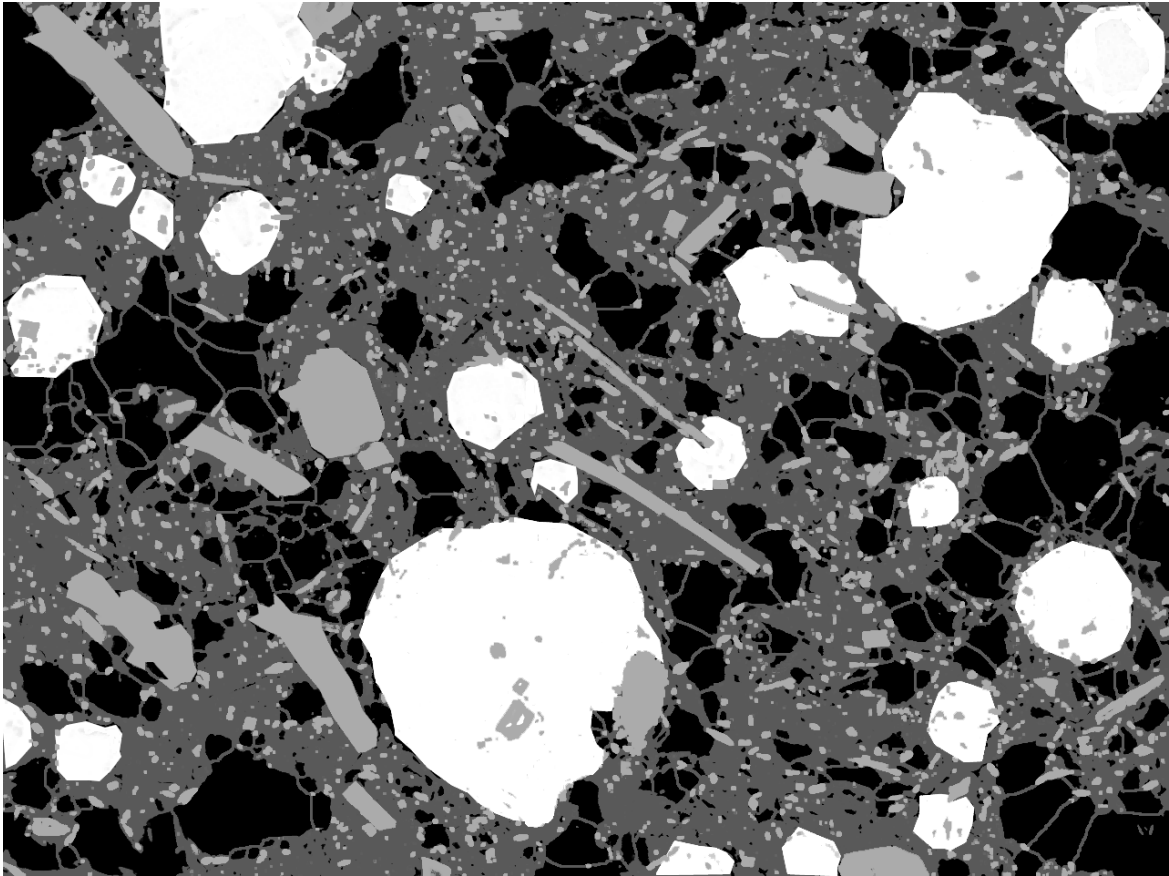


SEM image processing with Photoshop

Tips to make images ready for size analysis



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1. OBJECTIVE

The objective of this manual is ultimately to make SEM images ready for FOAMS. The required input for FOAMS is a set of images with distinct shades of gray corresponding to various analyzable objects (i.e. bubbles, crystals). Shades of gray have values between 0 and 255 (called Digital Numbers=DN). For instance, all bubbles might have a DN value of 0 and the other objects intermediate values between this and white (DN=255).

For example chosen DNs for measured objects can be:

- DN=0 (black) are bubbles
- DN=100 (dark grey) are leucites
- DN=200 (light grey) are glass walls
- DN=255 (white) are other crystals

The absolute DN value is not important since the language FOAMS uses is “what level of grey do I analyze?”. All that matters is that they must be different from each other.

