# Geochemical Analysis of Kula Volcanics

The primary objective of this research is to determine the origin and tectonic setting of the mafic magma source that produced extrusive igneous rocks collected just outside of Kula, Turkey. This is accomplished through the use of a new thermobarometer developed by Cin-Ty A. Lee, an associate professor at the University of Rice, and his colleagues, in conjunction with various geochemical analysis techniques, including Harker and spider diagrams and various rare earth element (REE) normalized plots.

The first step of this research is to further classify the samples based on alkaline content. Figure 1 plots wt% NaO + $K_2O$ vs. wt% $SiO_2$ with the common chemical classification scheme overlain.

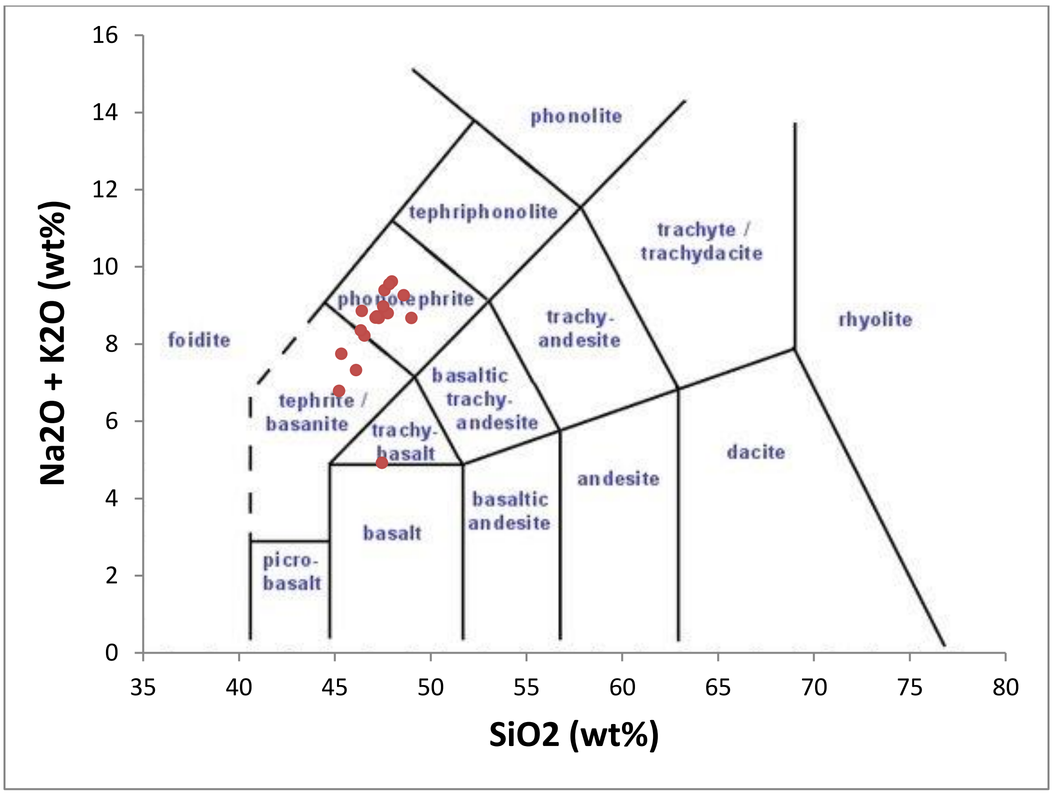



Figure 1: Basalt Classification of Kula Samples

As seen in Figure 1, the samples from Kula plot predominantly in the phonotephrite field, with several samples plotting as tephrites/basanites and one sample as a trachy-basalt. With the exception of the trachy-basalt, all of the samples are highly alkaline and basic in regard to $SiO_2$ content.

The next step is to create a set of Harker diagrams, in which various major element oxides are plotted against wt% $SiO_2$ to determine what possible minerals are crystallizing out of the melt and in what proportions. In addition, the mineralogy of the samples is investigated in order to compare and contrast with the Harker diagrams. Figure 2 shows a set of Harker diagrams created using the geochemical data from the Kula samples.

