

## 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)

This step by step application to Rooi Rand dyke swarm reprocess the image used with intercepts in grey level with a particular attention to SPO obliquity on dyke walls

Hastie, W.W., Aubourg, C., Watkeys, M.K. (2011) When an 'inverse' fabric is not inverse: an integrated AMS-SPO study in MORB-like dykes. *Terra Nova* 23, 49–55.

Hastie, W.W., Watkeys, M.K., Aubourg, C. (2011) Significance of magnetic and petrofabric in Karoo-feeder dykes, northern Lebombo. *Tectonophysics* 513, 96–111

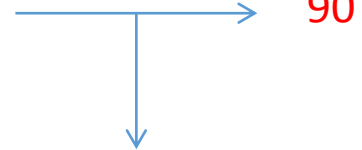
Hastie, W.W., Watkeys, M.K., Aubourg, C. (2013) Characterisation of grain-size, shape and orientation of plagioclase in the Rooi Rand dyke swarm, South Africa. *Tectonophysics*, 583, 145–157

Hastie, W.W., Watkeys, M.K., Aubourg, C. (2014) Magma flow in dyke swarms of the Karoo LIP: Implications for the mantle plume hypothesis. *Gondwana Research* 25 (2014) 736–755





XY  
Geographic orientation (strike/dip)  
115 / 6



Internal (relative) orientation:  
Orientation of the strike at **90** (right)  
and the dip at **90 +90** (bottom)

Site 4L. See location in Hastie et al. 2013

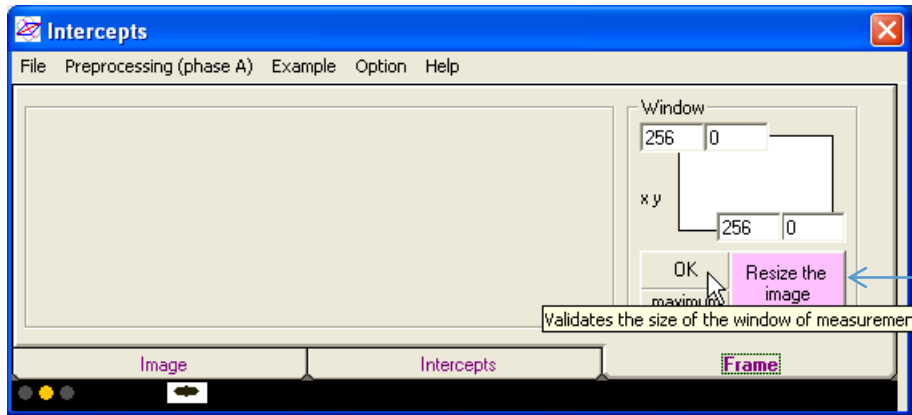
Bad lighting in corners

Open image

Set scale in cm (size of the image width)

Set image magnification

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



Resize the image to avoid darker corner

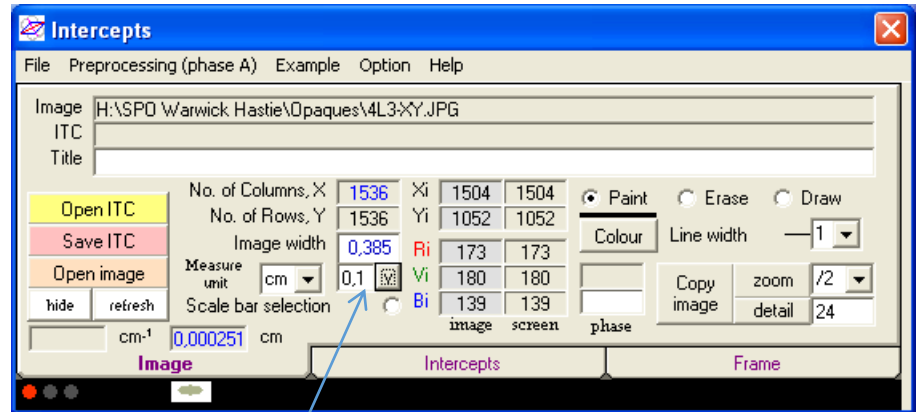
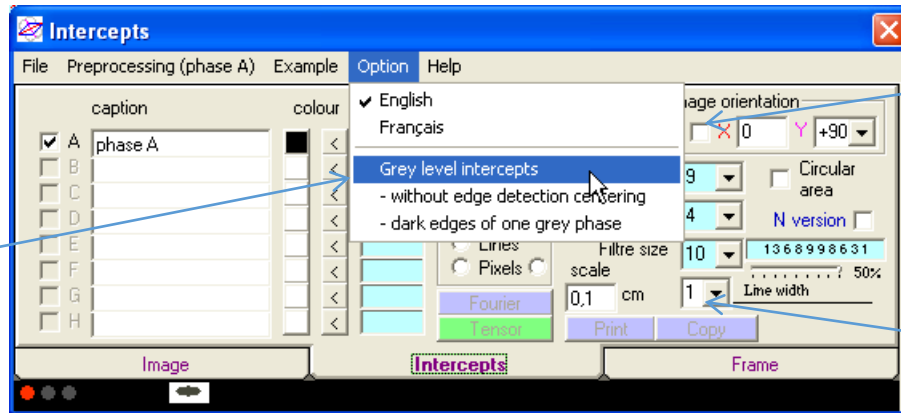


Image scale bare (click on V to print it on the image)

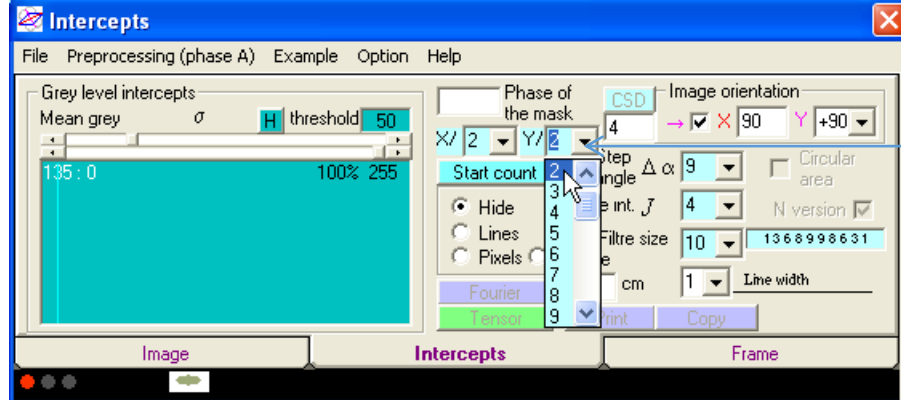
# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

Select intercepts counting in grey levels

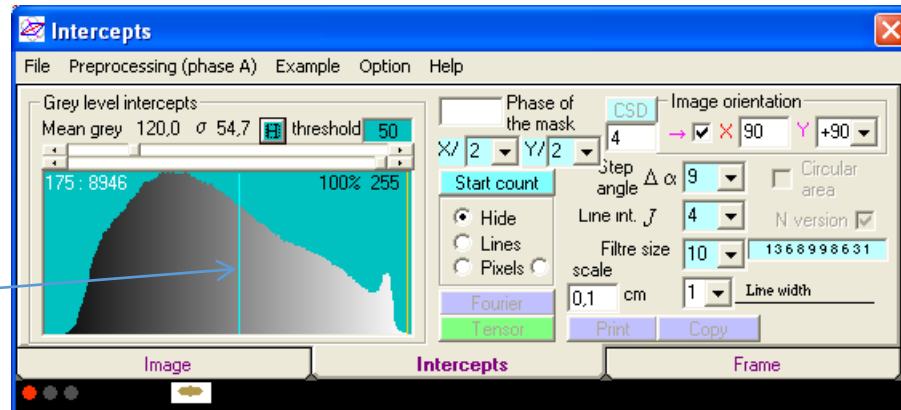
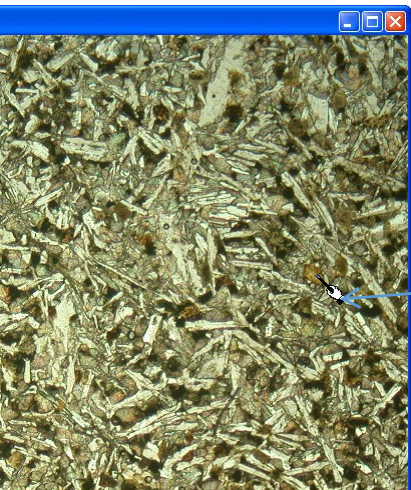


