Name: _____ Lab Section_____

Geology 115 – Earth's Climate: Past, Present, and Future
Fall 2007
Lab #6: Chemical Weathering
Field Trip to Easton Cemetery

Introduction:

Physical and chemical weathering processes combine to break down rocks at the earth's surface and form clasts, ions, and soils. In this lab, you will evaluate the rate of chemical weathering of a specific rock type by measuring the dissolution of carbonate rocks exposed to chemical weathering. The tombstones in the Easton Cemetery provide us with an opportunity to estimate chemical weathering rates in Eastern Pennsylvania. We will attempt to quantify weathering by comparing the legibility of the lettering on a tombstone to the length of exposure to weathering as indicated by the date inscribed on the tombstone. By restricting the analysis to a single rock type, it is feasible to estimate a mathematical relationship between time and weathering.

Carbon dioxide dissolves in water to form carbonic acid. Carbonic acid dissociates to form bicarbonate and hydrogen ions:

$$H_2O + CO_2 \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$$

Carbonic acid is a weak acid that reacts with minerals (e.g., calcite) and rocks (limestone and marble) made of calcium carbonate:

$$H_2CO_3 + CaCO_3 \text{ (calcite/limestone/marble)} \rightarrow Ca^{+2} + 2HCO_3^-$$

Carbonate rocks are also vulnerable to attack from nitric and sulfuric acids (i.e. **acid rain**), which are produced by the outgassing from volcanoes, decaying vegetation, and the burning of fossil fuels. In the United States, acid rain is derived primarily from automobile exhaust and coal-burning power plants.

PART 1: Collect Data

1) Looking around you, what rock types do you observe? What evidence did you use to determine this? Explain how you used the evidence to reach the conclusion you did. (8pts)

2*) Estimate the legibility of the lettering on as many white tombstones as possible and use the photographs provided at the end of your handout to assign a tombstone* ***legibility index*** *to each tombstone. For each tombstone that you evaluate, record the year of death, your legibility index value, the location (the direction that the stone is facing (i.e. N, S, E, W)), whether or not the tombstone is in a shaded spot (i.e. shaded (S) versus non shaded (NS)), and the grain-size of the marble (i.e. coarse grained (CG) or fine grained (FG)). Use your best judgment and try to be consistent in your interpretation of the amount of weathering of the tombstones.* ***NOTE: do not use white tombstones that are facing upward or stones that have raised lettering AND be sure to collect data from a RANGE OF AGES. (5pts)***

3) Before we leave, take a quick look at the igneous rock tombstones. Be sure to look at tombstones from a range of ages. How weathered are the tombstones made out igneous rocks relative to those made out of marble? Explain why the weathering rates are different. (6pts)

PART 2: Analyze Data

In the Geology computer lab (Room 120), use Microsoft Excel to create a spreadsheet showing the year of death in column 1, tombstone age in column 2 (you will need to calculate the ages), and your LI values in column 3. Make an X-Y scatter plot showing LI as a function of tombstone age. **Fit a straight line to your data using the add trendline option and show the equation and R^2 value on your graph. Label your axes and put your name in title of your graph. Print a copy of your plot and attach it to your lab. (15pts)**

1) Record the equation for your line and the R^2 value (4pts):

Using the equation for your regression line, answer the following questions. Please show your work where appropriate.

2) How long might a tombstone be exposed to weathering in this cemetery until one would assign an LI value that indicates the onset of visible weathering (i.e. LI= 1) (4pts)?

3) You could not directly observe the time necessary to reach the worst legibility index number (LI=10), nearly complete obliteration of the lettering on the tombstone, because you couldn't read the date! Use your regression equation to estimate how many years it would take for a brand-new marble tombstone to be completely unreadable (i.e. LI=10) (4pts).

4) Use your calculation from question 3 to estimate a chemical weathering rate for eastern Pennsylvania. Assume that the lettering on these tombstones originally averaged 4 mm in depth, and that legibility is reduced by the retreat of the surface of the tombstone while the recessed portion undergoes no retreat. Use this thickness and the number of years for complete obliteration (LI=10) that you calculated in question 3 to estimate a chemical weathering rate in mm/yr for eastern Pennsylvania (4pts).

