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Manual of ImageJ Macros for Mineral False Color Maps

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Introduction

Joy et al. (2012) utilized a new element mapping routine that was developed to locate specific phases in complex crystalline or brecciated rocks. Several simple computer routines (macros) were developed to manage the data and project it in a way that is useful. Because these routines can be used to process data for other studies, we are making them available to the entire community.

These macros are designed for element maps generated by FE-SEM (e.g., the JEOL JSM 7600F) and run on [ImageJ](#). These macros simplify the methodology initially developed by Joy et al. (2011). Please see Joy et al. (2011) for details of the mapping routines and their utility. These macros can also be used for tiff images generated by other techniques (e.g., EPMA). This manual is designed for applications using Windows on a PC computer, but the macros will also work on MAC computers.

Our macros contain three different programs:

- Adjust_image.ijm
- Minearl_Map.ijm
- Zircon-Phos.ijm

Please create a folder in a convenient place on your PC where the macros can be stored and retrieved. When run, these macros automatically create multi-element false-color maps that highlight silicate phases (based on Al, Ca, Ti, K, Si, Mg, Fe, and P) and zircon, metal, and troilite phases (based on Ca, Fe, and P) from individual element maps (tiff files) generated by FE-SEM and EPMA machines. In the following description of the macros, the manual implementation of the commands is also provided in *italics*. Thus, if files sizes that you try to process are too large for macro processing on your computer, you can step through the same process using the manual set of commands.

References

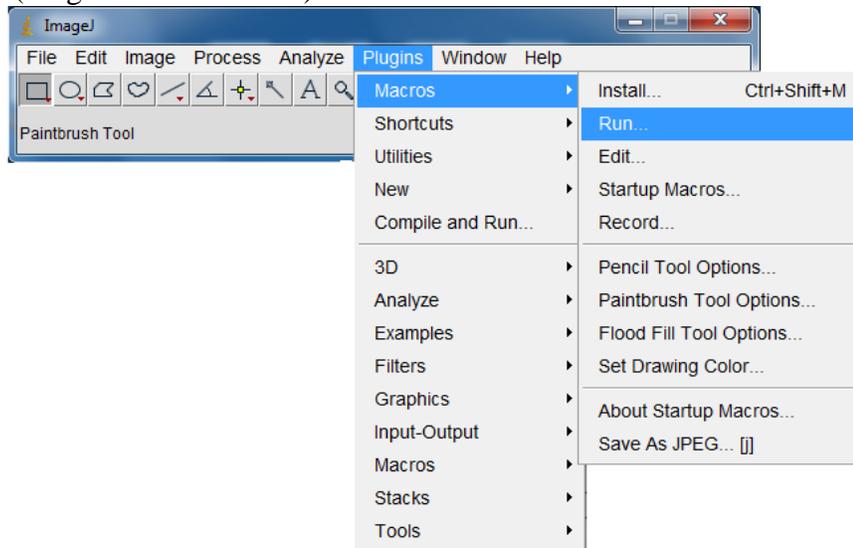
K. H. Joy, D. K. Ross, M. E. Zolensky, D. A. Kring (2011) [Reconnaissance element mapping of lunar regolith breccias](#). *Annual Meeting of LEAG (Lunar Exploration Analysis Group)*, Abstract #2007.

K. H. Joy, M. E. Zolensky, K. Nagashima, G. R. Huss, D. K. Ross, D. S. McKay, and D. A. Kring, (2012) [Direct detection of projectile relics from the end of the lunar basin-forming epoch](#). *Science* 336, 1429-1429.

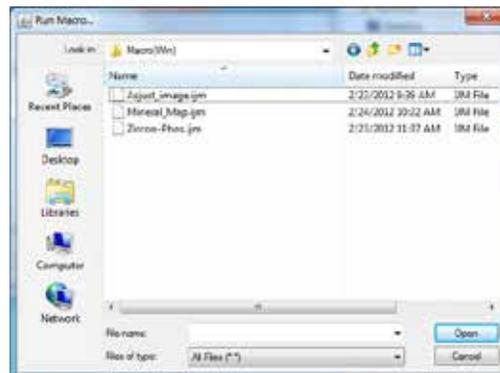
ImageJ. <http://rsbweb.nih.gov/ij/>

1. Image Preparation

1. Gather elemental maps (e.g., tiff files) in same folder.
Al, Ca, Ti, K, Si, Mg, Fe and P images are needed for create mineral and zircon maps.
2. Ensure that all the images are co-aligned in image pixel space.
3. Open ImageJ
4. Find and run the macro “Adjust_image.ijm”.
(Plugins>Macros>Run)



Select “Adjust_image.ijm”



5. Choose the folder where you stored the element maps.
6. Choose a folder where you would like the processed images to be saved.
7. Save all new images with the new name of **Element.tif** (e.g., **Al.tif**).
***The macros will not work if you do not use this filename format.**

Manual Procedure for Adjust_image.ijm macro

Open the original file.