These instructions were designed for Adobe Photoshop® and the applicability of this manual is not guaranteed for other software.

2. STEP-BY-STEP INSTRUCTIONS

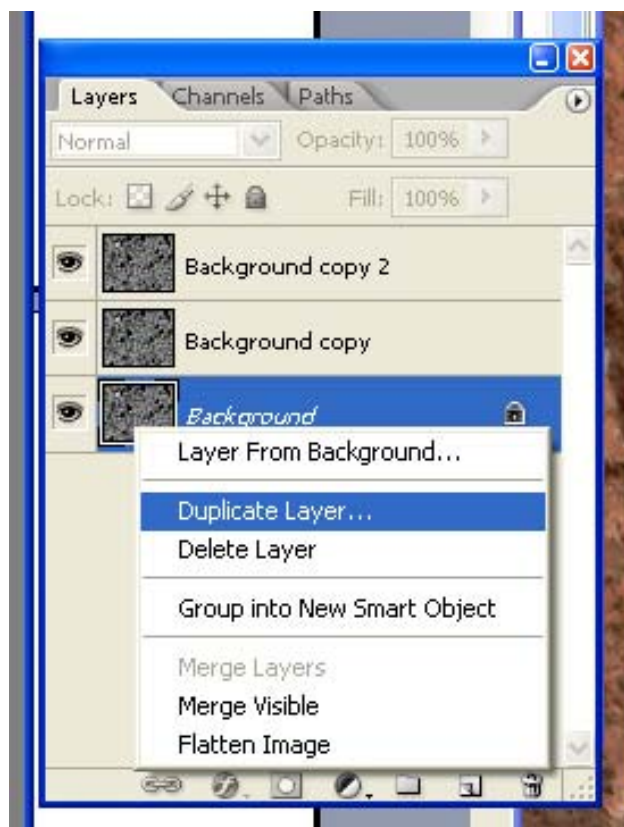
A. Making the image ready

The image is first opened in Photoshop. Most of the time, SEM images are in indexed mode. Less often they are saved as color or grayscale images. Since SEM only displays brightness differences we do not need to work with color. Therefore, the user must convert the image to grayscale:

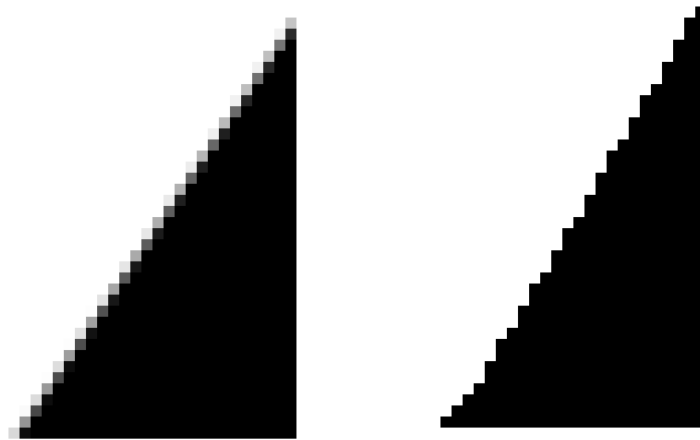
[Image] → [Mode] → [Grayscale]

To facilitate extraction of the various object types from the image, copies of the “background” layer are made. The user should have at least as many copies of the background as the number of different object types. These copies are made using:

**{Right-Click on background layer}
→ [duplicate]**



Important note: All the tools used to draw or select objects have by default ‘anti-aliasing’ checked. This is a useful thing to make nice transitions between boundaries, and who do not wish to have too many edgy pixels. For example, when selecting a triangular area inside a blank image, and using the bucket or the fill function to paint it black, if anti-aliasing is checked into the selection tool (lasso, rectangle, ellipse or polygonal), the edges will appear as though there is a gradient between black and white (see Figure below). This is the anti-aliasing smoothing effect. We absolutely DO NOT want this for our images. In all your selection tools, magic wand and paint bucket, uncheck anti-aliasing.



