XMapTools

Numerical tools for quantitative petrology

PETROCHRO-2018

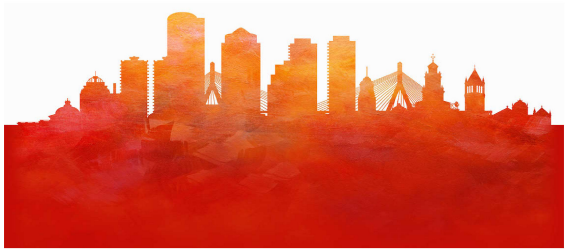
boston2018.petrochronology.org

www.xmaptools.com

Saturday 11th August 8:00 - Sunday 12th August 17:00

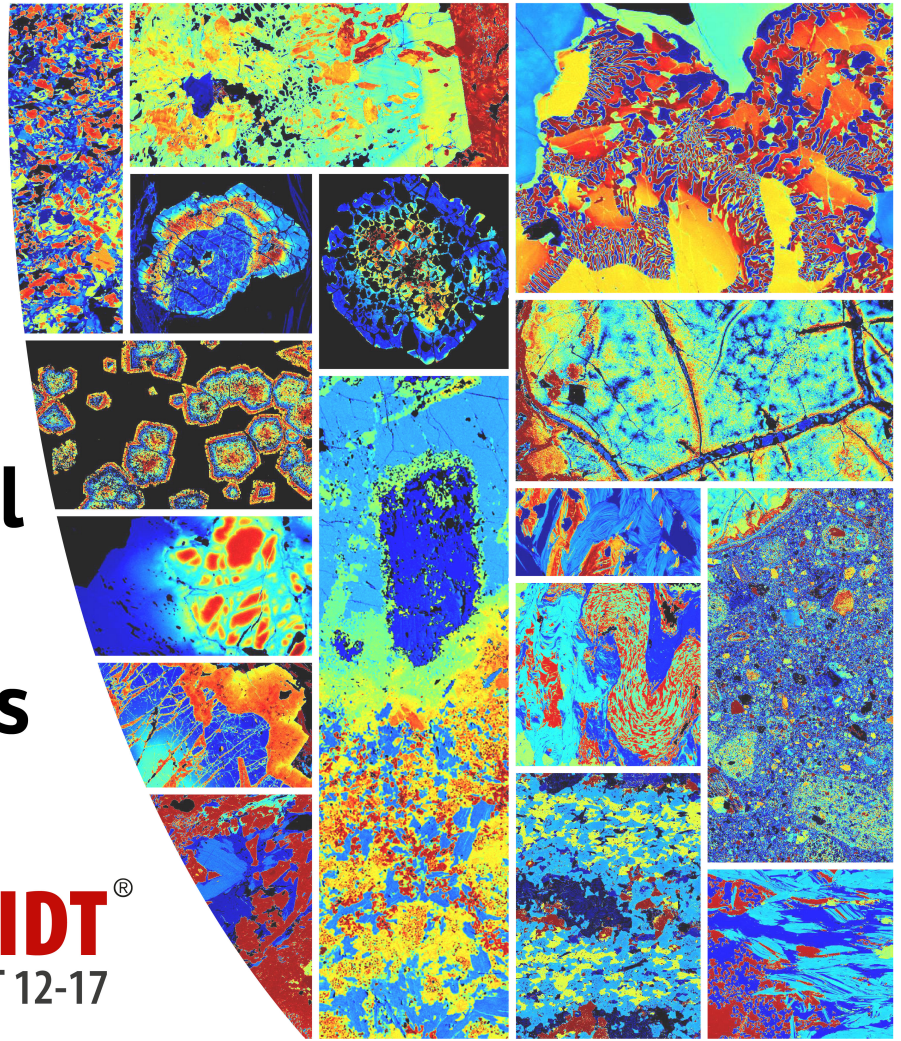
Workshop

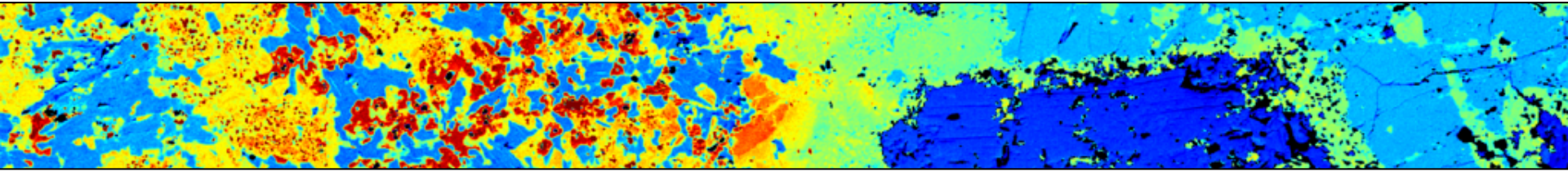
Quantitative Compositional Mapping of Geological Materials using XMapTools



GOLDSCHMIDT®

BOSTON 2018 | AUGUST 12-17





Lecture 6

Structural formulas; empirical and semi-empirical thermobarometry & chemical modules

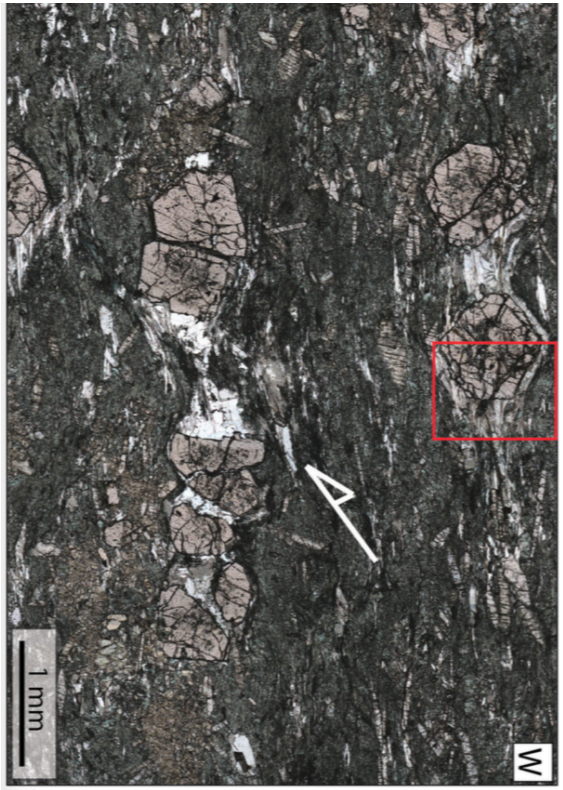
Dr. Pierre Lanari

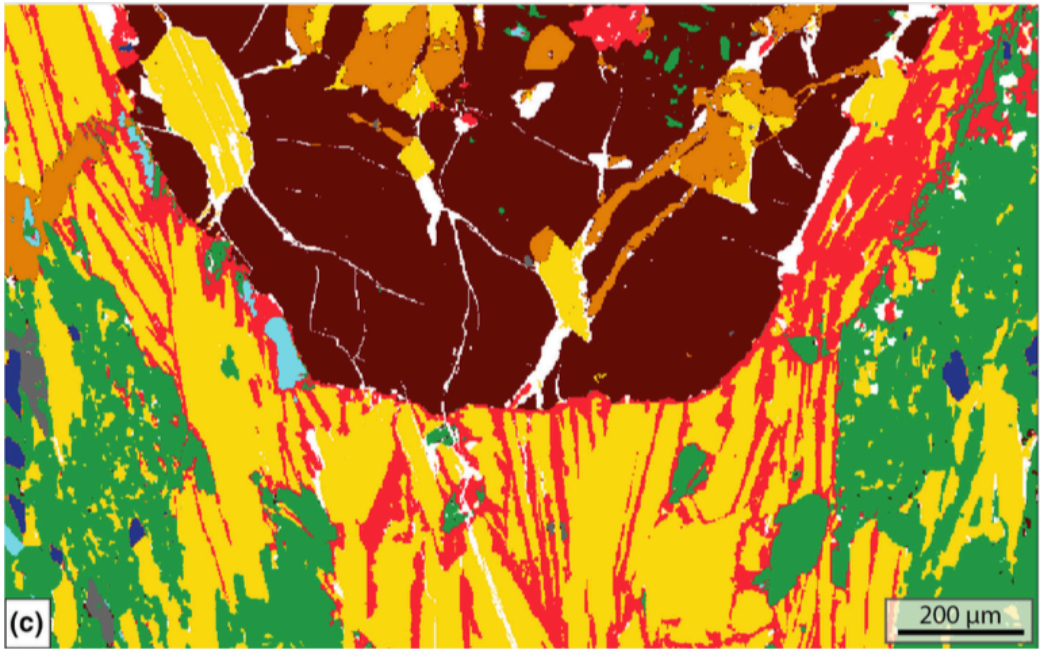
University of Bern - pierre.lanari@geo.unibe.ch

- Motivation and application example
- How to export compositions from the maps?
- Maps of structural formulas
- Chemical modules: Binary; Generator
- Termobarometry – Part 1 – Spot mode
- Termobarometry – Part 1 – Map mode

MOTIVATION AND APPLICATION EXAMPLES

- Understand the Pressure and Temperature record in metamorphic rocks (e.g. eclogite from Syros Island, Greece)





Masks (from XMapTools):

Fracture	Apatite	Omphacite
Titanite	Albite	White mica
Quartz	Epidote	Garnet

Jd + Qz → Ab

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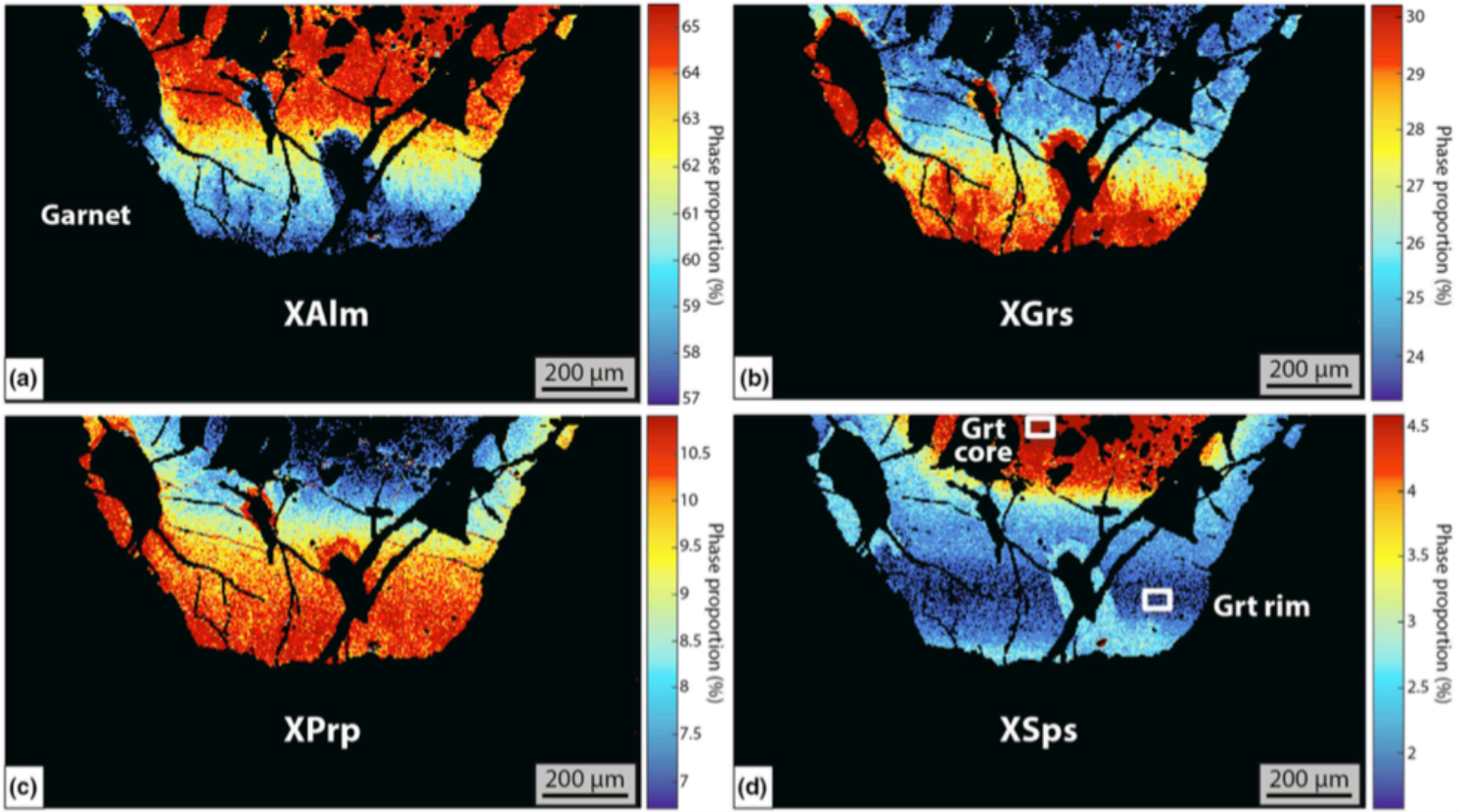

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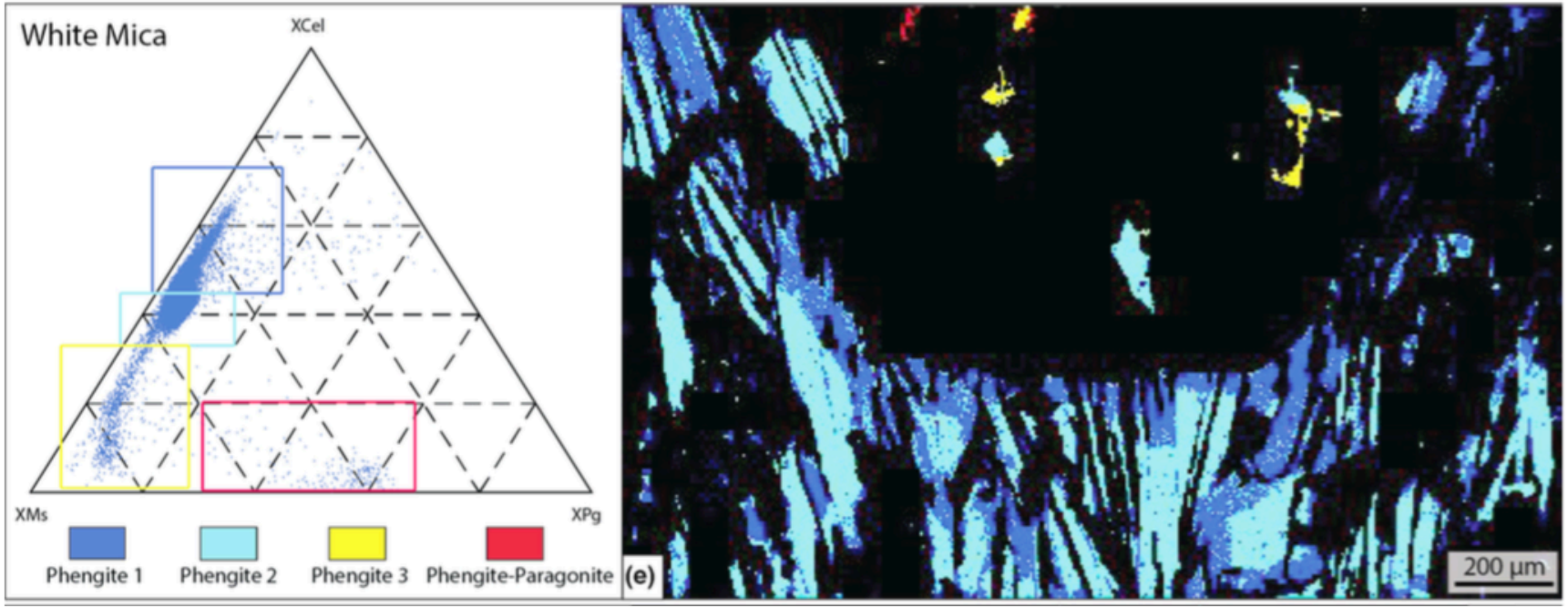

