GEL4050 Igneous and Metamorphic Petrology

CRYSTALLIZATION OF AN M&M MAGMA CHAMBER LAB

Name:	Section:	Grade: /25
Instructor's Comments:		

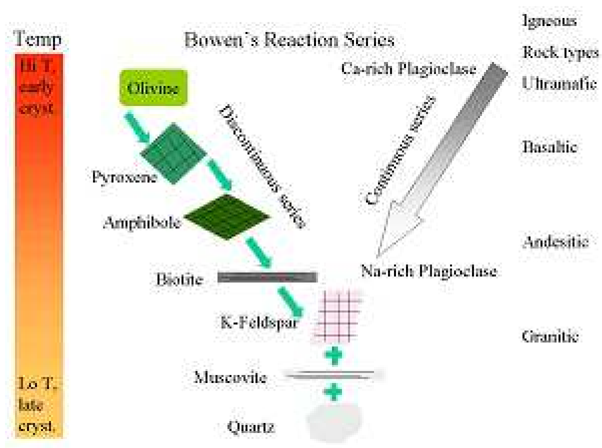
The following assignment was modified from *Calculating of a CIPW norm from a bulk chemical analysis* (2013) Kurt Hollocher, Geology Department, Union College NY, and *Differentiation of Magmas By Fractional Crystallization* (2014), Cynthia Fadem, Earlham College.

Materials:

□ Lots of M&Ms in multiple colors (about 450 total) □ Calculator □ Magma Chamber Tables

Introduction:

You have learned about Bowen's reaction series and the importance of crystal-melt fractionation in generating the spectrum of observed igneous rock compositions (e.g., basalt, andesite, rhyolite). Magmatic differentiation is the process by which diverse rock types are generated from a single magma. Differentiation is accomplished by crystal-melt fractionation, a two-stage process that involves the formation and mechanical separation of compositionally distinct phases. In 1844 Charles Darwin described flows from the Galápagos Islands in which the lowest flows contained greater proportions of feldspar crystals. These observations led Darwin to propose that density differences between crystals and melt would result in mechanical separation of these two phases and the formation of different magma types. This process, known today as gravity settling, was the focus of detailed experimental studies by N.L. Bowen. Today, several additional mechanisms of crystal-melt fractionation are also recognized, including: flow segregation, filter pressing, and convective melt fractionation.



Procedure:

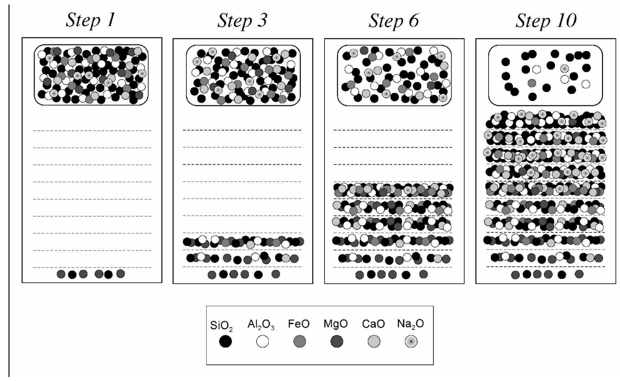
Constructing the Magma Chamber

1. Each major oxide (e.g., Si, Ti, Al) will be represented by a different M&M color. Count out the appropriate number of M&M's for each oxide (refer to data sheet). Your magma chamber is represented by a blank white piece of paper. Mix the M&M's and pile them in your magma chamber.

Crystallization and Fractionation of the Magma

2. Before you begin, note the general proportions of the different oxides (colors) in the magma chamber. Determine the composition and stoichiometry of each of the minerals involved in the crystallization process using the first table.
3. Create your minerals from the oxides in the magma chamber according to the table given. Once a mineral is formed, remove it from the melt by settling it to the bottom of the magma chamber. For each oxide, record the number that remains in the magma chamber in the appropriate table.

4. For each additional increment of crystallization, move the appropriate number of oxides (M&M's) from the melt to the floor of the chamber as they from minerals and fill in the table. (Note: it is helpful to group the oxides that were removed in each crystallization step in separate layers. In other words, move the M&M's that were crystallized during the first step the furthest away from the magma chamber; oxides from each additional crystallization step will be successively closer to the magma chamber. See illustration on right)



5. After each crystallization step, you should observe the proportions of the oxides (colored M&M's) in the remaining liquid and in the cumulus layers, recording this data in your tables as well.
6. Before your experiment is dismantled (or consumed), describe the general trends you observed during the fractional crystallization of the magma. Compiling your results into graphs to make your point will be helpful.

Analyzing the Results

7. Complete each data table and enter your data into a spreadsheet.
8. Generate x-y plots of the following:
   a. % Al, Mg, Fe, Ca, Na, K, and Ti oxides remaining in the melt versus % SiO_2 remaining in the melt
   b. % SiO_2 and MgO remaining in the melt versus fraction of liquid remaining (% Magma)
9. Plot the various rocks formed in each step on the IUGS diagram. Which trend are you observing in the generation of plutonic rocks through fractional crystallization? What influences this trend?

10. For full credit: TURN IN the complete package for grading, including your plots and calculations.