Problem 2 - can a lava flow explain a volcano and the earth?

The composition of the lines of descent inferred from eruptive units were given and analyzed. The question is what trends can we see if any from the composition data and can processes in a lava flow explain these trends. To begin we can start by analyzing the data from the Hat creek basalt. There is a lot to be said from basic data analysis. I started by determining standard deviation from the given values. Using

$$\sigma = \sqrt{\Sigma(x_i - u)^2) / N}$$

where u is the average and N is the number of values for a given mineral. We initially see that SiO_2 behaves as expected with an standard deviation value of ~10 while the others had $\sigma < 5$. The deviation is also high since we have a limited amount of data, this can also infer that the silicate composition changed dramatically in a short period of time. We can further and see if there is a correlation between two compounds. Since silicate is the most abundant compound I compared the permutations of the other compounds with silicate. We can find the correlation coefficient using covariance(COV) and standard deviation(σ).

$$COV = \sqrt{\Sigma(x_i - \overline{x})(y_i - \overline{y})} / N - 1$$

Where $\overline{x}$ and $\overline{y}$ are the mean value for the compound composition data set and we use N-1 to take into account degrees of freedom in the sample set. Now we can say that correlation coefficient(COR) is :

$$COR = COV(x, y)/\sigma(x)\sigma(y)$$

What we end up getting are correlation coefficient values of :
1.21(SiO2/TiO2), -0.76(SiO2/Al2O3), -1.22(SiO2/FeO), -.94(SiO2/MgO), -1.02(SiO2/MnO), -.99(SiO2/CaO), 0.55(SiO2/Na2O), 0.96(SiO2/K20), 9.91(SiO2/P2O5).

Since we normalized the covariance with standard deviation(to get correlation coefficient) we expect values of -1 or +1 to indicate a perfect linear relation where a negative value indicates an inverse relation (as silicate increases the other compound decreases) or a direct relationship. From the values we can infer that SiO2 and MnO have a strong relationship. We also see that SiO2 and P2O5 are not linearly related but we can't really say anything else. Looking at permutations of the other compounds out of the total combinations $\sum_{0}^{n-2} x_i$ = 44 (since we are only comparing two at a time) there were only 8 combinations that showed a linear relation that was within 10% of a perfect relation. This of course does not mean that there is no relation whatsoever. My assumption is that there is an exponential relation since silicate dominates most of the composition. When we compare silicate to the other compositions there seems to be stronger relations with the other compounds. I also briefly looked at the literature data for Seguam, Thingmuli, and Newberry and analyzed the data using the same process as with Hat creek basalt data. From this data I was able to see that there were certain compounds following a consistent “path” no matter what location it was taken from. This is evident when I graphed the liquid lines of descent comparing SiO_2 % in each volcano to the various other compounds in its composition. We can see that these paths are the crystallization path due to some lava flow processes. From this we can possibly infer partial melting took place. The graphs also provide evidence that in the Hat Creek basalt data, when comparing the various compounds there does seem to be a stronger relationship with Si02 and more of the other compounds. In, contrast when comparing other compounds with each other no obvious trends appear.

