Qualitative Differences in Mineral Composition via Spectroscope Analysis

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Introduction

Whatcom Community College (WCC) was recently gifted a Vreeland Spectroscope (*Figure 1*), which by burning a sample with an electric arc can identify its elemental composition by analyzing its associated emission spectrum (*Figures 2 and 3*).

Our goal was to determine methods to differentiate similar minerals and develop strategies to discern the elemental composition of unknown samples using the spectroscope.

We chose feldspar because they are one of the most common rock-forming minerals (Reitze et al., 2020). They also always contain silicon (Si), oxygen (O), and aluminium (Al); mainly differentiated with varying amounts of calcium (Ca), sodium (Na), and/or potassium (K) (*Figure 4*). This constrained us to a maximum of two elements to verify. This compositional variation depends on the temperature and elemental abundance of the magma from which it crystallized (Klein et al., 1985).

Figure 1 (left). Our Vreeland Spectroscope Model 6A.

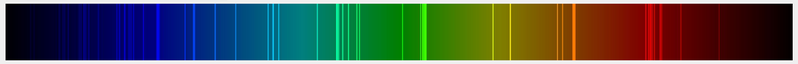

Figure 2 (bottom). An example emission spectrum. This is for pure calcium.
McZusatz (2013) Calcium spectrum; 400 nm - 700 nm. *Wikimedia Commons.*

Methods

We utilized the spectroscope to examine the emission spectra of our various samples.

Because the machine uses Na spectra for aligning the films, we volatilized table salt (NaCl) to determine how this baseline of Na would affect the analysis. We found that there was no adverse effect on our suspected levels of sodium.

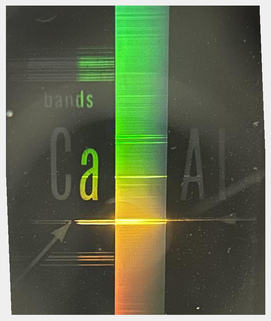

Figure 3 (left). Partial view of calcium spectra visible from Sample 3.

Figure 8 (right). A sample is loaded on carbon film and ceramic hearth.

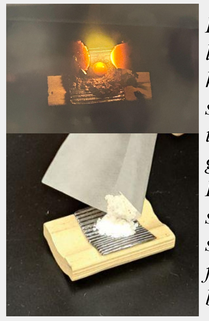

Figure 6 (top left). The arc heating a sample through the welding glass shield. Below the arc, a small amount of sample has formed a glass bead.

Feldspar Ternary Diagram

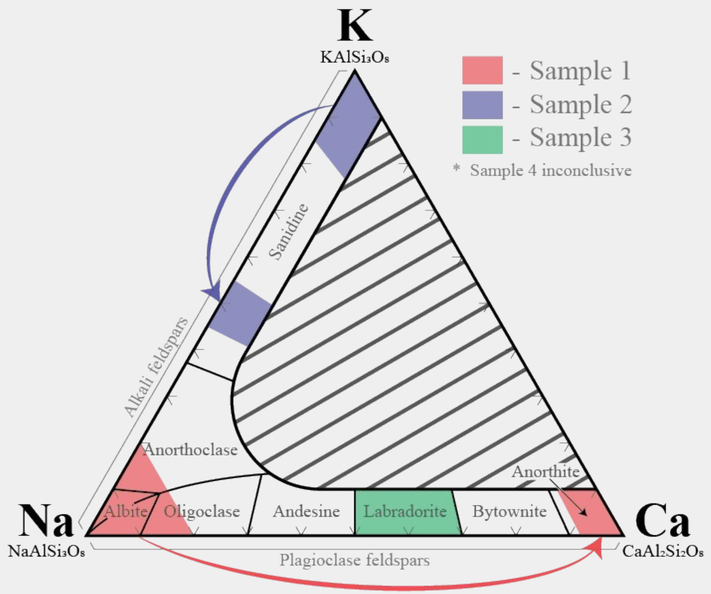

Figure 4. A molecular percentage ternary diagram for feldspar. Colored regions plot the initial suspected sample locations and their approximate locations after testing. Arrows show change in assumed composition. Adapted from Klein et al., 1985.

Figure 7. Our three feldspar samples in order from left to right: Sample 1 (suspected alkali feldspar), Sample 2 (suspected plagioclase feldspar), and Sample 3 (suspected labradorite), all provided by WCC. Sample 4 displays a suspected shale from the Chuckanut Formation, collected at Racehorse Falls of an unknown composition.

Limitations

The spectroscope cannot make quantitative measurements.

The strength of the emission spectra depends on the brightness of the arc, which can vary and make qualitative comparison of element abundance difficult.

References

Klein, C., Hurlbut, C. S., & Dana, J. D. (1985). *Manual of Mineralogy: (after James D. Dana)*. Wiley.

Reitze, M. P.,Weber, I., Kroll, H., Morlok, A., Hiesinger, H., & Helbert, J. (2020). Mid-infrared spectroscopy of alkali feldspar samples for space application. *Mineralogy & Petrology*.

Discussion

Our results conflicted with our hypotheses for Samples 1 and 2, while they supported Sample 3 being labradorite (*Figure 4*). Knowing the mineral compositions of each sample allowed us to approximate the formative magma temperature and rock type for each sample (*Figure 5*).

For example, Sample 1 is Ca-rich plagioclase feldspar which crystallized in a high-temperature, mafic magma, while Sample 2 is an alkali feldspar which came from a low-temperature, felsic magma (*Figure 5*).

Discerning feldspar mineral compositions via spectroscope analysis plays a vital role in understanding the minerals that make up more than 50% of the volume of Earth's crust (Reitze et al., 2020).

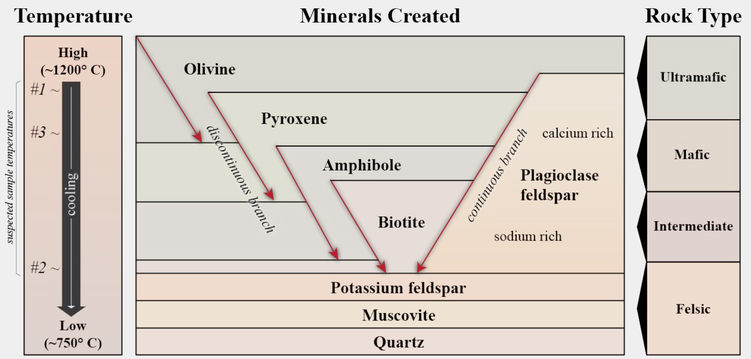

Figure 5. Bowen's Reaction Series. Adapted from NASA JPL (2024) Modeling Silicates and the Chemistry of Earth's Crust . *NASA JPL.*

Further Research

We found that all but one of our samples formed glassy beads when volatilized (*Figure 6*) that would short the arc when they touched. Finding the cause was beyond the scope of the project.

We attempted to identify a completely unknown sample we collected from Racehorse Falls (*Figure 7*), but our tests were inconclusive. Further development of identification strategies for unknown samples is recommended.

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