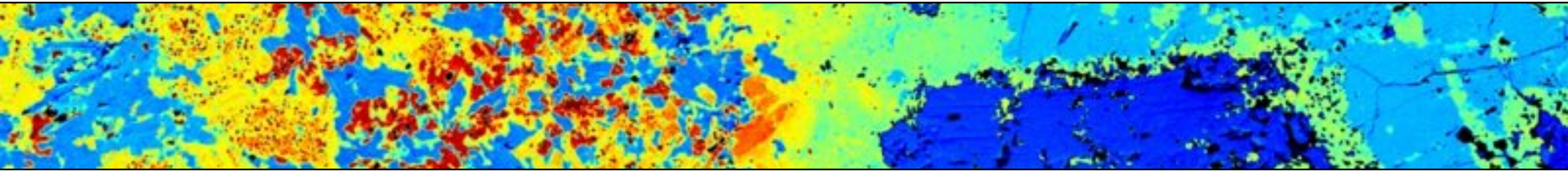

Lecture 5

Local bulk composition

Dr. Mahyra Tedeschi

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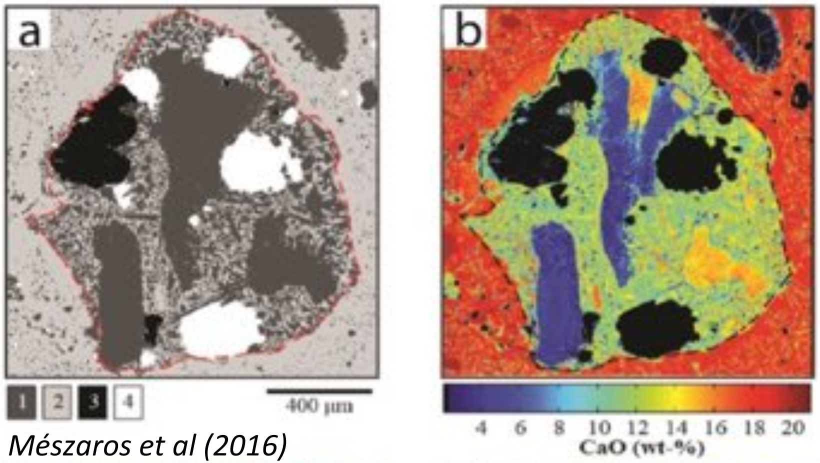
- Introduction
- Thermodynamic equilibrium
- Local equilibrium: why do we need local bulk rock?
- Domanial rocks
- Quantitative mapping of the local bulk composition as a basis for modeling

Why do we need local bulk estimates?

- ➢ Heterogeneities



Mészaros et al (2016)

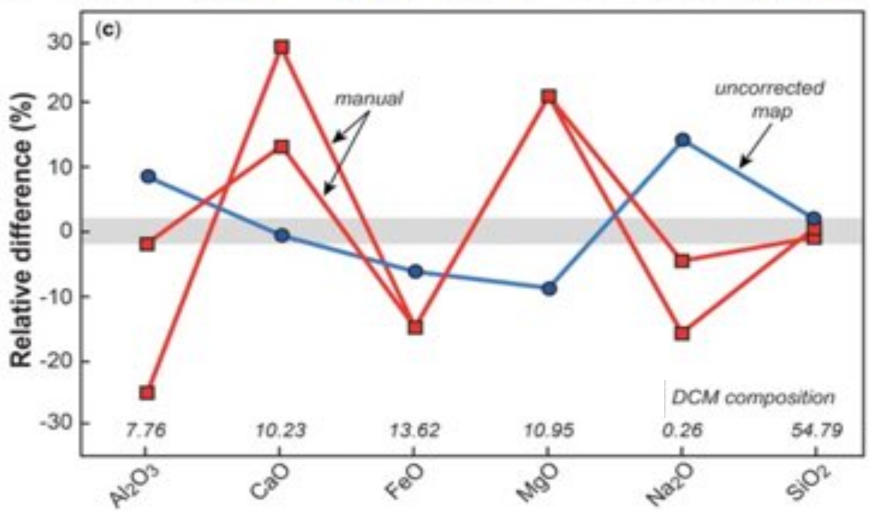
What approaches have been used?

Manual vs Standardized maps

Average spot analyses → no zoning

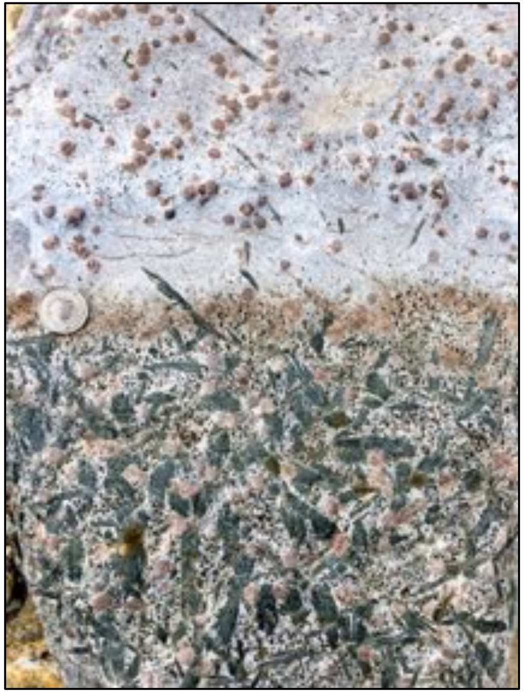
Density-corrected

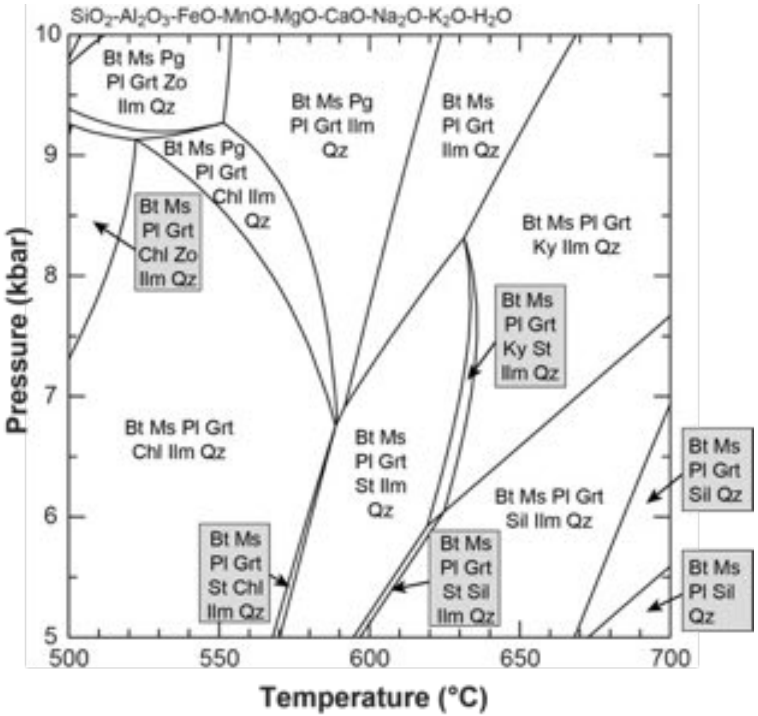
Uncorrected



Lanari et al (2018)

Heterogeneities





“Metamorphic rocks showing heterogeneities and complex textures are more the rule than the exception”

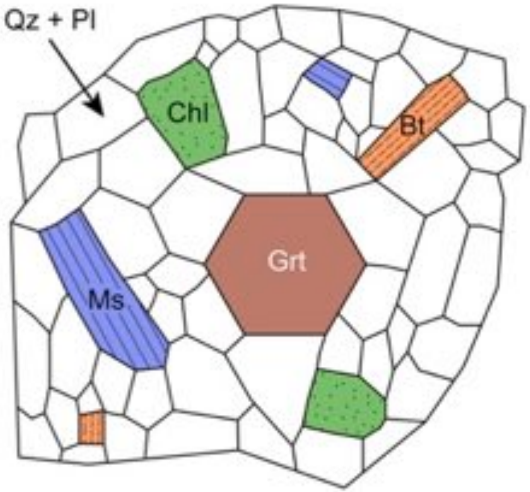
Implications for petrology?

Thermodynamic Equilibrium

Pressure
Temperature
Bulk rock composition
a_{H2O}, f_{O2}, etc…

→ Gibbs free energy minimization →

Stable mineral assemblage
Mineral modes
Mineral compositions



Lanari & Engi (2017)

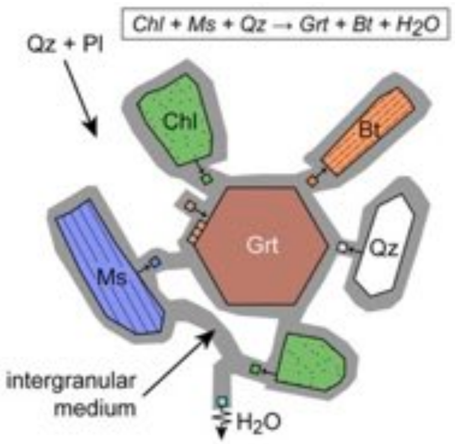
volumes and densities of stable phases:

solid phases	N	volume/mol	volume[ccm]	vol%
FSP_abh	0.0624	101.2524	6.3180	17.5978
ILM_ilm	0.0064	32.1453	0.2060	0.5739
GARNET_alm	0.0012	117.5547	0.1405	0.3915
CHLR_daph	0.0075	212.4772	1.5908	4.4310
PHNG_mu	0.0751	139.8738	10.5098	29.2735
BIO_ann	0.0269	151.0521	4.0559	11.2970
quartz	0.5681	23.0272	13.0811	36.4353
total of solids			35.9022	100.0000

gases and fluids	N	volume/mol	volume[ccm]
water.fluid	0.3714	20.2769	7.531

THERMODYNAMIC EQUILIBRIUM

Bulk rock effects



Lanari & Engi (2017)

Global equilibrium

↓ *Path independent*

No information about the previous stage(s) is preserved

(Un)fortunately in nature, metamorphic rocks do not always reach global equilibrium!

→ Disequilibrium features

→ Porphyroblast growth

- Stable assemblage at 500°C and 4 kbar:

volumes and densities of stable phases:

solid phases	N	volume/mol	volume[ccm]	vol%
FSP_abh	0.0701	101.4648	7.1155	19.6688
ILM_ilm	0.0078	32.1862	0.2516	0.6953
CHLR_daph	0.0120	213.0538	2.5485	7.0444
PHNG_mu	0.0769	140.8290	10.8359	29.9528
BIO_ann	0.0177	151.8042	2.6869	7.4273
quartz	0.5520	23.0769	12.7383	35.2114
total of solids			36.1767	100.0000

gases and fluids	N	volume/mol	volume[ccm]
water.fluid	0.3595	21.6127	7.769

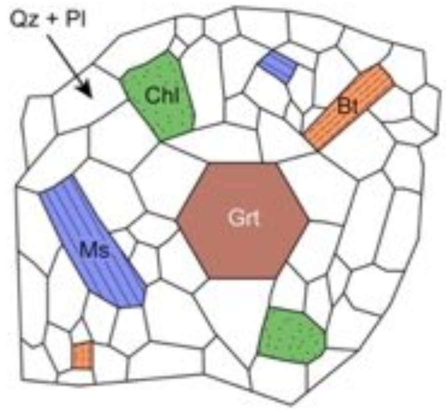
- Stable assemblage at 550°C and 6 kbar:

volumes and densities of stable phases:

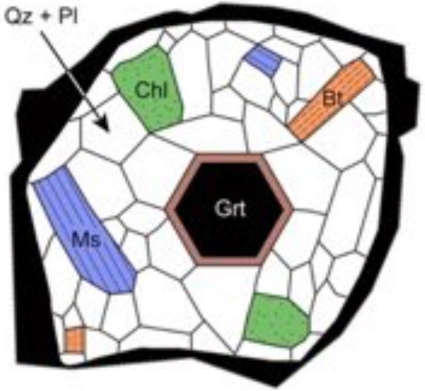
solid phases	N	volume/mol	volume[ccm]	vol%
FSP_abh	0.0624	101.2524	6.3180	17.5978
ILM_ilm	0.0064	32.1453	0.2060	0.5739
GARNET_alm	0.0012	117.5547	0.1405	0.3915
CHLR_daph	0.0075	212.4772	1.5908	4.4310
PHNG_mu	0.0751	139.8738	10.5098	29.2735
BIO_ann	0.0269	151.0521	4.0559	11.2970
quartz	0.5681	23.0272	13.0811	36.4353
total of solids			35.9022	100.0000

gases and fluids	N	volume/mol	volume[ccm]
water.fluid	0.3714	20.2769	7.531

LOCAL EQUILIBRIUM: WHY DO WE NEED LOCAL BULK ROCK?



Lanari & Engi (2017)



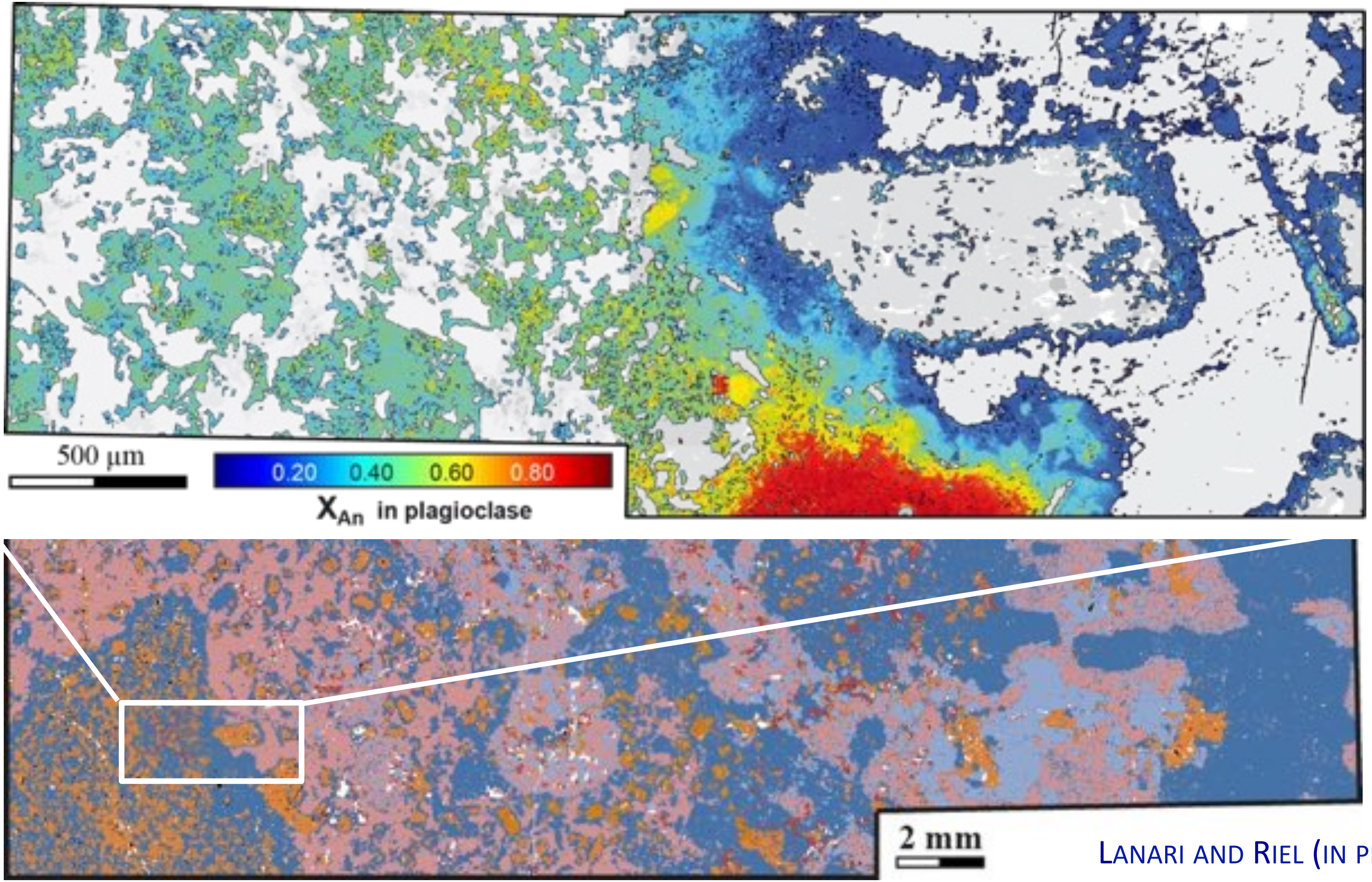
How to define an appropriate equilibration volume to be modeled?

- **Local equilibrium** (or mosaic equilibrium): Since chemical heterogeneity in a sample is primarily evident in solid solutions, local equilibria address only those situations where the minerals (or individual zones thereof) are chemically uniform

What is the relevant bulk rock composition?

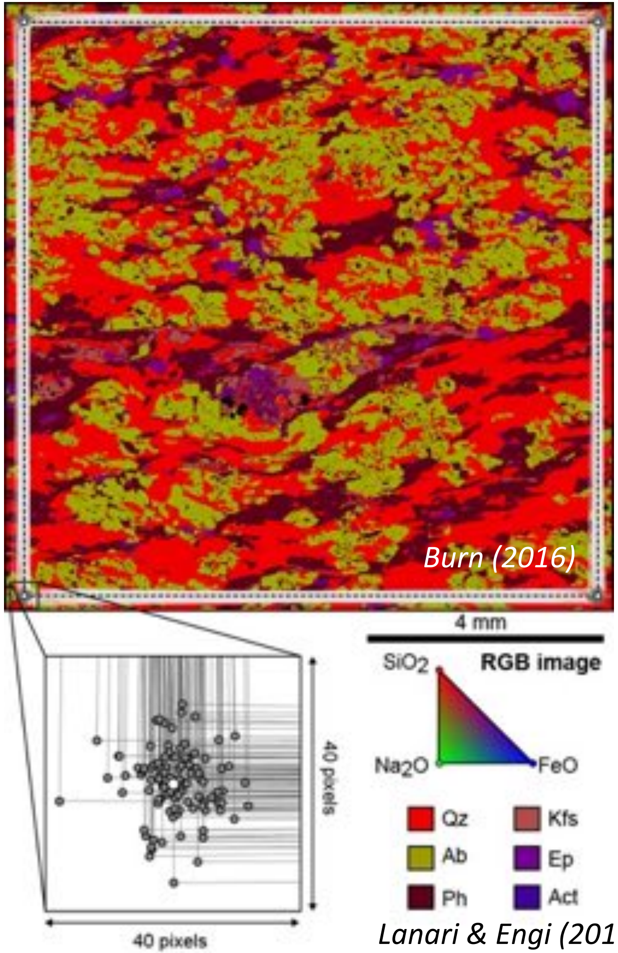
- The **reactive bulk composition** (effective bulk composition) is the composition of the equilibration volume at a specific stage

DOMANIAL ROCKS



Lanari and Riel (in prep.)

