ES 105 Laboratory # 6
STUDY OF SEDIMENTARY ROCKS

Introduction

Rocks are the materials of Earth, and understanding their origin and how they change enables us to begin to understand Earth and its processes. **Rocks** are aggregates of minerals and are classified into three groups based on the processes that formed them: **Igneous**, **Sedimentary**, and **Metamorphic**. This lab focuses on some of the common sedimentary rocks, which are formed at the surface of Earth.

Sedimentary rocks form from the consolidation and lithification of particles called **sediment**. Sediment is created either by physical processes breaking pre-existing rocks into smaller particles, or by inorganic or organic chemical processes, where mineral material is precipitated from solution. Sedimentary rocks form at or near Earth's surface in many different environments, including lakes (lacustrine), deserts (eolian or wind), streams (fluvial), alpine (glaciers), and oceans (marine). Some sedimentary rocks have features that reveal a great deal about the environment in which they formed. For example, the degree of rounding of the particles, the presence and nature of fossils, and the mineral composition may help decipher the conditions in ancient environments. This provides clues about ancient Earth history, and also aids in finding potential fossil fuel deposits.

Goals and Objectives

- Recognize the classes of sedimentary rocks: clastic and chemical, and be able to distinguish samples of each type
- Classify and name samples of sedimentary rocks by their composition and texture
- Hypothesize the environment of formation of a sedimentary rock based on the composition, size, shape and distribution of its grains.

Useful Websites

- http://geology.wr.usgs.gov/parks/rxmin/rock2.html
- http://www.physicalgeography.net/fundamentals/10f.html
- http://csmres.jmu.edu/geollab/fichter/SedRx/
- http://www.windows.ucar.edu/tour/link=/earth/geology/sed_clastic.html
- http://www.windows.ucar.edu/tour/link=/earth/geology/sed_chemical.html

Name_______**KEY**________________________

Lab Day _____ Lab Time_____________________

Prelab questions: Complete prior to arriving at your lab section.

Define TERMS that are in CAPITAL LETTERS, and answer the questions below:

1. CLASTIC SEDIMENTARY ROCK (Detrital Rock)

   Rock composed of particles eroded from preexisting rocks, transported by a fluid medium (water or air), deposited, then lithified by compaction and cementation.

2. What is the most common clastic sedimentary rock?

Shale

3. CHEMICAL SEDIMENTARY ROCK

Rock formed by precipitation of dissolved mineral material, directly by chemical processes, or by the action of organisms such as marine life (limestone) or land plants (coal).

4. What is the most common chemical sedimentary rock?

Limestone (second most common sedimentary rock)

5. CEMENTATION (of clastic rocks)

The precipitation of mineral material in the pore spaces, gluing the grains together.

6. List common sedimentary rock cements: **Calcite, silica, iron oxide, in order of abundance.**

Part A – Overview of Minerals in Sedimentary Rocks

A handful of minerals are commonly found in association with sedimentary rocks, including **quartz** (SiO_2), **potassium feldspar** ($KAlSi_3O_8$), **plagioclase feldspar** ($Na\ AlSi_3O_8,CaAl_2Si_2O_8$), **mica** (**muscovite** and **biotite**), **calcite** ($CaCO_3$), **halite** (NaCl), and **gypsum** ($CaSO_4 \cdot H_2O$). Table 2 is a summary of the diagnostic (i.e. distinguishing) physical properties that are used to identify these minerals. Use the set of mineral identification tools (Table 2, nails, pennies, dropper bottle of HCl, your eyes and intellect) and identify the names of the set of unknown mineral samples provided. List your results in Table 1. (NOTE: There is **one** example of each mineral, use the process of elimination to your advantage!)

Table 1: Identification of unknown minerals commonly associated with sedimentary rocks.

Sample Number	List of Diagnostic Properties (Used to Identify Each Mineral)	Mineral Name
#3	Harder than glass, no cleavage	Quartz
#5	Softer than fingernail, thin elastic cleavage sheets, brown	Biotite mica
#6	Softer than glass, three directions of perfect cleavage at 90^o	Halite
#8	Harder than glass, two directions of perfect cleavage at 90^o, may show striations or gray color-- if either: plagioclase feldspar, if neither can only be called: feldspar	Plagioclase feldspar
#10	Harder than glass, two directions of perfect cleavage at 90^o, may be of pink color: if so, it is potassium feldspar, if not can only be declared: feldspar	Potassium feldspar
#13	Softer than glass, harder than fingernail, three directions of perfect cleavage, not at 90^o, fizzes in dilute cold hydrochloric acid	Calcite
#14	Softer than fingernail, may show a single direction of perfect cleavage, and may show two other directions of poor cleavage (one of which is at 90^o to the perfect plane, the other is not at 90^o to either other direction)	Gypsum
#15	Softer than fingernail, thin elastic cleavage sheets, pale color	Muscovite mica

