Name: **San Diego Mesa College** **Grade:**

GEOL 101 - Physical Geology Laboratory

SEDIMENTARY ROCK CLASSIFICATION AND IDENTIFICATION

LAB PREPARATION SECTION – To be completed during lab intro lecture:

I. Introduction & Purpose:

The purpose of this laboratory exercise is to become familiar with identifying common sedimentary rocks and understanding their depositional origin. In this lab you will learn to identify sedimentary rocks in hand samples from their physical properties. You will also learn the nature and origin of sedimentary rocks, the major types of sedimentary rocks, and their structures, and the connection between plate tectonics and sedimentary rocks in the rock cycle will be explored.

II. General Overview and Classification of Sedimentary Rocks

A. The classification of sedimentary rocks is based upon two major criteria (see page 110 in text)

1. Texture = grain size and rock "fabric"
2. Composition = mineralogy

Sedimentary rocks are divided into **three major groups,** based on composition and/or texture:

1) Silico-clastic
2) Biological clastic/crystalline
3) Chemical crystalline

Silico-clastic sedimentary rocks consist of sediment grains (called clasts) of silicate minerals that are cemented together; these rocks have a "**clastic**" sedimentary texture. The sediment grains consist of one or more silicate mineral crystals that come from the weathering and erosion of preexisting source rock, such as granite or volcanic rock; any source rock type is possible. Detrital silico-clastic sedimentary rocks are classified primarily upon grain size, e.g. sand(-sized) stone versus silt(-sized) stone.

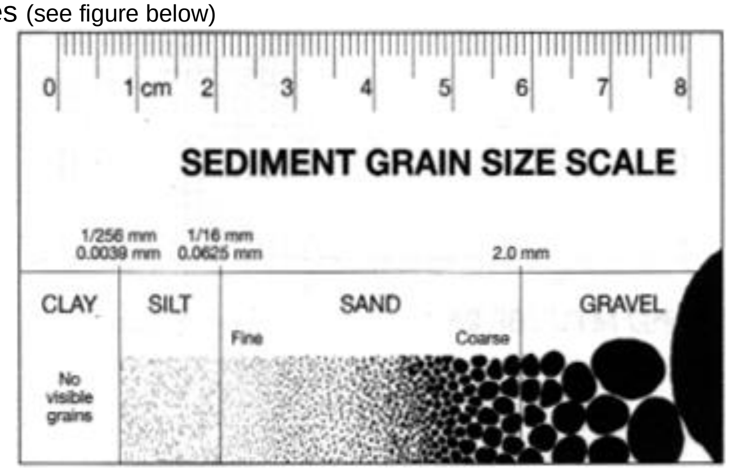
In contrast, **biochemical** and **chemical** sedimentary rocks consist mainly of mineral crystals that have crystallized directly out of aqueous solutions (water), either secreted by living organisms (biochemical), or by inorganic precipitation (chemical), respectively. Most of these chemically derived sedimentary rocks have a "**crystalline**"-looking sedimentary texture, much like that of igneous rocks. Biochemical and chemical sedimentary rocks are classified primarily upon mineral composition, e.g. limestone ($CaCO_3$) versus chert (SiO_2).

B. Grain Size and Texture: Examine **Figures 6.1 and 6.2** (pages 111-112) in your lab manual. These images of sediment grains and the major sedimentary rock types show the variation in sediment textures and chemical compositions by which sedimentary rocks are classified.

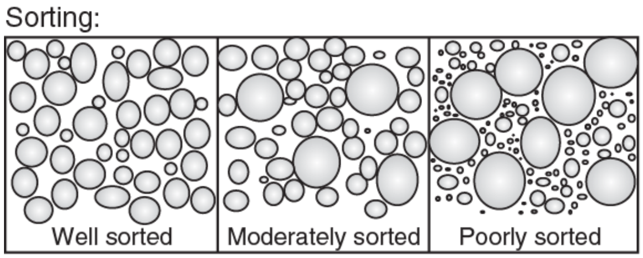
The 6 types of sedimentary grain sizes and the textures (see figure below)