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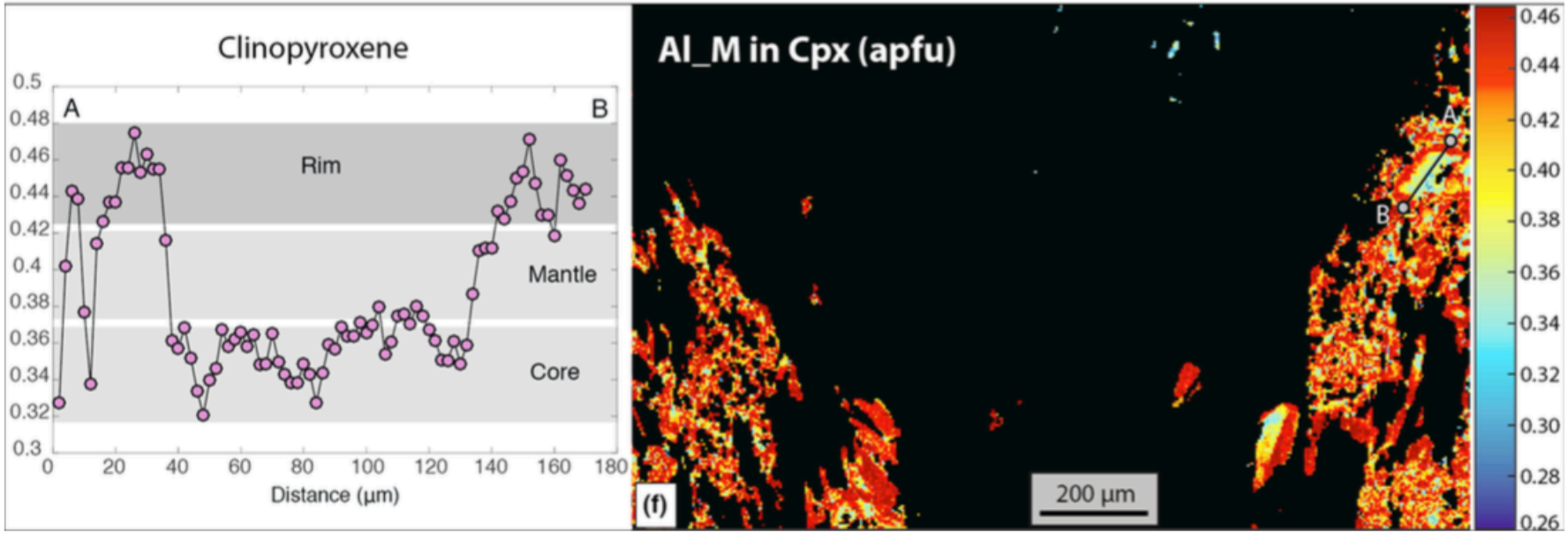


Motivation and application examples

- Understand the Pressure and Temperature record in metamorphic rocks (e.g. eclogite from Syros Island, Greece)

Thermometry

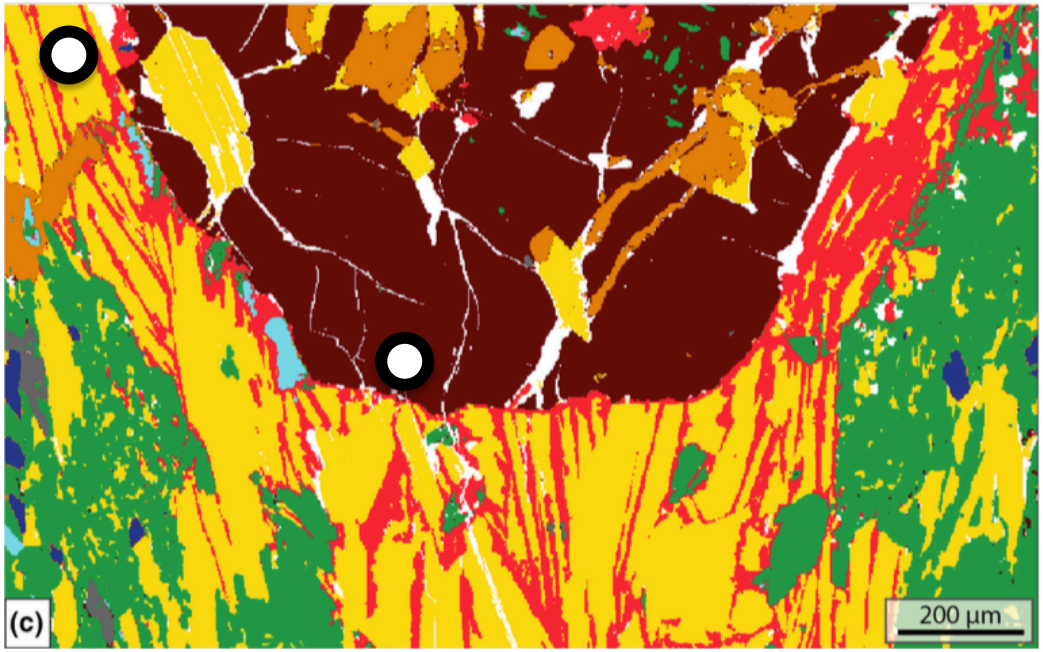
Cpx + Grt

Ravna (2000)

Barometry

Grt + Cpx + Ph

Waters & Martin (1996)



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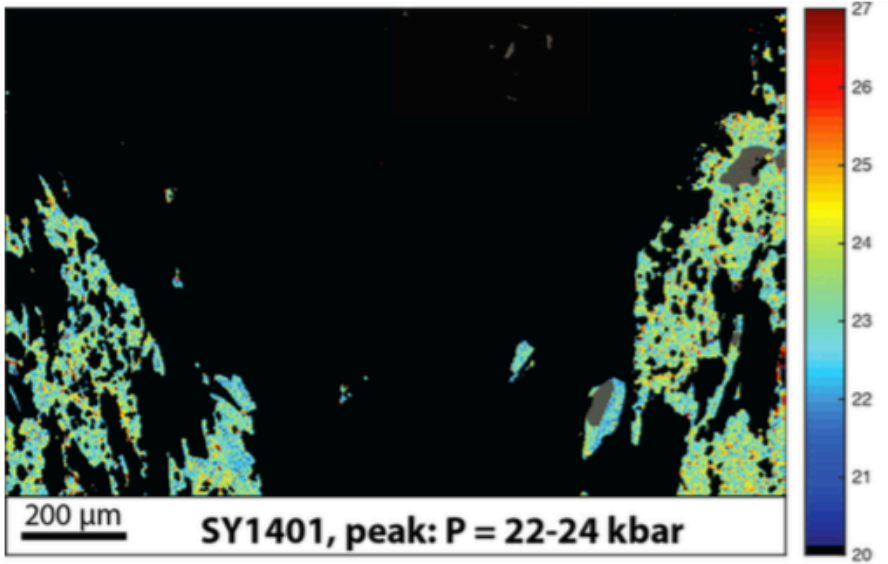

Thermometry

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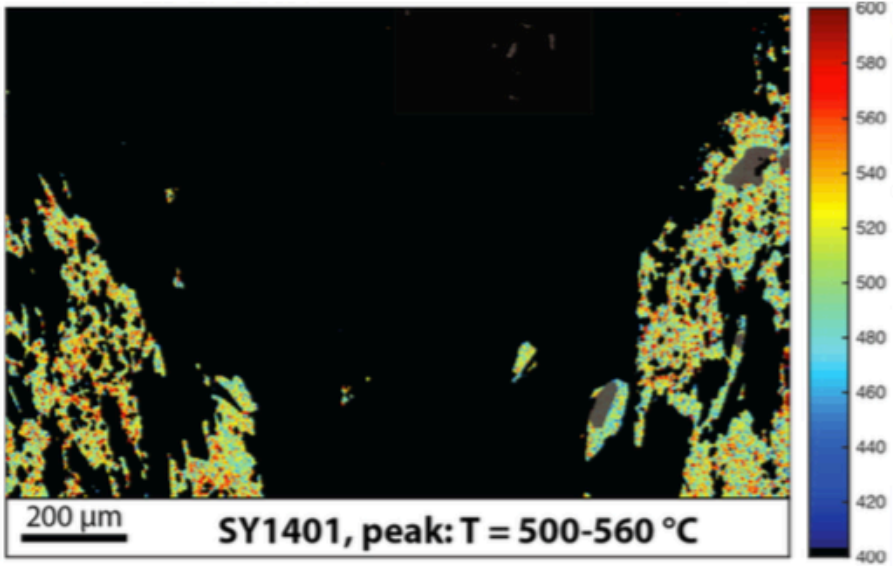

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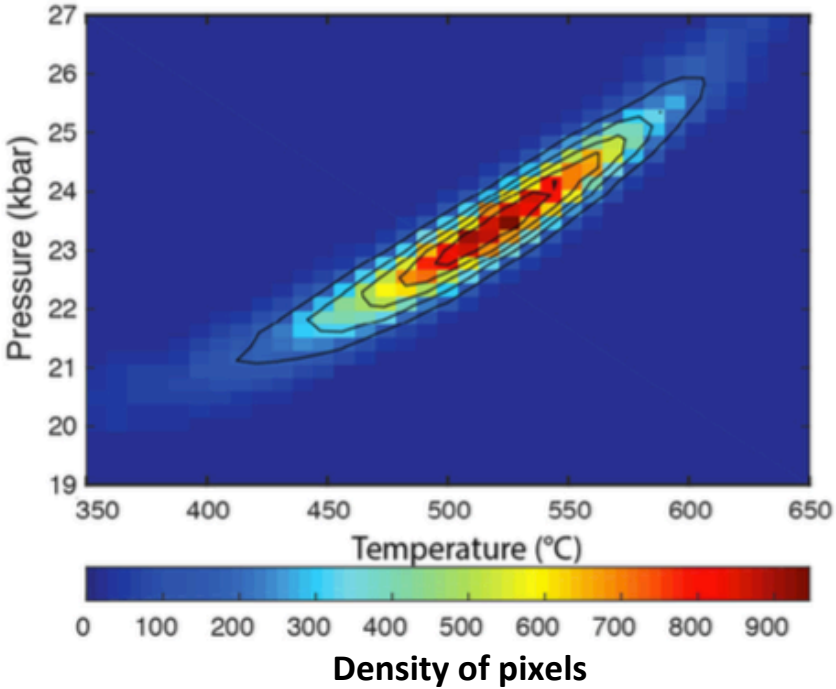
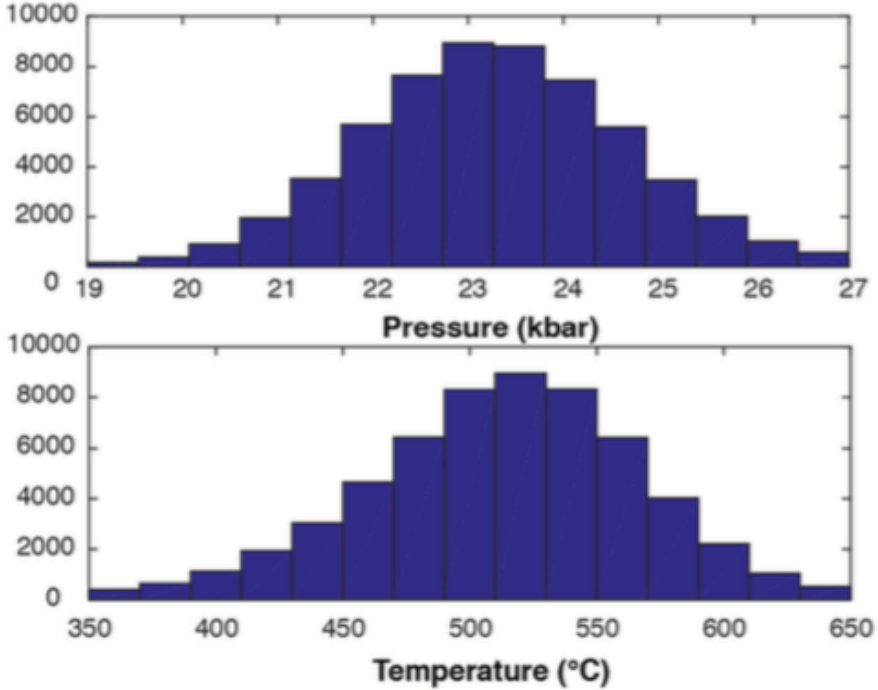
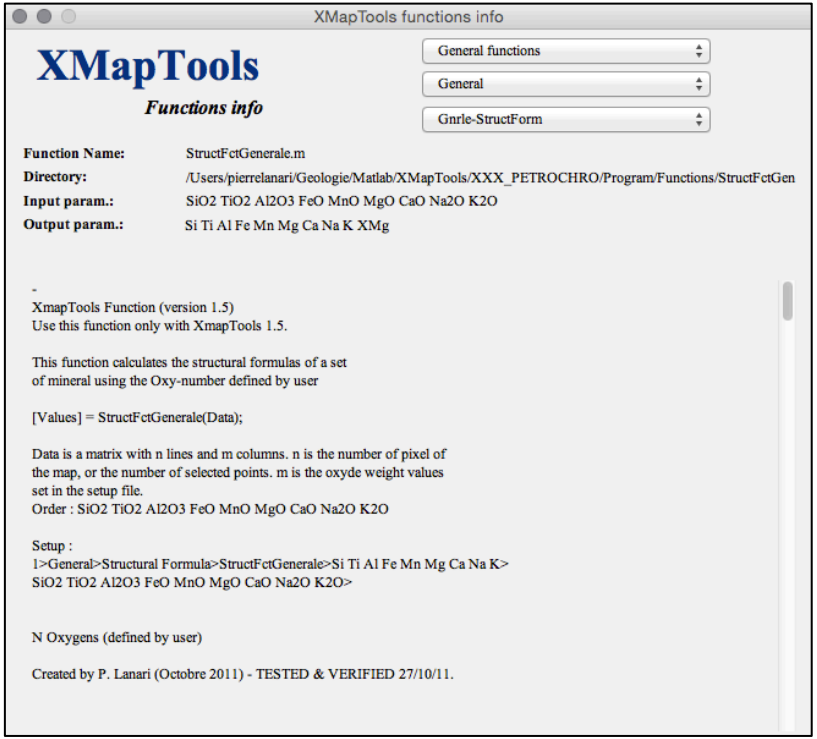




MOTIVATION AND APPLICATION EXAMPLES

- **External functions and modules**
  - Structural formulas
  - P-T / map mode
  - P-T / spot mode
  - General functions
  - Density functions
  - Transfer to results