Click on image orientation, enter 90 for X and select +90 for Y

Line width of all graphics



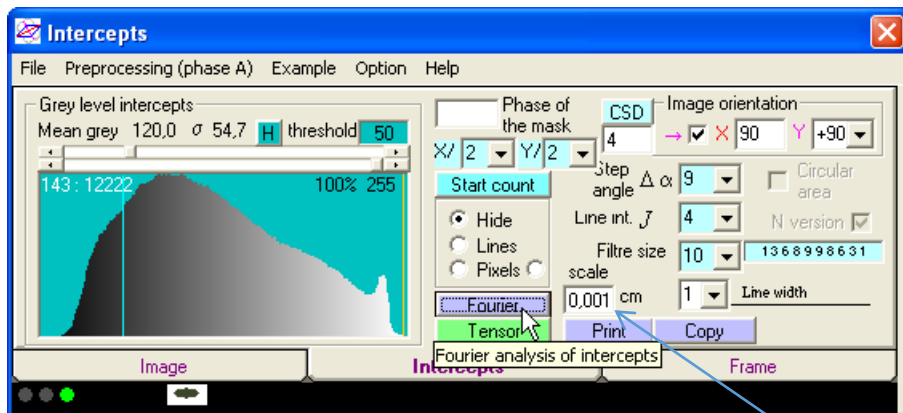
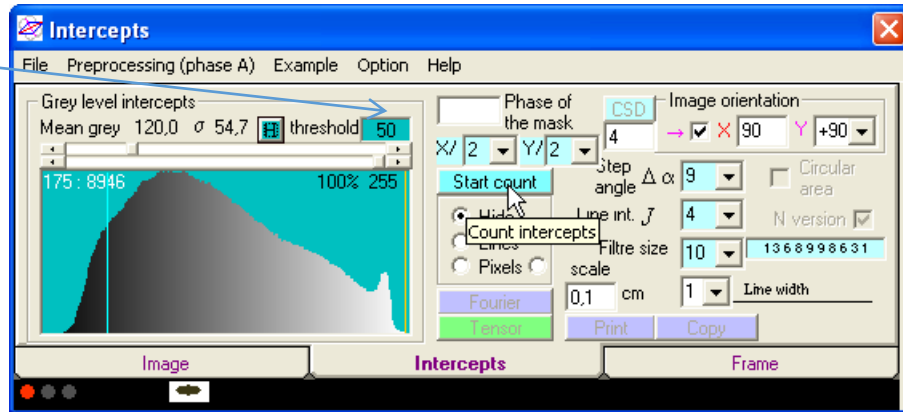
Select the number of sub-images along X and Y direction. 2 x 2 gives 4 subsets of data overlapping on each other to check results invariability by translation along X and Y directions



Click on H button for pre histogram calculation and scan the image with the mouse pointer to visualize the corresponding grey level in the histogram

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

When the grey level varies from 10 to 250 a limit of boundary detection at 50 grey level is correct. Change it if there is too much or not enough boundaries



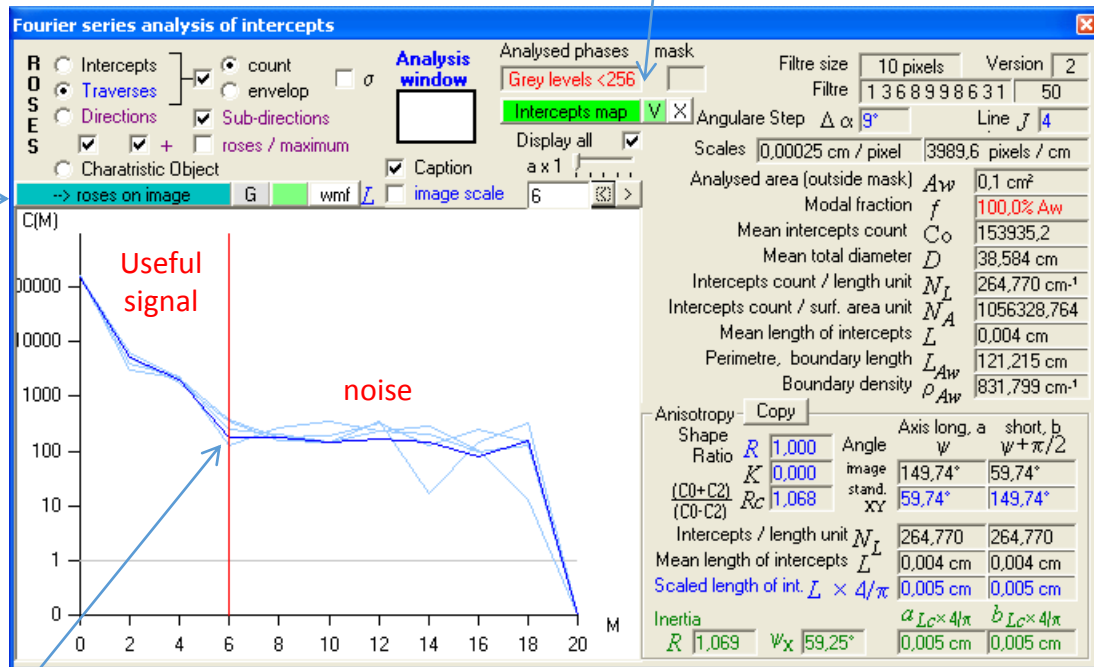
Fourier button visualizes results  
See 2 next slides

Enter scale bare size in graphics

Rose type selection

Draw any roses on the image

All green buttons visualize the boundaries or intercepts detection on the image

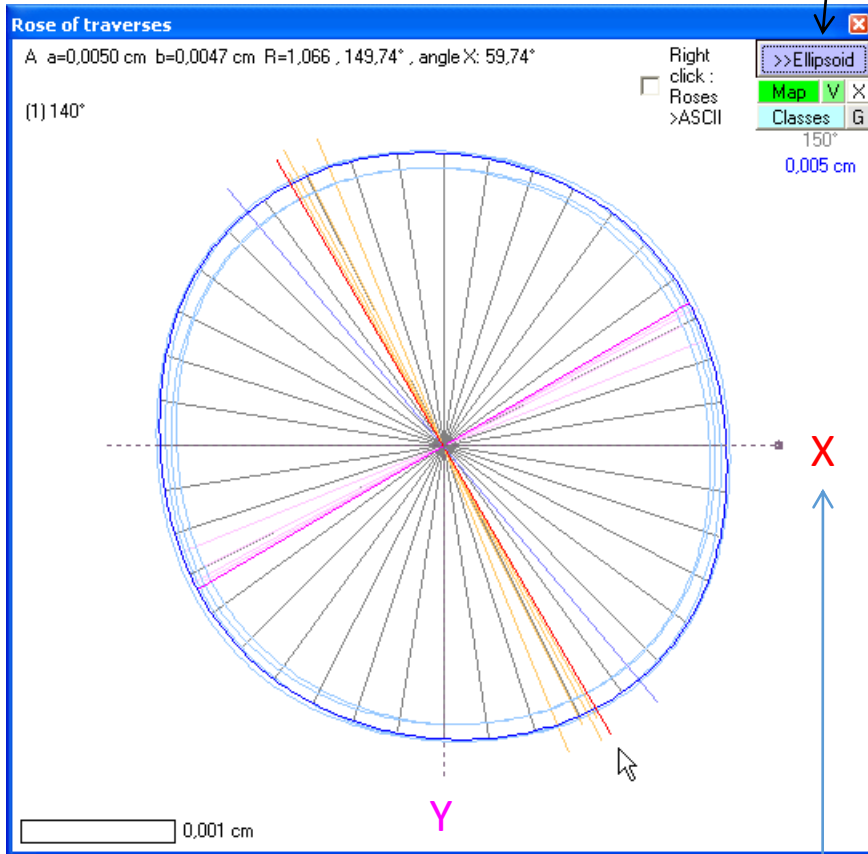


Select the level of rose diagram reconstruction without noise from the Fourier series (if the automatic detection of signal to noise threshold failed)

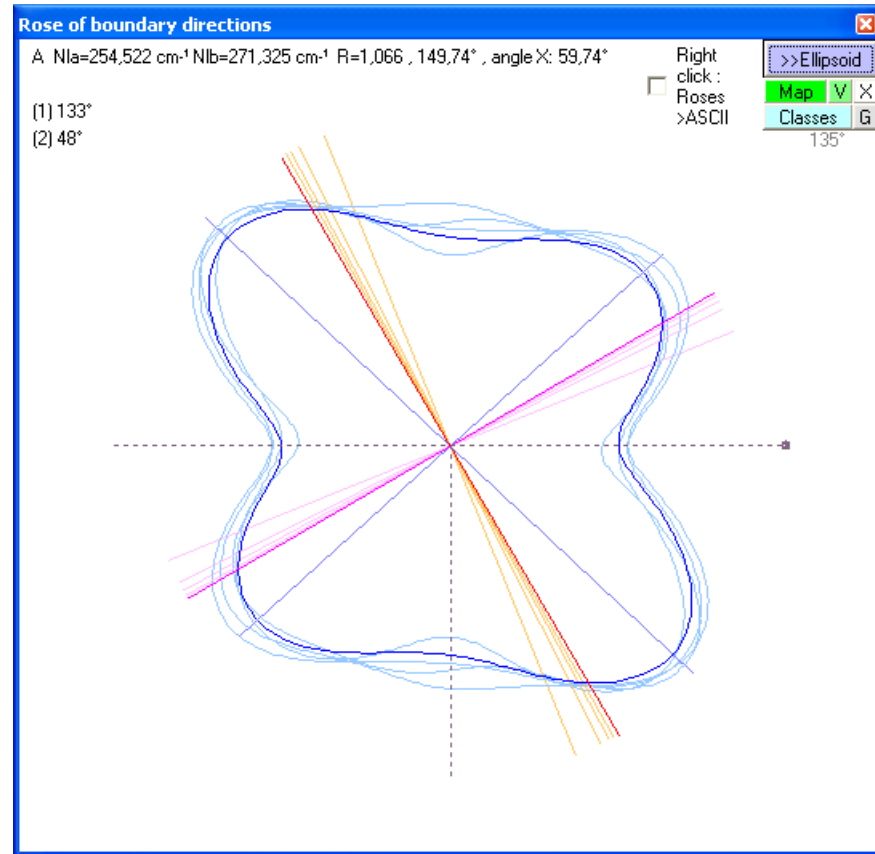
# Shape Preferred Orientation (OCW-UN-SPO) Launeau P. 2017

Click on >> Ellipsoid button to set up the data for their transfer in the Ellipsoid program