Quantitative mapping of the local bulk composition as a basis for modeling



Lanari & Engi (2017)

- **Local bulk composition from quantitative compositional maps**
  - Oxide weight percentage maps
  - Selection of a domain
  - Extraction of the local bulk composition
  - We can use this composition as input in the forward equilibrium models and compare the result with the models

XMapTools
Numerical tools for quantitative petrology

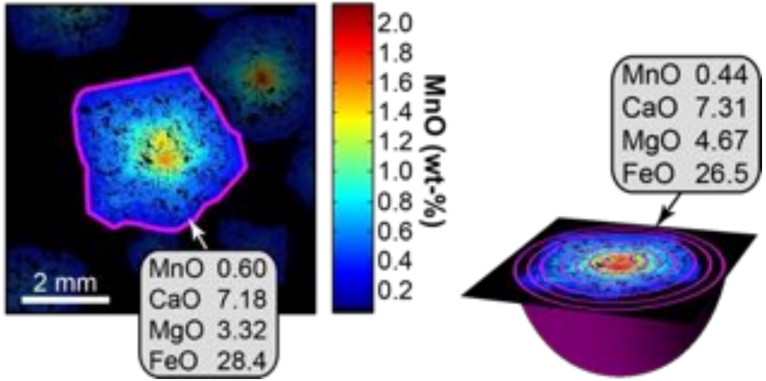
- **Sensitivity test: Uncertainty estimation**
  - Monte-Carlo simulation
  - 100 permutations
  - Displacement of each corner of ±10 pixels

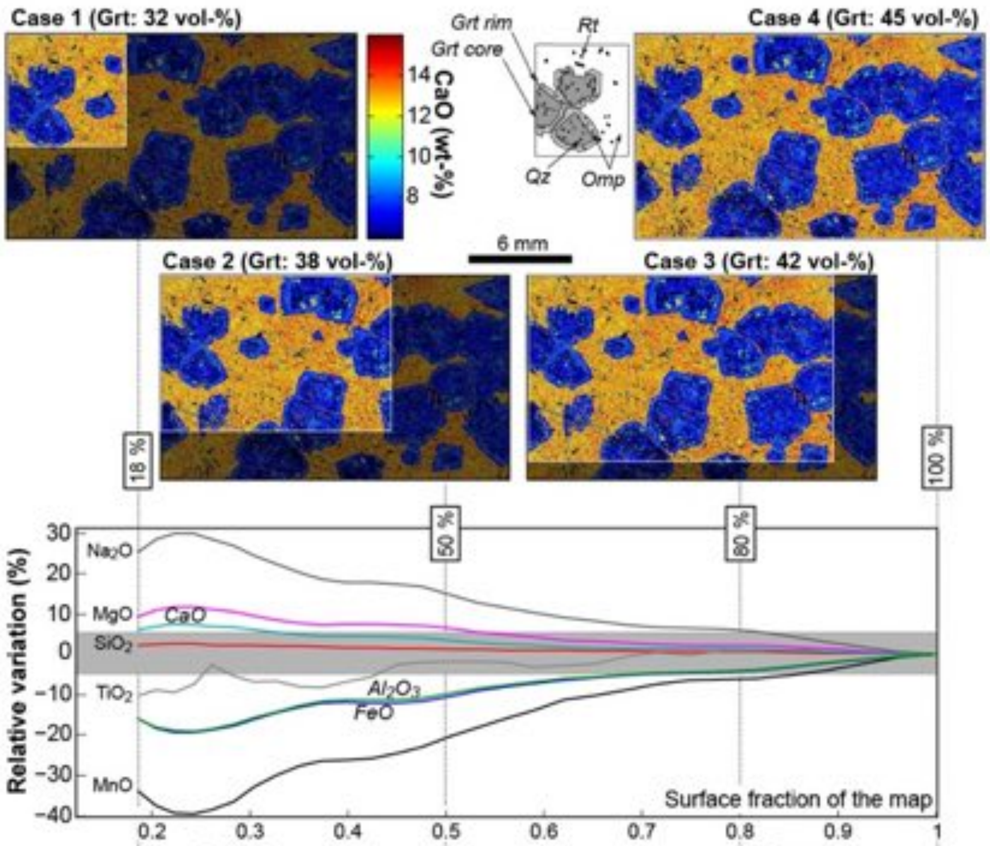
	Mean	Stdev. (2σ)	Unc. (%)
SiO_2	75.420	0.057	0.076
Al_2O_3	13.230	0.033	0.249
FeO	1.230	0.006	0.488
MgO	0.940	0.004	0.426
CaO	0.810	0.008	0.942
Na_2O	3.360	0.018	0.522
K_2O	3.090	0.017	0.551
Total	98.08		

Minor variation in the composition

Potential artifacts affecting the local bulk composition estimates

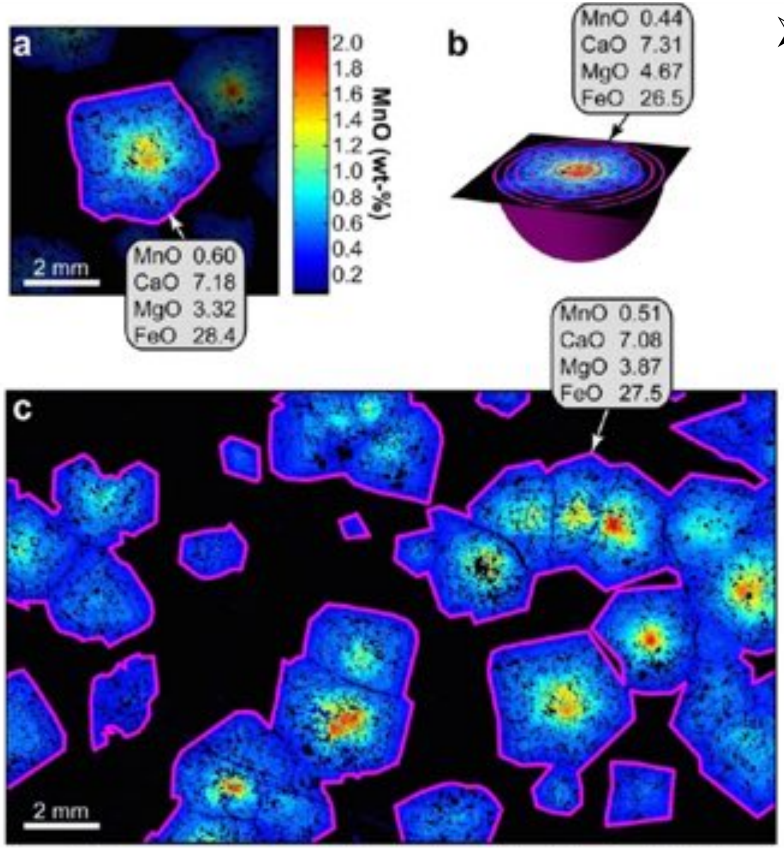
- Geometric effects
- Chemical equilibrium and the arbitrary choice of domains





Lanari & Engi (2017)

Potential artifacts affecting the local bulk composition estimates



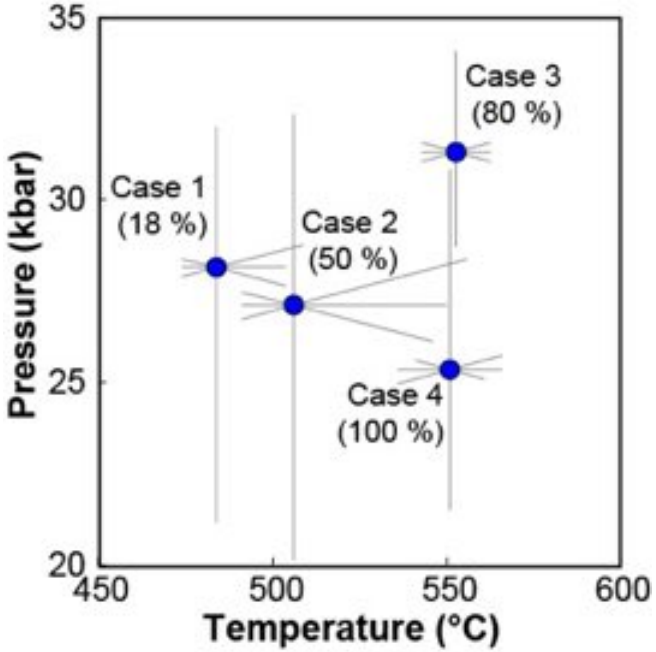
Lanari & Engi (2017)

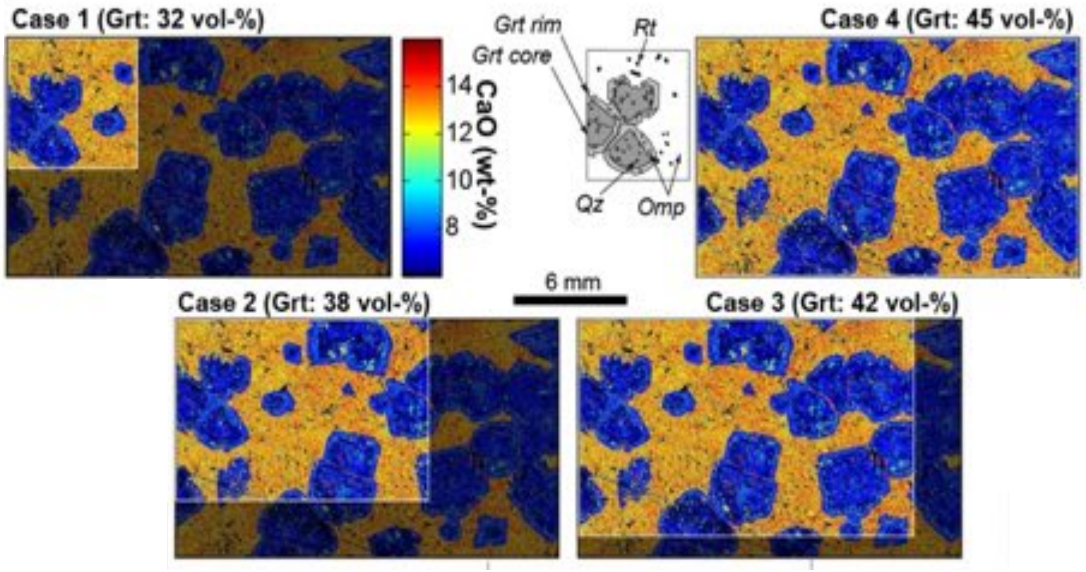
- **Geometric effects**
  - Sectioning a 3D texture of zoned crystals → surface fractions cannot be correlated with their volume fractions
    - *Equatorial cut* – overestimates core's contribution
    - *Not equatorial* – the composition will not be representative

How to minimize the effects?

- For a map containing many grains, such geometric effects are partially compensated by stochastic sampling of different sections
- Using a single crystal that is cut near the center (diagnostic element such as Mn) and apply the spherical correction.

Effects of the domain selection on forward models and P-T predictions



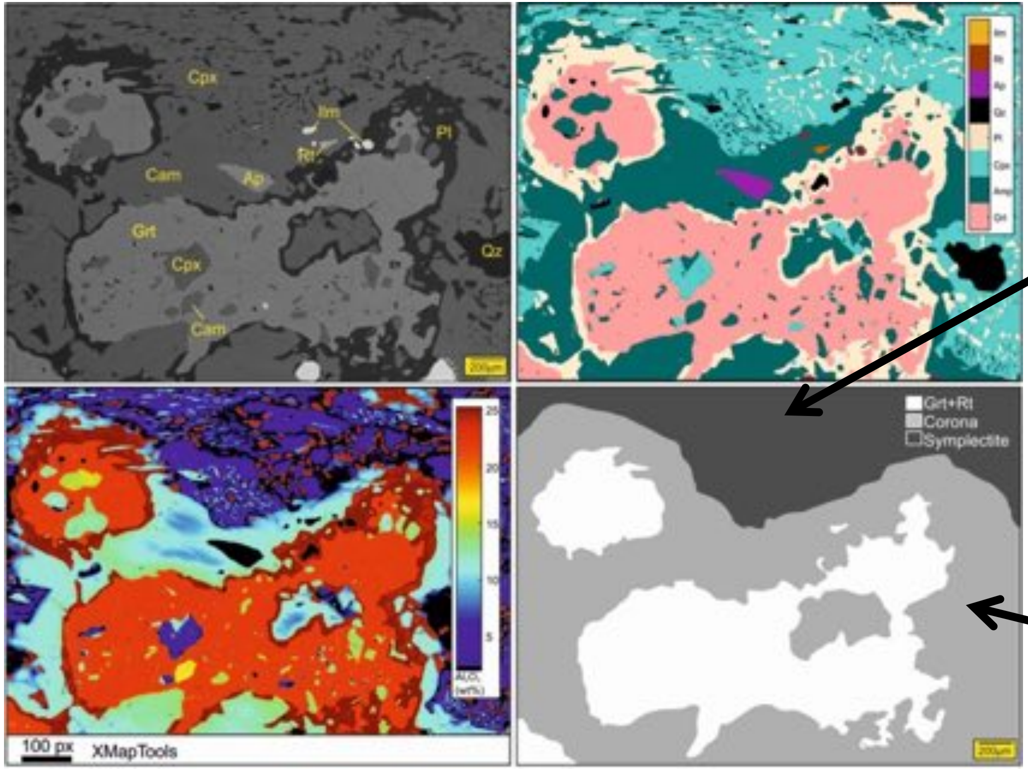


If a domain is assumed to be in chemical equilibrium at given *P–T* conditions, any smaller subdomain should yield a similar *P–T* estimate.

Lanari & Engi (2017)

QUANTITATIVE MAPPING OF THE LOCAL BULK COMPOSITION AS A BASIS FOR MODELING **AND OTHERS…**

Reconstruction of primary composition from pseudomorphic reactions

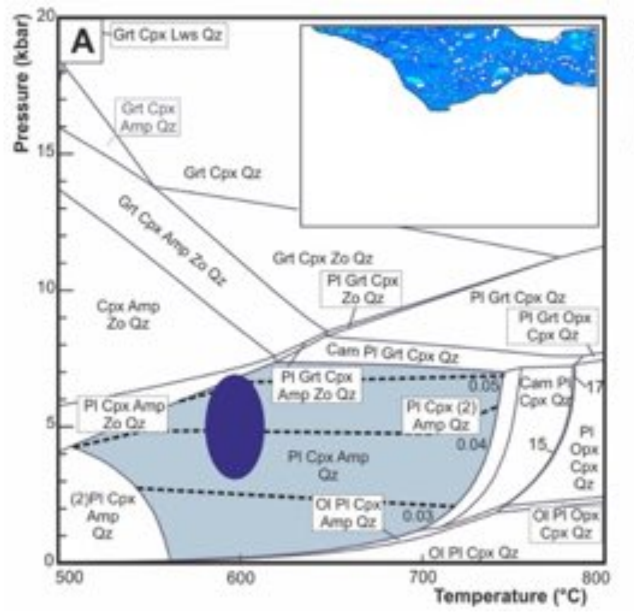


SiO_2: 54.28 wt%
Al_2O_3: 4.85 wt%
FeO: 8.40 wt%
MgO: 11.53 wt%
CaO:19.21 wt%
Na_2O:1.11wt%

SiO_2: 50.54 wt%
Al_2O_3: 1536 wt%
FeO: 9.45 wt%
MgO: 8.00 wt%
CaO:9.91 wt%
Na_2O:3.55 wt%

Tedeschi et al. (2017)

Reconstruction of primary composition from pseudomorphic reactions



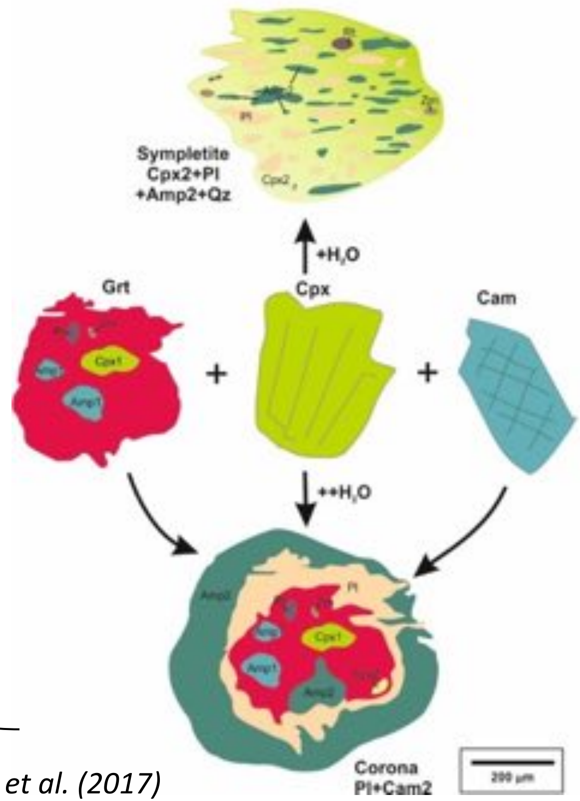
Symplectite composition: *apfu*

Si(2)Al(0.21)Mg(0.63)Fe(0.22)Ca(0.76)Na(0.08)

Omphacite in model:

Si(2)Al(0.20)Mg(0.62)Fe(0.18)Ca(0.80)Na(0.20)

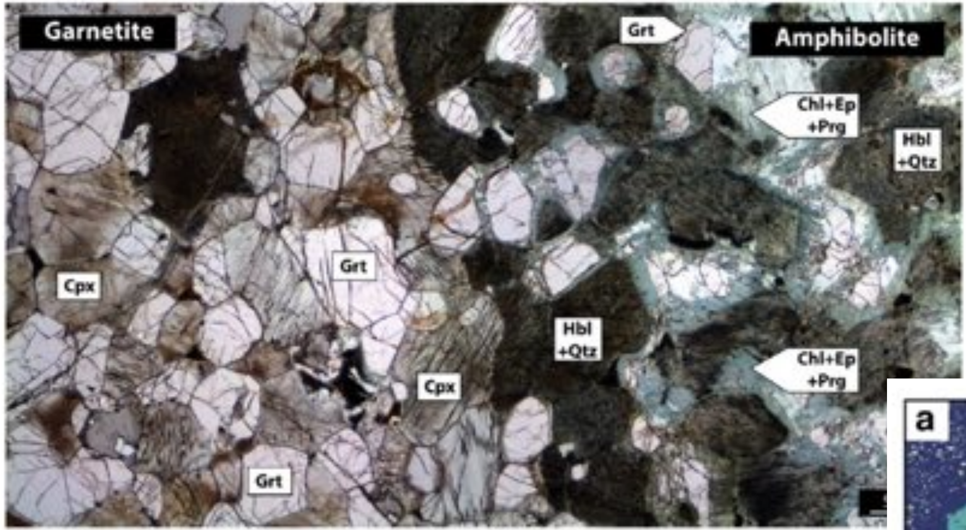
Coupled Reaction



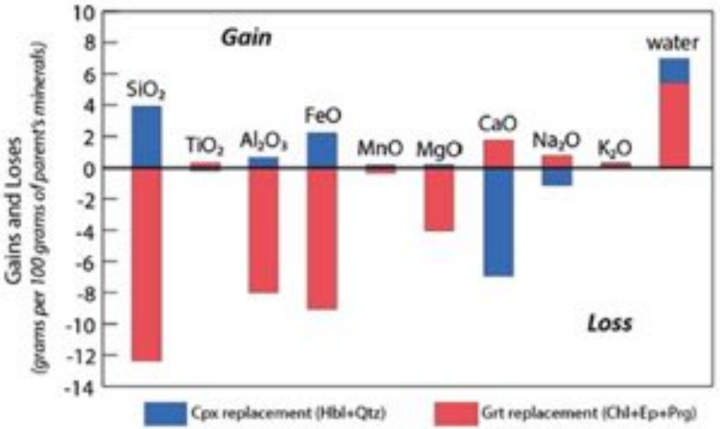
Tedeschi et al. (2017)

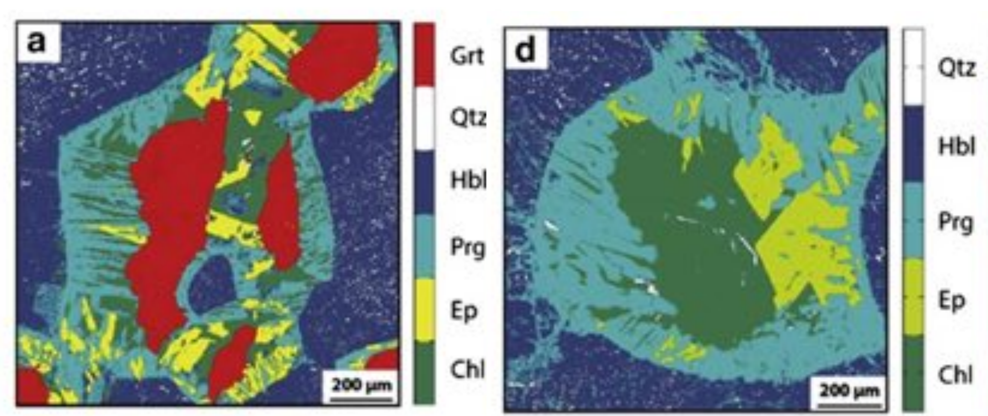
QUANTITATIVE MAPPING OF THE LOCAL BULK COMPOSITION AS A BASIS FOR MODELING **AND OTHERS…**

<u>Mass transfer evaluation and balance – Alteration front</u>

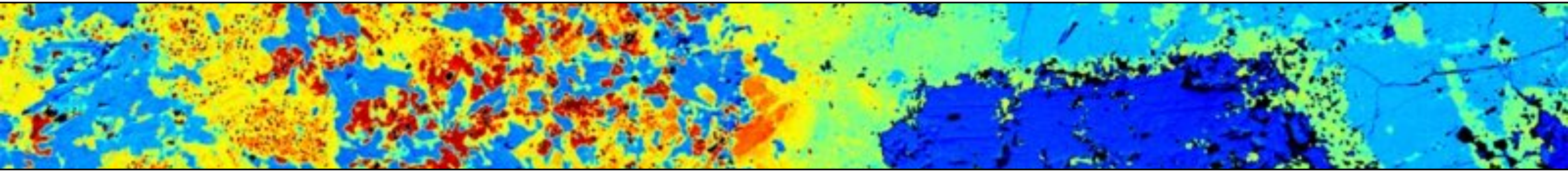


Centrella et al. (2015)





Questions / Discussion



Lecture 5

Local bulk composition estimates

Dr. Mahyra Tedeschi

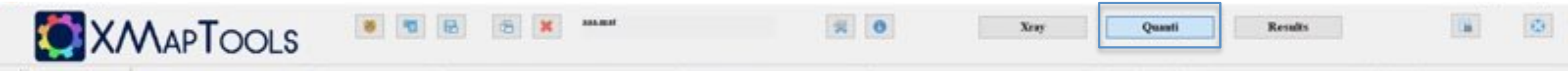
Federal University of Minas Gerais (UFMG) – mahyratedeschi@gmail.com

- How to extract local bulk compositions?
- Merge function
- Density correction and map density
- Selection area functions
- Extracting local bulk composition function

How to Extract Local Bulk compositions?