Table 2: Common sedimentary minerals and their diagnostic physical properties

Mineral Name	Diagnostic Physical Properties
Quartz SiO_2	Harder than glass (specimen will scratch glass) Glassy to waxy surface appearance (luster) Variable colors of rose, smoky gray, clear, and milky white
Potassium Feldspar $KAlSi_3O_8$	Harder than glass (specimen will scratch glass) Breaks into blocky, angular pieces (two directions of cleavage) Common variety is pink in color
Plagioclase Feldspar $NaAlSi_3O_8, CaAl_2Si_2O_8$	Harder than glass (specimen will scratch glass) Breaks into blocky, angular pieces (two directions of cleavage) Whitish to medium gray in color Parallel striations (line-like features) commonly visible
Mica $K[Al_2/(Mg_3, Fe_3)], (AlSi_3O_{10})(OH)_2$	Softer than fingernail (fingernail will scratch specimen) Breaks into thin sheets/flakes, book-like occurrence
Muscovite Mica	Clear to silvery in color. Breaks into thin silvery flakes
Biotite Mica	Black in color. Breaks into thin brown to black flakes
Calcite $CaCO_3$	Softer than a penny, harder than fingernail Breaks into rhombohedra (three directions of cleavage) Whitish in color Fizzes when touched with a drop of dilute hydrochloric acid (the “fizzing” with acid is the result of CO_2 release)
Halite NaCl	Softer than a penny, harder than fingernail Breaks into cubes (three directions of cleavage) Clear in color, tastes salty (Don’t lick lab samples!)
Gypsum $CaSO_4 \cdot H_2O$	Very soft, scratches easily with fingernail Clear to white to pink in color May show three directions of cleavage

Part B – Introduction to Classifying Sedimentary Rocks

Examine the sedimentary rock study sets provided and answer the following questions.

1. Study the set of sedimentary rocks provided. Determine whether each rock is clastic or chemical by separating into two groups. Place those that are made of pieces or fragments of mineral and/or rock material (but not the rocks that have shells or shell fragments) on one tray, and the rocks made of organic material (like shells or coal) or of crystals on the other tray. One group of samples is the clastic sedimentary rocks. The other group is the chemical sedimentary rocks. In the spaces below, list the sample numbers that occur in each group.

Clastic Sedimentary Rocks	Chemical Sedimentary Rocks
#1 breccia **#2 shale** **#3 conglomerate** **#4 quartzose sandstone** **#7 lithic sandstone**	**#5 coal** **#6 limestone (massive variety)** **#8 chert** **#9 coquina (variety of limestone)** **#10 fossiliferous limestone** **#11 oolitic limestone**

2. Pick up each **specimen** on your **clastic rock tray** and look at the size of the grains (the fragments of which it is composed). Use a magnifying lens and ruler to measure size of the grains. Separate the clastic specimens into two groups based on the grain size: those that have large grains (big enough to distinguish without a magnifying lens) from those that have small grains (too small to see individual grains without a magnifying lens, or sometimes even with one). In the spaces below, list the sample numbers that occur in each grain-size group.

Coarse Grained Clastic Rocks	Fine Grained Clastic Rocks
#1 breccia **#3 conglomerate**	**#2 shale** **#4 quartzose sandstone** **#7 lithic sandstone**

3. Study one of the coarse-grained clastic rock samples. **Describe** and **sketch** this clastic rock specimen focusing on the grains and the surrounding material.

#1 breccia or
#3 conglomerate

Examine the specimens in the tray of **chemical sedimentary rocks**. Because they form from a wide variety of processes, some chemical sedimentary rocks are crystalline, while others consist of organic material, including plant material, shells and shell fragments. Separate the chemical sedimentary rocks that are crystalline from the ones that are organic, and write the specimen number in the table below.

Crystalline	**Organic**
#8 chert **#11 oolitic limestone**	**#5 coal** **#6 limestone (massive variety)** **#9 coquina (variety of limestone)** **#10 fossiliferous limestone**

4. Limestone is the most abundant chemical sedimentary rock. It comes in many different varieties, which form by numerous processes, but one thing that all limestones have in common is that they are made of the mineral *calcite*. Calcite reacts with hydrochloric acid (HCl). When a small drop of HCl is placed on calcite, it fizzes vigorously. This is a good test for limestone. Limestone can precipitate directly from seawater, or can be formed from shells of marine organisms. After the organisms die, the shells become calcite sediment. Calcite also sometimes precipitates in the pores of clastic material as cement to hold the rock together. Test the sedimentary rocks with HCl and briefly describe your results.

