DEVELOPING A PROTOCOL FOR BSE IMAGE MAPPING OF ENTIRE THIN SECTIONS USING A PHENOM XL SEM

Fíona C. McGroarty, Elizabeth A. Johnson, Ron Phillips

James Madison University, Department of Geology and Environmental Science, Harrisonburg, VA, USA

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mcgroafc@dukes.jmu.edu

Abstract

Scanning electron microscopes (SEMs) are commonly used to image objects at a magnification beyond the range of a standard microscope. In this study, we developed a protocol to take a series of BSE (back-scattered electron) images of a thin section that are stitched together using photo-stitching software. This technique was developed to determine mineral modal abundances in two thin sections of anorthosite xenoliths from a Jurassic basalt sample from Augusta County, VA. The mineral abundances and compositions will be used to understand magmatic underplating and the evolution of a magma chamber in the region at the time. We used a Phenom XL SEM and the Phenom Pro Suite Image Mapping software to take a series of small pictures of each thin section. Taking a picture of a standard thin section at 380x magnification will create over 2000 tiles to stitch, leading to problems using the photo-stitching software. When we used Microsoft Image Composite Editor (MICE), the software could only work with a maximum of 750 images, leaving holes throughout the thin section image. We found that the best method of collecting images was to divide the thin sections into quadrants and image map each quadrant individually. Each quadrant was mapped at 370-380x magnification, at 10kV. Although there were fewer images using this method, MICE was still only able to stitch about ¼ of the images at a time, leading to experiments with Autostitch and Photostitcher. The completed images were entered into Image Color Summarizer, a color percentage calculator, to determine the percentage of each mineral in the thin section quadrant. The results for the first thin section found 67.29% feldspar, 11.06% pyroxene, and 21.60% minerals produced by reaction between the xenolith and basalt. Future work will include completing the mineral compositions for all thin section quadrants and using the modal abundances and whole-rock chemical data to determine the relationship between the basalt and anorthosite xenoliths.

Introduction

This project is part of a study to understand the evolution of a Jurassic magma chamber, about 152 Ma, under Augusta County, Virginia (Mazza et. al, 2017). Eruptions from this magma chamber occurred in Virginia and West Virginia during this time. Using Phenom XL SEM back-scattered electron (BSE) imaging will yield a highly detailed, magnified image of thin sections taken from basalt and anorthosite xenoliths in basalt samples in Augusta County. The Phenom XL SEM was selected because of its versatility and ability to hold more than one sample at a time. The images are then stitched together in order to obtain a more accurate mineral composition and abundance of the xenolith, while will be used to help understand the evolution of the Eocene Virginia magma chamber.

Figure 1. SEM lab at JMU with a Phenom XL SEM.

Methods & Data

1. A BSE image of the entire thin section was taken.

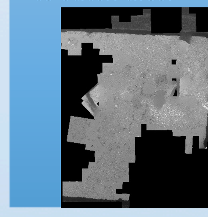
2. Time to take image was >36 hours. Thin section was then divided into quadrants to reduce imaging time.

3. Images taken using settings in following table. About 700 tiles per thin section quadrant.

SEM Imaging	Setting
Mode	High resolution (10 kV)
Vacuum	Low (60 Pa)
Intensity	Image
Detector	BSD Full
Resolution/ Quality	2048 - Best
Magnification	540x

4. Image tiles stitched using Microsoft Image Composite Editor (MICE).

5. MICE unable to stitch tiles.



6. Image tiles stitched using AutoStitch software.

7. AutoStitch unable to stitch tiles.

8. Image tiles stitched using Photostitcher.

9. Photostitcher unable to stitch tiles. Error when attempting to stitch.

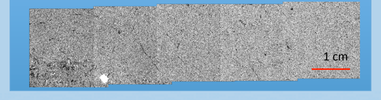
10. Thin section quadrants re-imaged using settings in Table 2. About 300 tiles per quadrant.

SEM Imaging	Setting
Mode	High resolution (10 kV)
Vacuum	Low (60 Pa)
Intensity	Image
Detector	BSD Full
Resolution/ Quality	2048 - Best
Magnification Overlap	300x 10% overlap

11. Tiles stitched using Gigapan Stitch. Gigapan Stitch unable to stitch images.

12. Tiles hand aligned and stitched using PowerPoint to save tiles as one image.

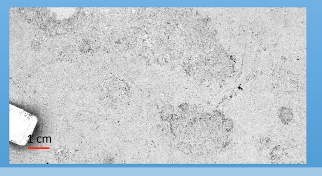
13. Hand-stitched images



14. Brightness/contrast adjusted to make aligning tiles easier for the computer. Lower brightness, higher contrast used. No quantitative settings for this adjustment on Phenom XL SEM. Image overlap set to 10%.

15. Images stitched using Phemon XL SEM software.

16. Quadrant of a thin section.



17. Image uploaded to Image Color Summarizer to determine mineral abundances. 10 color image selected, medium quality

18. Output from Image Color Summarizer

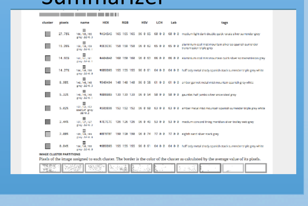


Figure 2. Flowchart outlining the methods and process of this project.