Traverses or mean length intercepts used for 3D calculation of ellipsoid



Boundary directions deduced from intercepts for sub-fabric analysis

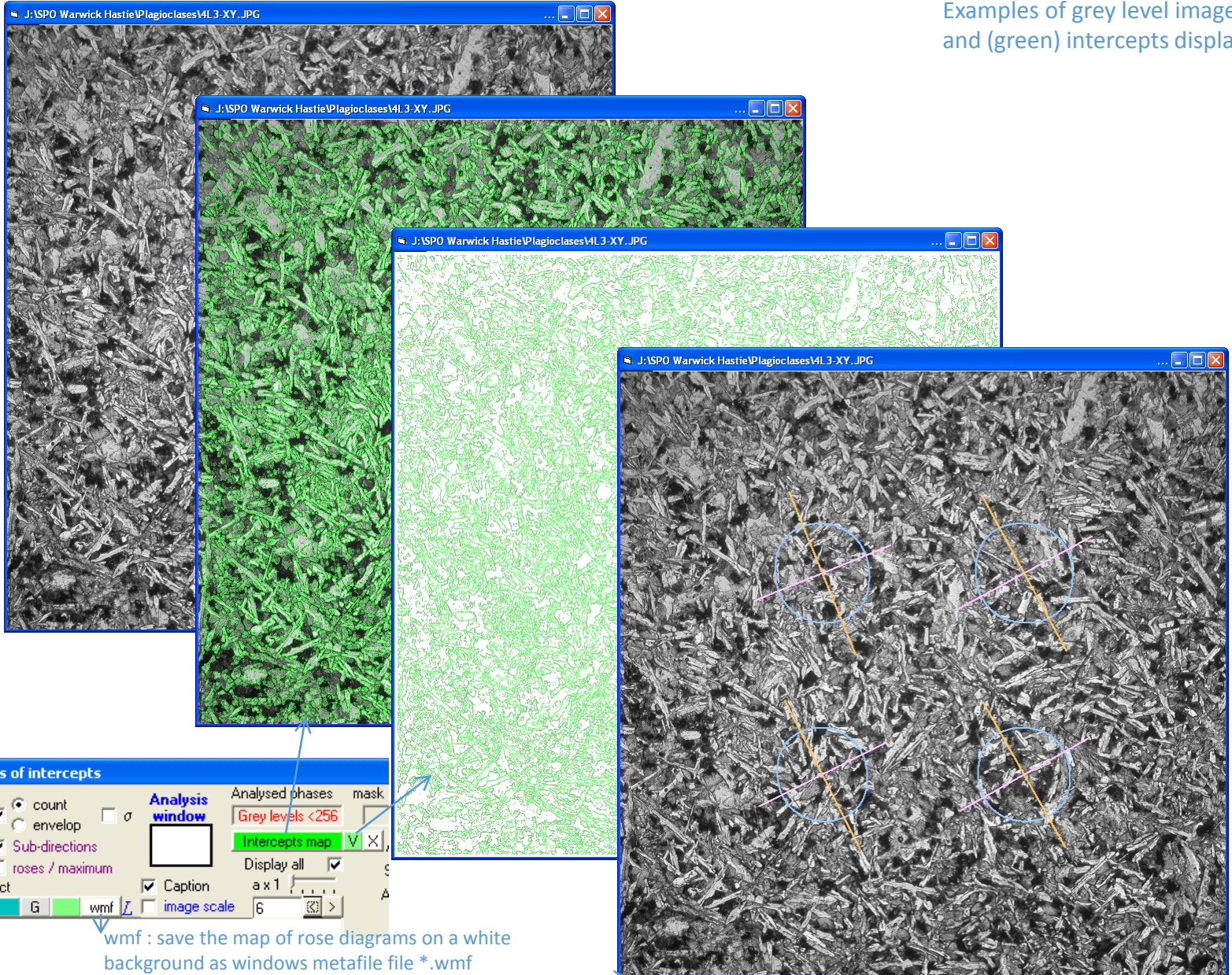


Check the orientation before transferring the data



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

Examples of grey level image and (green) intercepts display



**Fourier series analysis of intercepts**

R  Intercepts  
O  Traverses  
S  Directions  
E  roses / maximum  
S  Charatristic Object

count  envelop  $\sigma$

**Analysis window**

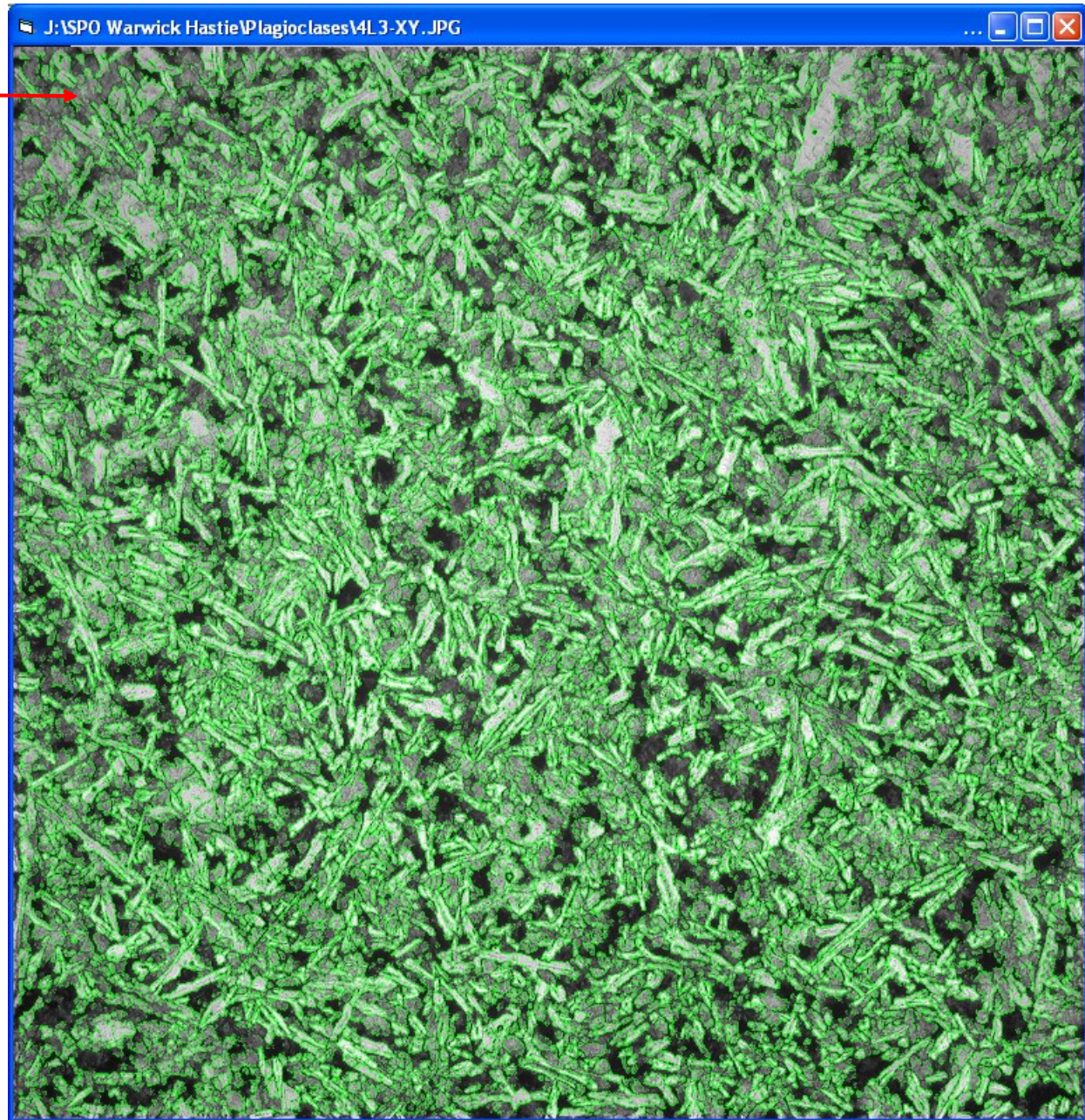
Analysed phases mask  
Grey levels <256  
Intercepts map

Display all  a x 1  
Caption  image scale 6

--> roses on image G wmf image scale

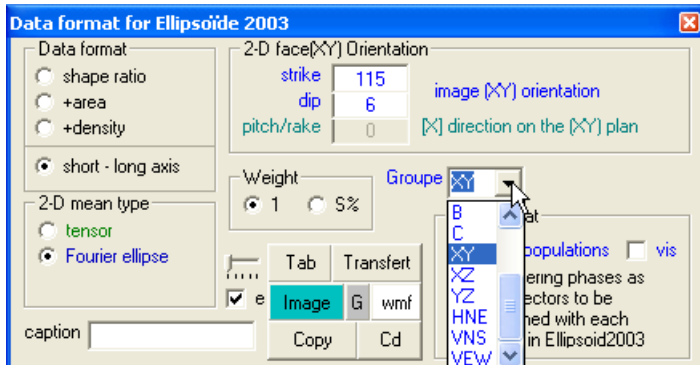
C(M)

wmf : save the map of rose diagrams on a white background as windows metafile file \*.wmf