XMapTools

<u>**…after standardizing**</u>



➢ **Procedure to export local bulk compositions:**

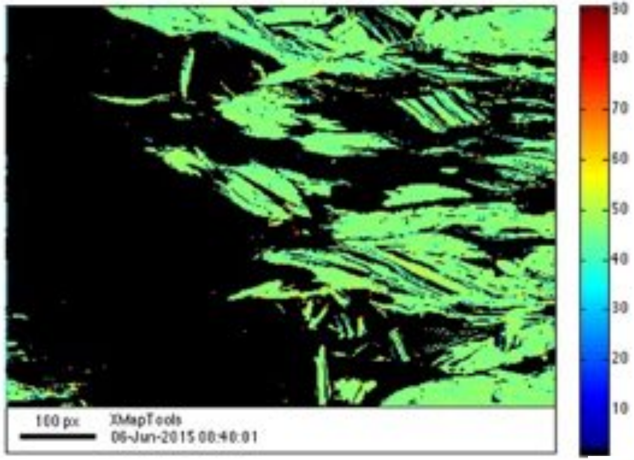
1) Merge the mineral maps, i.e. generate a *merged map*

2) Select the area of interest and clear the other pixels

3) Generate a density map

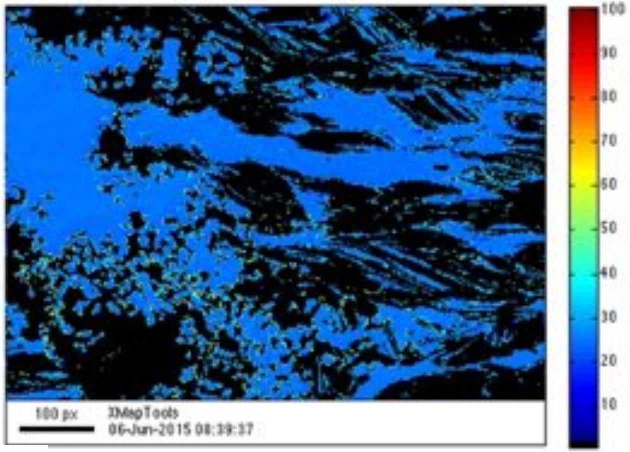
4) Correct for density effects, i.e. generate a *density-corrected map* (*DCM)

5) Export the local composition



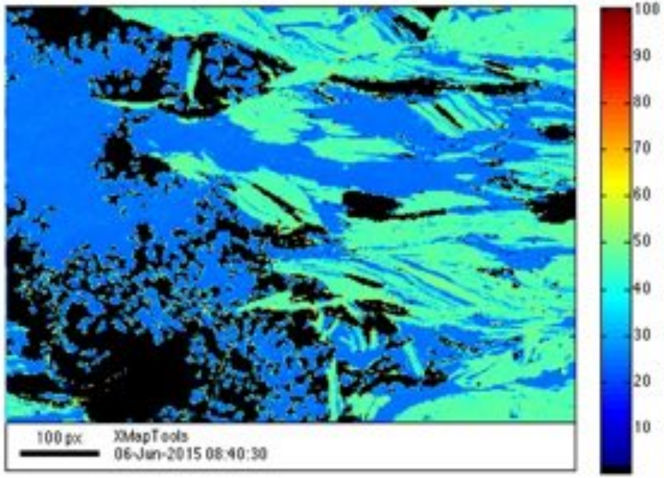
Phengite (SiO2)

+



Chlorite (SiO2)

Merged map



How does it work?

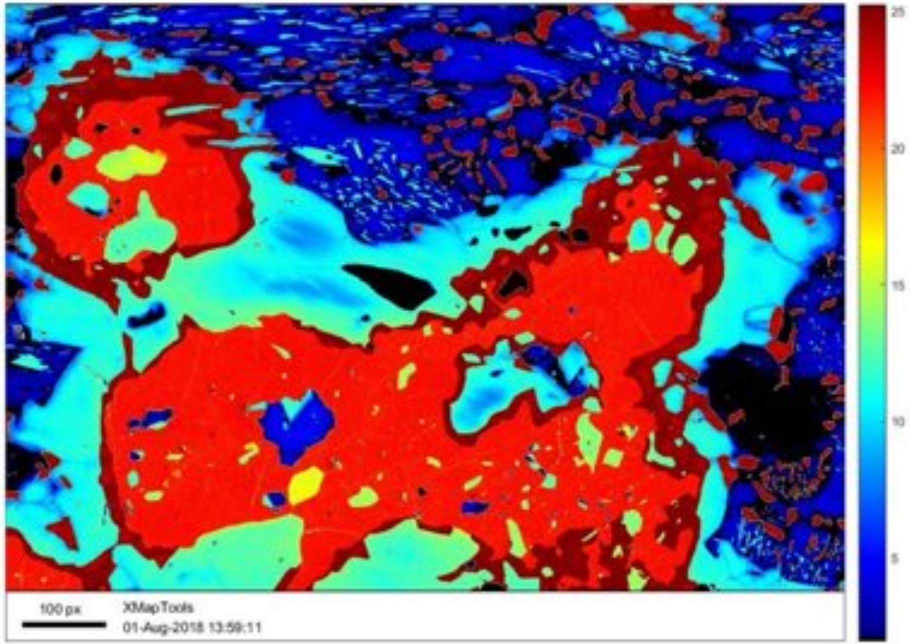
WARNING

- Maps should be selected only once
- Check the sum of oxides !!

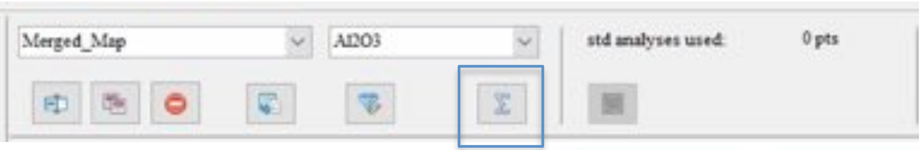
MERGE FUNCTION

XMapTools

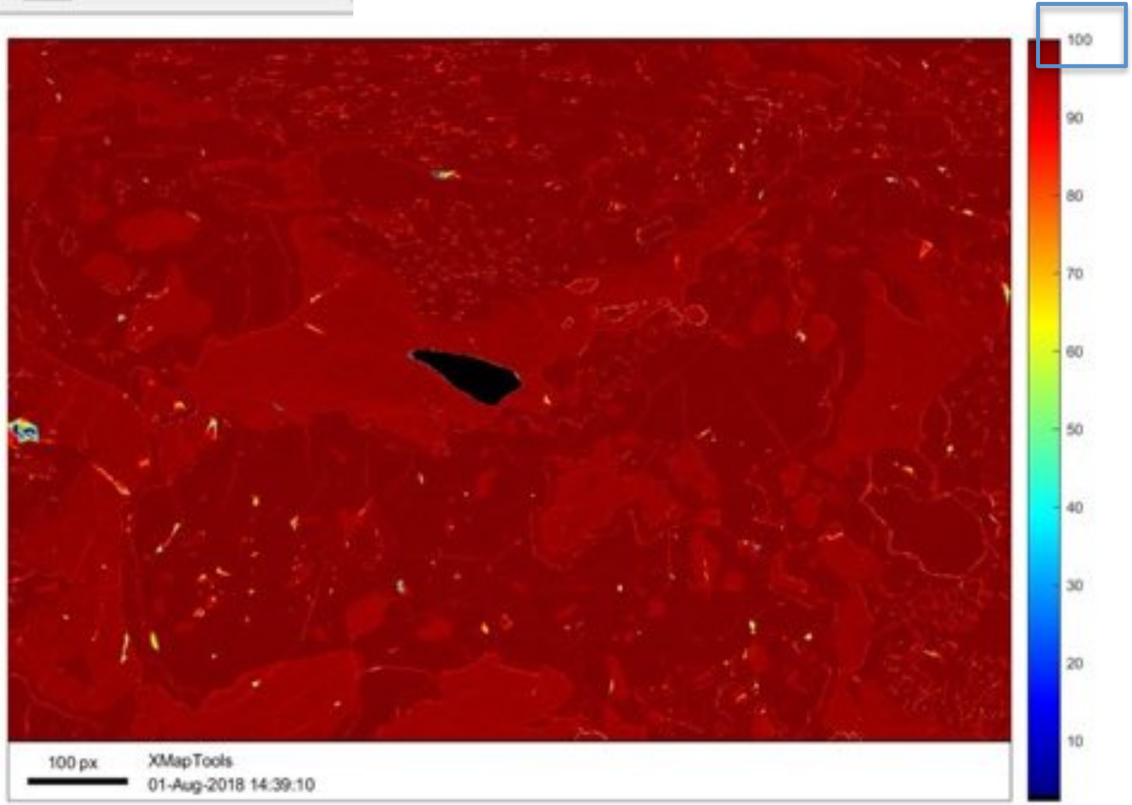
- **Maps should be selected only once**
- Check the sum of oxides !!



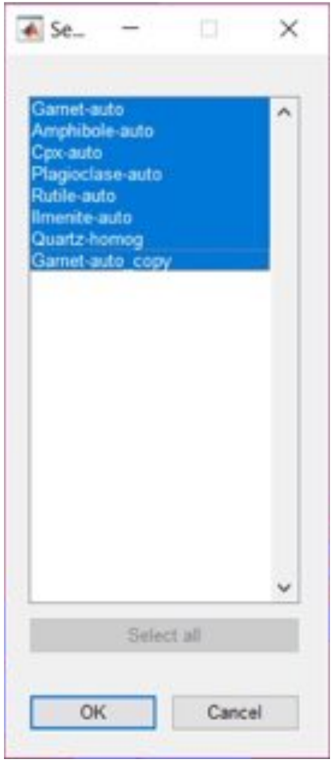
Grt+Amp+Cpx+Pl+Rt+Qz+Ilm

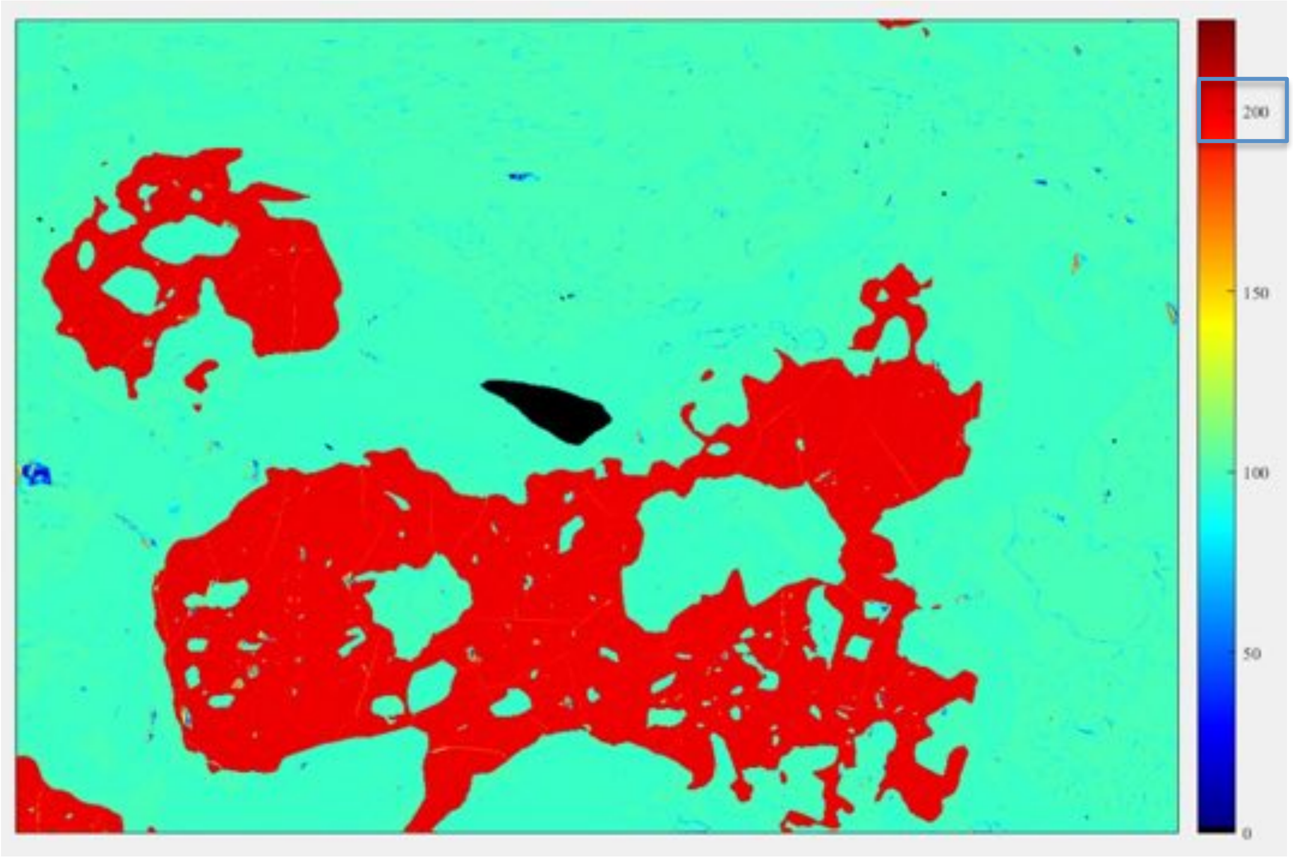


- Maps should be selected only once
- **Check the sum of oxides !!**



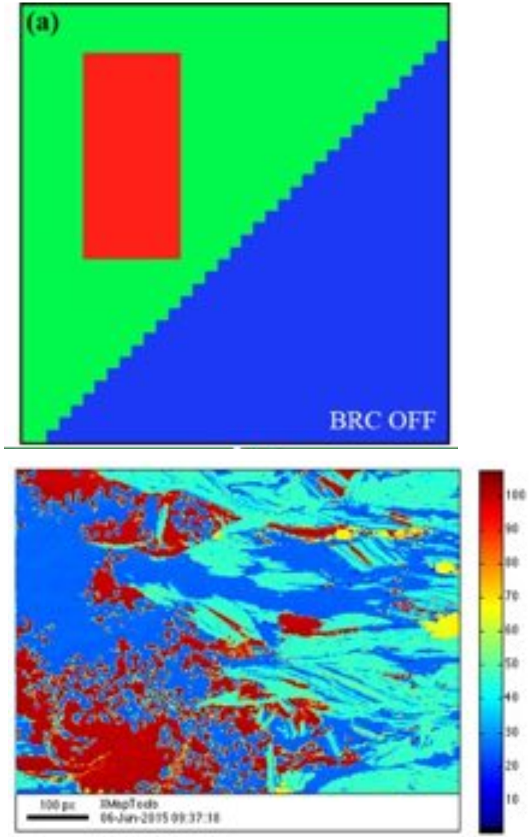
MERGE FUNCTION

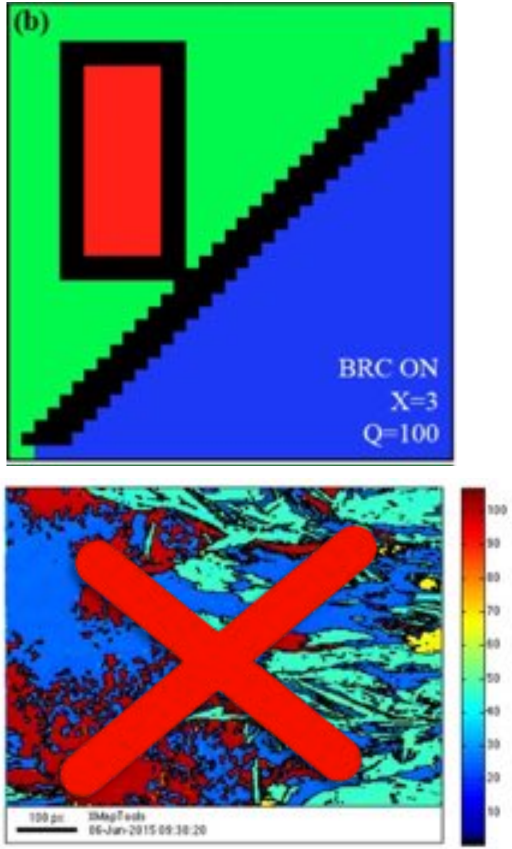




- **Effect of the BRC correction**

10 vol%
40 vol%
50 vol%





08 vol%
37 vol%
55 vol%

- **Effect of the BRC correction**

	A	B	C	D	E	F	G
1		BRC-Map	Map	BRC-Local	Local	BRC-Prop	Prop
2	Al2O3	19.0174	18.4505	22.9654	21.7617	13.2681	12.5308
3	CaO	0.030908	0.1099	0.03723	0.14667	0.0055502	0.0074749
4	Cr2O3	0.043678	0.042211	0.052576	0.049295	0.024595	0.01499
5	FeO	15.1398	14.5033	13.3288	13.2877	5.101	5.3193
6	K2O	2.856	2.7555	4.3895	3.9635	2.844	3.0571
7	MgO	5.3509	5.1322	4.8842	4.8233	1.9685	2.267
8	MnO	0.26957	0.25441	0.22844	0.22632	0.11571	0.073704
9	Na2O	0.40831	0.40321	0.61432	0.56589	0.29457	0.17874
10	SiO2	49.2752	49.956	45.5707	46.4534	73.2016	72.8057
11	TiO2	0.13912	0.1767	0.2049	0.24123	0.12221	0.10967
12							
13	SUM	92.5308	91.7839	92.276	91.519	96.945	96.3644

Principles

APPENDIX 1—LOCAL BULK COMPOSITIONS FROM OXIDE WEIGHT PERCENTAGE MAPS

Let us consider a domain of rock composed of three mineral phases Min_1, Min_2 and Min_3, each homogeneous in composition C_1^i, C_2^i and C_3^i of the oxides of the element *i*. *C* is expressed in oxide wt%. This is convenient here because chemical analyses of silicate minerals are commonly reported in wt% of the oxides determined. The local bulk composition of this domain C_{LB} can be calculated as:

$$C_{LB} = w_1C_1^i + w_2C_2^i + w_3C_3^i \quad \text{(A1)}$$

With w_1, w_2 and w_3 the mass fractions of the mineral phases Min_1, Min_2 and Min_3. This relation can be generalized for a map of a given domain containing n pixels:

$$C_{LB} = \sum_{j=1}^{n} w_jC_j^i \quad \text{(A2)}$$

w_j and C_j^i are the mass fraction and composition in oxide weight percentage of pixel *j*. The use of Relation (A2) is not straightforward, as it requires the knowledge of the mass fraction of every pixel that may belong to different phases, each with a different molar mass.

Principles

$$v_k = s_k \quad (A3)$$

In metamorphic petrology, this relation may be reasonable if (i) the sample was sectioned perpendicular to the foliation or schistosity, (ii) the compositional map is acquired on an unaltered rock surface devoid of local compositional heterogeneities, (iii) the size of the map is sufficient to ensure good sampling, (iv) the resolution of the map is high enough to avoid issues with the smaller grain size population, and (v) 3D effects are negligible. Possible pitfalls and issues are discussed under 'Potential artifacts affecting the local bulk composition estimates'. The relationship between the mass fraction and the volume fraction is:

$$w_k = \frac{\rho_k}{\rho_{\text{mixture}}} v_k \quad (A4)$$

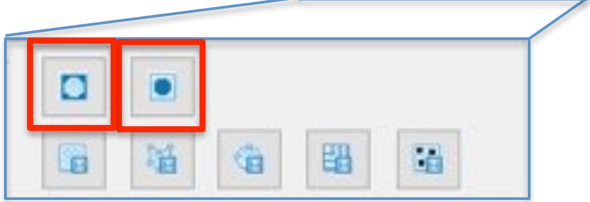
with ρ_k being the density of the phase k and the average density ρ_{mixture} of the domain. Integrating the density correction in Equation (A2) leads to a more convenient expression of the local bulk composition of the domain:

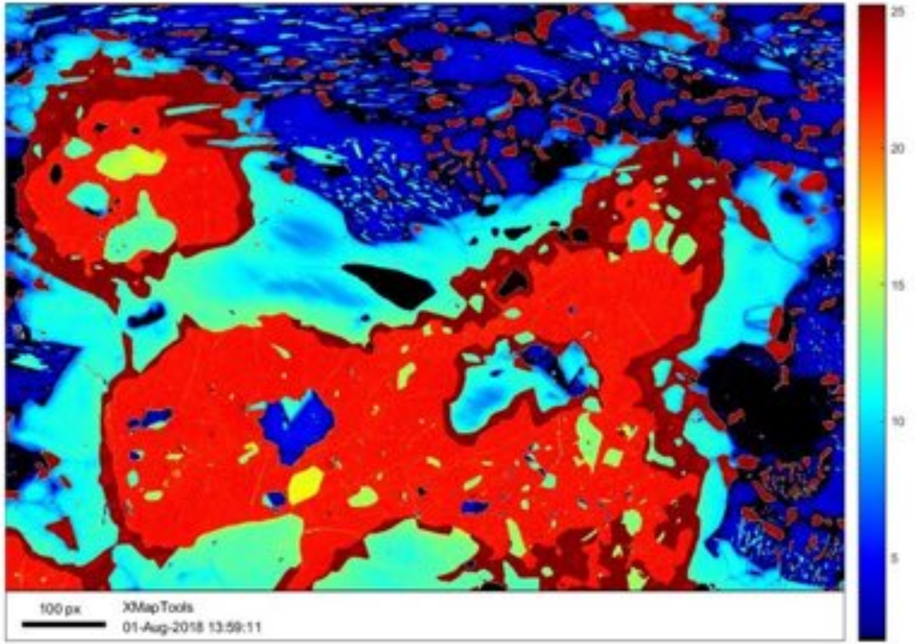
$$C_{\text{LB}} = \sum_{j=1}^{n} \frac{\rho_k}{\rho_{\text{mixture}}} v_j C_j^i \quad (A5)$$

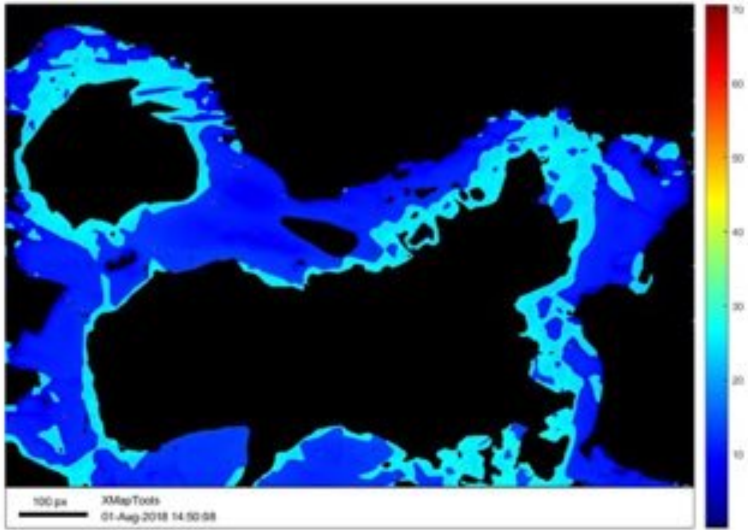
From this relationship it is possible to extract the local bulk composition of a domain using the average density of every phase involved.