The effects of anti-aliasing being checked “on” (left triangle) and “off” (right triangle)

B. Obtaining object layers automatically

We will start by making a new layer for our Class 1 (bubbles). To do this, do either:

[Layer] → [New] → [Layer]

or do:

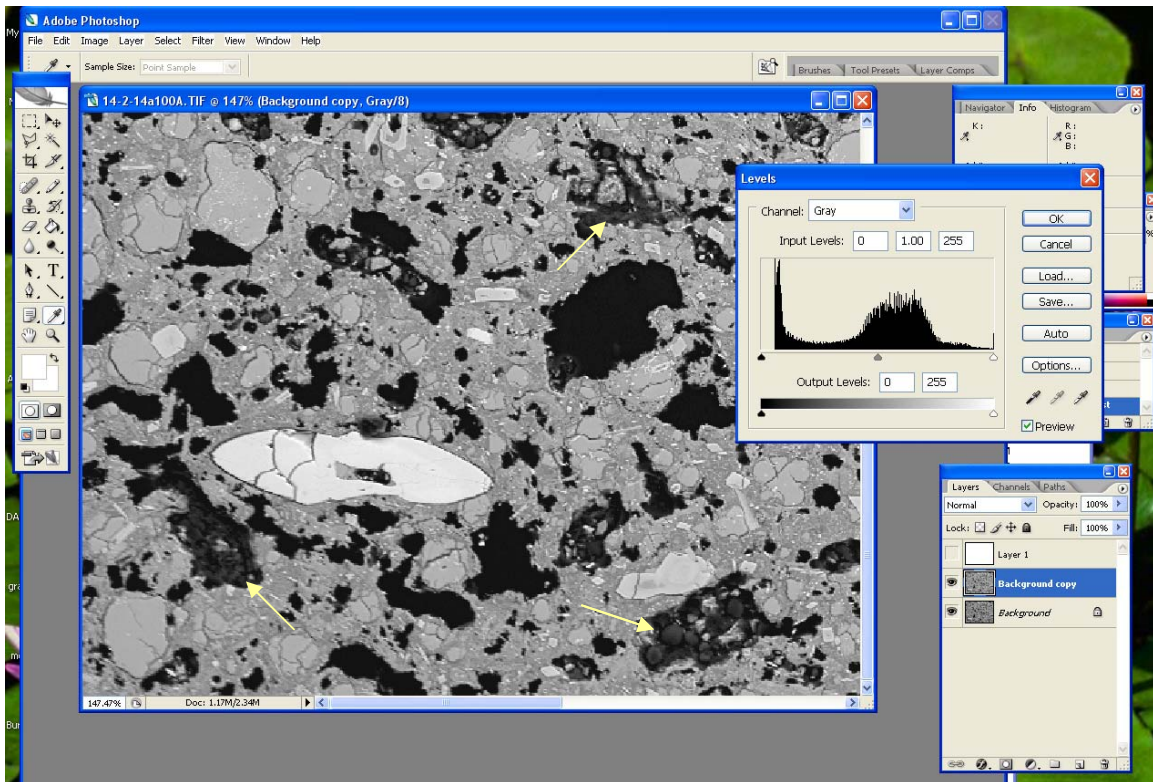
Shft+Ctrl+N

Now rename your new layer (“bubble” for instance). Select one of your background images as your active layer (click on it on the layer window). The grayscale levels need to be adjusted so that bubbles stand out as well as possible.

