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 of the intercepts method in grey levels to the Adamello Batholith use one of the sites of Anne Schöpa thesis used in the following publication.

Schöpa A., D. Floess, M. de Saint Blanquat. C. Annen, P. Launeau (2015) “The relation between magnetite and silicate fabric in granitoids of the Adamello Batholith”. Tectonophysics 642 1–15.

It is a step by step tutorial of Intercepts2003 and Ellipsoid2003 programs from 2D image orientation to 3D ellipsoid calculation with precious warning on false interpretations.

The site 11AS11 is a tonalite made of dark hornblende, intermediate grey quartz and white plagioclase presenting local heterogeneity well explain by the comparison of large field image analyses with small block sample section analyses.

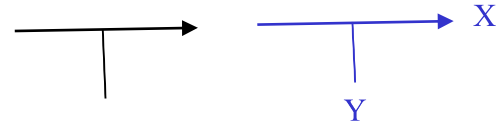
This image displays all necessary information:

- Sample number 11 + section label A. See 11AS11 site location in Schöpa et al (2015).
- Scale in cm
- Strike X (N 164) of the image plane perpendicular to the camera lens constituting the axis Z
- Dip Y (18) taken in the direction X + 90 (W)

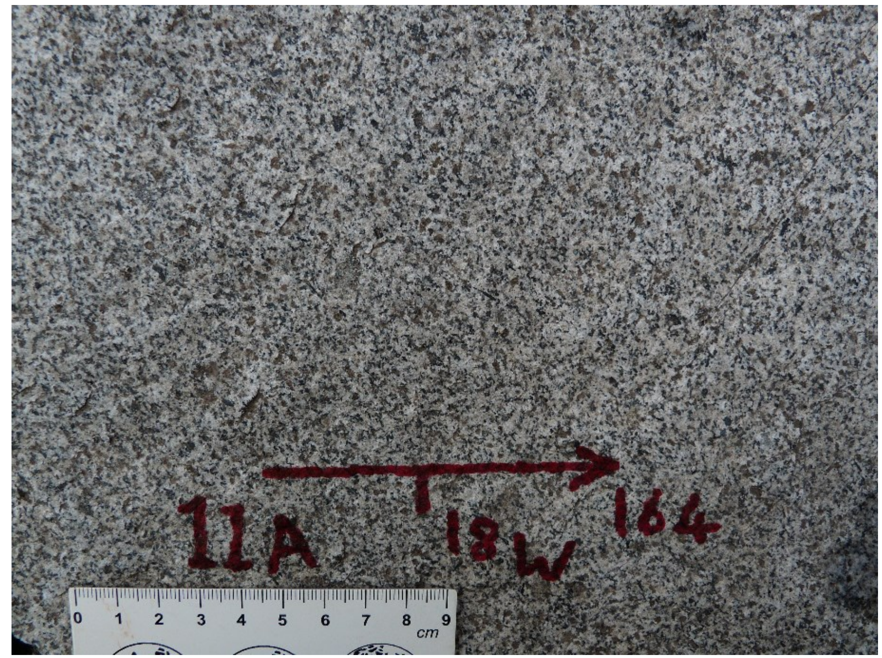
With angle in degrees.

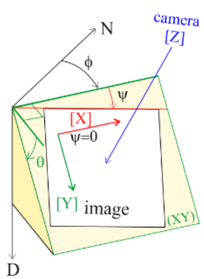
The strike of 164 degrees from the N, dipping towards the W with an angle of 18 degrees becomes in the right hand rule, clockwise orientation system ϕ / θ : 164 / 18

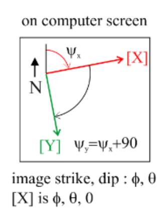
For image analysis purpose, it is necessary to complete the orientation with the indication that Y is at +90 of X.



164 W 18 = 164 / 18 Y dip at + 90 of X on normal plane

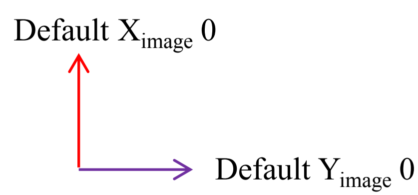


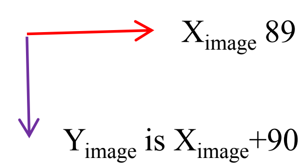




See course 2 page 14

Within the image X is:





This 2nd image displays all necessary information:

- Sample number 11+ section label C. See 11AS11 site location in Schöpa et al (2015).
- Scale in cm
- Strike X (N 302) of the image plane perpendicular to the camera lens constituting the axis Z
- Dip Y (76) is reversed as shown by the inverted dipping sign and taken in the direction X + 90 (SW)

The strike of 302 degrees from the N, dipping towards the SW with an angle of 76 degrees presents a normal dip direction Y at : 302-90=202 degrees, on the left of X (X-90).

In the right hand rule, clockwise orientation system ϕ / θ the dip direction Y must be on the right. To do so we take the opposite strike 302–180=122 which put the dip direction on the right of the strike and finally gives : 122 / 76

For image analysis purpose, it is necessary to complete the orientation with the indication that Y is at –90 of X.

Warning: the geographic dip direction Y is on the right of the geographic strike X but it appears on the image inverted plane on the left as X_{image} which is at 274 degrees. So, X_{image} is at 274 degrees and Y_{image} is X_{image}–90 within the image.

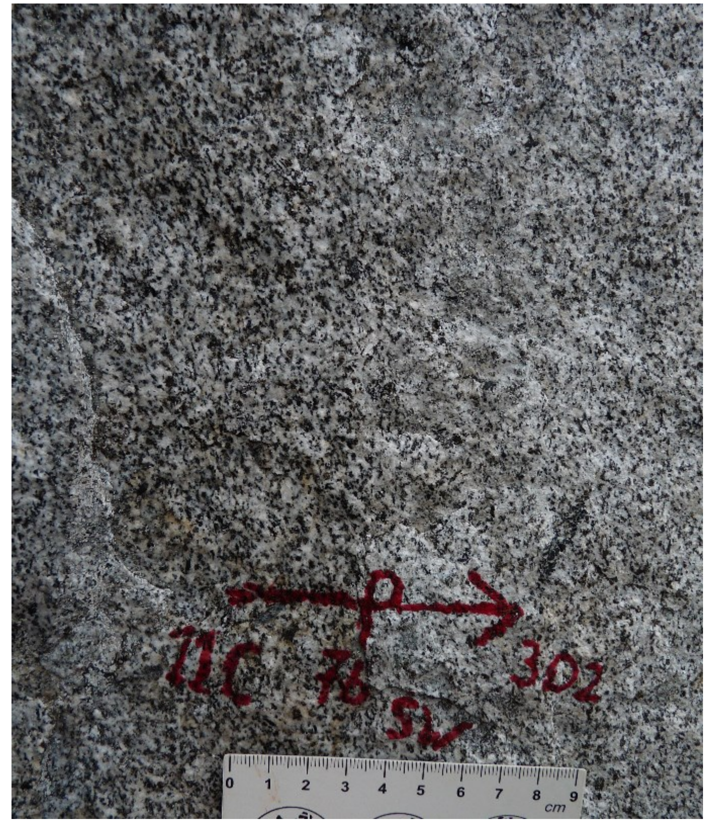
Inverted dip

X

Y

Normal dip

302 SW 76 = 122 / 76 Y normal dip at +90 of X on inverted plane

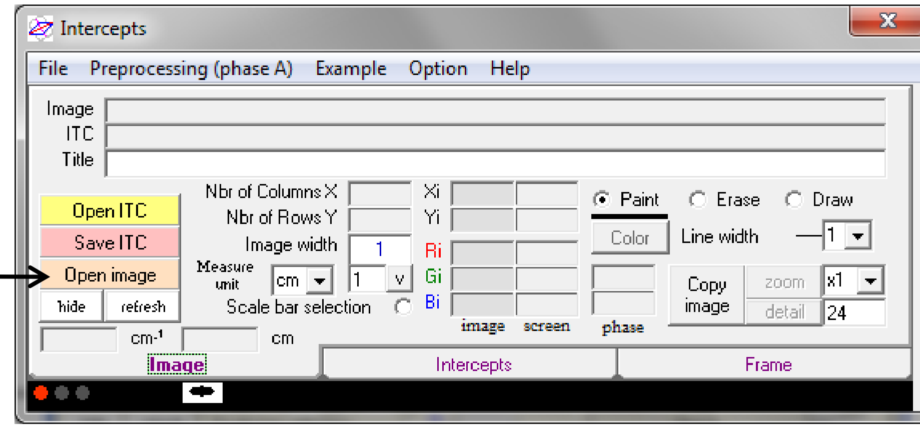


Within the image X is: X_{image} 274

Y_{image} is X_{image}–90

Let now start the program Intercepts2003

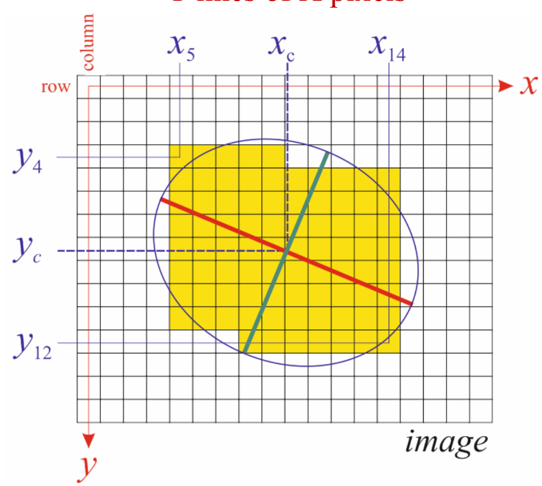
And click on the “Open image” button



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.

Warning, do not confuse:
•the number X of pixels in a row, which gives the ordinal number Xi of a column or pixel in that row,
•with the default direction X of the image indicating the N.
Do not confuse either:
•the number Y of rows, which gives the ordinal number Yi of a line or row of pixels in the image
•with the default direction Y of the image indicating the E.

Y lines of X pixels



X, Y default image orientation respectively parallel to N, E

on computer screen

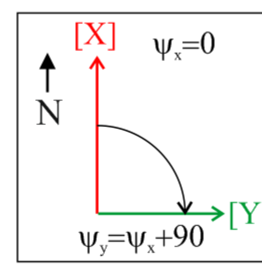
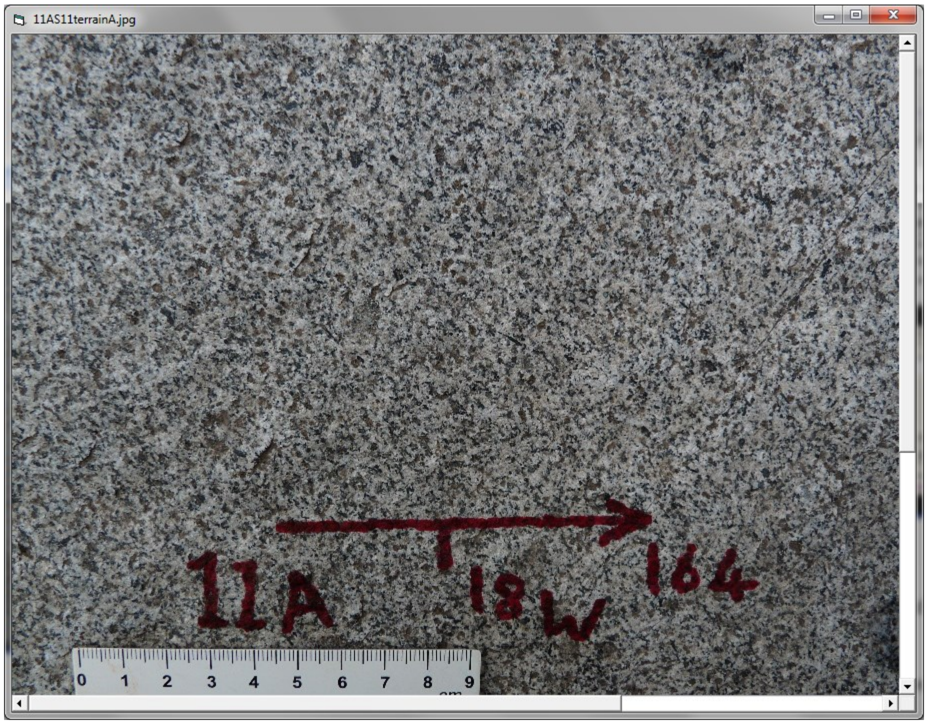


image strike, dip : 0, 0

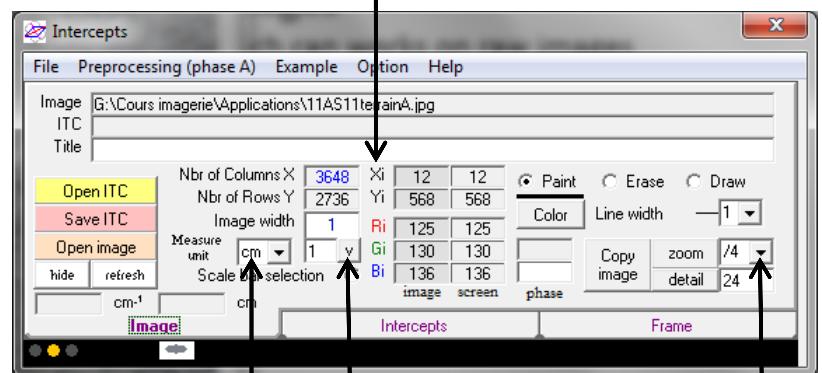
See course 4 pages 4 and 5

See course 2 page 13 and 14

The maximum image size is 3000 by 3000 pixels so you may need to zoom out to visualize the full image on your screen



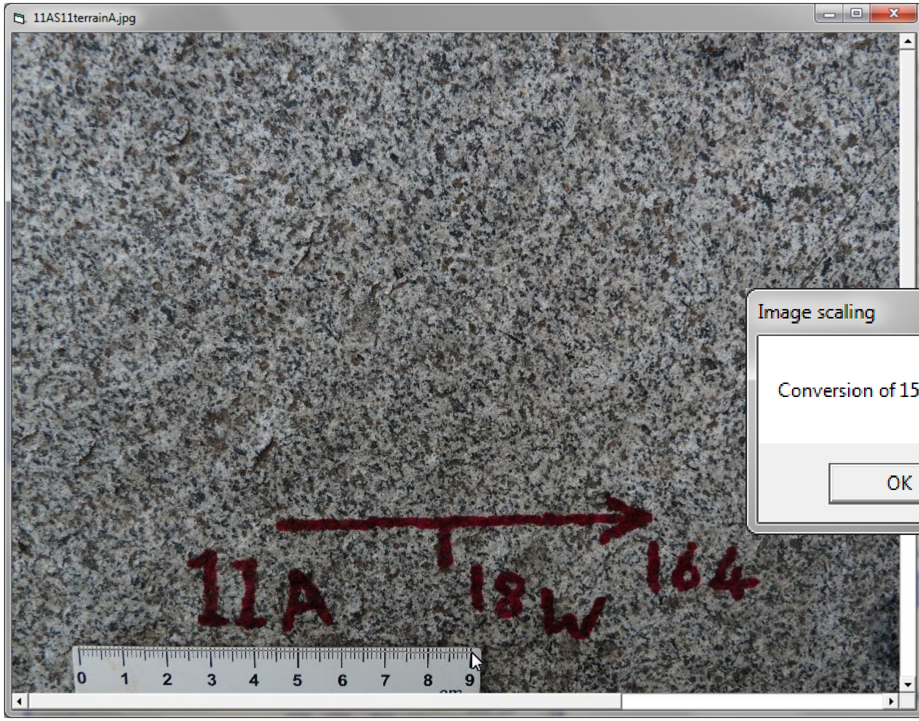
Xi, Yi are coordinates of the current pixel at mouse location in the image and Ri, Gi, Bi are intensities, or grey levels, of each channel red, green blue. Identical values in all channels characterize greyscale images.

