Laboratory 3

Weathering of Rocks and Formation of Sediment - Exercises

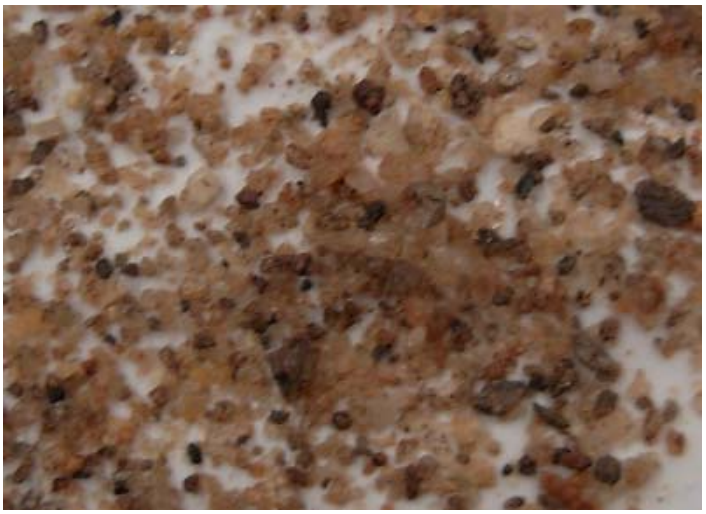
Pre-Lab Exercises

1. For each of the following sedimentary rock descriptions, interpret these five paleoenvironmental factors:

- **Source area lithology** (rock type from which it was derived)
- **Paleoclimate** (humid? arid?)
- **Tectonic activity** (high or low tectonic activity)
- **Energy levels** (high or low, consistent or inconsistent energy levels)
- **Time** (long or short time in depositional basin)

Sedimentary rock descriptions	Paleoenvironmental factors				
	Source area lithology	Paleoclimate	Tectonic activity	Energy levels	Time
Quartz sandstone, well sorted, well rounded					
Arkose, poorly sorted, poorly rounded					
Quartz sandstone, angular, muddy, poorly sorted					
Arkose, well sorted, well rounded					
Litharenite, poorly sorted, no mud, angular					

2. Examining river sand samples.



River sand, Atlanta, GA. Photo by Pamela Gore, 2008.

a. Using the guide in this lab, describe the sorting of this sand. Is this sand very well sorted, well sorted, moderately well sorted, poorly sorted, or very poorly sorted?

_____

b. Using the guide in this lab, describe the roundness of this sand. Is this sand well rounded, rounded, sub-rounded, sub-angular, or angular?

_____

c. Has this sand been in the depositional basin (river) for a long time or for a short time?

_____

d. This sand was derived from the weathering of granites and gneisses. What minerals do you expect to be in this sand, and why?

_____

e. Why does this sand have a brown color? What has happened to it?

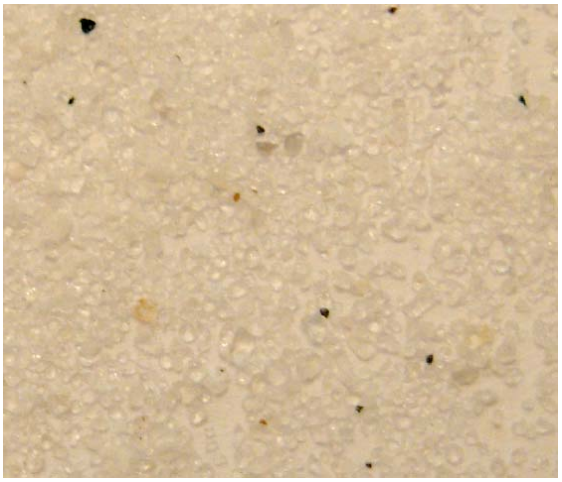
_____

f. Predict what will happen to this sand as it travels downstream to the Atlantic Ocean.

_____

_____

3. Examining beach sand samples.



Beach sand, Destin, Florida.
Photo by Pamela Gore, 2008.

Beach sand, Kure Beach, North Carolina
Photo by Pamela Gore, 2008.

These three beach sands come from the southeastern U.S. Destin, Florida is on the Gulf Coast. Kure Beach, NC and Washington Oaks Gardens State Park, FL are on the Atlantic coast.

Beach sand, Washington Oaks Gardens State Park, Florida. Photo by Pamela Gore, 2008.

a. Using the guide in this lab, describe the sorting of each of these sand specimens. Are these sands very well sorted, well sorted, moderately well sorted, poorly sorted, or very poorly sorted?

