections. 3 parallel sections cannot retrieve a 3D ellipsoid which have to be as perpendicular as possible.

3 × 3 windows per image section × 3 sections give $9^3 = 729$ potential combinations of ellipsoids.

So, check "active" to activate the calculation of the 729 combinations, then click again on "Ellipsoid".



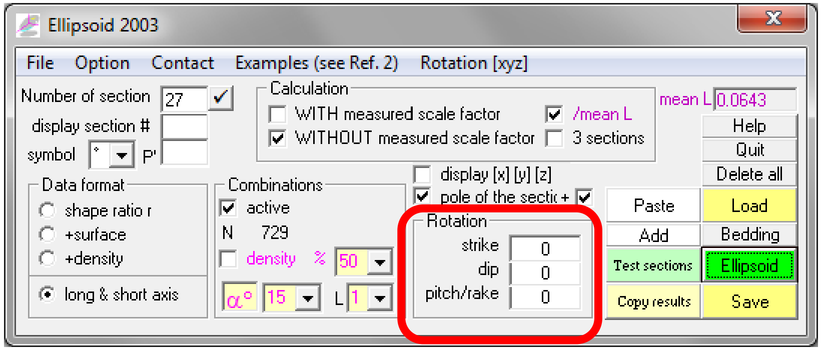


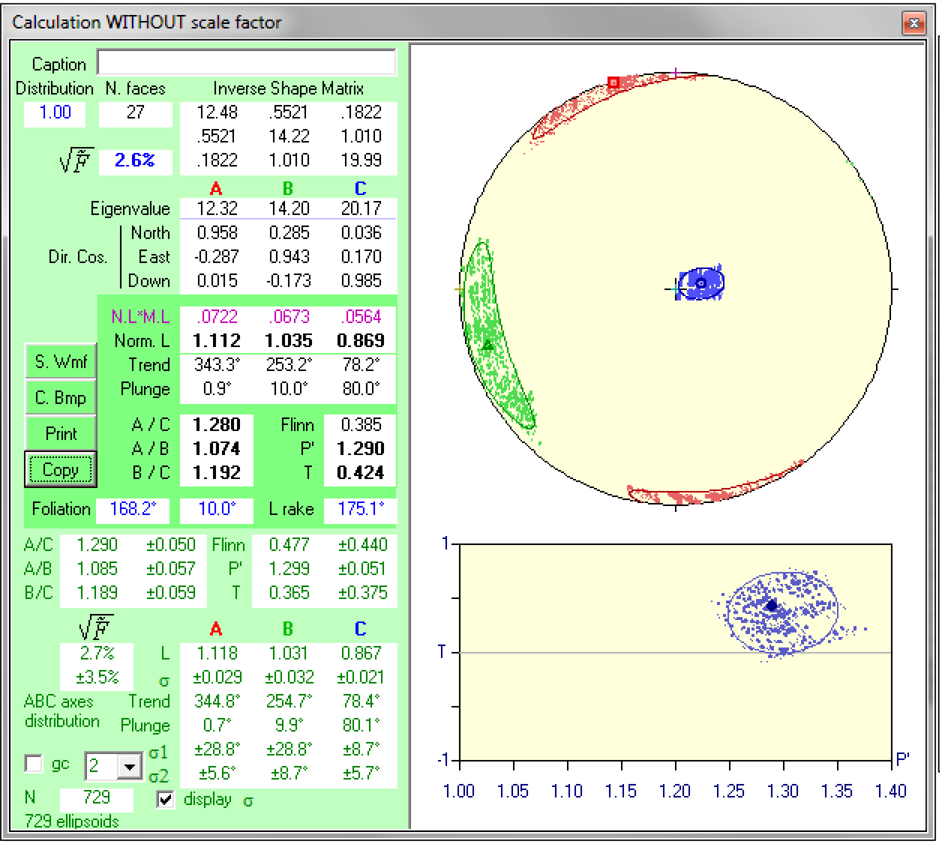
Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