Calcite tests on chemical rocks	Calcite tests on clastic rocks
#5 coal **does not fizz**	#1 breccia **does not fizz**
#6 limestone (massive variety) **fizz**	#2 shale **does not fizz**
#8 chert **does not fizz**	#3 conglomerate **does not fizz**
#9 coquina (variety of limestone) **fizz**	#4 quartzose sandstone **does not fizz**
#10 fossiliferous limestone **fizz**	#7 lithic sandstone **may show fizz of cementing material**
#11 oolitic limestone **fizz**	

Part C – Classification of Sedimentary Rocks

Classification of sedimentary rocks is based on how the sediment that makes up the sedimentary rock originates. Using the classification charts (Table 3 and 4), assign correct names to the lab specimens. Begin by describing the texture and composition of the rock. Identify the rocks in the study set using the rock identification charts. Complete Table 5.

<u>Clastic Sedimentary Rocks</u> are made from deposits of broken and/or weathered rock. Clastic rocks are first classified by the size and shape of the particles, and secondly by the composition of the particles within the rock.

Table 3: Clastic Sedimentary Rock Classification

Particle Size	Characteristics	Rock Name
> 2mm (bb size)	Clasts are angular	**Breccia**
	Clasts are rounded	**Conglomerate**
2 mm to nearly microscopic	Sand grains consisting of pure quartz	**Quartzose Sandstone**
	Sand grains consisting of dark fragments and quartz	**Lithic Sandstone**
microscopic	Typically layered and soft	**Mudstone/Shale**

<u>Chemical Sedimentary Rocks</u> are derived from material that had been dissolved in water. They are composed of crystals that precipitated from water by physical or organic processes. They may have formed when water evaporated in shallow lakes leaving chemicals behind to form evaporite deposits. They are also are formed by organisms extracting dissolved material to create their hard parts. For this reason, deposits of shell debris or plant material are considered chemical sedimentary rocks. In some cases, the shell material is easily observable, but in other cases, the shells cannot be seen without a microscope. Note that *fossil-rich* is used as a descriptor for any rock containing visible fossils.

Table 4: Chemical Sedimentary Rock Classification

Mineral Composition	Characteristics	Rock Name
calcite	Fizzes in HCl; massive is fine grained, oolitic contains small balls	**Limestone (use descriptors like massive, fossil-rich, oolitic)**
quartz group	Dense porcelain like, sometimes sharp edges, hardness = 7	**Chert**
gypsum	Soft, hardness = 2	**Rock Gypsum**
halite	Translucent, cubic cleavage, salty taste (do not taste lab samples!)	**Rock Salt**
calcite	Dull appearance, soft, fizzes in HCl	**Chalk**
calcite	Visible shell fragments, fizzes in HCl	**Coquina**
opal	Dull appearance, soft, does not fizz	**Diatomaceous Earth**
carbon/plant material	Glassy, black, brittle, low density	**Coal**

Table 5: Sedimentary Rock Description Table.

Sample Number/ sediment-tary group	**Composition / Minerals Present**	**Grain Size / Texture**	**Rock Name**
1 **detrital**	**rock fragments** **chert pieces**	**½ to 30 mm+, angular, poorly sorted**	**breccia**
2 **detrital**	**soft** **?clay minerals** **Does not fizz**	**very fine—can barely see with lens**	**shale**
3 **detrital**	**rock fragments** **chert pieces**	**1-10 mm, rounded, moderately sorted**	**conglomerate**
4 **detrital**	**quartz grains** **iron oxide cement makes it pink, also silica cement**	**¼ to ½ mm, rounded**	**quartzose sandstone**
5 **chemical**	**black, shiny, undecayed plant material**	**very fine, microscopic**	**coal**
6 **chemical**	**calcite (fizzes)**	**very fine, some 1/10 mm sand grains in calcite matrix**	**(sandy) limestone**
7 **detrital**	**feldspar, mica, rock fragments, quartz**	**1/10 to 1 mm, subangular, poorly sorted**	**lithic sandstone**
8 **chemical**	**chert—harder than glass, microcrystalline**	**extremely fine—cannot see with lens, glossy rock**	**chert**
9 **chemical**	**calcite (fizzes)—shell fragments**	**shells are 10 mm +, very porous**	**coquina (variety of limestone)**
10 **chemical**	**calcite (fizzes)—shells and mud**	**very fine to 10 mm +**	**fossiliferous limestone (not entirely shell fragments with porespace like the coquina)**
11 **chemical**	**calcite (fizzes)—concentrically layered grains**	**½ to 1 mm, very well sorted, concentrically layered balls of calcite**	**oolitic limestone (the concentric balls are ‘oolites’)**