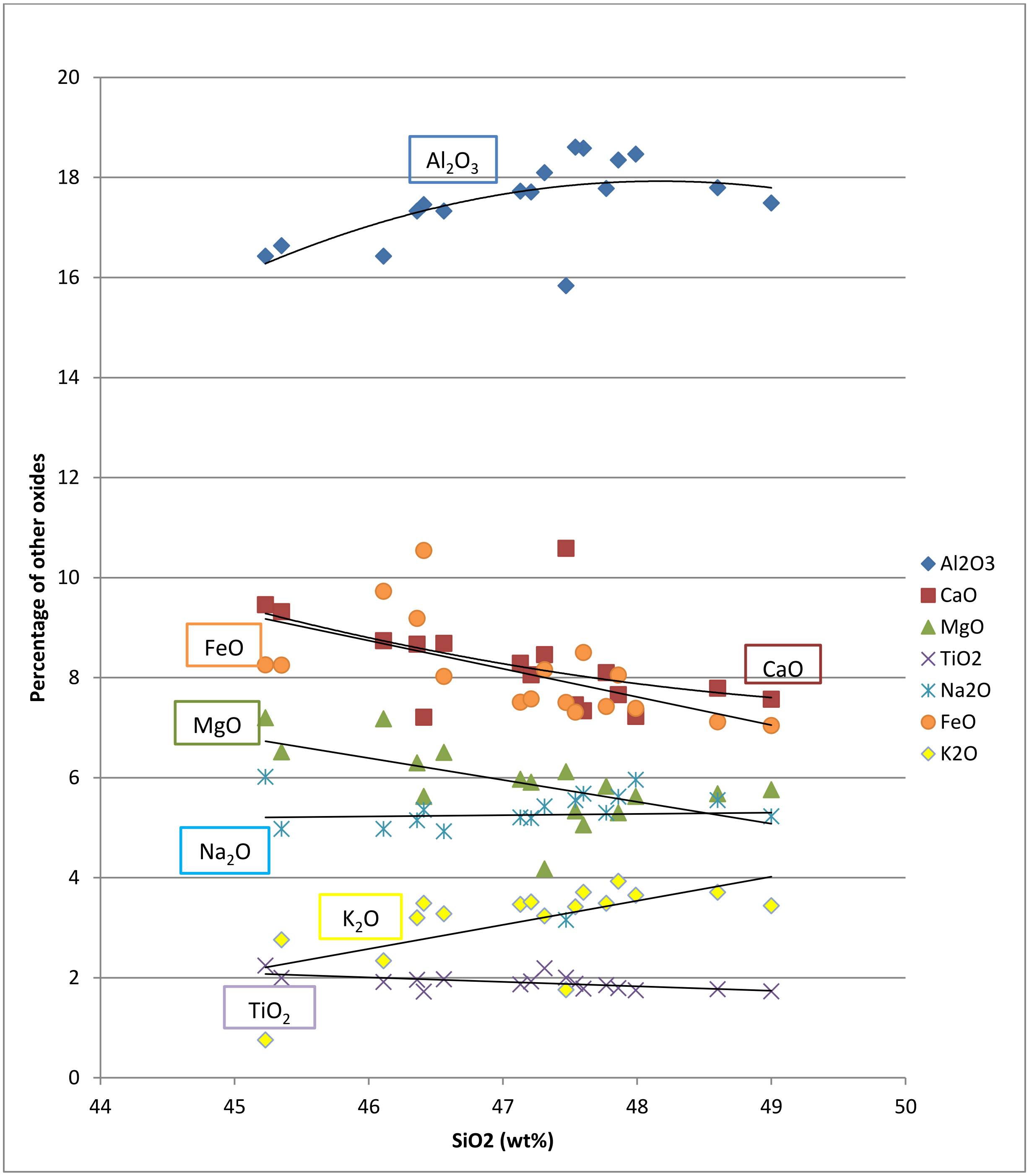