Sand Specimen	Sorting
Destin, FL	
Kure Beach, NC	
Washington Oaks Gardens, FL	

b. What would you interpret about the energy levels of the depositional environment of these sands?

_____

c. What is the common colorless mineral that all three of these sands have in common?

_____

d. What type of sandstone would you predict that the sands from Destin and Kure Beach would make?

_____

e. The colored grains in the Kure Beach sand include orange mollusc (clam) shells, silver or greenish muscovite, black biotite, and other fine grained black minerals.
The large orange grains in the Washington Oaks sand are also mollusc shells.
What would you interpret about the source area lithology from these sands? (Give the rock type or types, not the minerals)?

_____

f. What would you interpret about the climate from examining these sands?

_____

g. What would you interpret about the time in the depositional basin from these sands?

_____

h. Which of these three sands has spent the LEAST TIME in the depositional environment?

_____

i. Explain your reasoning for the above answer.

_____

j. What would you interpret about the tectonic setting of these sands or their source area?

_____

k. How do the beach sands differ from the river sand?

_____

l. Why do the beach sands differ from the river sand? What processes were involved?

_____

_____

4. Examining sand from Colorado.

Sand from a dry stream bed at the foot of the Rocky Mountains in Colorado. Photo by Pamela Gore, 2008.

a. What mineral are the square-looking pink grains in this sand?

_____

b. What mineral are the tan or gray grains in this sand? _____

c. There are two large grains on the right side of this image that are not individual mineral grains. What type of grains are they?

_____

d. What type of sandstone would you predict that the sand from Colorado would make?

_____

e. What would you interpret about the source area lithology from this sand? (Give the rock type, not the minerals.).

_____

f. What would you interpret about the climate from examining this sand?

_____

g. What would you interpret about the time in the depositional basin from this sand?

_____

h. Using the guide in this lab, describe the sorting of this sand specimen. Is this sand very well sorted, well sorted, moderately well sorted, poorly sorted, or very poorly sorted?

_____

i. Using the guide in this lab, describe the roundness of the grains in this sand specimen. Are they well rounded, rounded, sub-rounded, sub-angular, or angular?

_____

j. What would you interpret about the tectonic setting of these sands or their source area?

_____

k. What would you interpret about the energy levels of the depositional environment of these sands?

_____

Laboratory Exercises

1. Examining granite

a. Examine the sample of granite in the lab and describe it.

What color (s) is it? _____

Is it hard, or does it crumble easily? _____

b. Describe the texture of the granite. (Use an igneous texture term.)

_____

c. What is its grain size (in mm)? _____

d. Identify four minerals present in the granite sample

_____ _____

_____ _____

2. Examining granite saprolite

Examine the specimen of granite saprolite in the lab. Do all work over a paper towel or sheet of paper to catch the rock particles.

a. Describe the appearance of the saprolite.

What color is it? _____

Is it hard, or does it crumble easily? _____

b. What is its grain size (in mm)? _____

c. List four minerals you can identify in the saprolite.

_____ _____

_____ _____

3. Comparing granite to saprolite

a. What two minerals are missing from the saprolite compared with the minerals you identified in the granite?

_____ _____

b. Why are they missing? What happened to them? What weathering processes were involved?

Missing mineral	**Weathering process(es) involved**

c. Estimate the percentages of each of the following in your saprolite sample. Your percentages must total to 100%.

Mineral	**Estimated percentage**
Kaolinite (white clay)	
Quartz	
Muscovite	
Iron oxides (reddish brown)	
Other minerals (if any)	
TOTAL	100%

d. What mineral weathered to form the kaolinite? _____

e. What mineral (or minerals) weathered to form the iron oxides?

_____

f. What kind of igneous rock contains these minerals? _____

g. Compare and contrast the texture of the saprolite and the texture of the igneous rock that you named.

4. From saprolite to sediment
You may do this experiment, or your instructor may demonstrate it for you. (Not required of online students unless saprolite is available.)

Instructions
- Crumble some of the saprolite into a jar or empty plastic water bottle.
- Fill the jar or bottle with more than enough water to cover the saprolite .
- Put the lid on and shake vigorously until the saprolite is totally separated into individual grains, and no lumps remain.
- Set the jar or bottle down and observe the settling of the sediment.