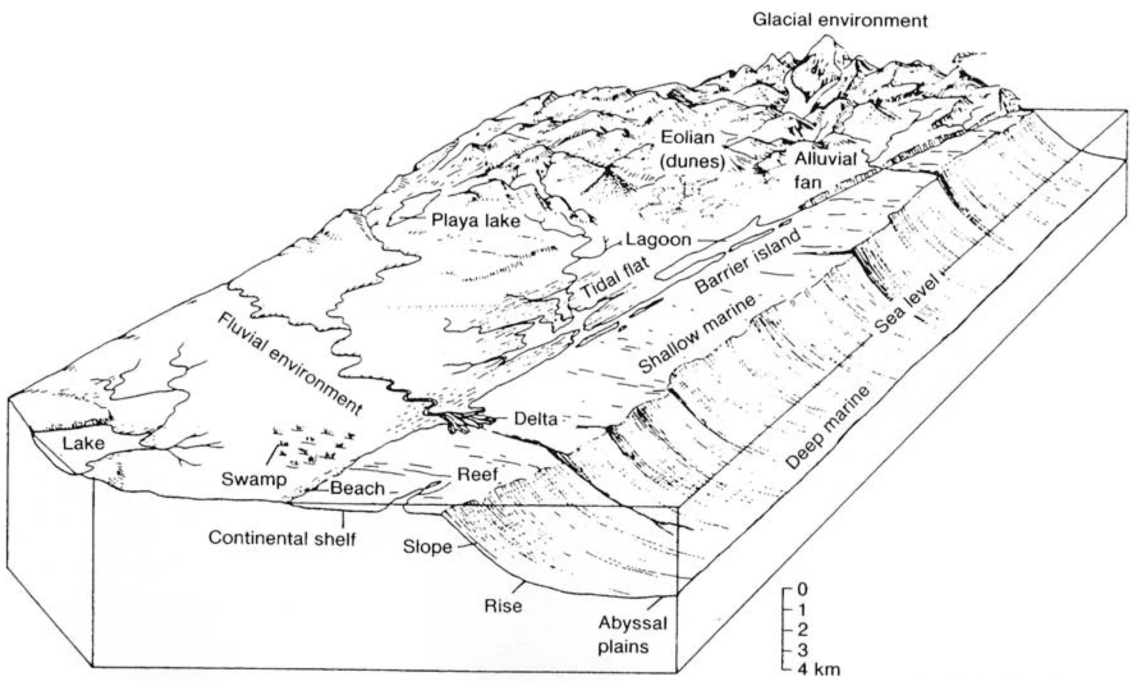

Figure 1: Environments in which sediments are deposited. The diagram is not to scale.

You will refer to this diagram in the post-lab exercise. Think about the energy of the environment, and the characteristics of the sediment types that may be formed there. You may want to look up some of the terms listed in the diagram in your textbook or from other sources.

Name____**KEY**____________________________

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POST LAB ASSESSMENT QUESTIONS

1. List three sedimentary rocks (from table 3 and/or 4) that are the most likely to contain fossils. Explain why this is so, in terms of composition and environment of formation.

Fossil limestone (#10), coquina (#9), from shallow marine environments that are very productive

Coal (#8), composed of incompletely decayed plants. Any others with proper explanation.

2. What is a good test to determine if a sedimentary rock is limestone? Does this test cause a physical change or chemical reaction? Explain how you can tell.

Putting a drop of dilute hydrochloric acid on the rock will liberate carbon dioxide gas in a chemical reaction, which is not readily reversible, if the rock is composed of calcite (calcium carbonate).

3. Why is the study of sedimentary rocks important for understanding how and where fossil fuels such as oil, natural gas, and coal (hydrocarbons) are likely to be found?

Sedimentary rocks are the source of the fossil fuels (from ancient organisms) and in the case of fluids (petroleum and natural gas), are a common porous reservoir rock.

4. Study Figure 1 (previous page) and list at least two environments where the following sedimentary rocks would be deposited. Think about the energy necessary to transport the grains. Describe the overall characteristic of the depositional environment for each rock type.

a. **SANDSTONE—energy high enough to carry sand, and remove finer material**

Fluvial environment—river will carry sand, deposit it in channel bars or natural levees

Beach, barrier island—sea deposits sand on shores, carries fine material to deep sea

Dunes—wind carries fine sand, deposits it where wind slows

Continental shelf—sea transports some sand a short distance off shore

Alluvial fan, delta—water drops sand where it slows due to loss of channel

b. **SHALE—energy low enough to allow fine grains to settle out**

Back swamps of fluvial environments—river deposits fine material here at flood stage

Lakes—receive fine sediment from streams

Abyssal plains—get dust from wind, deposited on sea surface to sink as abyssal mud

Lagoons, tidal flats—low energy area where standing water can allow fine sediment to settle

c. **LIMESTONE—marine organisms produce calcite for shells**

Shallow marine—where there is enough light for biotic productivity

Reef—composed of skeletons of marine organisms