MOTIVATION AND APPLICATION EXAMPLES

ListFunctions.txt

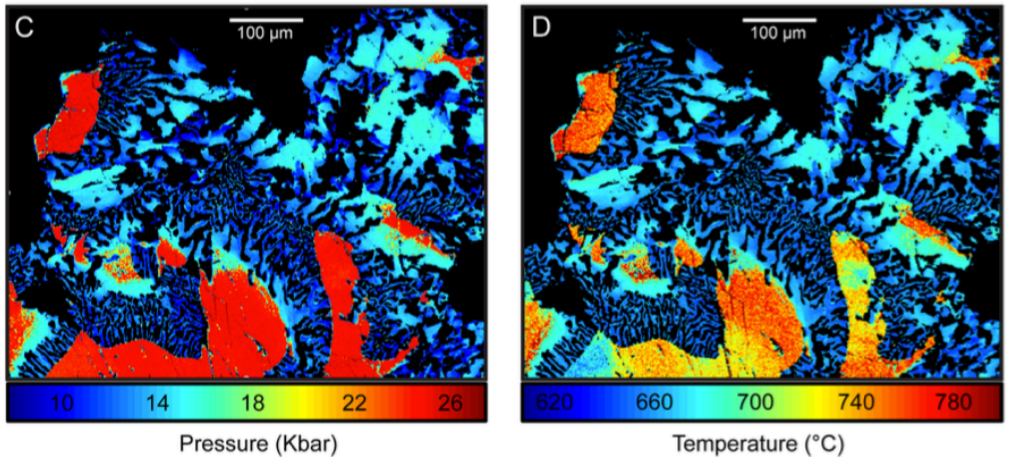
```
!
! ListFunction.txt version 2.5.1 (20.06.2018)
!
!
!
!
!------------------------- Structural Formulas (1) -------------------------
!
! * * * * * AMPHIBOLES * * * * *
1>Amphibole>CaAmp-StructForm>StructFctAmphiboles>Si4 Aliv Alvi Al_T2 Al_M2 XFe XMg Mg_M2 Fe_M2 Fe_M13 Mg_M13 Ca_M4 Na_M4 Na_A V_A XTr XFtr XTs XPrg XGln>SiO2 TiO2 Al2O3 FeO MnO MgO
CaO Na2O K2O>
1>Amphibole>CaAmp-StructForm-Fe3>StructFctAmphiboles3>Si4 Aliv Alvi Fe2 Fe3 XFe XMg Ca_M4 Na_M4 Na_A V_A XAl_T2 XSi_T2 XFe3_M2 XFeMg_M2 XAl_M2 XNa_M4 XCa_M4>SiO2 TiO2 Al2O3 FeO MnO
MgO CaO Na2O K2O>
!
!
! * * * * * BIOTITE * * * * *
1>Biotite>Bio-StructForm>StructFctBiotite>Si_T1 Si_T2 Ti_T2 Al_T2 Fe_M1 Mg_M1 Vac_M1 Al_M2 Fe_M2 Mg_M2 K_A Ca_A Na_A Vac_A XMg XFe XAnn XPhl XSid XEas Xsum>SiO2 TiO2 Al2O3 FeO MnO
MgO CaO Na2O K2O>
!
!
! * * * * * BRUCITE * * * * *
1>Brucite>Bruc-StructForm>StructFctBruciteROMAIN>Si Ti Al Fe Mn Mg Ca Na K XMg As Sb Cs>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O As2O5 Sb2O3 Cs2O>
!
!
! * * * * * CHLORITE * * * * *
1>Chlorite>Chl-StructForm-(Si<3)>StructFctChlorite>Aliv Alvi Fe3 Fe2 Al_M4 Si_T1 Si_T2 Al_T2 V_M1 Al_M2M3 Al_M1 Mg_M1 Fe_M1 Mg_M2M3 Fe_M2M3 X_Mg DeltaLacune XAme XClc XDph XSud
Xsum>SiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
1>Chlorite>Chl-StructForm-(All)>StructFctChloriteAll>SiT Aliv Alvi DT XAlvi fe2 fe3 XMg XFe V_M1 Al_M1 Mg_M1 Fe2_M1 Al_M23 Mg_M23 Fe2_M23 Al_M4 Mg_M4 Fe2_M4 XAlfchl XAme XClc XDph
XSud Xsum>SiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
!
!
! * * * * * CHLORITOID * * * * *
1>Chloritoid>Ctd-StructForm>StructFctChloritoid>Si Al Fe Mg Mn XMg XCld XFcld XMcld>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
!
!
! * * * * * CORDIERITE * * * * *
1>Cordierite>Cor-StructForm>StructFctCordierite>Si_T Ti_T Al_T Al_M Fe_M Mg_M XCrd XFcrd>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
!
!
! * * * * * CLINO-PYROXENES * * * * *
1>Clinopyroxene>Cpx-StructForm-Cats-Fe3>StructFctCpxFe3>Si_T1 Al_T1 XMg XFe Fe2 Fe3 Al_M1 Mg_M1 Fe2_M1 Fe3_M1 Ca_M2 Na_M2 XJd XDi XHd XCats XAcm Xsum SumM1 SumM2>SiO2 TiO2 Al2O3 FeO
MnO MgO CaO Na2O K2O>
1>Clinopyroxene>Cpx-StructForm-Cats>StructFctCpx>Si_T1 Al_T1 XMg XFe Al_M1 Mg_M1 Fe_M1 Ca_M2 Na_M2 XJd XDi XHd XCats Xsum SumM1 SumM2>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
1>Clinopyroxene>Cpx-StructForm>StructFctCpxW>Si_T1 XMg XFe Al_M1 Mg_M1 Fe_M1 Ca_M2 Na_M2 XJd XDi XHd Xsum SumM1 SumM2>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
1>Clinopyroxene>Cpx-StructForm-Fe3>StructFctCpxWFe3>Si_T1 XMg XFe Fe2 Fe3 Al_M1 Mg_M1 Fe_M1 Ca_M2 Na_M2 XJd XDi XHd XAcm Xsum SumM1 SumM2>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
!
!
! * * * * * EPIDOTE * * * * *
1>Epidote>Epi-StructForm>StructFctEpidote>Si_T Al_M1 Al_M2 Al_M3 Fe_M1 Fe_M3 Ca_A XEp XCzo XFep>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
1>Epidote>Allanite-StructForm>StructFctAllanite>Si Al Mg Fe2 Fe3 Mn Ca Yt Th Ti La Ce Pr Nd Sm Gd Dy U Pb Na Sr Sum_REE Sum_M Sum_A Sum_REE_Th Sum_A_M>SiO2 Al2O3 MgO FeO MnO CaO
Y2O3 ThO2 TiO2 La2O3 Ce2O3 Pr2O3 Nd2O3 Sm2O3 Gd2O3 Dy2O3 UO2 PbO Na2O SrO>
!
!
! * * * * * FELDSPARS * * * * *
1>Feldspars>Feld-StrucForm>StructFctFeldspar>Si_T Al_T Na_M1 Ca_M1 K_M1 XAb XAn XMc Xsum SumT SumM>SiO2 TiO2 Al2O3 FeO MnO MgO CaO Na2O K2O>
!
!
! * * * * * NEPHELINE * * * * *
```

EXAMPLE FOR THE TUTORIAL: ECLOGITE FROM THE STAK MASSIF (PAKISTAN; NW-HIMALAYA)

GEOLOGY, February 2013; v. 41; no. 2; p. 111–114; Data Repository item 2013027 | doi:10.1130/G33523.1 | Published online 6 November 2012

Deciphering high-pressure metamorphism in collisional context using microprobe mapping methods: Application to the Stak eclogitic massif (northwest Himalaya)

Pierre Lanari[1], Nicolas Riel[1], Stéphane Guillot[1], Olivier Vidal[1], Stéphane Schwartz[1], Arnaud Pêcher[1], and Keiko H. Hattori[2]
[1]ISTerre, University of Grenoble 1, CNRS, 1381 rue de la Piscine, 38041 Grenoble, France
[2]Department of Earth Sciences, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada



XMap Tools

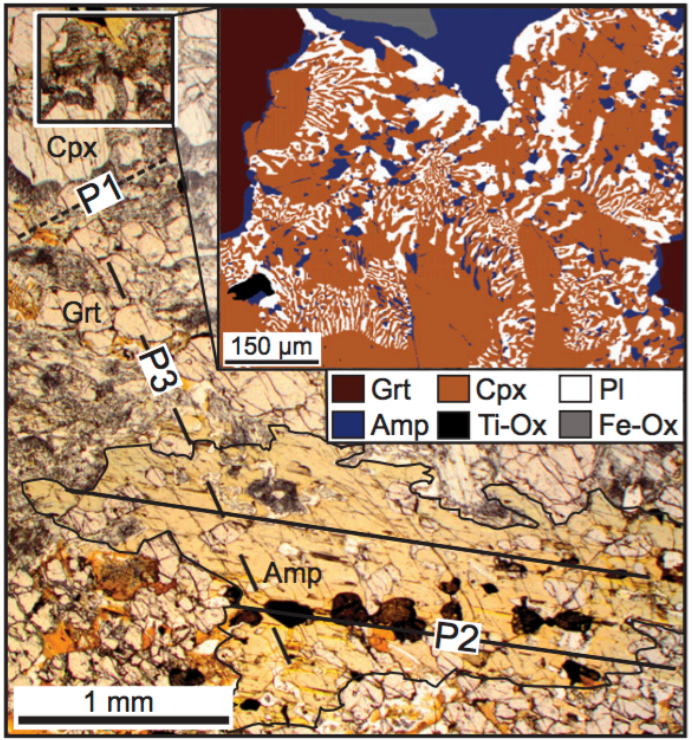


Figure 2. Photomicrograph showing the texture of the studied sample. Three main parageneses were identified (labeled P1, P2, and P3; see text). Inset shows mapped area. Grt—garnet; Cpx—clinopyroxene; Pl—plagioclase; Amp—amphibole; Ti-Ox—Ti-oxide; Fe-Ox—Fe-oxide.

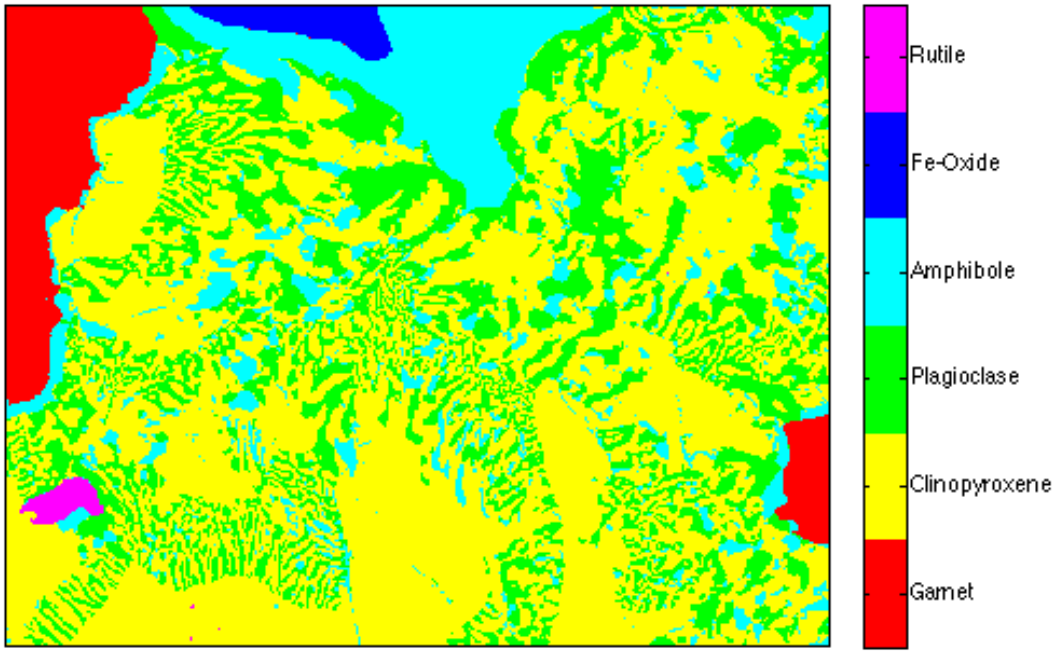
~350'000 quantitative analyses and ~200'000 P-T estimates

EXAMPLE FOR THE TUTORIAL: ECLOGITE FROM THE STAK MASSIF (PAKISTAN; NW-HIMALAYA)

① In MATLAB©, go to the directory *Documents/MATLAB/Mapping_Data/Example-3-STAK/*

② Launch XMAPTOOLS and open the project *aaa.mat* using the command: *>> XMapTools open aaa*

③ Take a quick look at the maps in the workspace X-ray and identify the main mineral phases



The phases Cpx, Pl, Amp and Grt were standardized (BRC and no BRC)

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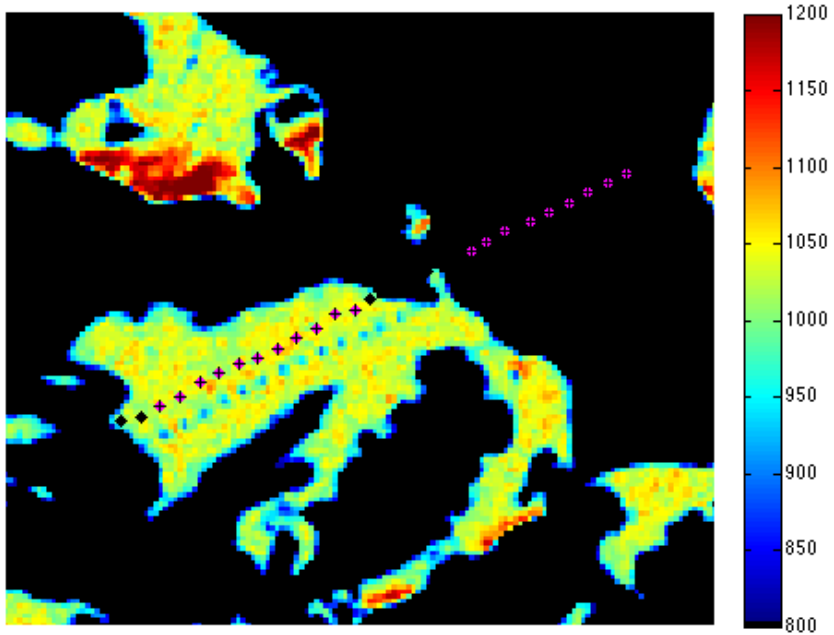
Na in plagioclase



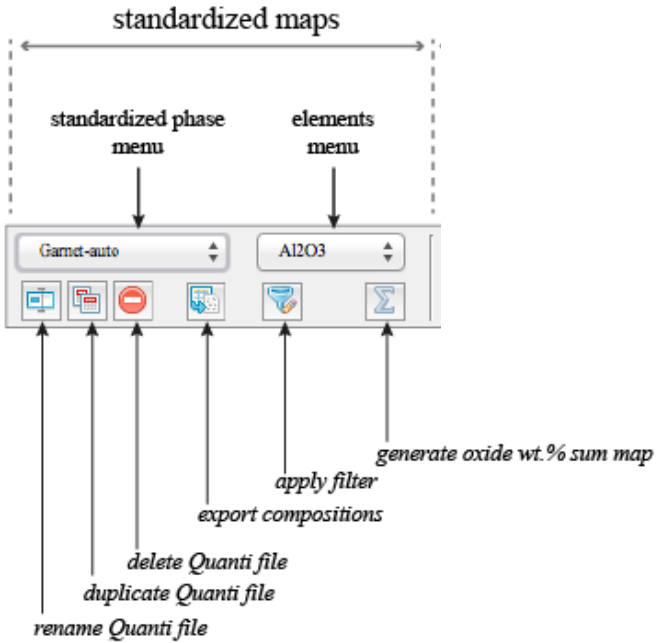
Key steps

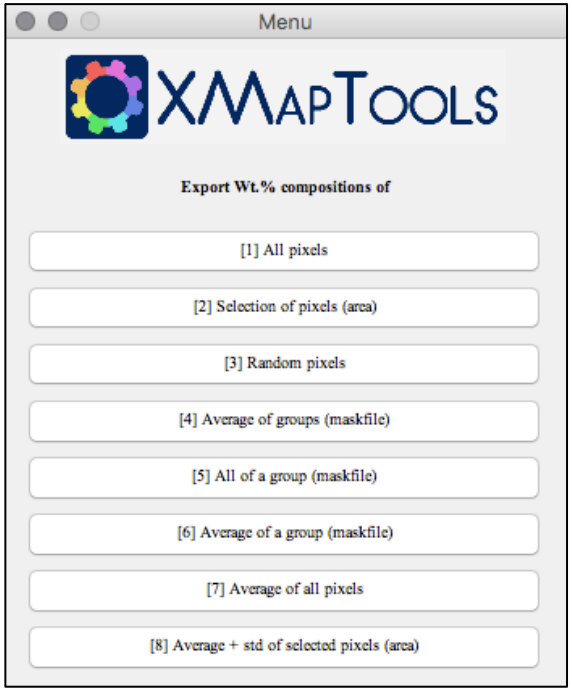
- Export compositions from maps
- Calculate structural formulas of minerals
- Chemical modules
- Thermobarometry Part 1 – spot mode
- Thermobarometry Part 2 – map mode

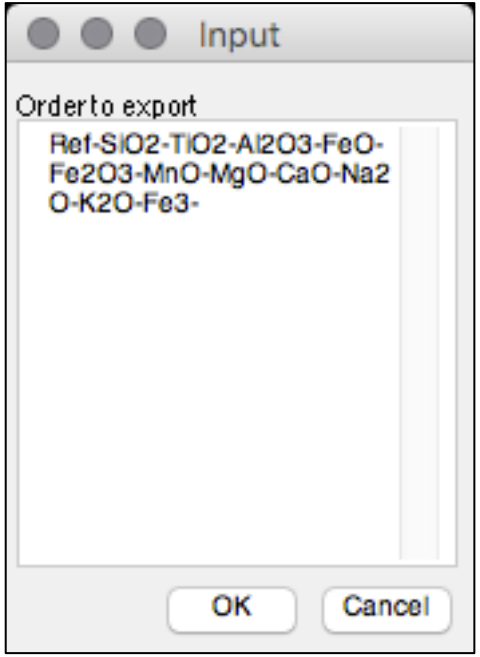
How to export compositions from the maps?