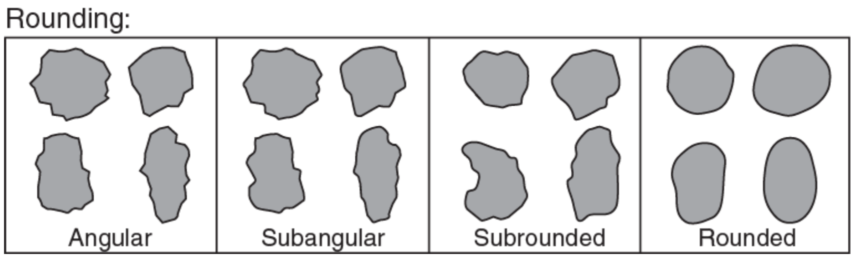
Grain Size Name — **Grain Size** (range)

1. ___Gravel-size_ _____mm to _____ mm
2. ___Sand-size_____ _____mm to _____ mm
3. ____Silt-size_____ _____mm to _____ mm
4. ___Clay-size____ smaller than _____ mm
5. _Macrocrystalline Visible to naked eye
6. _Mirocrystalline__ Need microscope to see



C. Grain Shape: Detrital grains are typically rock fragments that have been weathered and eroded from pre-existing rock and transported, over time, a certain amount of distance from its source. As a rule, the farther and longer the grains have been transported from their source, the more rounded they become. Thus, the detrital grain shape gives an indication of its "**maturity**" in the sedimentary cycle.





1. List the four types of sediment grain ***shapes*** exhibited in detrital rocks (See above figure)

Detrital Grain Shapes

a. ________________ b. ________________ c. __________________ d. ______________

2. Question: Which grain shape type would you expect to be the *least* "mature"? Why?

3. Question: Which grain shape type would you expect to be the *most* "mature"? Why?

D. Grain Arrangements/Sorting: Transported sediment grains become sorted (according to size), over time, as the fluid mediums that transport them, such as running water and wind, selectively deposit some grains while continuing to carry the smaller grains ever greater distances from the source region. The causes for sorting include systematic variation in flow rate and turbulence of the transporting medium over distance and time. As a general rule of thumb, greatest sorting occurs within consistently medium to high energy transport mediums over long periods of time (effective winnowing of sediment), whereas the condition of poorest sorting occurs where either, flow rate changes drastically or is very inconsistent (effective dumping of sediment). Additionally, non-fluid transport mediums such as glaciers do not have the capability to sort sediment by size, and therefore sediments directly deposited by glaciers are virtually unsorted.

1. **List** the three types of sediment grain ***sorting*** found in detrital rocks (See above figure)

a. __________________ b. ___________________ c. ____________________

2. **Question:** Why would a river be good at sorting sediment and a glacier not?

E. Composition of Sedimentary Rocks: The mineral composition of a sedimentary rock is a reflection of 1) **source material** and 2) **sedimentary processes**. Sources include virtually all types of geologic, biologic, hydrologic, and cosmologic materials such as: 1) land-derived materials such as weathered and eroded igneous, metamorphic and sedimentary rocks; 2) hard-part remains (shells) of marine organisms; and 3) seawater chemical precipitates.

Sedimentary lithification processes, termed "diagenesis" can both, alter and add chemicals and minerals to the rock, such as clast-amalgamating ***rock cement***. A review of the composition of all the major sedimentary rock types shows a surprising conclusion: *that there are only a small number of major sedimentary rock-forming minerals and rock fragment detrital types.*

THE *BIG THREE* SED MINERALS: The vast bulk of sedimentary rocks comprise only *THREE MAJOR mineral constituents*: **Clay; Quartz**, and **Carbonate** (mostly calcite and dolomite). Other important sedimentary minerals include feldspar, mica, clay, iron oxide, amphibole, halite, gypsum and various minor amounts of tough silicate minerals like garnet, corundum, monazite, and zircon. The primary reason for this compositional simplicity - compared to those of igneous and metamorphic rocks - is the fact that most of the sedimentary rock-forming minerals are stable or meta-stable at Earth surface conditions. In contrast, most igneous and metamorphic rock-forming minerals are unstable at the surface and with sufficient time will chemically alter to clay and dissolved solids However, immature, coarse-grained silicate rock -derived sediments may contain lots of feldspar and parent rock fragments.