SELECTION AREA FUNCTION

XMapTools

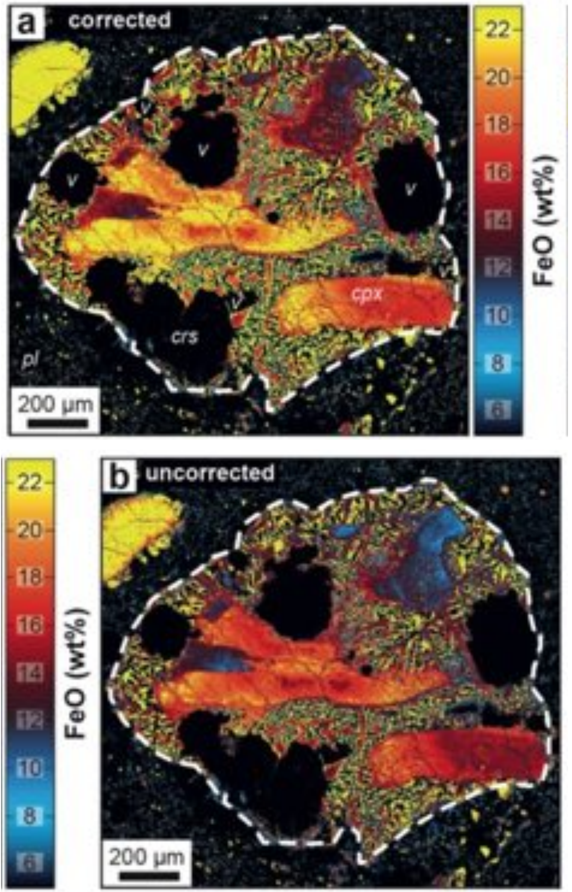






Grt+Amp+Cpx+Pl+Rt+Qz+Ilm

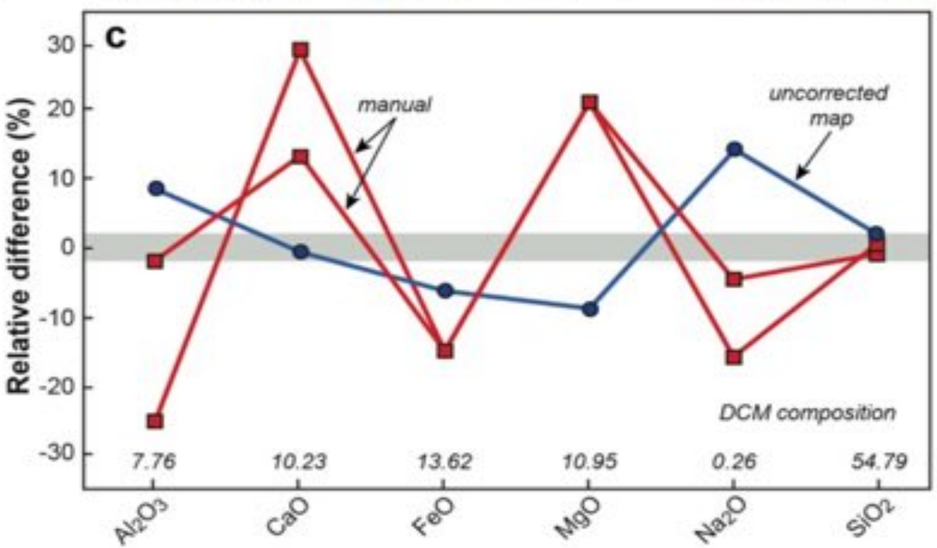
Merged map



Why is density correction important?

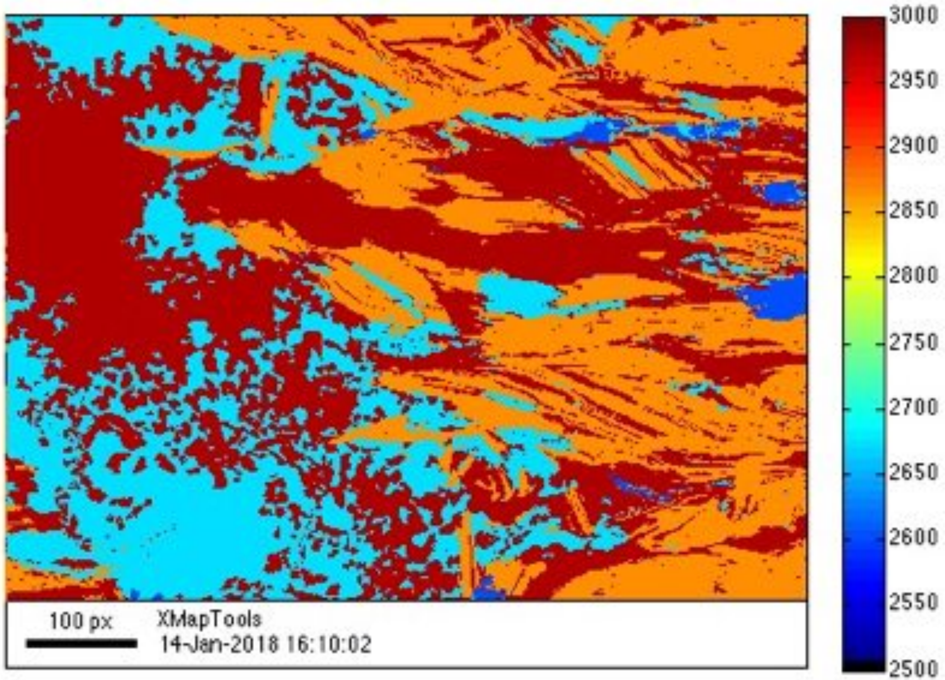
- **Convert sample area in weight fraction**

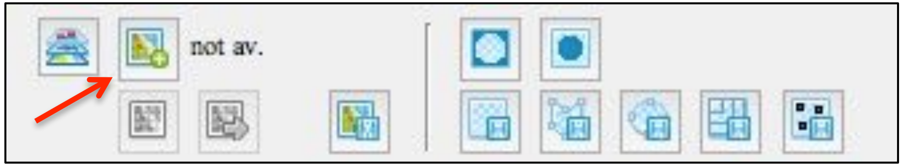
The weight-per-pixel of FeO and MgO in pyroxene is higher in the DCM because the density contribution of pyroxene to the average density of the domain is high (~110 %). The weight-per-pixel of Al2O3 in plagioclase is lower in the density corrected map because plagioclase has a lower relative density (~85 %).



Lanari et al (2018) modified from Mészaros et al (2016)

Generate a density map



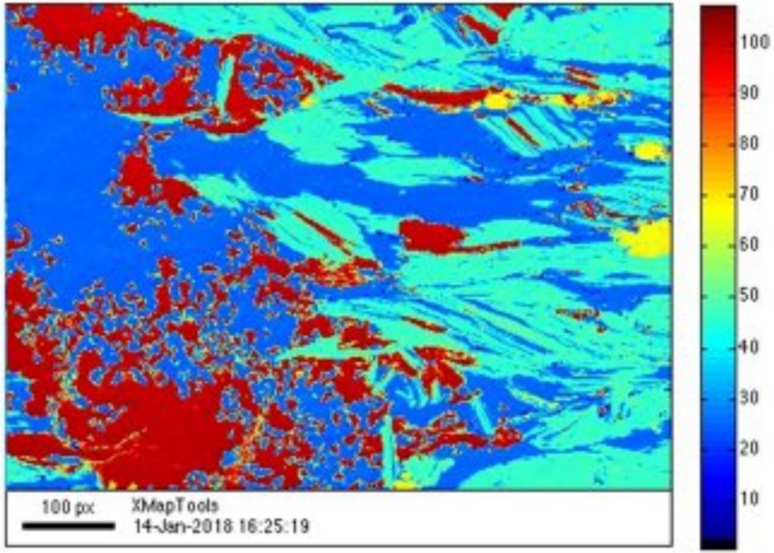


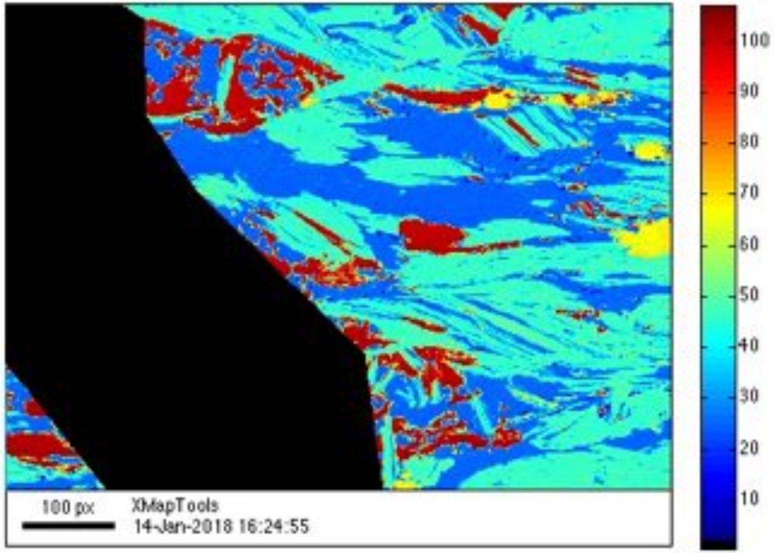
Density Correction on XMapTools

➢ **Density-correction & local bulk composition**

1-Duplicate the merged map

2-Clear the pixels that are in the quartz vein





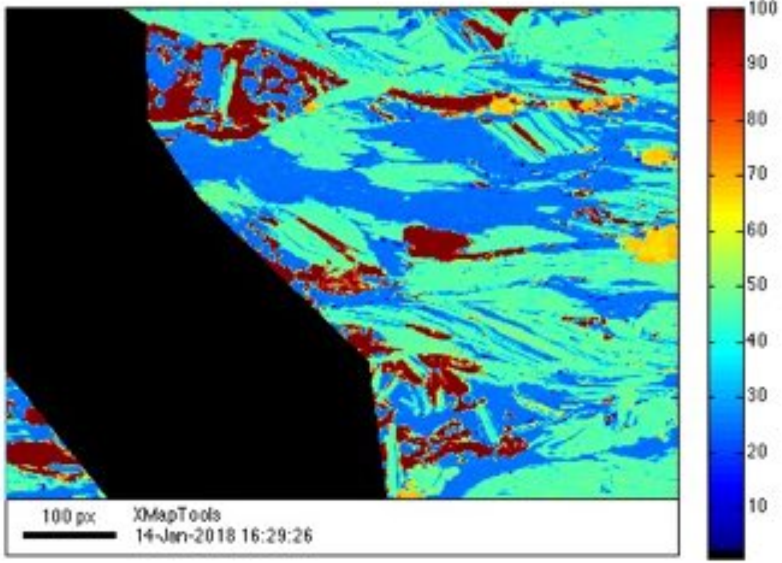
- **Density-correction & local bulk composition**

Calculate a density-corrected map

$$w_k = \frac{\rho_k}{\rho_{mixture}} v_k$$

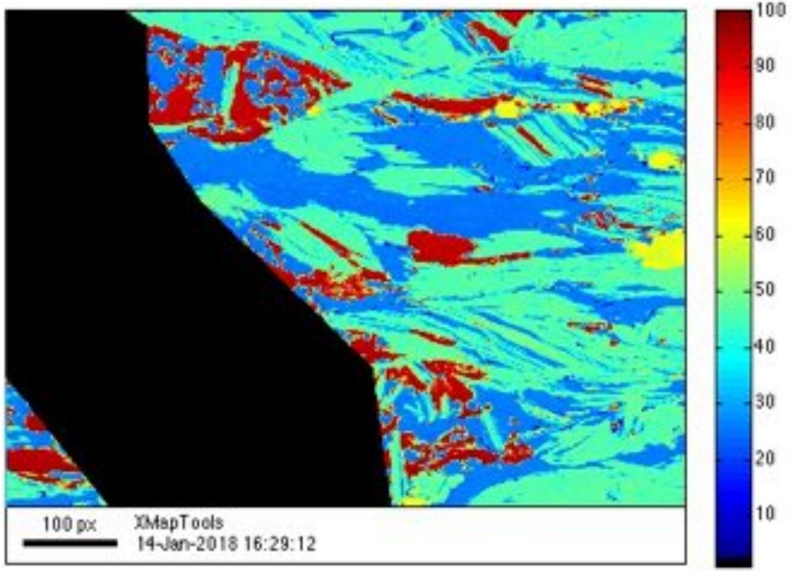
No-DCM

Si map



DCM

Chl(1.04); Ph(1); Qz(0.93); Ab(0.91)



- **Density-correction & local bulk composition**

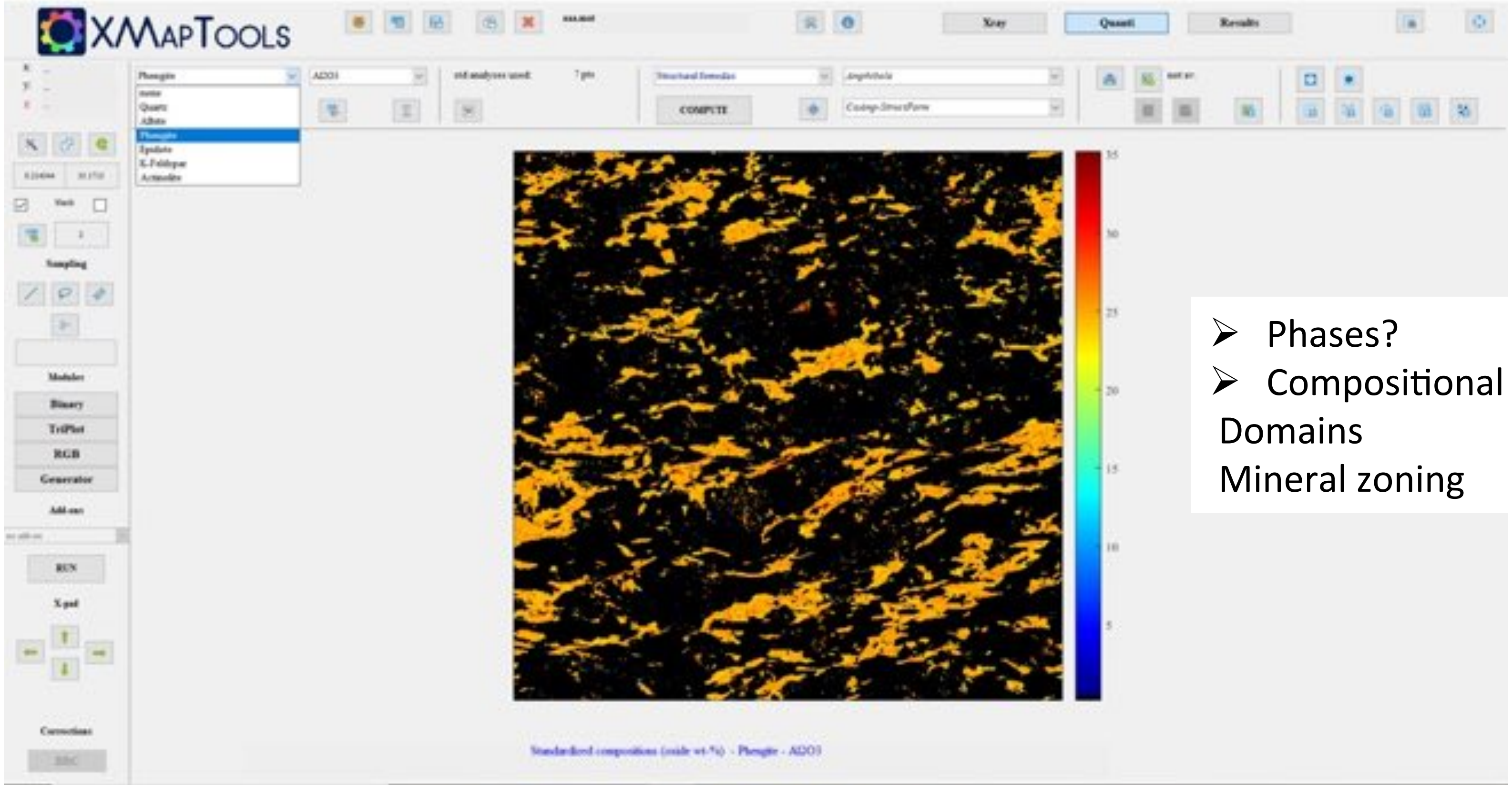
Export the local bulk compositions from the two maps and compare the results

4		noDCM	DCM
5	Al2O3	22.4031	22.5741
6	CaO	0.19559	0.18355
7	Cr2O3	0.09819	0.098738
8	FeO	14.7143	15.0953
9	K2O	4.5662	4.5599
10	MgO	5.0321	5.1607
11	MnO	0.36461	0.37157
12	Na2O	0.6671	0.64964
13	SiO2	45.3695	44.6347
14	TiO2	0.9628	0.96314
15			
16	SUM	94.3735	94.2914

QUESTIONS / DISCUSSION

Let's Practice

- **Open existing project:** EXAMPLE-2-AlpsBurn2016 (aaa.mat)



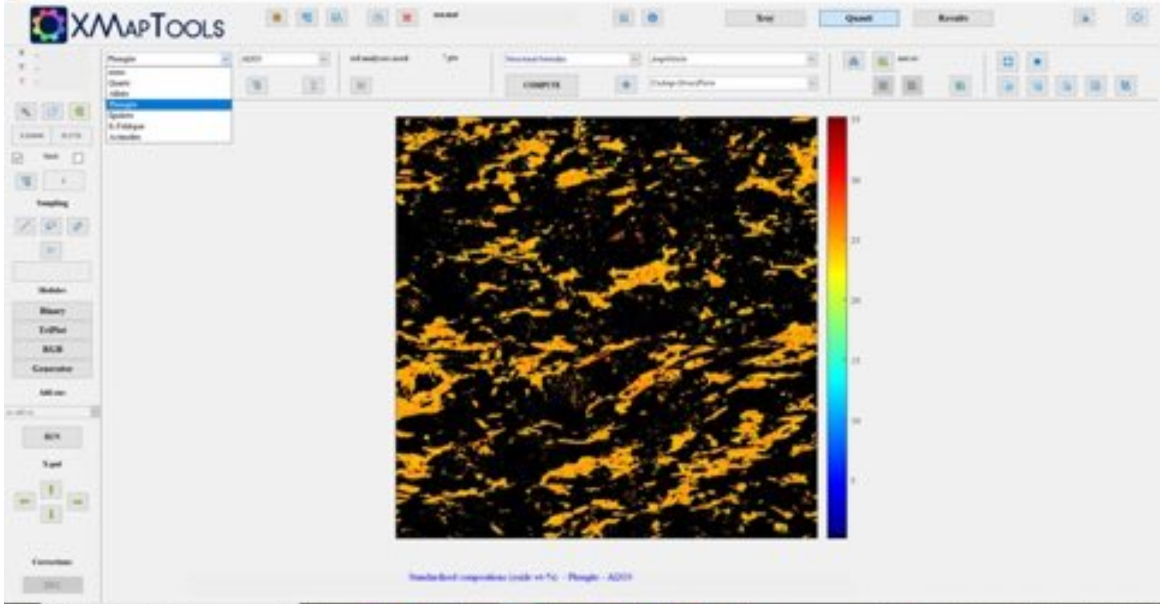
- Phases?
- Compositional variability?