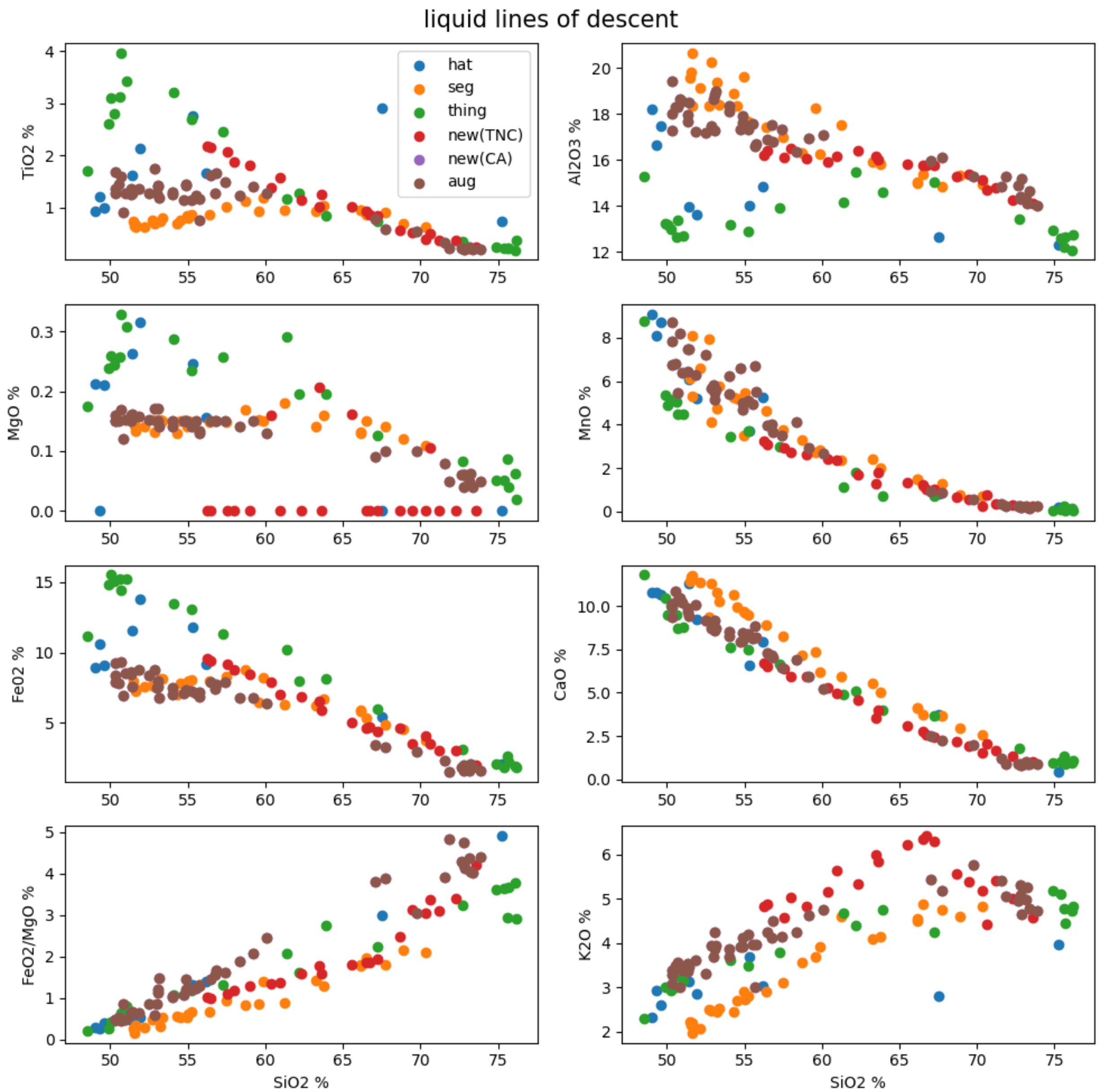

Figure 1. Liquid lines of descent comparing SiO2 to each other compound found in the whole-rock compositions. The legend in the top left graph shows what color corresponds to what data set and is the same for each of the graphs.

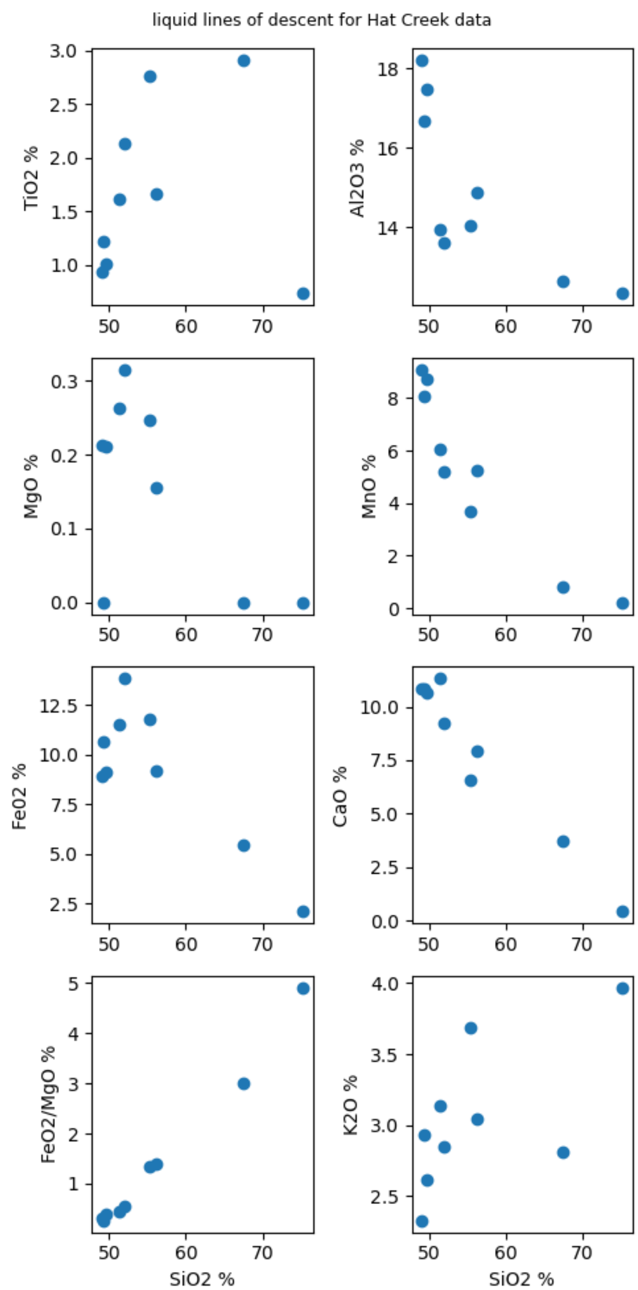

Figure 2. Liquid line of descent plots of the Hat Creek Basalt data. SiO2 is plotted against all the other compounds found in the glass composition.