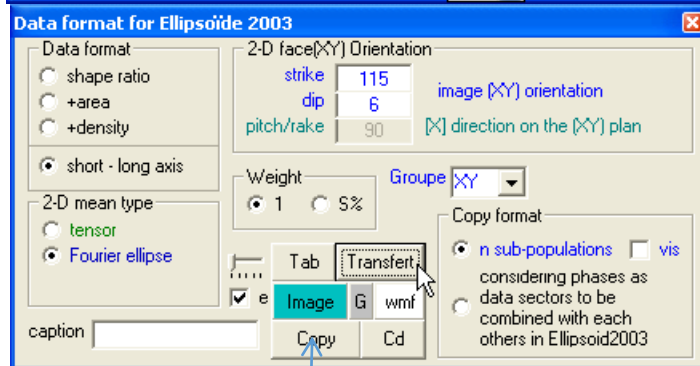


The attenuation of the contrast in the image corner distorts the results which explain the importance of image resizing in p. 4

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



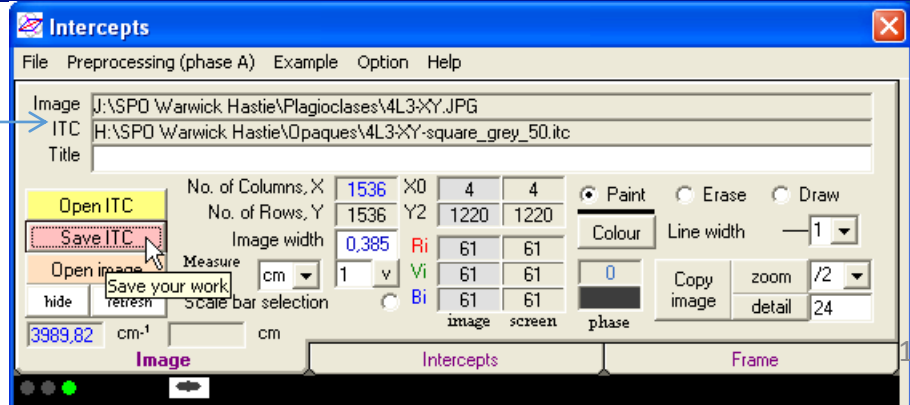
Enter strike, dip and select the image section type necessary for Ellipsoid2003



Click on Transfer to visualize the table of results

|   | #    | strike | dip | rake   | long axis | short axis | weight | xc      | yc      |
|---|------|--------|-----|--------|-----------|------------|--------|---------|---------|
| 1 | 1_XY | 115    | 6   | 67.817 | 0,004969  | 0,004600   | 1      | 512,00  | 512,00  |
| 2 | 2_XY | 115    | 6   | 61,526 | 0,005036  | 0,004777   | 1      | 1024,00 | 512,00  |
| 3 | 3_XY | 115    | 6   | 63,285 | 0,004690  | 0,004414   | 1      | 512,00  | 1024,00 |
| 4 | 4_XY | 115    | 6   | 60,531 | 0,004711  | 0,004547   | 1      | 1024,00 | 1024,00 |

Save your work and then click on Copy to send the data in the clipboard of your system



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

Launch Ellipsoid2003 and paste the first data



|   | #    | strike | dip | rake   | long axis | short axis | 1 | weight |
|---|------|--------|-----|--------|-----------|------------|---|--------|
| 1 | 1_XY | 115    | 6   | 67.817 | 0,004969  | 0,004600   | 1 | 1      |
| 2 | 2_XY | 115    | 6   | 61.526 | 0,005036  | 0,004777   | 1 | 1      |
| 3 | 3_XY | 115    | 6   | 63.285 | 0,004690  | 0,004414   | 1 | 1      |
| 4 | 4_XY | 115    | 6   | 60.531 | 0,004711  | 0,004547   | 1 | 1      |

Click on Add for XZ and YZ images

|    | #    | strike | dip | rake    | long axis | short axis | 1 | weight |
|----|------|--------|-----|---------|-----------|------------|---|--------|
| 1  | 1_XY | 115    | 6   | 67.817  | 0,004969  | 0,004600   | 1 | 1      |
| 2  | 2_XY | 115    | 6   | 61.526  | 0,005036  | 0,004777   | 1 | 1      |
| 3  | 3_XY | 115    | 6   | 63.285  | 0,004690  | 0,004414   | 1 | 1      |
| 4  | 4_XY | 115    | 6   | 60.531  | 0,004711  | 0,004547   | 1 | 1      |
| 5  | 1_XZ | 25     | 90  | 95.080  | 0,004815  | 0,004604   | 1 | 1      |
| 6  | 2_XZ | 25     | 90  | 106.997 | 0,005015  | 0,004748   | 1 | 1      |
| 7  | 3_XZ | 25     | 90  | 98.201  | 0,004451  | 0,004267   | 1 | 1      |
| 8  | 4_XZ | 25     | 90  | 89.471  | 0,004647  | 0,004387   | 1 | 1      |
| 9  | 1_YZ | 295    | 84  | 86.354  | 0,004928  | 0,004602   | 1 | 1      |
| 10 | 2_YZ | 295    | 84  | 88.080  | 0,004861  | 0,004598   | 1 | 1      |
| 11 | 3_YZ | 295    | 84  | 81.243  | 0,004644  | 0,004404   | 1 | 1      |
| 12 | 4_YZ | 295    | 84  | 78.948  | 0,004720  | 0,004452   | 1 | 1      |

| Option                                      | Contact | Examples (see Ref)   |
|---|---------|----------------------|
| Franglais                                   |         |                      |
| <input checked="" type="checkbox"/> English |         |                      |
| <input checked="" type="checkbox"/> F½      |         | e(section/ellipsoid) |
| P   |         |                      |
| <input checked="" type="checkbox"/> P'      |         |                      |
| K   |         |                      |
| Combinations                                |         |                      |

XY XZ YZ

Use Option to select the type of image combination for 3D calculation (# last 2 letters)

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

First display after one click on the green button Ellipsoid if the combination between XY, XZ YZ images as been selected before

Click here for combination calculation

Ellipsoid 2003

File Option Contact Examples (see Ref. 2) Rotation [xyz]

Number of section: 12  Calculation:  WITH measured scale factor  WITHOUT measured scale factor mean L: 0,0047

display section #:  symbol: 0 P'

Data format:  shape ratio r  +surface  +density  long & short axis

Combinations:  active N: 64  density %: 50   $\alpha^\circ$ : 15 L: 1

display [x] [y] [z]:  pole of the sect+  Rotation: strike: 0 dip: 0 pitch/rake: 0

Buttons: Paste, Add, Test sections (Ellipsoid), Copy results, Load, Bedding, Save

Enter dyke wall orientation

Results for each sub-image and error parameter F

| Sections |      |       |      |       |        |     |     |        |       |      |        |     | F1/2 |      |         |       |
|----------|------|-------|------|-------|--------|-----|-----|--------|-------|------|--------|-----|------|------|---------|-------|
| #        | az   | pl    | rake | r     | rake 1 | r 1 | e 1 | rake 2 | r 2   | e 2  | rake 3 | r 3 | e 3  | with | without | e(ab) |
| 1        | 1_XY | 115,0 | 6,0  | 67,8  | 1,080  |     |     | 61,2   | 1,054 | 2,7% |        |     |      | 1 C  | 2,4%    |       |
| 2        | 2_XY | 115,0 | 6,0  | 61,5  | 1,054  |     |     | 61,2   | 1,054 | 0,1% |        |     |      | 2 C  | 0,1%    |       |
| 3        | 3_XY | 115,0 | 6,0  | 63,3  | 1,063  |     |     | 61,2   | 1,054 | 0,9% |        |     |      | 3 C  | 0,8%    |       |
| 4        | 4_XY | 115,0 | 6,0  | 60,5  | 1,036  |     |     | 61,2   | 1,054 | 1,7% |        |     |      | 4 C  | 1,4%    |       |
| 5        | 1_XZ | 25,0  | 90,0 | 95,1  | 1,046  |     |     | 99,7   | 1,043 | 0,5% |        |     |      | 5 B  | 0,6%    |       |
| 6        | 2_XZ | 25,0  | 90,0 | 107,0 | 1,056  |     |     | 99,7   | 1,043 | 1,4% |        |     |      | 6 B  | 1,4%    |       |
| 7        | 3_XZ | 25,0  | 90,0 | 98,2  | 1,043  |     |     | 99,7   | 1,043 | 0,1% |        |     |      | 7 B  | 0,2%    |       |
| 8        | 4_XZ | 25,0  | 90,0 | 89,5  | 1,059  |     |     | 99,7   | 1,043 | 1,8% |        |     |      | 8 B  | 1,8%    |       |
| 9        | 1_YZ | 295,0 | 84,0 | 86,4  | 1,071  |     |     | 84,4   | 1,067 | 0,4% |        |     |      | 9 A  | 0,5%    |       |
| 10       | 2_YZ | 295,0 | 84,0 | 88,1  | 1,057  |     |     | 84,4   | 1,067 | 1,0% |        |     |      | 10 A | 1,0%    |       |
| 11       | 3_YZ | 295,0 | 84,0 | 81,2  | 1,054  |     |     | 84,4   | 1,067 | 1,3% |        |     |      | 11 A | 1,1%    |       |
| 12       | 4_YZ | 295,0 | 84,0 | 78,9  | 1,060  |     |     | 84,4   | 1,067 | 0,9% |        |     |      | 12 A | 1,1%    |       |

Calculation WITHOUT scale factor

Caption:

Distribution: N. faces: 12 Inverse Shape Matrix: 210,5 1,983 1,913; 1,983 233,3 2,718; 1,913 2,718 199,7

$\sqrt{F}$ : 1,0%

Eigenvalue: 199,2 210,6 233,7

Dir. Cos.: North: -0,154 0,984 0,092; East: -0,069 -0,103 0,992; Down: 0,986 0,146 0,084