Domains

Mineral zoning

One step further… After standardizing

- **Open existing project:** EXAMPLE-2-AlpsBurn2016 (aaa.mat)

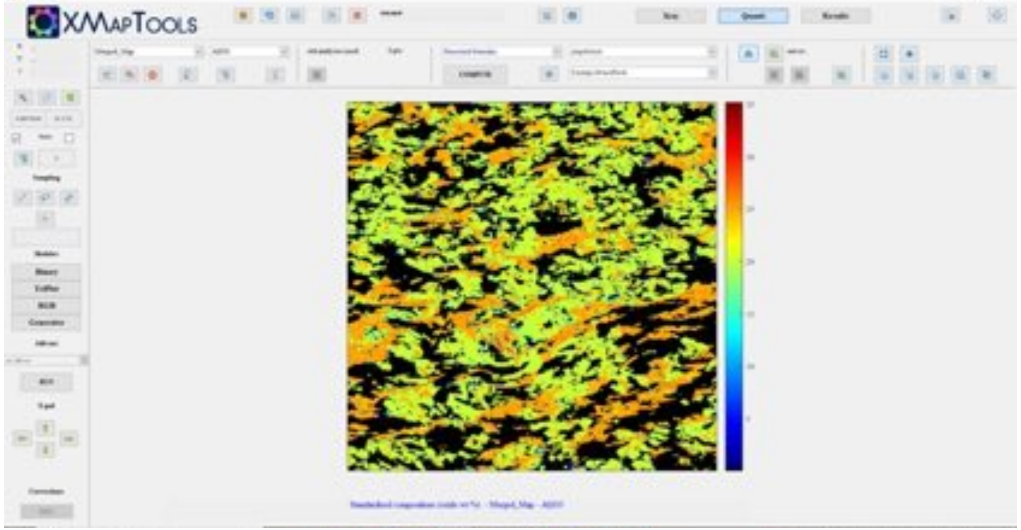


QUANTI WORKSPACE

Dwell time: 70 ms
Size: 1024 × 1024 pixels
Pixel size: 10 µm

Merge Function

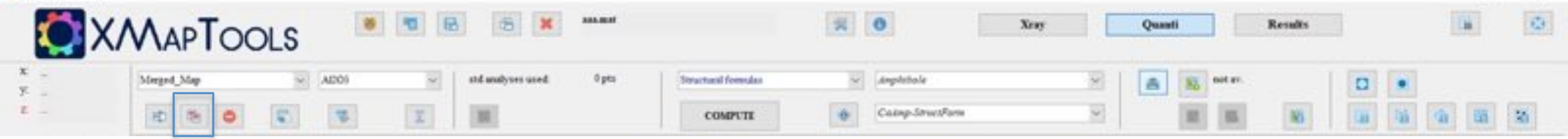
Generate a **Merged_map** using the standardized maps of quartz, albite, phengite, epidote, K-feldspar and actinolite (no BRC)



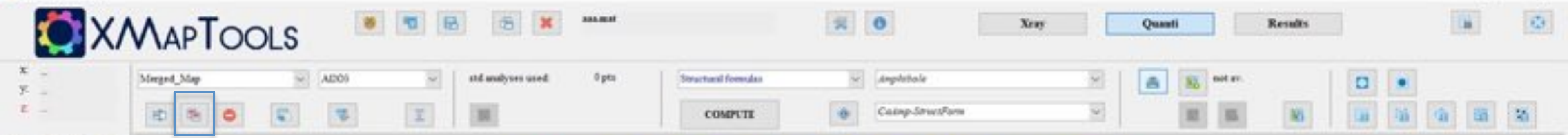
- Maps should be selected only once
- **Check the sum of oxides !!**

Duplicate, Rename and delete functions

Duplicate the **Merged_Map** (keep it as backup)



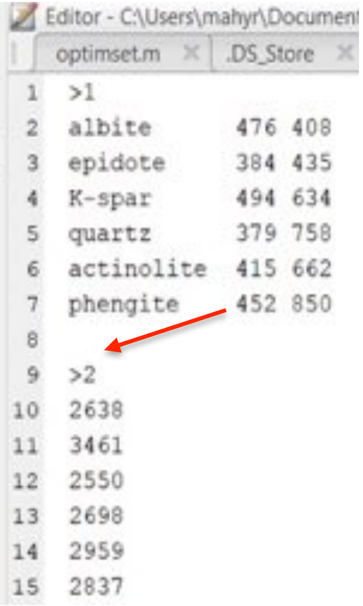
Rename one **Merged_Map** file as Bulk_1 (for the upper domain)



Density-correction

In the file *Classification.txt, add* the density values of each phases

- THERIAK-DOMINO
- Webmineral



Actinolite – 2959
Albite – 2638
Epidote – 3461
K-feldspar – 2550
Phengite – 2837
Quartz – 2698

Exercise 2 - Glacier Rafray (Alps)

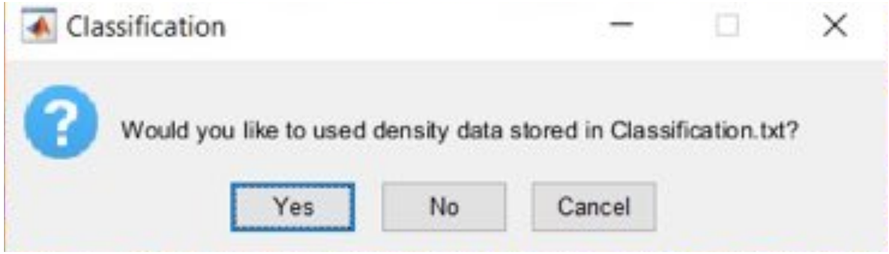
XMapTools

Density-correction

Generate a density map ***DCM_Bulk_1**

A

B



C

Remember selecting the right mask file on Xray workspace!

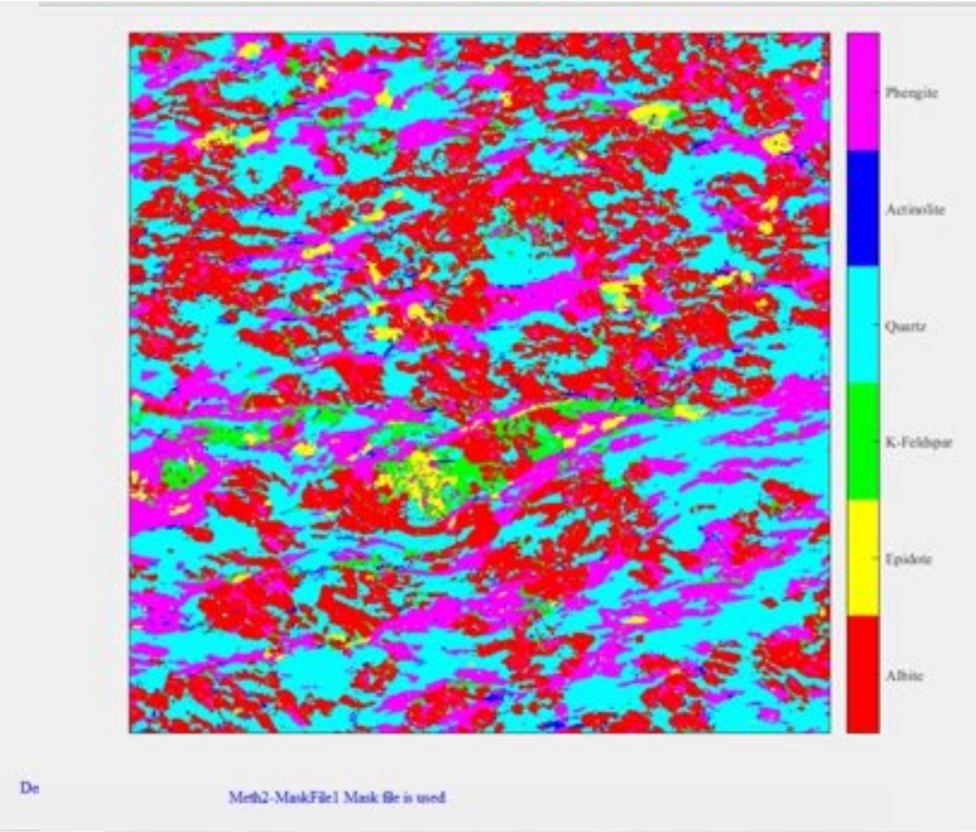
Density-correction

Compute a density-corrected oxide map

This map should only be used to export local bulk compositions because each pixel is multiplied by

$$\frac{\rho_i}{\rho_{mixture}}$$

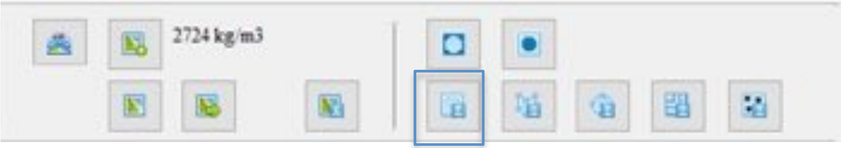
The sum is not anymore 100 wt-%.



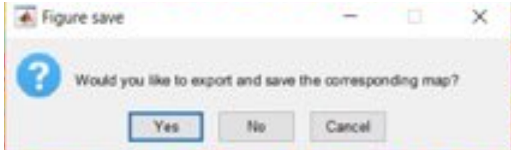
Density-correction

Export the local bulk-rock ***DCM_Bulk_1**

A



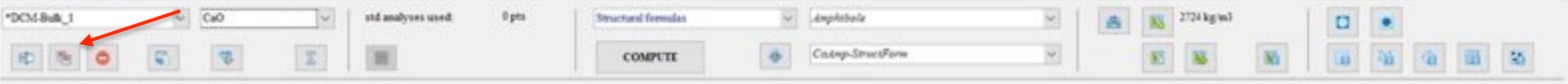
B



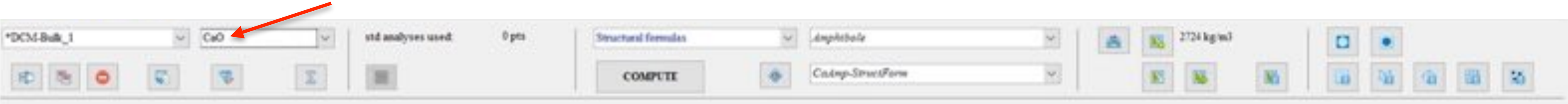
C

Local bulk: 2a – Export Local Composition area function

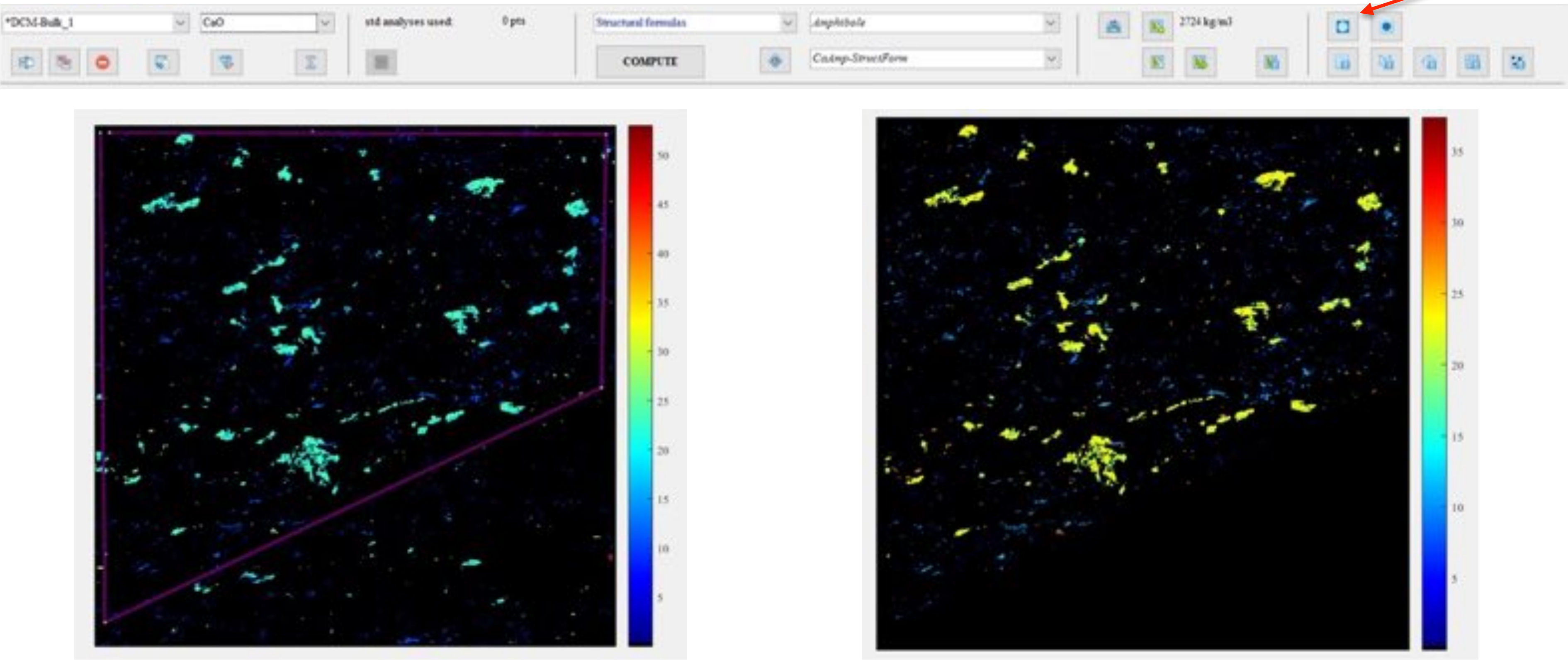
Duplicate the **Merged_map** and *rename* it as **Upper_domain**



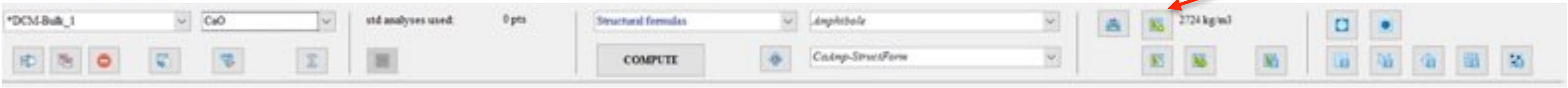
Select ***CaO* map** and identify the upper epidote-rich domain



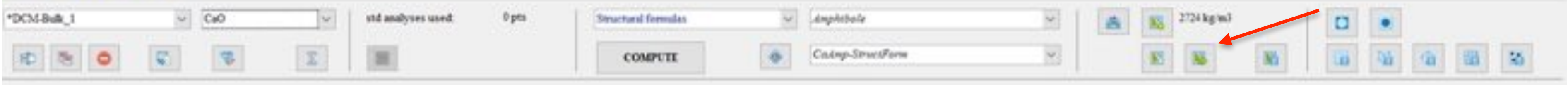
Select an area in this domain with *Select and area & delete pixels outside*



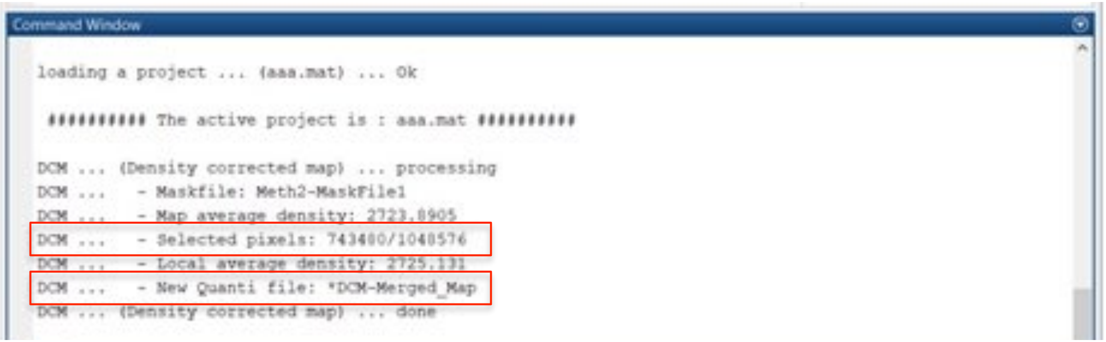
Generate a density-corrected oxide map



Compute a density-corrected oxide map of the upper domain (rename it as Upper_domain)



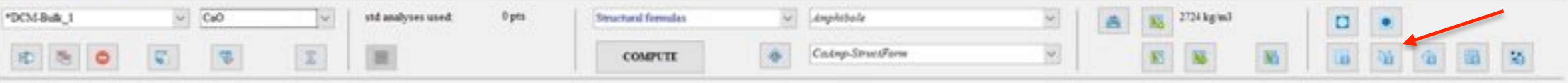
Compare the densities from the **Merged_map** and the **Upper_domain** in the Matlab window

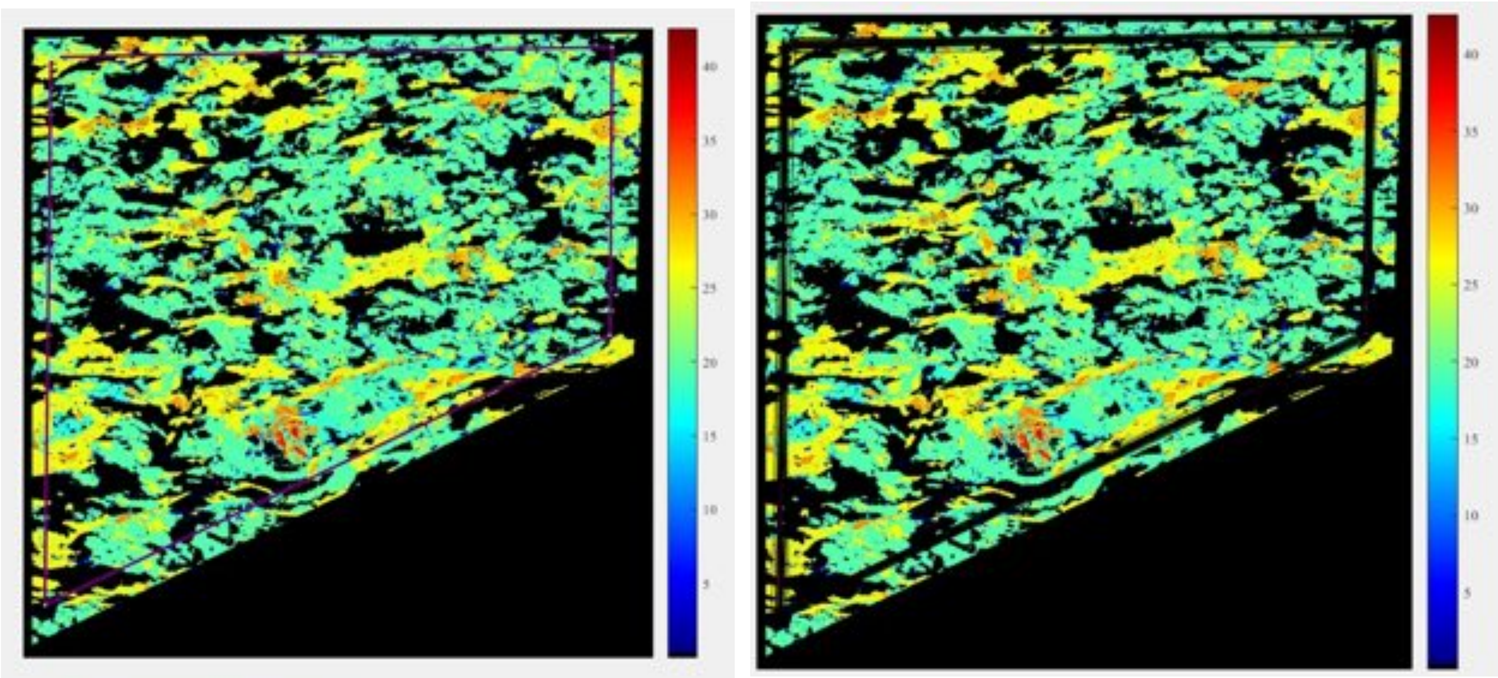


EXERCISE 2 - GLACIER RAFRAY (ALPS)

XMapTools

Select *Export local composition area* and select a smaller area (do not select the edges)

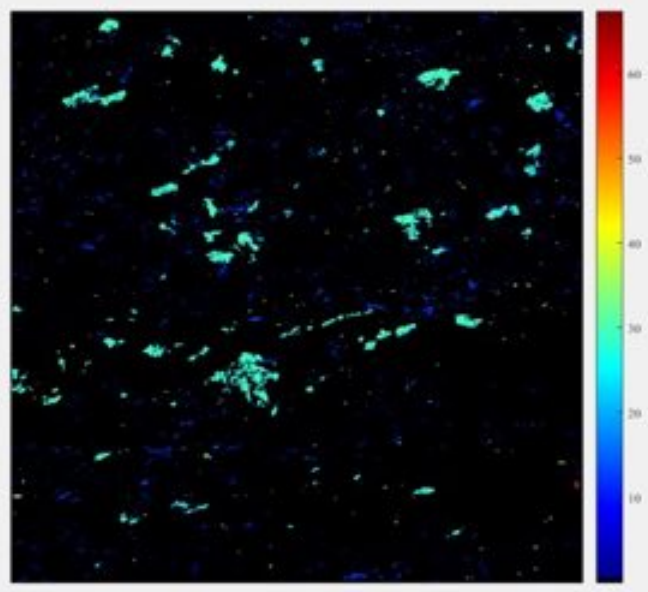




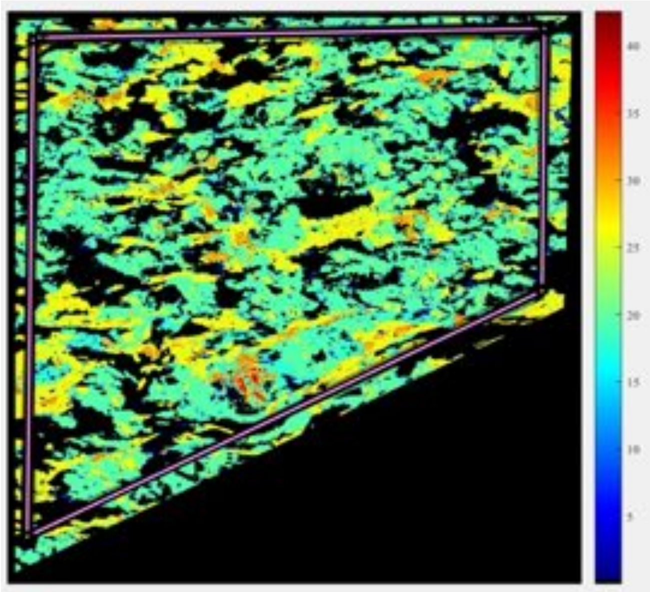
Elem.	Mean	Std
Al2O3	13.91	0.02
CaO	1.11	0.01
FeO	1.34	0.00
K2O	3.13	0.01
MgO	0.93	0.00
MnO	0.05	0.00
Na2O	3.66	0.01
SiO2	74.02	0.03
TiO2	0.06	0.00
SUM	98.2038	

EXERCISE 2 - GLACIER RAFRAY (ALPS)

Compare bulk rock obtained from the **Merged_map** and the **Upper_domain map**



	Bulk	Upper_domain	
Elem.		Mean	Std
Al2O3	13.24	13.91	0.02
CaO	0.81	1.11	0.01
FeO	1.23	1.34	0.00
K2O	3.09	3.13	0.01
MgO	0.94	0.93	0.00
MnO	0.05	0.05	0.00
Na2O	3.36	3.66	0.01
SiO2	75.42	74.02	0.03
TiO2	0.06	0.06	0.00
SUM	98.20	98.20	



In this case domain selection do not interfere significantly in the bulk determination!!