5) Name 3 sources of data scatter in this experiment (Note: there are <u>at least</u> 4)? On the basis of your data, do you think that there is a significant relationship between the amount of weathering and tombstone age? Why or why not? (8pts)

PART 3: Further Interpretation

1) What process in addition to natural carbonic acid dissolution is contributing to the weathering of the stones that you evaluated? In the eastern US, which source of acid is likely to cause the most damage? Explain why. (6pts)

2) In center city Philadelphia carbonate rock weathering rates are 0.035 mm/yr, whereas in rural areas in the greater Philadelphia area they are 0.005 mm/yr. Explain why the rates are different in urban settings versus rural settings. How does your weathering rate compare with these? Is your rate consistent with what you would expect for a small city near Philadelphia? Explain why or why not. (8pts)

3) An implicit assumption you made in this lab is that the intensity of chemical weathering has not varied from the original carving of oldest gravestone to the present. Based on your response to Part 3 question 1, explain why we should suspect that this assumption may have been violated. (6pts)

4) If you plotted on your graph 15 igneous tombstones of varying ages where would they plot? How might your results be affected if you included igneous tombstones in your analysis? (6pts)

5) On your plot of LI versus tombstone age, draw a line indicating the expected weathering rate for granite and label it. Explain why you gave the line the slope you did. (6pts)

#	Date	LI	Facing (N,S, E, W)	Shaded? (S, NS)	Grain size (CG, FG)
1					
2					
3					
4					
5					
6					
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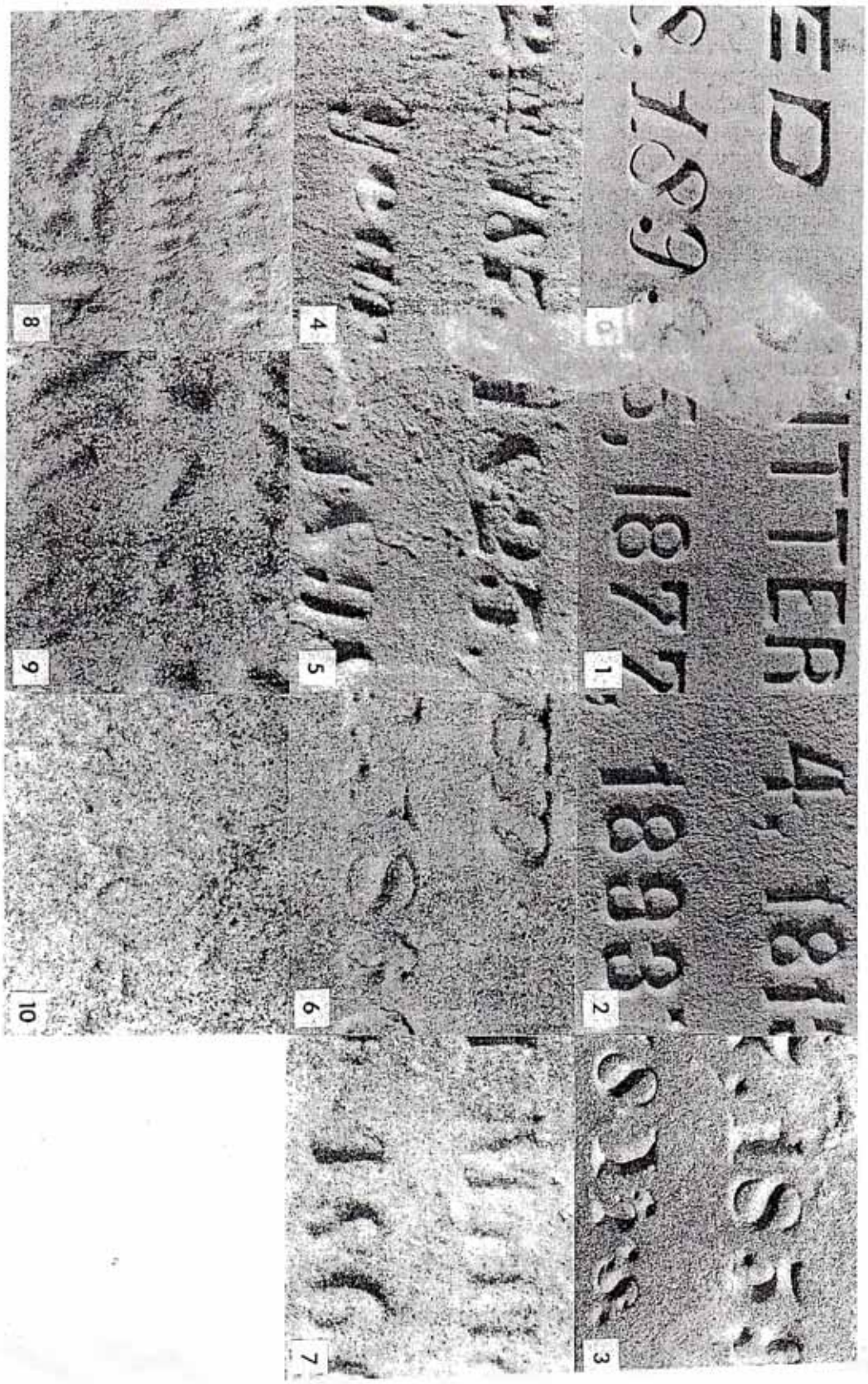

Legibility Index (LI)