Geochemical Evolution of the Akaroa Volcanic System in View Hill, Banks Peninsula

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Abstract

View Hill, Banks Peninsula contains a unique volcanic history that can be pieced together with geochemical analysis. View Hill contains volcanic features such as two Ridges on the northern and southern endpoints composed of lava flows, a Fissure, Trachyte Dome, and lava flows above the Trachyte Dome. This study analyzed one field location that correlated the Northern Ridge and lava flows near a Trachyte Dome to previously studied features within View Hill. Major and trace element analysis through X-Ray Fluorescence Spectroscopy (XRF) revealed trends and rock types that helped to correlate the Northern and Southern Ridges, as well as begin to identify the relationship between the Fissure, Trachyte Dome, and the lava flows above that appear to crosscut each other. This geochemical analysis reveals the evolution of the Akaroa Volcanic System within View Hill with major and trace element geochemical data analysis.

Introduction

Geochemical analysis is a powerful tool in establishing the identification and interpretation of volcanic environments. While studying physical geology offers loose interpretations from observing volcanic deposits, geochemical analysis can provide a greater understanding of rock samples' origin through major and trace element data. Furthermore, geochemical analysis allows for an in depth correlation of lava flows. Considering the ratios of major and trace elements, respectively, helps date lava flows and describe their magmatic history. The analysis of these ratios helps decipher eruptive behaviors and their evolution. Study of these eruptive behaviors and structures, and specifically their evolution, are analyzed at View Hill, Banks Peninsula, New Zealand.

View Hill is a part of the Akaroa Volcanic System, composed of rocks dating back to 8-9 million years old (Sewell 1988). Many studies have examined View Hill in specialized sectors and identified many features through extensive mapping and geochemical analysis. Scoria deposits have been discovered along with dike intrusions (Rosen 2013). Continued mapping through this study revealed the location of a scoria cone. View Hill also experienced the creation of a trachy-andesitic dome, while the remaining area is encompassed by extensive lava flows (Eisenberg 2013). However, no work has been conducted to correlate the lava flows and other eruptive features to provide a detailed account of the volcanic evolution of View Hill.

This study aims to reveal the overall volcanic history of View Hill. This study undertook a specific field location at View Hill to collect mapping information and geochemical data. By taking previous research done on View Hill, the lava flows will be stratigraphically correlated using geochemical data analysis of major and trace element ratio trends. This study serves to reveal the volcanic evolution of View Hill by correlating the lava flows and other eruptive features through geochemical analysis.

Geologic Setting

Banks Peninsula is located on the East Coast of New Zealand's South Island and is composed of two volcanic complexes formed during the Miocene era. The composite shield volcanoes that formed were the Lyttleton Volcanic System (11-9.7 Ma) and the Akaroa Volcanic System (9-8 Ma). The Akaroa Volcanic System is located in the southeastern sector of Banks Peninsula (Sewell 1988). The volcanic systems formed as a result of intraplate volcanism that led to aesthenospheirc upwelling (Timm et. Al 2009).

View Hill is a field area located in the north-east region of Banks Peninsula (Figure 1a). View Hill is composed of extensive lava flows, scoria deposits and cones, a trachyte dome, dikes, and a fissure (Eisenberg 2013, Hampton and Cole 2009). The lava flows range in composition from picritic basalt, hawaiite, to mugearite with some trachyandesitic inclusions as well. View Hill consists of two intersecting ridges composed of basaltic lava flows and welded scoria layers that crosscut to meet the trachyte dome (Rosen 2013, Portner 2013). Figure 1b shows the volcanic features in retrospect to each other. This study aims to describe their evolution and eruptive sources.

Methods

Along with detailed field mapping, rock samples were taken from View Hill and narrowed down to 31 samples for preparation of geochemical analysis. The samples were taken sequentially from each lava flow to provide a better correlation of the stratigraphy. Rock samples were cut then crushed into fine powders for major and trace element analysis. The powders were prepared into glass fusion beads for major element analysis and created into pressed powder pellets for trace element analysis. The powders were put through X-Ray Fluorescence Spectroscopy (XRF) through a Philips PW2400 Sequential Wavelength Dispersive X-Ray Fluorescence Spectrometer by lab technicians at the University of Canterbury (Johnson 2012). Geochemical trends were analyzed by using Igpet 2013. Previous geochemical data of other field areas within View Hill were included to further study and identify chemical trends. Georeferenced air photos from Google Earth were overlain with field coordinates of sample waypoints on ArcMap. CorelDraw helped create figures. Using geochemical data along with geomorphological imagery, the stratigraphic correlation of the lava flows and other eruptive features were determined through inspection of the imagery and chemical analysis.