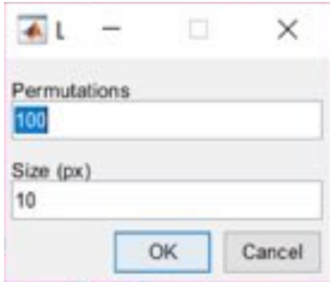
EXERCISE 2 - GLACIER RAFRAY (ALPS)

XMapTools

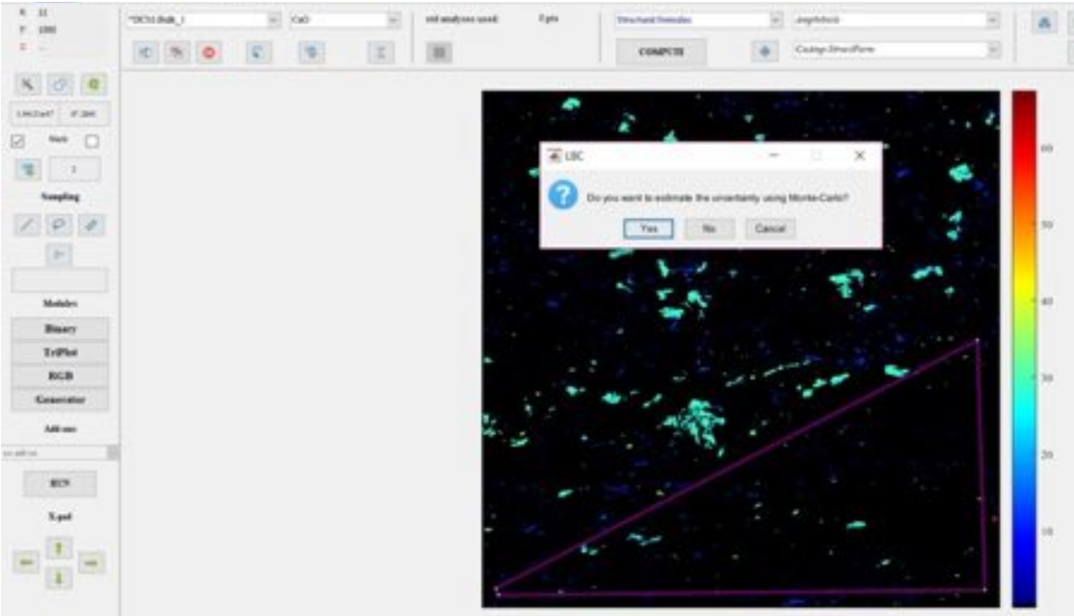
A

Duplicate the **Merged_map**, *generate* a density-corrected ***DCM-Bulk_1** map and *Export local composition area* of the lower domain

B



Remember: The use of the general ***DCM-Bulk_1 map** is only possible because the density of the rock did not change considerably when calculating separate domains!



Save as lower_domainA

C

Elem.	Mean	Std
Al_2O_3	12.17	0.05
CaO	0.26	0.01
FeO	1.02	0.01
K_2O	3.25	0.03
MgO	0.94	0.01
MnO	0.044	0.00
Na_2O	2.66	0.03
SiO_2	77.89	0.07
TiO_2	0.067	0.00
SUM	98.1613	

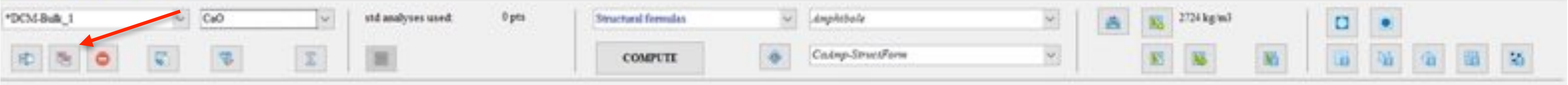
EXERCISE 2 - GLACIER RAFRAY (ALPS)

XMapTools

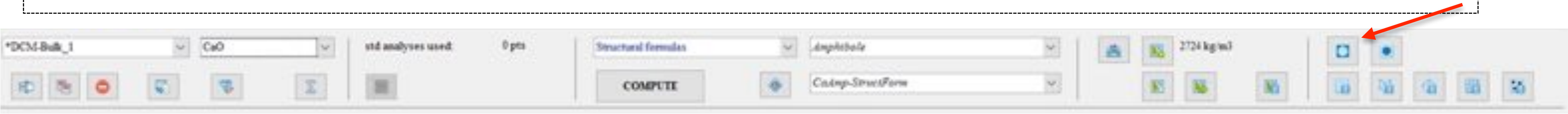
Now, let's try with a appropriate approach:

<u>Lower domain B – Select an area and delete pixels outside function</u>

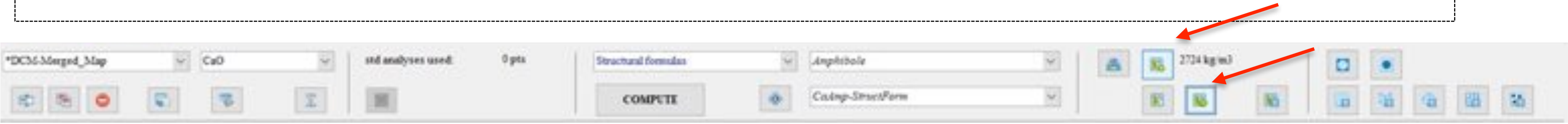
Duplicate the **Merged_map** and rename it as **Lower_domain_B**



Select *Select an area and delete pixels outside* function

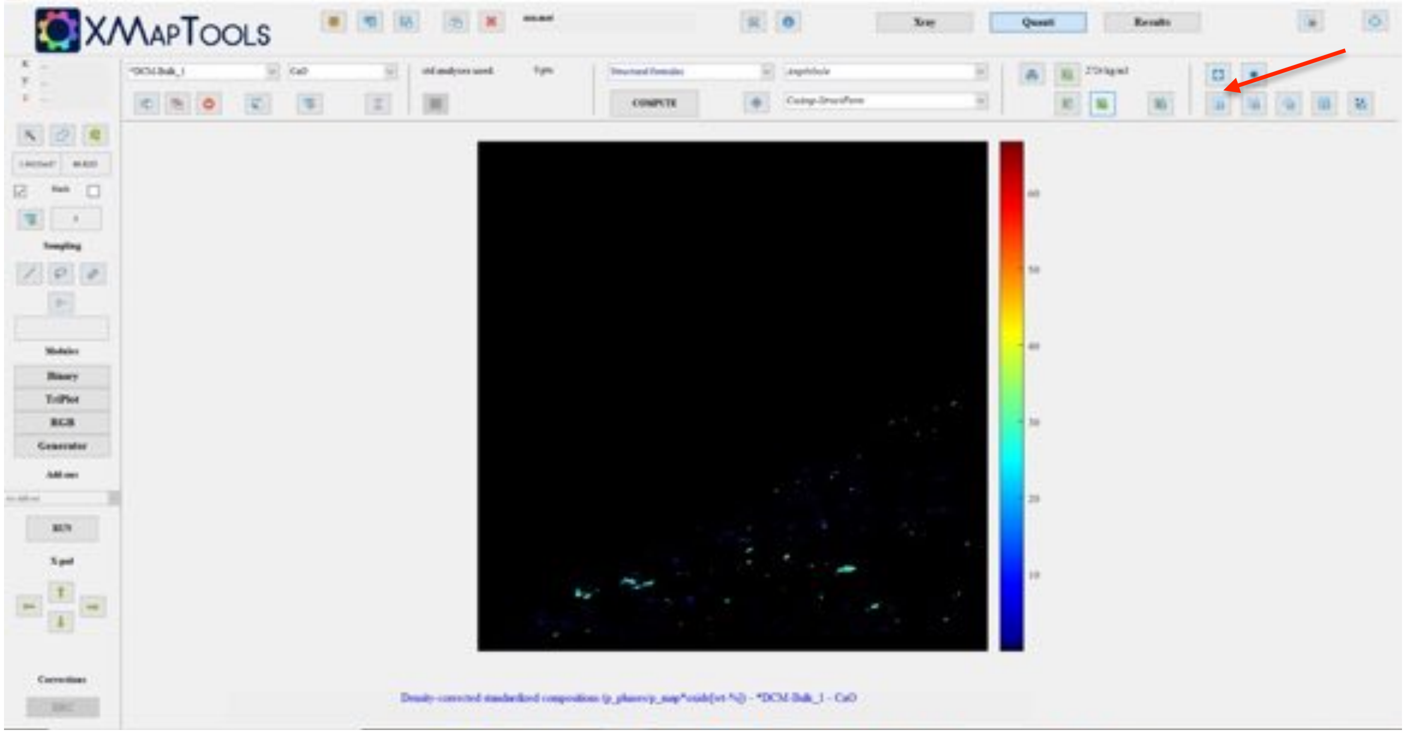


Generate and Compute a density-corrected oxide map of the upper domain



A

Select *Export local composition map*

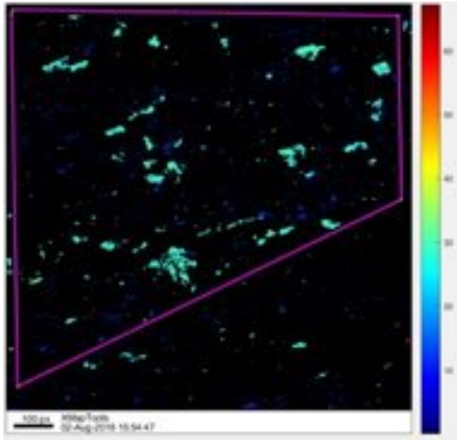


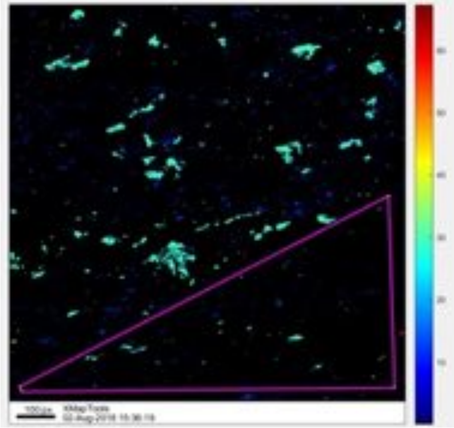
B

Save as Lower_domainB

Al2O3	12.14
CaO	0.26
FeO	1.03
K2O	3.26
MgO	0.95
MnO	0.04
Na2O	2.65
SiO2	77.86
TiO2	0.07
SUM	98.25

	Bulk	Upper_domain		Lower_domainA		Lower_domainB
Elem.		Mean	Std	Mean	Std	
Al2O3	13.24	13.91	0.02	12.17	0.05	12.14
CaO	0.81	1.11	0.01	0.26	0.01	0.26
FeO	1.23	1.34	0.00	1.02	0.01	1.03
K2O	3.09	3.13	0.01	3.25	0.03	3.26
MgO	0.94	0.93	0.00	0.94	0.01	0.95
MnO	0.05	0.05	0.00	0.044	0	0.04
Na2O	3.36	3.66	0.01	2.66	0.03	2.65
SiO2	75.42	74.02	0.03	77.89	0.07	77.86
TiO2	0.06	0.06	0.00	0.067	0	0.07
SUM	98.20	98.20		98.1613		98.25

