

Lab 2: MINERALS, ROCKS, AND FOSSILS

Bring a hand lens to lab (available in bookstore).

INTRODUCTION

The purpose of this week's lab is to learn how to identify rocks in preparation for later labs, including our field trips to investigate the local geology. Before coming to lab, you should read Chapter 5 and Interlude A of your text, which is all about minerals and rocks.

Identifying rocks is an important skill and the more you practice, the easier it becomes. You start out by determining the general class of rock — igneous, metamorphic, or sedimentary — and then proceed to identify the minerals that make up the rock and then the texture of the rock. The *mineralogy* of a rock is a list of chemical compounds that form the grains in a rock, and the *texture* is the size, shape, and arrangement of those grains. Fossils are an especially important component of sedimentary rocks because they can tell us about the environment in which the rocks formed (and also the rocks age), so we'll also gain some familiarity with commonly occurring fossils.

The first part of lab will be spent learning some of the basics of rock identification; then you will identify 5 unknown samples, and then after the lab period, you will identify the rocks used in some of the buildings on campus.

PART I. MINERALS

There are thousands of different minerals, but fortunately, most of them are very rare, so that if you are familiar with a very small set of these minerals, you can do just fine. Some important, common rock-forming minerals are: quartz, calcite, dolomite, k-feldspar, plagioclase feldspar, biotite, muscovite, hornblende, pyroxene, olivine, hematite, pyrite.

Physical Properties Of Some Important Minerals

Physical properties such as color, crystal form, hardness, cleavage, luster, etc. are useful in identifying minerals and they provide clues to the internal structures or chemical compositions of unknown grains. What follows is a brief guide to these physical properties — at certain points, you're prompted to look at different mineral specimens in the lab — your TAs can help you locate the relevant samples. There are also a number of lab manuals that contain more extensive discussions of these physical properties and include keys for mineral identification.

COLOR

A few minerals can be distinguished by color alone - consider the two common micas; biotite is always dark and muscovite is always light. Unfortunately, color is not always so helpful in mineral identification. Some minerals may be colored by minor impurities or minute inclusions. To get a good sense of the variability of color, look at the varieties of quartz and other forms of silica (SiO₂) displayed in the lab.

STREAK

Some minerals are colored similarly (especially opaque, metallic, dark ones), but can be distinguished by the color of their powder which is obtained by rubbing the unknown mineral against a piece of unglazed porcelain (a streak plate). This works well with the three iron oxides (hematite, limonite, magnetite), the dark, rather heavy minerals. Their streak should identify them: hematite has a reddish-brown streak; limonite, yellowish-brown; and magnetite, black.

LUSTER

Luster refers to the quality of the light reflected from the mineral surface. There are a number of unusual adjectives that are used to describe luster — pearly, vitreous (glass-like), greasy, metallic, etc. Don't get too wrapped up in these descriptive terms — they're too subjective. Differences in luster in some minerals may be caused by alteration. Feldspar, for example, may be glass-clear when crystallized rapidly from magma (molten rock). More commonly, feldspars contain minute grains that make them dull. Often the grains are muscovite, which forms readily when the feldspar cools in the presence of water. Quartz, on the other hand, almost always has a glassy luster because it cannot alter readily. On the basis of luster, see if you can distinguish quartz from the feldspars.

HARDNESS

The hardness of minerals is a useful property as long as tests are made by scratching (rather than crushing) one mineral against another. It is difficult to test for hardness of fine-grained aggregates unless you are sure you are testing a single grain and not breaking grains off. The most useful way of expressing hardness is in the form of a number from 1 to 10, using a scale known as Mohs' hardness scale (see lab manuals or your text).

CRYSTAL FORM

The shapes of well-formed crystals (ones that grew without any constraints) are classified according to their symmetry. The lab manuals in the lab describe how to use this classification system. This physical property is not readily observable in the minerals found in most rocks, but there are some good examples displayed in the museum outside the lab — in such cases, the crystal form is useful in identifying the mineral.

MAGNETISM

All minerals are magnetic, but very few minerals are *ferromagnetic* (possessing permanent magnetic fields), and therefore magnetism can be a distinctive identifying property when present — magnetite is just about the only common ferromagnetic mineral that is strong enough to be detected with a normal magnet.

CLEAVAGE

Regardless of whether or not a mineral develops perfect crystal faces, it may cleave (break) along regular planes that are related directly to planes of weakness in its atomic structure. Fluorite and calcite, for example, cleave readily in four and three directions (planes) respectively. Cleavage is one of the most useful properties for identifying common minerals.