Results

Transect Rock Type Identification

Geochemical analysis of Transect 1 revealed silica contents ranging from 47-53 wt % and total alkali content of 6-8 wt % indicating compositions of hawaiite and mugearite. The overall chemistry of the samples did not vary greatly, highlighted in a stratigraphic diagram through Figure 2a. In comparison, this appears unusual with other transects containing more notable changes in chemistry, and is discussed in further detail in later sections of this project. Transect 2 is separated into three different categories: scoria, lava flows, and dike samples. The scoria samples range in silica content of 49-51 wt % and total alkali content of 6-7 wt % composing of two hawaiite and one mugearite samples. The lava flows range in silica content of 45-50 wt % and total alkali content of 4-8 wt % with compositions such as picrite basalt, mugearite, and hawaiite. The dike samples range in silica content from 44-56 wt % and total alkali content of 4-9 wt % and this is due to the samples containing a trachy-anedsite along with mugearite and picrite basalt compositions. Due to its anomalous behavior, the dike intrusion within Transect 2 was not focused upon in this research. The stratigraphic diagram of all of the samples and in their subgroups of Transect 2 is identified in Figure 2b. Transect 3 contains silica content ranging from 45-47 wt % and total alkali content of 3.5-5 wt % resulting in sample composition of picrite basalt. Figure 2c puts the samples in a stratigraphic diagram. The Southern Ridge transect is put in a stratigraphic diagram in Figure 2d for comparison with the Northern Ridge (Transect 2). Previous work on View Hill was also included, and all of the samples are recognized in Figure 3 through the use of the TAS diagram plotted on Igpet.

Northern and Southern Ridges

Major and trace element analysis reveals similar trends between the Northern and Southern Ridges' lava flow transects. Following the work of McGee et al. (2012), the major elements were plotted against MgO values for comparison. Figures 4a-4d highlight the similar trends of both the ridges with TiO_3, SiO_2, CaO and K_2O against MgO values. The trace element data highlights the correlation of the two ridges in Figure 4e-4g, where Zr and V values are plotted against each other and with MgO values.

Trachyte Dome, Fissure, and Transect 1 Flows

Analysis revealed similar correlation between the fissure and Transect 1 flows, while the Trachyte Dome contains values that differ. Trends were plotted in similar fashion to the Ridges. Figures 5a-5c highlight these correlations with Fe_2O_3T, SiO_2, and K_2O against MgO values (McGee et al. 2012).

Discussion

Geochemical analysis of the Northern and Southern Ridge reveals major and trace element trends that suggest they are correlated. The plots implicate that following a stratigraphic trend the Ridges follow the same linear pattern of the element analysis. This indicates that the Ridges should actually be the same lava flows that extend around View Hill, however they appear crosscut by other volcanic features. The similarities of the two ridges can also be seen not only on their major and trace element trend plots, but also their stratigraphic diagrams.

Study of the relationship between the Trachyte Dome, Fissure and Transect 1 flows suggests that there is a correlation between the Fissure and the Flows. Figures 5a-

5c all illustrate that the Fissure sample's chemistry is very similar to that of the flows. However, in stratigraphic trend the Fissure places out of order based on the geochemical trends. While the lava flows demonstrate the correct trends as they evolved, the Fissure places as if it were younger than the flows in terms of chemistry. This could suggest that after the Fissure developed, the magma source for the lava flows also developed and produced the chemical composition found in Transect 1 and creating the very thinly stacked flows.

The Trachyte Dome appears to have been a part of its own intrusive event. Based on previous work of the Dome by Eisenberg (2013), the Dome does not show a determined direction of flow with sporadic strike and dip measurements (Figure 6). This is suggestive of an intrusive model meaning that the Trachyte Dome formed as a part of its own event that intercepted between the Fissure and Transect 1.

It would appear that the evolution of View Hill occurred in many cross-cutting fashions. The Northern and Southern Ridges appear to be part of the same original event, providing the ground layer of original lava flows based on geochemical analysis. Further analysis and study of the geomorphological features would bring the Fissure as the next event to occur, which then is related to the deposition of the lava flows at Transect 1. The Trachyte Dome then intruded as a part of another event that intersects in the middle of all of the features at View Hill as the final process of its evolution.

Conclusion

The geochemical analysis and study of the View Hill area within Banks Peninsula provides an insight into the volcanic evolution of the processes and features present. Major and trace element trend analysis has revealed correlations between the Northern and Southern Ridge of View Hill as a part of the same preliminary event. Between the ridges, a Fissure crosscuts and leads up to Transect 1 lava flows that are intercepted by an intrusive Trachyte Dome event. The study of View Hill through geochemical analysis has revealed an insight into the evolution of its volcanic history.

Future work to help establish clear relationships between the Trachyte Dome, Fissure, and Transect 1 would require better sampling. Only one rock sample made it from the Fissure location of past research and limited the ability to make true correlations. Similarly, a lot of rock samples taken from the Ridges from this study's field location were weathered and not available for geochemical analysis. Better sampling of rocks, and stratigraphically, would aid in making more reliable correlations. Future research could be taken upon following the ridges and flows of View Hill and studying their evolution.

Acknowledgements

I would like to thank Spencer Irvine and Eric Barefoot for their field assistance. I would also like to thank Sam Hampton and Darren Gravley for their guidance and insight throughout this project's development. I would really like to thank Frontiers Abroad for the wonderful opportunity for this research and one-of-a-kind experience.