Image>type>8-bit

Image>Adjust>Brightness/contrast

Press Auto

Adjust Minimum to 39

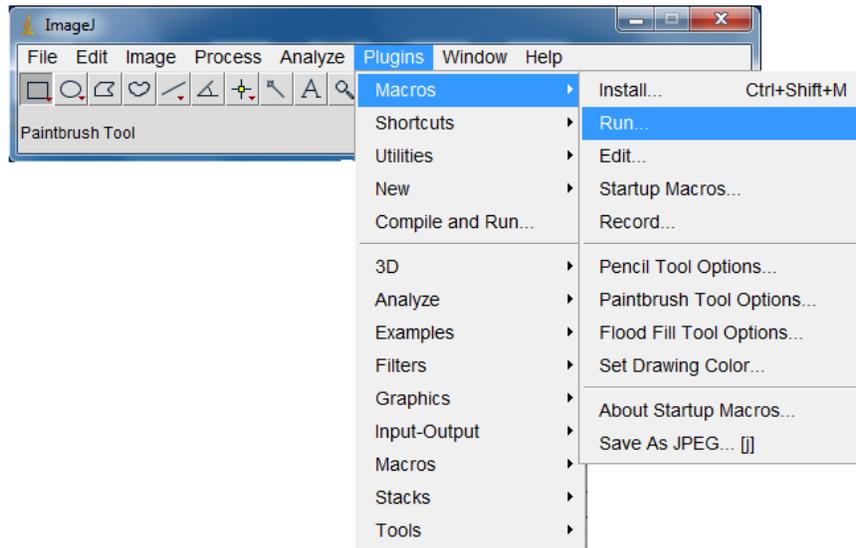
Adjust Maximum to 294

Save the file with new name (Element.tif; e.g., Al.tif)

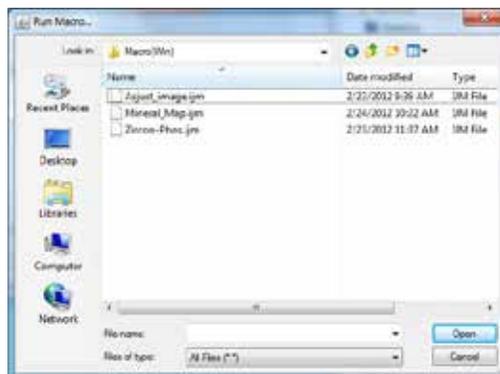
Do for all element maps.

2. Make False-color Mineral Maps for silicates

1. Run the macro “Mineral_Map.ijm”



2. Choose “Mineral_Map.ijm”



3. Choose the folder that includes the new images produced by Adjust_Image.ijm.

*The created Mineral Map is automatically saved in the same folder.

*The following color scheme is applied.

Ti=pink
Al=white
Ca=yellow
K=cyan
Si=blue
Mg=green
Fe=red

Manual procedure for Mineral_Map.ijm macro

File>Open
Open "Al.tif"
Image>Type>RGB color

Image>color>Merge Channels
red=Al.tif
green=Al.tif
blue=Al.tif
*gray=*None**
Check "create composite" and "Keep Source Images"
/Al map turn to white/
Save the file (e.g., Al-color.tif)

File>Open
Open "Ca.tif"
Image>Type>RGB color

Image>color>Merge Channels

red=Ca.tif
green=Ca.tif
*blue=*None**
*gray=*None**
Check "create composite" and "Keep Source Images"
/Ca map turn to yellow/
Save the file (e.g., Ca-color.tif)

Process>Image calculator
Image 1: Al-color.tif
Operation: Add
Image 2: Ca-color.tif

Check the box on "create new window"
Press OK
Save the file (e.g., AlCa.tif)

File>Open
Open "K.tif"
Image>Type>RGB color

Image>color>Merge Channels
*red=*None**
green=K.tif
blue=K.tif

*gray=*None**
Check “create composite” and “Keep Source Images”
/K map turn to Cyan/
Save the file (e.g., K-color.tif)

Process>Image calculator
Image 1: AlCa-color.tif
Operation: Add
Image 2: K-color.tif

Check the box on “create new window”
Press OK
Save the file (e.g., AlCaK.tif)

File>Open
Open “Ti.tif”
Image>Type>RGB color

Image>color>Merge Channels
red=Ti.tif
*green=*None**
blue=Ti.tif
*gray=*None**
Check “create composite” and “Keep Source Images”
/Ti map turn to pink/
Save the file (e.g., Ti-color.tif)

Process>Image calculator
Image 1: AlCaK.tif
Operation: Add
Image 2: Ti-color.tif

Check the box on “create new window”
Press “OK”
Save the file (e.g., AlCaK Ti.tif)

File>Open
Open “Si.tif”

Image>type>RGB color

Image>Hyperstack>Channel Tool

Channel 1 uncheck

Channel 2 uncheck

Channel 3 check

If there is message, press OK.