Note that quartz does not break along cleavage planes (don't mistake crystal faces for cleavage planes). Its irregular pattern of breaking is called *conchoidal* fracture. This lack of cleavage is often very useful in identifying quartz.

Feldspars are an important group of silicates and the most common minerals in the crust of the earth. There are two kinds of feldspar - the potassium feldspars such as orthoclase (also known as K-spar), and the sodium-calcium feldspars collectively called plagioclase. All feldspars have two cleavage directions.

It is often important to determine the relative amounts of the two feldspars in a rock. The cleavages of orthoclase and plagioclase are too similar to be useful in distinguishing between them. However, a crystal

growth phenomenon called twinning helps greatly in distinguishing the feldspars. During their growth, plagioclase crystals often repeat, or twin, in a plane parallel to one of the cleavage planes. Orthoclase (K-spar) doesn't have this property. The twinning causes one set of the cleavage planes to be oriented at slight angles to each other. These planes then reflect light in a regular series of very thinly-spaced lines or striations. Look at the striations on the display sample of plagioclase — you'll need a hand lens to see them.

PART II. ROCKS & FOSSILS

Rocks are identified based on their mineral content and their *texture*, or the way the mineral particles are arranged in the rock as well as their sizes and shapes. Classification schemes for igneous, metamorphic, and sedimentary rocks are displayed in the lab - these serve as one of your most important resources as you begin to learn how to identify rocks. Additional information on identifying rocks can be found in some of the lab manuals that are in the lab.

IGNEOUS ROCK

Study the igneous rock classification and the igneous textures displays on the side counter in the lab. The texture (i.e., grain size) of an igneous rock reflects the cooling history of the magma. The mineral composition of an igneous rock reflects the chemical composition of the magma from which it crystallized. The three most important mineralogical criteria are:

- 1) the presence or absence of **quartz**, which is identified by its glassy luster, hardness, and conchoidal fracture;
- 2) the composition of feldspar minerals, most of which have good cleavage surfaces at 90° to each other and have pearly to glassy luster (**K-spar** is commonly pink or salmon-colored, **plagioclase** is identified by the closely spaced parallel striations or twin planes); and
- 3) the proportion and types of dark (generally green or black) ferromagnesian (mafic) minerals - **biotite**, hornblende, pyroxene, and olivine. The diagram on igneous rocks below should be particularly helpful in assigning a rock name based on the mineral content. This diagram can also be used to test hypotheses - e.g., "if this rock is an andesite, we expect to find little or no quartz, lots of plagioclase, some amphibole and pyroxene".

One important thing to bear in mind is that if individual mineral grains are too small to be seen with a hand lens, then you cannot identify the rock on the basis of mineralogy (you would have to use a more powerful microscope) and you are forced to make a tentative identification based mainly on the color and other textures. Refer to the classification schemes for help here.

Also a couple of terms need to be defined: **aphanitic** = mineral grains too small to be seen w/ naked eye; **phaneritic** = mineral grains big enough to be seen with naked eye; these two terms could be modified by adding another term - **porphyritic** = some grains significantly larger than the others. So a rock could be aphanitic porphyritic or, more rarely, phaneritic porphyritic.

METAMORPHIC ROCKS

Metamorphic rocks (sedimentary or igneous rocks transformed by the effects of high pressures and temperatures) are also classified by their mineralogy and texture. Rocks with abundant platy minerals (usually micas or clays) are typically layered on a fine scale; this layering is called **foliation**. Three foliated metamorphic rocks are **slate**, **phyllite**, and **schist**. The size of the mica grains increases from slate to phyllite to schist, corresponding with an increase in the temperatures and pressures that the rocks were subjected to during the metamorphism. If micas are clearly visible with a hand lens, the rock is a *schist*. If

the rock has a shiny luster (caused by microscopic-sized micas), the rock is a *phyllite*. If the rock is foliated, but has a dull luster (not shiny), the rock is a *slate*.

Another foliated rock is **gneiss**, but it is usually foliated on a coarser scale. Foliation in gneisses is caused by segregation of minerals into different layers. In most gneisses, equi-dimensional mineral grains of quartz and feldspar are more abundant than the platy micas.

Non-foliated metamorphic rocks include **marble**, **quartzite**, and **hornfels** (a fine-grained, hard rock). Some of the lab manuals in lab have more complete descriptions of metamorphic rocks. Boundaries between most of these textural categories are fuzzy.

Metamorphic rocks are named by prefacing the textural name (schist, gneiss, etc.) with the names of the minerals present (those that you can identify). Some typical rock names are glaucophane-garnet-muscovite schist, biotite-garnet gneiss, and quartz-biotite-garnet schist.