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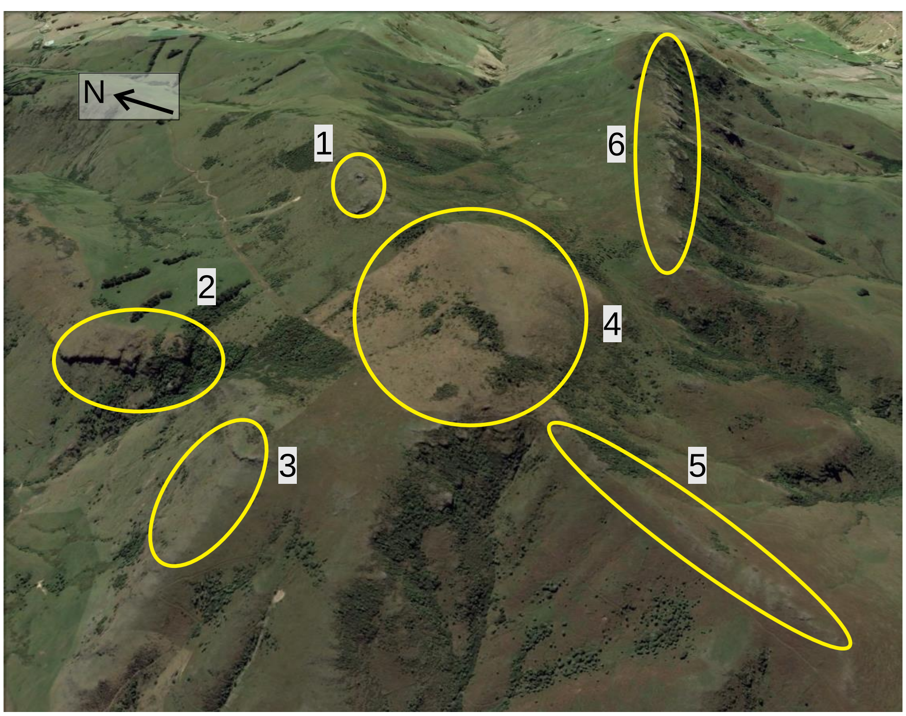
Figures and Tables

Figure 1a. Location of View Hill on aerial map of Banks Peninsula, New Zealand

Figure 1b. Features and Transects of research within this study of View Hill



1. Transect 1: lava flows possibly sourced from fissure dike
2. Transect 2:Northern-most ridge, scoria cone, and dike intrusion
3. Transect 3: lava flows
4. Trachy-andesitic Dome
5. Fissure Dike
6. Southern-most ridge

Figure 2a. Stratigraphic Diagram of Transect 1 Rock Samples. Older lava flow samples occur on the bottom and progressively become younger at the top of the diagram.

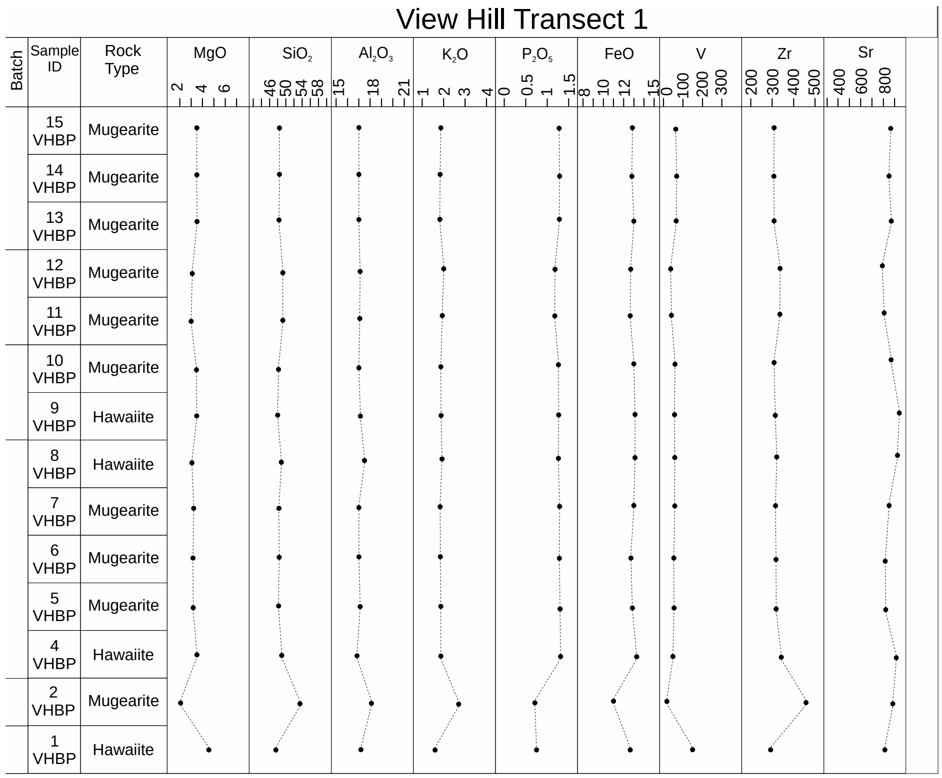


Figure 2b. Stratigraphic Diagram of Transect 2 Rock Samples. For each group, older lava flow samples occur on the bottom and progressively become younger at the top of the diagram.