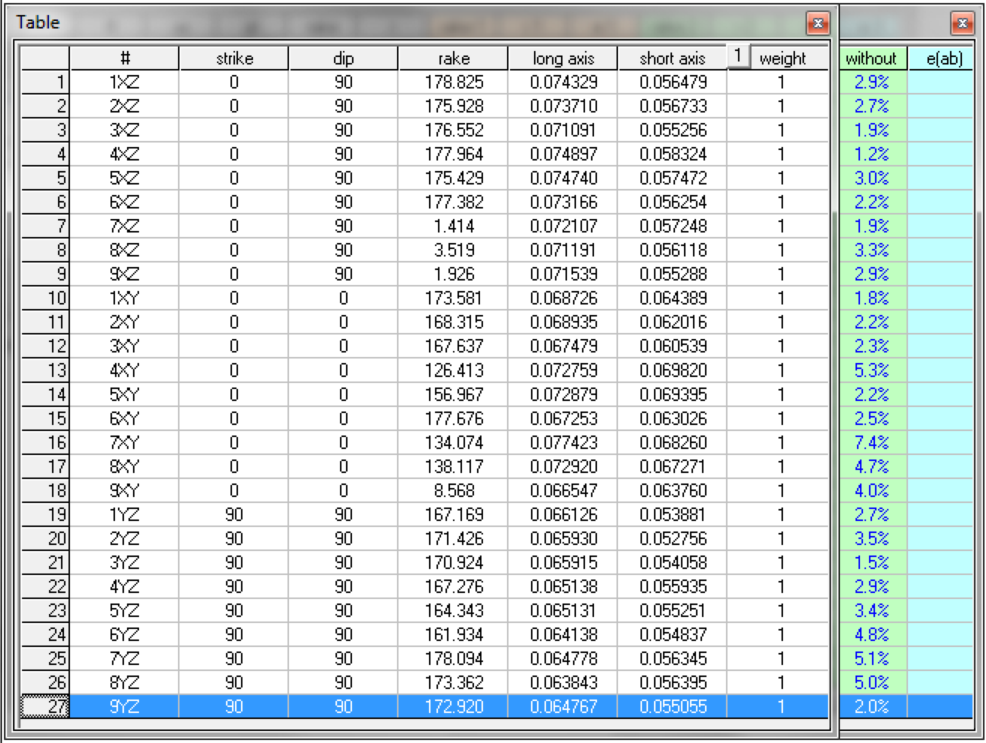
This output is in the relative block sample orientation 0 / 0 / 0

It is now necessary to rotate it at once in the geographic coordinate system with the strike dip rake of the top (xy) of the block sample and the rake orientation of [x] on that plane.

Geographic block sample orientation is **317 / -10 / -10**
137 / 10 / 170







Table

	#	strike	dip	rake	long axis	short axis	weight	without	e(ab)
1	1XZ	0	90	178.825	0.074329	0.056479	1	2.9%	
2	2XZ	0	90	175.928	0.073710	0.056733	1	2.7%	
3	3XZ	0	90	176.552	0.071091	0.055256	1	1.9%	
4	4XZ	0	90	177.964	0.074897	0.058324	1	1.2%	
5	5XZ	0	90	175.429	0.074740	0.057472	1	3.0%	
6	6XZ	0	90	177.382	0.073166	0.056254	1	2.2%	
7	7XZ	0	90	1.414	0.072107	0.057248	1	1.9%	
8	8XZ	0	90	3.519	0.071191	0.056118	1	3.3%	
9	9XZ	0	90	1.926	0.071539	0.055288	1	2.9%	
10	1XY	0	0	173.581	0.068726	0.064389	1	1.8%	
11	2XY	0	0	168.315	0.068935	0.062016	1	2.2%	
12	3XY	0	0	167.637	0.067479	0.060539	1	2.3%	
13	4XY	0	0	126.413	0.072759	0.069820	1	5.3%	
14	5XY	0	0	156.967	0.072879	0.069395	1	2.2%	
15	6XY	0	0	177.676	0.067253	0.063026	1	2.5%	
16	7XY	0	0	134.074	0.077423	0.068260	1	7.4%	
17	8XY	0	0	138.117	0.072920	0.067271	1	4.7%	
18	9XY	0	0	8.568	0.066547	0.063760	1	4.0%	
19	1YZ	90	90	167.169	0.066126	0.053881	1	2.7%	
20	2YZ	90	90	171.426	0.065930	0.052756	1	3.5%	
21	3YZ	90	90	170.924	0.065915	0.054058	1	1.5%	
22	4YZ	90	90	167.276	0.065138	0.055935	1	2.9%	
23	5YZ	90	90	164.343	0.065131	0.055251	1	3.4%	
24	6YZ	90	90	161.934	0.064138	0.054837	1	4.8%	
25	7YZ	90	90	178.094	0.064778	0.056345	1	5.1%	
26	8YZ	90	90	173.362	0.063843	0.056395	1	5.0%	
27	9YZ	90	90	172.920	0.064767	0.055055	1	2.0%	

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

Geographic block sample orientation is **317 / -10 / -10**
137 / 10 / 170

Both orientation give the same results. The main axis of the block sample are visualized with this checkbox.