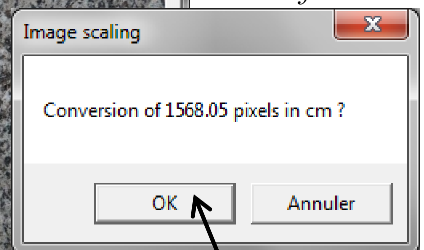


Zoom out / 4

1) Click on this button to select the scale bar on the image.

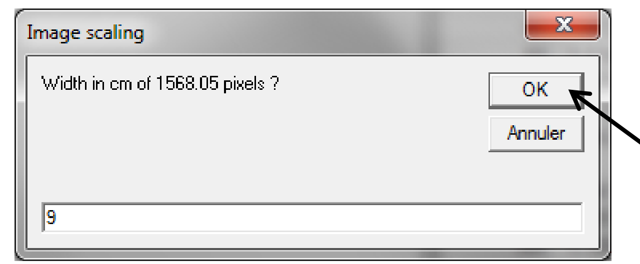
You may select another scale unit here

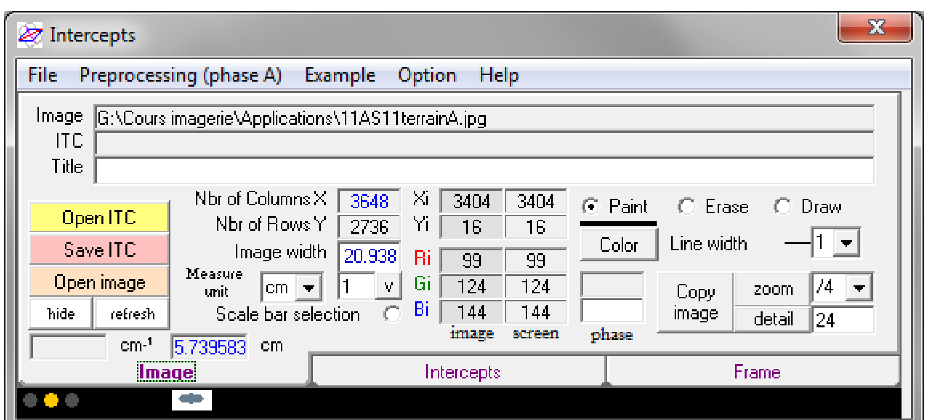


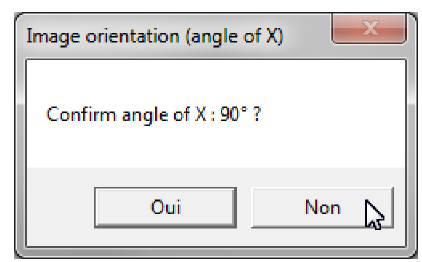


2) Click on the scale graduation 0, hold down the left mouse button and move the cursor to the graduation 9. Then release the mouse button. The Image scaling pop up. Click on OK to continue with the next step of image scaling. *Default button captions use the system language*.

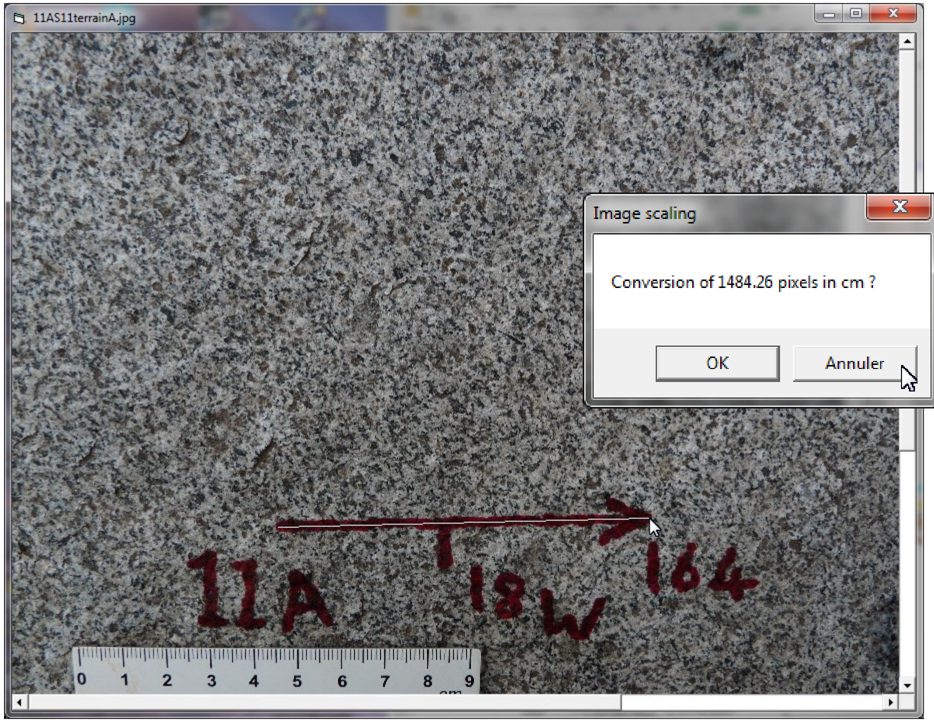
3) Enter the size in cm which corresponds to 1568 pixels: 9 cm in this case.







4) Click on no since the cm scale is not aligned with the strike

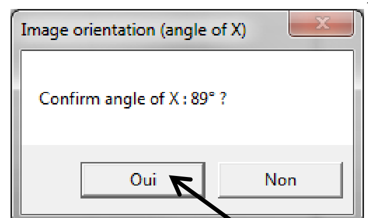


5) Click again on the Scale bar selection (see p. 6).

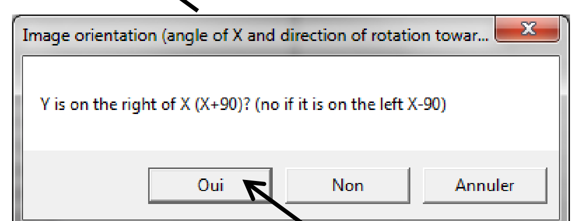
6) Click on the beginning of the red arrow, hold down the left mouse button and move the cursor to the end of the arrow. Then release the mouse button. The Image scaling window pop up. Click on cancel to skip the conversion of pixels in cm.

6) The Image orientation of X window pop up. Click on Yes to validate the angle of X in the image: 89 in this example.

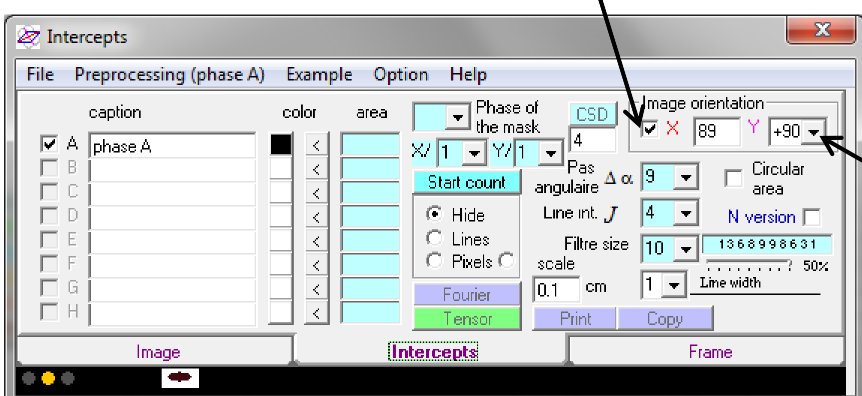
7) Then Image orientation of Y pop up. Click on Yes to validate Y at X+90, on No for Y at X–90 or cancel.



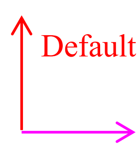
It is also possible to enter all value directly without using the Scale bar selection option



8) Check this box to activate the Image orientation

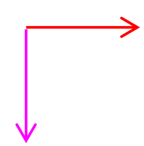


X_{image} is now at 89 degrees and Y_{image} is at 89+90 in the image



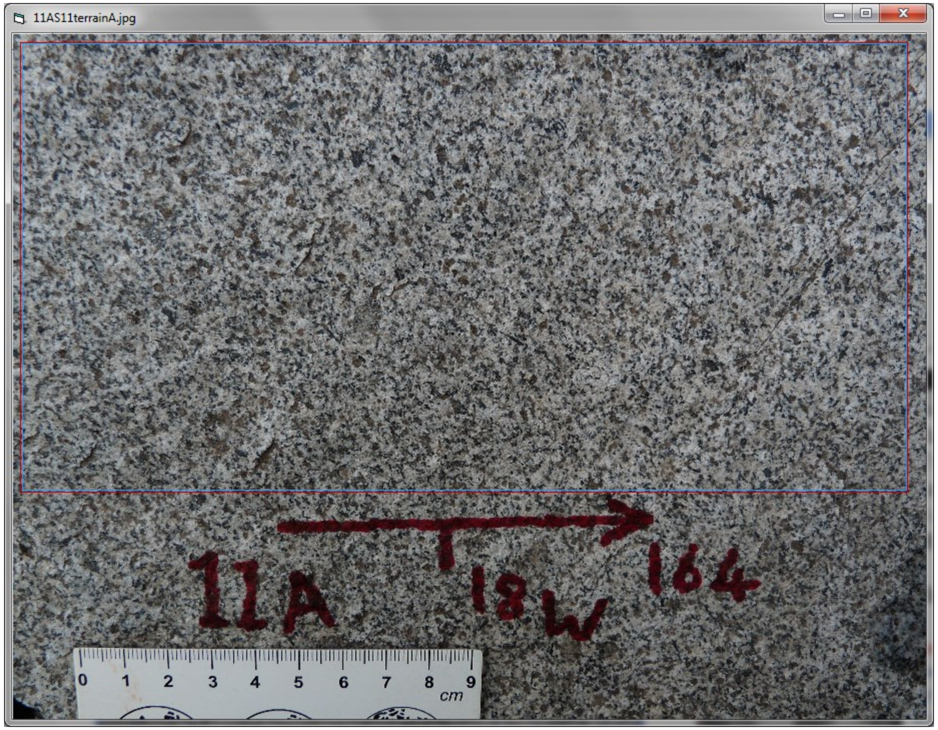
Default X_{image} 0

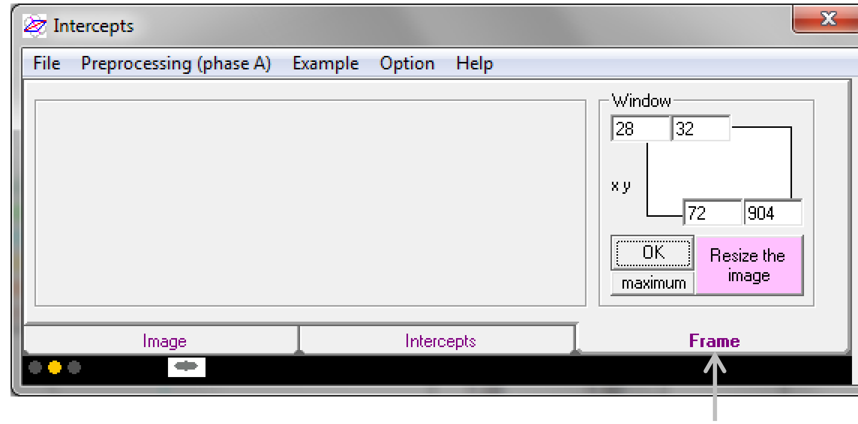
Default Y_{image} +90



X_{image} 89

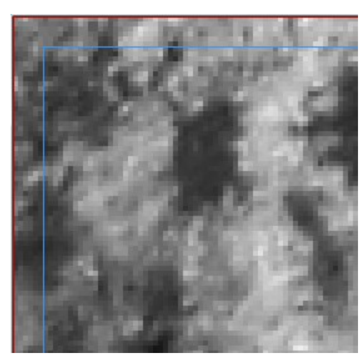
Y_{image} +90





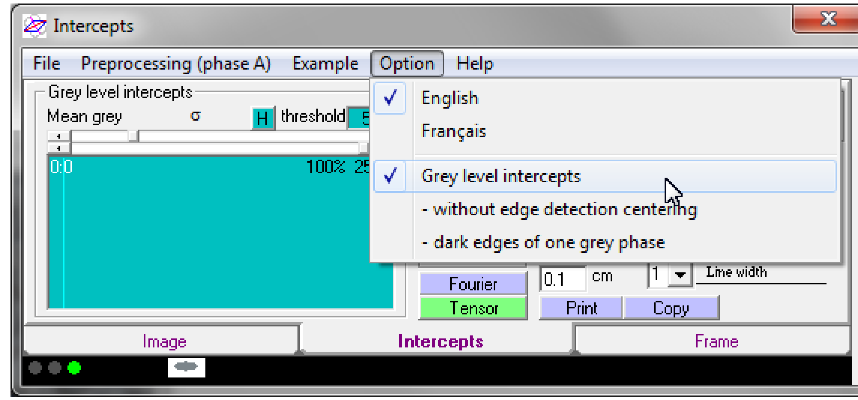
Since the cm scale bar should not be taken in the image analysis click on Frame tab, then click on the first pixel of the image and hold down the left mouse button until the last pixel of the area of interest window whose coordinates appear in their respective box: first upper left and last down right. Release the mouse button and click on Resize the image to do it.

You are now ready to start the image analysis.

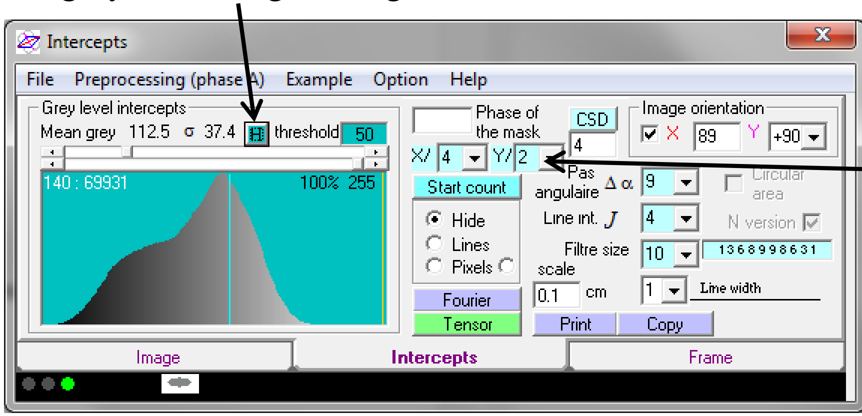


Border of the image
Border of the area of analysis by using filter size of 10 pixels to count the intercepts. This define a margin of 5 pixels around the image borders.

The program Intercepts2003 works by default on classified images with a maximum of 8 classes (from A to H). So, click on Option in the menu and select the Grey level intercepts mode of analysis. (see course 5)



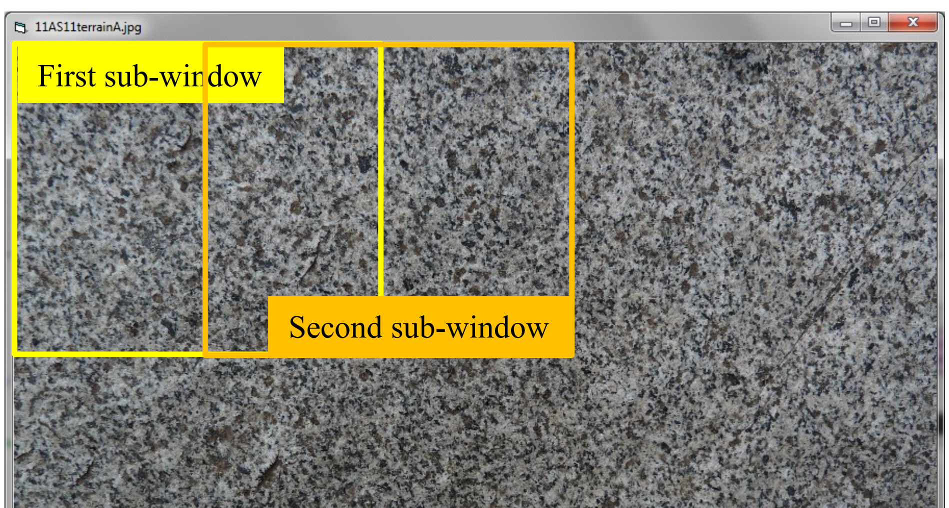
You may click on H to calculate and display the greyscale image histogram.



