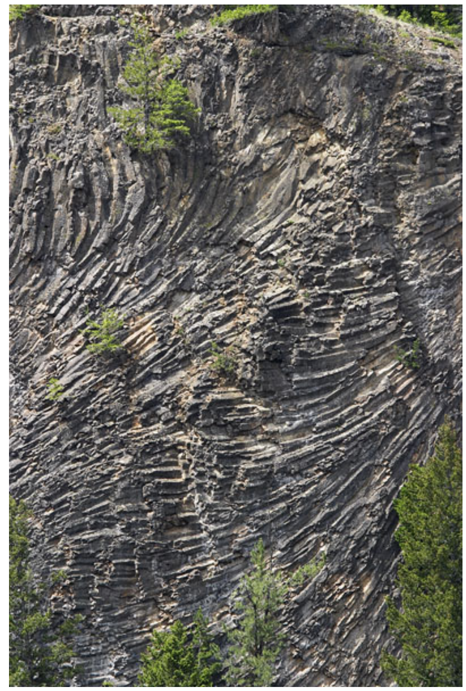
GEOL 452 - Mathematical Tools in Geology
Lab Assignment # 7- March 18, 2010 (Due March 25) Name:

Radioactive Decay and Age Dating of the Columbia River Basalts Using Exponential Functions



A. Determing Half-Life

The Columbia River Basalts were deposited over a period of 17 - 6 My ago in several flow fronts in the Pacific Northwest along what is now the Columbia River Gorge. The basalt flow is 15-20 km thick and spans a million square kilometers along the border of Oregon and Washington. Much work has been done to try and understand the age of these basalt flows and cause of massive volcanism that is in the class of *continental flood basalts* world wide including the Deccan Traps and Siberian Flood Basalts.

1. You are a very young and budding scientist studying volcanism in the Pacific Northwest. You are in the field collecting the Columbia River Flood Basalts (CRB) samples and have discovered a new isotope which can be used for dating of basalts and their time of formation. You decide to name the new isotope after yourself with a suffix "ium" after it (e.g. Emilium). Using this example, you've found that ^{40}Emilium decays to ^{39}Adewalium but you do not know its half-life. First write the equation for radioactive decay using the variables, P for parent isotope, P_o for daughter isotope, λ for the decay constant, and t for time. What variable in this equation will tell you the half-life of ^{40}Emilium decaying to ^{39}Adewalium ?

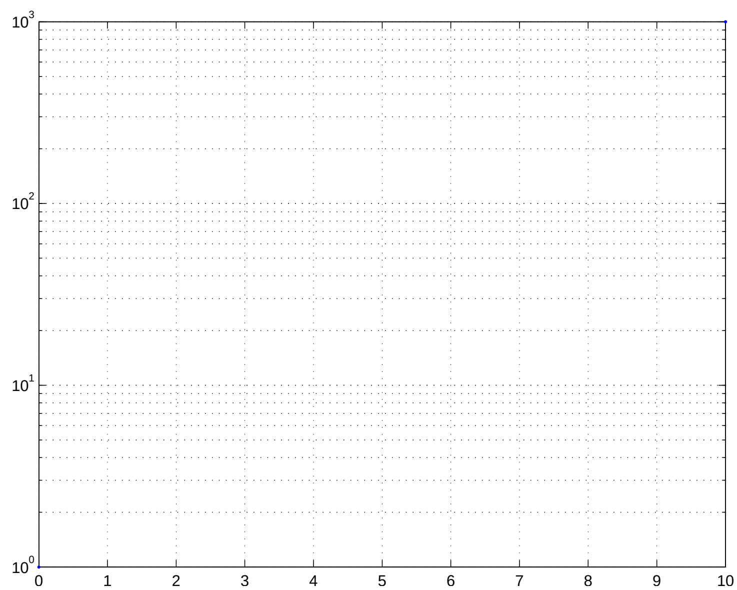
2. From your class notes, what does the variable λ stand for if broken down ? (Write the equation)

3. Can you transform your equation from problem #1 to put the variable that you need to determine half-life in a place which is easier to work with ? (hint: you might want to think about logarithms)

4. What kind of equation did you formulate in problem #3 ? In this equation what purpose does your variable of interest hold ?

5. In the laboratory you are able to measure the abundance of Emilium over a 10yr time period as shown in the table below. Plot this data first on a linear-linear scale, and then on a linear-log scale (show your work). Use one of these plots to determine the value of the variable you are seeking.

time (yrs)	0	1	2	3	4	5	6	7	8	9	10
Emilium (ppm)	1000	606.5	367.9	223.1	135.3	82.1	49.8	30.2	18.3	11.1	6.7



6. Determine the half-life for your new isotope system using your answer from problem #2. Give your answer with the correct units of time.

B. Calculate the age of your Columbia River Basalt sample

7. While your new isotope system is ground breaking and has made you famous in the scientific field, you decide that it's half-life is too short for use in measuring the age of your CRB sample which should be somewhere between 17-6 My old. You will use the ^{40}K-^{40}Ar system instead. The half-life for decay of ^{40}K to ^{40}Ar is already known at 1.3 billion years. You determine in the laboratory that the current abundance of the parent isotope, ^{40}K, is 3798 ppm and you estimate that the original amount of ^{40}K was somewhere near 4000 ppm. Use this information to determine the age of your sample. To do this, first write the equation describing radioactive decay (the same as in problem #1).

8. Reformulate this equation so that it will solve for time (t). (Hint: you may need to use logarithms).

9. In order to be able to use your given information about the half-life of the ^{40}K to ^{40}Ar system, you will need to expand the variable, λ (as in your answer in problem #2).

10. Solve for time, t, and determine the age of this basalt flow. Give your answer with the correct units of time.

11. You find out that your estimate of the original amount of the parent isotope ^{40}K was too high by 2000 ppm. Determine how much this new information will change the result of your answer. To do this, make a linear-linear plot of your system plotting the parent isotope concentration over a time range from 0 to 50 My (in 5 My increments). Make two plots on one graph (using Excel or Octave): one which uses the original amount of parent isotopes you assumed in problem #7; and a second data plot which uses the new estimate of your original parent isotope (show each with different symbols like circles and squares).