Questions
a. How long does it take for the larger grains to settle? _____

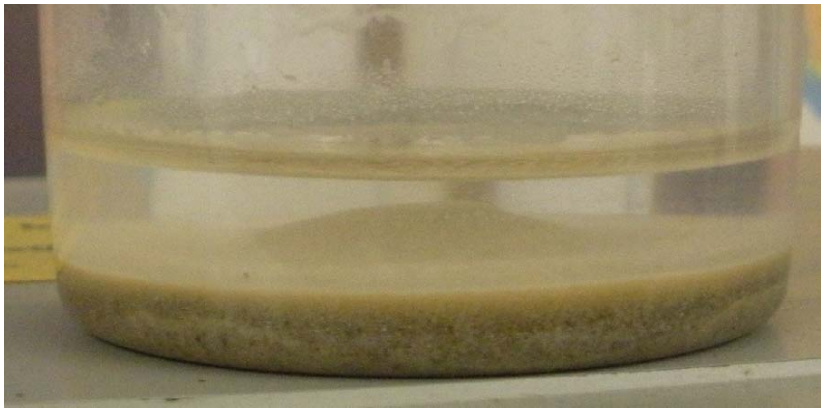
b. How long does it take for the finest grains to settle? _____

c. After all of the particles have settled and the water is clear, examine the layering you see. (Or examine the photo below.) Describe the characteristics of each layer you can observe. Use Wentworth Scale terms to describe the grain sizes.

_____

_____

_____



Example of saprolite that has been allowed to settle in water. Photo by Pamela Gore, 2008.

d. Write a hypothesis to explain your observations.

_____

_____

5. Examining and Characterizing Sand Samples

Materials needed:

- Data Table for Sand Samples (below)
- Several different sand samples (glued onto cards)
- Hand lenses (or microscopes - preferred)
- Sand gauges for grain size determination

Examine the sand sample(s) and answer the following questions. Write your answers in the Data Table for Sand Samples. Space is available for ten sand samples.

Begin by collecting data on each of the sand samples.

. Where was it collected? (Read the label)

. What color(s) is it? Is it one color or a mixture of many colors?

. Examine the sand with a stereo-zoom microscope (or a hand lens if microscopes are not available).
Is the sand all made of one mineral, or are there different minerals in it?
What minerals can you identify in the sand?

. Are there any rock fragments present in the sand? (If so, can you determine what kinds of rocks?)

. Are there any shells or other remains of organisms in the sand?

. Look at the size of the sand grains. Compare them with a sand gauge.

- Are all of the grains the same size?
- How big is the largest grain of sand? (Use the sand gauge to determine grain size)
- How big is the smallest grain of sand? (Use the sand gauge to determine grain size, or estimate using the graph paper)
- What would you estimate is the average grain size in millimeters of the sand grains?
- Think about this one. No need to write.
    - Are some of the minerals typically larger than others?
    - Which are the larger minerals?
    - Which are the smaller minerals?
- Write the range of grain sizes in the table.

. Use the guide in this lab to estimate the sorting of the sand sample. Is this sand very well sorted, well sorted, moderately well sorted, poorly sorted, or very poorly sorted?

. Use the guide in this lab to estimate the roundness of the majority of the grains in this sand sample. Are they well rounded, rounded, sub-rounded, sub-angular, or angular? If

they are not all the same roundness, indicate which minerals have which roundness, and/or which grain sizes have which roundness (i.e., green grains are rounded but black grains are angular OR big grains are rounded and little grains are angular, etc.).

Data Table for Sand Samples

Sand #	Data collected from the sand sample							
	A. Location?	B. Color	C. Identify Minerals Present	D. Rock frag-ments?	E. Shells ?	F. Grain size range? (mm)	G. Sorting	H. Grain roundness
1								
2								
3								
4								
5								
6								
7								
8								
9								

10								

6. Interpreting Paleoenvironment of Sand Samples

Interpret the following five paleoenvironmental factors for each sand sample that you described above.

1. **Source area lithology** (original rock type from which it was derived?)
2. **Paleoclimate** (humid? Arid?)
3. **Tectonic activity** (high or low tectonic activity?)
4. **Energy levels** (high or low? Consistent or inconsistent energy levels?)
5. **Time** (long or short time in depositional basin?)

Write your answers in the "Sand Sample Interpretation Table", below.

Sand Sample Interpretation Table

Sand	Location	A. Source Area Lithology?	B. Paleo-climate?	C. Tectonic Activity?	D. Energy Levels?	E. Time?
1						
2						
3						
4						
5						
6						
7						

8						
9						
10						

7. WEB EXERCISE - The Virtual Sand Collection

The questions below are adapted with permission of Dr. Dave Douglass, from the Virtual Sand Collection website at Pasadena City College in California.
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SANDHP.htm

For each question, go to the web links given to see the sand sample, as viewed through the microscope. Click on "ZOOM IN" several times to increase the magnification so that you can get a closer look at individual sand grains under higher magnification with the microscope.