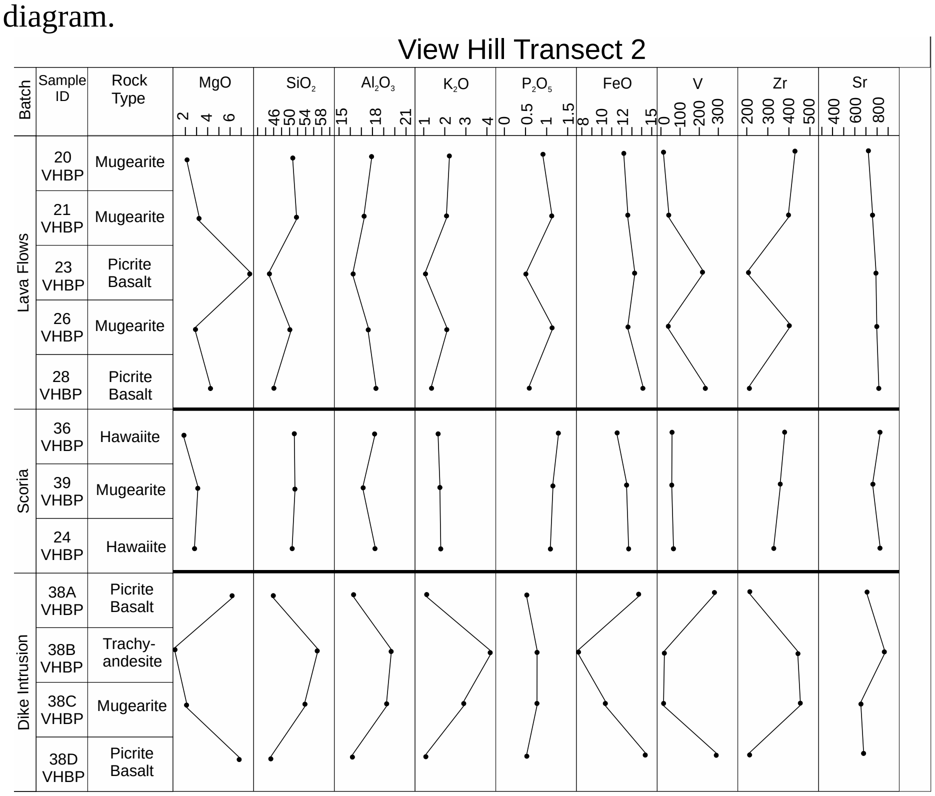


Figure 2c. Stratigraphic Diagram of Transect 3 Rock Samples. Older lava flow samples occur on the bottom and progressively become younger at the top of the diagram.

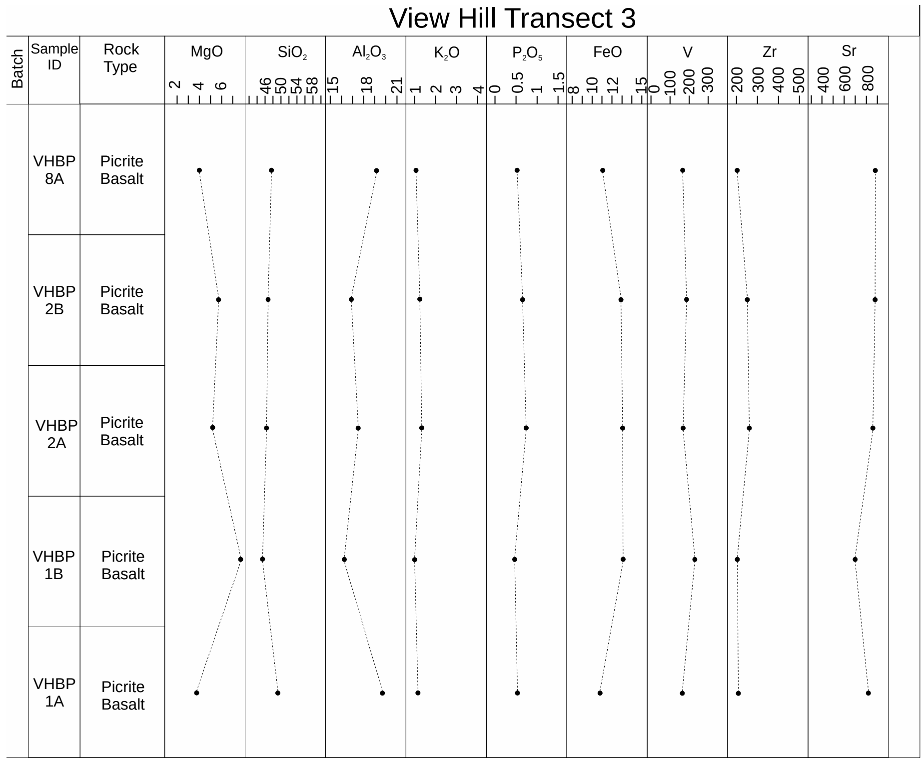


Figure 2d. Stratigraphic Diagram of Southern Ridge rock samples previously recorded from older research. Older lava flow samples occur on the bottom and progressively become younger at the top of the diagram.

