Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Geology 12

**Cereal Magma Chamber**

**-Understanding Bowen’s Reaction Series-**

* Clean your table with paper towel and water.
* Count out the following number of each atom. If you find a Froot Loop with an ambiguous colour, eat it.

|  |  |  |  |
| --- | --- | --- | --- |
| **Element** | **Symbol** | **Represented by…** | **Number** |
| Silicon | Si | Cheerios | 184 |
| Aluminum | Al | Purple Froot Loops | 70 |
| Iron | Fe | Orange Froot Loops | 39 |
| Magnesium | Mg | Yellow Froot Loops | 40 |
| Calcium | Ca | Green Froot Loops | 34 |
| Sodium | Na | Pink Froot Loops | 24 |

* Mark out a space on your table, using masking tape, to represent your magma chamber. Put all your atoms in the magma chamber. Make sure you leave room at the bottom of the chamber – this is where the minerals will sink to after they crystalize.
* Remember that Bowen’s reaction series is for silicate minerals. Which obvious element is missing? Why do you think I left it out? Let me know once you think you’ve got the answer.
* Now let your magma chamber slowly “cool” by following the steps below. In each step, some minerals will crystalize and then fall to the bottom of the magma chamber. Have your diagram for Bowen’s reaction series in front of you as you go. After each step, fill in the data tables on the next page.  
    
  When you finish step 5, stop and take a look at what has crystalized and what is remaining in the magma chamber. What element has been affected the most? The least? Does this fit with what we know about Bowen’s reaction series? Why or why not? Call Mr. Q over when you have discussed these questions with your group and you think you have the answers.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Steps** | | | | | | | | | |
| **Mineral** | **Formula** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Olivine (Forsterite) | Mg2SiO4 | 2 | 3 | 4 | 3 | 2 |  |  |  |  |  |
| Plagioclase Feldspar (Calcium-rich) | CaAl2Si2O8 |  | 1 | 2 | 3 | 3 | 4 | 3 | 3 | 1 | 1 |
| Olivine (Fayalite) | Fe2SiO4 |  |  | 1 | 1 | 1 | 1 |  |  |  |  |
| Pyroxene | CaMgSi2O6 |  |  |  | 1 | 1 | 4 | 2 | 2 | 1 | 1 |
| Magnetite | Fe3O4 |  |  |  |  | 1 | 3 | 2 | 2 | 1 | 1 |
| Plagioclase Feldspar (Sodium-rich) | NaAlSi3O8 |  |  |  |  |  | 1 | 3 | 6 | 5 | 7 |
| Quartz | SiO2 |  |  |  |  |  |  |  |  | 1 | 4 |

**Data Tables**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Amount Left in Magma After Each Step** | | | | | | | | | |
| **Element** | **Initial** | --1-- | --2-- | --3-- | --4-- | --5-- | --6-- | --7-- | --8-- | --9-- | --10-- |
| Si | 184 |  |  |  |  |  |  |  |  |  |  |
| Al | 70 |  |  |  |  |  |  |  |  |  |  |
| Fe | 39 |  |  |  |  |  |  |  |  |  |  |
| Mg | 40 |  |  |  |  |  |  |  |  |  |  |
| Ca | 34 |  |  |  |  |  |  |  |  |  |  |
| Na | 24 |  |  |  |  |  |  |  |  |  |  |
| Total # of Atoms |  |  |  |  |  |  |  |  |  |  |  |
| % of Initial Magma  Remaining | 100% |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **What Percent of the Magma Does Each Element Account For?** | | | | | | | | | |
| **Element** | **Initial** | --1-- | --2-- | --3-- | --4-- | --5-- | --6-- | --7-- | --8-- | --9-- | --10-- |
| Si | 47.1% |  |  |  |  |  |  |  |  |  |  |
| Al | 17.9% |  |  |  |  |  |  |  |  |  |  |
| Fe | 10.0% |  |  |  |  |  |  |  |  |  |  |
| Mg | 10.2% |  |  |  |  |  |  |  |  |  |  |
| Ca | 8.7% |  |  |  |  |  |  |  |  |  |  |
| Na | 6.1% |  |  |  |  |  |  |  |  |  |  |

**Analysis**

Use Excel to make six graphs – one for each element. On the x-axis put the percent of initial magma remaining (from the first data table). On the y-axis put the percent of the magma that element accounts for (from the second data table). Looking at your graphs, answer the following questions.

1. In each step in the activity, it’s as if we crystalized one “rock” that was made of many minerals. Use the chart below to classify the rock that was created during the last step that you managed to get to.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rock Name…** | Basalt | Andesite | Dacite | Rhyolite |
| **Si %...** | 46% to 52% | 52% to 63% | 63% to 68% | 68% to 77% |

1. Let’s say that you got a different answer from the group beside you. Both groups did the exercise correctly, but in the same amount of time they completed a different number of steps. Come up with a few good ideas for how this could happen in nature.
2. As you look at the graphs, where does the original magma plot (i.e. before any minerals have crystallized)? What direction should you move on the graphs as crystallization proceeds?
3. Look at the graph for silicon. As crystallization proceeds, how is the percent of Si changing? With each crystallization step you are taking Si out of the system. How, then, can you explain the trend shown in the plot?
4. Explain the kinks in the Fe and Na plots in terms of Bowen’s reaction series.
5. Using the table from question 1, draw the layers of rock as you’d expect them to appear in a pluton (a solidified magma chamber).  
     
     
     
     
     
   All magma chambers start underground. Imagine you came across some dacite on the surface. What would have had to happen in order for this to occur?
6. We know that mafic magma is runny and felsic magma is viscous. Looking at your graphs and at Bowen’s reaction series, come up with what you think are the two main things that control magma viscosity.