Method Development for the Measurement of Water in Plagioclase using Fourier Transform Infrared (FTIR) Spectroscopy

DEPARTMENT OF GEOLOGICAL, ENVIRONMENTAL, AND PLANETARY SCIENCES

Lydia Kendzierski

GEOL394

Advisor: Dr. Megan Newcombe, Mentors: Madelyn Sita, Sumedha Desikamani

Introduction

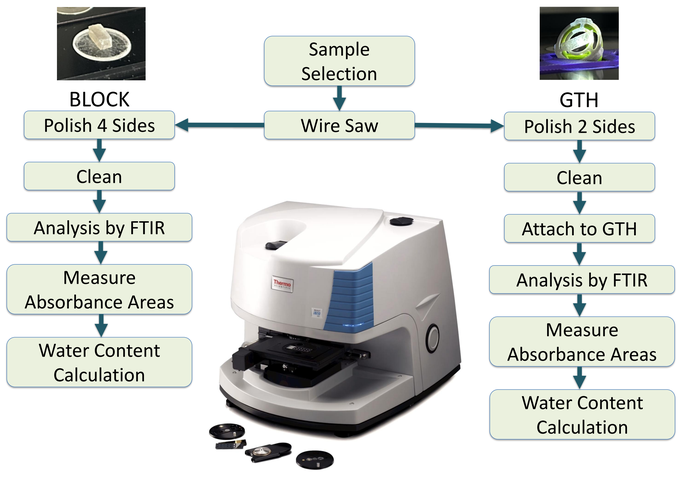
Measuring H_2O in plagioclase is useful for constraining water in magma and understanding the water budget of meteorites. Current methods involve extensive sample preparation making it difficult to create and analyze a large number of samples. The goal of this project was to develop an easier method for measuring the water content of plagioclase using FTIR spectroscopy.

Hypothesis

H_0: Using a FTIR spectrometer, the total water content determined from measuring 3 perpendicular directions within a slab of plagioclase on a tetrahedron holder, and the water content found from measuring 3 perpendicular directions of a polished block, will be the same.

Methods

Figure 1: The Process & Beer-Lambert Equation



$$C_{H_2O}\ (\text{ppm}) = \frac{A * mw}{\rho * d * \varepsilon} * 10^6$$

area of absorbance peaks; molecular weight of water; density of plagioclase; beam path length; molar absorbance coefficient

Results

Figure 2: Block Method and GTH Method

The top two images (O1 and O2) are the two orientations used in the Block method. The bottom image (GTH) is the Gies Tetrahedron Holder (GTH) on 3D printed stage plate with crystal attached on the lid used for the GTH method.

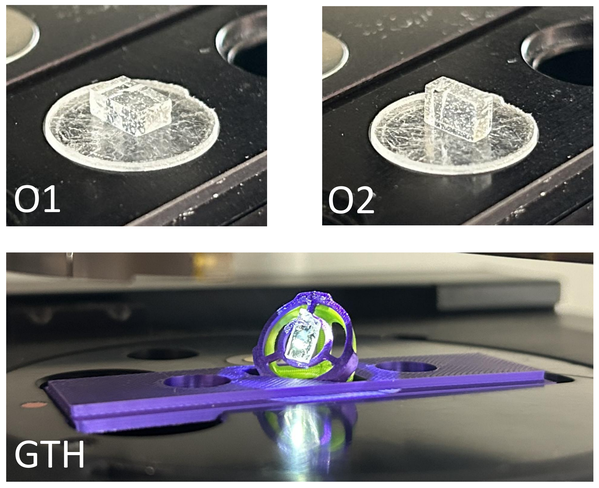


Figure 3: Block Method vs. GTH Method Spectra

This are spectra from the Great Sitkin Island, AK anorthite sample. The block method is the spectra on the left. The top spectrum is Orientation 1 (O1) 0° polarized light (0°P), followed by O1 90° polarized light (90°P), then Orientation 2 (O2) 90°P. The GTH method is on the right. The top spectrum is O2, middle is O1, and the bottom is Orientation 3 (O3).