N.L\*M.L: 4,84E-3 4,71E-3 4,47E-3

Norm. L: 1,037 1,008 0,957

Trend: 204,3° 354,0° 84,7°

Plunge: 80,3° 8,4° 4,8°

A / C: 1,083 Flinn: 0,519

A / B: 1,028 P': 1,085

B / C: 1,054 T: 0,303

Foliation: 174,7° 85,2° L rake: 81,6°

Used for computing a plane from 2 or more lines of intersection given by strike dip rake

Bedding

Sections: 1 strike: 0,0 dip: 0,0  $\sigma$ :  $\pm 0,0^\circ$  With rotation:  OK

|       | 1 * | 2 * | 2 * | 2 * |
|-------|-----|-----|-----|-----|
| North | 0   | 0   | 0   | 0   |
| East  | 0   | 0   | 0   | 0   |
| Down  | 0   | 0   | 0   | 0   |

Obliquity: 0 0 0 0

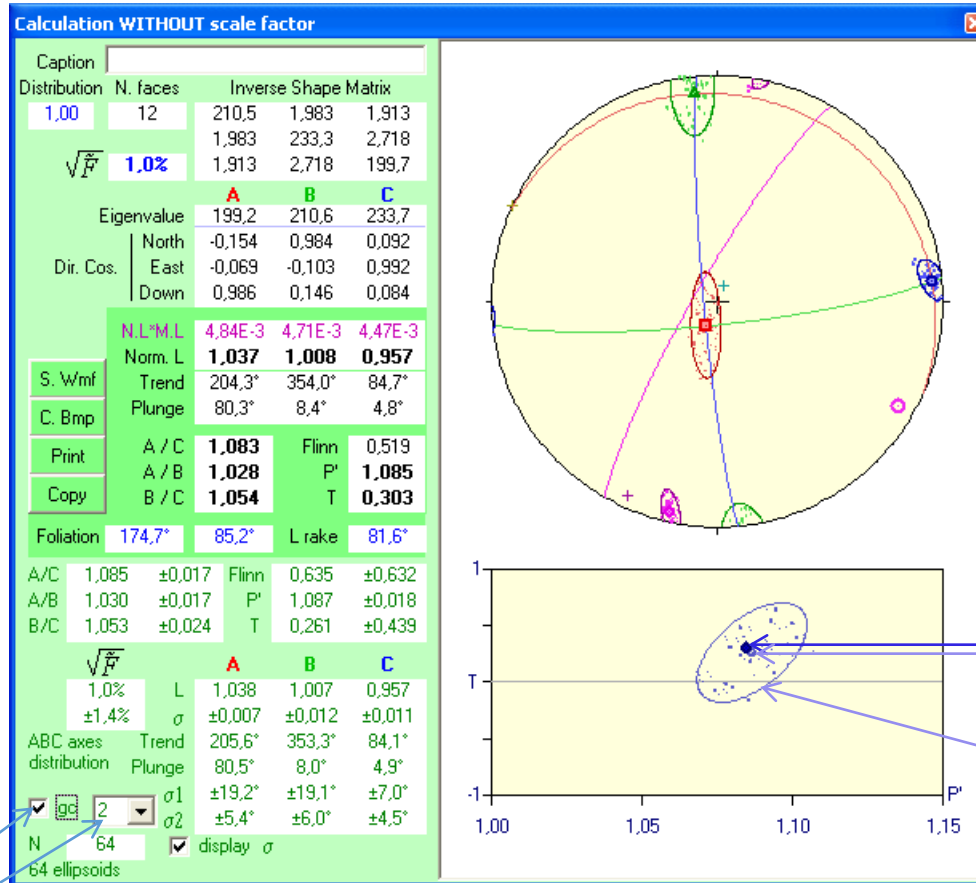
trend: 0 0 0 0

plunge: 0 0 0 0

| # | strike | dip | rake |
|---|--------|-----|------|
| 1 | 210    | 82  | 0    |

Type orientation of the bedding or dyke wall directly here if it is known (rake is used for intersections combinations)

Second display with all parametrizations



Main results of the whole data

Mean results of the sub-images data

For great circle display

Long axis A is red  
Short axis C is blue  
Intermediate axis B is green  
Bisector between SPO and wall is magenta

Standard deviation ellipses are set by default at 2 sigma

Graphics are exportable as:

- Windows Metafile [S. Wmf]
- Bitmap in clipboard [C. Bmp]
- Ascii data in clipboard [Copy]

Main (P',T) calculated at one time  
Mean (P',T) of 64 sub-images results close to each other characterize accurate results with a precision estimation given by the standard deviation ellipse of sub-images data

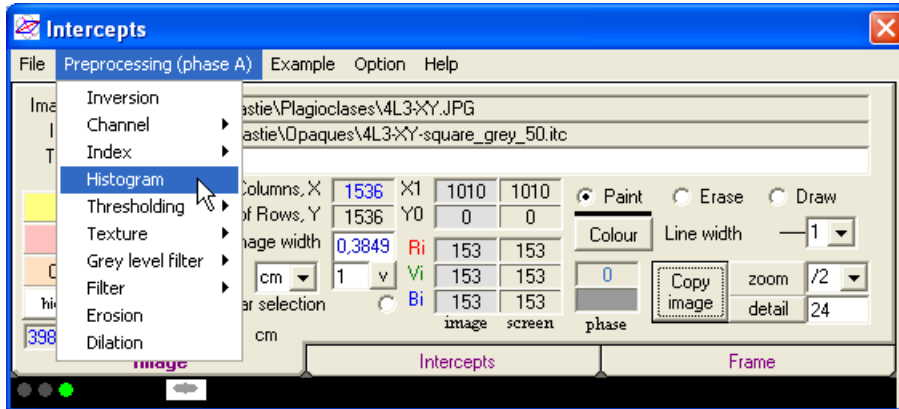
Obliquity between SPO foliation and dyke wall with orientation of its bisector (main results)

**Bedding**

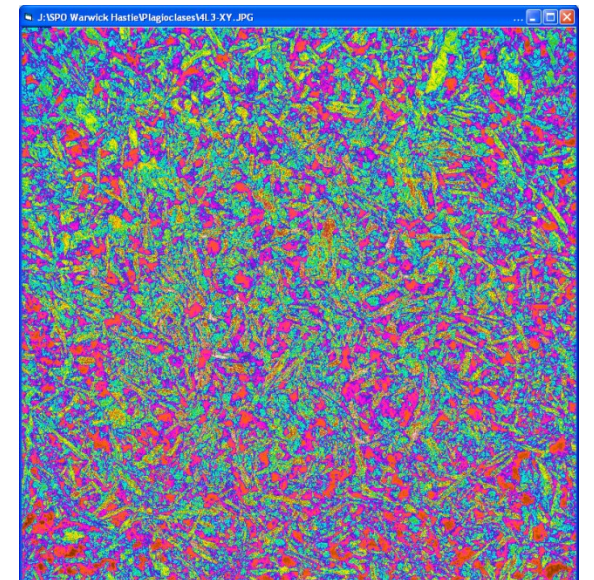
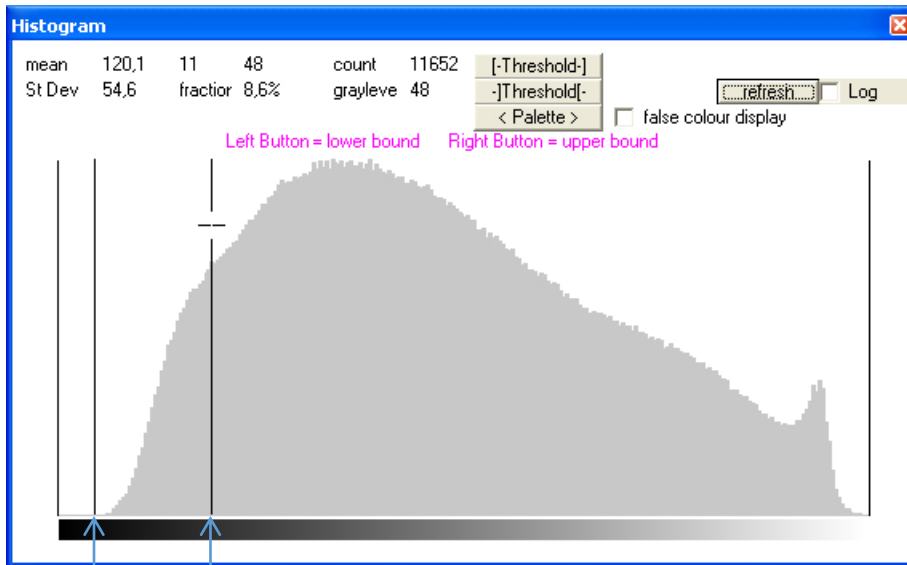
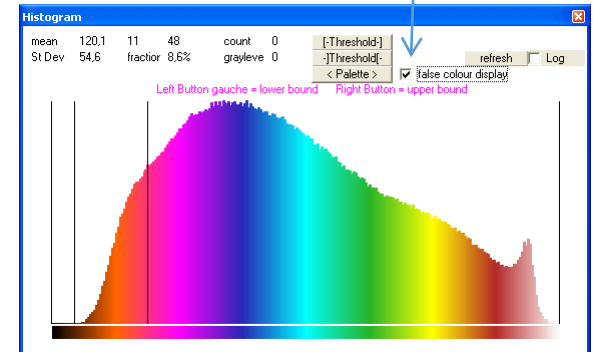
| Sections                                | strike   | dip          | $\sigma$ | <input type="checkbox"/> With rotation |              |   |        |   |   |
|---|----------|--------------|----------|--|--------------|---|--------|---|---|
| 1                                       | 210,0    | 82,0         | ±0,0°    | <input type="button" value="OK"/>      |              |   |        |   |   |
| <input checked="" type="checkbox"/> Ori | <b>1</b> | <b>2</b>     | <b>2</b> | <b>2</b>                               | trend        | 0 | 192,5° | 0 | 0 |
| Obliquity                               | <b>0</b> | <b>35,2°</b> | <b>0</b> | <b>0</b>                               | plunge       | 0 | 5,2°   | 0 | 0 |
| trend                                   | 0        | 192,9°       | 0        | 0                                      | $\sigma 1$ * | 0 | ±10,4° | 0 | 0 |
| plunge                                  | 0        | 5,2°         | 0        | 0                                      | $\sigma 2$ * | 0 | ±2,4°  | 0 | 0 |
|   | #        | strike       | dip      | rake                                   |              |   |        |   |   |
|   | 1        | 210          | 82       | 0                                      |              |   |        |   |   |