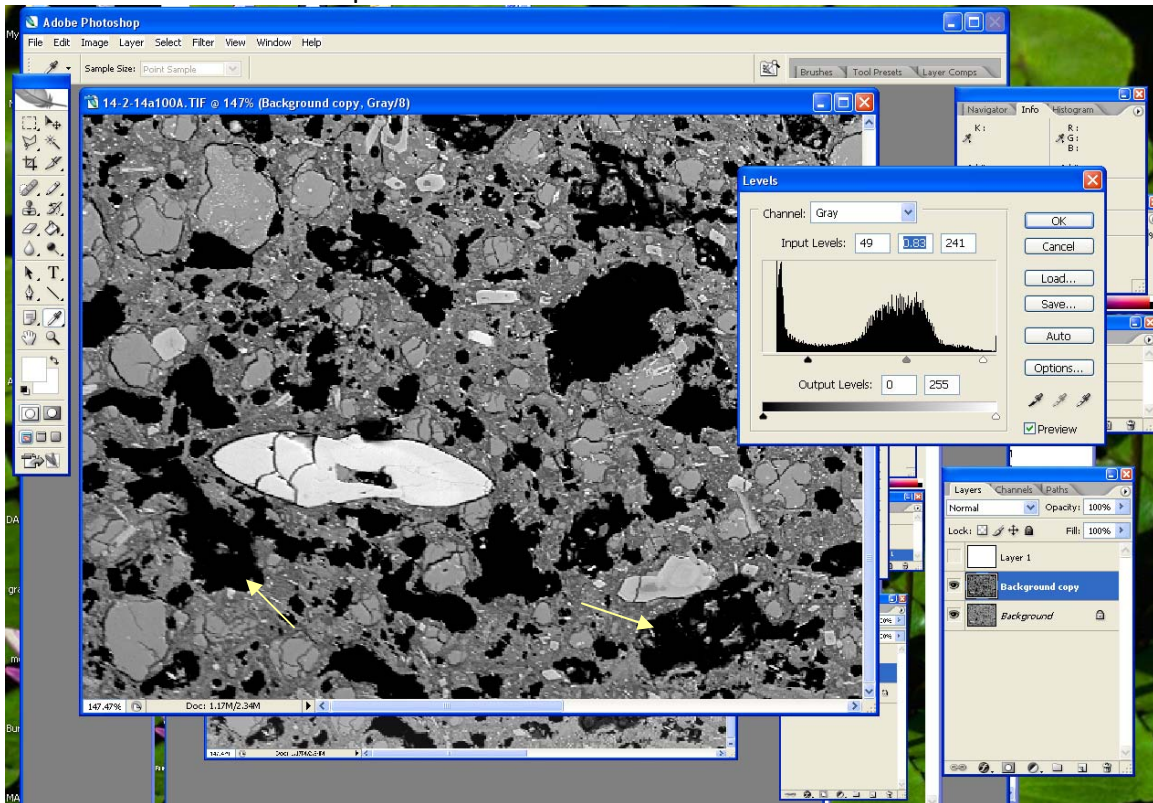
Go to:

[Image] → [Adjust] → [Levels]

and displace your bars to whichever value gives you the best result.



In the image above, some bubbles are often not well imaged (see arrows). In this case, the *left level marker* in the histogram can be displaced to the right and the *light level* to the left. The middle one is positioned to obtain the best result.

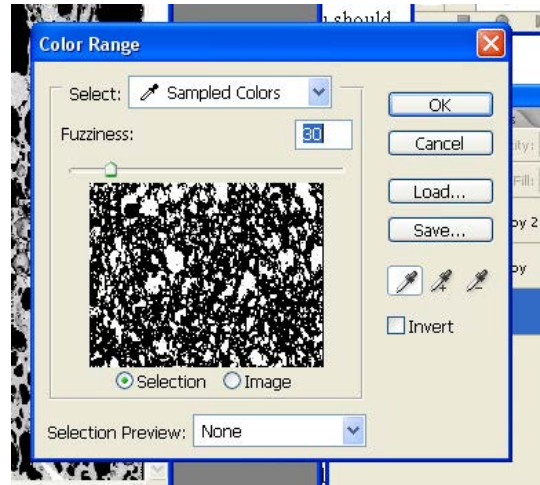


Now these areas are completely black but still have little broken “glass” pieces inside them.

After this is done, bubbles will be selected according to their level of gray. To do this, do:

[Select] → [Color Range]

A small window appears that allows the user to sample a color on the image. The cursor is now an eyedropper. Click on the image into one of these objects (black bubbles). Set the threshold bar named ‘Fuzziness’ located in the small window to a satisfactory level. When set too low, some bubble pixels that are not completely black will not be accounted for. On the preview image the bubbles should now appear as white objects.