① Go to the workspace *QUANTI* and select the phase *Garnet-advanced-BRC*

② Export 200 analyses of garnet (random selection) and save the corresponding figure







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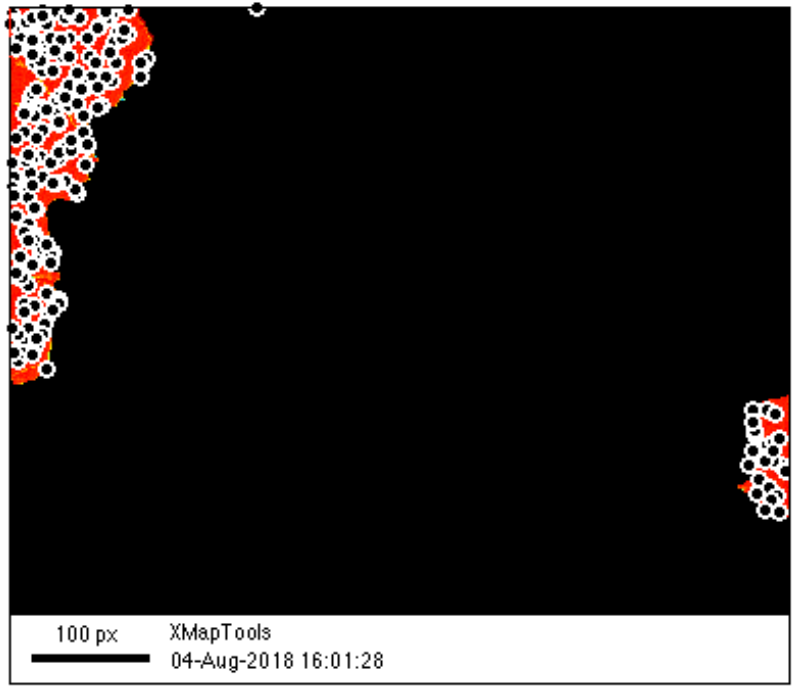
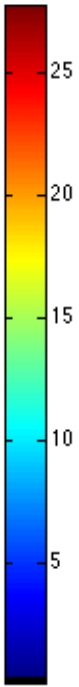




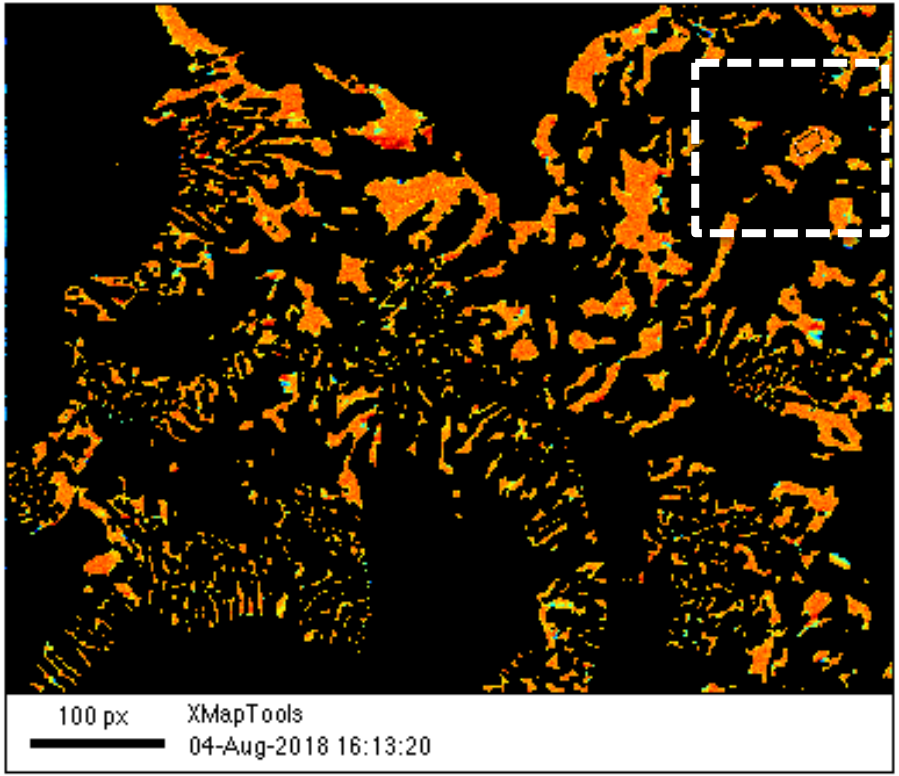
/Users/pierrelanari/Desktop/EXAMPLE-3-STAK/Exported-Oxides/Garnet-200random.txt

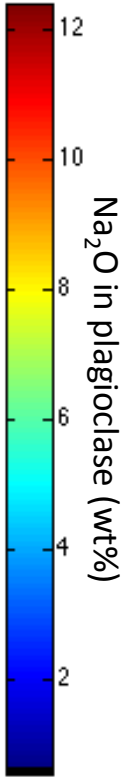
```
1   Oxide mineral compositions (Wt%) from XMapTools
2   04-Aug-2018
3   Analyses: 200
4   Standardized phase: Garnet-advanced-BRC
5   Order: Ref-SiO2-TiO2-Al2O3-FeO-Fe2O3-MnO-MgO-CaO-Na2O-K2O-Fe3-
6
7   15.00 40.89 0.00 23.41 26.73 0.00 0.24 5.44 4.43 0.81 0.00 0.00
8   1046.00 40.03 0.00 22.86 23.49 0.00 0.48 8.79 6.36 0.02 0.00 0.00
9   1174.00 40.00 0.05 22.96 22.79 0.00 0.40 9.07 7.17 0.02 0.00 0.00
10  1715.00 40.30 0.12 23.75 22.97 0.00 0.55 8.65 7.03 0.02 0.02 0.00
11  1835.00 40.10 0.00 23.34 24.13 0.00 0.40 9.07 6.77 0.02 0.00 0.00
12  2092.00 39.66 0.12 23.23 22.58 0.00 0.44 9.02 6.58 0.04 0.00 0.00
13  2093.00 40.18 0.00 23.53 23.20 0.00 0.51 9.65 6.64 0.04 0.02 0.00
14  2113.00 39.64 0.05 23.39 23.64 0.00 0.53 9.21 6.52 0.04 0.00 0.00
15  2226.00 40.48 0.00 23.51 22.12 0.00 0.49 9.16 7.09 0.03 0.02 0.00
16  2232.00 39.85 0.04 23.19 23.20 0.00 0.51 9.51 7.15 0.04 0.00 0.00
17  2242.00 39.77 0.14 23.75 23.17 0.00 0.49 9.14 6.70 0.04 0.02 0.00
18  2376.00 40.23 0.19 23.44 23.63 0.00 0.55 9.22 7.33 0.03 0.01 0.00
19  2713.00 40.68 0.08 23.09 21.58 0.00 0.39 8.80 7.67 0.04 0.00 0.00
20  2779.00 40.25 0.01 23.78 23.82 0.00 0.44 9.08 6.86 0.02 0.04 0.00
21  3136.00 40.28 0.14 23.29 22.93 0.00 0.50 9.52 6.87 0.05 0.00 0.00
22  3156.00 40.01 0.05 23.91 23.49 0.00 0.46 9.35 6.63 0.02 0.00 0.00
23  3348.00 40.28 0.00 23.53 22.84 0.00 0.49 8.52 7.06 0.06 0.00 0.00
24  3872.00 40.27 0.00 23.34 22.73 0.00 0.52 8.82 6.97 0.04 0.04 0.00
25  3920.00 39.98 0.00 23.33 22.77 0.00 0.46 9.16 6.84 0.04 0.00 0.00
26  3944.00 39.74 0.05 23.07 23.82 0.00 0.41 8.90 7.16 0.04 0.00 0.00
27  4707.00 39.86 0.03 23.83 22.86 0.00 0.44 9.26 6.76 0.03 0.00 0.00
```

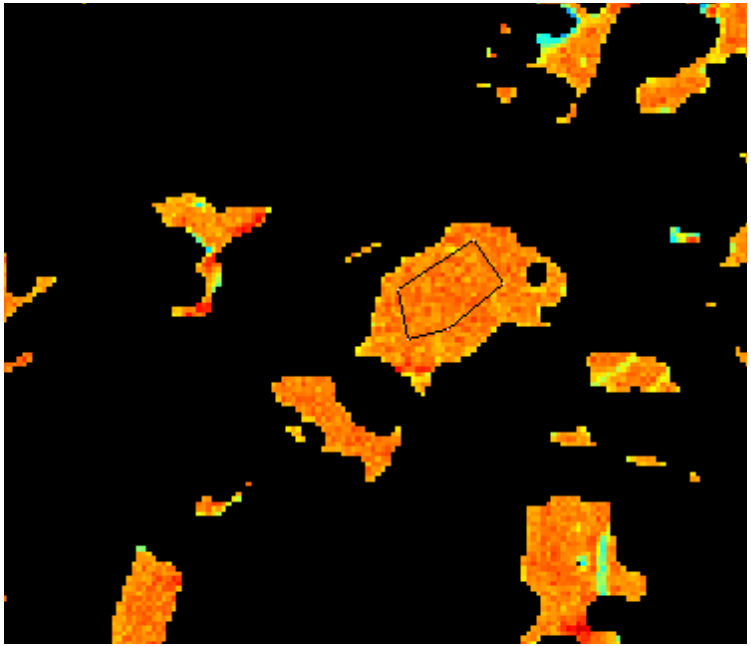
plain text file Ln 1 Col 1

How to export compositions from the maps?

③ Select the phase *Plagioclase-advanced-BRC* and export the pixel compositions of this area:







Key steps

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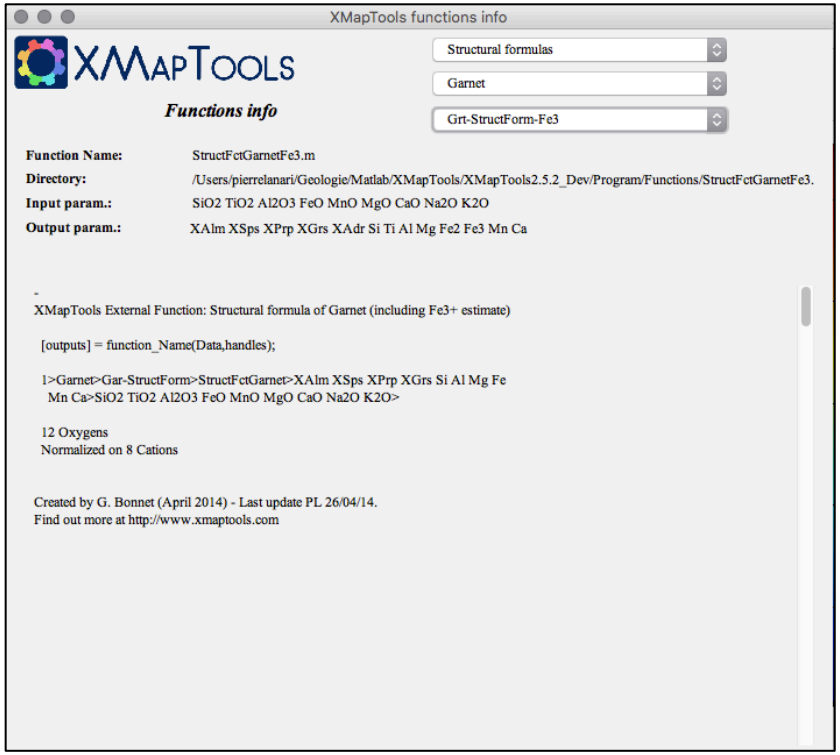
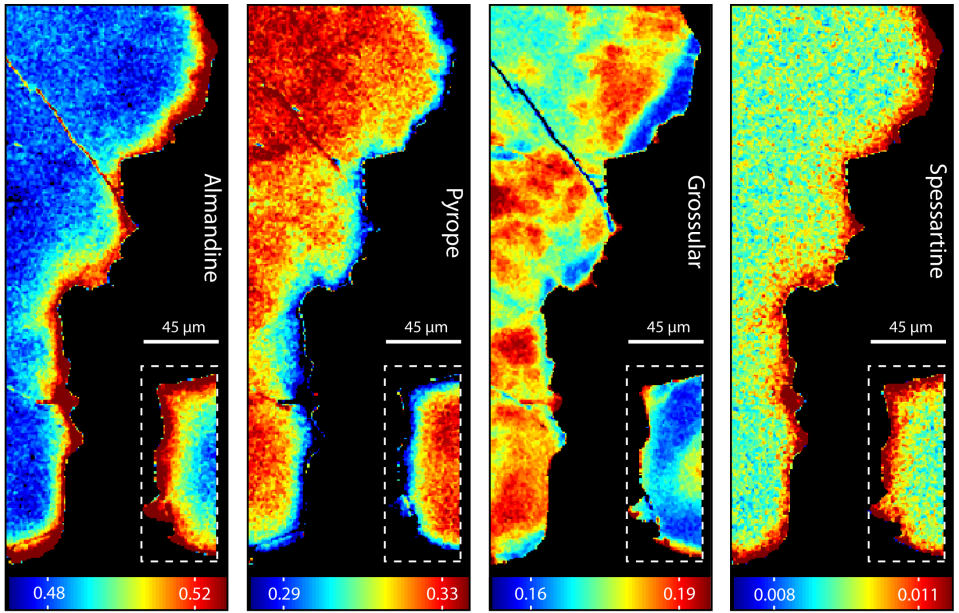
- Calculate structural formulas of minerals
- Chemical modules
- Thermobarometry Part 1 – spot mode
- Thermobarometry Part 2 – map mode

MAPS OF STRUCTURAL FORMULAS

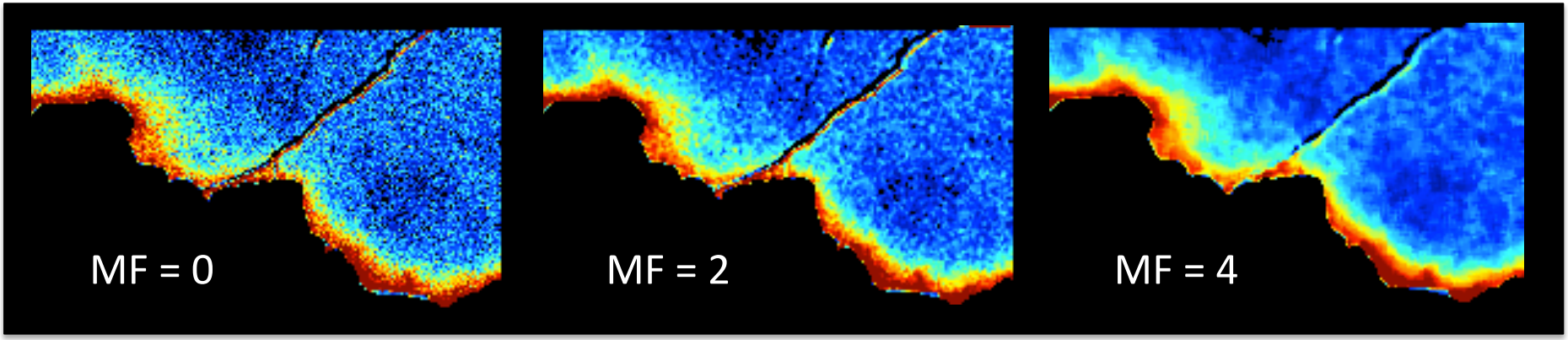
① Select the phase *Garnet-advanced-BRC* and use the external function *Grt-StructForm-Fe3* to compute the structural formula and export the maps of Xalm, Xprp and Xgrs (applying a median filter)