Bisector statistics

Extraction of the opaque grains by grey level histogram thresholding

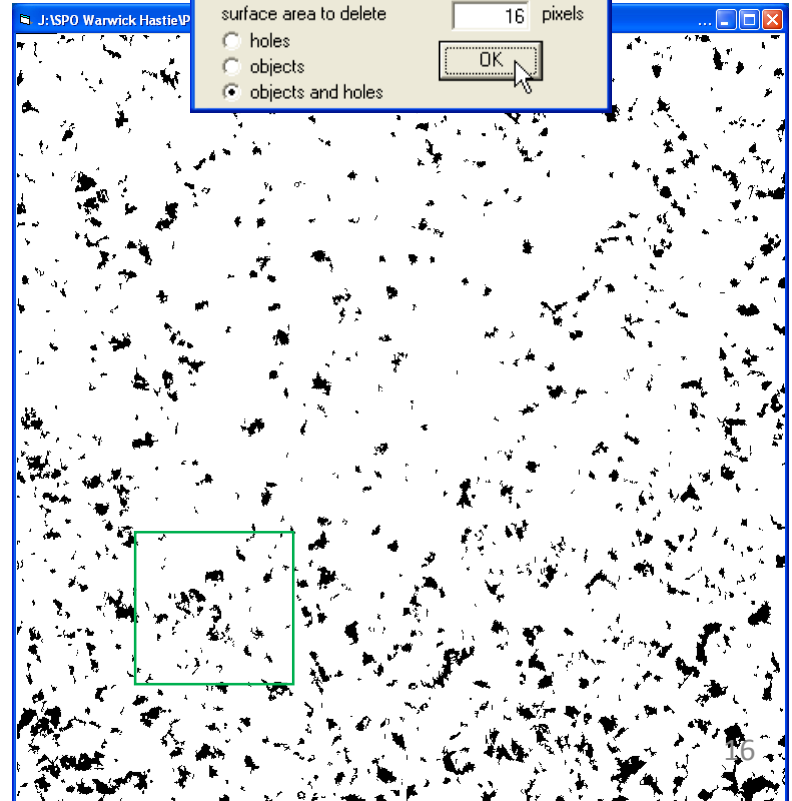
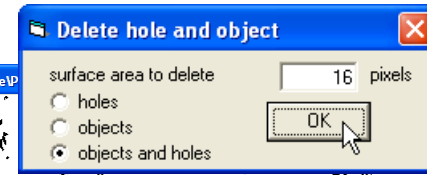
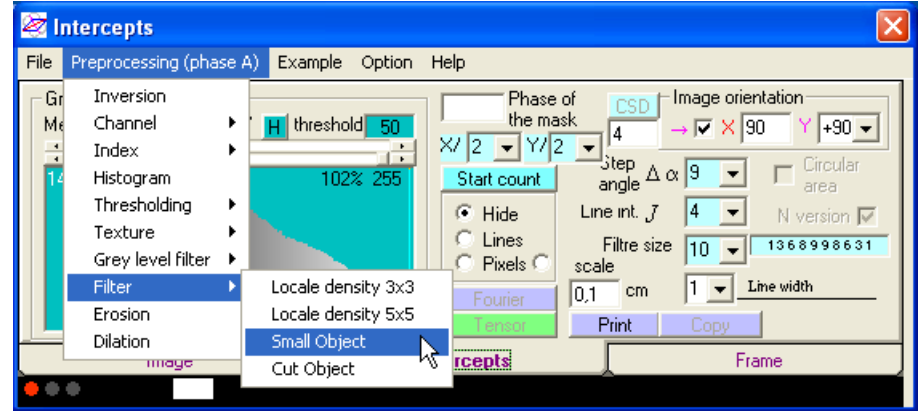
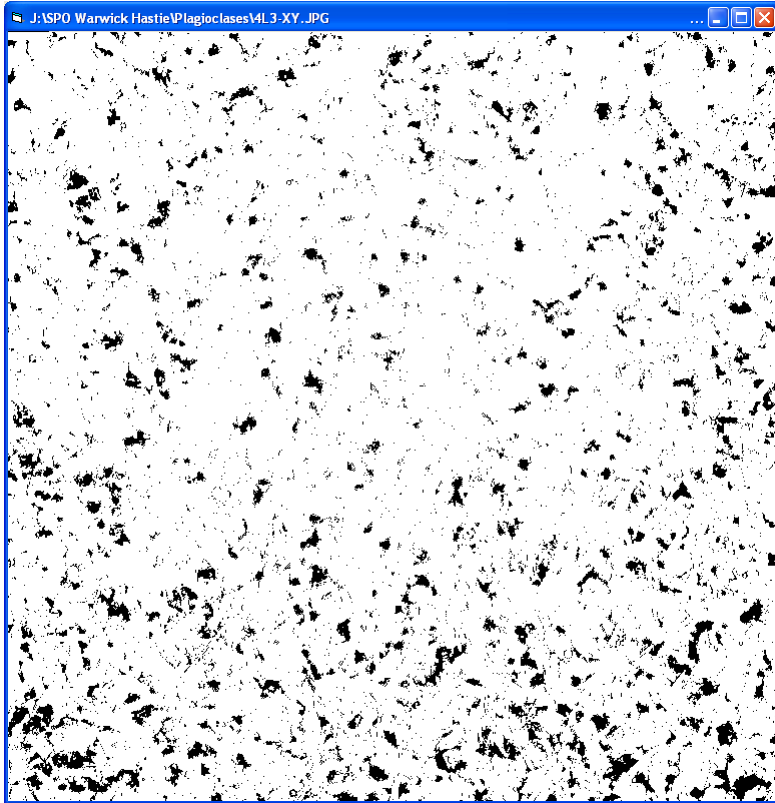


Color table helping setting the best threshold values



Selection of the opaque grains

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

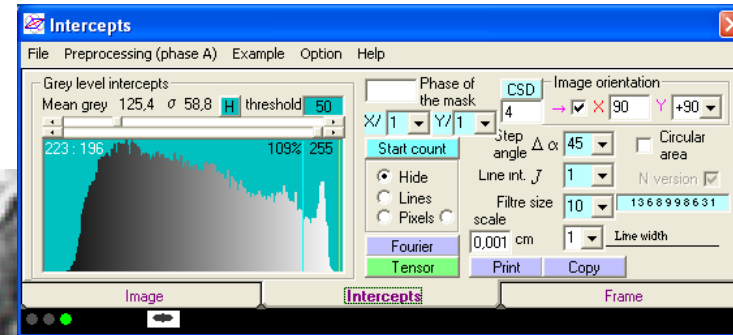
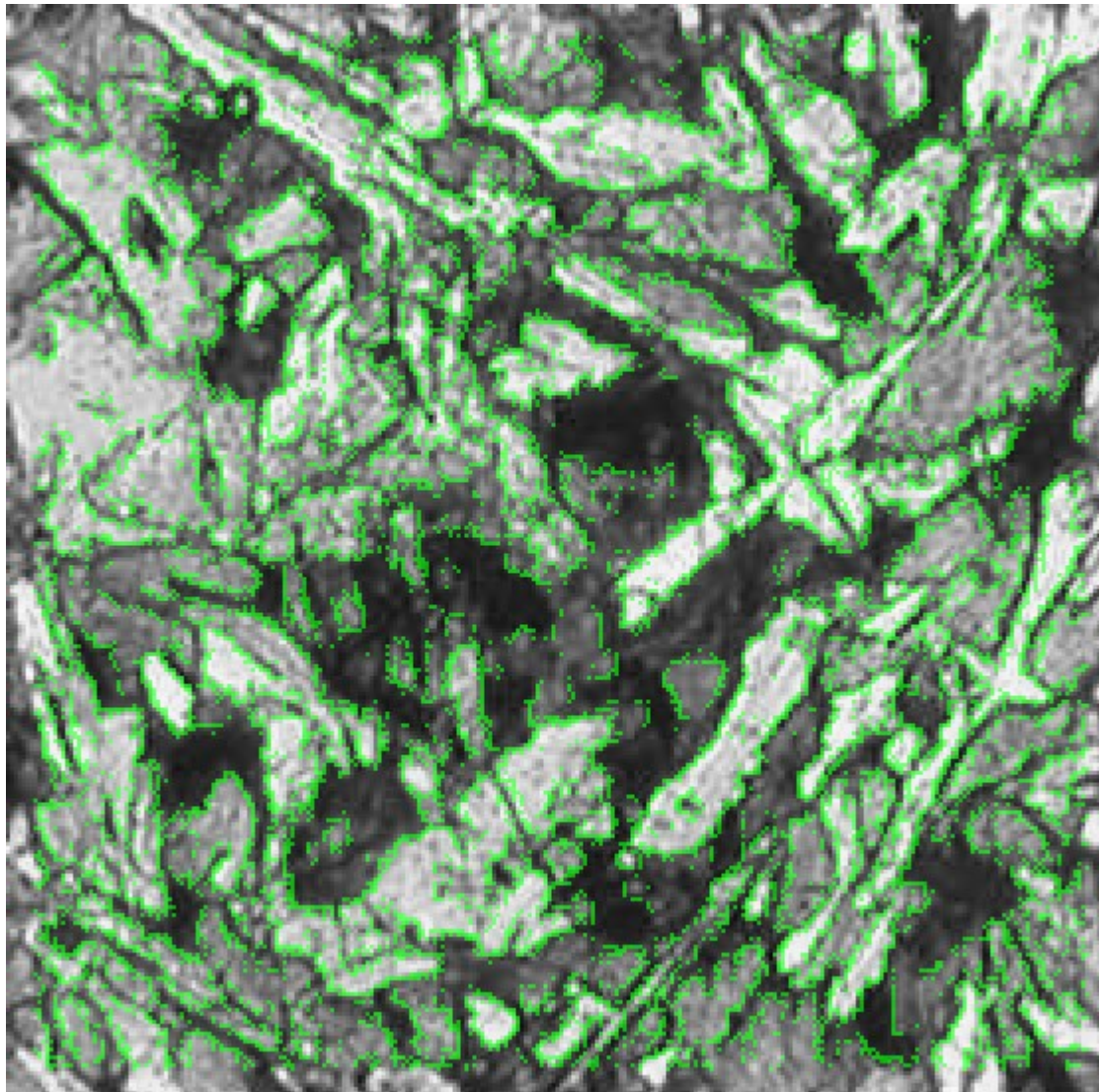