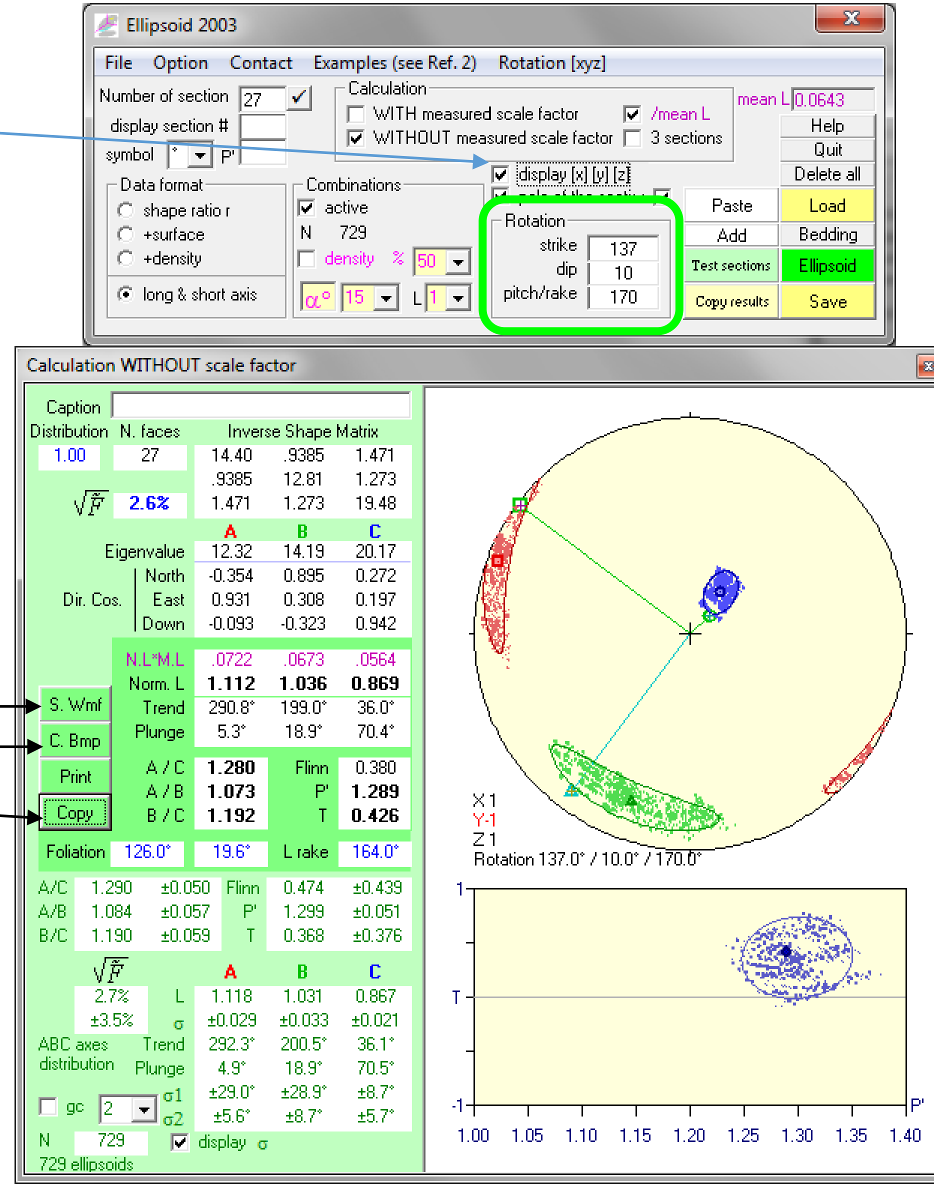
As mentioned p. 4 the axis [y] is plunging upwards towards the NE with a negative angle. This is highlighted here with a red Y-1 warning in the graphic.

The ellipsoid is now in the geographic coordinate system and can be save again for recording its new orientation.

Eigenvalues are calculated on inverse shape matrix as shown by their invers order of intensity.

See course 6 p. 11 to 13 for comments.

Save a windows metafile of the plot with
A bitmap of it with
Copy the results with
see next page.