Sand #1 - California Beach Sand, San Clemente, California
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SandPile/SanClem.htm#anchor428329

This light-colored sand appears tan to the naked eye, but most of the grains are colorless under the microscope. The composition of this sand is similar to the composition of granitic rocks found in nearby mountains, namely minerals such as feldspar, quartz and biotite.

a. Zoom in several times to find and enlarge a grain of the colorless mineral. Describe how the colorless mineral breaks.

_____

b. Identify the colorless mineral. It is one of the three minerals listed above.

_____

c. Look for a grain of biotite in the sand. Based on what you learned about mineral weathering in this lab, what two weathering processes affect biotite, and what are the weathering products of each (i.e., what new minerals are formed as biotite is weathered)?

Weathering process affecting biotite	Weathering product (new mineral)

d. Because biotite weathers easily, what does the presence of biotite in this sand suggest about much these grains have been weathered, and how far they have been transported? Circle the correct answer below.

a. Heavily weathered and/or transported far from the source area
   or
b. Not weathered much and not transported far from the source area

Sand # 2 - Carbonate Sand from Gun Beach, Guam
http://www.paccd.cc.ca.us/SAND/SandPile/GunBech.htm

Sand #3 - Carbonate Sand from O'Carrol's Cove, Ireland
http://www.paccd.cc.ca.us/SAND/SandPile/Ocarrol.htm

e. Sands #2 and #3 are very different from those on California beaches. The sands are composed mainly of calcium carbonate produced by the activities of living organisms. The sands consist of bits of shells, foraminifera tests, and pieces of other organisms such as algae or coral. Zoom in several times and examine the microscopic fossils in these two sands. These microfossils are called **foraminifera** (or **forams** for short), and their shells are called **tests**. Sketch a foram test from each sand as it appears under highest magnification.

Gun Beach, Guam	O'Carrol's Cove, Ireland

f. The foraminifera are quite interesting, but very different in each sand. Why do you think the forams are so different? Hint: Locate Guam and Ireland on a world map.

_____

g. Why do you suppose we do not find carbonate sands dominated by foraminifera on beaches in southern California? Hint: Think about the source area lithology, climate, and tectonic setting. How might one or all of these affect California sand to make it different from Sands #2 and #3?

_____

_____

Sand #4 - Heavy Mineral Sand from Dockweiler Beach, California
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SandPile/DocWilr.htm

h. This is a different kind of sand from southern California called a "heavy mineral sand" because it is largely made up of minerals which have a higher than average density. (Georgia also has heavy mineral sands, although they contain different heavy minerals.) Most of the grains in this heavy mineral sand are what color?

_____

i. Zoom in to look at the clear, red sand grains. Using the table in this lab, "Identifying Minerals in Sands", what is this mineral?

_____

j. Look at the black grains. Click "MAGNET" to see what happens when they are placed next to a magnet. Using the table in this lab, "Identifying Minerals in Sands", what is this mineral?

_____

Sand #5 - Volcanic Black Sand from Jokulska River Mouth, Iceland
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SandPile/Iceland.htm

k. This is another black sand, but this one is very different from the one from Dockweiler Beach. What are three ways in which these sand grains differ from those at Dockweiler Beach?

_____

_____

_____

l. What additional tests might you want to do on these sand grains in order to determine that the sand from Iceland is different from the sand from Dockweiler Beach? List two additional tests you could perform on the sand.

1. _____
2. _____

m. The black sand from Iceland is composed of obsidian, a black volcanic glass. Zoom in to the maximum and look at the grains closely. What evidence can you see to suggest that this glass came from volcanic rocks?

_____

Sand #6 - Olivine Sand from Toilet Bowl, Oahu, Hawaii
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SandPile/TBowl.htm

Sand #7 - Olivine Sand from Green Sand Beach, Hawaii
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SandPile/GrnSand.htm

Both of these samples are green sand, composed almost entirely of the mineral **olivine**.

n. Zoom in on each of the olivine sands. Using the sandstone roundness guides in this lab, describe the roundness of each of the sands. Are they well rounded, rounded, sub-rounded, sub-angular, or angular?

Sand Specimen	Roundness description
Toilet Bowl, Oahu, Hawaii	
Green Sand Beach, Hawaii	

o. Where do you think the olivine comes from? _____

Why? Explain your reasoning. _____

p. Which of the two sands has the larger grains? _____

q. From your observation of grain size, predict which beach has the higher wave energy.

_____

r. How does grain size relate to roundness? Are the larger grains rounder or less rounded?