Smaller grains and holes lower than 16 pixels can be removed by using Filter Small Object

The next page focus on this small area (green square) to outline the effect of each setting on classified images (opaque minerals black other white)

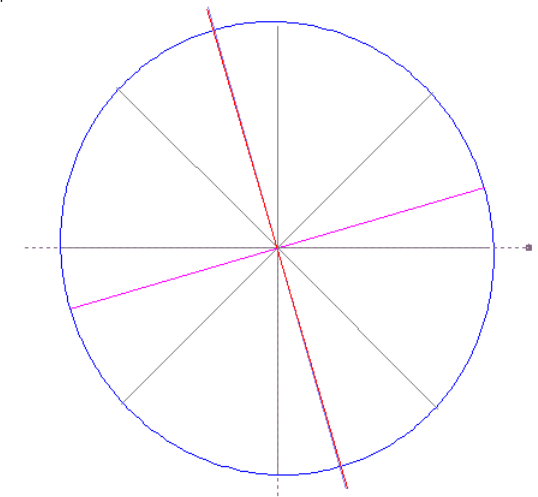


This example count intercepts in grey levels with a boundary detection for each local contrast greater than 50 grey levels



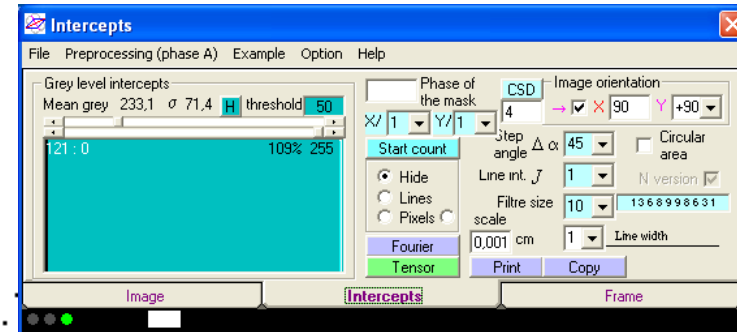
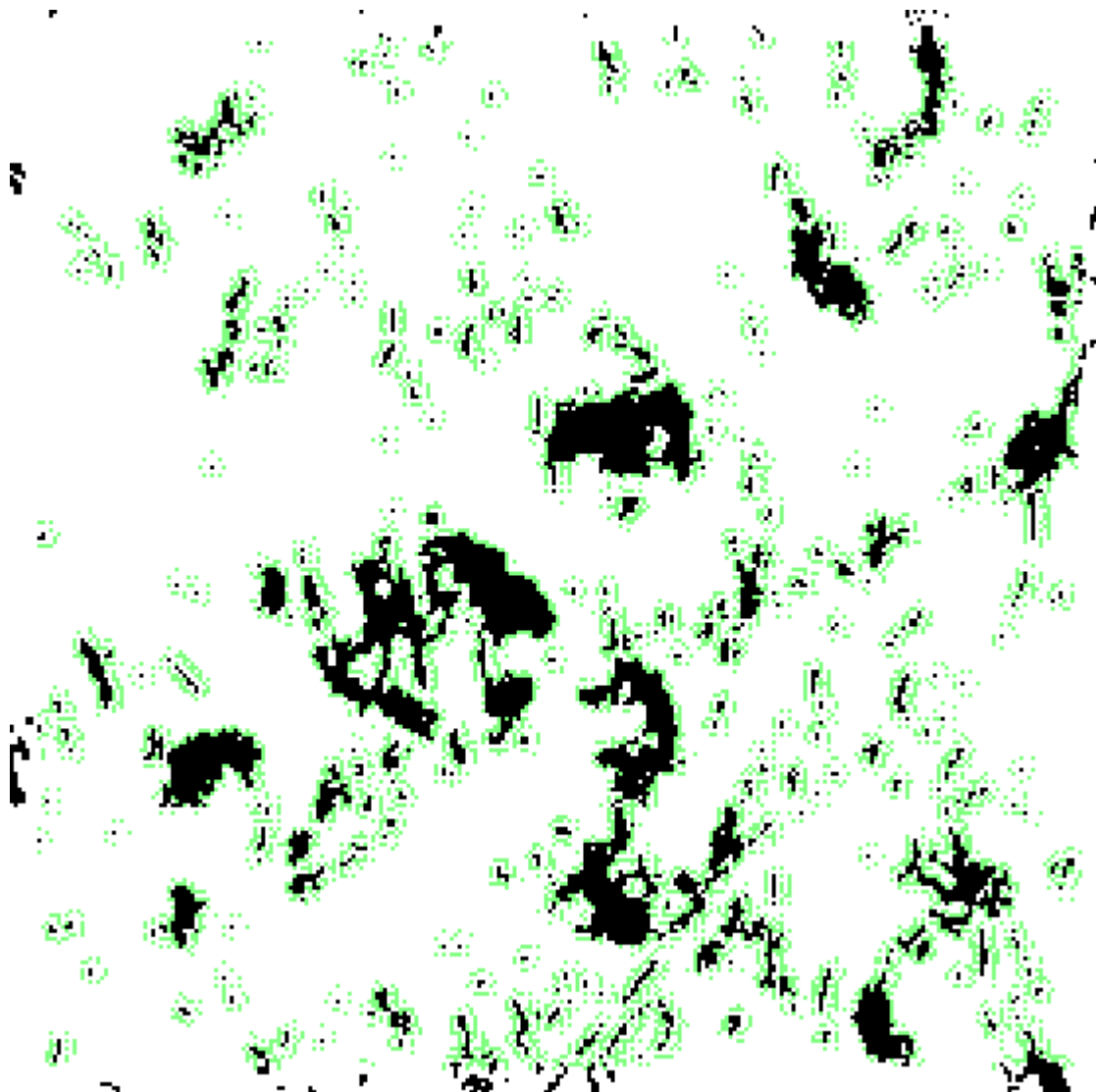
A = 0,0045 cm b = 0,0043 cm R = 1,054 , 163,79° , angle X: 73,79°

(1) 164°



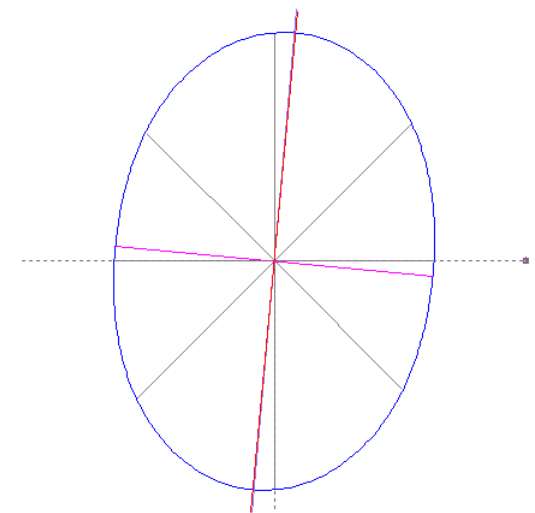
0,001 cm

This example count intercepts in grey levels right after thresholding



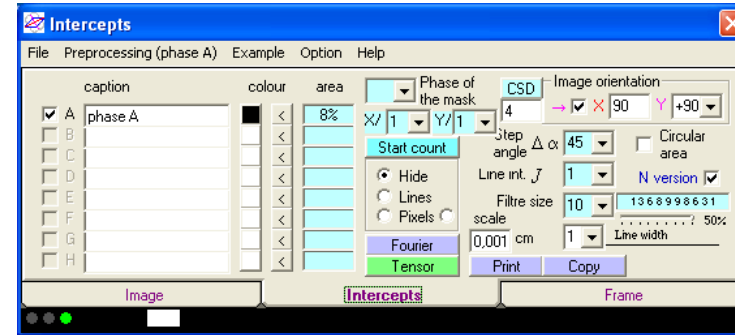
A = 0,0136 cm b = 0,0094 cm R = 1,438 , 5,42° , angle X: 95,42°

