GEOL 333 - Lab 9 (Carbonate Sedimentary Rocks in Hand Sample and Thin Section)

Sedimentary Rock Classification - As we learned last week, sedimentary rock, which forms by accumulation and lithification of **sediment** (loose grains), has considerable economic and geologic importance. Sedimentary rocks are commonly divided into 3 categories based on their origin. Last week we learned about **clastic sedimentary rocks** (emphasizing sandstone), which form by transportation and deposition of layers of clastic sediment (loose individual grains of a preexisting rock), which is compacted and cemented. This week we will study **chemical** sedimentary rocks, which form by chemical precipitation where dissolved ions combine to form solid mineral grains, and **organic (or biochemical)** sedimentary rocks, which form by accumulation of plant and animal remains, such as calcite shells. Because of their abundance and geologic significance, this week we will emphasize **carbonate sedimentary rocks** (limestone and dolostone), which have both chemical and organic origins. Because chemical and organic sedimentary rocks are usually monomineralic (dominated by one mineral), their names usually reflect their main mineral composition.

Carbonate Rock Texture - Composition and texture are used to classify (name) sedimentary rocks and give clues about their environment of formation. Because chemical sedimentary rocks form by chemical precipitation of minerals from water, they commonly have a **crystalline** texture (large or small interlocking grains, similar to the texture of most igneous rocks). Fossiliferous limestone commonly has a **bioclastic** texture, which involves $CaCO_3$ shells (bioclasts) of variable size with **pore space** (space between the $CaCO_3$ shells) that usually is filled with either **spar** (crystalline calcite cement that formed during burial) or **micrite** (fine-grained $CaCO_3$ mud).

Carbonate Sedimentary Rock - Nature and Origin - The most common carbonate rocks are **limestone**, which consists mainly of $CaCO_3$ (calcite or aragonite, less commonly) and **dolostone**, which consists mainly of $CaMg(CO_3)_2$ (dolomite). Most limestone forms in relatively shallow, warm ocean water far from any sources of clastic sediment (quartz sand and clay mineral-rich mud). Most dolostone forms during burial by chemical alteration of a preexisting limestone with Mg-rich water. Most limestone and dolostone consist of one or more of the following: **allochems** (sand-size or coarser carbonate grains that include $CaCO_3$ shells and **oolites**, which are ~1 – 2 mm spherical grains of inorganically precipitated concentric layers of $CaCO_3$ that commonly have a detrital quartz grain in the middle that served as a base for precipitation), **micrite** ($CaCO_3$ mud) and **spar** (crystalline calcite cement). The relative abundance of allochems, micrite and spar is the basis for most classification schemes of carbonate rocks.

Carbonate Rock Classification - We will use the limestone classification scheme in Fig. 1.3 under the column labeled "Alternate Classification". **Biomicrite** and **Biosparite** are limestones with abundant $CaCO_3$ shells and either micrite matrix or spar cement, respectively. (Coquina is porous and poorly cemented limestone consisting almost entirely of whole or broken $CaCO_3$ shells.) Fig. 8-1 shows common fossils that consist of $CaCO_3$ shells, except for trilobites and graptolites. We won't emphasize precise identification of $CaCO_3$ shells because it can be challenging to do that in thin section. **Oomicrite** and **Oosparite** are limestones with abundant oolites and either micrite matrix or spar cement, respectively. **Micrite** is composed almost entirely of $CaCO_3$ mud. (One type of micrite is chalk, a relatively soft and poorly cemented limestone consisting of tiny shells of marine plankton (floating organisms including coccoliths and foraminifera).) **Crystalline Limestone** and **Crystalline Dolostone** are dominated by interlocking crystals of calcite and dolomite, respectively. NOTE: It is difficult to distinguish dolomite from calcite in thin section unless the thin section was treated with a specific stain. The different reactions to acid are an easy way to distinguish dolomite from calcite in hand sample.

Depositional Environment of Carbonate Rock - 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 8.2 lists depositional environments associated with common chemical and organic sedimentary rocks. As discussed above, the depositional environment of limestone (and dolostone because it usually forms from limestone after burial) usually is shallow, warm seawater. Broken fossil pieces, spar cement, and oolites usually indicate active water such as shallow water with waves whereas unbroken large fossils and micrite usually indicate quiet water such as in a lagoon or deeper water.