The major source materials for the three sedimentary rock types (see Figure 6.2 page 114)

Detrital-Silicic (Clastic-origin)

1. **Clay** 2. **Quartz** 3. Feldspar 4. Rock fragments 5) Dark silicates and oxides

Biochemical (Organic-origin)

1. Shells and Shell and coral fragments (**calcite** and **quartz**) 2. Carbon and Charcoal

Chemical (Inorganic-origin)

1. **Calcite** 2. Dolomite 3. **Silica** 4. Gypsum 5. Halite 6. Iron-bearing minerals

1. Question: Clay is the most common sedimentary mineral. Why so much?

2. Question: Quartz is the second most common sedimentary mineral. Why so much?

3. Question: Calcite is the third most common sedimentary mineral. Why so much?

Review the Common Sedimentary Rock-Forming Minerals

Directions: Re-examine these common sedimentary mineral samples in lab that you studied in the mineral labs. Note that rock hardness is your first step in determining rock mineralogy.

Hard Minerals	Soft Minerals
Quartz (most abundant)	Clay (most abundant)
Feldspar	Calcite/Dolomite
Amphibole	Biotite
Garnet	Muscovite
Olivine	Halite
Iron Oxide	Gypsum

F. Detrital Silico-clastic Rocks: Detrital silico-clastic rocks are named primarily upon their grain size, while their composition, which is a reflection of the source rocks and subsequent weathering erosion history, is secondary to naming a detrital rock, e.g. arkose and wacke. The five major **detrital** (silicio-clastic) rock types that are based on grain size and shape. Note: siltstone and shale are lumped together as "mudstones". (See top of Figure 6.8, page 118).

Rock Name	*Clastic Character*
1. Breccia	Very Coarse-grained – Angular clasts / Lithic fragments, quartz, feldspar
2. Conglomerate	Very Coarse-grained – Rounded clasts / Lithic fragments, quartz, feldspar
3. Sandstone	Medium- to Coarse-grained / Commonly quartz-rich; lesser feldspar
4. Siltstone	Fine-grained / Commonly quartz-rich, lesser feldspar and clay
5. Shale	Very fine-grained / Clay-rich; lesser amounts of quartz

G. Naming of Biochemical Rocks: Biochemical rocks are named based primarily upon their composition, e.g. calcium carbonate fossil shell or plant material, and secondarily upon their texture, e.g. sandy, shelly, crystalline, microcrystalline, etc. Limestone is a sedimentary rock named primarily for being rich in calcium carbonate. The types of limestone are named by the type and texture of the calcium carbonate. As an example, coquina is a poorly cemented mass of large-sized shell fragments, whereas, chalk is a super fine-grained mass of microfossils. Five major **biochemical rock** types are based primarily on mineral composition.

Rock Name	***Clastic Character***
1. _____Coal______	Massive – low density / Dark, dull to shiny hydrocarbon material
2. Coquina Limestone	Coarse-grained – Loosely cemented shell fragments + sand / Carbonate
3. Fossiliferous Limestone	Coarse- to fine-grained clastic grains with crystalline calcite; Fossils
4. __Chalk Limestone__	Very fine-grained and chalky; Carbonaceous microfossil-rich

H. Nomenclature of Chemical Rocks: Chemical sedimentary rocks are also named based primarily on composition. However, **all** chemical sedimentary rocks have **crystalline** textures that reflect their direct precipitation of ions from an aqueous fluid such as seawater.

Rock Name	***Clastic Character***
1. Oolitic Limestone	Coarse- to fine-grained crystalline grains packed with spherical concretions
2. Travertine Limestone	Coarse- to fine-grained crystalline with layering / light-colored, calcite-rich
3. _Dolostone	Coarse- to fine-grained crystalline; massive / light colored, dolomite-rich
4. _Rock salt_	Coarse- to medium-grained crystalline; massive / light colored, halite-rich
5. _Rock Gypsum_	Coarse- to fine-grained crystalline; massive / light colored, gypsum-rich
6. __Chert_	Very fine-grained crystalline; massive / light to dark colored, quartz-rich

III. Depositional Settings of Sedimentary Rocks

A. Sedimentary rocks and their sediments retain a memory of the conditions in which they formed in, and their sediment source or provenance. That information is recorded by the rock's grain texture, mineralogy, fossils, and bedding structures. By observing and studying today's depositional environments and the type and structure of the sediments that collect there, we can infer the depositional setting and history of sedimentary rock assemblages by comparing their sedimentary characteristics to that of modern day depositional systems.