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

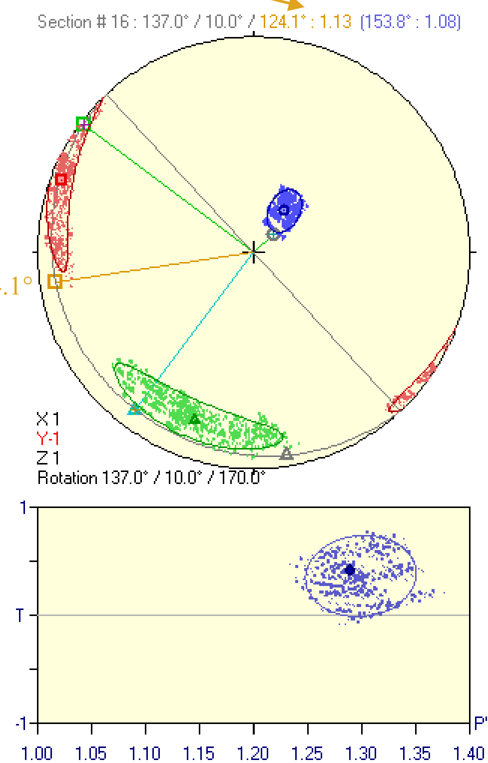
Example of output →

Click on one row of the following table of incompatibility index to visualize the results of one section

F½	with	without	e(ab)
1 B		2.9%	
2 B		2.7%	
3 B		1.9%	
4 B		1.2%	
5 B		3.0%	
6 B		2.2%	
7 B		1.9%	
8 B		3.3%	
9 B		2.9%	
10 C		1.8%	
11 C		2.2%	
12 C		2.3%	
13 C		5.3%	
14 C		2.1%	
15 C		2.5%	
16 C		7.4%	
17 C		4.7%	
18 C		4.0%	
19 A		2.7%	
20 A		3.5%	
21 A		1.5%	
22 A		2.9%	
23 A		3.4%	
24 A		4.8%	
25 A		5.1%	
26 A		5.0%	
27 A		2.0%	

Rake shape ratio of the Ellipsoid section

Contribution of the sample with rake and shape ratio



output example of C. Bmp

	A	B	C
N	27		
F	2.57E-02		
	A	B	C
nLenght	1.111545452	1.035640723	
	0.868687665		
strike	290.8441197	199.0240267	
	35.95151643		
dip	5.314386645	18.85216132	
	70.35814427		
aLength	7.22E-02	6.73E-02	5.64E-02
F-L	125.9515164	19.64185573	
	164.0056822		
ac	1.28		
ab	1.073		
bc	1.192		
P	1.28943551		
T	0.426170707		
	A	B	C
Ln	1.11820286	1.031494102	
	0.867230022		
s	1.45E-02	0.016252802	1.04E-02
strike	292.2517468	200.5477233	
	36.12803405		
dip	4.884473879	18.91262228	
	70.46731061		
s1	14.47611052	14.46166044	
	4.329446532		
s2	75.24195685	74.86922383	84.8103036
ac	1.289615912	2.50E-02	
ab	1.084465021	2.86E-02	
bc	1.189727023	2.96E-02	
P'	1.299137479	2.56E-02	
T	0.367685085	0.187870264	

Example of output

Click on one row of the following table of incompatibility index to visualize the results of one section

Table

	#	strike	dip	rake	long axis	short axis	1	weight
1	1XZ	0	90	178.825	0.074329	0.056479		1
2	2XZ	0	90	175.928	0.073710	0.056733		1
3	3XZ	0	90	176.552	0.071091	0.055256		1
4	4XZ	0	90	177.964	0.074897	0.058324		1
5	5XZ	0	90	175.429	0.074740	0.057472		1
6	6XZ	0	90	177.382	0.073166	0.056254		1
7	7XZ	0	90	1.414	0.072107	0.057248		1
8	8XZ	0	90	3.519	0.071191	0.056118		1
9	9XZ	0	90	1.926	0.071539	0.055288		1
10	1XY	0	0	173.581	0.068726	0.064389		1
11	2XY	0	0	168.315	0.068935	0.062016		1
12	3XY	0	0	167.637	0.067479	0.060539		1
13	4XY	0	0	126.413	0.072759	0.069820		1
14	5XY	0	0	156.967	0.072879	0.069395		1
15	6XY	0	0	177.676	0.067253	0.063026		1
16	7XY	0	0	134.074	0.077423	0.068260		1
17	8XY	0	0	138.117	0.072920	0.067271		1
					0.066547	0.063760		1
					0.066126	0.053881		1
					0.065930	0.052756		1
					0.065915	0.054058		1
					0.065138	0.055935		1
					0.065131	0.055251		1
					0.064138	0.054837		1
					0.064778	0.056345		1
					0.063843	0.056395		1
					0.064767	0.055055		1