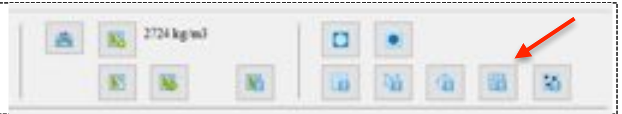


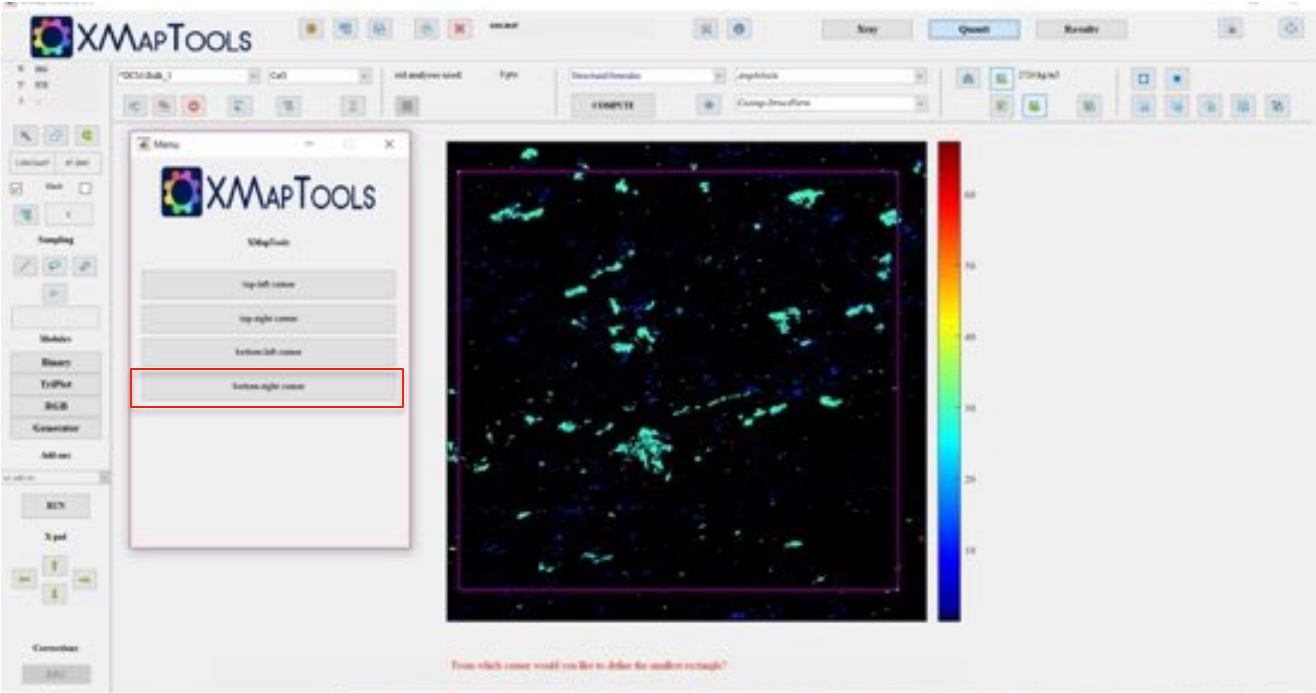


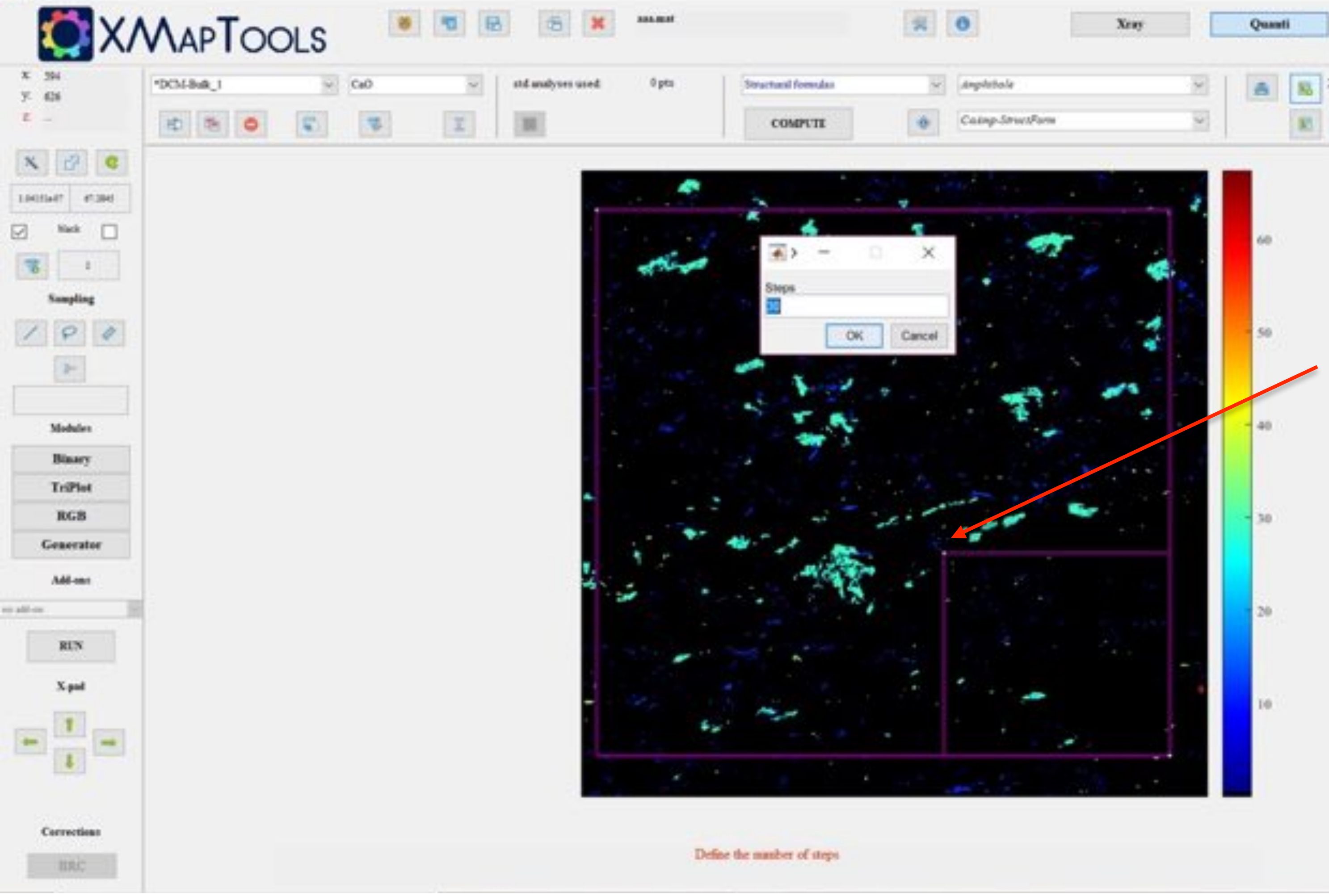
- **Effect of the domain selection**

Export Local Composition variable size rectangle

Select *Export local composition variable size rectangle*

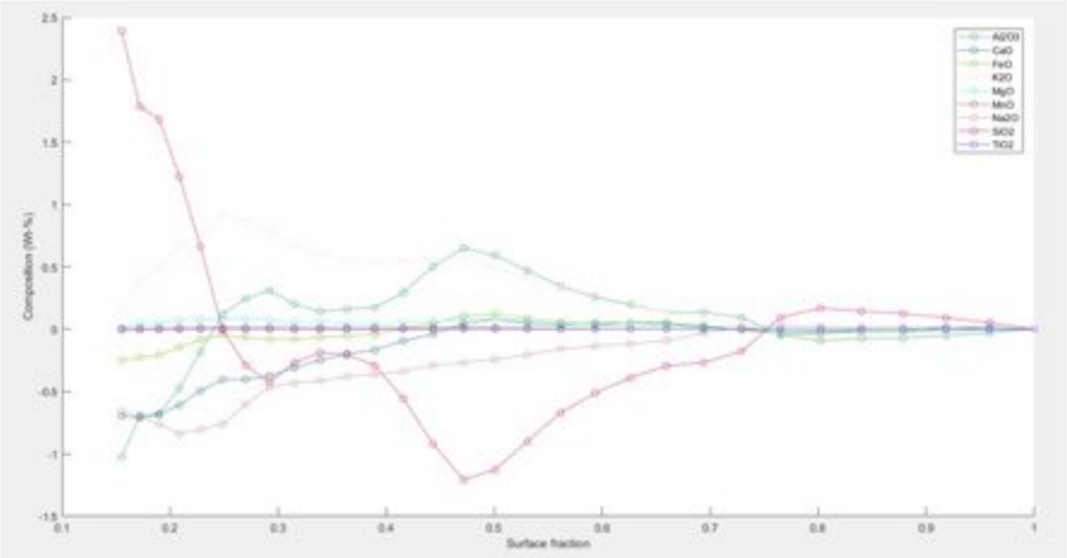


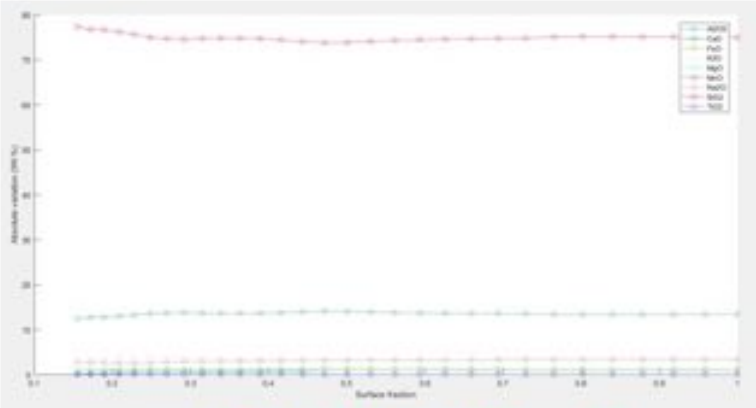


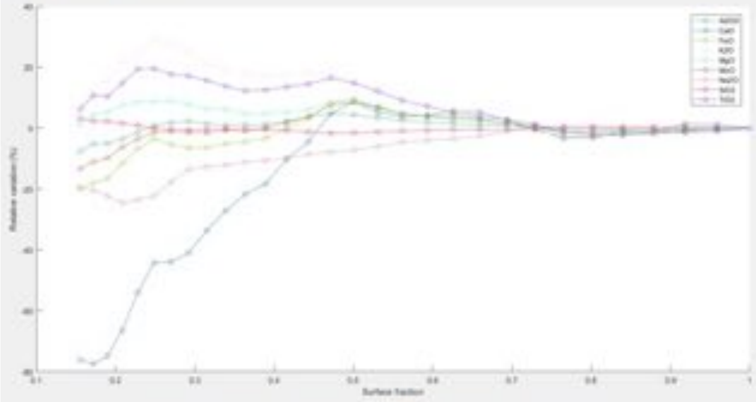


Select a point by the end of the epidote-poor domain

Export Local Composition variable size rectangle



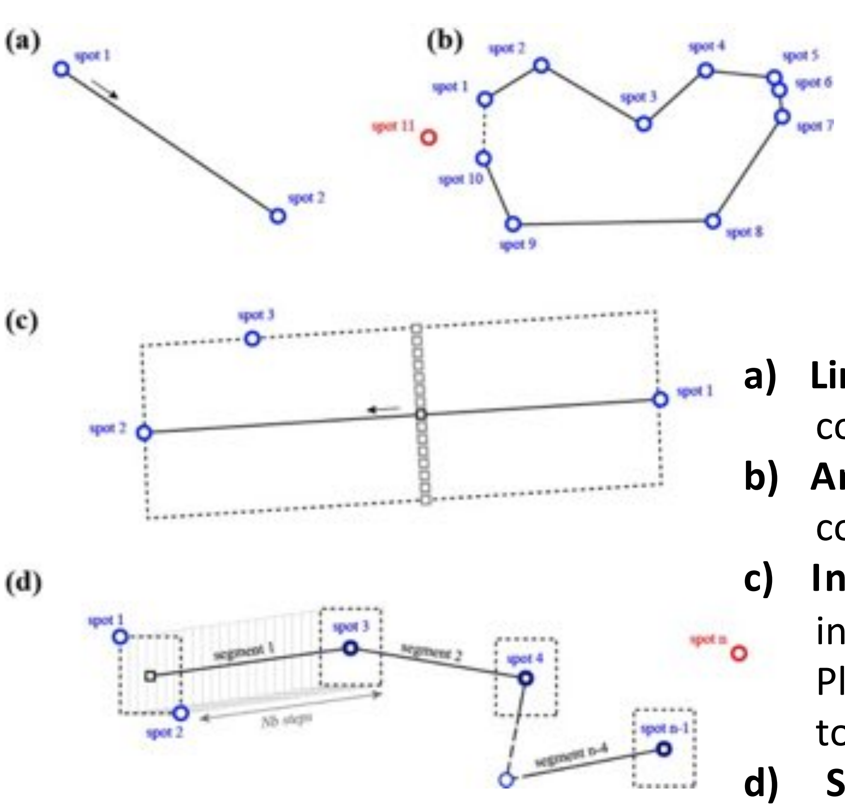




This function does not save any file with the composition of the successive domains

Sampling Functions

XMapTools



- **Can be used in all the workspace on the displayed map**

  Determines chemical composition in terms of counts per pixel in the **Xray workspace** and chemical composition in oxide (wt%) in the **Quanti workspace**

a) **Line** - diagram pixel position against chemical composition

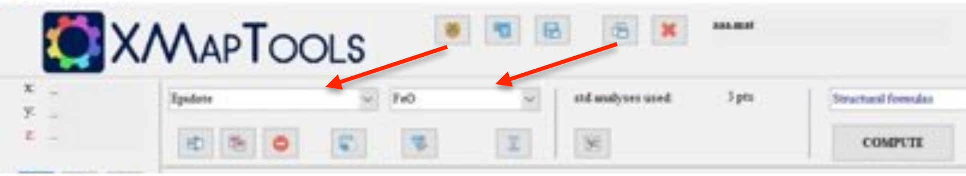
b) **Area** - average composition of the pixels contained in a region

c) **Integrated lines** - composition variations integrated perpendicular to a reference transect. Plots the average values of the transects parallel to the reference transect defining a rectangle

d) **Scanning window** - composition variations using a moving average window

Sampling function

Select *Epidote* and *FeO* maps



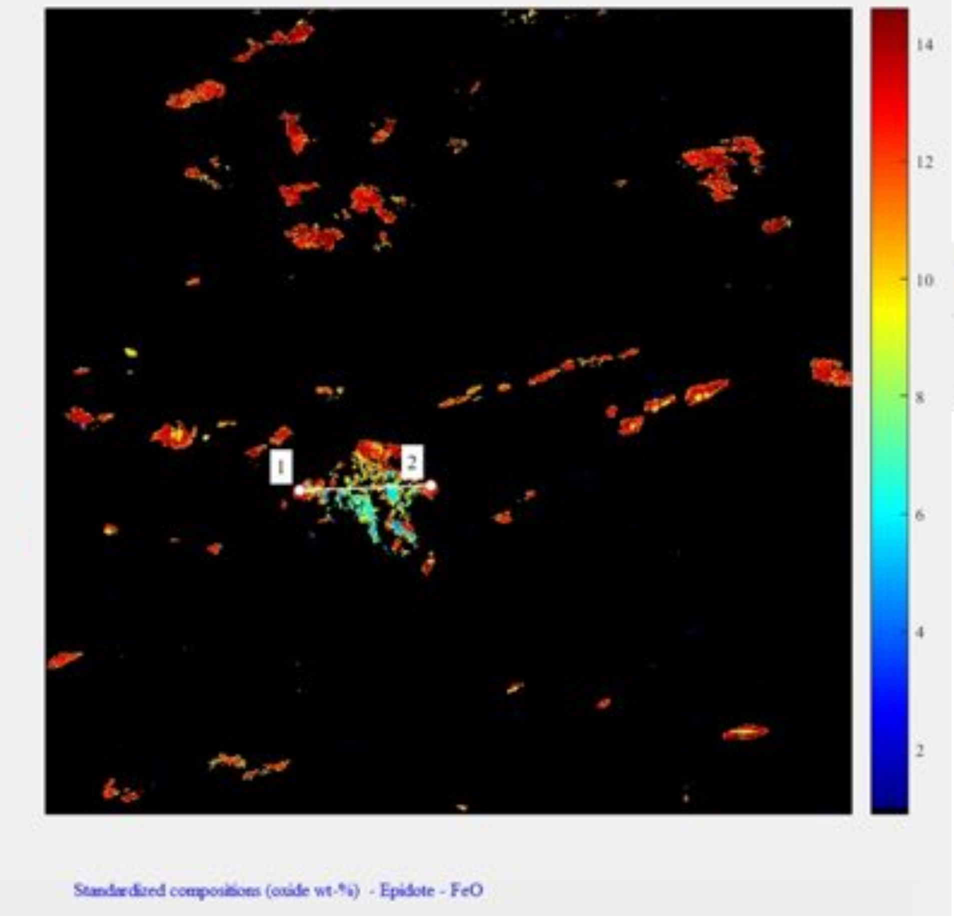
Select *Line mode*

Store X-ray data here

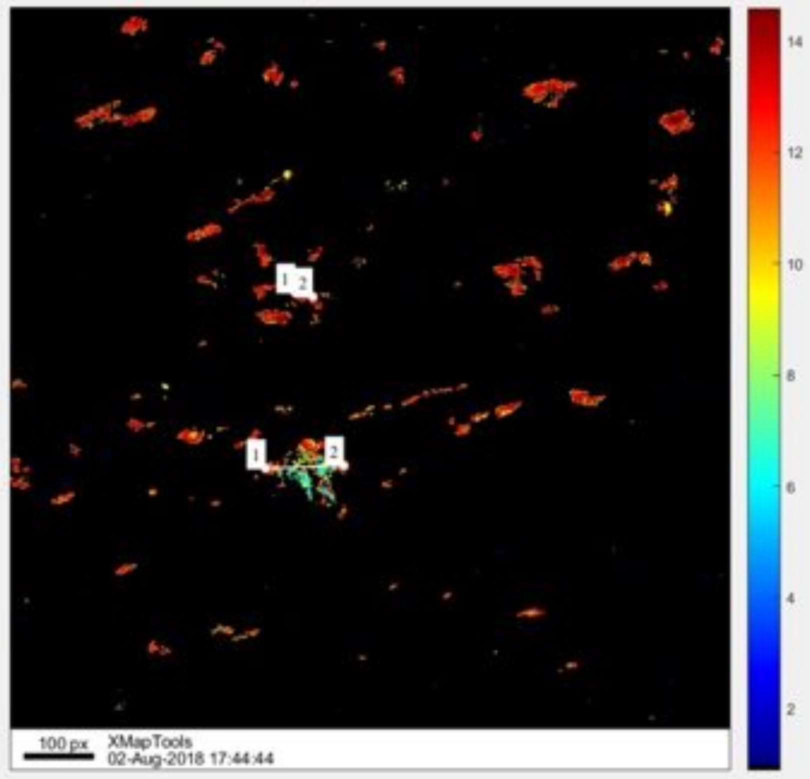
... /Maskfiles

... /Exported-Sampling

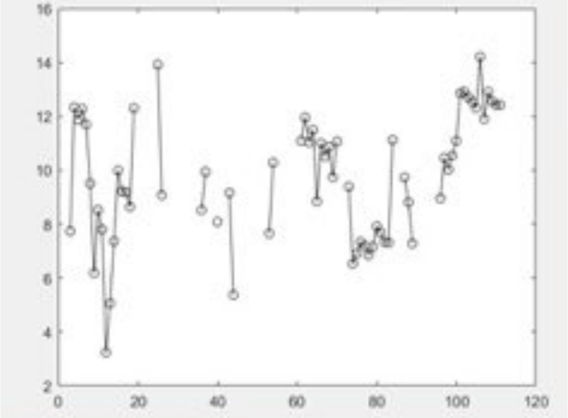
Select an area of interest and draw a line to see the variability of composition of epidote. Save the results in an external file (epidote12.txt)



Sampling function - Line



epidote12

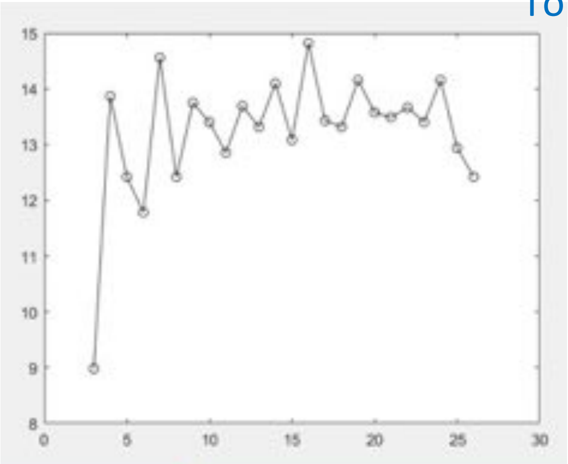


Method: Line

Ref Value
1 NaN
2 NaN
3 [illegible]
4 [illegible]
5 [illegible]
6 [illegible]
7 [illegible]
8 [illegible]
9 [illegible]
10 [illegible]
11 [illegible]
12 [illegible]
13 [illegible]
14 [illegible]
15 [illegible]
16 [illegible]
17 [illegible]
18 [illegible]
19 [illegible]
20 NaN
21 NaN
22 NaN
23 NaN
24 NaN
25 [illegible]
26 [illegible]
27 NaN
28 NaN
29 NaN
30 NaN
31 NaN
32 NaN
33 NaN
34 NaN
35 NaN
36 [illegible]
37 [illegible]
38 NaN
39 NaN
40 [illegible]
41 NaN

To be continued

Epidote12_ single grain



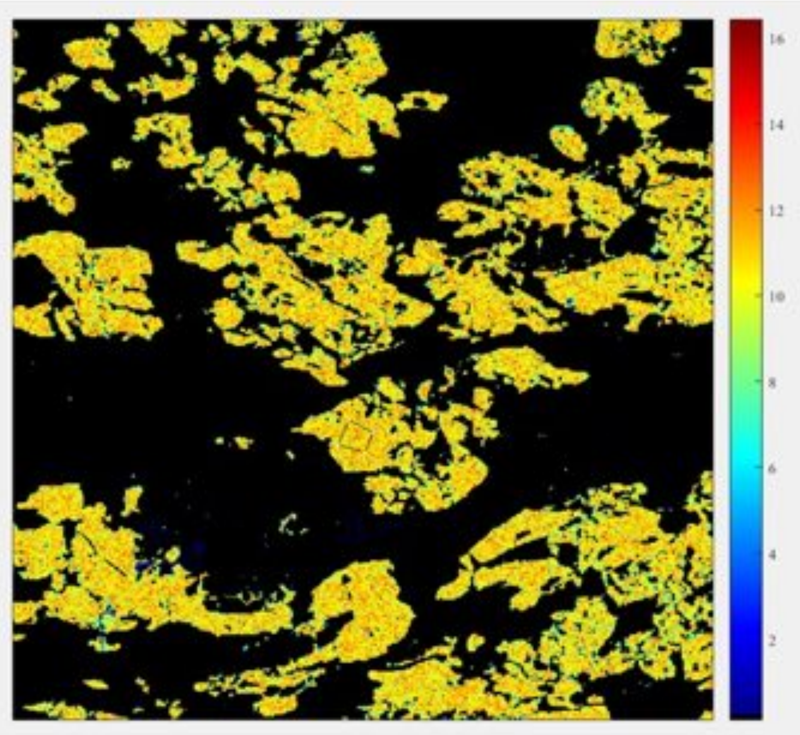
Sampling from XMapTools
02-Aug-2018
Method: Line

Ref Value
1 NaN
2 NaN
3 8.9833
4 13.8657
5 12.4211
6 11.7856
7 14.5591
8 12.4211
9 13.7501
10 13.4034
11 12.8545
12 13.6923
13 13.3167
14 14.0968
15 13.0856
16 14.8191
17 13.4323
18 13.3167
19 14.1546
20 13.5768
21 13.4901
22 13.6634
23 13.4034
24 14.1546
25 12.9412
26 12.4211

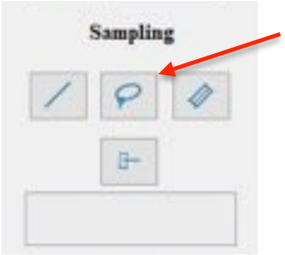
Sampling function - Area

A

Select **Albite** and **Na2O** maps



B



C

Select a domain within an albite crystal

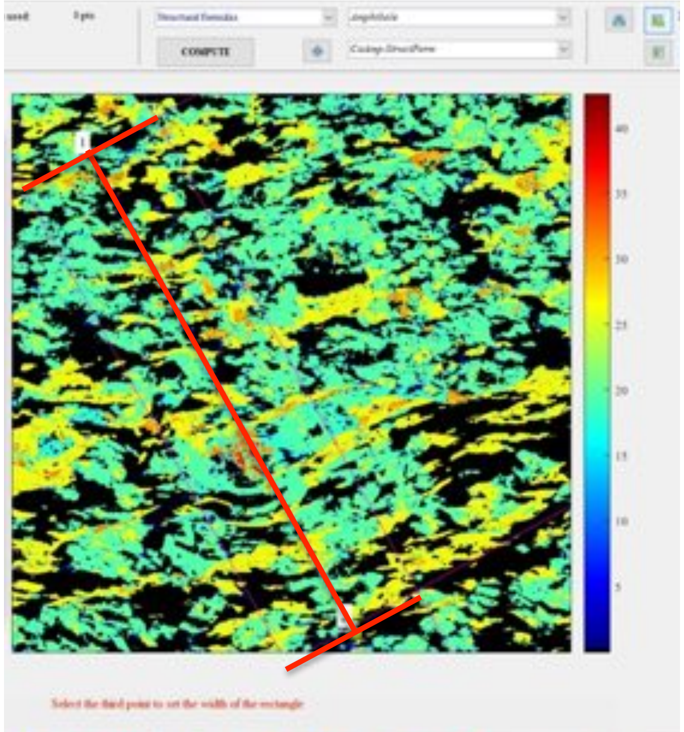
D

Ref	Value	StdDev	N	StdErr
1	10.9427	1.17	273	0.0708

Sampling function – Integrated lines

A

Select the ***DCM-Bulk_1** and **Al2O3** maps



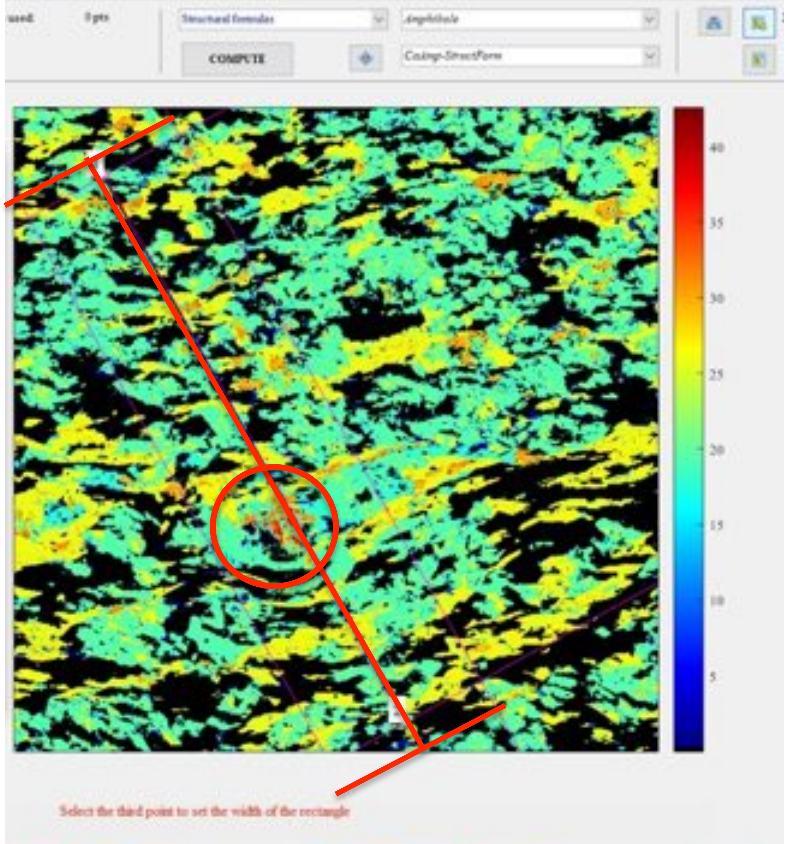
B

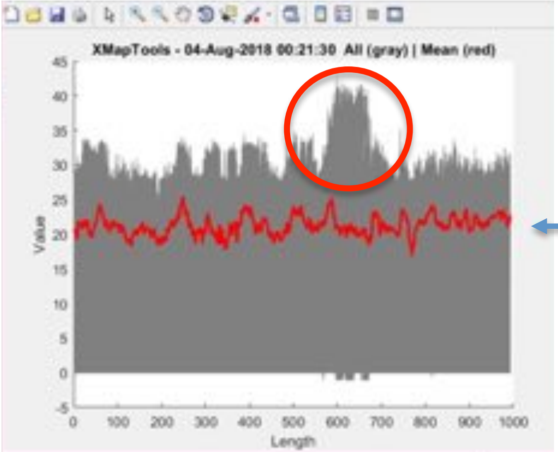
C

Select a transect and its extent (3 points)