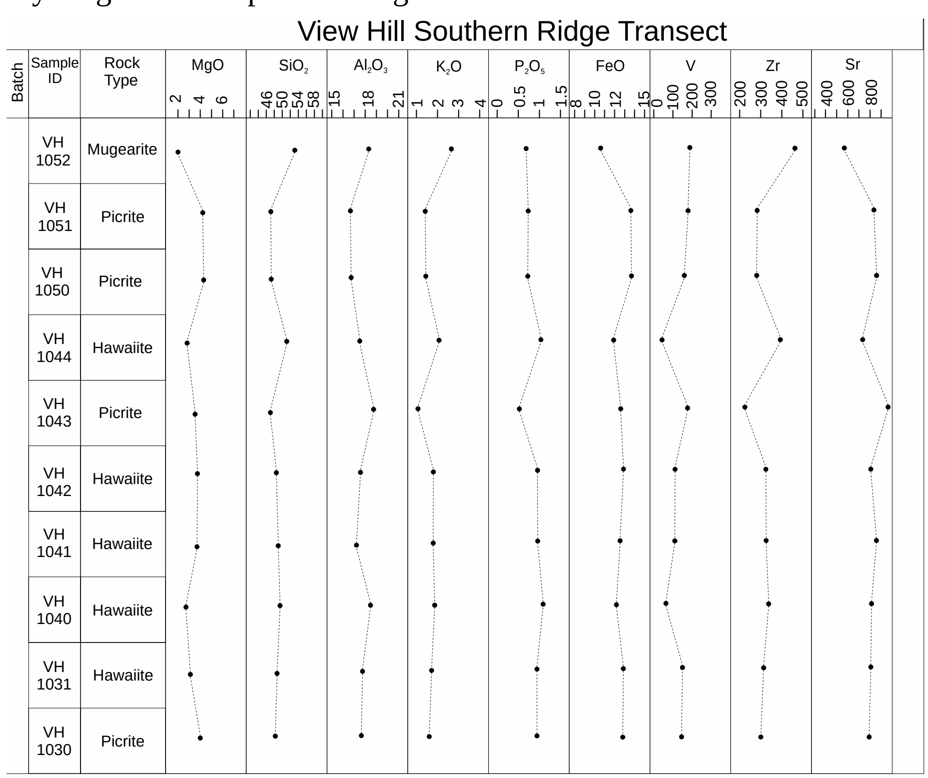


Figure 3. TAS diagram identifying rock type of the samples within Transects and other locations within View Hill. The Legend holds true for all figures containing the same symbols. It is important to note that the Trachyte Dome samples plot as Benmorite in composition, however previous research used an alternative diagram to plot these samples. This TAS diagram is used in order to keep consistency with the majority of the rock sample identification.