Other Chemical and Organic Sedimentary Rocks (Chert, Evaporates, Ironstone, Coal) - Chert, which consists mainly of fine-grained quartz, forms by recrystallization (dissolution of the original mineral and precipitation of a new mineral) of both silica fossil skeletons (microscopic plankton called diatoms and radiolaria) and inorganically precipitated silica. Evaporites, which usually form by precipitation of evaporating seawater, include rock salt (mostly halite) and rock gypsum (mostly gypsum). Ironstones form by chemical precipitation of Fe-oxide minerals such as hematite, magnetite, and goethite. Banded iron formation, which is the major source of iron ore, consists of alternating bands of Fe-oxide minerals and chert. Peat, partly decomposed plant debris, converts to coal during burial. The various grades of coal (coal rank) include lignite (brown), bituminous (dull black) and anthracite (shiny black).

Descriptive Terms

Crystalline Texture - large or small interlocking grains, typical for chemical sedimentary rocks

Bioclastic Texture - $CaCO_3$ shells (bioclasts) of variable size with empty or filled pore space

Allochems - sand-size or coarser carbonate grains that include $CaCO_3$ shells and oolites

Spar - crystalline calcite cement

Micrite - fine-grained $CaCO_3$ mud

Sorting - similarity of grain sizes within a sample; well sorted = narrow range in grain size (often associated with an active water for carbonates), poorly sorted = wide range in grain size (often associated with an quiet water for carbonates)

Packing - closeness of allochems, which depends on degree of compaction; increased packing produces closer grain contacts

Recrystallization - dissolution of the original mineral and precipitation of a new mineral in the same space occupied by the original mineral; dolostone usually forms by recrystallization of limestone that can either preserve some of the original limestone texture or destroy it and create a crystalline texture

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

Induration - degree of lithification, which depends on level of compaction, cementation, and recrystallization

Lab Exercise

Complete an Unknown Rock Identification Sheet (found at the very end of this document) for each of the following 4 carbonate sedimentary rocks:

1) 26
2) 27
3) 29
4) 8030

Unknown Rock Identification Sheets - Explanation of Terms

For the 4 carbonate sedimentary rocks 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?

- Grain Size

Determine the average grain size (mm) of the rock overall.

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

- 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)

- Packing

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

- 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.

- 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 (the gray tuff we saw last week). If you cannot rub off grains with your bare hands, the rock is well indurated.

- Roundness (excluding $CaCO_3$ shells, spar cement and micrite matrix)

Describe the roundness of the grains, excluding $CaCO_3$ shells, spar cement and micrite matrix. **VA** = very angular, **A** = angular, **SA** = subangular, **SR** = subrounded, **R** = rounded, and **WR** = well rounded.

- Color

Describe the overall color of the rock.

- Allochem and Detrital Grain Composition

Fill out the percentage, grain size, rounding, and other characteristics of each allochem ($CaCO_3$ shell or oolite) and detrital grain type in the rock. The percentage should be **of the total rock**. You should describe the calcite grains in the other row.

- 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 we discussed in class. Be as specific as you can, e.g., biosparite with abundant brachiopods and crinoids. **Write the name of the rock under the Thin Section sketch**.

Optical Characteristics of Minerals in Carbonate Sedimentary Rocks (Bold represents important distinguishing features between Calcite and Dolomite)

Mineral Name (hand sample characteristic)	**Plane Polarized Light**	**Cross Polarized Light**
Calcite (**strong reaction with dilute acid**)	High relief, perfect rhombohedral cleavage (3 directions at 60° and 120°), **usually clear appearance**	Very high (>3rd order) birefringence (often appears white)
Dolomite (**weak reaction with dilute acid**)	High relief, perfect rhombohedral cleavage (3 directions at 60° and 120°), **commonly cloudy appearance**	Very high (>3rd order) birefringence (often appears white)
Quartz	Low Relief, no cleavage, clear appearance	Low (1st order) birefringence (white or gray)

Begin to prepare your soil presentation (scheduled for April 5)!

Carbonate Rock Identification Sheet

Sample # ______________________________ Name____

1. Hand sample color:

2. Contacts: P 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. Does the sample have a crystalline texture? [1.5 pts]
   A. If so, what is the mineralogy, size, & abundance of the crystals?

   B. If not, complete the following table. Use the 'Characteristics' row to describe specific features of a component like kinds of fossils, the components of oolites, etc.

	Pore Space Filling		Allochems			Detrital Grains		Other	
	spar	micrite	ooids	fossils	other	A	B	A	B
mineralogy									
size									
characteristics									
% abundance									

7. Based on your description of the sample in question 6, what name would you give this rock? Use the alternate classification scheme in figure 1.3 of the handout. [0.1 pts]

Rock Name:____

8. What is a possible depositional environment for this sediment? What happened to this sediment after it was deposited? [0.2 pts]

/2.5 pts.

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