Select the number of sub-windows in X columns and Y rows. Then, the comparison between sub-windows results will allow to check the invariance of the results by translation of the sub-windows of analysis.

Move the mouse cursor over the histogram to display the count in the its corresponding grey level class of histogram.

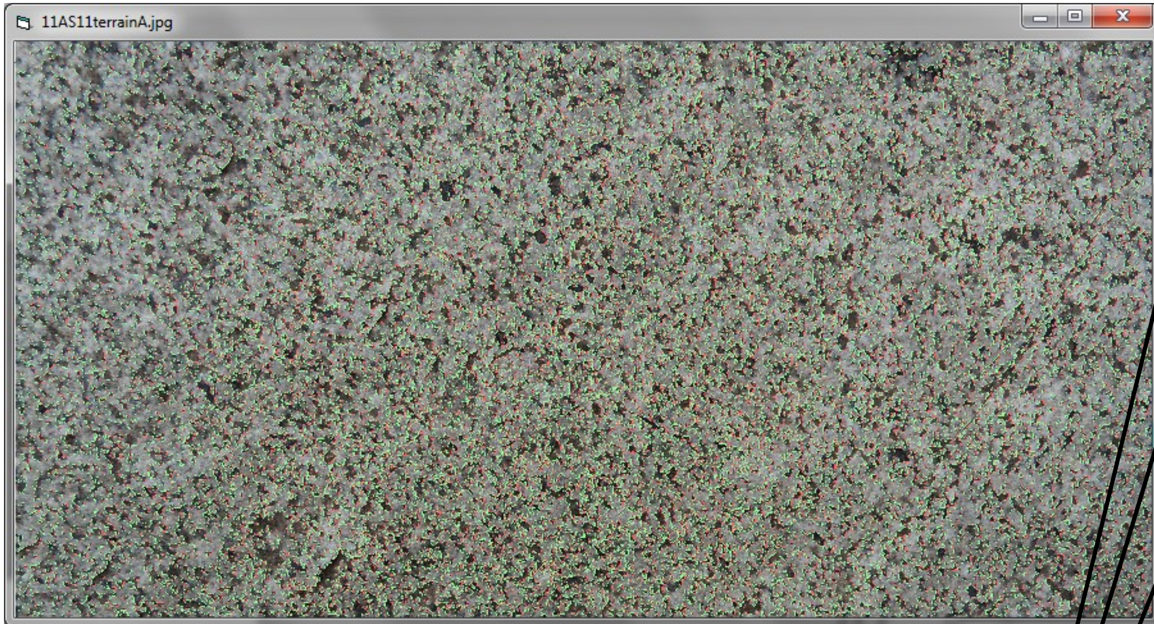
Move this cursor on the image to visualize its grey level in the histogram.



Columns X / 4

Rows Y / 2

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

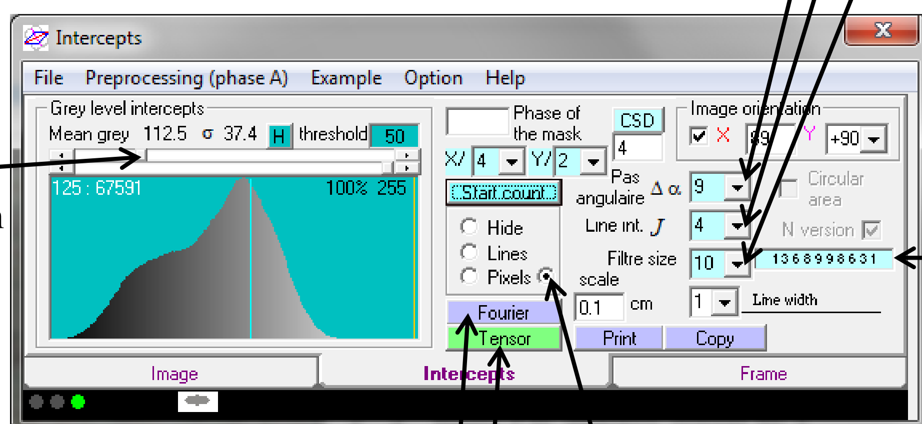


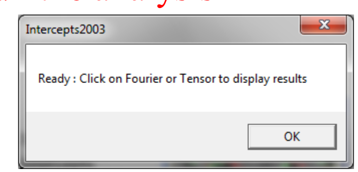
Selection of the angular step α used by the rotating grid of analysis.

Interline distance *J* between lines of analysis. The distance along lines *I* is always equal to 1.

Intercepts counting filter size (default is 10).
See course 5 page 1

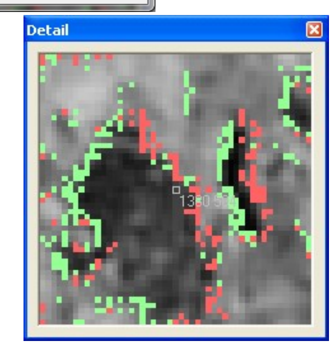
Then click on button Start count to run the analysis





Selection of the grey level detection of intercept: 50
A difference between two pixels greater or equal to 50 grey levels is a boundary

Weight of the intercepts counting filter



Option visualizing the intercept detection
Like for example with intercepts in and out in green and red

Display the results with Fourier series analysis

Fast calculation of rose by inertia tensor method p. 14
(see also course 4 p. 14)

The Detail window is available in the tab Image

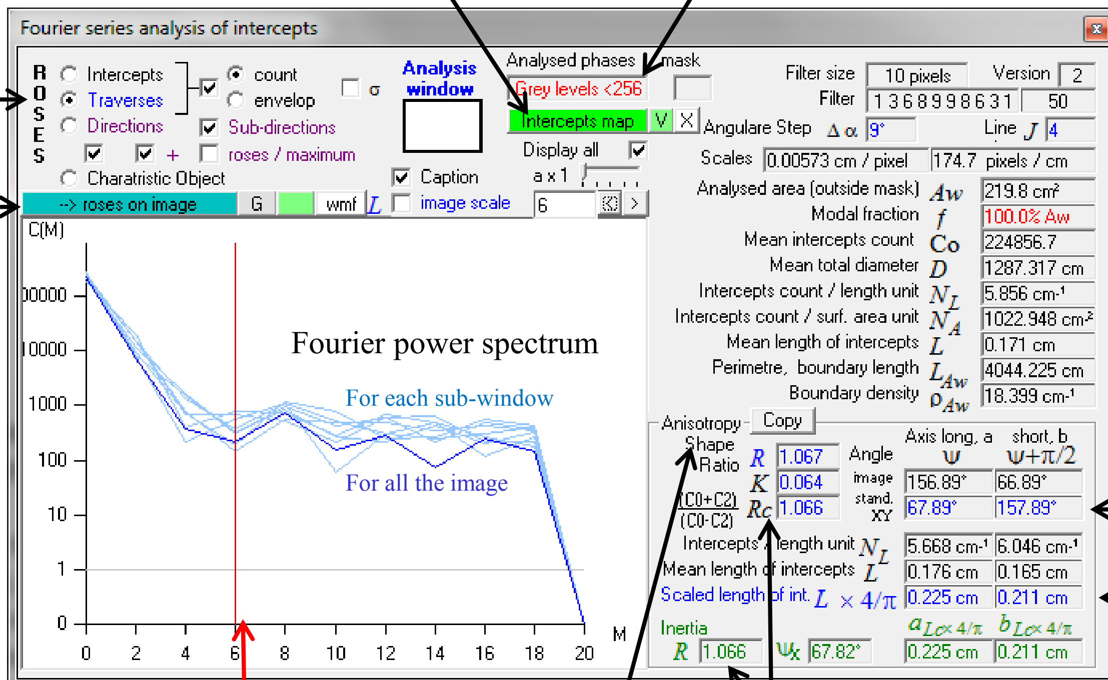
Results with Fourier series analysis

Draw the intercept boundaries on the top of the image; alone (V); delete them (X)

There is only one phase when processing the data in grey levels

Rose diagram selection with display options

Draw the roses on the image; with phases in grey; on the top of intercept boundaries; on a white background with metafile (wmf) recording; with image scale



Angle calculated from the X orientation of the image for exportation to Ellipsoid2003.exe

Size adjustment assuming that objects are ellipses (not appropriate for rectangular objects)

Anisotropy given by the 2[nd] harmonic (see course 4 p. 16) and inertia (see course 4 p. 14)

Selection of the number of harmonics used to rebuilt the rose diagrams
6 means that we sum all data from 0 to 6 and 8 to 20 are a blank noise

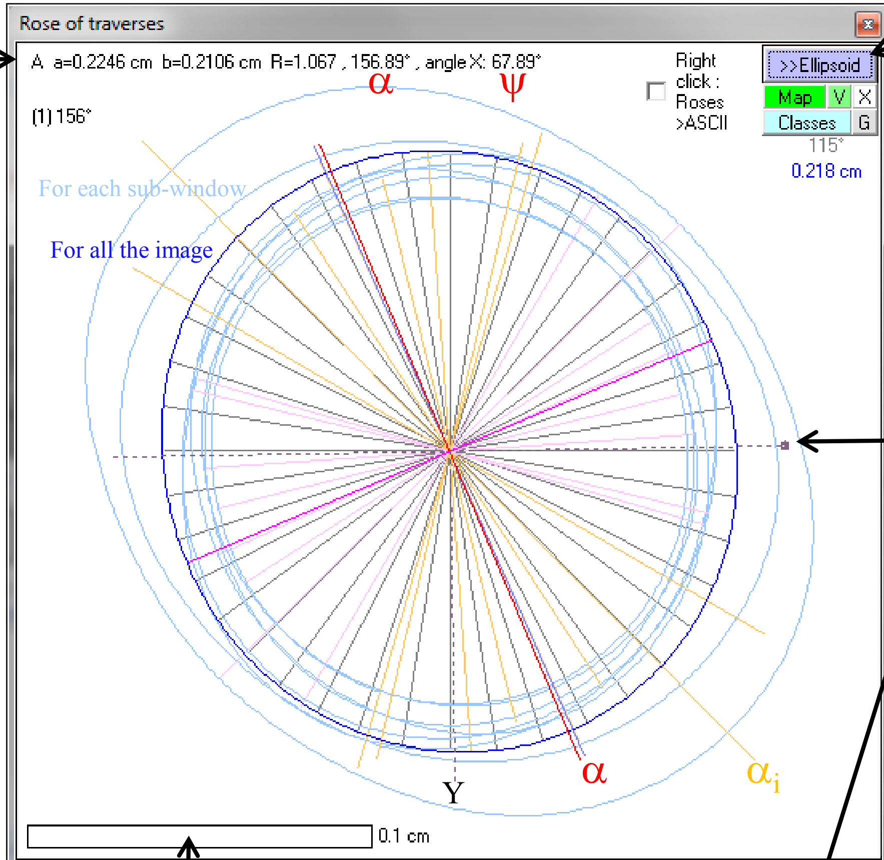
Full shape ratio using power spectrum from 0 to 6 (see course 4 p. 17)

Results with Fourier series analysis

Mean length intercept rose diagram or rose of traverses

For exportation of the data to Elliposid2003

Results



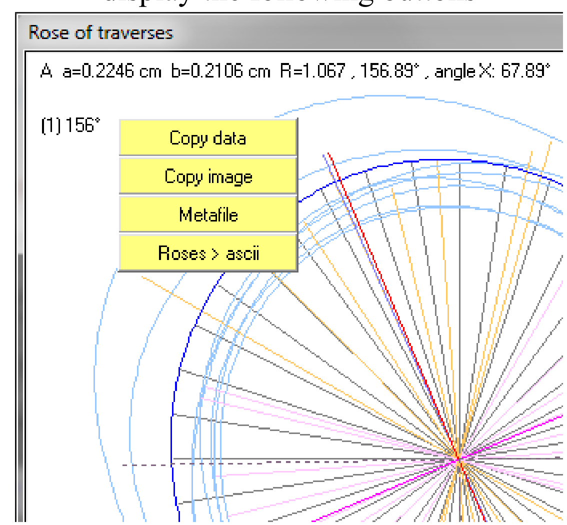
Draw the intercept boundaries on the top of the image; alone (V); delete them (X); with classes colour; with classes in grey

Image plane is 164 / 18

Ellipse is 164 / 18 / 68 with R=1.07

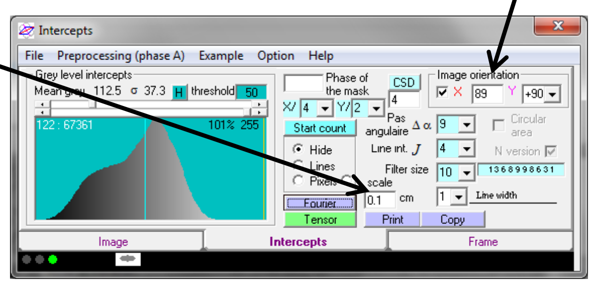
Image orientation X (corresponding to the strike)

Click with left button to display the following buttons



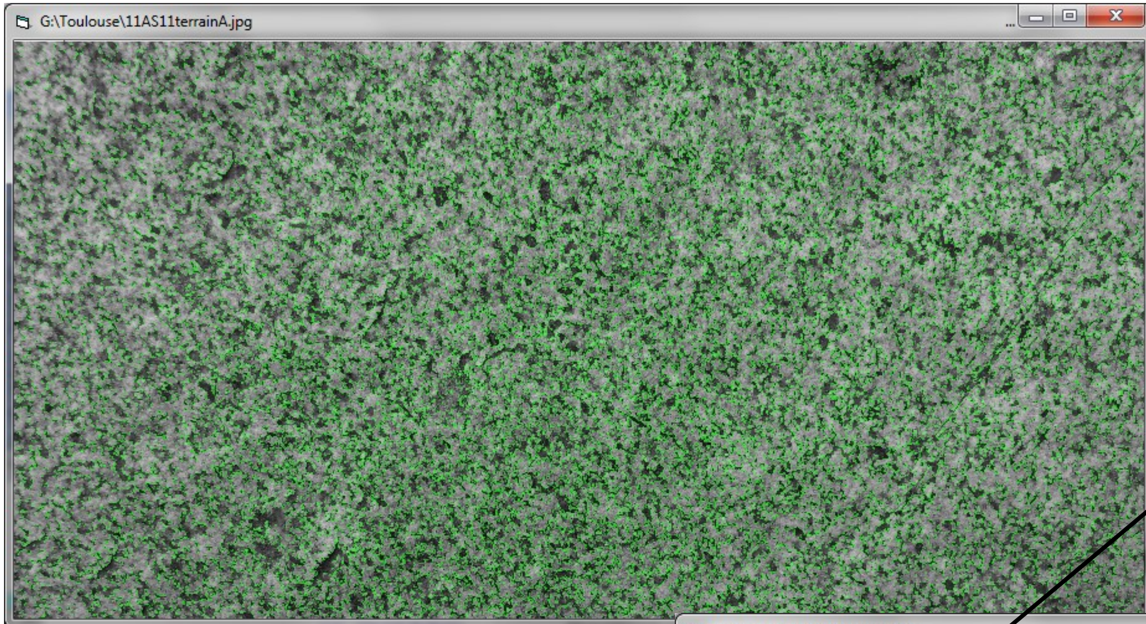
Metafile are compatible with Illustrator, Coreldraw, …

Scale



α is the image internal angle
ψ (α – 89) is the pitch on the image plane in the geographic coordinate system ϕ θ ψ.