To see what is actually selected, press **[OK]**.

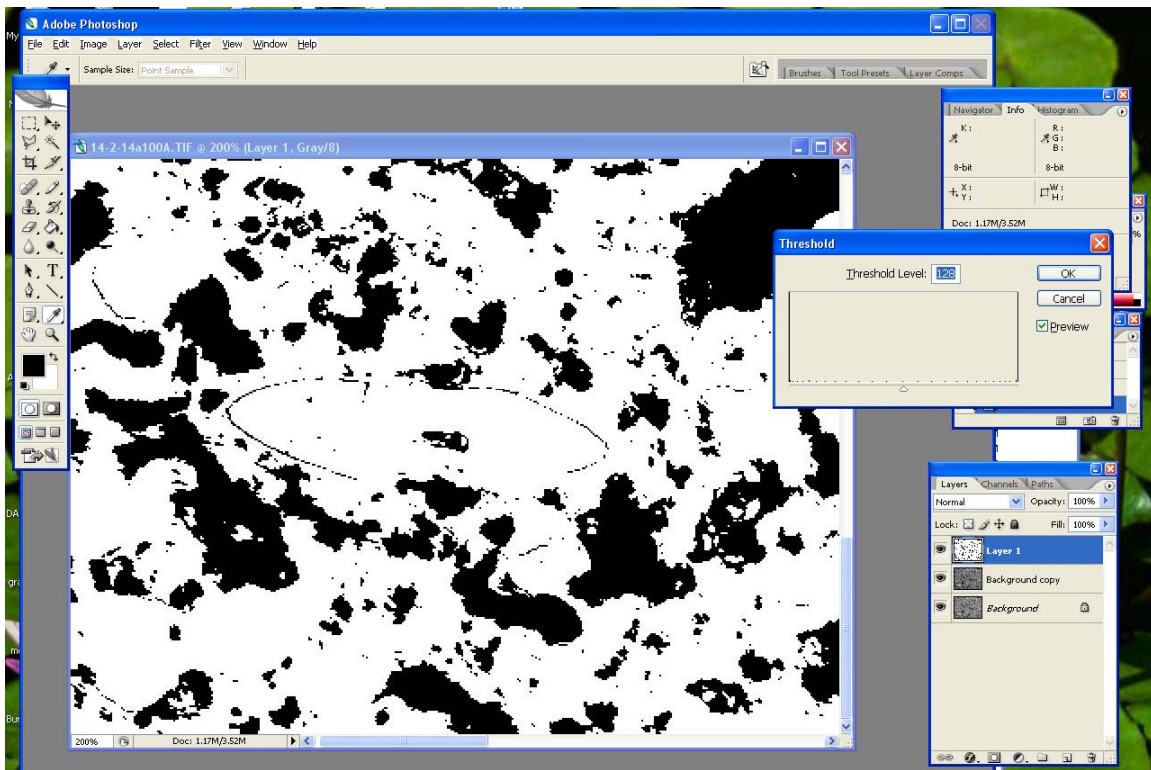
Zoom in on different parts of your bubble borders to see if they have been well included. If you see that some are missing, undo your last step (**Ctrl+Z** to go back one step, **Ctrl+Alt+Z** to go back further steps) and redo with a different fuzziness.

The other quicker way to do it, is to use the magic wand tool. The fuzziness is substituted by ‘tolerance’ which can be set to 20; To ensure that all objects are selected, uncheck the “contiguous” option in the toolbar (and the anti-alias if not already done). Click on any black bubble and the rest should now be selected as well.

Now activate your ‘bubble’ layer by clicking on it. The bubble selection should still be active. Fill your selection with black (DN=0) either using the paint bucket (unchecking *contiguous* in the tool options above) or by doing:

[Edit] → [Fill]

Now your objects should be fully black.