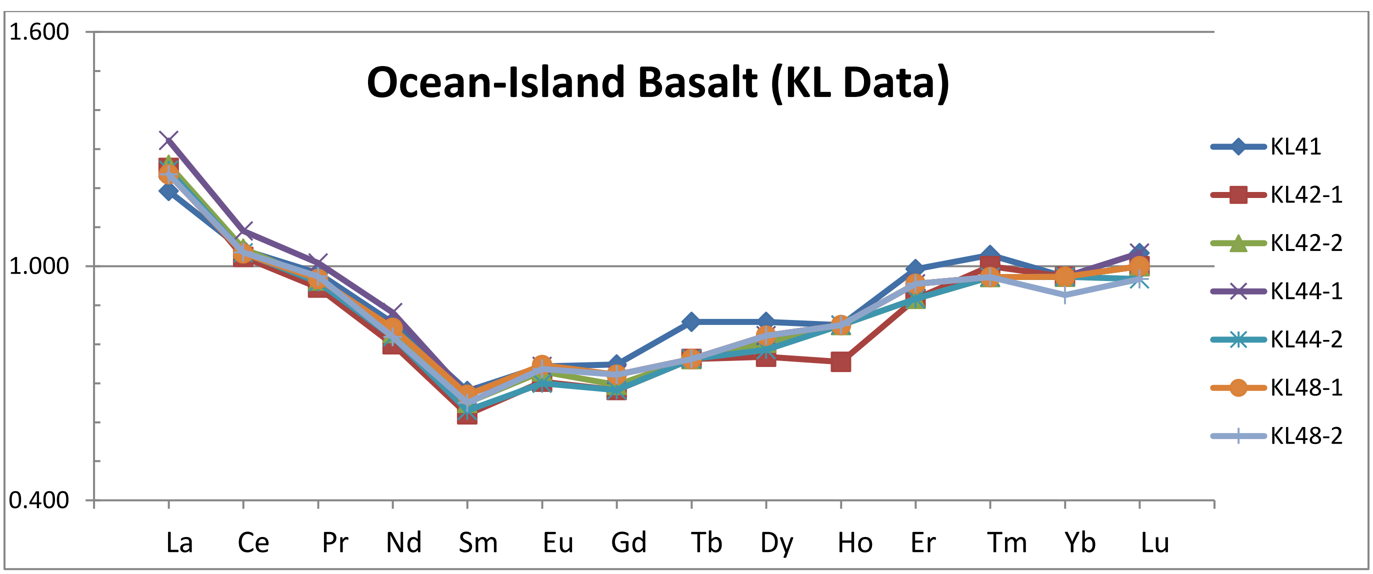