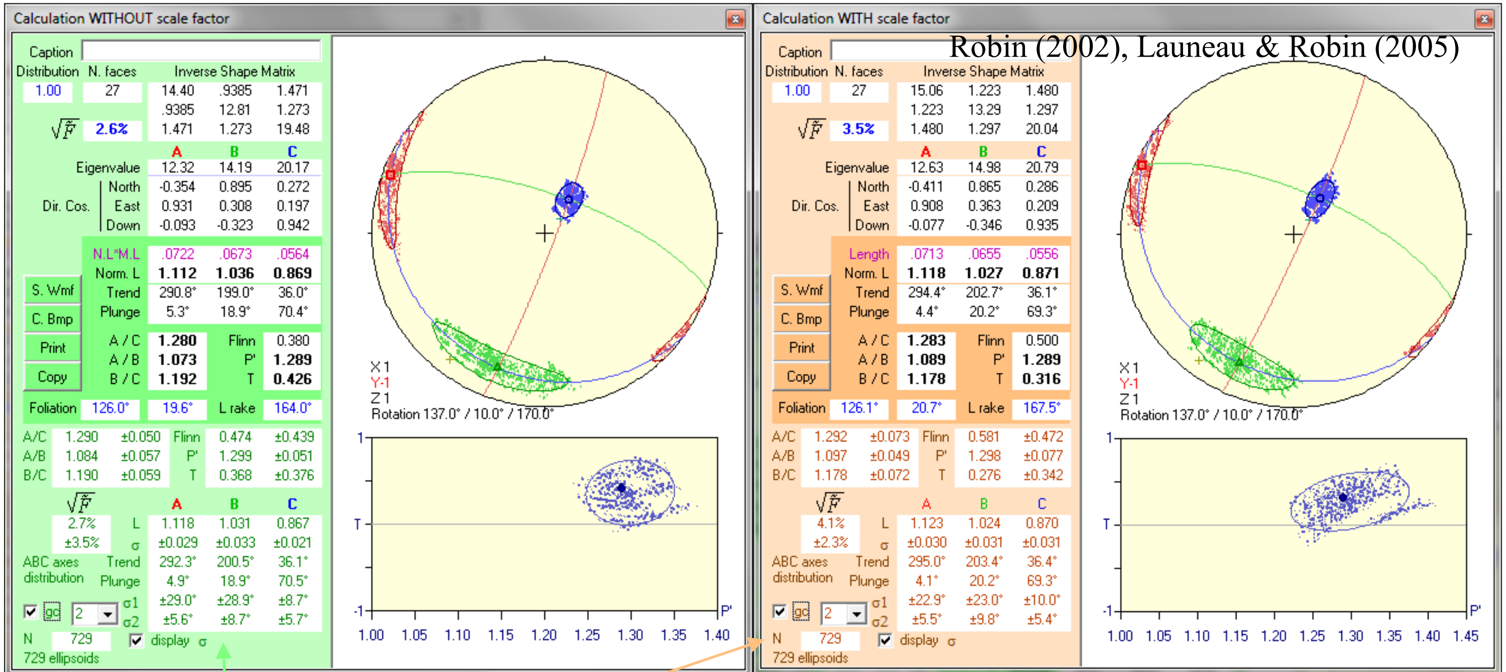
F½

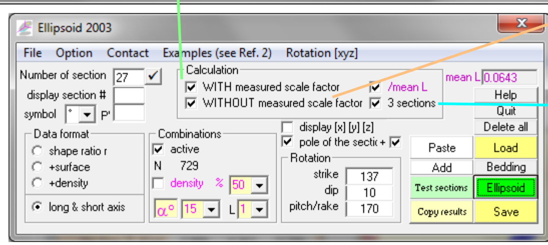
	with	without	e(ab)
1 B		2.9%	
2 B		2.7%	
3 B		1.9%	
4 B		1.2%	
5 B		3.0%	
6 B		2.2%	
7 B		1.9%	
8 B		3.3%	
9 B		2.9%	
10 C		1.8%	
11 C		2.2%	
12 C		2.3%	
13 C		5.3%	
14 C		2.1%	
15 C		2.5%	
16 C		7.4%	
17 C		4.7%	
18 C		4.0%	
19 A		2.7%	
20 A		3.5%	
21 A		1.5%	
22 A		2.9%	
23 A		3.4%	
24 A		4.8%	
25 A		5.1%	
26 A		5.0%	
27 A		2.0%	

