GEOL 333 - Lab 8 (Clastic Sedimentary Rocks in Hand Sample and Thin Section)

Introduction Sedimentary rock, which forms by the accumulation and lithification of **sediment** (loose grains), is by far the most abundant rock type at Earth's surface and it is important as an economic resource and for geologic research. Sandstone and limestone are used as building stone, which is rock cut into blocks or slabs for use in construction. Both sandstone and limestone were used to make the Natural History Building. Crushed limestone and dolostone are used for aggregate, which is used in asphalt paving, mixed with cement to make concrete, or used alone as a base for roads, sidewalks or railroads. Ground up limestone and shale are used to make cement and shale is used to make bricks. In terms of research, paleontologists study fossil-bearing rocks to help determine what types of plant and animal life previously existed on Earth and the environments in which they lived. Sedimentary rocks can also tell geologists about the geologic history of an area, including the environment where the sediment accumulated, i.e., depositional environment.

Classification Sedimentary rocks are commonly divided into three categories based on their origin. **Clastic** (or detrital) sedimentary rocks form by the transportation and deposition of layers of sediment (loose individual grains of a preexisting rock) that is compacted and cemented. Shale and sandstone are examples of clastic sedimentary rocks, which we will study this week. **Chemical** sedimentary rocks form by the process of chemical precipitation where dissolved ions combine to form solid mineral grains. Examples of chemical sedimentary rocks include limestone and rocksalt. **Organic (or biochemical)** sedimentary rocks form by the accumulation of the remains of plants and animals, such as calcite shells. Examples of organic sedimentary rocks include fossiliferous limestone and coal. Commonly there is overlap among these three categories. For example, limestone can contain fossil shells, chemical precipitated minerals, and even detrital minerals. Next week we will study **carbonate sedimentary rocks** (limestone and dolostone).

Clastic sedimentary rocks are classified based on the size of the mineral grains (Table 6.1). If the grains are large (>2 mm, i.e., a coarse-grained texture) and rounded, the rock name is **conglomerate**. **Breccia** has coarse and angular grains**.** For coarse-grained clastic sedimentary rocks, a prefix is put before the rock name depending on the specific size of the grains, e.g., pebble conglomerate or cobble breccia. S**andstones**, which have a medium grain size between 2 - 0.0625 mm, are subdivided based on the type of sand-size (**framework**) mineral grains (quartz, feldspar, or lithic/rock grains) and the abundance of **matrix** (fine-grained mud in pore space between framework sand grains). Sandstone with little (<5%) matrix is called **arenite** and sandstone with abundant (>5%) matrix is called **wacke** (Fig. 15.3). A prefix is put before the sandstone name depending on the composition of framework grains, e.g., quartz arenite, feldspathic arenite (also called arkose), and lithic wacke. **Siltstone** consists of fine grains between 0.0625 - 0.004 mm in size. We will use two names for clastic sedimentary rock with very fine grains (< 0.004 mm): **shale** is **fissile**, which means it splits easily into thin layers and **mudstone** is massive and does not easily split. Because of their abundance, geologic significance, and ease of study using the optical microscope, we will study only sandstones this week.

Clastic Sediment Maturity **Mature sediment** is well sorted (narrow range in grain size), well rounded, and consists mainly of quartz with little matrix. It has undergone much physical and chemical weathering and probably was transported extensively from a weathering site by wind or moving water. **Immature sediment** is poorly sorted (wide range in grain size), angular, and contains abundant feldspar, lithics (rock fragments) and matrix. It has undergone little physical and chemical weathering and probably was not transported far by wind or moving water.

Depositional Environment - Study of sedimentary rocks gives an understanding of the depositional environment, the chemical, physical, and biological conditions at Earth's surface associated with sediment deposition. Table 7.2 lists many depositional environments associated with clastic sediment, which after burial becomes clastic sedimentary rock. It is also useful to characterize the nature of the **source area** of clastic sediment, i.e., the kinds of rock undergoing weathering to produce sediment. **Quartz arenite** is derived from quartz-rich rock, e.g., sandstone and highly weathered granite, f**eldspathic arenite** is usually derived from relatively unweathered granite, and **lithic wacke** is derived from a variety of relatively unweathered rocks, e.g., volcanic, metamorphic, and sedimentary.

New Descriptive Terms

Clastic Texture - grains (usually comprised mainly of silicate minerals) of variable size with empty or filled pore space, the space between grains

Framework Grains - sand-size mineral grains (for sandstone), comprised mainly of quartz, feldspar or lithic grains

Lithic Grains - fragments of a preexisting rock, e.g., volcanic, chert, shale, quartzite

Cement - precipitated mineral (commonly quartz or calcite) in pore space

Matrix - fine-grained (silt and clay-size) minerals in pore space

Arenite - sandstone with little (<5%) matrix

Wacke - sandstone with abundant (>5%) matrix

Sorting - similarity of grain sizes within a sample, see Fig. 14.16 for terms that describe sorting

Mature Sediment - well sorted, well rounded and consists mainly of quartz with little matrix

Immature Sediment - poorly sorted, angular and contains abundant feldspar, lithics (rock fragments) and matrix

Packing - closeness of framework grains

Diagenesis - processes that occur after deposition, e.g., compaction and cementation

Recrystallization - dissolution of a mineral and reprecipitation of another mineral in the same space occupied by the original mineral

Monocrystalline quartz - a sedimentary rock grain made entirely of one crystal of quartz.