Results

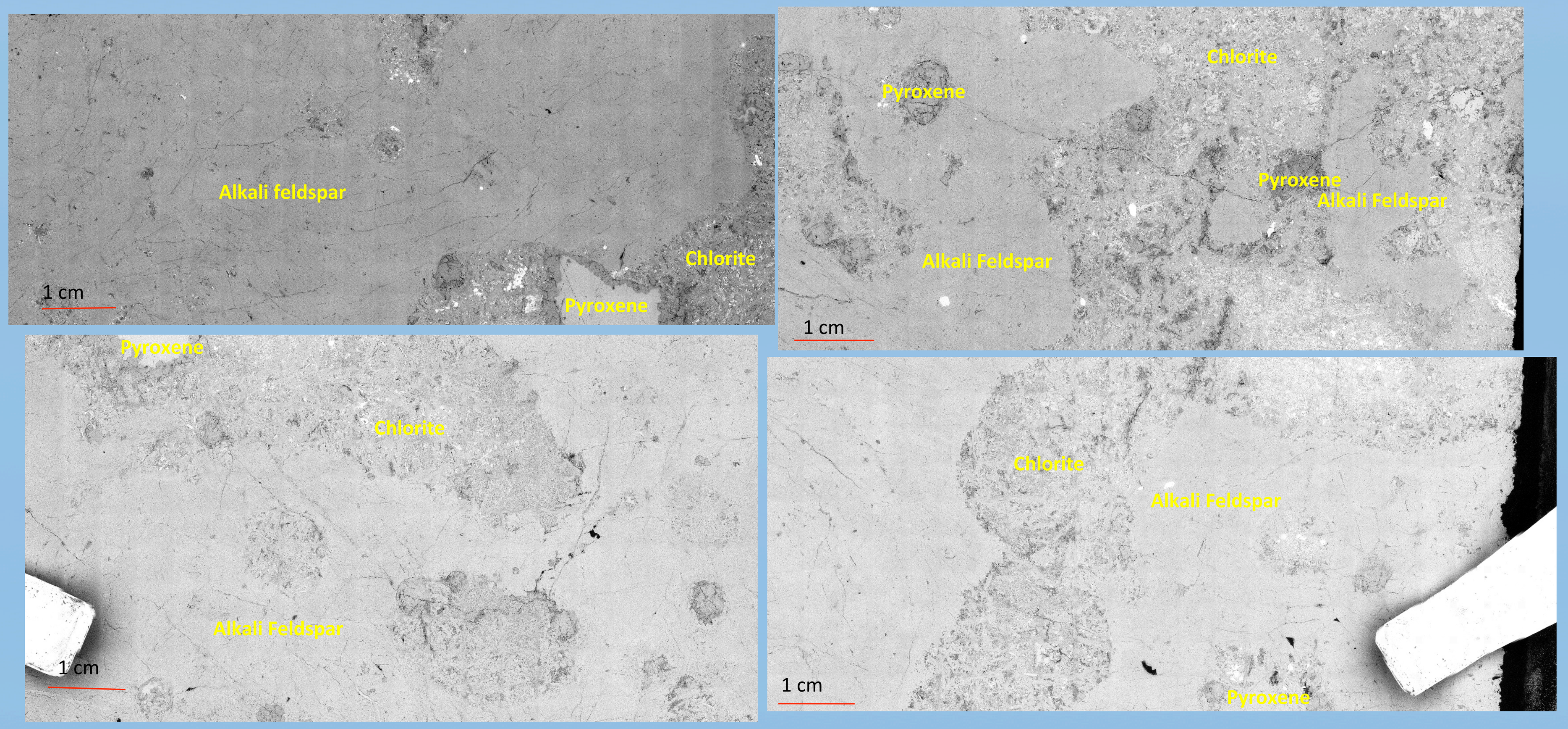


Figure 3. Completed imaging of a thin section. Each image represents one quadrant of a thin section, and are aligned in their relative positions as laid on the thin section.

Discussion

The Phenom SEM automatically stitches the tiles together, but this file is unreasonably large and cannot be opened on most standard computers. Each thin section took over 48 hours to image and resulted in over two thousand images to stitch, so it was more efficient to break the thin section into quadrants to image. A magnification of 430x was first used, and then replaced with one of 300x. Despite this, the images still yielded too high a number to stitch using Microsoft Image Composite Editor (ICE). The files resulted in a convoluted, garbled image with holes and incorrectly aligned images (see results). Autostitch was also used, but with the same results. The best results were from aligning the images by hand. Alternatively, if a more powerful computer is available, the automatically stitched images may be a feasible option; however, these are not reliable for standard computers and are not recommended for use.

Using Image Color Summarizer (ICS) yielded the mineral abundances of 67.29% feldspar, 11.06% pyroxene, and 21.60% of chlorite and other minerals produced by reaction between the xenolith and basalt. Since ICS included the colors in the sample holder and the background region around the sample, the results had to be normalized to remove those percentages and account for the difference in percentages of the actual composition materials. In addition, since some minerals were assigned more than one color depending on how their orientation affected their appearance in the SEM, the results had to be sorted and combined manually after removing the non-mineral colors to calculate the actual abundances.

The best methods to photograph a thin section using an SEM were found to include photographing the image in high resolution but low magnification. High contrast worked better than low to align the tiles, with brightness set to make the image details clearly visible. Hand stitching remains the best option to align the images, although the most recent Phenom XL SEM software update includes a way to automatically stitch the images which may be possible to install on the SEM.

References

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Callan Bentley,
Robin Rohback
Department of Geology
Northern Virginia Community College
Woodbridge, VA, USA