B. Examine **Figure 6.12** (page 128) in your lab manual. This illustration shows most of the major types of modern sedimentary environments where sediments are depositing and sedimentary rocks are forming. **Directions:** List the depositional environments where each type of sedimentary rock forms as shown in Figure 6.12 in your lab manual.

Sedimentary Rock Type	**List the Depositional Environments Where Rock Forms**
1. Breccias	____________________
2. Conglomerates	____________________
3. Sandstones	____________________
4. Mudstones	____________________
5. Limestones	____________________
6. Cherts	____________________
7. Rock Salt and Gypsum	____________________

LAB ACTIVITY SECTION – Sedimentary Rock Classification and Identification

I. Examination of the Shoreline Sediments:

A. Introduction: Clastic sedimentary rocks consist of sediment grains (clasts) that are cemented together. In this section you will observe, describe, and measure two types of beach sediments, and compare and contrast them in terms of their composition and texture.

Directions: Carefully observe, and analyze two different beach sediments under a microscope. For each sediment sample you will determine both **1)** ***composition*** *(mineralogy, including mineral abundance as percentages)*, and 2**) texture** (grain size, grain shape, and grain sorting).

1. San Diego Beach Sand

This sample from a San Diego beach is mainly derived from the weathering and erosion of granitic rocks from the mountains behind San Diego. Examine this local beach sand and the accompanying granitic source rock sample. Estimate the abundance of each mineral in the sand (grain) sample using the "Percentage Composition" chart. Your total must equal 100%.

Mineral Grains	Percentage in Sample
Quartz (clear, glassy grains; conchoidal faces)	
Feldspar (white, yellow, or pink, blocky grains)	
Mica (flat, flaky, black or golden flakes)	
Tourmaline (dark, glassy, prismatic grains)	
Magnetite (metallic, dark gray, blocky/equant grains)	
Hornblende/Augite (nonmetallic, dark, tabular grains)	
TOTAL	**100%**

2. Hawaiian Beach Sand

1. **Comparing the Textures of the Two Beach Sands: San Diego versus Hawaii**

a) Compare these two sand samples under the microscopes, and use the grain cards and charts provided to complete the table below.

Texture	San Diego Sand	Hawaii Sand
Grain size		
Roundness		
Sorting		

b) You have seen the difference in composition between the San Diego sand and the Hawaii sand. Both of these sands are **mainly derived from the weathering and erosion of rocks**. Why is there such a big difference in composition? Think source.

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c) What is the main difference in the rocks types that supplied the sediment to the San Diego's beach versus the Hawaii's beach?

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d) Why the difference in grain roundness? ____

____

e) Which sample has been exposed to longer/more intense wave action? How do know this?

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I. Preliminary Examination of the Sedimentary Rock Types:

A. Introduction: A **reference collection** ("S" collection box) of sedimentary rocks are found on your lab table. The reference set includes the three major types of sedimentary rocks: Siliciclastic samples S1 through S6; Bio-clastic/chem samples S7 - S9; and chemical samples S10 – S14.

Directions: Carefully observe, analyze, and note each rock's **1) *composition*** *(mineralogy)*, **2) texture** (grain size/shape/sorting), and **3)** inferred **origin** (depositional environment.)

B. The Silici-clastic Sedimentary Rocks:

Sample#	Rock Name	Mineral Composition	Texture	Depositional Setting
S1	Conglomerate	____________________	________________	______________
S2	Breccia	____________________	________________	______________
S3a-d	Sandstones	____________________	________________	______________
S4	Siltstone	____________________	________________	______________
S6	Shale	____________________	________________	______________

1. Question: Name the primary difference between the breccia's and conglomerate's texture?

2. Question: What's the primary difference between the siltstone's and shale's mineralogy?

3. List the different types of mineral cement that bond sediment grains together in clastic sedimentary rocks.

a. ___________________ b. __________________ c. __________________

4. Question: How can you test whether calcite is the cementing agent in quartz sandstone?

5. Question: How can you test whether iron oxide is the cementing agent in a quartz sandstone?

C. The Bio-Sedimentary Rocks:
Note that bio-sedimentary rocks can vary from a mostly clastic texture to a mostly crystalline textur, but can most samples will have evidence of a biological origin, e.g. shells, or shell fragments in the rock.