Study the metamorphic rocks on display and familiarize yourself with some of the varieties of foliated and non-foliated metamorphic rocks.

SEDIMENTARY ROCKS

Sedimentary rocks may be classified in a number of ways, and there is no general agreement or a single best classification. Most systems rely on the mineralogy of the particles or clasts.

1.Siliciclastic Sedimentary Rocks - composed of fragments (clasts) of silicate minerals and rocks of various sizes. These rocks may also contain fossils, but mineral grains form the major part of these rocks.

Siliciclastic rocks are grouped according to the size of the particles:

Particle Size	Type of Particle	Rock Name
64 mm and larger	cobbles	conglomerate
2-64 mm	pebbles	conglomerate
1/16 - 2 mm	sand	sandstone
1/256 - 1/16 mm	silt	siltstone
smaller than 1/256 mm	clay (mud)	mudstone or shale

Study the siliciclastic rocks on classification chart to familiarize yourself with the characteristics these rocks.

2.Carbonate Sedimentary Rocks - composed of the shells and skeletons of plants and animals that are made of carbonate minerals (calcite, dolomite, or aragonite). The most common texture of these rocks is called bioclastic (fragments of skeletons) in which the particles are held together by either a matrix of mud (usually carbonate mud) or calcite cement or a little of each.

Limestone is the most common type of carbonate rock. The chief mineral component is **calcite**, CaCO_3 , which is readily identified because it reacts vigorously with weak hydrochloric acid. Look at the display of limestones to see how variable they are.

Limestone textures will differ according to the relative amounts of large skeletal particles, fine carbonate mud, and clear calcite cement present. It is not always possible to see the skeletal fragments without a microscope; some skeletons, especially those of algae (phytoplankton), are extremely small. Other skeletal fragments can become ground up into equally small pieces by wave action or biological destruction. This material forms the carbonate mud that commonly makes a matrix surrounding larger fragments.

In certain conditions (quite common), the mineral calcite can be replaced by another carbonate mineral, dolomite ($\text{CaMg}(\text{CO}_3)_2$) during diagenesis. In the conversion to dolomite some of the structures found in

the original limestone may be destroyed, leaving a featureless mass of dolomite crystals. The new rock is called a ***dolostone***. Dolomite will only react with weak hydrochloric acid if the grain size is first greatly reduced by scratching the surface of the mineral or rock with a hammer.

3. Other Sedimentary Rocks

This category contains rocks such as *cherts* and other siliceous sedimentary rocks, *evaporites*, *phosphorites*, and *iron-rich sediments*. The siliceous rocks are the most common of these other sedimentary rocks — see the display in the lab.

Siliceous Sedimentary Rocks

These rocks are composed of the siliceous skeletons of plants and animals. On display is a *diatomite* formed from the skeletons of single-celled phytoplankton (algae that live in the surface waters of the oceans) called diatoms. When diatomite, or any other kind of siliceous sediment is compressed, the skeletons dissolve, and the silica reprecipitates to form a rock called *chert*, which can occur as nodules or in beds. Chert can also be composed of the siliceous skeletons of radiolaria, single-celled animals (zooplankton that live in the surface waters of the oceans), or sponge spicules, the hard parts of sponges. Many chert nodules are diagenetic replacement features and do not necessarily originate from the siliceous skeletons of organisms.

FOSSILS

Fossils are important components of sedimentary rocks for two reasons - they tell us something about the **depositional environment**, and they can be used to tell us the **age** of the rock. The environment of deposition indicated by a fossil is deduced by studying the types of environments preferred by modern relatives of these ancient organisms. Most species survive for a few million years at most before they become extinct, so the correct identification of fossil species is a useful means of dating sedimentary rocks. Unfortunately, it is often difficult to identify fossils to the species level, which limits the resolution of the age that we can assign to the rock - genera and families occur over longer periods of time.

For our purposes, it will be useful to become familiar with a few kinds of fossils. In the lab, there is a small collection of relatively complete (unfragmented) fossils of **crinoids**, **brachiopods**, **bryozoans**, **trilobites**, and **gastropods**. Study these and think about how you might distinguish between these fossils if you were just looking at fragments.

ASSIGNMENT

I. IDENTIFICATION OF 3 UNKNOWN ROCKS

Organize your observations and interpretations into categories; some of these will be left blank. For instance, in a basalt, you will not find fossils, nor will you be able to identify many (if any) minerals because they are too small.