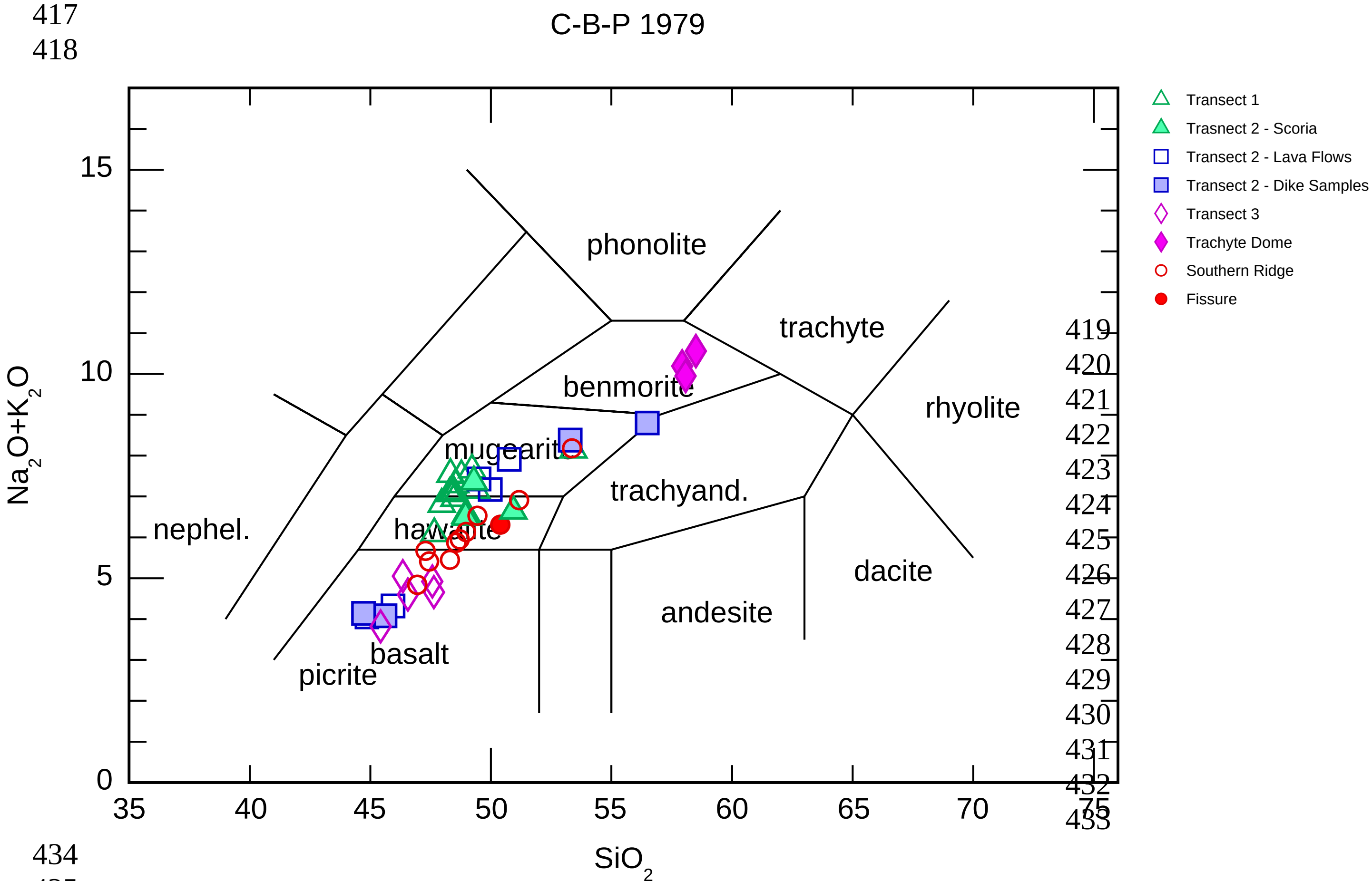
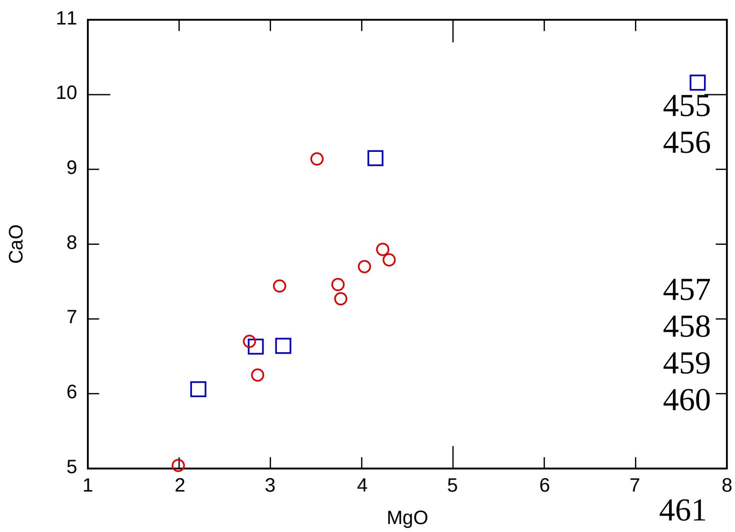
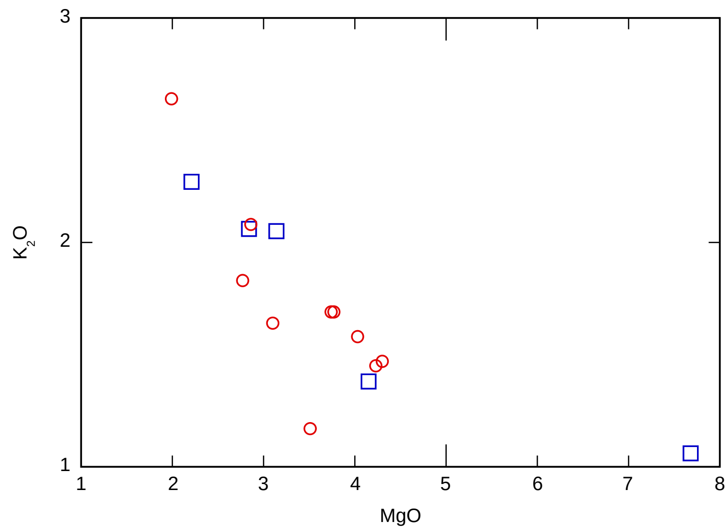


Figure 4. Major and Trace Element Trend Analysis of the Northern and Southern Ridges

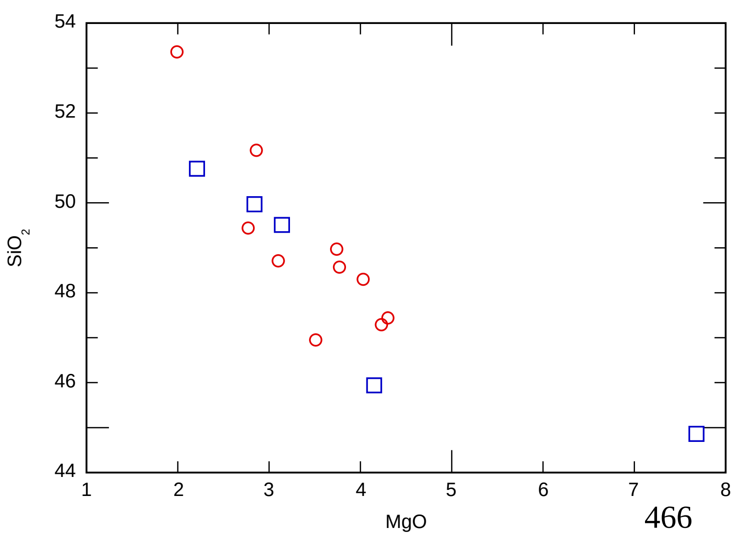
a.