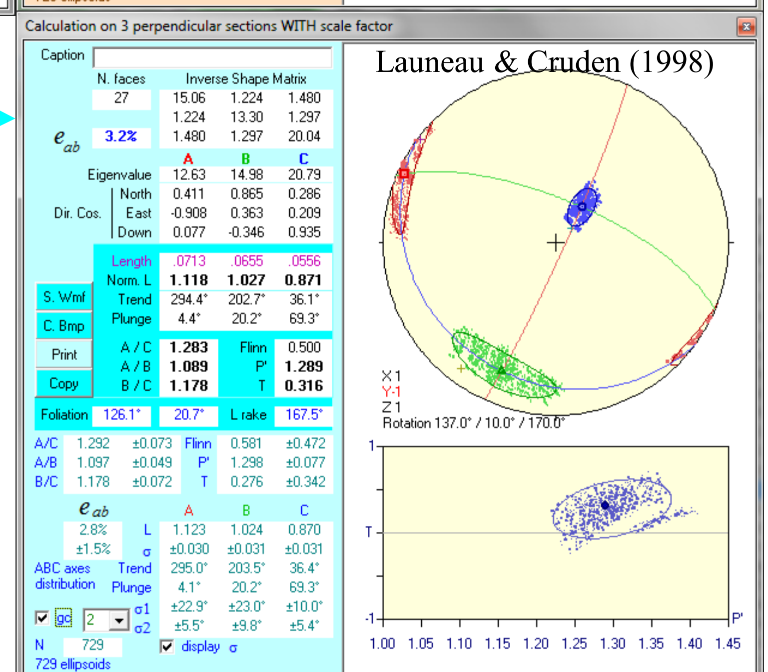
Sections

	#	az	pl	rake	r	rake 1	r 1	e 1	rake 2	r 2	e 2	rake 3	r 3	e 3
1	1XZ	306.8	80.2	0.6	1.316				0.4	1.266	4.4%			
2	2XZ	306.8	80.2	177.7	1.299				0.4	1.266	3.2%			
3	3XZ	306.8	80.2	178.3	1.287				0.4	1.266	2.0%			
4	4XZ	306.8	80.2	179.7	1.284				0.4	1.266	1.6%			
5	5XZ	306.8	80.2	177.2	1.300				0.4	1.266	3.3%			
6	6XZ	306.8	80.2	179.1	1.301				0.4	1.266	3.1%			
7	7XZ	306.8	80.2	3.2	1.260				0.4	1.266	1.3%			
8	8XZ	306.8	80.2	5.3	1.269				0.4	1.266	2.0%			
9	9XZ	306.8	80.2	3.7	1.294				0.4	1.266	2.9%			
10	1XY	137.0	10.0	163.6	1.067				153.8	1.080	1.7%			
11	2XY	137.0	10.0	158.3	1.112				153.8	1.080	3.1%			
12	3XY	137.0	10.0	157.6	1.115				153.8	1.080	3.4%			
13	4XY	137.0	10.0	116.4	1.042				153.8	1.080	5.1%			
14	5XY	137.0	10.0	147.0	1.050				153.8	1.080	3.0%			
15	6XY	137.0	10.0	167.7	1.067				153.8	1.080	2.1%			
16	7XY	137.0	10.0	124.1	1.134				153.8	1.080	7.3%			
17	8XY	137.0	10.0	128.1	1.084				153.8	1.080	3.5%			
18	9XY	137.0	10.0	178.6	1.044				153.8	1.080	4.3%			
19	1YZ	37.1	88.3	157.3	1.227				160.5	1.198	2.8%			
20	2YZ	37.1	88.3	161.6	1.250				160.5	1.198	4.7%			
21	3YZ	37.1	88.3	161.1	1.219				160.5	1.198	1.9%			
22	4YZ	37.1	88.3	157.4	1.165				160.5	1.198	3.2%			
23	5YZ	37.1	88.3	154.5	1.179				160.5	1.198	2.5%			
24	6YZ	37.1	88.3	152.1	1.170				160.5	1.198	3.6%			
25	7YZ	37.1	88.3	168.2	1.150				160.5	1.198	4.9%			
26	8YZ	37.1	88.3	163.5	1.132				160.5	1.198	6.1%			
27	9YZ	37.1	88.3	163.1	1.176				160.5	1.198	2.1%			

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





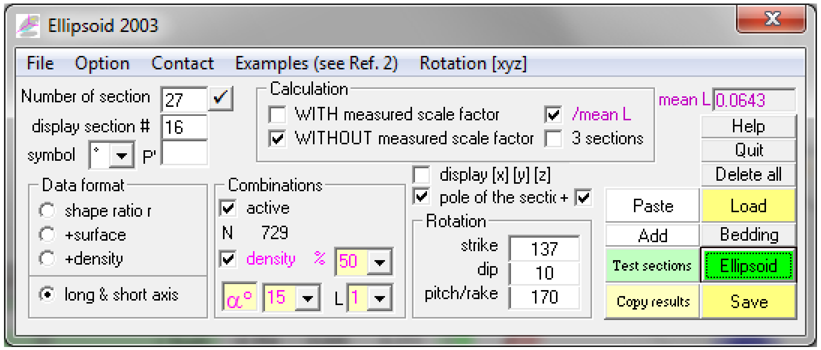


The ellipsoid calculation on any section with Robin (2005) method can use or not scale factor insuring the consistency of the ellipses on sections with the ellipsoid volum.