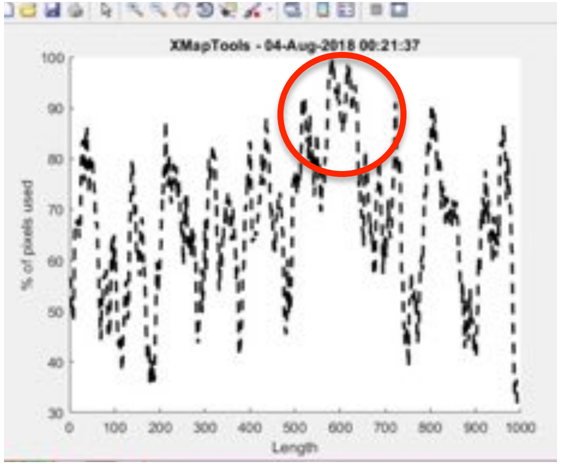
D

Sampling function – Integrated lines





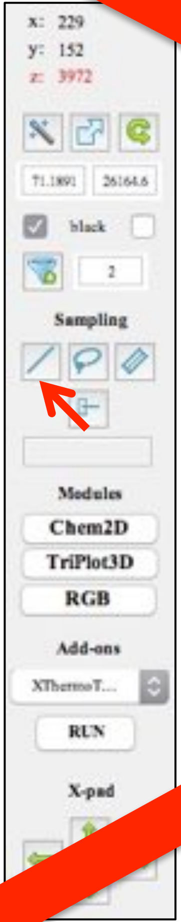
Average Al2O3 bulk rock



Epidote → outlier

Questions / Discussion

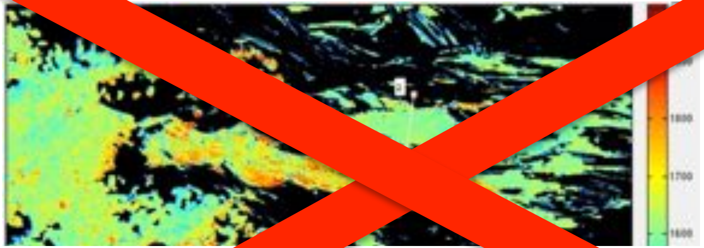
SAMPLING FUNCTIONS

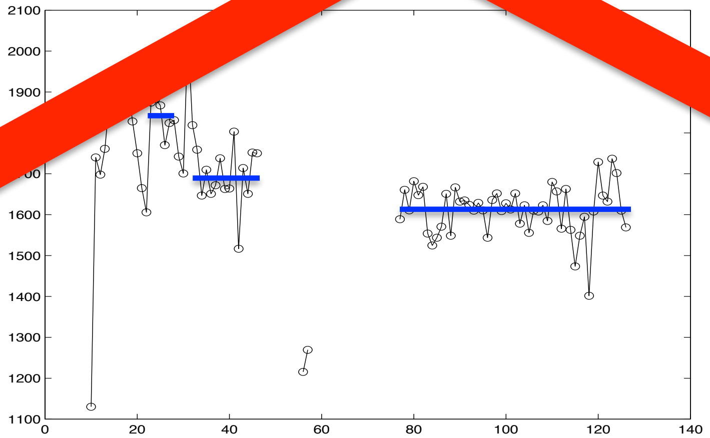


Line:

Sele[...] area of interest and draw a line to see the variability of c[...]osition of chlorite. S[...]he results in an external file (AB.txt)

Mg (counts) in chlorite





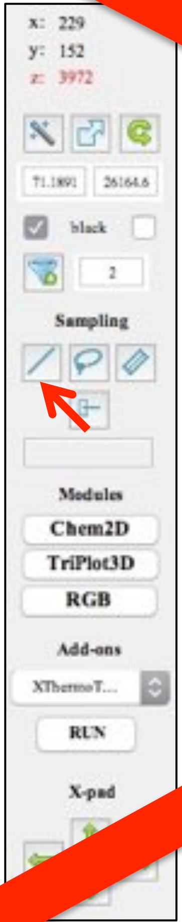
Store X-ray data here

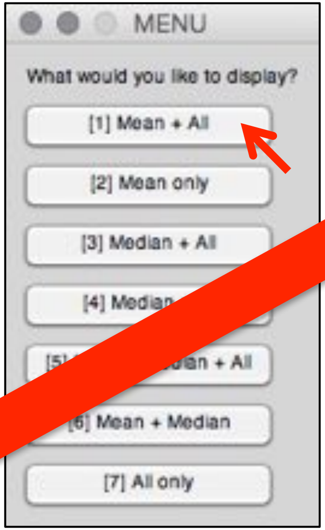
... /Maskfiles
... /Exported-Sampling

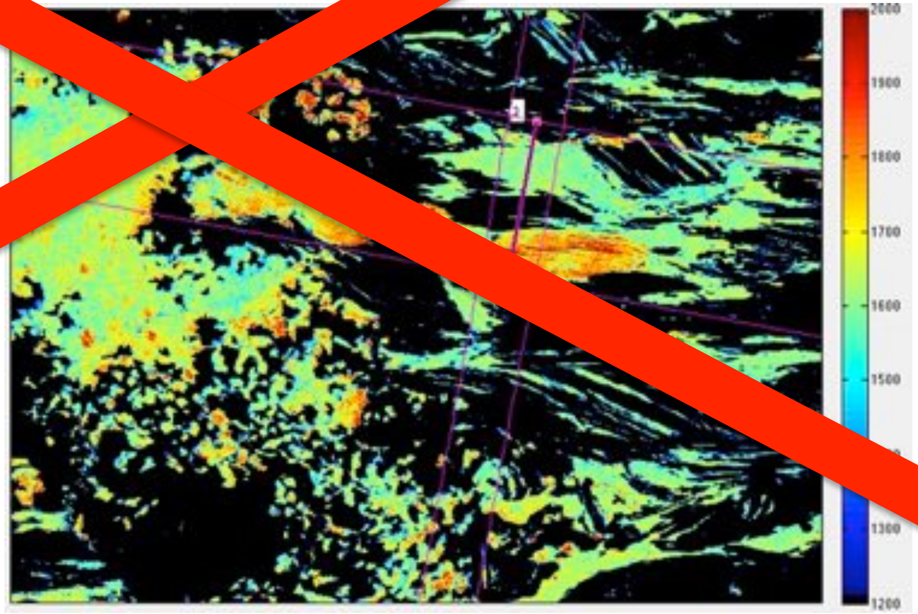
How to i[...]ve the characterizati[...] this transect?

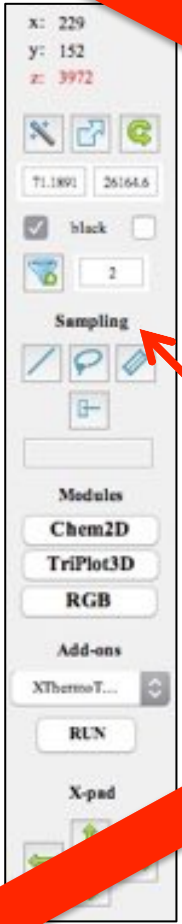
Integrated lines

The sa… g mode *integrated line* is efficient to highligh… adients of composition (… lti-phases system, if we use densit… rrected maps)



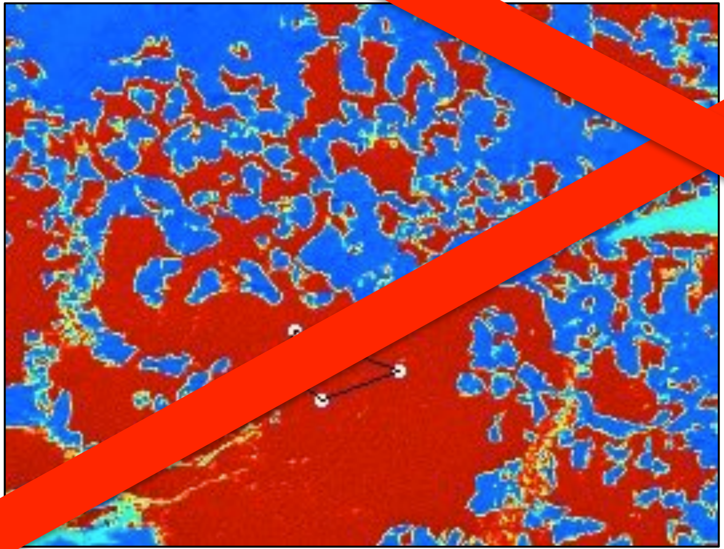


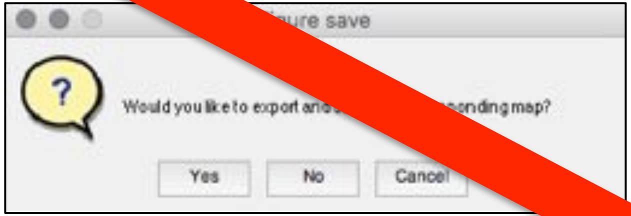


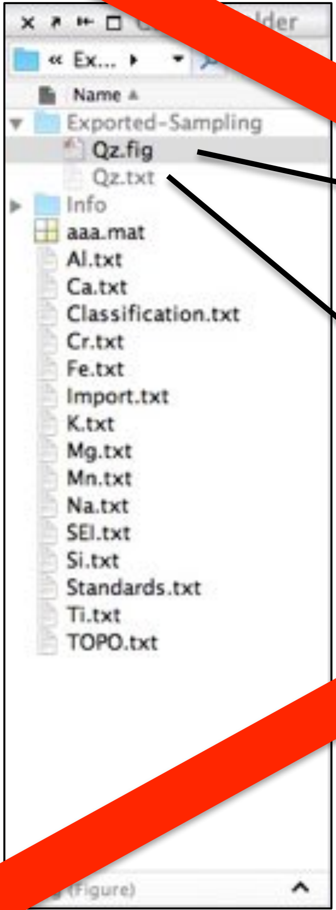


Area

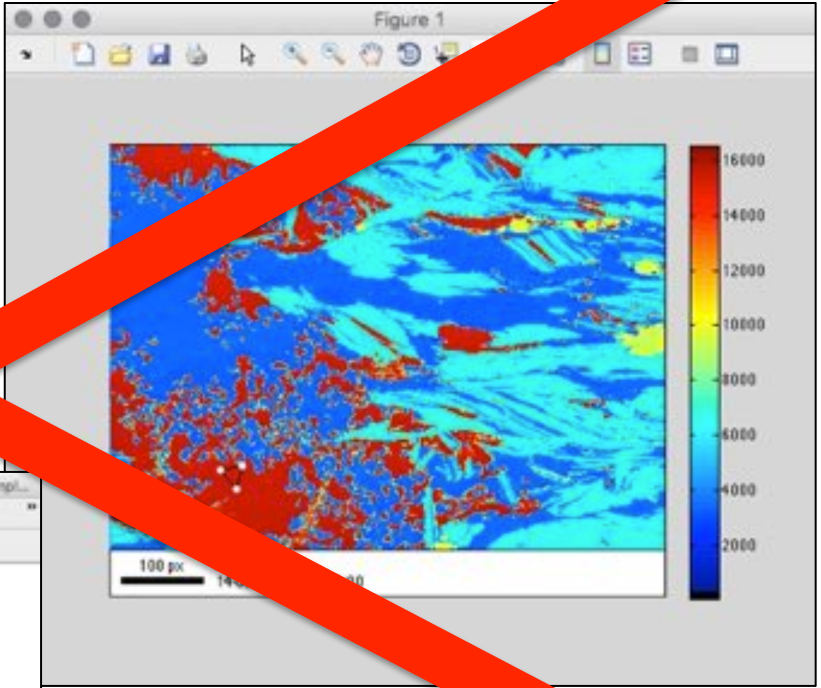
Press sampling: area mode and select an area in quartz (map: Si)

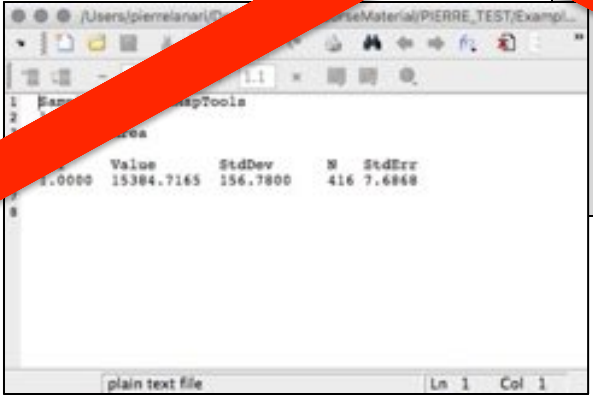






- **Area**

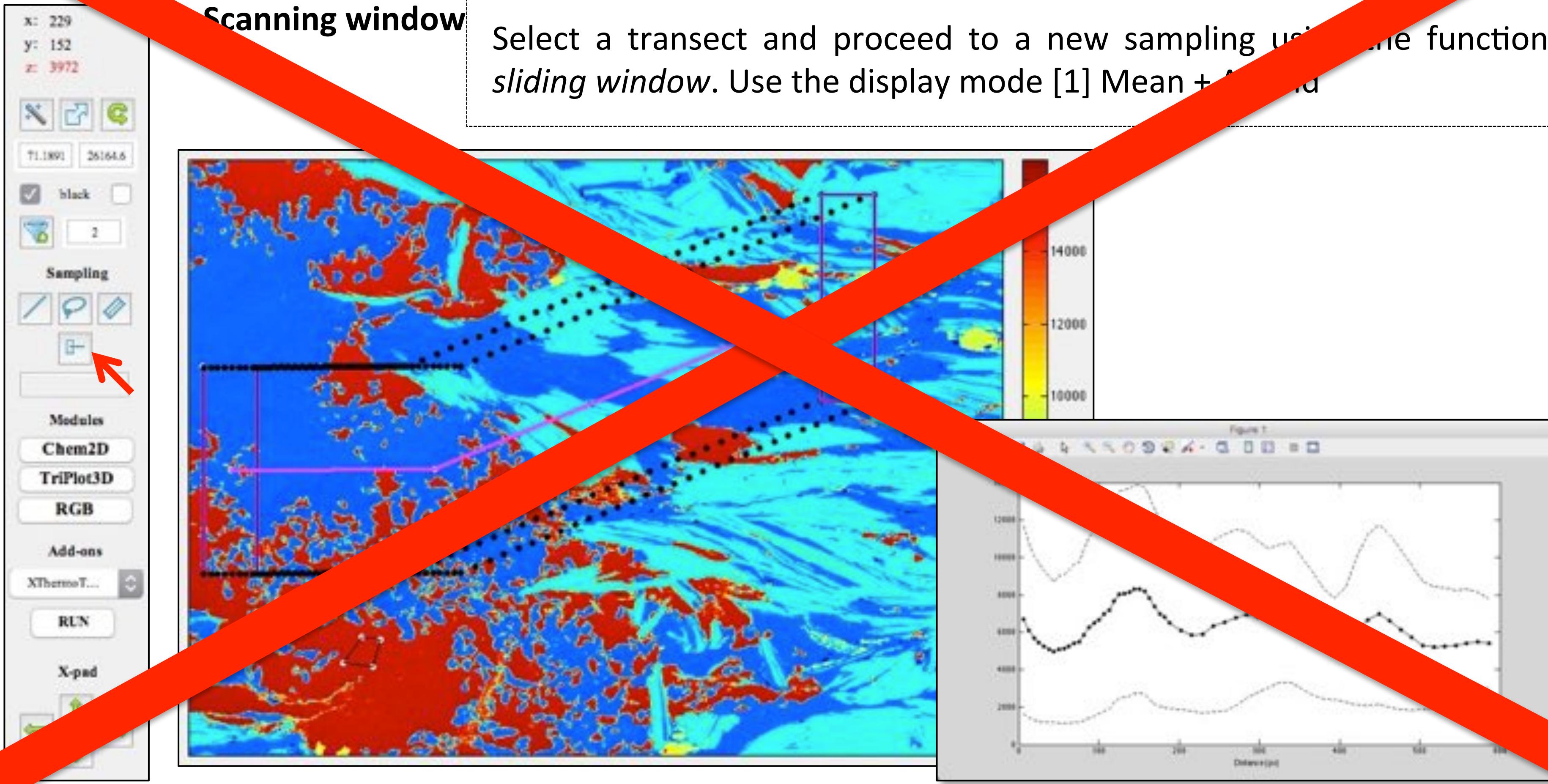




The sampling modes line … area can be used to quantify the analyt… rror on different elements

Scanning window

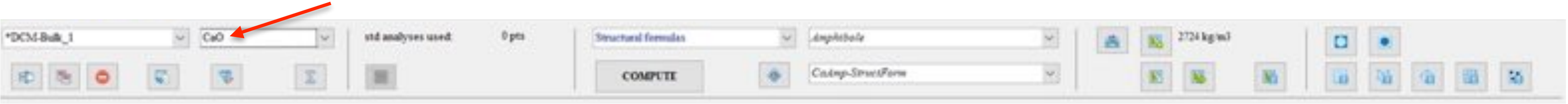
Select a transect and proceed to a new sampling usi… the function *sliding window*. Use the display mode [1] Mean + … d



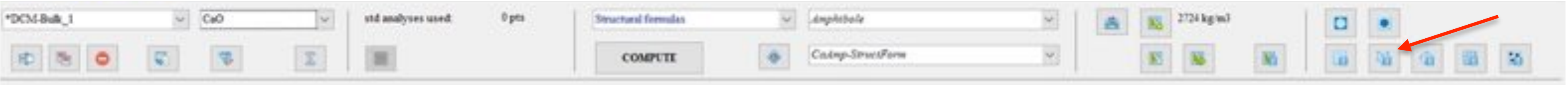
Back to the first approach: Export local composition area function!!!

Local bulk: 3 – Export Local Composition area function

Select *CaO* map again

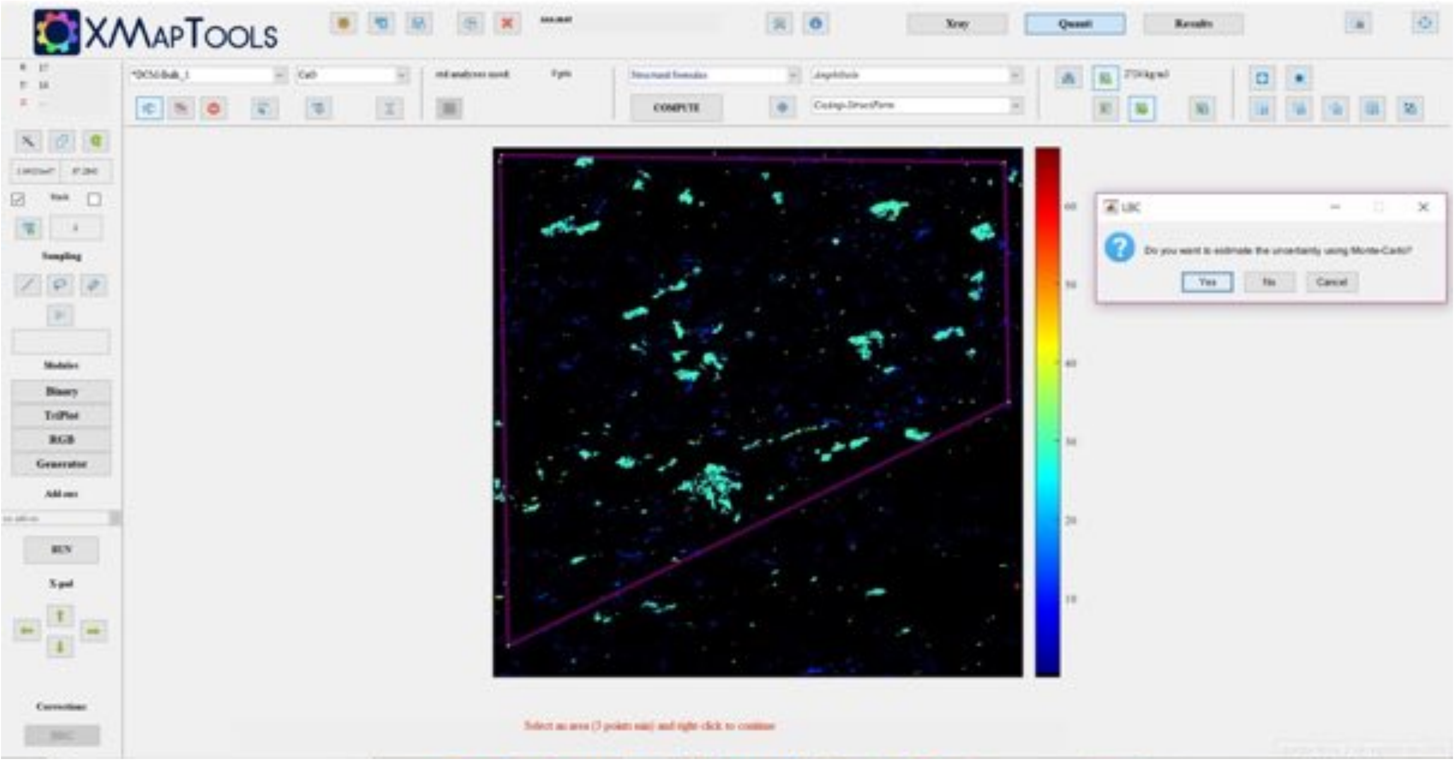


Select *Export local composition area*

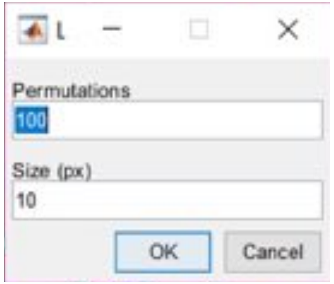


EXERCISE 2 - GLACIER RAFRAY (ALPS)

A



B



C

6 – Save as Bulk_3

Elem.	Mean	Std
Al2O3	13.8839	0.014988
CaO	1.0622	0.006082
FeO	1.3326	0.004516
K2O	3.1247	0.010576
MgO	0.93796	0.002627
MnO	0.052195	0.000134
Na2O	3.6489	0.011151
SiO2	74.1231	0.028845
TiO2	0.062918	0.000195
SUM	98.2284	