Figure 2: Harker Diagrams for Kula Samples

As seen in Figure 2, as the magma evolves (wt% $SiO_2$ increases), the weight percentages of CaO, MgO, FeO and $TiO_2$ all decrease at a steady rate, while $K_2O$ increases steadily and $Na_2O$ gently increases. $Al_2O_3$ increases steadily at first, reaches a maximum value around $SiO_2$ wt% of 48%, and then begins to decrease. These trends are consistent with the crystallization of olivine and clinopyroxenes in the early stages and calcic plagioclase and biotite later in the sequence.

To validate the results of the Harker Diagrams, a comprehensive study of the mineralogy of the samples in thin section is performed. The results can be seen in Table 1. The minerals present in the Kula basalts closely resemble what is expected based on major element analysis discussed earlier. However, further analysis is necessary to validate the mineralogy of the samples.

Next, the geochemical data of the Kula samples is compared to calculated values from McDonough & Sun, et. al. Figure 3 shows the values of REE in ppm normalized to values taken from McDonough & Sun. The plots show good consistency between amounts of trace elements in the Kula samples versus the values taken from McDonough & Sun. All of the normalized values are $1 \pm 0.5$, implying that the source of the Kula basalts closely resembles that of a generic ocean-island basalt magma.



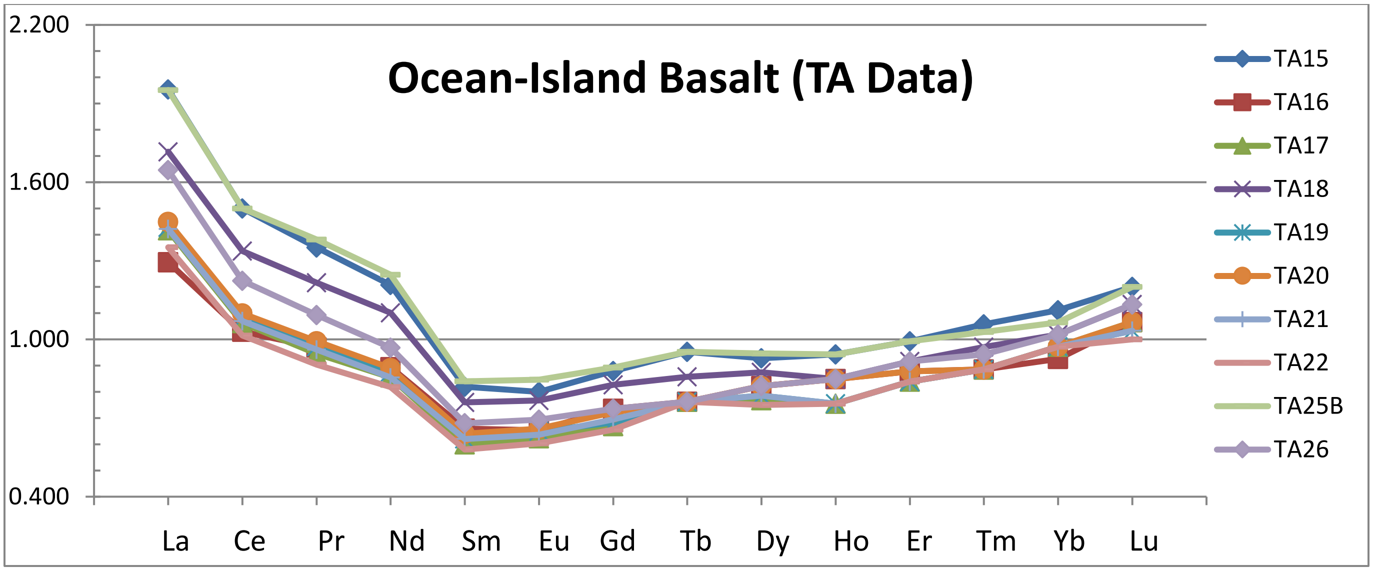



Figure 3: OIB Normalized Data for a) KL data and b) TA data. Data normalized to values from McDonough & Sun, et. al.

To help validate the results found up to this point, a new thermobarometer developed by Cin-Ty A. Lee is used. The thermobarometer uses geochemical data to back calculate the composition of the primary magma. Then, assuming a periodotitic source, the program calculates the average pressures and temperatures of melt segregation from the mantle. The program also plots P vs. T for the samples entered. To analyze the Kula samples, all of the geochemical data from the samples was entered to produce Figure 4. The average pressure and temperature calculated for the samples ranges from 1.74-3.35 GPa and 1296-1491°C.