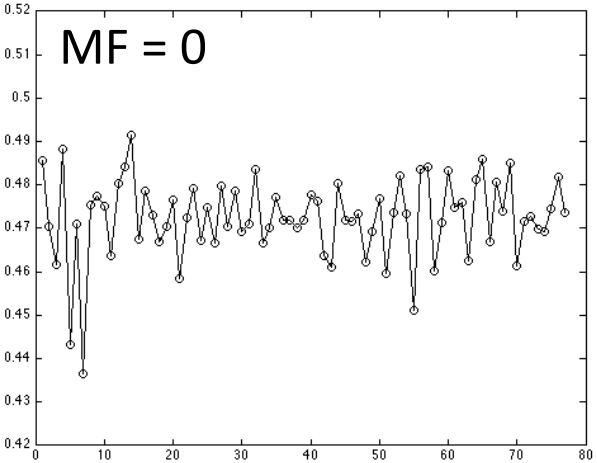


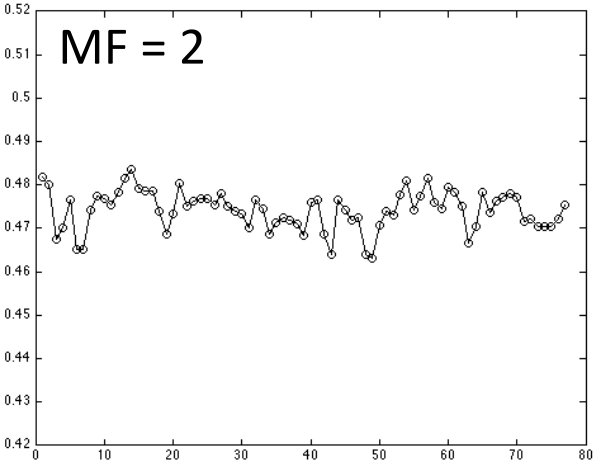


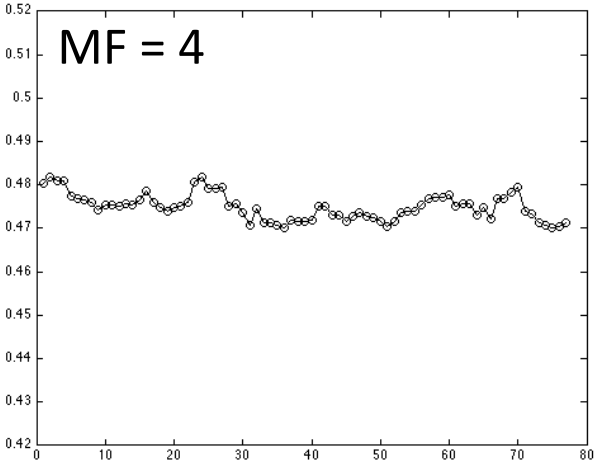
Lanari et al. (2013), *Geology*

Median Filter





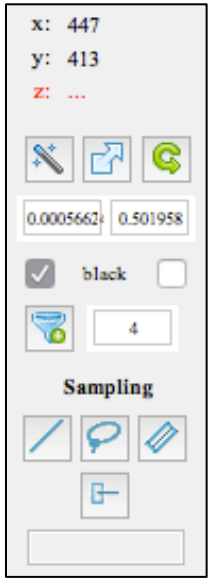


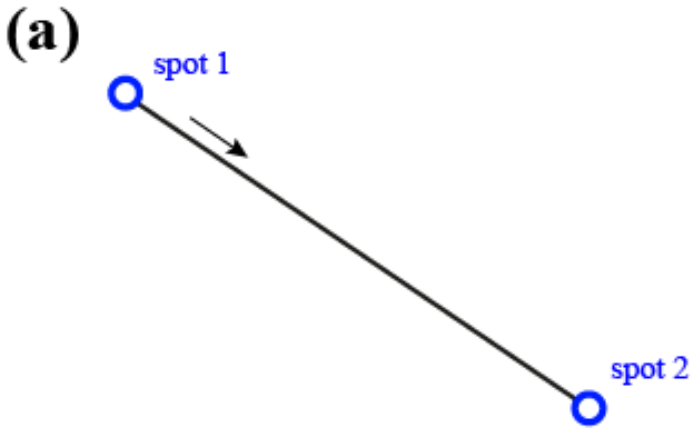


MAPS OF STRUCTURAL FORMULAS

① Select the phase *Clinopyroxene-advanced-BRC* and use the external function *Cpx-StructForm-Cats-Fe3* to compute the structural formula

② Display the map of Xjd and sample a profile going from the omphacite to the clinopyroxene in the symplectite

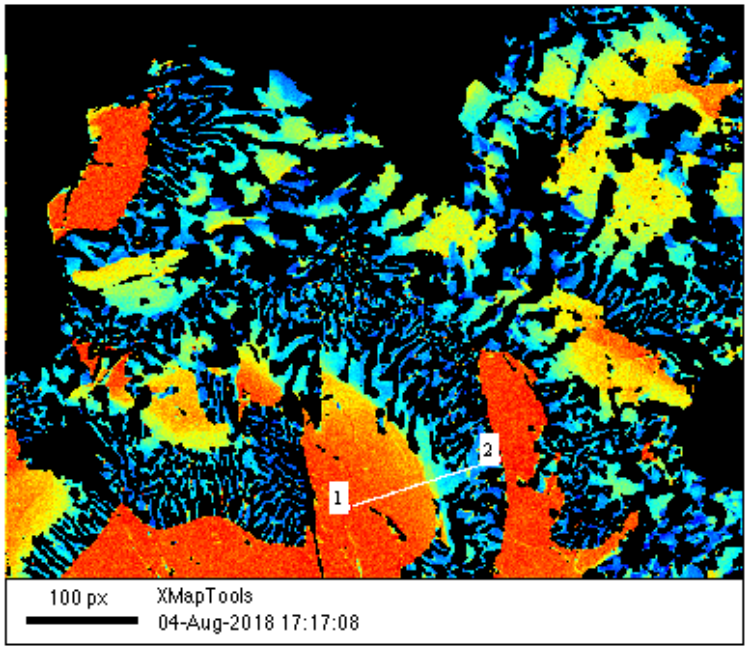


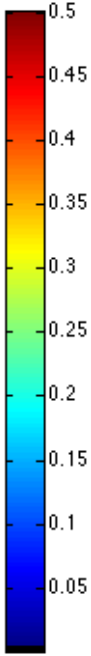


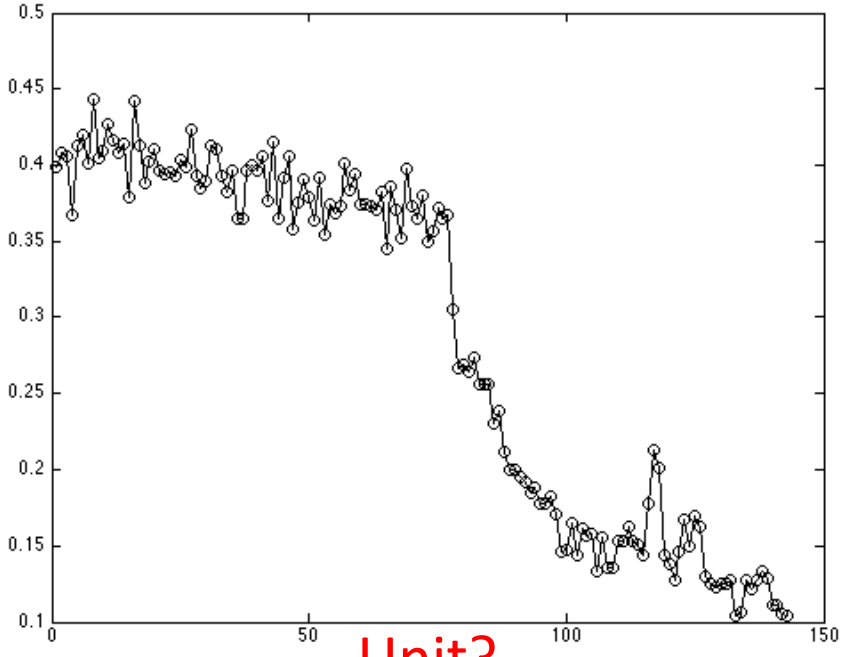
MAPS OF STRUCTURAL FORMULAS

① Select the phase *Clinopyroxene-advanced-BRC* and use the external function *Cpx-StructForm-Cats-Fe3* to compute the structural formula

② Display the map of Xjd and sample a profile going from the omphacite to the clinopyroxene in the symplectite





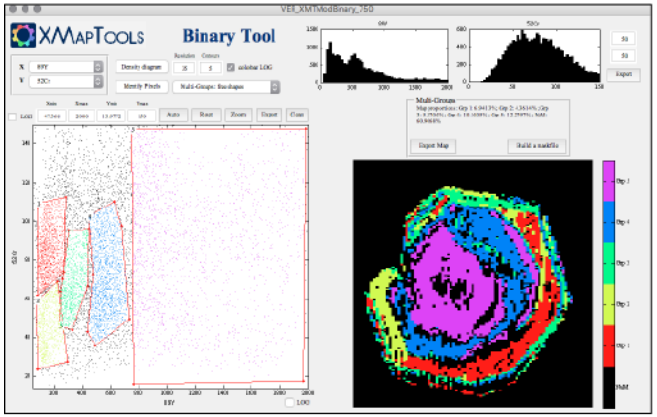


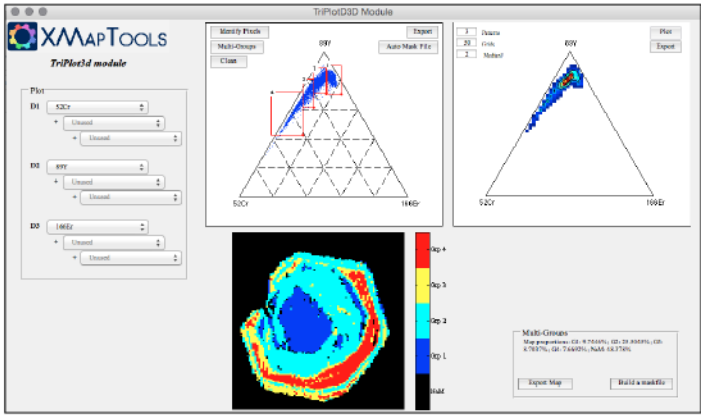
Unit?

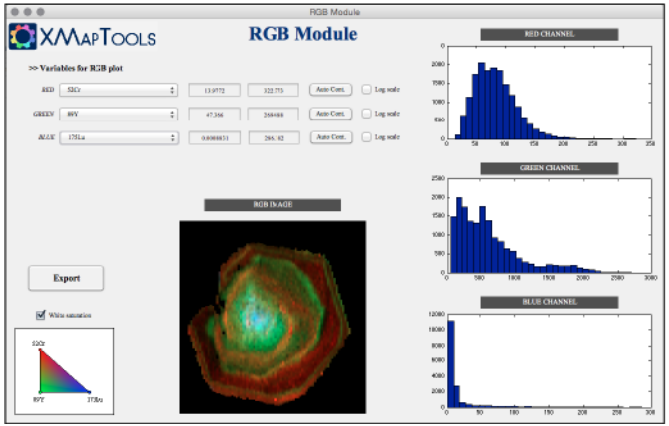
Key steps

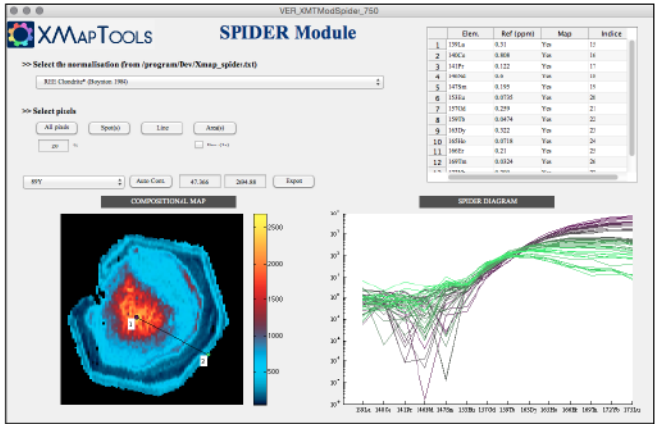
- Export compositions from maps
- Calculate structural formulas of minerals
- Chemical modules
- Thermobarometry Part 1 – spot mode
- Thermobarometry Part 2 – map mode

CHEMICAL MODULES





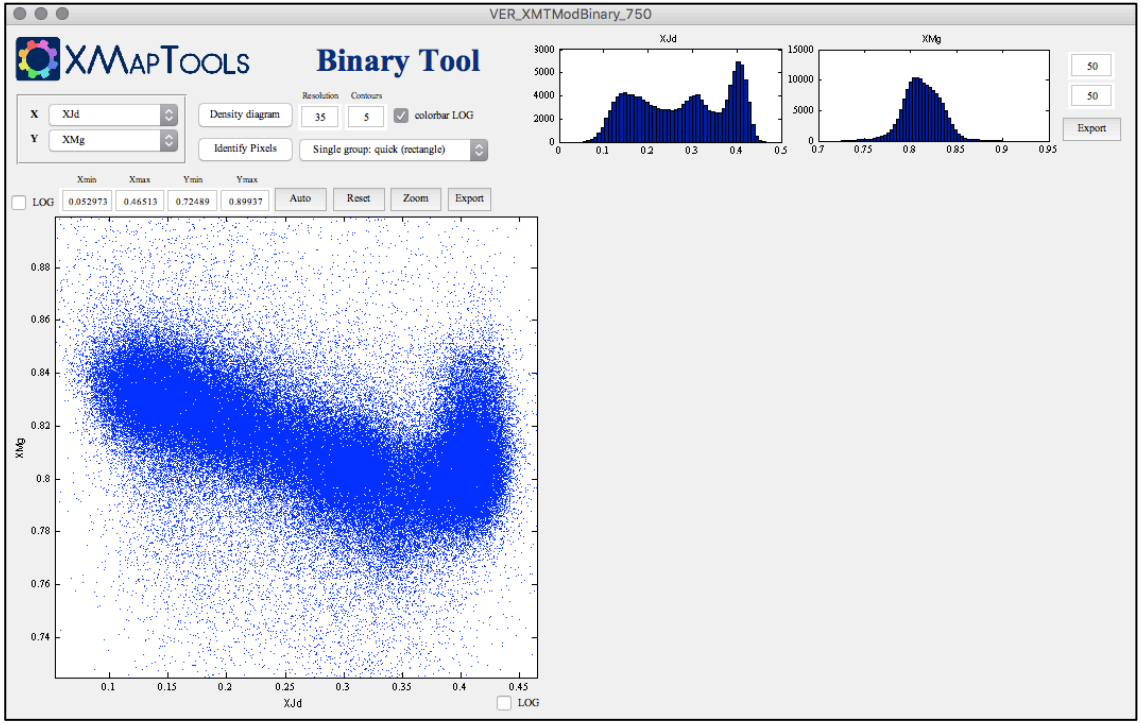




CHEMICAL MODULES: BINARY

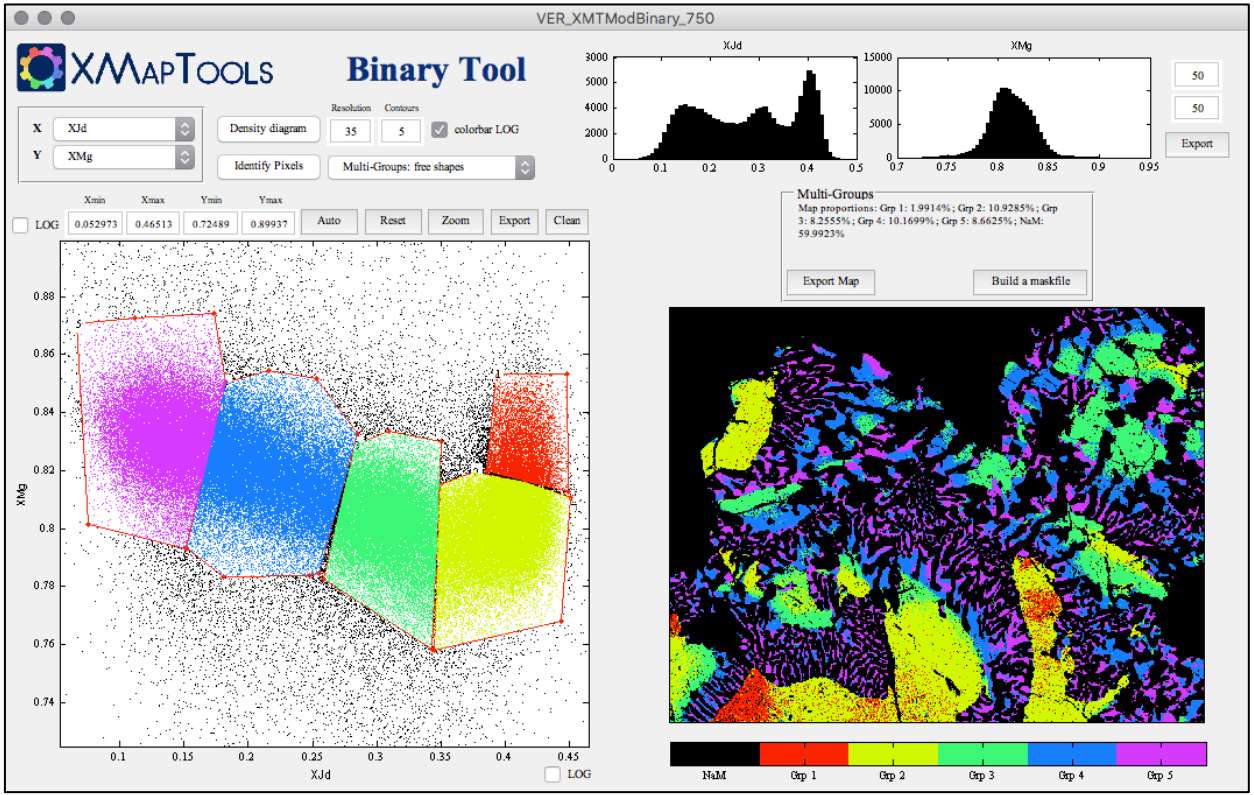
① Select the result *Cpx-StructForm-Cats-Fe3* and launch the module ***Binary***