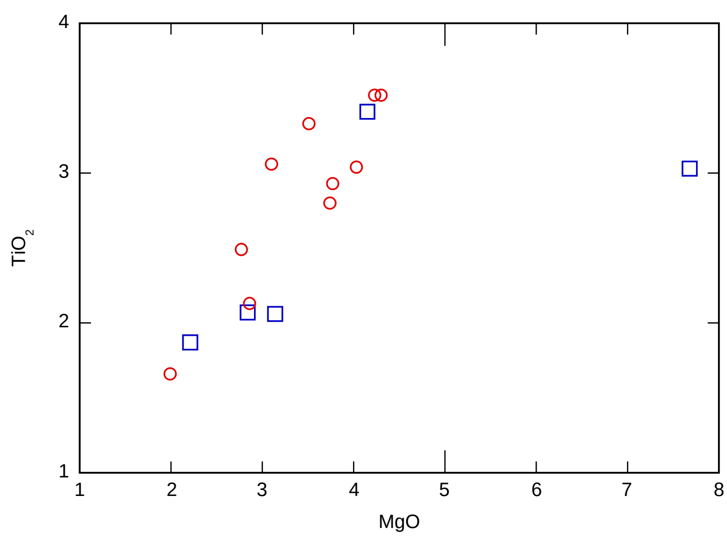
b.



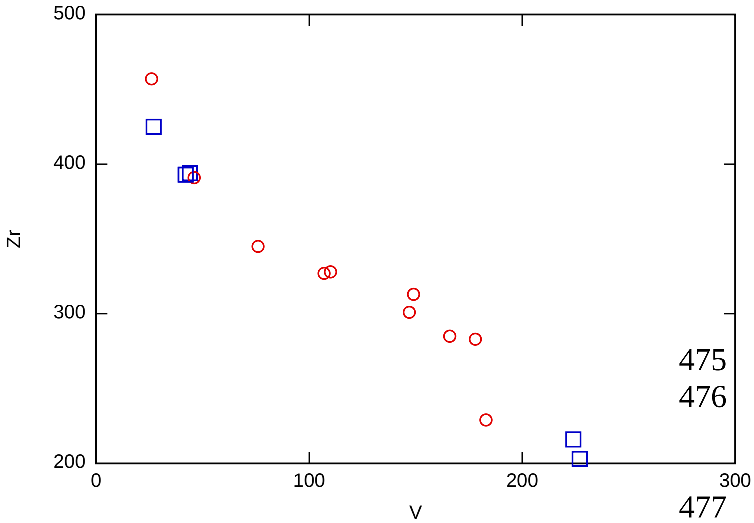
c.



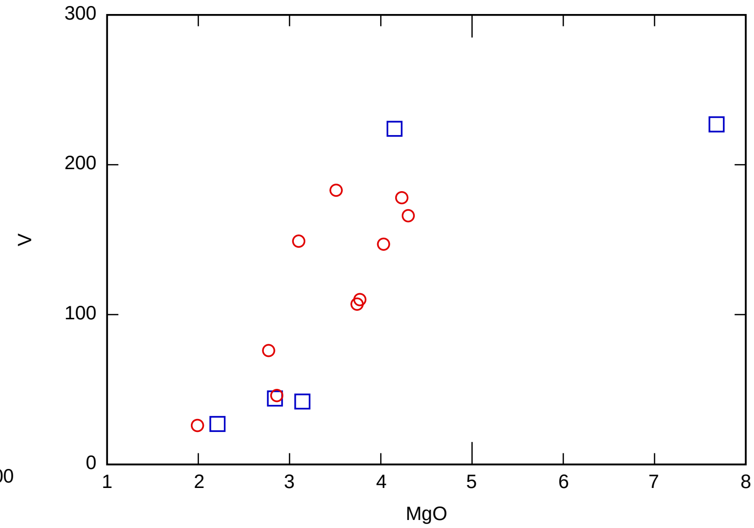
d.



e.



f.



g.