/Si map turn to Blue/

Save the file (e.g., Si-color.tif)

Process>Image calculator

Image 1: AlCaKTi.tif

Operation: Add

Image 2: Si-color.tif

Check the box on “create new window”

Press “OK”

Save the file (e.g., AlCaKTiSi.tif)

File>Open

Open “Fe.tif”

Image>type>RGB color

Image>Hyperstack>Channel Tool

Channel 1 check

Channel 2 uncheck

Channel 3 uncheck

If there is message, press OK.

/Fe map turn to Red/

Save the file (e.g., Fe-color.tif)

Process>Image calculator

Image 1: AlCaKTiSi.tif

Operation: Add

Image 2: Fe-color.tif

Check the box on “create new window”

Press "OK"
Save the file (e.g., AlCaKTiSiFe.tif)

File>Open
Open "Mg.tif"

Image>type>RGB color

Image>Hyperstack>Channel Tool
Channel 1 uncheck
Channel 2 check
Channel 3 uncheck

If there is message, press OK.

/Mg map turn to Green/
Save the file (e.g., Mg-color.tif)

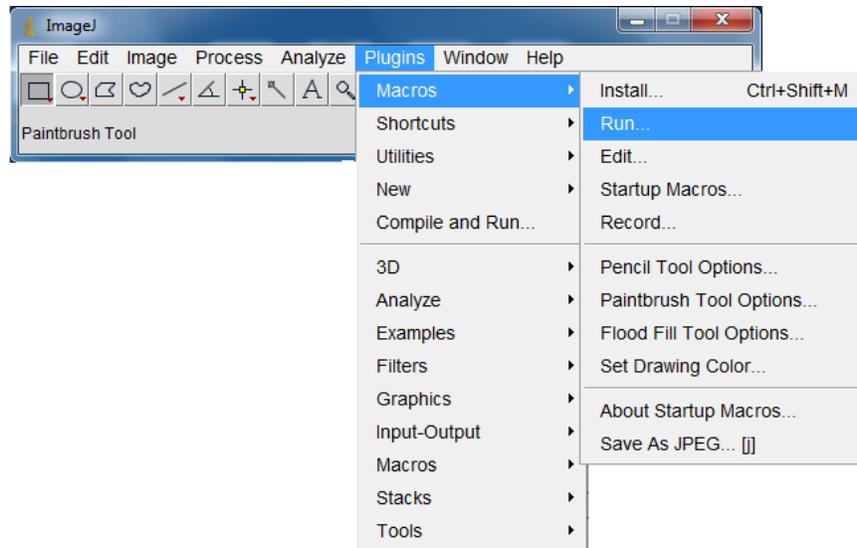
Process>Image calculator
Image 1: AlCaKTiSiFe.tif
Operation: Add
Image 2: Mg-color.tif

Check the box on "create new window"
Press "OK"
Save the file (e.g., AlCaKTiSiFeMg.tif)

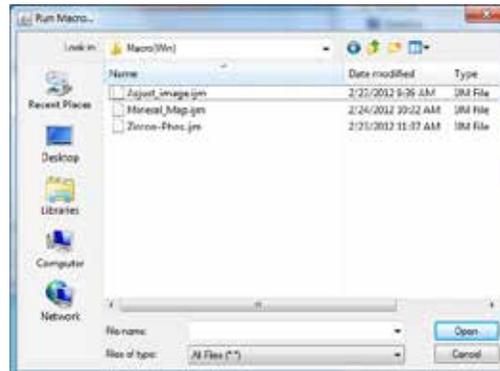
3. Make Mineral Maps for Zr- and phosphate phases.

Because X-ray lines from P (*K lines*), Zr (*L lines*) and S (*K lines*) have close energy peak positions in EDS spectra, there is often a lot of overlap between them making it difficult to distinguish pixel/phases that are either rich in Zr or P. This macro can be used to distinguish these phases and, thus, identify the location of phosphate minerals and zircons and also discriminate sulfide phase (Joy et al., 2011).

1. Run the macro (Plugins > Macros >Run)



2. Choose “Zircon-Phos.ijm”



3. Choose the folder that includes the new images produced by Adjust_Image.ijm.

*The created Mineral Map is automatically saved in the same folder.

*The following color scheme is applied.

Ca=blue
Fe=Red
P=Green

Green: Zirconium bearing minerals such as zircon or baddeleyite

Yellow: Sulfides

Cyan (light blue): Phosphate

Red: Fe-Ni metal

Manual procedure for Zircon-Phos.ijm macro

File>Open

Open "Ca.tif"

Image>Type>RGB color

Open "Fe.tif"

Image>Type>RGB color

Open "P.tif"

Image>Type>RGB color

Image>color>Merge Channels

red=Fe.tif

green=P.tif

blue=Ca.tif

*gray=*None**

Check "create composite" and "Keep Source Images"

Save the file (e.g., Fe-P-Ca.tif)