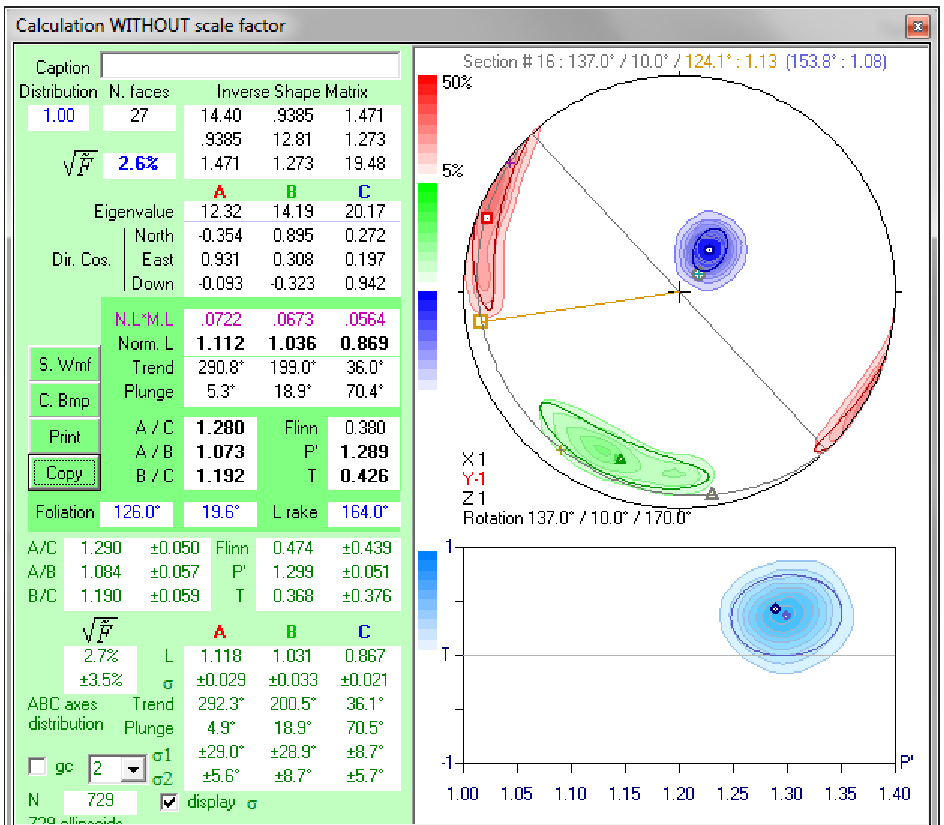
When the 3 sections are perpendicular to each other the older method of Launeau and Cruden (1998) is equal to the new method with scale factor.

We now rather use the calculation without scale factor of Robin (2005) for which we don't have to worry about accurate scaling of the ellipses on sections.

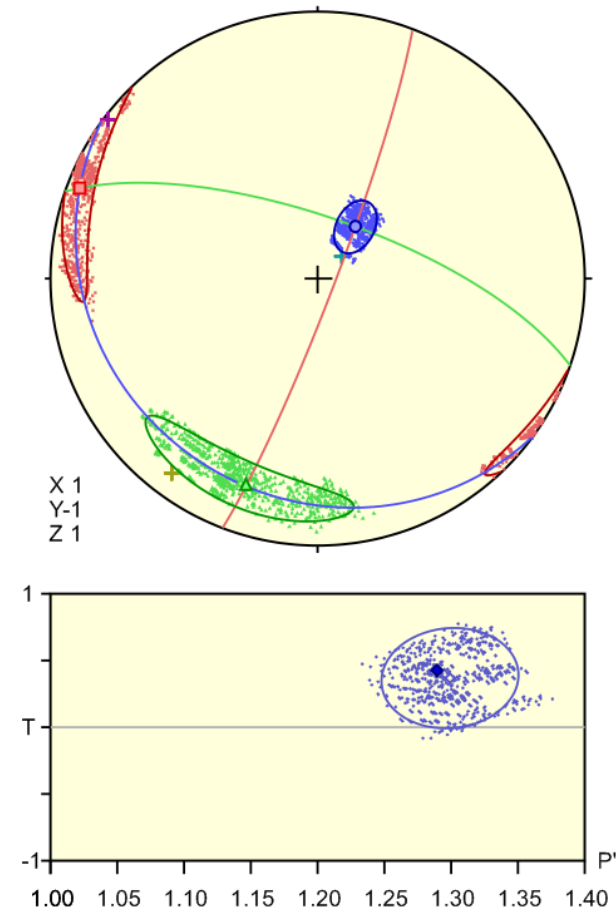
Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