② Plot *XJd vs XMg* and adjust the limits of X and Y axes

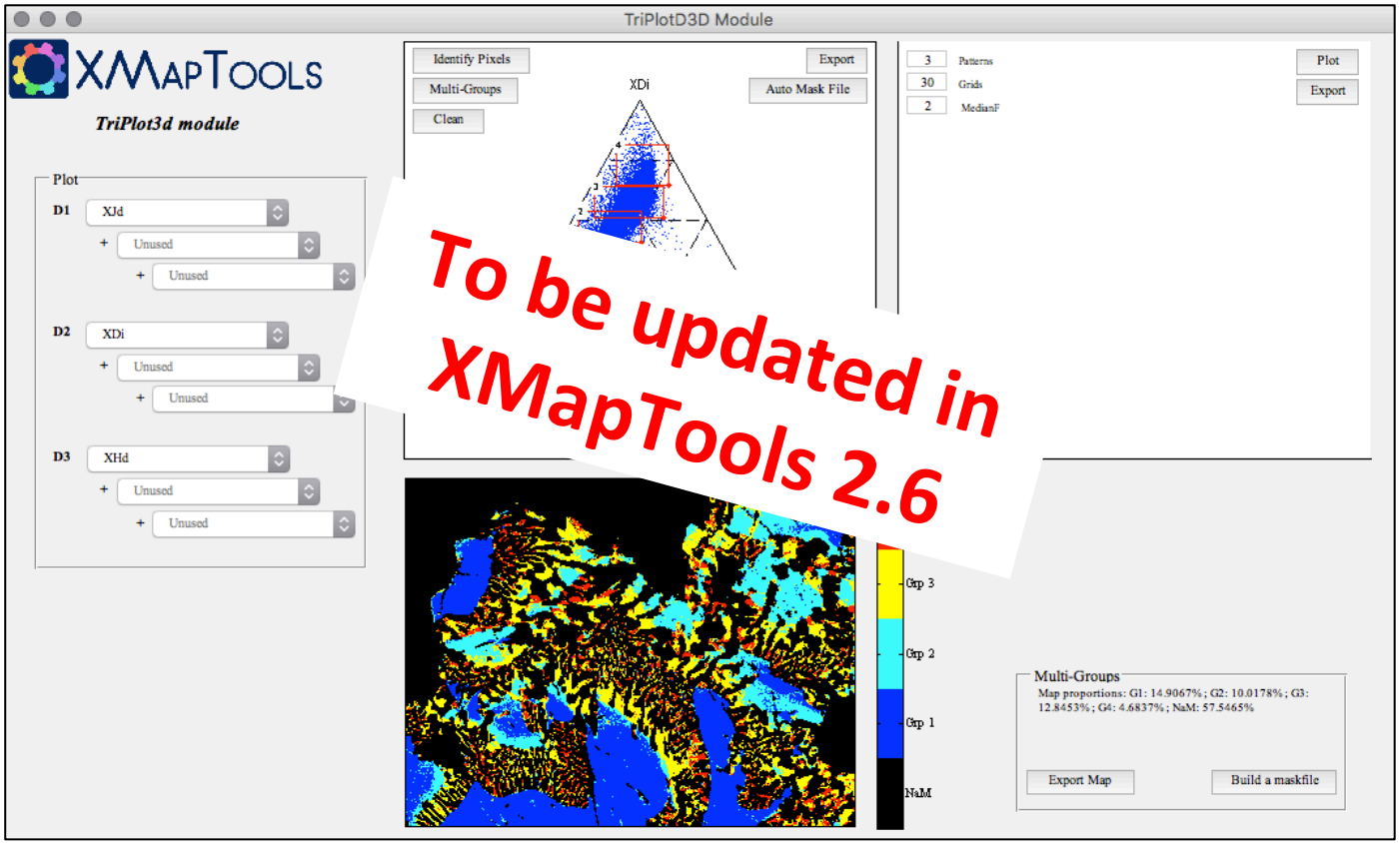


CHEMICAL MODULES: BINARY

③ How many chemical groups can you identify using the *Identify pixels* tool?

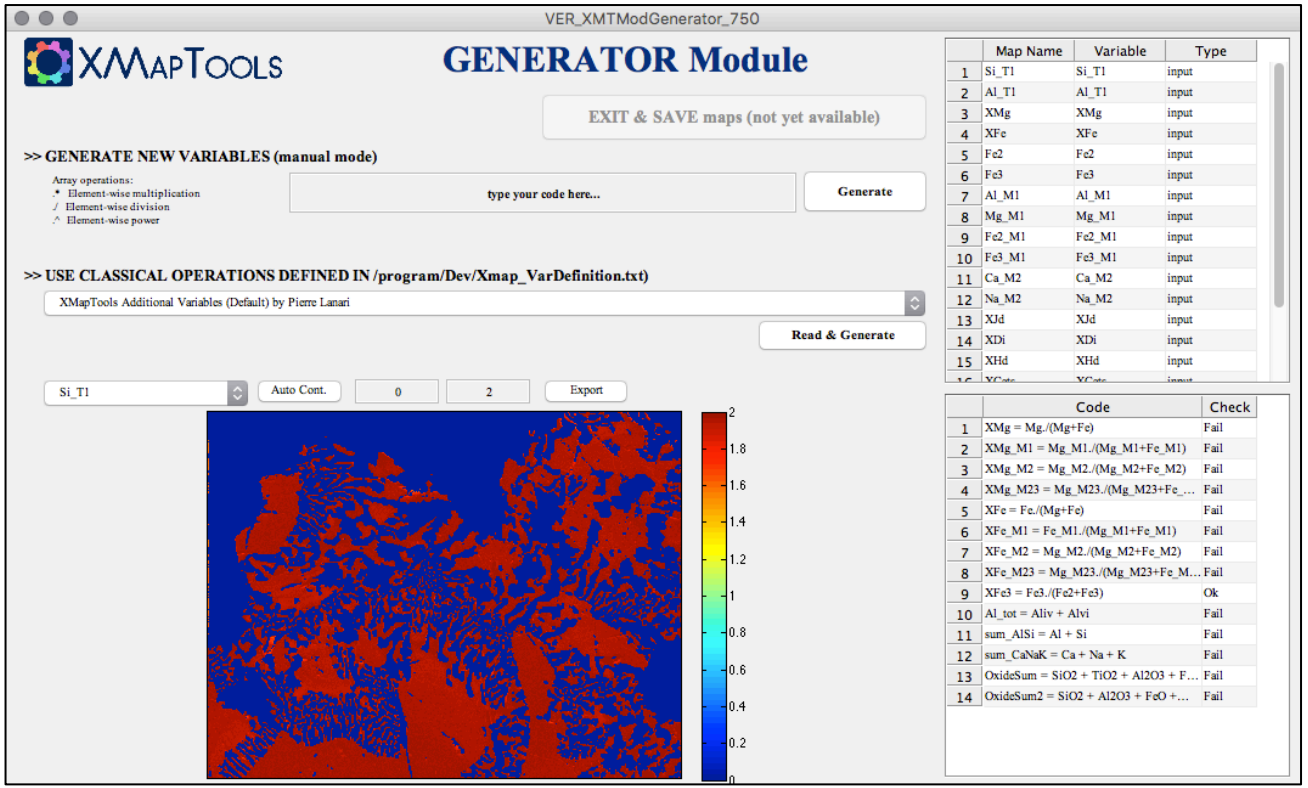


Note: you can do the same in the module TriPlot3D (e.g. *Jd vs Di vs Hd*)



CHEMICAL MODULES: GENERATOR

① Select the result *Cpx-StructForm-Cats-Fe3* and launch the module ***Generator***



CHEMICAL MODULES: GENERATOR

① Select the result *Cpx-StructForm-Cats-Fe3* and launch the module ***Generator***

	T1 (2)	M1 (1)	M2 (1)
Jadeite	Si,Si	Al	Na
diopside	Si,Si	Mg	Ca
Hedenbergite	Si,Si	Fe	Ca
Ca-Tschermak	Si,Al	Al	Ca
Acmite	Si,Si	Fe^{3+}	Na

Table 2.6-1: *Site allocation model used for Clinopyroxene*

② Generate two new variables:

Xjd_Na = Na_M2 - Fe3;

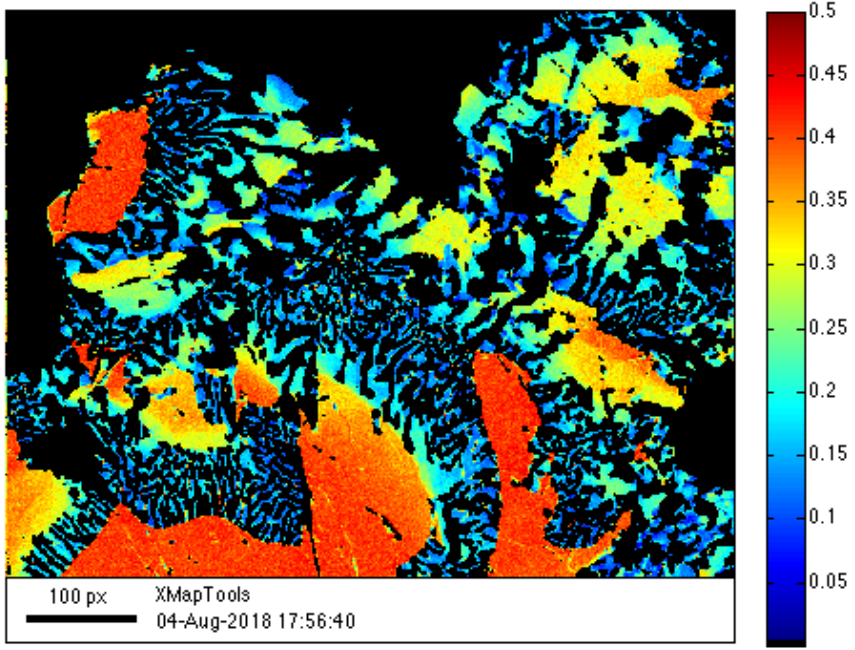
Xjd_Al = Al_M1 - Al_T1;

③ Press the button *Exit and save 2 maps in XMapTools*

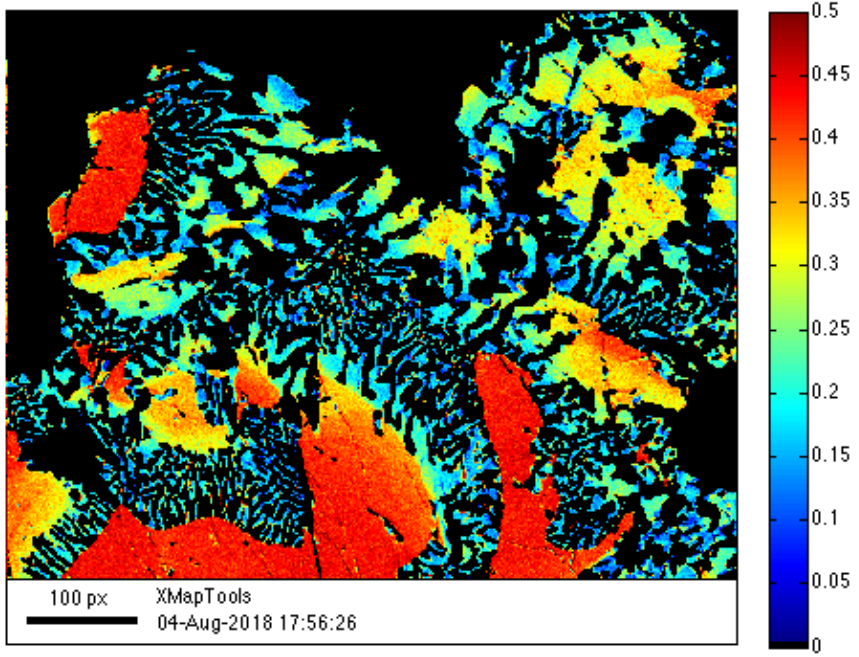
CHEMICAL MODULES: GENERATOR

④ Compare the two maps using the same color scale

Xjd_Na = Na_M2 - Fe3;



Xjd_Al = Al_M1 - Al_T1;



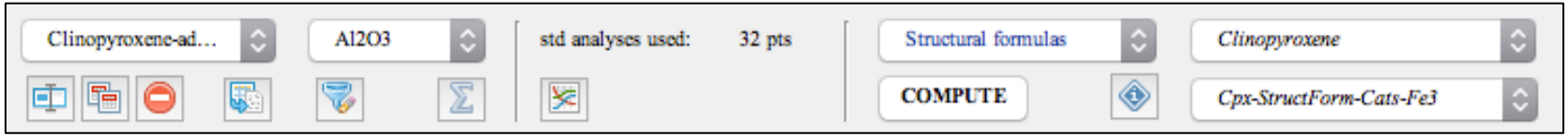
Key steps

- Export compositions from maps
- Calculate structural formulas of minerals
- Chemical modules
- Thermobarometry Part 1 – spot mode
- Thermobarometry Part 2 – map mode

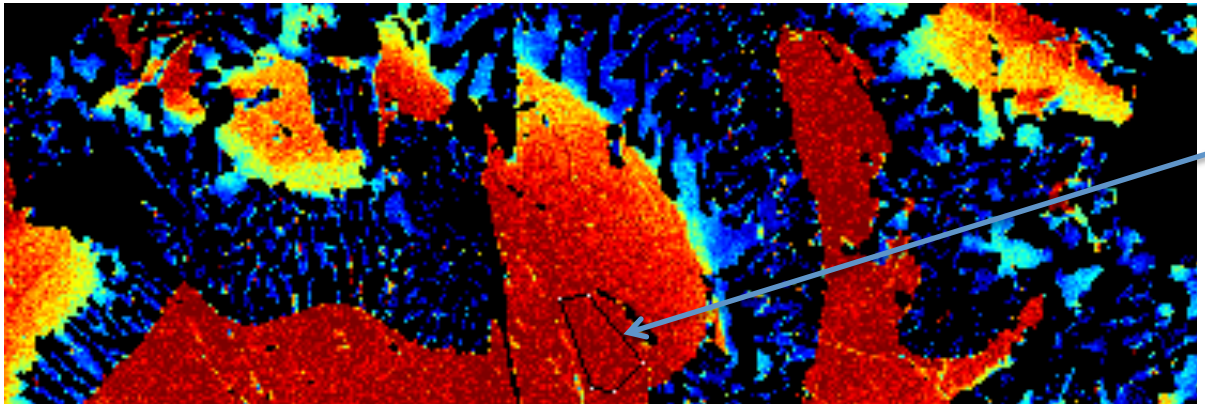
How to export compositions from the maps?

① Go back to the workspace *QUANTI* and select the phase *Clinopyroxene-advanced-BRC*

② Select the external function *Cpx-StructForm-Cats-Fe3* (IMPORTANT!)