Several issues can be typically noted at this stage if all layers BUT the bubble layer are unchecked. On the image, some thin black contours appear and they are obviously not bubbles but probably crystal contours. We can correct for these now, or later. If only a few of them are present, they should be erased manually for minimum error. If the image is full of such small unwanted areas, there is an easy way to get rid of them by making however a small sacrifice on the accuracy of object boundaries. Do:

[Select] → [Color Range] (or magic wand)

Sample a bubble color. Then do:

[Select] → [Modify] → [Contract]

and choose 1 pixel. This eliminates all the smallest noise objects (in theory!) however note that the selection zones concerning your other objects are also now reduced. Do

[Select] → [Modify] → [Expand]

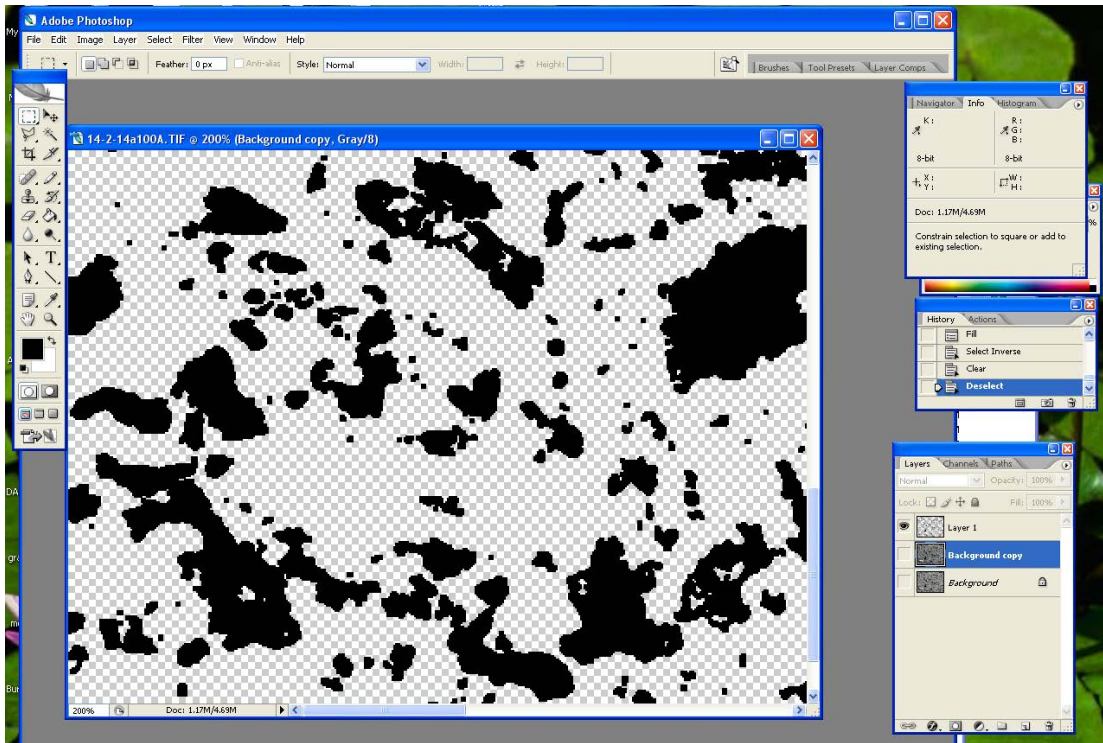
and choose 1 pixel again.

Finally, go to

[Select] → [Inverse]

and delete the areas that were outside your now corrected selection.

The higher the # of pixels used for the contraction/expansion phase, the less coherent your object shapes will be when re-expanding.
Once all of this is done the image should not contain non-bubble areas:



More often than not, glass wall fragments that are not part of a bubble or other heterogeneities can be present within bubble areas. They should be removed by coloring the area in black using the pencil tool (choose an adequate pencil thickness). To identify easily such regions of the image, activate your background and look for portions that need reworking.

C. Making subsequent object layers

This step is necessary when the sample contains more than two phases (e.g. more than glass and bubbles). Often samples contain phenocrysts whose areas have to be discarded from the analysis of bubbles in order to reference them to melt only. If this is the case, make a new layer. Select it, rename it ("crystals" here). Activate your "background crystals". If there is a significant number of large crystals, do [\[levels\]](#) and the rest of the automatic selection procedure described above. If only few are present they can be easily contoured and filled using selection tools.