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



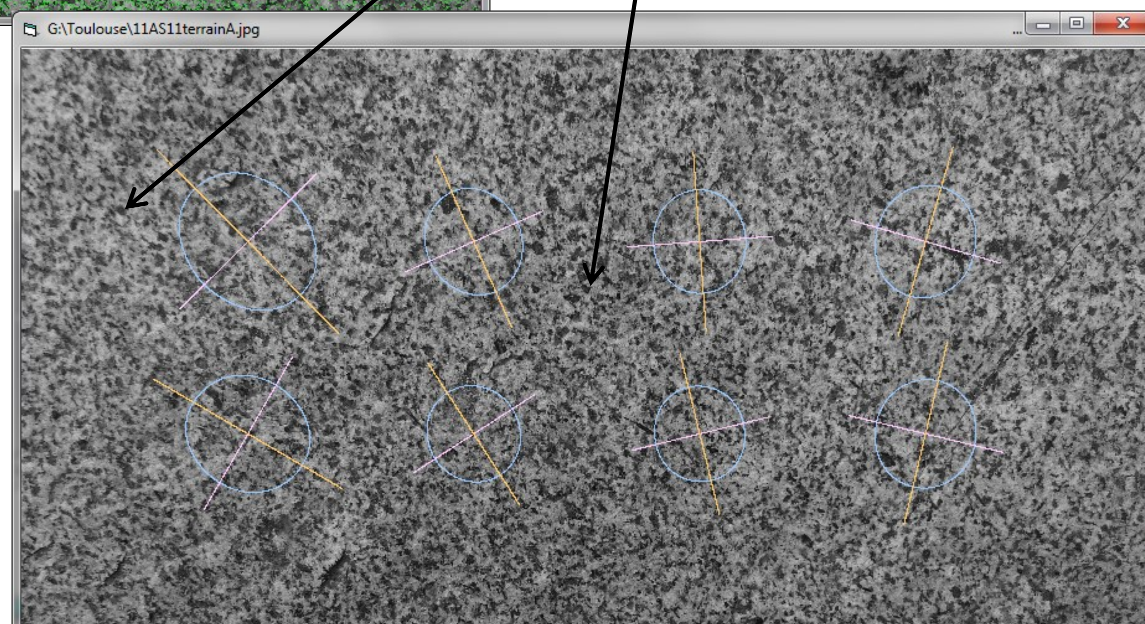
Intercepts map

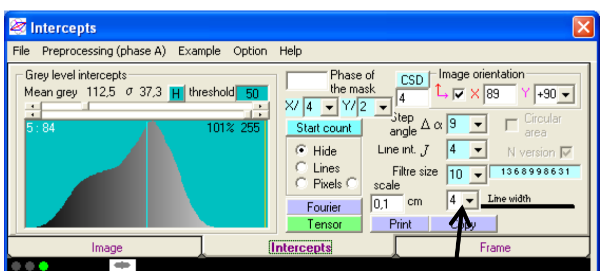
This is a selection of possible outputs of the results

Area with less thin dark but well oriented hornblende and more intermediate grey quartz

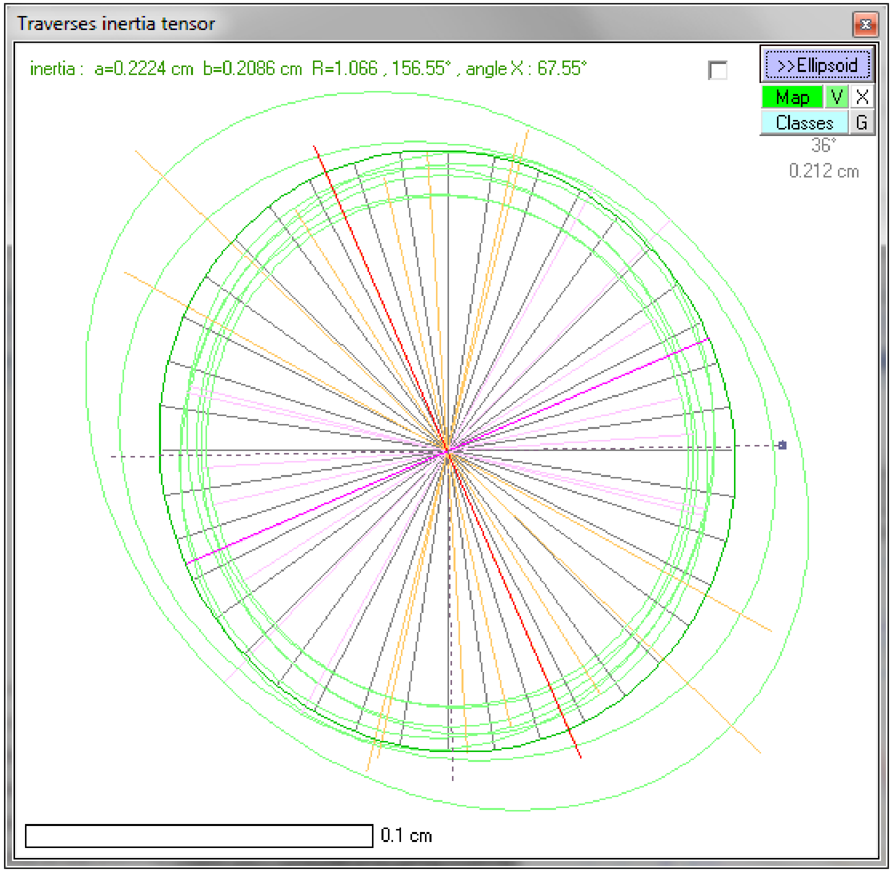
Area with more stocky dark hornblende

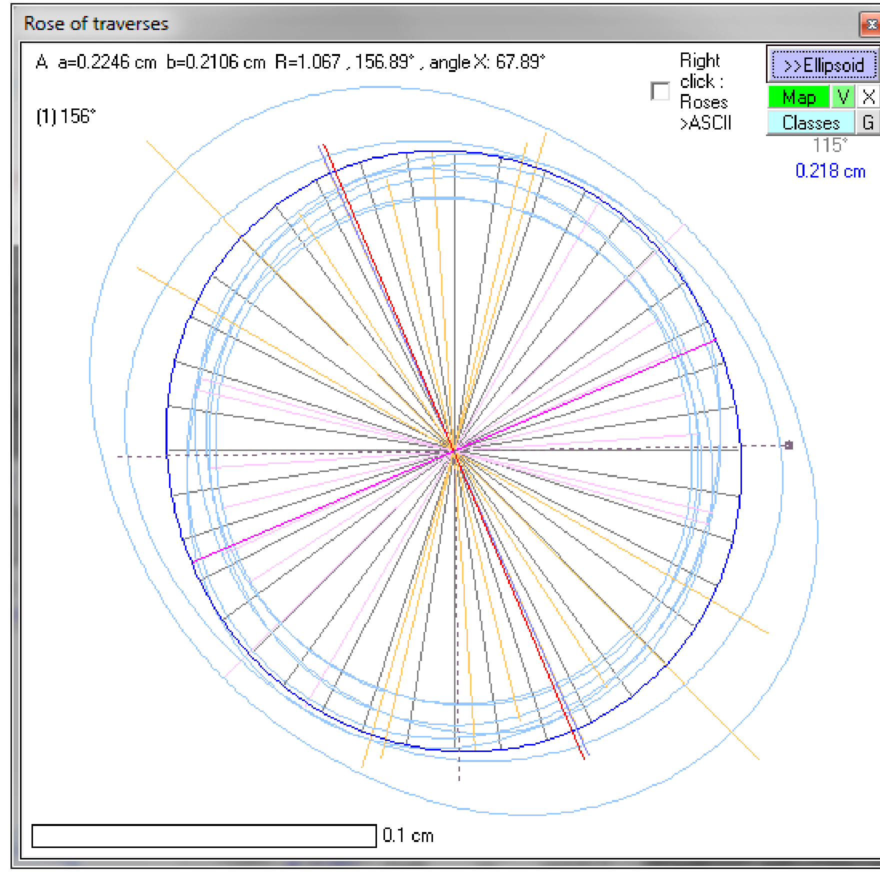
Roses on image





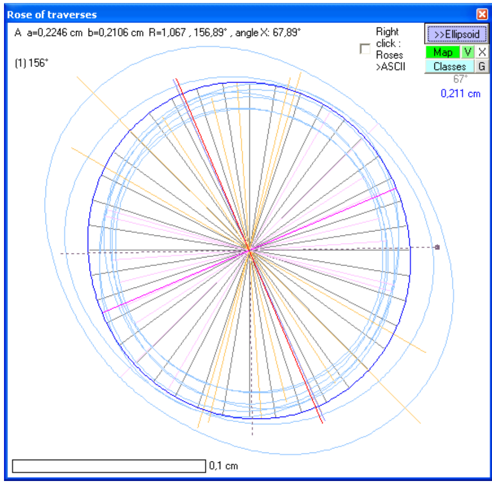
Display with a line width of 4 pixels to be visible on a zoom / 4





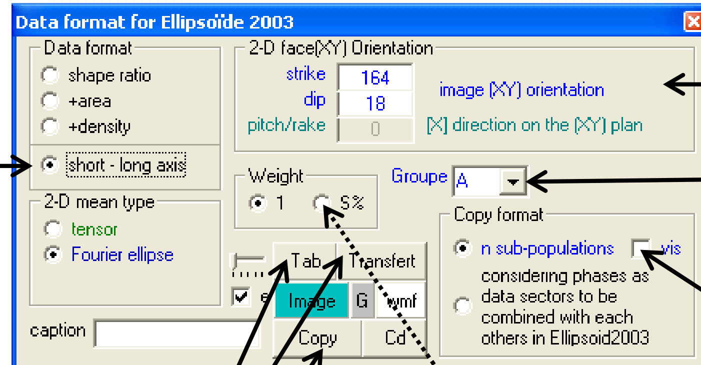
The inertia tensor of the traverses rose diagram can be used instead of the Fourier series.
It is fully automatic and doesn't required any harmonic selection. It is then useful for those who are not familiar with Fourier series.

Results with Fourier series analysis



Click on >>Ellipsoid

Data format selection



1) Enter strike and dip image orientation

2) Group of images to be combined in ellipsoid

Use it to visualize each sub-window in the image

3) Click on Tab to open the table of output

4) Click on Transfer to transfer the data in that table

5) Click on Copy to send the data in clipboard

Cd copy also sub-window positions for other purposes

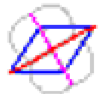
Table

	#	strike	dip	rake	long axis	short axis	weight	xc	yc
1	1_A	164	18	46,331	0,292344	0,238919	1	728,80	620,00
2	2_A	164	18	67,108	0,212886	0,187021	1	1457,60	620,00
3	3_A	164	18	86,882	0,202492	0,180606	1	2186,40	620,00
4	4_A	164	18	107,174	0,222036	0,194771	1	2915,20	620,00
5	5_A	164	18	31,148	0,245641	0,220170	1	728,80	1240,00
6	6_A	164	18	58,194	0,190721	0,180309	1	1457,60	1240,00
7	7_A	164	18	77,182	0,187691	0,175889	1	2186,40	1240,00
8	8_A	164	18	104,323	0,213017	0,196718	1	2915,20	1240,00

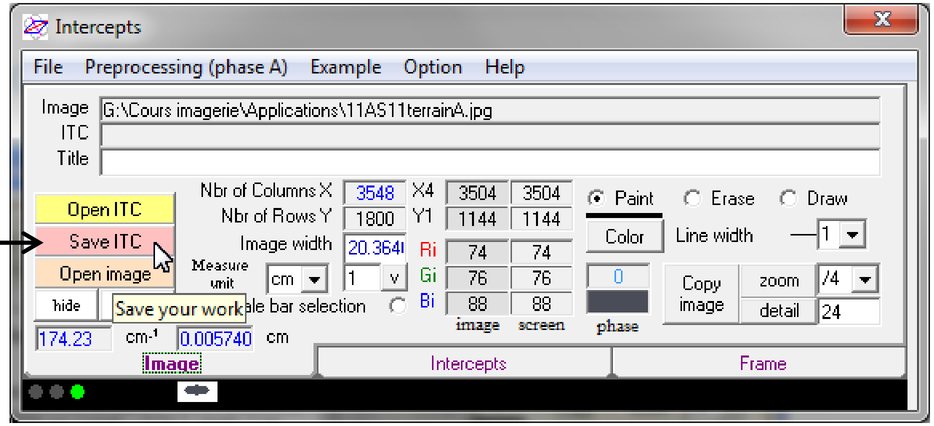
Coordinates of the sub-windows not used in Ellipsoid

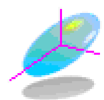
You may add a caption that will be printed between the sub-window number and the code of image group

Click on S% to weight each data to its surface area %



6) Save your work with all the orientations and the image compressed in “packbit” with 8 bits per pixel (grey level or phase color code)





7) Then open Elliposoid.exe

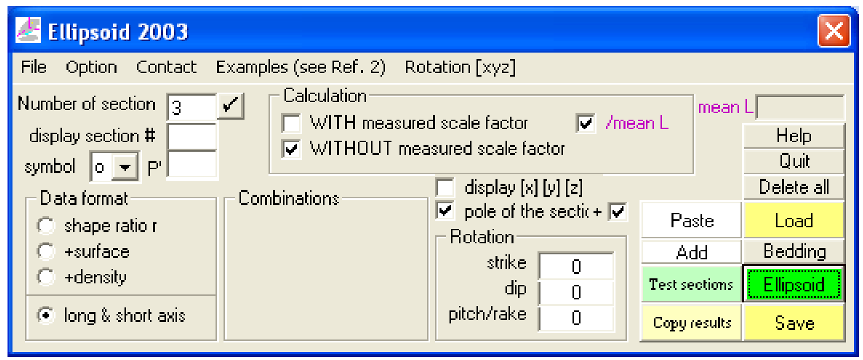
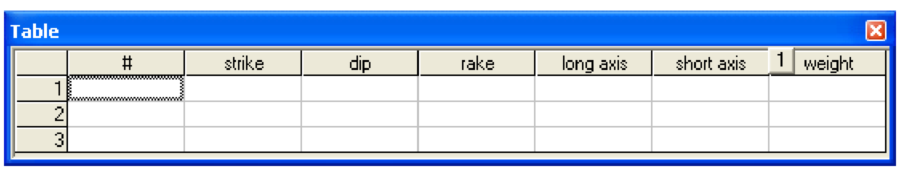


Table for input data



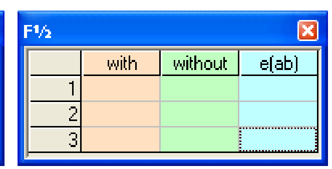
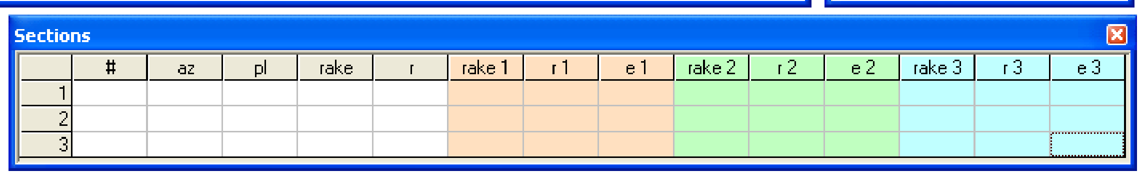
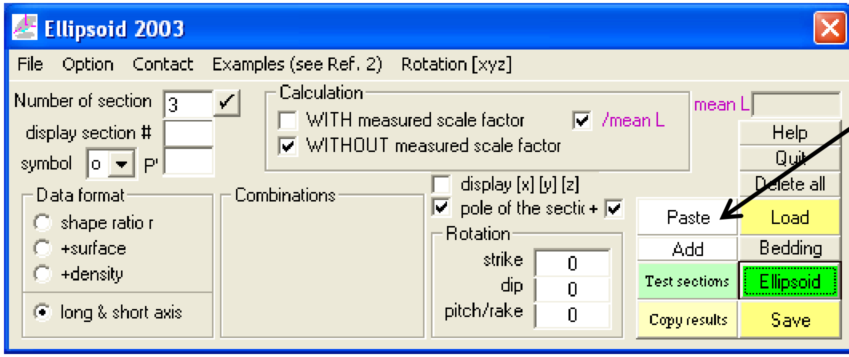