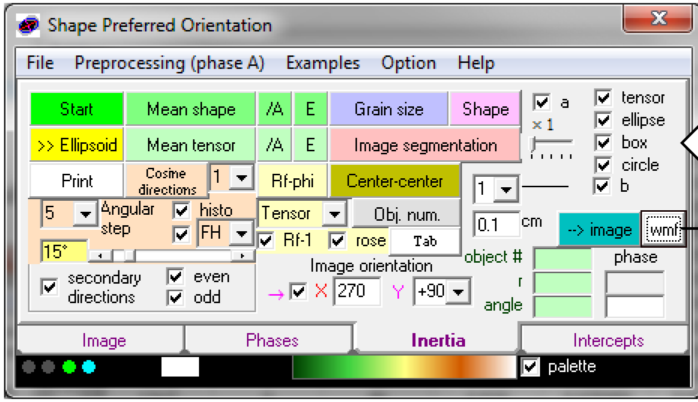


Calculation of unweighted (L set to 1) data density with a Gaussian function normalized to 50% of the data and having 15° width at mid height



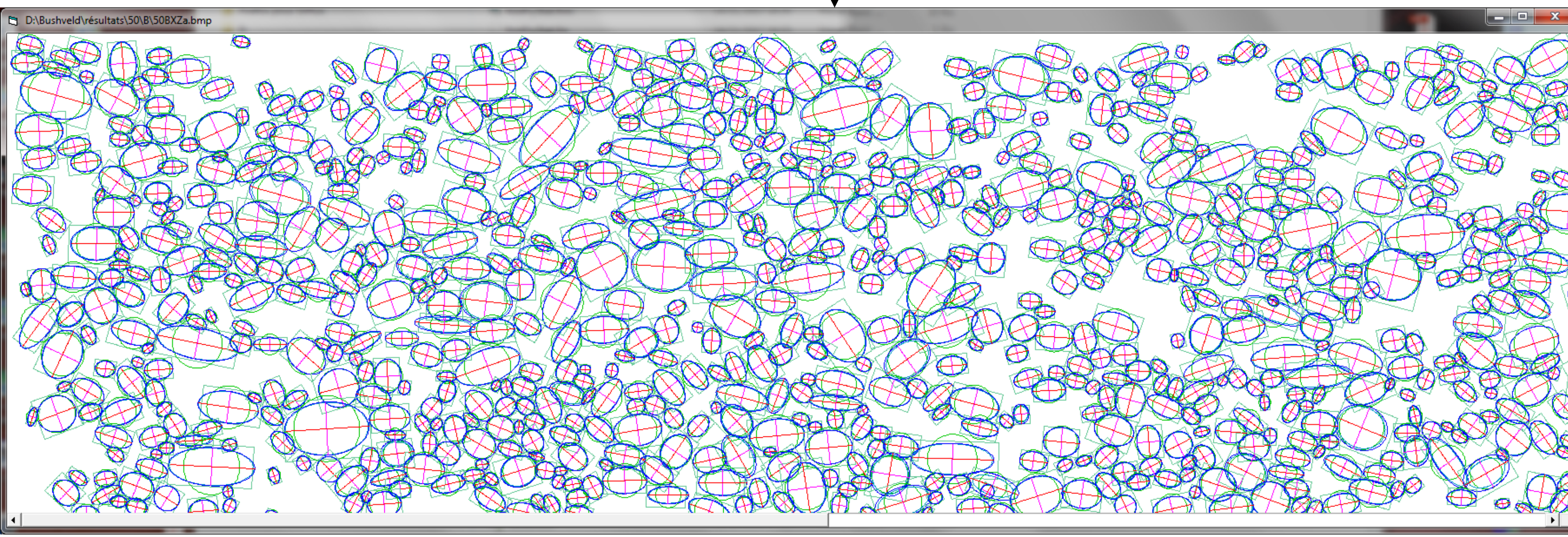
Example of output via windows metafile open in a drawing software





Back to SPO for other available outputs

“wmf” for drawing on a white page with an option to save it as a windows metafile.
“→image” for drawing on the image at its pixel resolution



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

An other possible output in 2D, not recommended for 3D transfer (!), but useful for the analysis of local orientations.