D. Manually selecting the rest of the objects

These are the objects that cannot be distinguished from one another only by brightness differences (for example a leucite or plagioclase crystal and volcanic glass) and the image contains a substantial number of them. These need to be contoured and filled. Any way is good to do this. We generally follow this procedure:

Make a new layer. Activate. Use the polygonal or another lasso selection tool and fill. As it can be bothersome to always have to use the mouse to get to the different menus I strongly advise the use of macros. For example, I use the F2 key to fill objects instead of going to the menus.

To make a “fill” macro:

- Select any kind of object on any image in Photoshop
- Choose any color in the color selection window
- Go into your Actions window and click on the little icon that says **[New Action]** or on the black triangle to the right. It will ask you which Function key you wish to assign to your macro, I selected F2 for instance. I named my action 'Fill'.
- Press **[Record]**, this will start the recording of any further action in Photoshop.
- Now as a selection is active do **[Edit] → [Fill]**.
- On the actions window, press the black square to stop recording.
- The macro should now work, and F2 can be used to fill.

This is just an example and any other key or action can be made to accelerate the process.

E. Creating the “glass” layer

This layer should represent all the background stuff that will not be analyzed in FOAMS. In our case these are the glass walls corresponding to the areas that are neither bubbles, nor crystals.

- First create a new layer name “glass”. Deactivate it.
- Make duplicates of each of the other layers that contain the different objects (crystals, bubbles...).
- Activate only the object duplicates and deactivate everything else.
- In each copy, use the magic wand or the select color range tool to select all objects. Fill them all in black. Everything except the background should now be black.
- Now merge the visible duplicates together with [\[Layer\]→\[Merge Visible\]](#).
- Then either do a magic wand on a black area or select color range, and go to [\[Select\]→\[Invert\]](#).
- Activate the new “glass” layer you created and do a fill with the color you chose for your base object (ex: light gray). And Voila! You can delete the duplicate layer created with merged objects.

F. Putting it all together

Layers should be organized before making the final merge. To change their order (top to bottom), just displace them into the layer window. In our case we have:

- Crystals (white)
- Leucites (dark grey)
- Glass (light grey)
- Bubbles (black)

At this stage, especially in the case of pumice, some glass wall reconstructions need to be performed.

G. Reconstruction

Use the pencil tool for glass wall reconstruction since it is devoid of any anti-aliasing and smoothing. This is a long and tricky part. Unfortunately no automation can come to our rescue here.

Because you are going to want to often make the layer you are modifying visible/invisible to compare with the background layer (which you should leave visible at all times) a good thing to have at that point is a macro to be able to toggle views with your keyboard. To generate such a macro:

- make the current active layer invisible but still activated
- create another action just like you did for your F2 'fill' function
- name it 'visible' for example and choose the F3 function key
- now press OK, it will start recording your actions
- go to the **[Layer]** menu and select **[show layers]** your layer should be visible now
- on the little actions windows press the little blackish square to stop recording
- now do the same except that you start with your layer being visible and choose the F4 function key
- when it records choose **[Layer]** and **[Hide layers]**
- stop recording and test your F3 and F4 toggling visible/invisible

Another way to have the background somewhat visible is to make the glass layer transparent (60% opacity or less).

H. The final image

When you feel all reconstructions/corrections are done, save another version of your work as a merged image of only the objects layers generated and the glass layer. To do do **[Layers] → [Merge visible]**. Now save your work again but this time as a .tif document with the extension 'merged'.

Some helpful shortcut keys and clicks:

Deselect all: Ctrl+D

Undo: Ctrl+Z

Undo previous: Ctrl+Alt+Z

Make new layer: Ctrl+Shift+N

Levels: Ctrl+L

Choose the Pencil tool: N

Choose the Lasso tool: L

Zoom in: Alt+Mousewheel up

Zoom out: Alt+Mousewheel down

Pan Horizontally: Ctrl+ Mousewheel up (left) or down (right)

Pan Vertically: Mousewheel up or down

REMEMBER TO SAVE YOUR WORK VERY OFTEN!