Polycrystalline quartz - multiple crystals of quartz in a single grain, usually has sutured contacts between crystals

Undulose extinction - wavy extinction, common in quartz particularly from metamorphic rock

Lab Exercise

1) As stated above, sandstone with mature sediment contains mostly well-sorted, well-rounded quartz grains with little matrix whereas sandstone with immature sediment contains mostly poorly sorted, angular grains of feldspar and lithics with little matrix. List a specific name of sandstone with mature sediment and a specific name of sandstone with immature sediment.

2) What physical and chemical processes can cause differences in sediment maturity of sandstone? Hint: Think of the different processes involved in forming sedimentary rock.

3) Complete an Unknown Rock Identification Sheet (found at the very end of this document) for each of the following four sandstones:

    - L8 or L8s
    - 84-6-6u
    - 536
    - 6253

Unknown Rock Identification Sheets - Explanation of Terms

For the four sandstones assigned today, you will fill out an identification sheet that includes your observations on both the hand sample and associated thin section. These observations are key to naming the sample, however the most important part is an accurate description of the mineral content and texture. Normally, the more information you collect and record about the sample, the better.

- **Rock Texture**

Rock texture refers to the size, shape and arrangement of the mineral grains. In your rock descriptions use the appropriate mineralogical terms for texture given in several lists below. Examples of questions to address include: What is the average grain shape? Are the grains similar in shape or is there a wide range? What is the average grain size? Are most of the minerals the same size or two groups of sizes or a wide range of sizes? Is the shape similar for all mineral grains?

- Color

Describe the overall color of the rock.

- Contacts

Describe the grain contacts. **F** stands for floating grains (not touching), **T** = touching at small points, **L** = touching along long, straight contacts, **CC** = touching along long, concavo-convex (curved) contacts, and **S** = sutured contacts, similar to an interlocking texture. Use Fig. 5.8 in this handout.

- Packing

Are the grains close together or far apart? Is there abundant pore space?

- Degree of Induration

Describe how well indurated the rock is. Induration describes the cohesiveness of the rock. If a rock crumbles to the touch, it is poorly indurated. If you cannot rub off grains with your bare hands, the rock is well indurated.

- Sorting

Circle the best descriptor of the overall sorting in the rock: **VW** = very well sorted (narrow range in grain size)**, W** = well sorted, **M** = moderately sorted, **P** = poorly sorted (wide range in grain size). Use Fig. 14.16 in this handout.

- Framework Sand Grain Characteristics

Fill out the % abundance, grain size, rounding, and other characteristics of each framework sand grain type in the rock. The major framework grain types are quartz, feldspar (both plagioclase and alkali) and lithics (fragments of igneous, metamorphic and sedimentary rocks). The percentage should be **of the total rock**.

- Grain Size

Field of View Size for our Petrographic Microscopes (used for grain size determination)

Power	**Width of field**	**Radius**
2.5x (low)	4.5 mm	2.25mm
10x (med.)	1.8mm	0.9mm
40x (high)	0.45mm	0.225mm

Grain Size Terms

1. Fine-grained – < 0.1 mm
2. Medium-grained - between 0.1 – 2 mm
3. Coarse-grained - > 2 mm

- Rounding

Describe the roundness of the framework sand grains only, not cement and matrix. **VA** = very angular, **A** = angular, **SA** = subangular, **SR** = subrounded, **R** = rounded, and **WR** = well rounded. Use Fig. 1 from your Class Notes handout.

- Matrix, Cement, and Porosity

Try to determine the mineralogy, % **of the total rock**, crystal/grain size, and any other distinguishing features of the matrix, cement, and porosity.

- Sketch

Draw a representative sketch of the rock under low (2.5x) or medium power (10x) magnification. Make sure your circle the correct magnification and whether the sketch is from plane-polarized light (PPL) or cross-polarized light (XP).

- Rock Name

Classify the rock based on your observations in hand sample and thin section using the given classification scheme in Fig. 15.3 of this handout. Be as specific as you can, e.g., quartz arenite with abundant calcite cement. **Write the name of the rock under the Thin Section sketch**.