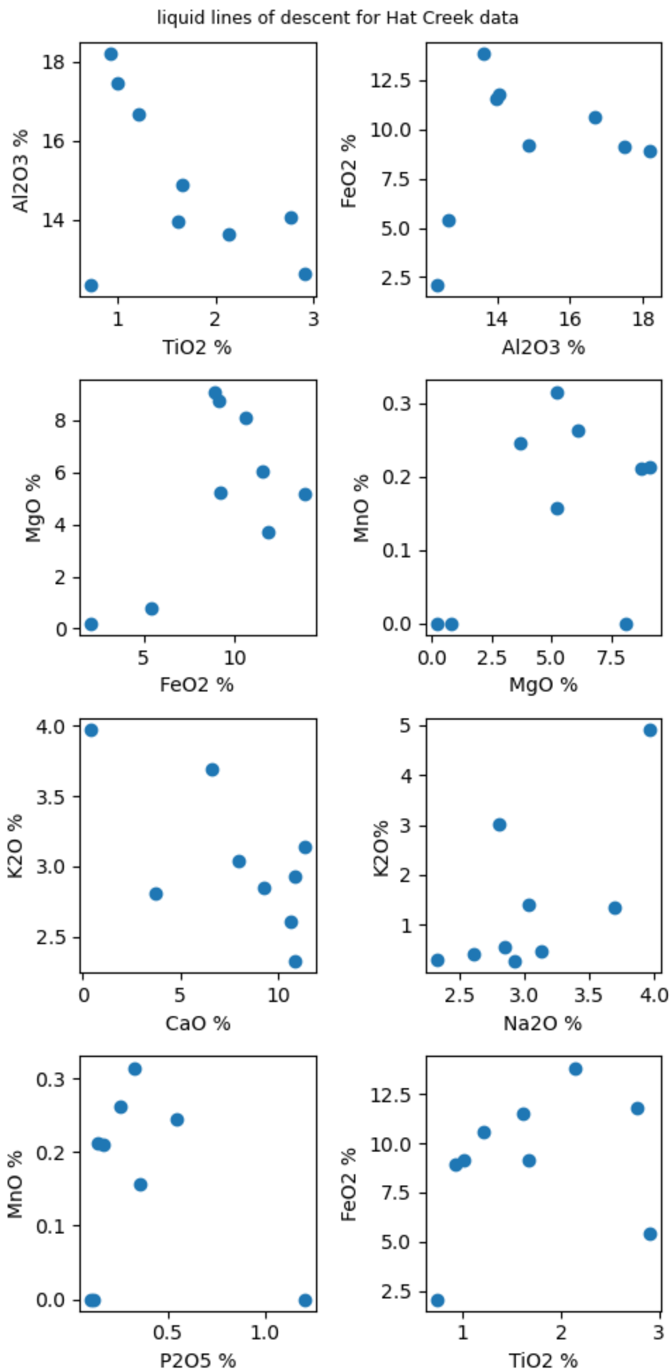

Figure 3. Liquid line of descent plots of the Hat Creek Basalt data. Various compounds are compared.

Post discussion report

We deduced that there are similarities between the graphs comparing the liquid line of descent graphs. During our discussion I also verified that there are common negative and positive correlations between all the given data sets. The correlation coefficients I initially found seem to be accurate in terms of direction, although I don't have enough evidence to say that there were any linear relations, and can say that trends do exist. I also gained more insight into why my correlation coefficients, although normalized, still varied greatly. This is most likely due to the varying stoichiometry of the crystals being formed in the melts.

During fractional crystallization there is separation in melt from mineral precipitate. There are however a few things to consider that affect the melts composition. Crystallization of melts that form from mafic and ultramafic rocks will vary to the MgO and SiO2 concentrations in melts, consequently this will affect the crystals that are able to form. The water content and pressure can also affect the final composition.

We considered the crystals found in basaltic melts such as Olivine and plagioclase. By taking a look at their chemical formulas (Mg, Fe)2SiO4, NaAlSi3O8 – CaAl2Si2O8, and also considering Ca(Mg,Fe)[Si2O6], we can see they require Mg, Fe, Al, and Ca to form. From this we can deduce that as they form in the melt and silicate increases then these compounds using these elements decrease to form the crystals. Conversely, if an element is not needed to form a crystal then it will become more abundant during the crystallization process. From the graphs we can see that crystallization is inferred and that these initial melts (ranging from about ~50% SiO2) become felsic rock(ballistic becomes rhyolitic). We are able to observe the evolution of a volcano from the crystallization process!