③ Export the *average composition + std of selected pixels (area)* of omphacite (DO NOT CHANGE ELEMENT ORDER); *Apply the external function: YES*



How to export compositions from the maps?

	A	B	C
13	...	[Mean]	[Std]
14	Ref	0	0
15	SiO2	55.847	0.489
16	TiO2	0.176	0.077
17	Al2O3	11.823	0.263
18	FeO	3.916	0.202
19	Fe2O3	0	0
20	MnO	0.039	0.062
21	MgO	9.081	0.239
22	CaO	13.61	0.162
23	Na2O	5.99	0.245
24	K2O	0.015	0.015
25	Fe3	0	0
26	Si_T1	1.97	0.01
27	Al_T1	0.03	0.01
28	XMg	0.806	0.01
29	XFe	0.194	0.01
30	Fe2	0.115	0.007
31	Fe3	0.001	0.003
32	Al_M1	0.461	0.009
33	Mg_M1	0.478	0.012
34	Fe2_M1	0.115	0.007
35	Fe3_M1	0.001	0.003
36	Ca_M2	0.514	0.007
37	Na_M2	0.41	0.016
38	XJd	0.409	0.015
39	XDi	0.478	0.012
40	XHd	0.115	0.007
41	XCats	0.015	0.005
42	XAcm	0.001	0.003
43	Xsum	1.017	0.022
44	SumM1	1.054	0.009
45	SumM2	0.924	0.017

Cpx_Grp1.txt

Normal View | Ready

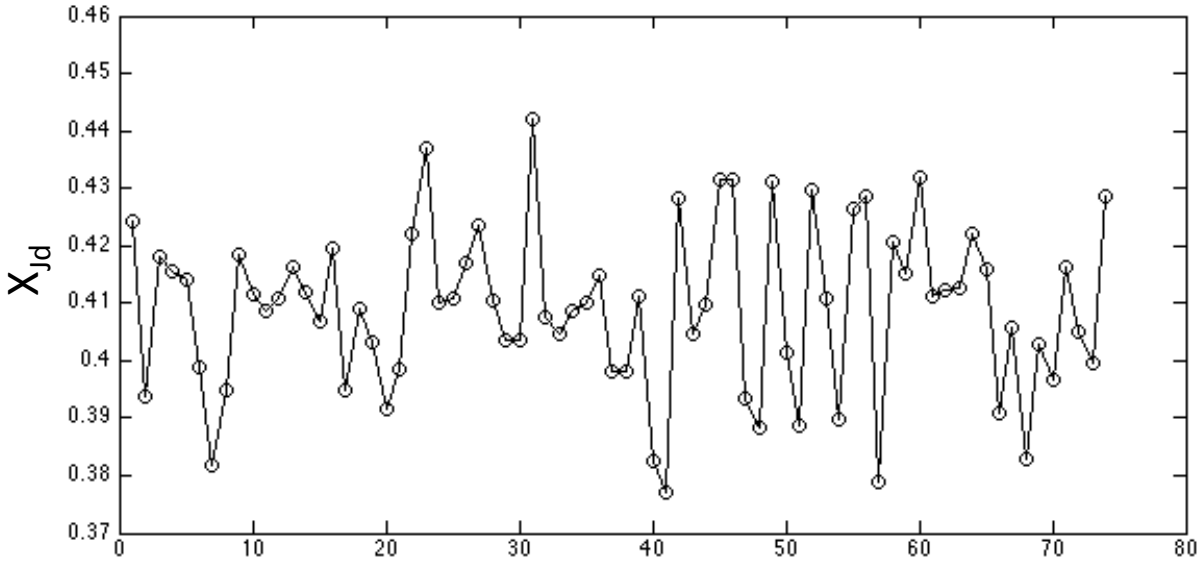


Table for publication!

Key steps

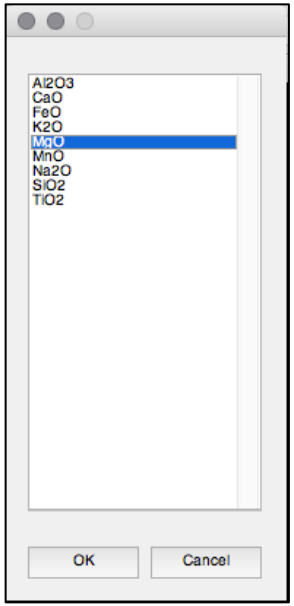
- Export compositions from maps
- Calculate structural formulas of minerals
- Chemical modules
- Thermobarometry Part 1 – spot mode
- Thermobarometry Part 2 – map mode

THERMOBAROMETRY PART 1 – SPOT MODE

① Go to the workspace *Quanti* and select the phase *Garnet-advanced-BRC*

② In the external function menu, select *P-T / spot mode*, *Garnet+Clinopyroxene* and *T- Ravna 2000,*

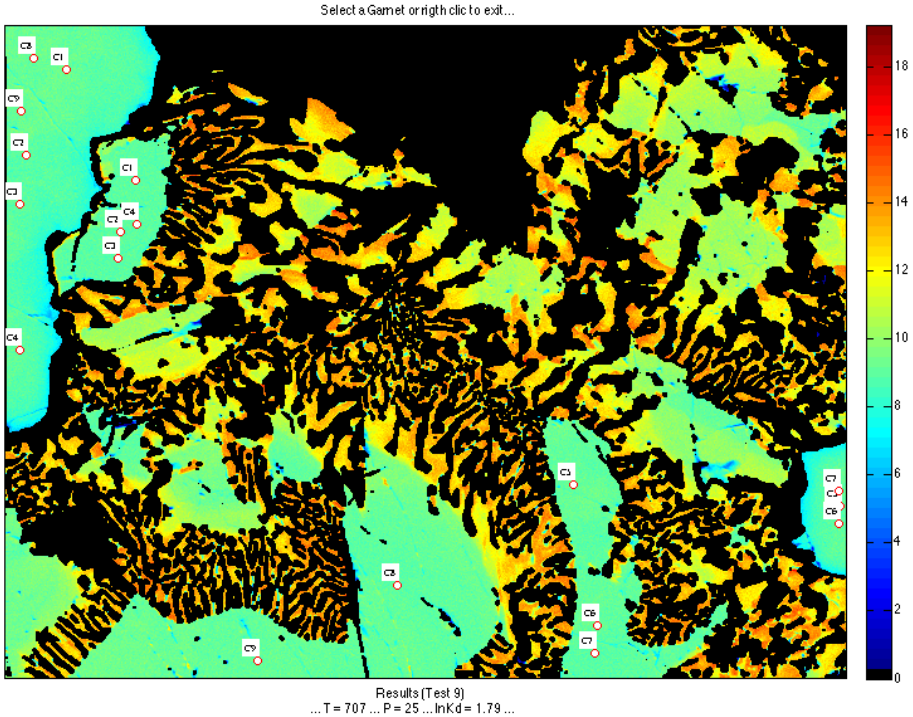
③ Press the button *COMPUTE* and select *Spot (single estimate)* the map MgO and the corresponding Quanti files for garnet and then clinopyroxene



THERMOBAROMETRY PART 1 – SPOT MODE

④ Increase the size of the map and calculate the temperature of > 10 garnet (core) and omphacite pixels at 25 kbar

⑤ Save the data (*T-spots_Grt-Omph.txt*)



/Users/pierrelanari/Desktop/EXAMPLE-3-STAK/Results/T-spot_Grt-Omph.txt

```
Results from XMapTools
Method: T- Ravna 2000
Minerals: Garnet+Clinopyroxene

* * * * * * * * Couple 1 * * * * * * * *
Garnet composition: 40.325      0.10396       24.31       23.208
Clinopyroxene composition: 55.088     0.036066       11.946       4.16
... T = 727 ... P = 25 ... lnKd = 1.71 ...

* * * * * * * * Couple 2 * * * * * * * *
Garnet composition: 39.715     0.077974       23.389       23.229
Clinopyroxene composition: 55.756      0.24038       11.846        4.0
... T = 717 ... P = 25 ... lnKd = 1.77 ...

* * * * * * * * Couple 3 * * * * * * * *
Garnet composition: 40.106     0.051987       23.028        23.32
Clinopyroxene composition: 56.596      0.14423       11.672       4.08
... T = 726 ... P = 25 ... lnKd = 1.72 ...

* * * * * * * * Couple 4 * * * * * * * *
Garnet composition: 39.816     0.090968       23.605       23.543
Clinopyroxene composition: 55.786      0.20433       11.662       3.71
... T = 686 ... P = 25 ... lnKd = 1.86 ...

* * * * * * * * Couple 5 * * * * * * * *
Garnet composition: 40.173            0       23.433       23.249
Clinopyroxene composition: 56.391      0.10818       12.046        3.5
... T = 683 ... P = 25 ... lnKd = 1.85 ...

* * * * * * * * Couple 6 * * * * * * * *
Garnet composition: 40.198     0.11696       23.405       23.654
Clinopyroxene composition: 55.498      0.08414       11.767       3.73
... T = 677 ... P = 25 ... lnKd = 1.88 ...
```

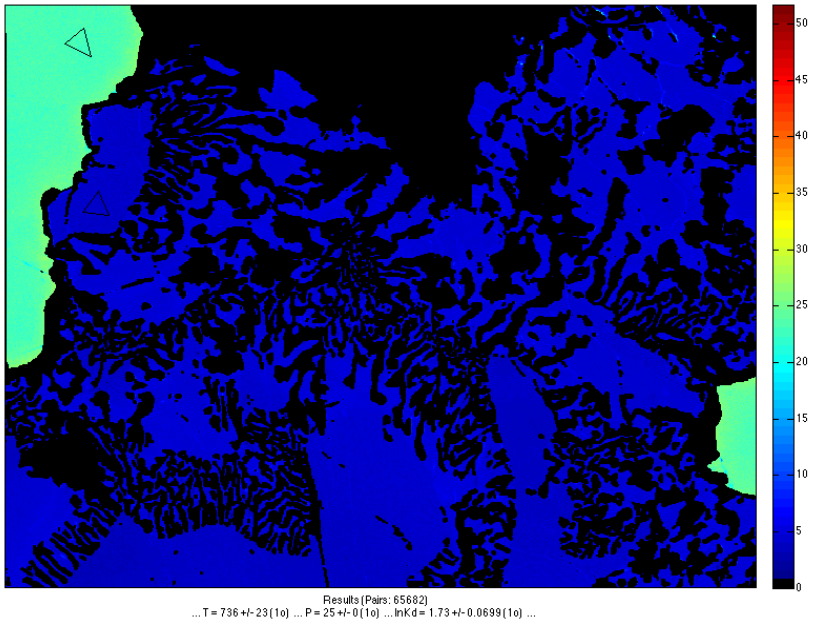
plain text file | Ln 11 Col 20

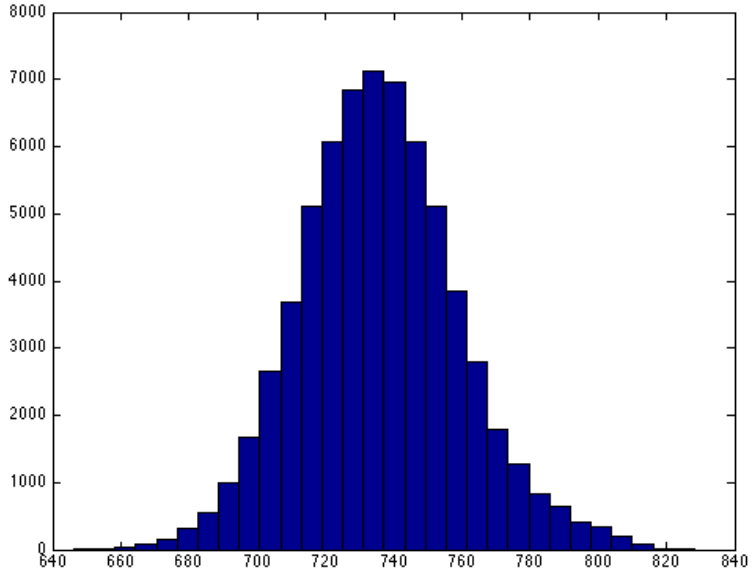
THERMOBAROMETRY PART 1 – SPOT MODE

① In XMAPTOOLS, press again the button *COMPUTE* and select *Area (average estimate)* the map FeO and the corresponding Quanti files for garnet and then clinopyroxene; select a pressure of 25 kbar

② Select two small areas in garnet and omphacite (all the permutations are tested!) and save the data (*T-area_Grt-Omph.txt*)

Results (Pairs: 65682)
... T = 736 +/- 23 (1σ) ... P = 25 +/- 0 (1σ) ... lnKd = 1.73 +/- 0.0699 (1σ) ...

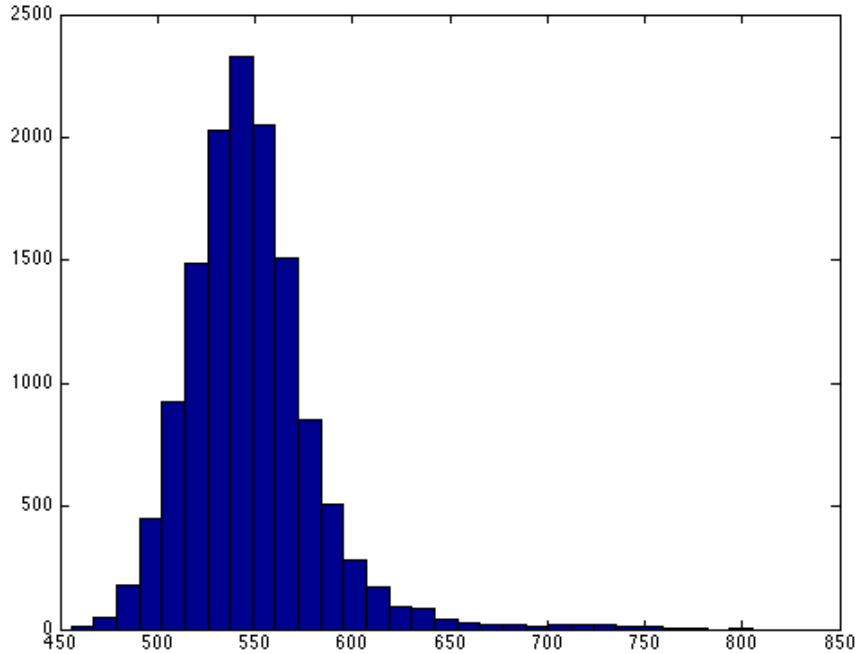




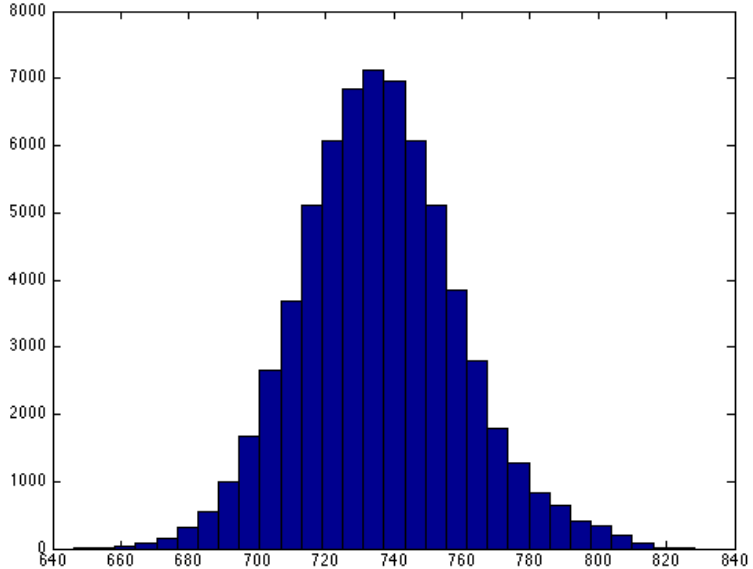
THERMOBAROMETRY PART 1 – SPOT MODE

① Calculate the temperature of the small garnet rim showing a textural equilibrium relationship with amphibole

Results (Pairs: 13189)
... T = 548 +/- 34 (1σ) ... XCaGrt = 0.159 +/- 0.00365 (1σ) ... XMnGrt = 0.013 +/- 0.00114 (1σ) ... lnKd = 1.49 +/- 0.0869 (1σ) ...