Sample#	Rock Name	Mineral Composition	Texture	Depositional Setting
S7	Coal	______________	______________	______________
S8	Fossil Limestone	______________	______________	______________
S9	Chalk	______________	______________	______________

1. Question: How might you easily test for whether your sedimentary rock is a limestone?

2. Question: How can you tell a fine-grained limestone (chalk) from a claystone sample?

____

D. The Chemical Sedimentary Rocks:
Note that chemical sedimentary rocks have a totally crystalline texture and may "look" somewhat similar in texture, but can have very different hardnesses, due to varying mineral composition.

Sample	Rock Name	Composition	Texture	Site of Formation
S10	Oolitic Limestone	______________	______________	______________
S11	Crystalline Limestone	______________	______________	______________
S12	Rock Salt	______________	______________	______________
S13	Rock Gypsum	______________	______________	______________
S14	Chert	______________	______________	______________

1. **Question:** What is the primary difference between a chemical and biochemical limestone?

2. Question: How might you easily test whether or not you have a limestone versus a chert?

3. Question: How might you test whether or not you have rock salt versus rock gypsum?

4. Questions: Which of the chemical sed rocks fizzed in acid? ______________________________

5. Questions: Which of the chemical sed rocks is very hard? ______________________________

6. Question: Which of the chemical sed rocks can be scratched by a fingernail? ______________.

III. Analysis and Identification of 10 Unknown Sedimentary Rock Samples:

Directions: Identify ten unknown sedimentary rock samples found in **sample Collection "UN"**. Follow the **6-step procedure** below - along with the sedimentary classification chart in your **lab manual -** for describing and identifying the ten sedimentary unknown rocks:

- **Step a): Mineral Composition:** Identify and record (circle) the rock's most abundant minerals
- **Step b): Rock Type:** Identify (circle) the rock's sedimentary type: choose from three types
- **Step c): Grain size:** Identify and record the rock's grain size (texture)
- **Step d): Other Texture:** List any/all distinctive properties like grain shape, rounding, fossils, layering, etc.
- **Step e): Rock Name:** Name the sedimentary rock
- **Step f): Depositional Environment:** List the most likely depositional environment(s) that the rock formed, such as the foot of a mountain or glacier, river bed, lake bed, desert dune, swamp, bay/tidal flats, evaporative coastal basin, beach, offshore shelf, tropical reef, or deep sea bottom.

Sample# SU1

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ____________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# SU2

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** _______________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# SU3

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ___________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# SU4

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ______________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# SU5

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ______________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# SU6

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ______________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# UN7

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ____________________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# SU8

a) **Composition**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **Sed Rock type**: Silici-clastic; Bio-Sed; Chemical c) **Grain size**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ____________________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____

Sample# SU9

a) **<u>Composition</u>**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **<u>Sed Rock type</u>**: Silici-clastic; Bio-Sed; Chemical c) **<u>Grain size</u>**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** ______________________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____________________________________

Sample# UN10

a) **<u>Composition</u>**: Rock fragments; quartz; feldspar; clay; calcite; gypsum; salt; carbon; fossils

b) **<u>Sed Rock type</u>**: Silici-clastic; Bio-Sed; Chemical c) **<u>Grain size</u>**: Very fine; Fine; Medium; Coarse

d) **Distinctive features**: ____

e) **Rock name:** _______________________

f) **Most-likely sedimentary setting(s) where rock formed:** ____________________________________

IV. SEDIMENTARY ROCK LABORATORY REFLECTION

Directions: Write a 3-paragraph reflection of the lab activity, explaining its purpose, the methods used, the results obtained, and a brief personal reflection of what you enjoyed and learned about doing this sedimenaty lab (*3 points possible*). Answer the following 3-point question reflection set on a separate sheet of paper:

1) *What was the purpose of this lab? What did you actually discover and learn during this lab?*

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2) *What did you enjoy most about this lab? Also, what was challenging or thought-provoking?*

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3) *What are your constructive comments about the design and execution of this lab? What's good? What's bad? Offer suggestions for making the lab better.*

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