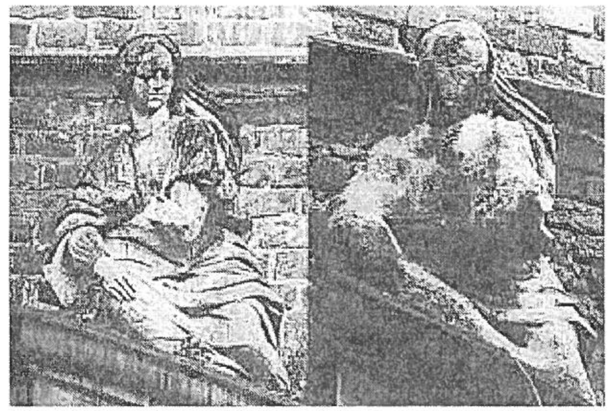
Lab: Reaction Rates for Chemical Weathering of Limestone

Whether it's the granite of a New Hampshire mountain breaking down into sand and clay or the limestone of Kentucky decomposing to form rich soil, all chemical weathering processes involve water. What effect does the temperature of the water have on the rate at which chemical weathering occurs?

As you know, carbonic acid is a weak acid that forms when carbon dioxide dissolves naturally in rain, in streams, or in groundwater. A common chemical weathering process is the reaction between carbonate rocks, such as limestone and marble, with carbonic acid. In this lab activity, you will observe a model of this reaction. By changing the temperature of the water, you can model the effect of the temperature on the rate of the reaction between carbonate rocks and carbonic acid.



Materials:

5 – 250 mL beakers
5 effervescent antacid tablets
water
5 thermometers
Stopwatch

Procedure:

1. Arrange 5 beakers in a row. Assign each beaker a number from 1 to 5. Place a thermometer in each beaker. Each beaker should contain 200 mL of water. The water temperature in each beaker will need to be adjusted to match the following temperatures (use ice or hot H_2O as needed to make adjustments).
   - Beaker 1: 0° – 10°C
   - Beaker 2: 10° – 20°C
   - Beaker 3: 20° – 30°C
   - Beaker 4: 30° – 40°C
   - Beaker 5: 40° – 50°C
2. Begin with Beaker 1. Remove any pieces of ice from the water. Check to be sure that the water is within the correct temperature range and that the thermometer has stopped changing. Read the temperature of the water in Beaker 1 to the nearest half degree and record it in DATA TABLE A. Remove the thermometer from the beaker and set it aside in a safe place.
3. READ ALL OF THIS STEP BEFORE CONTINUING. Drop one of the antacid tablets into beaker 1. Start the stopwatch at the instant the tablet enters the water. Stop the stopwatch when the last piece of the tablet dissolves. (It is not necessary to wait for all of the bubbling to stop; wait only for all pieces of the tablet to disappear.) Read the time on the stopwatch. Record the time in Data Table A.
4. Repeat steps 3 and 4 for each of the remaining beakers.
5. Copy the Beaker 1 data from Data Table A to Data Table B. The remaining values in data Table B will need to be calculated. For the temperature values, add 10° C to the reading for Beaker 1 and record that as the temperature for Beaker 2. In the same way, continue to add 10°C to each temperature reading for Beakers 3, 4 and 5 Data Table B.
6. For the time values on Data Table B, divide each reading in half to get the next reading. For example, the time for Beaker 2 will be one half the time for Beaker 1 and so on. When you divide the values, round to the nearest whole second.
7. Create a graph of the data for the 5 trials. The x-axis will be Temperature (°C) and the y-axis will be Time (sec). Connect the 5 points with a smooth curve. Label the curve OBSERVED DATA.
8. Using this same graph, plot the values from Data Table B. Connect the points with a smooth curve. Label this curve THEORETICAL DATA.

DATA TABLE A

Beaker Number	Temperature (°C)	Time (seconds)
1		
2		
3		
4		
5		

DATA TABLE B

Beaker Number	Temperature (°C)	Time (seconds)
1		
2		
3		
4		
5		

Analysis and Conclusions:

1. In which beaker did the reaction occur most slowly? In which beaker did the reaction occur most rapidly? What do you think is the relationship between the temperature and the rate of reaction?
2. This experiment is designed to be a simulation of the chemical weathering of limestone by hydrolysis. What do you think is meant by the term hydrolysis?
3. What do you think is the relationship between the temperature and the rate of natural chemical weathering?
4. Look at the temperatures that you recorded. Are all of these temperatures likely to occur on Earth's surface? EXPLAIN.
5. Would a limestone building weather more rapidly in Homer, Alaska or Honolulu, Hawaii? (both cities receive about the same amount of precipitation per year) EXPLAIN your answer.
6. Which area would have thicker soil? WHY?
7. How would the rate of the reaction have been different if the tablets had been ground into a powder before they were dropped into the water? WHY would this make a difference?
8. Would a graph for the reaction described in question 7 result in a curve above or below the line of your actual data? WHY?
9. List several factors that might change the surface area of rocks and explain how these would affect the rate of weathering.
10. Look at the calculated values in Data Table B. On your graph, is the line for the theoretical data above, below, or the same as your line for the actual data?
    - What does this mean about the rate of the reaction you observed compared with the theoretical rate of reaction?
    - What change in the procedure might have made your actual results more like the theoretical results?
11. Many historic buildings are facing the dissolution of the once finely chiseled features on the sculptures. Historic cemeteries are also facing this problem on tombstones. Explain the process at work here.
12. Describe how you would design an experiment to explore the effects of various strengths of acid solutions would have on the rate of chemical weathering.