Optical Characteristics of Minerals in Sandstone

Mineral/Grain Name	Plane Polarized Light	Cross Polarized Light
Quartz	Low Relief, no cleavage, clear appearance	Low (1st order) birefringence (white or gray), never altered to clay minerals
Plagioclase Feldspar	Low relief, usually altered to clay (cloudy appearance)	Polysynthetic twinning (black and white stripes), Low (1st order) birefringence (white or gray), clay alteration involves small, highly birefringent grains
K-feldspar	Low relief, 2 directions of cleavage (parallel lines) at 90° (moderately developed), can be partly altered to clay (cloudy appearance)	May show twinning (black and white criss-cross pattern) and exsolution lamellae (thin, parallel lines), Low (1st order) birefringence (white or gray), clay alteration involves small, highly birefringent grains
Lithic (rock fragment)	Variable properties, contains multiple minerals within single sand grain	Variable properties, contains multiple minerals within single sand grain
Calcite (cement)	High relief, perfect rhombohedral cleavage (3 directions at 60° and 120°), usually clear appearance	Very high (>3rd order) birefringence (often appears white)
Clay (matrix)	fine-grained	moderate birefringence

Reading Assignment for Next Week - Chemical Sedimentary Rocks

p. 352 - 360 in Klein and Philpotts (2013); p. 110 - 113, 130 - 139 in MacKenzie and Adams (1994)

Clastic Rock Identification Sheet

Sample # _____ Name_____

[#'s 1-5 are worth 0.25 pts each]

1. Hand sample color:

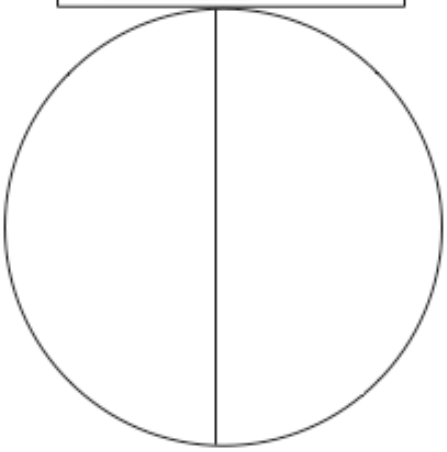
2. Contacts: F T L CC S N/A

3. Packing: close together -or- far apart -or- N/A

4. Degree of Induration: well -or- not so well

5. Sorting: VW W M P N/A

Thin Section Sketch (Color)
PPL/XP
Label Grains [0.2 pts]



6. Complete the following table. Use the 'other features' row to describe things like alteration, poly or monocrystalline quartz grains, etc. [12 pts]

	Pore Space Filling			Framework Grains			Other	
	Cement	matrix	porosity	quartz	feldspar	lithic clasts	A	B
min/comp			X	X				
size			X					
rounding	X	X	X					
other features			X					
% abundance								

X = N/A

7. Is this mature or immature sediment? Why? [0.2 pts]

8. Based on your description of the sample in question 6, what name would you give this rock? Use the classification scheme in figure 15.3 of the handout. [0.2 pts]

Rock Name:_____

9. What are possible depositional environments for this sediment? What are your thoughts on the source of the sediment (i.e. is it derived from felsic or mafic igneous rocks, metamorphic rocks, or other sedimentary rocks)? [0.2 pts]

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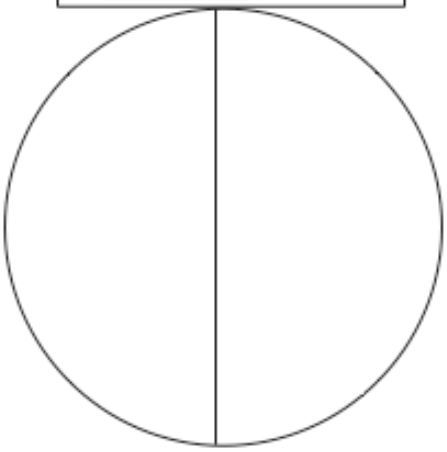

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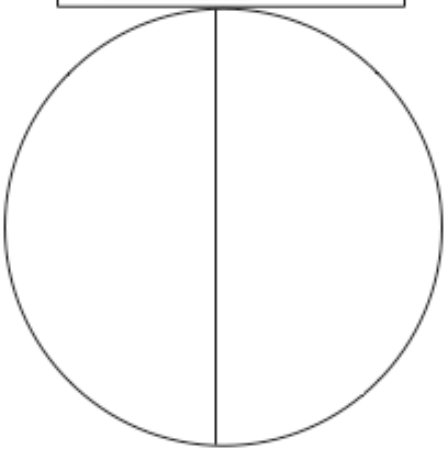

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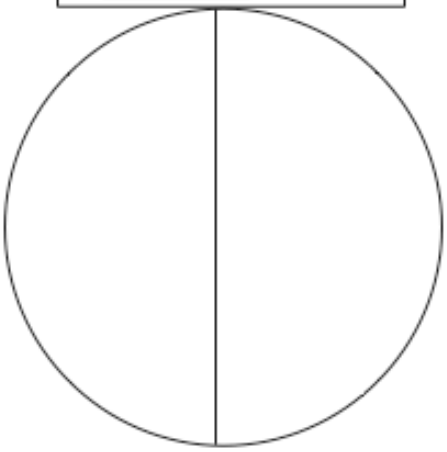

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