Table of 2D ellipse incompatibility with 3D ellipsoid

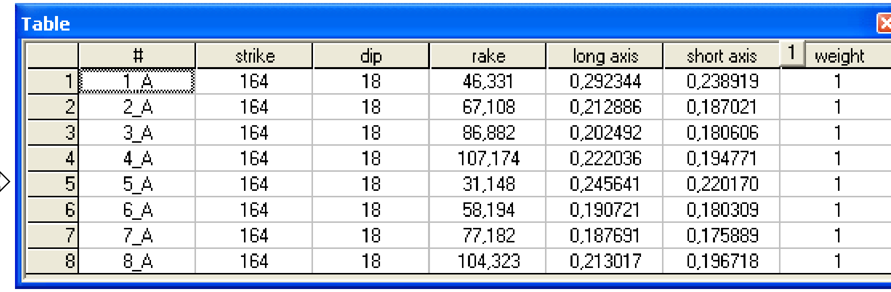
Table of comparison between shape ratio r and orientation rake of input data and output results for each image section (number, azimuth, plunge)



Results 1 with scale factors; 2 without scale factors; 3 with simple averaging on perpendicular sections. e is an error estimate given by the vector linking input and output long axes



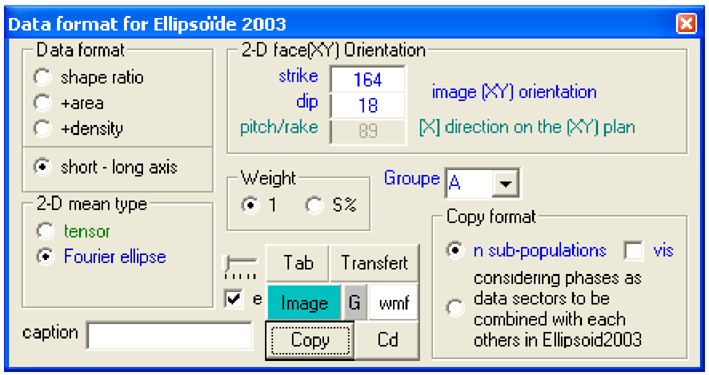
8) While intercepts data are in the clipboard, click on Paste for the first image



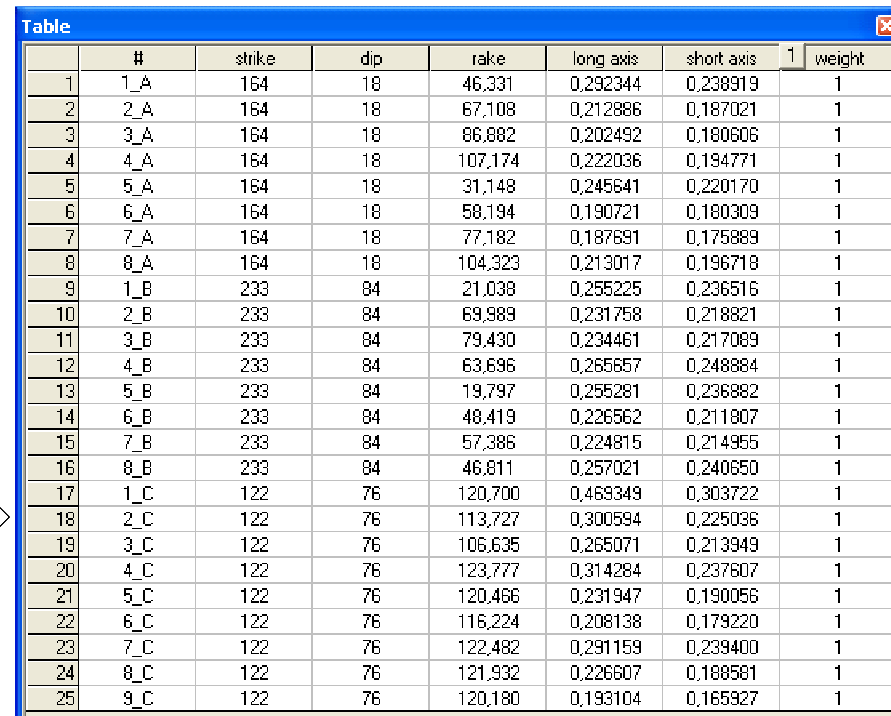
Table

	#	strike	dip	rake	long axis	short axis	weight
1	1_A	164	18	46,331	0,292344	0,238919	1
2	2_A	164	18	67,108	0,212886	0,187021	1
3	3_A	164	18	86,882	0,202492	0,180606	1
4	4_A	164	18	107,174	0,222036	0,194771	1
5	5_A	164	18	31,148	0,245641	0,220170	1
6	6_A	164	18	58,194	0,190721	0,180309	1
7	7_A	164	18	77,182	0,187691	0,175889	1
8	8_A	164	18	104,323	0,213017	0,196718	1

9) Go back to Intercepts2003 to load next image



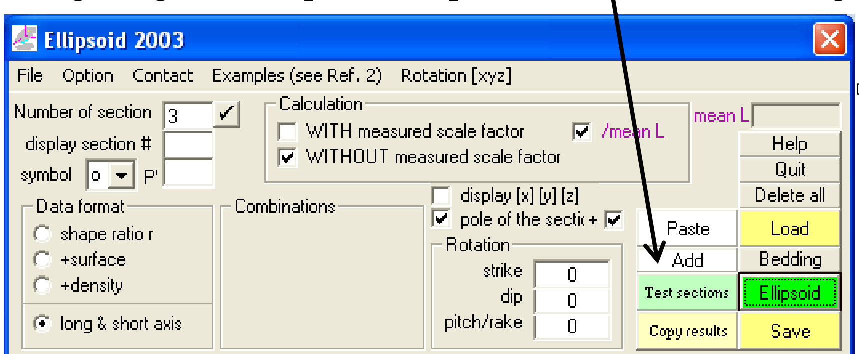
. . .



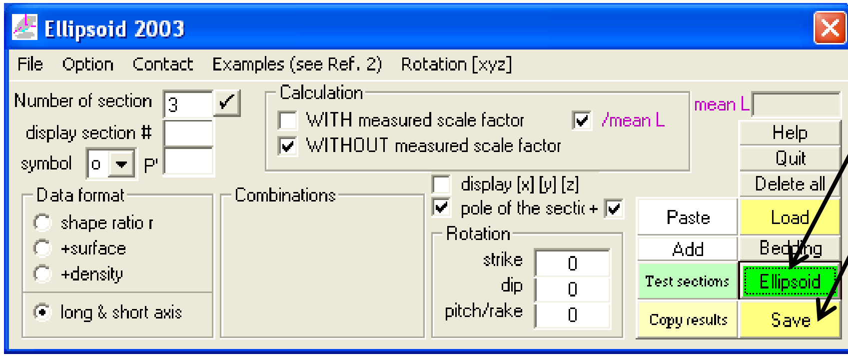
Table

	#	strike	dip	rake	long axis	short axis	weight
1	1_A	164	18	46,331	0,292344	0,238919	1
2	2_A	164	18	67,108	0,212886	0,187021	1
3	3_A	164	18	86,882	0,202492	0,180606	1
4	4_A	164	18	107,174	0,222036	0,194771	1
5	5_A	164	18	31,148	0,245641	0,220170	1
6	6_A	164	18	58,194	0,190721	0,180309	1
7	7_A	164	18	77,182	0,187691	0,175889	1
8	8_A	164	18	104,323	0,213017	0,196718	1
9	1_B	233	84	21,038	0,255225	0,236516	1
10	2_B	233	84	69,989	0,231758	0,218821	1
11	3_B	233	84	79,430	0,234461	0,217089	1
12	4_B	233	84	63,696	0,265657	0,248884	1
13	5_B	233	84	19,797	0,255281	0,236882	1
14	6_B	233	84	48,419	0,226562	0,211807	1
15	7_B	233	84	57,386	0,224815	0,214955	1
16	8_B	233	84	46,811	0,257021	0,240650	1
17	1_C	122	76	120,700	0,469349	0,303722	1
18	2_C	122	76	113,727	0,300594	0,225036	1
19	3_C	122	76	106,635	0,265071	0,213949	1
20	4_C	122	76	123,777	0,314284	0,237607	1
21	5_C	122	76	120,466	0,231947	0,190056	1
22	6_C	122	76	116,224	0,208138	0,179220	1
23	7_C	122	76	122,482	0,291159	0,239400	1
24	8_C	122	76	121,932	0,226607	0,188581	1
25	9_C	122	76	120,180	0,193104	0,165927	1

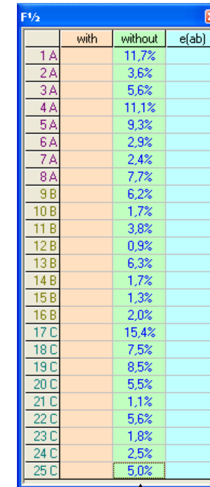
10) Go back to Ellipsoid2003 and click on Add for all following images and repeat the operation until the last image



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

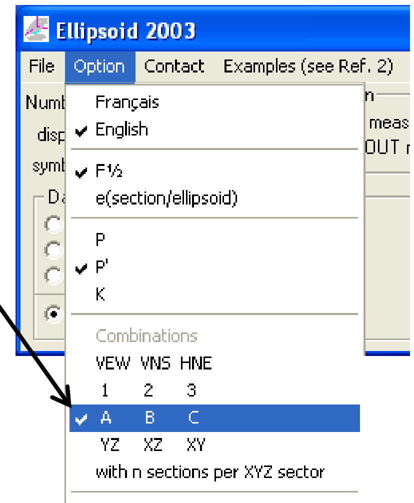


Click on Ellipsoid to display the first result and
Click on Save it before selecting any option

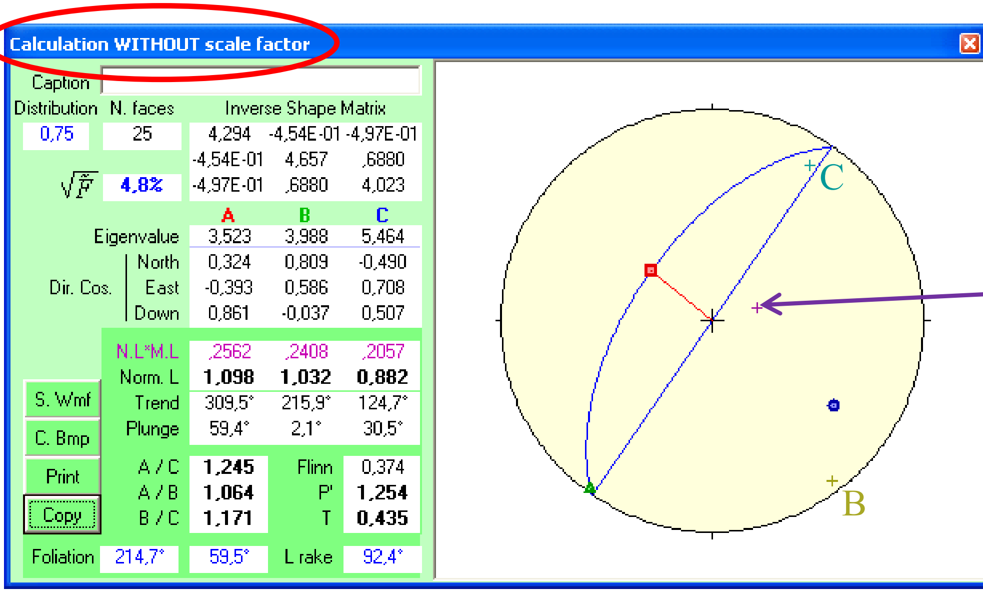


	with	without	e(ab)
1 A		11,7%	
2 A		3,6%	
3 A		5,6%	
4 A		11,1%	
5 A		9,3%	
6 A		2,9%	
7 A		2,4%	
8 A		7,7%	
9 B		6,2%	
10 B		1,7%	
11 B		3,8%	
12 B		0,9%	
13 B		6,3%	
14 B		1,7%	
15 B		1,3%	
16 B		2,0%	
17 C		15,4%	
18 C		7,5%	
19 C		8,5%	
20 C		5,5%	
21 C		1,1%	
22 C		5,6%	
23 C		1,8%	
24 C		2,5%	
25 C		5,0%	

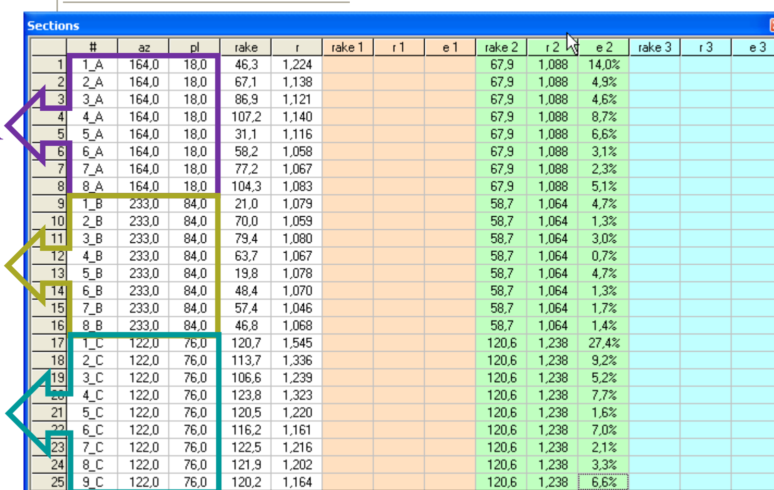
Incompatibility index: smallest values best fit the ellipsoid



Select the option A B C to process your data ending with this code defining 3 type of sections roughly perpendicular to each other

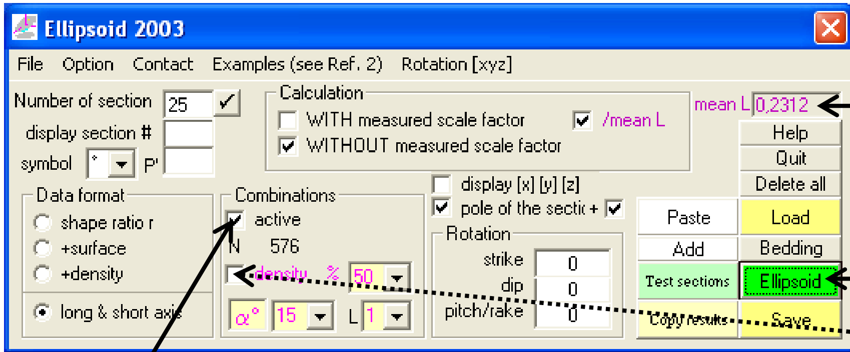


N.L*M.L : normalized length (in arbitrary unit) times mean length (in metric unit)



	#	az	pl	rake	r	rake 1	r 1	e 1	rake 2	r 2	e 2	rake 3	r 3	e 3
1	1_A	164,0	18,0	46,3	1,224				67,9	1,088	14,0%			
2	2_A	164,0	18,0	67,1	1,138				67,9	1,088	4,9%			
3	3_A	164,0	18,0	86,9	1,121				67,9	1,088	4,6%			
4	4_A	164,0	18,0	107,2	1,140				67,9	1,088	8,7%			
5	5_A	164,0	18,0	31,1	1,116				67,9	1,088	6,6%			
6	6_A	164,0	18,0	58,2	1,058				67,9	1,088	3,1%			
7	7_A	164,0	18,0	77,2	1,067				67,9	1,088	2,3%			
8	8_A	164,0	18,0	104,3	1,083				67,9	1,088	5,1%			
9	1_B	233,0	84,0	21,0	1,079				58,7	1,064	4,7%			
10	2_B	233,0	84,0	70,0	1,059				58,7	1,064	1,3%			
11	3_B	233,0	84,0	79,4	1,080				58,7	1,064	3,0%			
12	4_B	233,0	84,0	63,7	1,067				58,7	1,064	0,7%			
13	5_B	233,0	84,0	19,8	1,078				58,7	1,064	4,7%			
14	6_B	233,0	84,0	48,4	1,070				58,7	1,064	1,3%			
15	7_B	233,0	84,0	57,4	1,046				58,7	1,064	1,7%			
16	8_B	233,0	84,0	46,8	1,068				58,7	1,064	1,4%			
17	1_C	122,0	76,0	120,7	1,545				120,6	1,238	27,4%			
18	2_C	122,0	76,0	113,7	1,336				120,6	1,238	9,2%			
19	3_C	122,0	76,0	106,6	1,239				120,6	1,238	5,2%			
20	4_C	122,0	76,0	123,8	1,323				120,6	1,238	7,7%			
21	5_C	122,0	76,0	120,5	1,220				120,6	1,238	1,6%			
22	6_C	122,0	76,0	116,2	1,161				120,6	1,238	7,0%			
23	7_C	122,0	76,0	122,5	1,216				120,6	1,238	2,1%			
24	8_C	122,0	76,0	121,9	1,202				120,6	1,238	3,3%			
25	9_C	122,0	76,0	120,2	1,164				120,6	1,238	6,6%			