(1) 5°



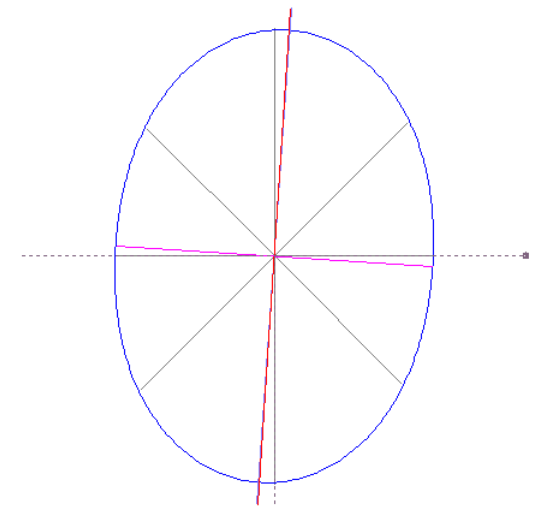
0,001 cm

This example count intercepts in grey levels small holes and objects filtering



A a=0,0332 cm b=0,0233 cm R=1,425 , 3,70° , angle X: 93,70°

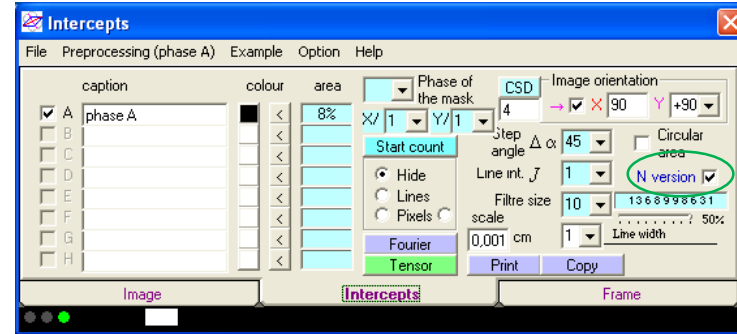
(1) 4°



□ 0,001 cm

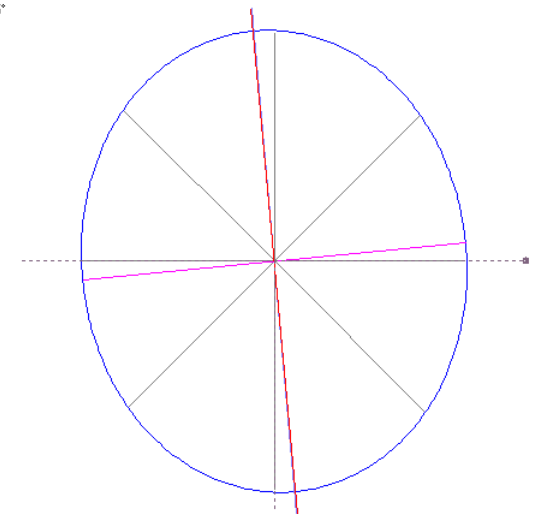
This setting detect all small digitations of grains and aggregates boundaries

This example count intercepts in binary mode (remove gray scale selection in option see slide 3) for each class with the new grey scale algorithm of boundary detection (8 classes can be processed at the same time)



A =0,0029 cm b=0,0024 cm R=1,201 , 174,59° , angle X: 84,59°

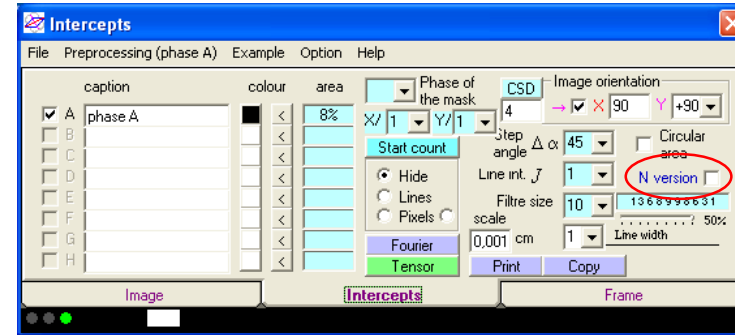
(1) 175°



0,001 cm

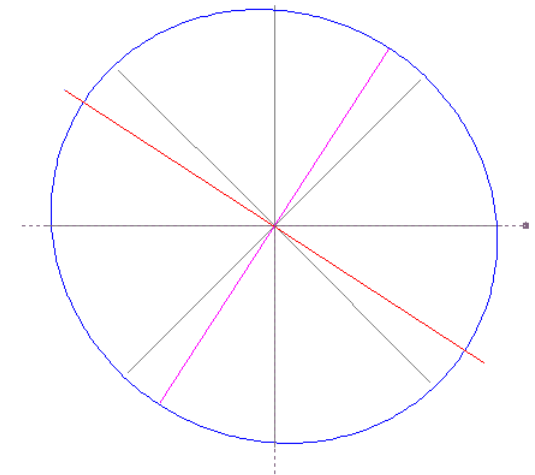
This setting also detect all small digitations of grains and aggregates boundaries in binary mode

This example count intercepts in binary mode for each class with the old algorithm of phase boundary detection (8 classes can be processed at the same time)



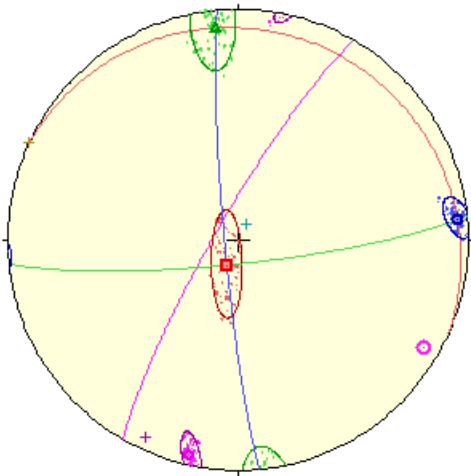
A a=0,0038 cm b=0,0035 cm R=1,074 , 122.97° , angle X: 32.97°

(1) 123°

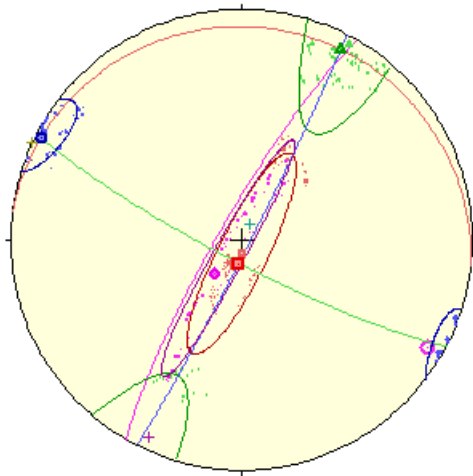


This setting do not detect the smallest digitations of grains and aggregates boundaries which are seen as noise and removed when thinner than 4 pixels<sup>21</sup>

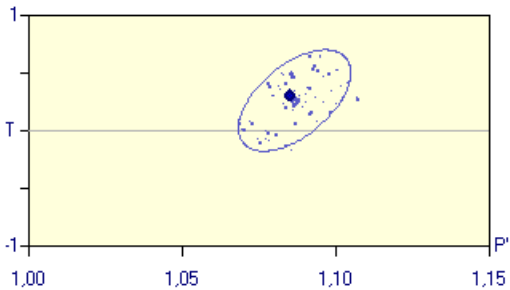
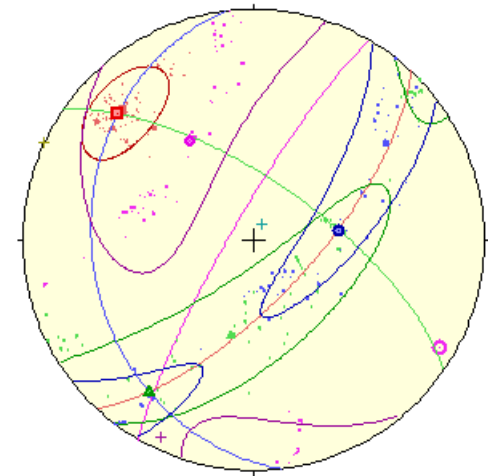
Greyscale intercepts analysis of the whole greyscale image



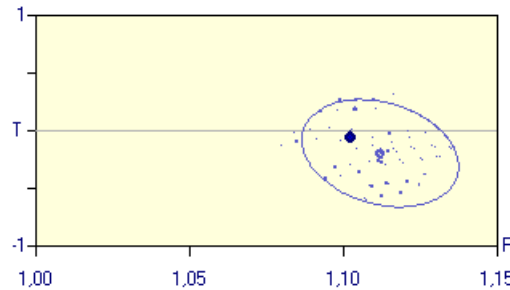
Greyscale intercepts analysis of the opaque grains with greyscale algorithm



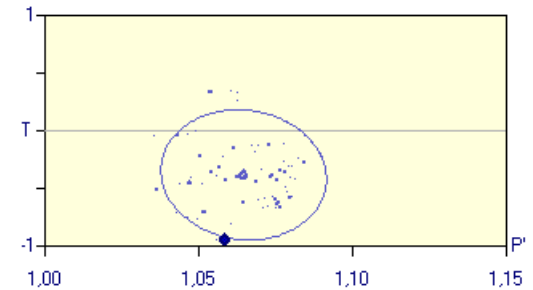
Intercepts analysis of the opaque grains with classified image and binary algorithm



It gives the whole SPO of the rock (mainly plagioclase)



It gives the SPO of the finest grains forming larger opaque aggregates



It gives the SPO of the main surface area weight of opaque aggregates