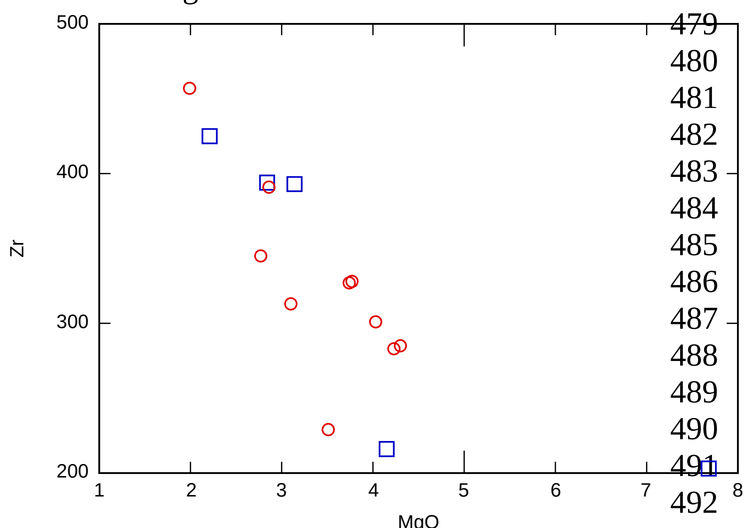
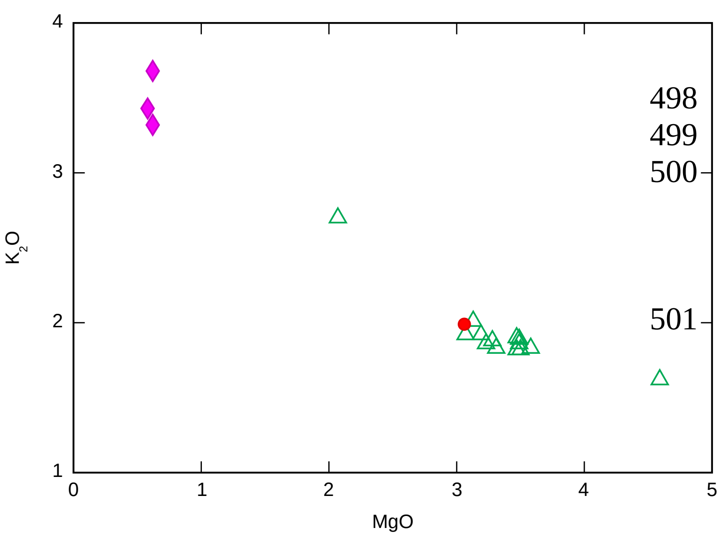


Figure 5. Major and Trace Element Trend Analysis of the Trachyte Dome, Fissure, and Transect 1 Lava Flows

a.



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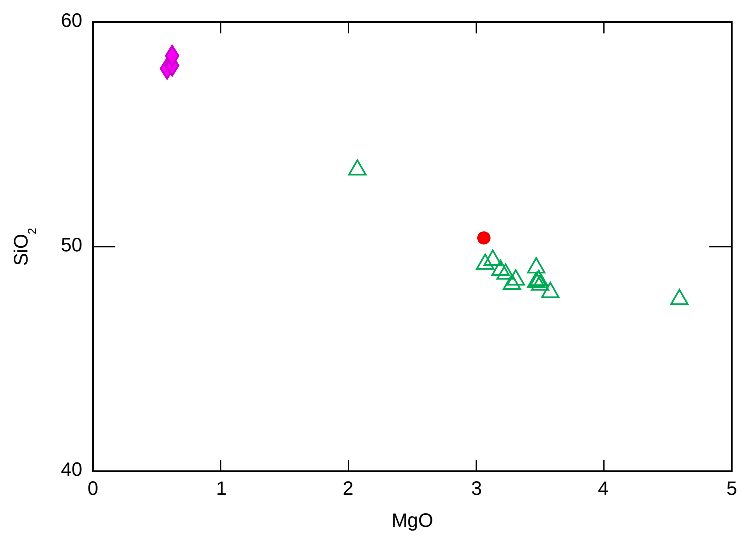

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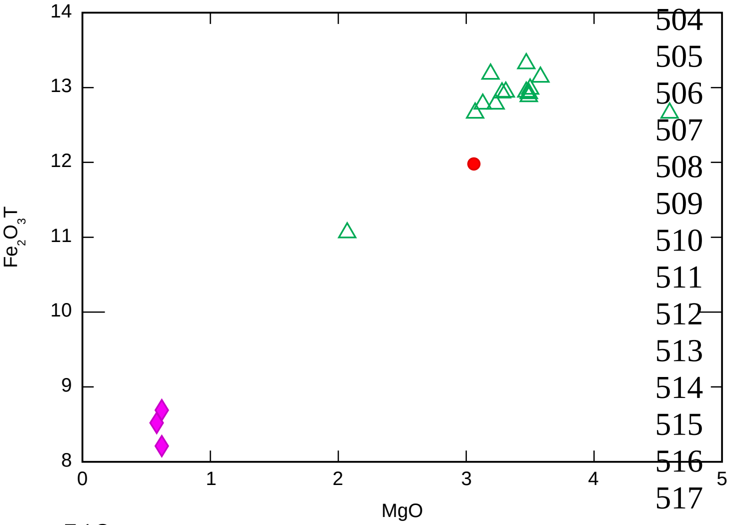

Figure 6. Strike and Dip model of the Trachyte Dome provided by Eisenberg (2013).