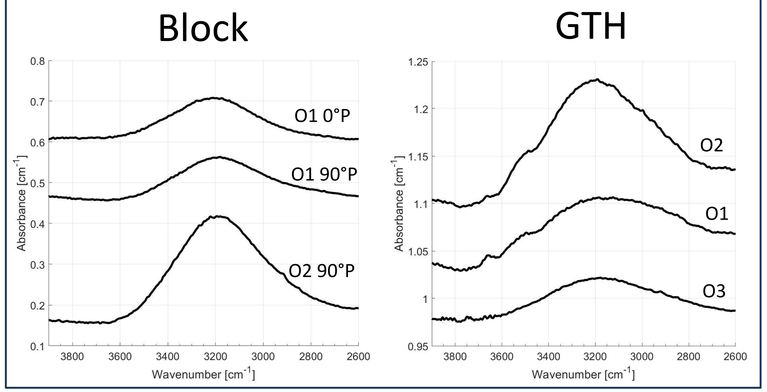
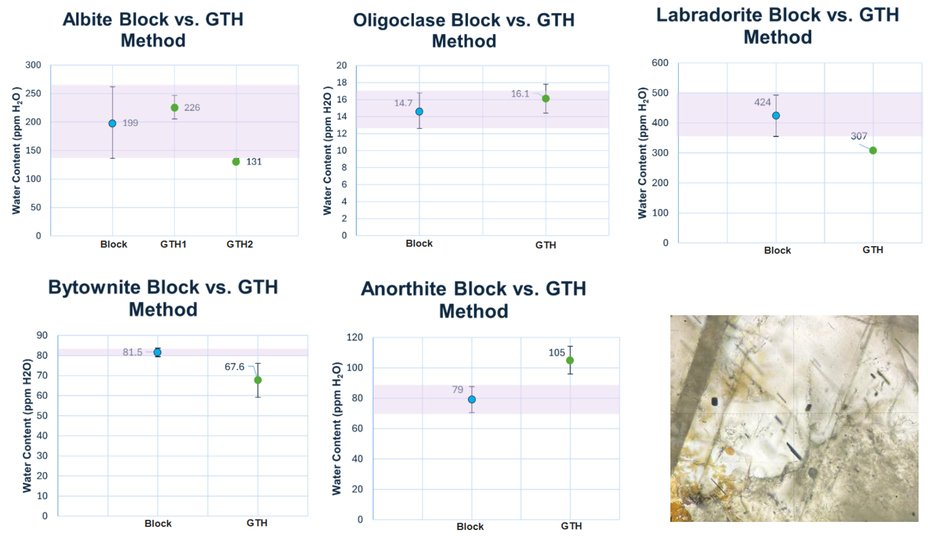


Figure 4: Method Comparison for all Compositions

The purple area is the acceptable range for the water content for each composition determined by the block method. The bottom right image is of the labradorite sample which includes inclusions that are microns in size.



Conclusions

- Only the oligoclase GTH value is in agreement (2σ uncertainty) with the block method value.
- The albite sample was riddled with fluid inclusions and was found to be heterogeneous. The labradorite when investigated under the microscope, was found to have many inclusions and phases present (**Fig. 4**). These samples were not suitable for this method and were excluded from the percent comparison.
- All samples without fluid inclusions or inclusions were found to be within ~33% of the block method. Other methods, like the Kovacs method, have a ~20% uncertainty when using 10 slabs.
- Future work to assess the effect of heterogeneity will include the testing of more slabs from a sample and the use of the block for both the GTH method and the block method.

Acknowledgements and References

Kovacs, I., Hermann, J., O'Neill, H. S. C., Gerald, J. F., Sambridge, M., & Horváth, G. (2008). Quantitative absorbance spectroscopy with unpolarized light: Part II. Experimental evaluation and development of a protocol for quantitative analysis of mineral IR spectra. *American Mineralogist*, *93*(5-6), 765-778.

Mosenfelder, J. L., Rossman, G. R., & Johnson, E. A. (2015). Hydrous species in feldspars: A reassessment based on FTIR and SIMS. *American Mineralogist*, *100*(5-6), 1209-1221.

Johnson, E. A., & Rossman, G. R. (2003). The concentration and speciation of hydrogen in feldspars using FTIR and 1H MAS NMR spectroscopy. *American Mineralogist*, *88*(5-6), 901-911.

Johnson, E. A., & Rossman, G. R. (2004). A survey of hydrous species and concentrations in igneous feldspars. *American Mineralogist*, *89*(4), 586-600.

Thank you to my advisor, Dr. Megan Newcombe, my mentors, Sumedha and Maddy, and all my friends, family, and loved ones for their support.