Rake and shape ratio of Ellipsoid section
With deviation *e* between 2D measure and 3D section

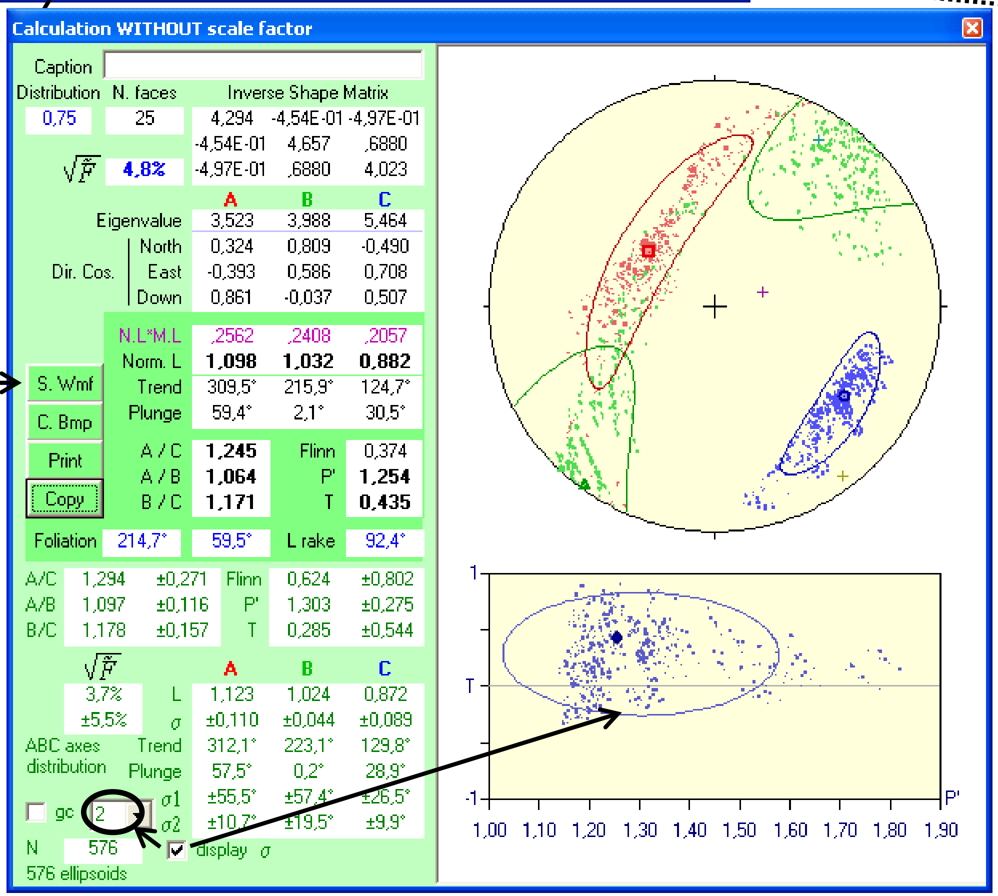


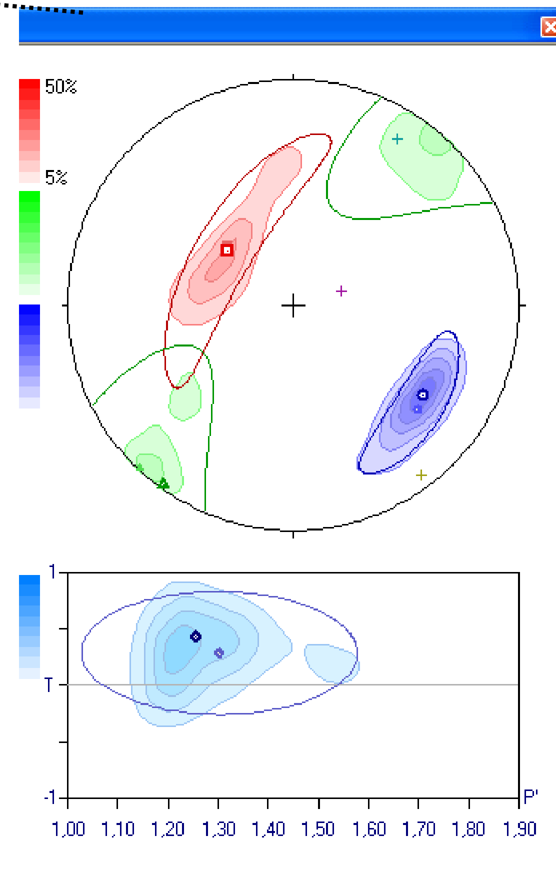
Mean length given by the input data

/mean L avoid overflow and facilitate the calculation of eigenvalues

Click again on Ellipsoid to calculate the ellipsoid with combination of the 9 sub-windows per section A, B, C in 576 ellipsoids

To export the plot in a metafile



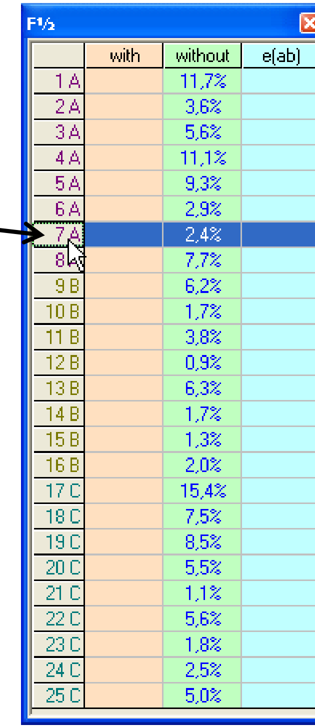


The density calculation may be time consuming

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

Comparison between calculated ellipsoid sections and ellipse measurements

Click on this row to display the data of this section in the graphic

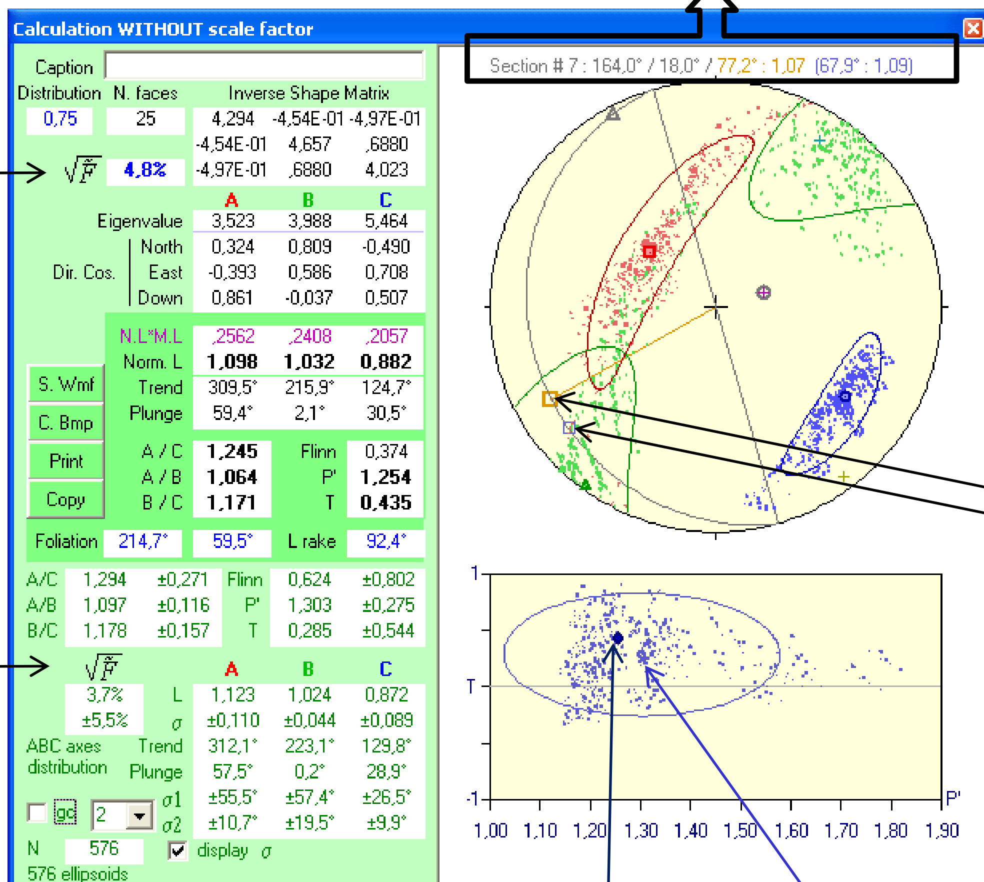


Section #7 : strike / dip

2D calculated Ellipsoid section / rake : shape ratio

2D measured Ellipse (rake : shape ratio)

F ½ : incompatibility index between all 2D ellipsoidal sections and the 3D ellipsoid



Input data long axis

Long axis found on the section of the ellipsoid (F ½ =2.4% and e=2.3%)

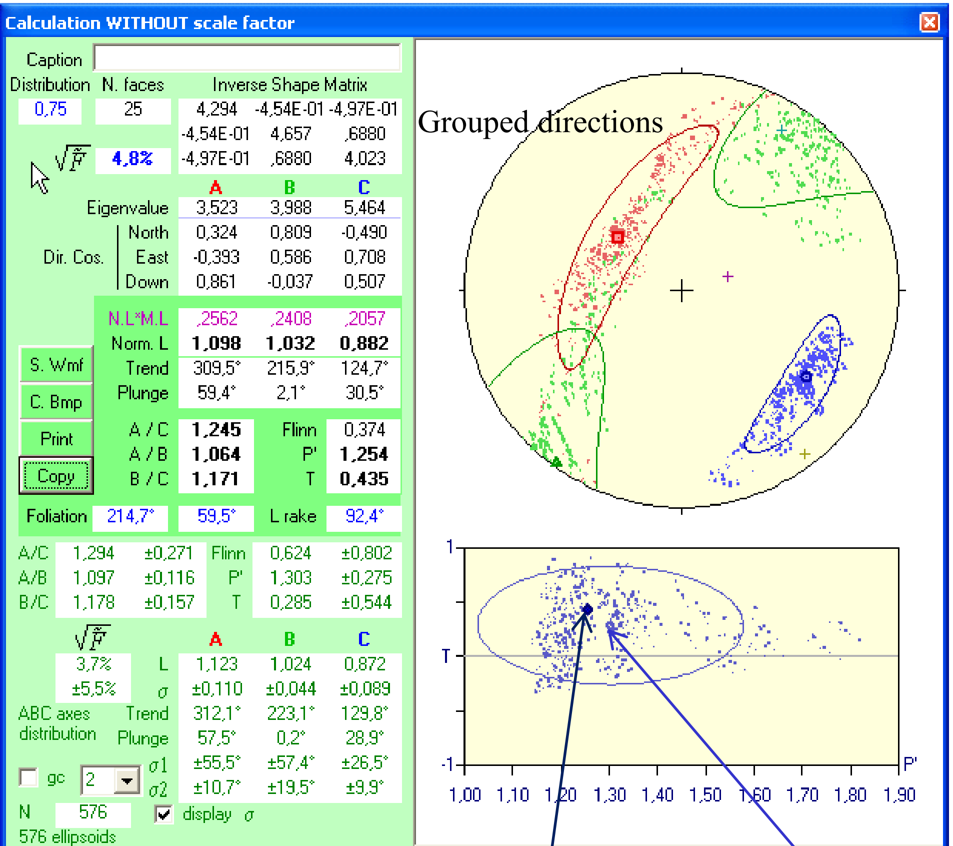
Mean F ½ : incompatibility index between 2D ellipsoidal sections and the 576 intermediate 3D ellipsoid

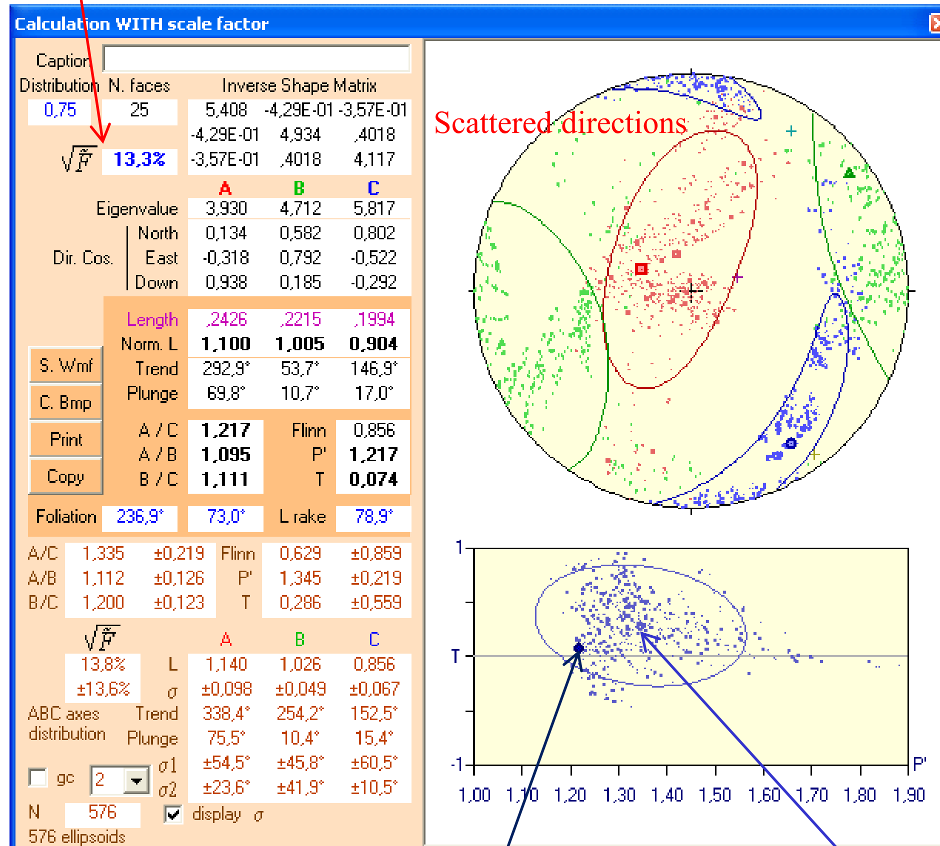
Check the consistency between the full ellipsoid and the mean ellipsoid of the 576 combinations of sub-windows.

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

Warning: Be careful when using scale factor!