_____

Sand #8 - Oolitic Sand from the Great Salt Lake, Utah
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SandPile/SltLake.htm
This is a lake sediment, sand like this also found in warm shallow seas in tropical regions. Look at this sand carefully under high magnification. These grains are called **oolites** (or ooids), and they are composed entirely of calcium carbonate.

s. Using the sandstone roundness guide in this lab, describe the roundness of the sand. Is it well rounded, rounded, sub-rounded, sub-angular, or angular?

_____

t. Using the sandstone sorting guide in this lab, describe the sorting of this sand. Is it very well sorted, well sorted, moderately well sorted, poorly sorted, or very poorly sorted?

_____

u. Interpret the energy level of the depositional environment of this sand. _____

v. Go online to research the origin of oolitic sand. Write a paragraph on the origin of oolites. Use the following references.
Go to http://books.google.com and search for:

1. *Encyclopedia of Sediments and Sedimentary Rocks* - Page 129
2. *Microfacies of carbonate rocks* - Pages 142-156

http://geology.utah.gov/utahgeo/rockmineral/collecting/oolitic.htm
http://www.nysm.nysed.gov/virtual/collections/splendor_in_stone/splendortour17.html

_____

_____

_____

Sand #9 - Eolian Sands from Al Wasrah, Kuwait
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SandPile/AlWasra.htm
Eolian sands differ from other types of sands in that they have been deposited by the action of wind.

w. Using the sandstone roundness guide in this lab, describe the roundness of the sand. Is it well rounded, rounded, sub-rounded, sub-angular, or angular?

_____

x. Using the sandstone sorting guide in this lab, describe the sorting of this sand. Is it very well sorted, well sorted, moderately well sorted, poorly sorted, or very poorly sorted?

_____

y. Compare the eolian sand with the beach sands. List three differences.

_____ _____

_____

8. Heavy Mineral Sand Analysis

This exercise involves examining an analysis of a heavy mineral sand sample from one of the Georgia barrier islands, doing some calculations and drawing a pie diagram.

For this exercise, you should use a computer with spreadsheet software, such as Excel. If a computer is not available, you may use:

- calculator
- drawing compass (a point on one end and a pencil on the other)
- protractor (to measure and plot angles on the circle you will draw)
- ruler

Examine the composition of a Georgia heavy mineral sand in the table below. The sample weight was 147 grams and the weight of each mineral is given in grams. Calculate the percentage of each mineral present in the sample. To check your work, add all the weights to confirm that the sample weighed 147 g. Then add the calculated percentages to confirm that the total equals 100%.

Write your answers on the table below or attach a printout from your spreadsheet program. Attach a separate sheet with your pie diagram.

Mineral	Sample weight (g)	% Total Weight
Ilmenite	74.59	
Zircon	32.74	
Staurolite	9.94	
Epidote	8.57	
Rutile	7.97	
Leucoxene	2.63	
Monazite	2.54	
Kyanite/sillimanite	2.25	
Garnet	2.23	
Quartz	1.21	
Hornblende	1.18	
Tourmaline	1.00	
Corundum	0.15	
Other	0.0	
	Total = 147 g	

Now, draw a pie diagram to illustrate the percentages of each of the heavy mineral components. This is easily done by computer using Excel.

If you do not have access to a computer, you may draw your pie diagram by hand, following these instructions.

- Using a drawing compass, draw a circle with a radius of x mm. Do not draw the circle freehand. You must use a drawing compass.
- Using a calculator, compute the relative proportions of each mineral from the data provided in terms of degrees of arc.
  Example: Zircon = 22.27%, therefore 360 degrees x .2227 = 80.172 degrees, which can be plotted to the nearest degree [i.e., 80 degrees].
- Use a protractor to measure the angle in degrees, and draw a line using a ruler.
- Plot the number of degrees of arc in the pie to represent each mineral.
- Each mineral should be identified in a legend and colored on the pie chart.

Heavy mineral data from Bishop, G.A. and Marsh, N. B., 1997, "Activity 3", The Geology of Georgia, Virtual Fieldtrip to Georgia Coast. [online].

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9. OPTIONAL ACTIVITY (May be applicable to those interested in K-12 teaching)

The Ocean's Sand, A Natural Resource, Minerals Management Service, U.S. Department of the Interior. http://www.mms.gov/mmskids/PDFs/sandanaturalresource.pdf.
Examine sand, make a beach profile, analyze grain types, and analyze sediment size distribution.

References:

Bishop, G.A. and Marsh, N. B., 1997, "Activity 3", The Geology of Georgia, Virtual Fieldtrip to Georgia Coast.

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The SEGa Times, v. 8, issue 4, Australian Company Mines for Titanium in Brantley.
http://www.segardc.org/The_SEGa_Times/mar_apr_04.pdf.