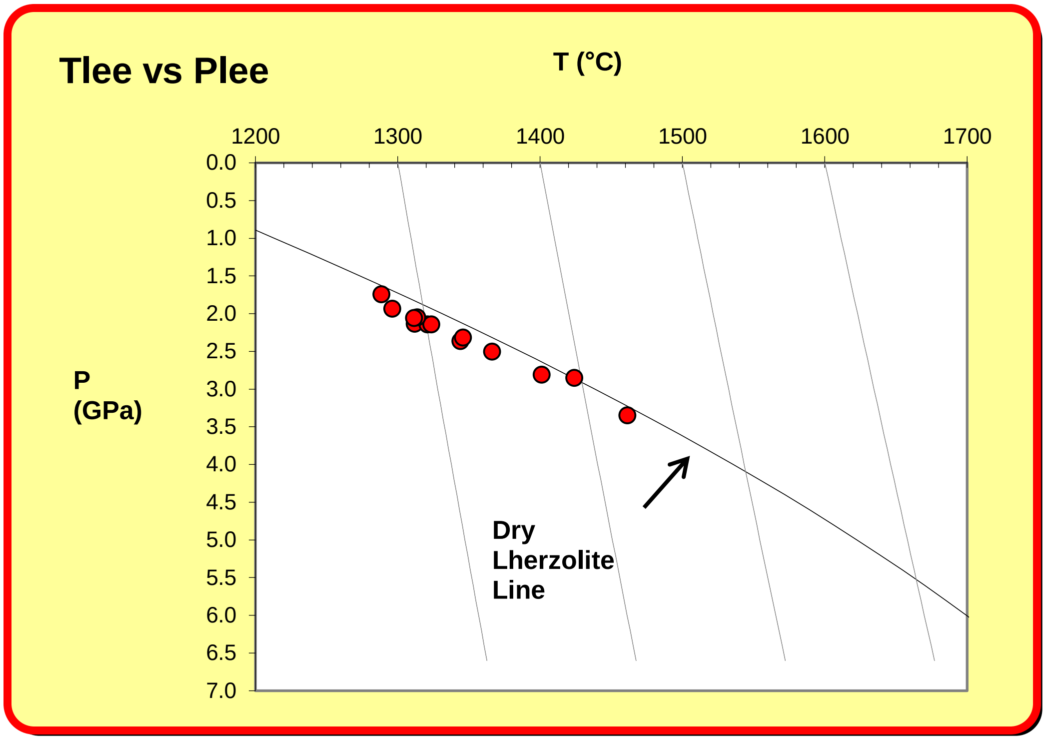



Figure 4: Calculated Pressure vs. Temperature for Kula samples. Graph produced using thermobarometer developed by Cin-Ty Lee

As seen in Figure 4 above, all of the samples fall on or near the dry Lherzolite solidus, implying mantle production of the magma associated with these rockes, with little to no water involved.

For comparison, the thermobarometer was also used to plot samples from previous research done on extrusive igneous rocks in the Kula region, including work done by Tokcaer, Innocenti and Alici. Figure 5 plots all of the samples from these three reports as well as the samples used for this study. All of the samples show good consistency, implying that all of the samples came from a similar mamgatic body, if not the same.

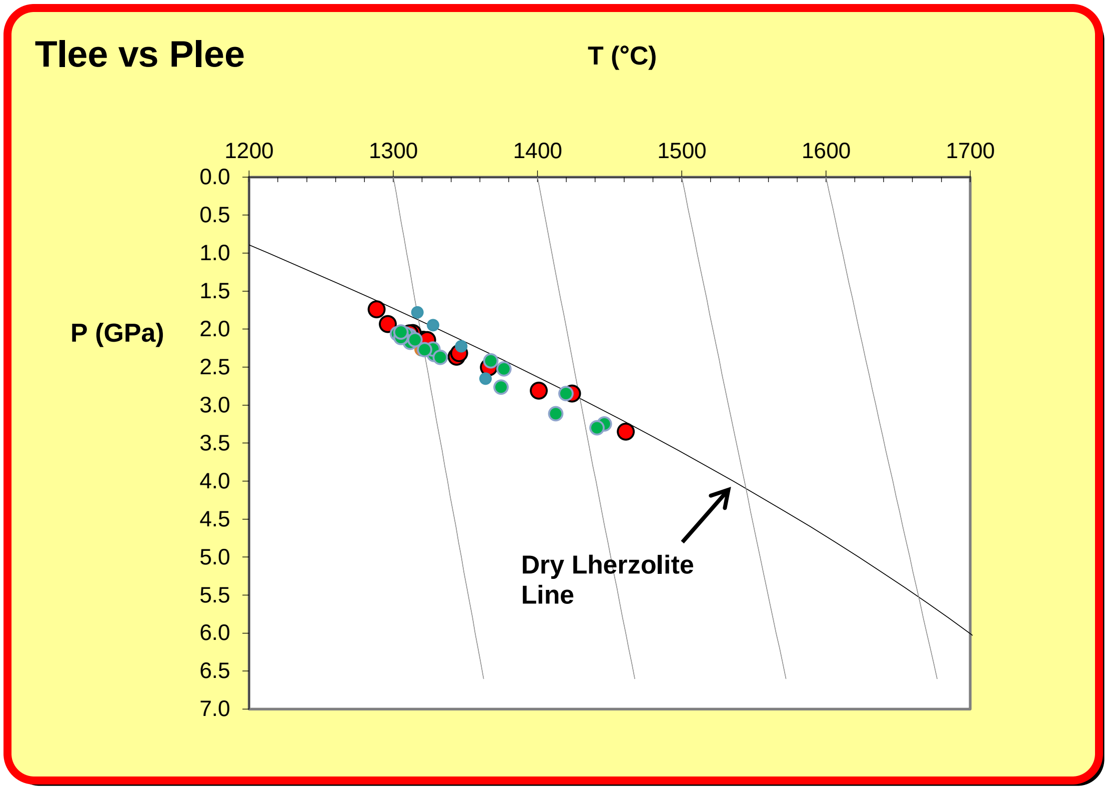



Figure 5: Calculated Pressure vs. Temperature for Kula samples from Catlos, Tokcaer, Innocenti and Alici. Graph produced using thermobarometer developed by Cin-Ty Lee.