A strong F ½ indicates that sizes may be wrong (no consistency between images)



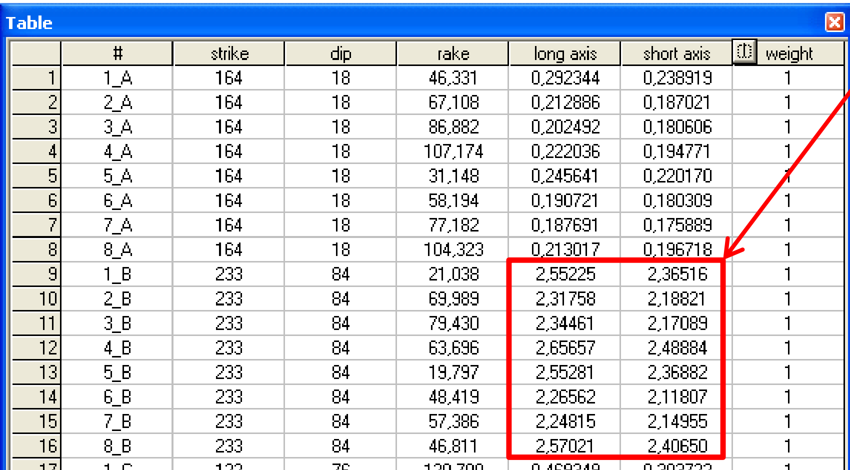


The full ellipsoid P' is close to the mean P' value of the 576 sub-windows ellipsoids

Consistent P' parameters

The full ellipsoid P' is not close to the mean P' value of the 576 sub-windows ellipsoids

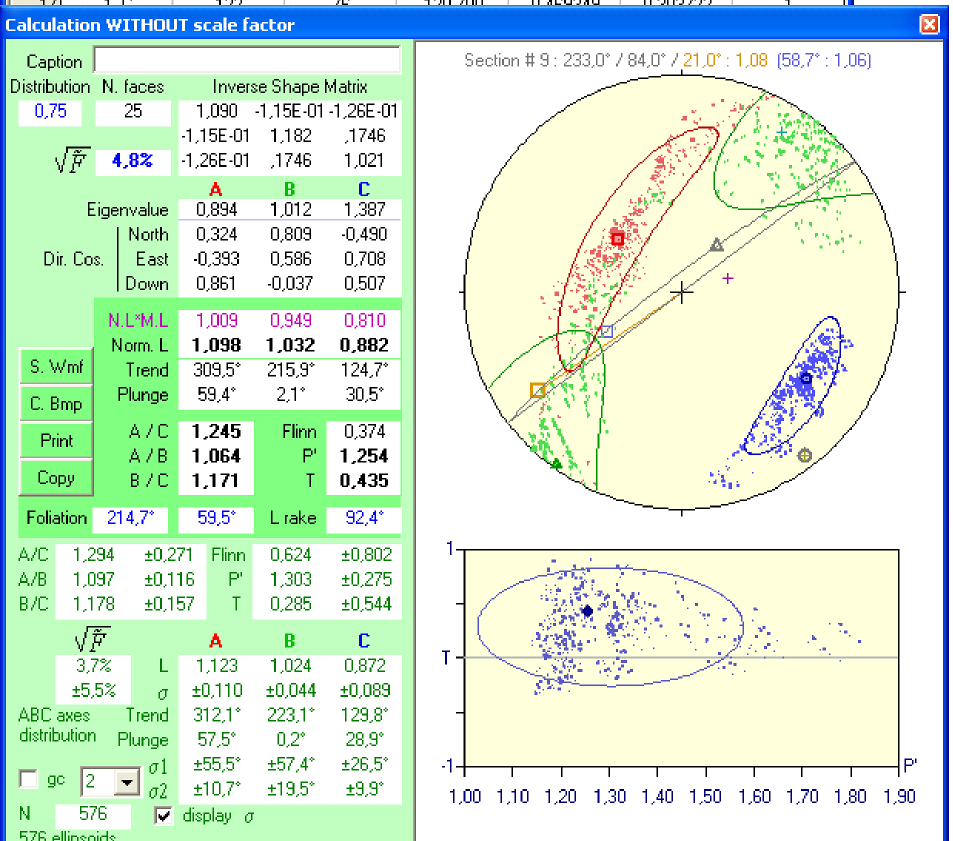
Not consistent P' parameters

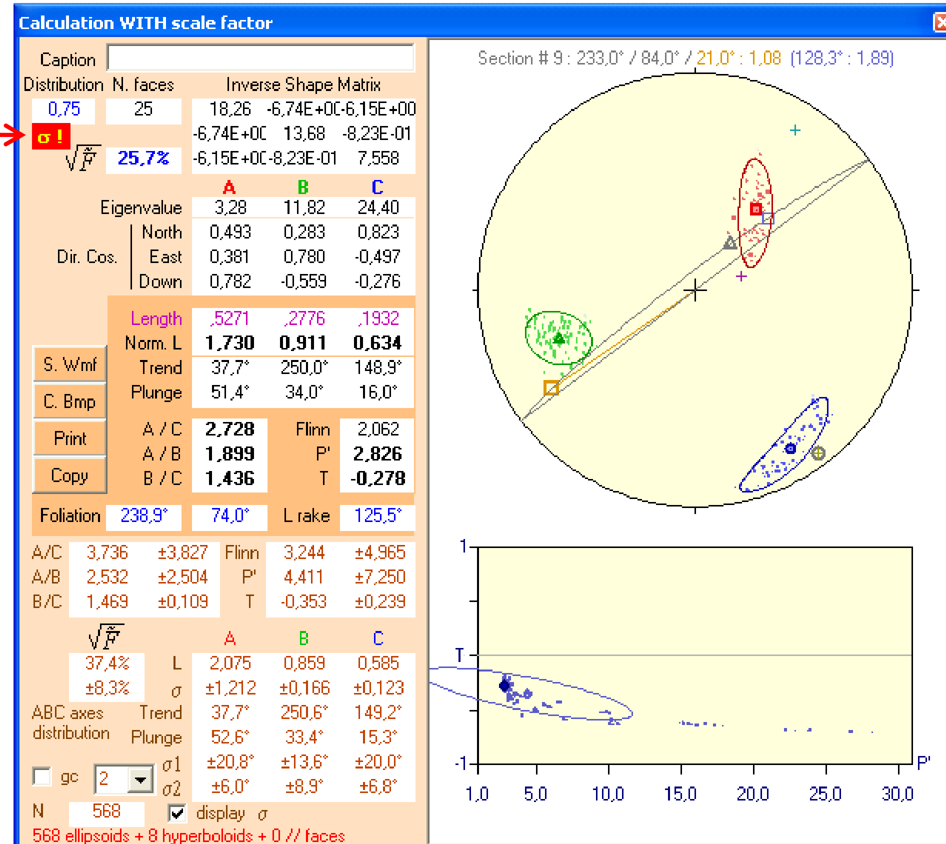


Table

	#	strike	dip	rake	long axis	short axis	weight
1	1_A	164	18	46,331	0,292344	0,238919	1
2	2_A	164	18	67,108	0,212886	0,187021	1
3	3_A	164	18	86,882	0,202492	0,180606	1
4	4_A	164	18	107,174	0,222036	0,194771	1
5	5_A	164	18	31,148	0,245641	0,220170	1
6	6_A	164	18	58,194	0,190721	0,180309	1
7	7_A	164	18	77,182	0,187691	0,175889	1
8	8_A	164	18	104,323	0,213017	0,196718	1
9	1_B	233	84	21,038	2,55225	2,36516	1
10	2_B	233	84	69,989	2,31758	2,18821	1
11	3_B	233	84	79,430	2,34461	2,17089	1
12	4_B	233	84	63,696	2,65657	2,48884	1
13	5_B	233	84	19,797	2,55281	2,36882	1
14	6_B	233	84	48,419	2,26562	2,11807	1
15	7_B	233	84	57,386	2,24815	2,14955	1
16	8_B	233	84	46,811	2,57021	2,40650	1

The sizes of the long and short axes of the B section have been multiplied by 10 to show that calculation with a wrong scale factor in one section may gives false results whereas calculation without scale factor remains correct.



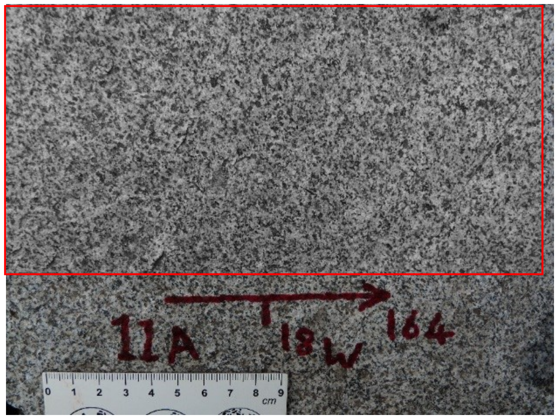


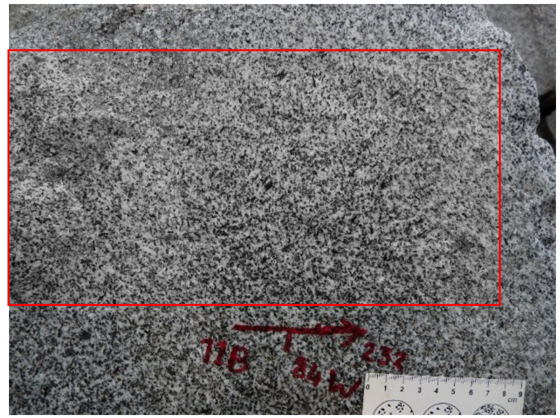
The gathering of directions along A, B and C is due to an intersection effect which force those directions to rotate towards the image plans or their poles. Such error can be detected by anomalous standard deviations, hyperboloids or strong F ½ (25% and mean at 37% here). See hyperboloid in course 6 p. 9.

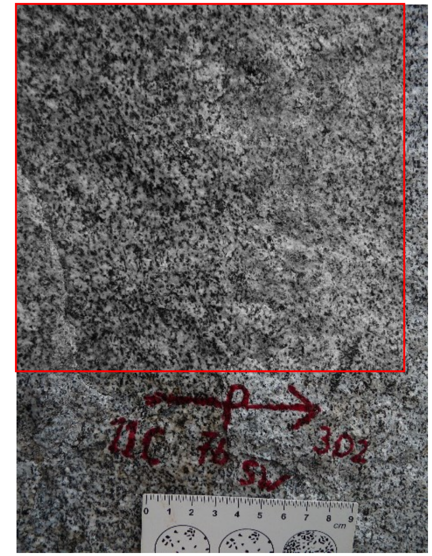
Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

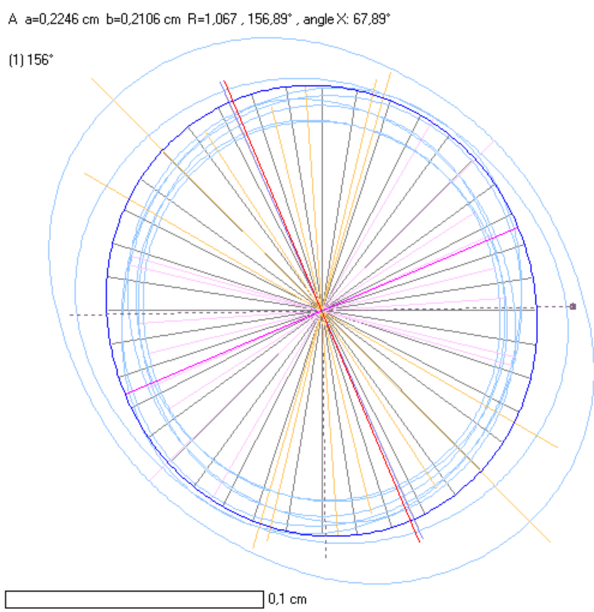
Summary of the field image analysis

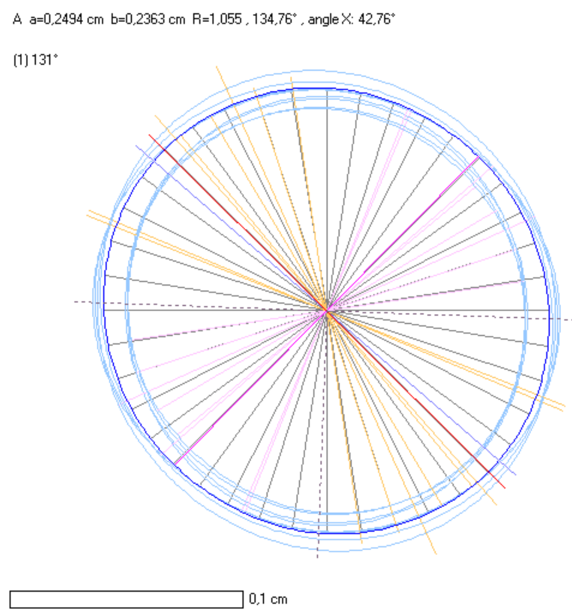
Window area of analysis

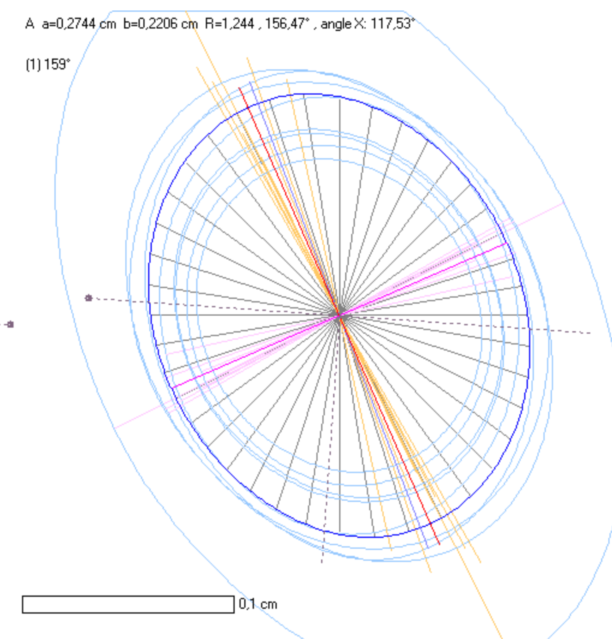








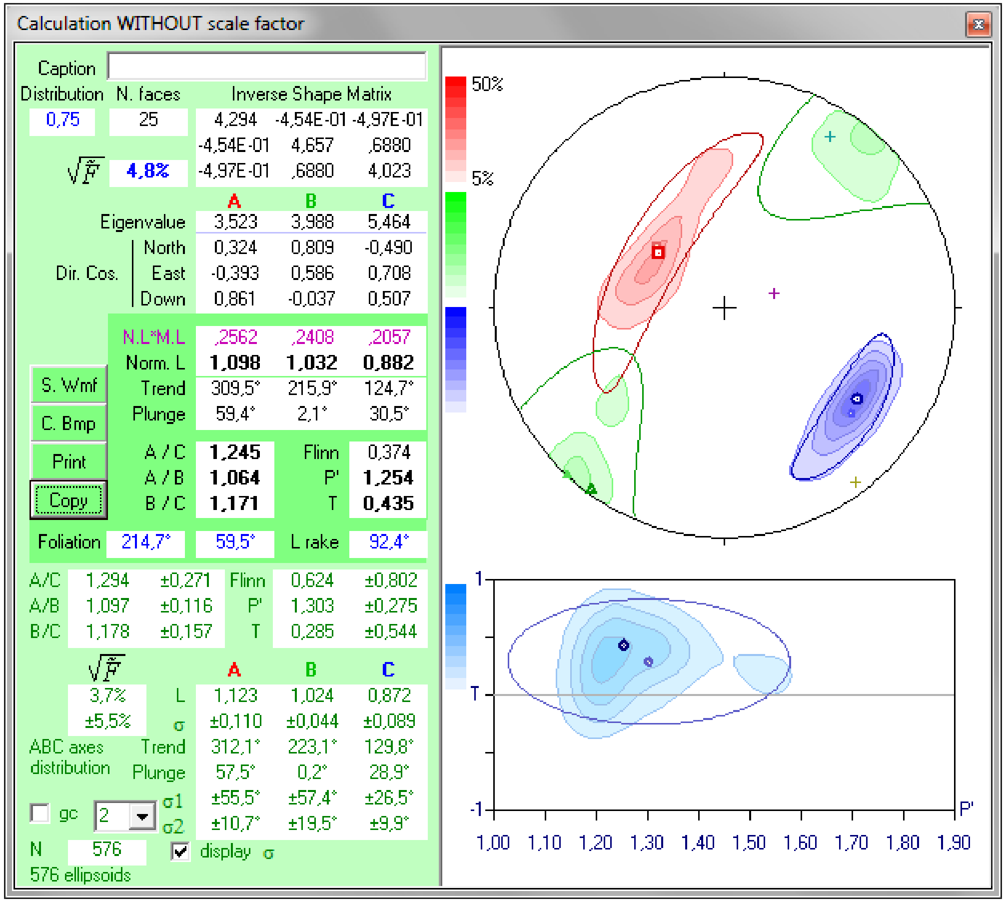


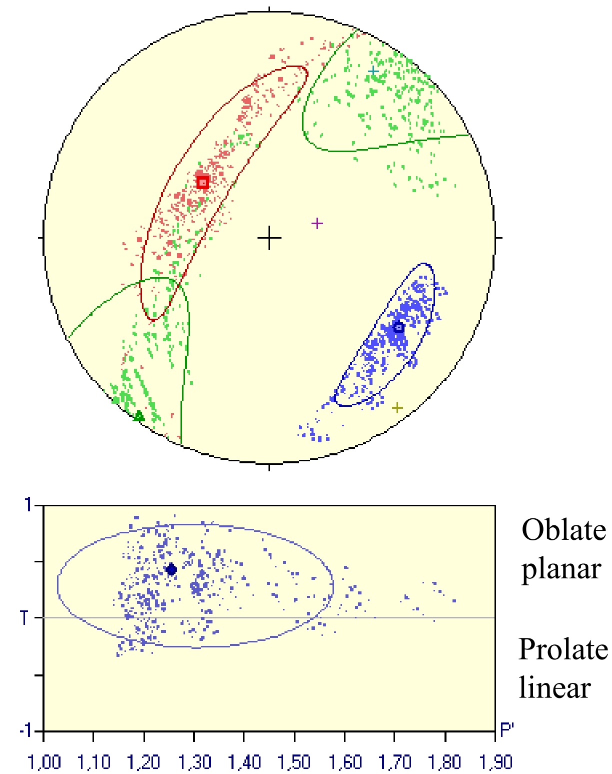


0.006 cm/pixel

Summary of the field image analysis

See page 6 that local variations of mineralogy, in the field plane A 20 cm wide, can explain the data scattering.