Results (Pairs: 65682)
... T = 736 +/- 23 (1σ) ... P = 25 +/- 0 (1σ) ... lnKd = 1.73 +/- 0.0699 (1σ) ...



Key steps

- Export compositions from maps
- Calculate structural formulas of minerals
- Chemical modules
- Thermobarometry Part 1 – spot mode
- Thermobarometry Part 2 – map mode

THERMOBAROMETRY PART 2 – MAP MODE

① Select the phase *Clinopyroxene-advanced-BRC* In the workspace *Quanti*

② Set the min and max values of the color bar to 5 and 8 (activate both black layers)

③ Apply a filter to generate a *Quanti file* containing only the pixels in this compositional range

④ Rename this quanti file: *Omphacite*

THERMOBAROMETRY PART 2 – MAP MODE

① Select the phase *Clinopyroxene-advanced-BRC* In the workspace *Quanti*

② Set the min and max values of the color bar to 0 and 5 (activate both black layers)

③ Apply a filter to generate a *Quanti file* containing only the pixels in this compositional range

④ Rename this quanti file: *Cpx*

THERMOBAROMETRY PART 2 – MAP MODE

① Calculate P-T maps of omphacite using the function *Cpx-P-T Rav (Cpx+Grt+Phg)* with fixed garnet and phengite compositions

② Plot the results in a binary P-T diagram (x-axis: 450-900°C; y-axis: 5-30 kbar).

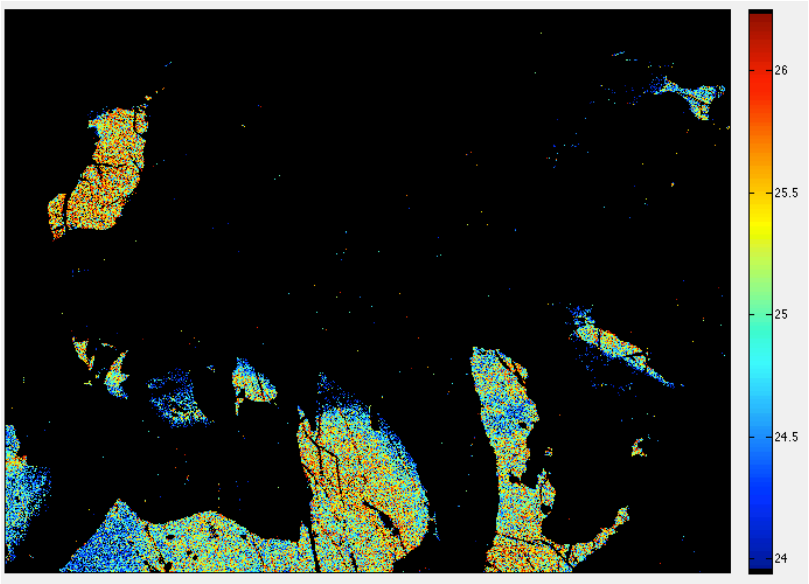
Garnet: Xalm(0.48), Xpyr(0.34), Xgro(0.18)

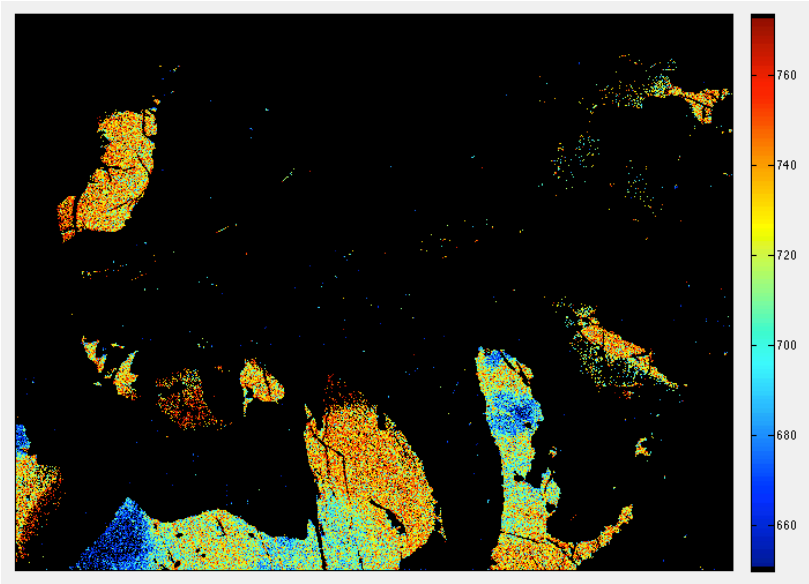
Phengite: Si(3.28), Al(2.22), Ti(0.065), Cr(0.055), Fe(0.065), Mn(0)
Mg(0.34), Ca(0.005), Na(0.02), K(0.975)

THERMOBAROMETRY PART 2 – MAP MODE

① Calculate P-T maps of omphacite using the function *Cpx-P-T Rav (Cpx+Grt+Phg)* with fixed garnet and phengite compositions

② Plot the results in a binary P-T diagram (x-axis: 450-900°C; y-axis: 5-30 kbar).





THERMOBAROMETRY PART 2 – MAP MODE

① Calculate P-T maps of omphacite using the function *Cpx-P-T Rav (Cpx+Grt+Phg)* with fixed garnet and phengite compositions

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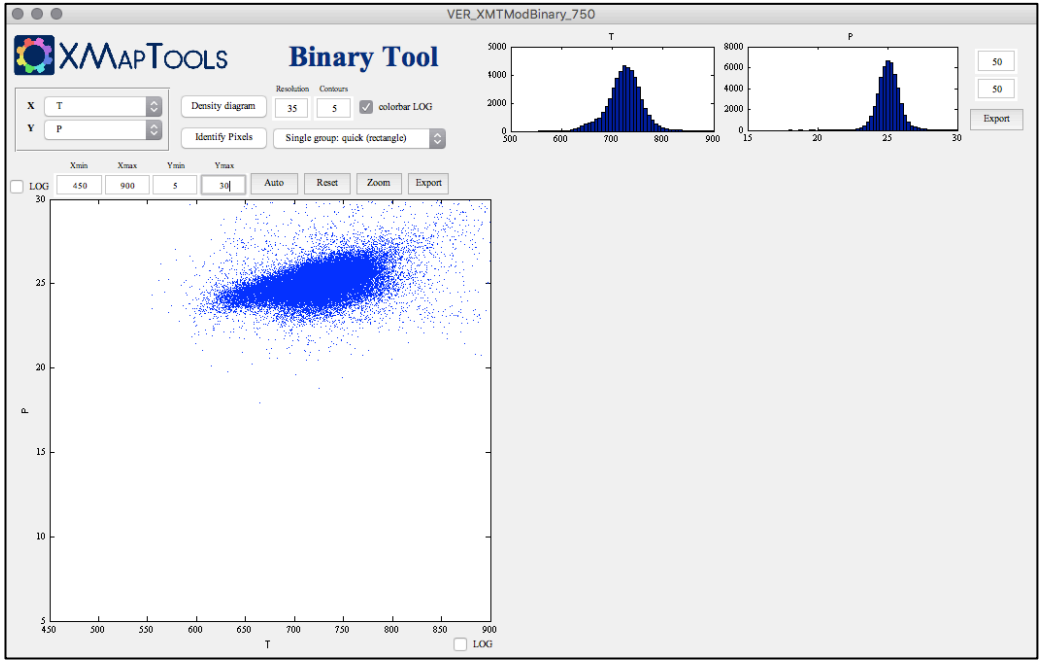
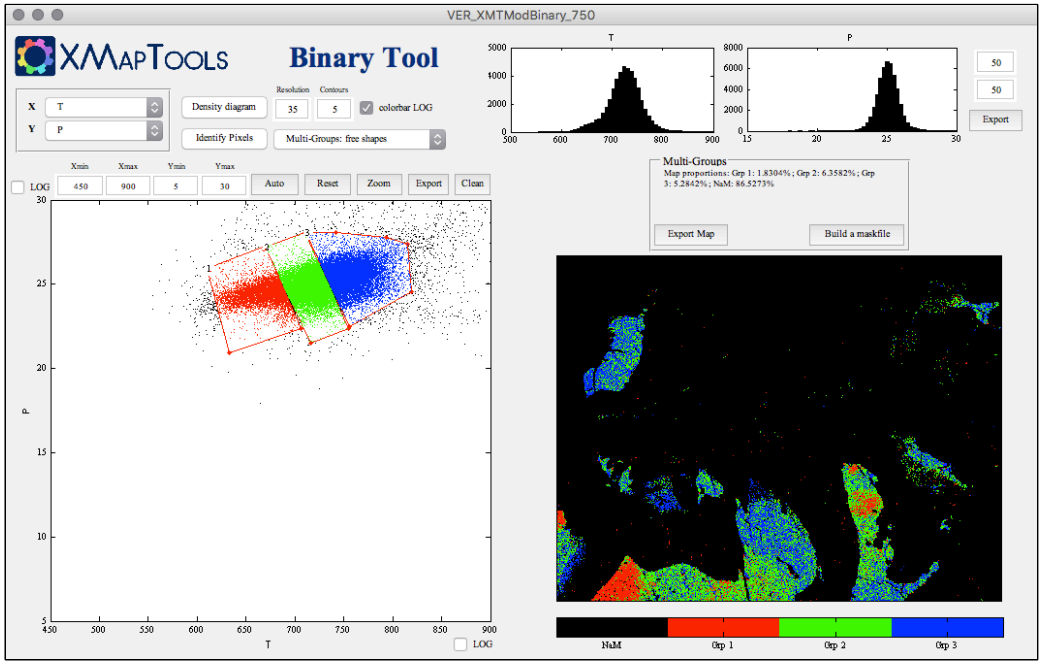


THERMOBAROMETRY PART 2 – MAP MODE

① Calculate P-T maps of omphacite using the function *Cpx-P-T Rav (Cpx+Grt+Phg)* with fixed garnet and phengite compositions

② Plot the results in a binary P-T diagram (x-axis: 450-900°C; y-axis: 5-30 kbar).



THERMOBAROMETRY PART 2 – MAP MODE

① Calculate P-T maps of omphacite using the function *Cpx-P-fT (Cpx+Amph+Pla)* with fixed amphibole and plagioclase compositions as well as a fixed relationship between Na-content in Cpx and temperature

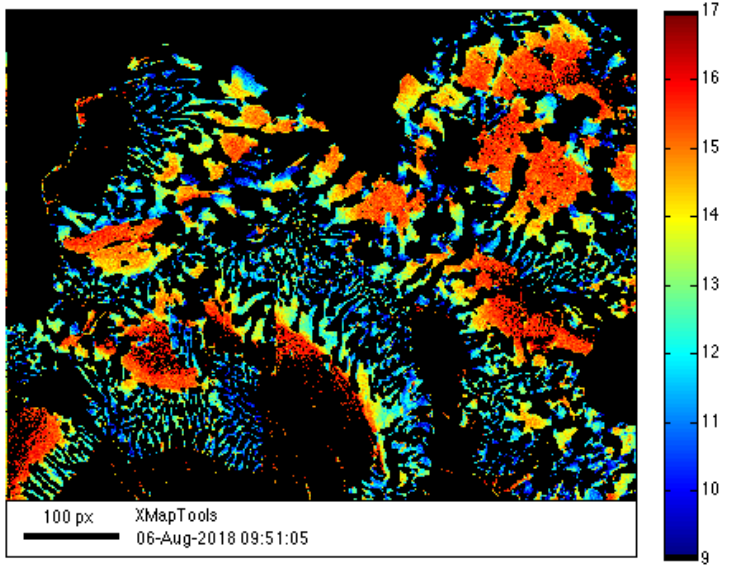
② Plot the results in a binary P-T diagram (x-axis: 450-900°C; y-axis: 5-30 kbar).

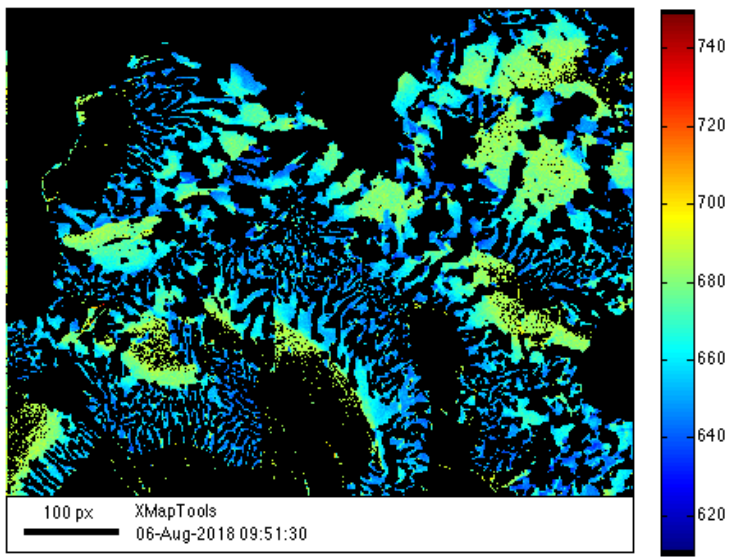
Plagioclase:	Xalb(0.87)	
Amphibole:	Si(6.40), Al(2.35), Fe(1.23), Mg(3.01), Na(0.78), Ca(1.72)	
Clinopyroxene:	Na-cpx:	0.1 0.3 0.4
	Interp. Limits	0 0.001 0.6
	Temp	640 680 700

THERMOBAROMETRY PART 2 – MAP MODE

① Calculate P-T maps of omphacite using the function *Cpx-P-fT (Cpx+Amph+Pla)* with fixed amphibole and plagioclase compositions as well as a fixed relationship between Na-content in Cpx and temperature

② Plot the results in a binary P-T diagram (x-axis: 450-900°C; y-axis: 5-30 kbar).

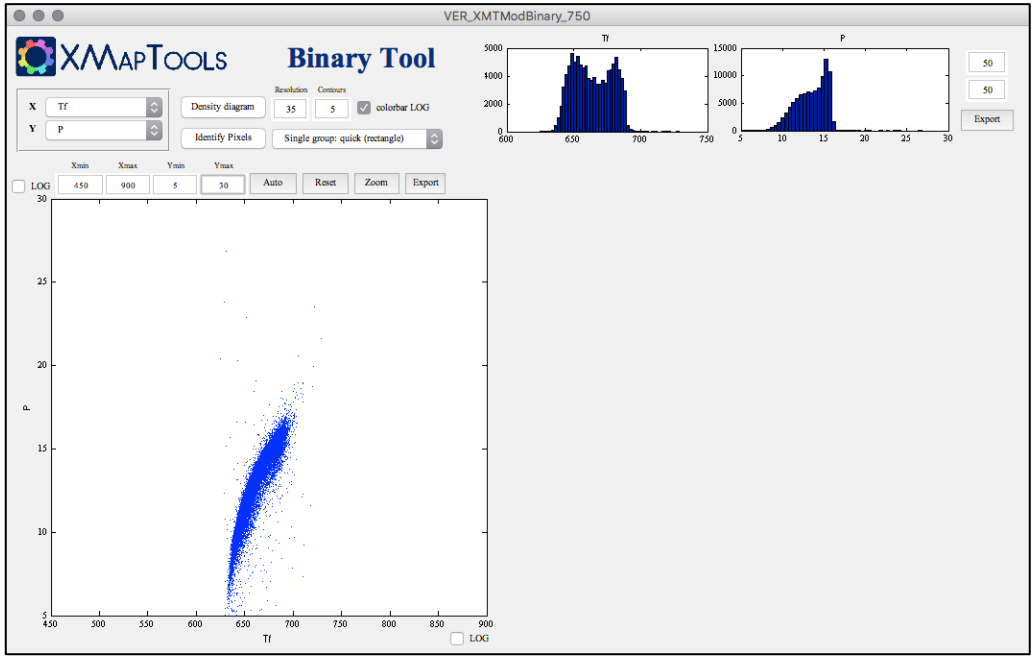




THERMOBAROMETRY PART 2 – MAP MODE

① Calculate P-T maps of omphacite using the function *Cpx-P-fT (Cpx+Amph+Pla)* with fixed amphibole and plagioclase compositions as well as a fixed relationship between Na-content in Cpx and temperature

② Plot the results in a binary P-T diagram (x-axis: 450-900°C; y-axis: 5-30 kbar).



Questions / Discussion