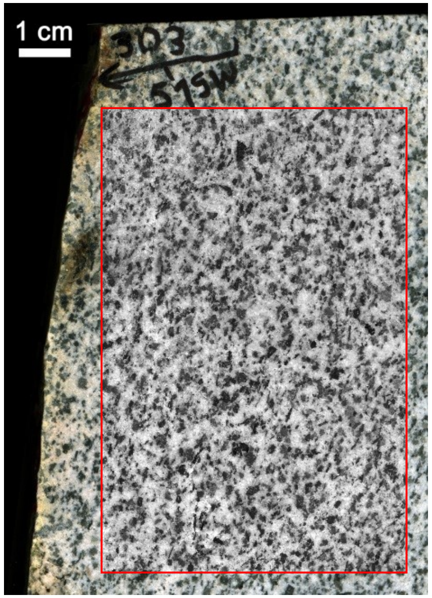


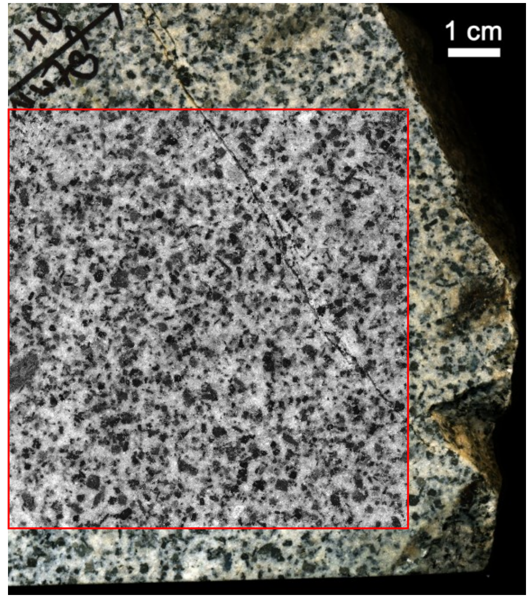


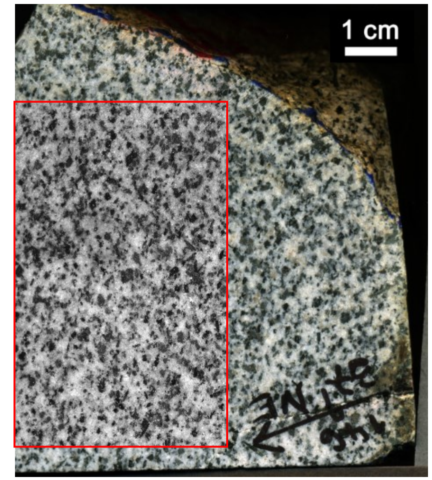
The ellipsoid is planar to planolinear with planar sub-ellipsoid and planolinear sub-ellipsoid

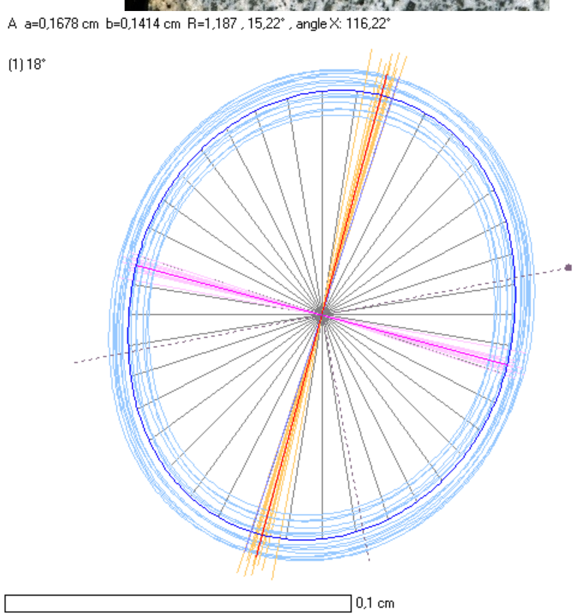
Summary of the block sample section image analysis

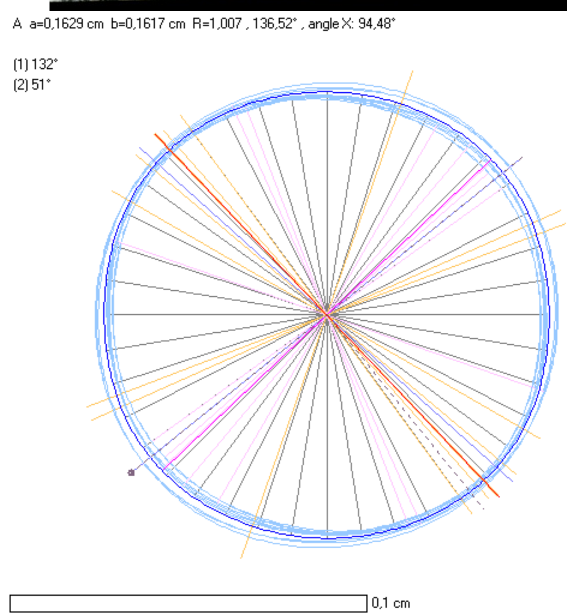
Window area of analysis

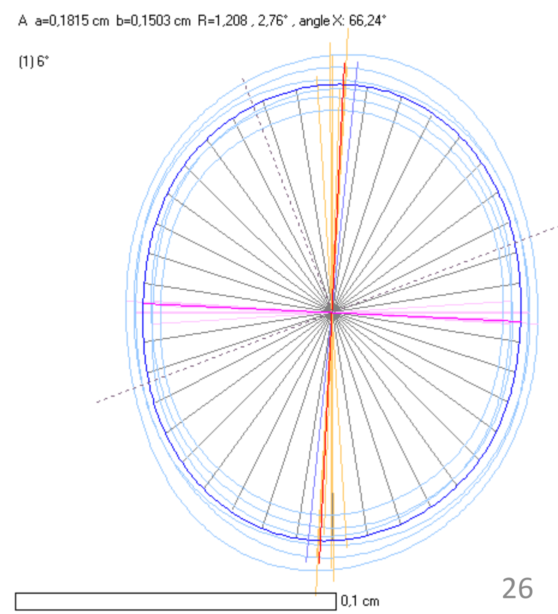








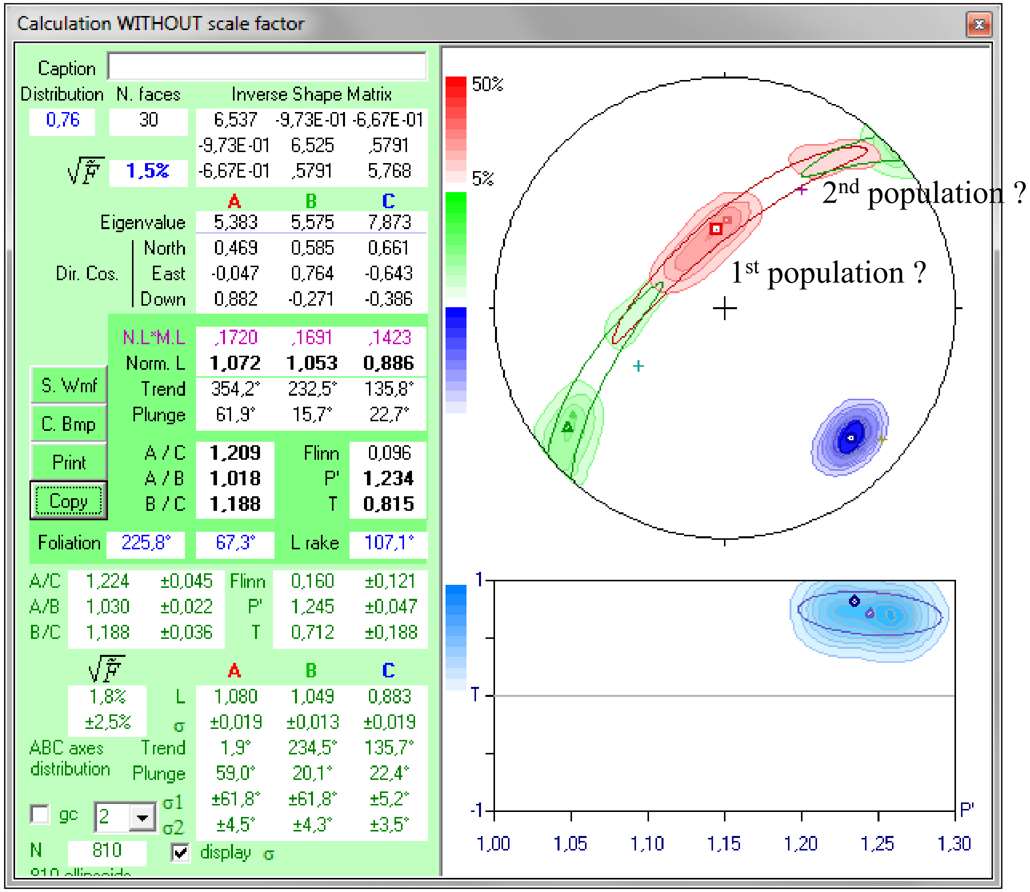


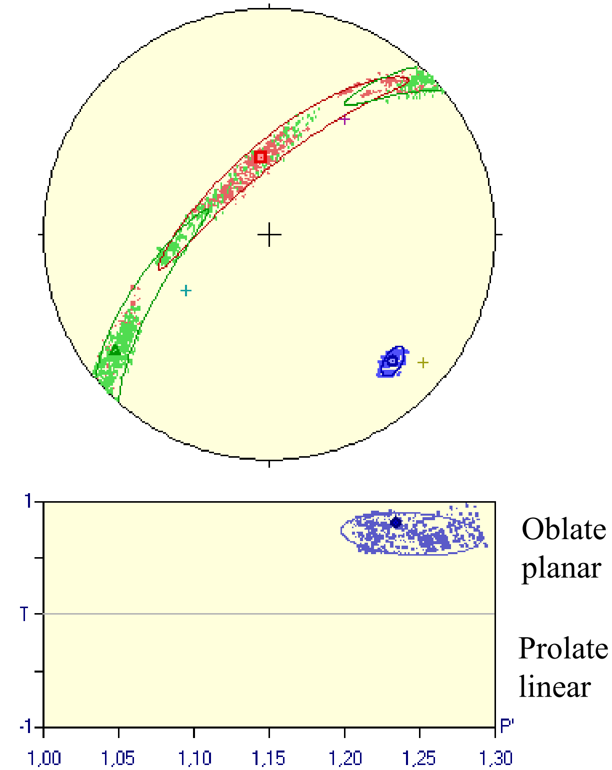


0.004 cm/pixel

Summary of sample section image analysis. Each section was oriented

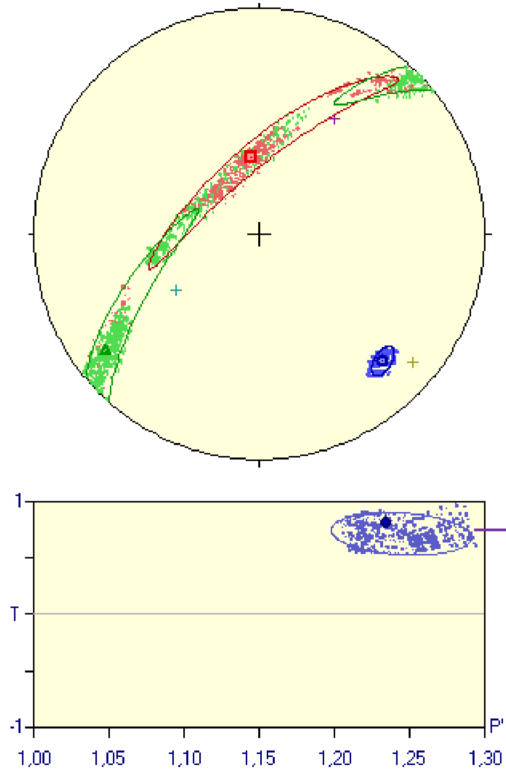
The sample section A area of analysis is ~ 6 cm wide which is ~30% of one field image.



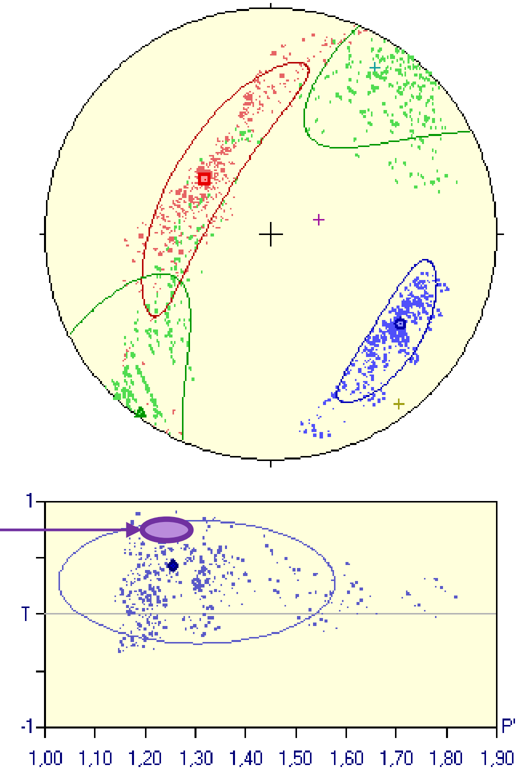


The main ellipsoid is planar like all sub-ellipsoids. If the axis C of the ellipsoid is well concentrated in one direction the other axes A and B seem displaying a bimodal distribution on the plane (AB).

Analysis of block sample sections



Analysis of field oriented pictures



The sample block displaying smaller sectional areas and a smaller volume, it gives the SPO of small homogenous magma flow.
The field images analyzing larger areas forming a larger volume which display heterogeneous SPO probably include several flows of magma.