#1	General Rock Type (circle one):	igneous	metamorphic	sedimentary
	Color(s)	_____		
	Identifiable Minerals	_____		

	Texture (terms depend on whether it is igneous, metamorphic, or sedimentary)	_____		

	Fossils (if present)	_____		
	Rock Name	_____		
#2	General Rock Type (circle one):	igneous	metamorphic	sedimentary
	Color(s)	_____		
	Identifiable Minerals	_____		

	Texture (terms depend on whether it is igneous, metamorphic, or sedimentary)	_____		

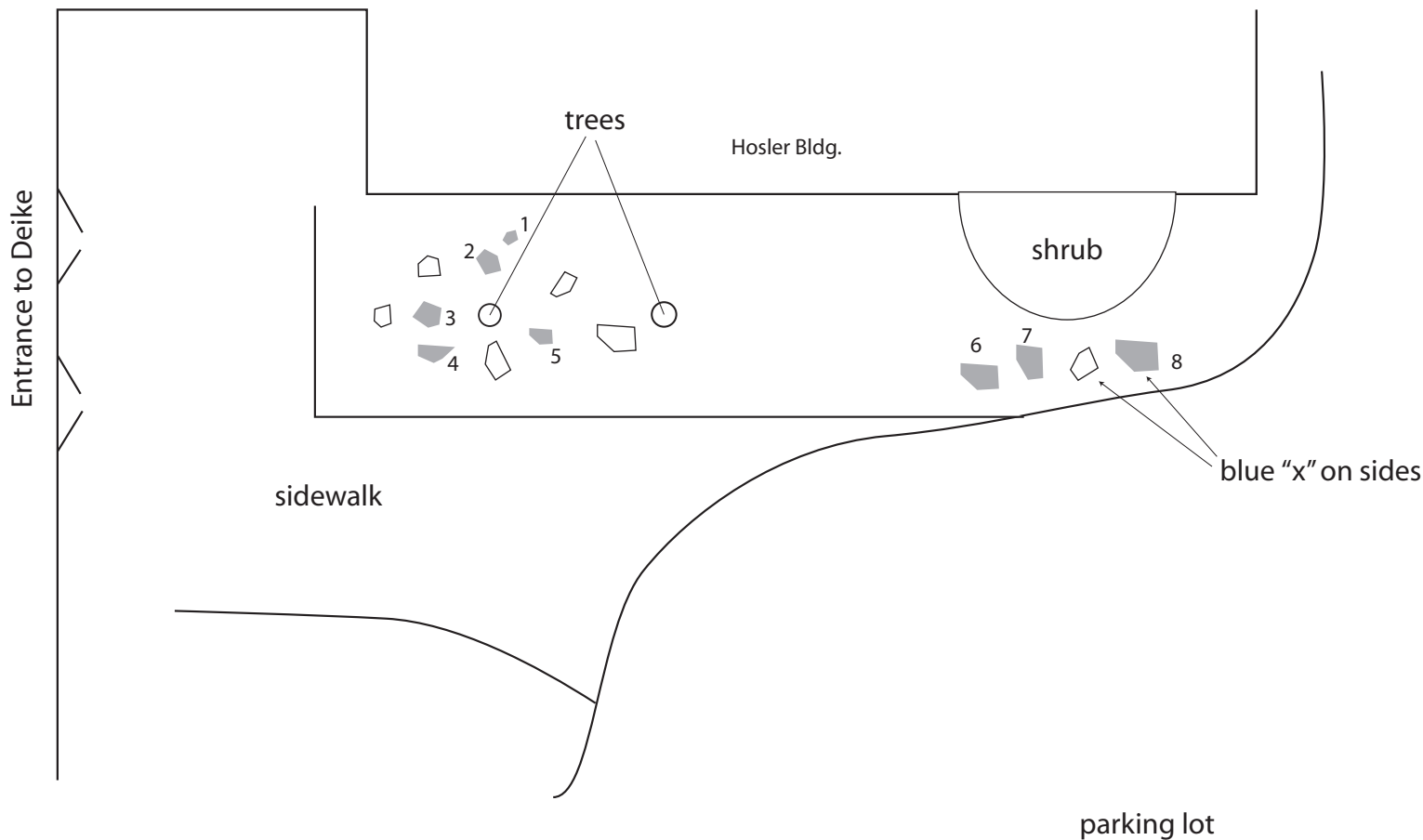
	Fossils (if present)	_____		
	Rock Name	_____		
#3	General Rock Type (circle one):	igneous	metamorphic	sedimentary
	Color(s)	_____		
	Identifiable Minerals	_____		

	Texture (terms depend on whether it is igneous, metamorphic, or sedimentary)	_____		

	Fossils (if present)	_____		
	Rock Name	_____		

II. IDENTIFICATION OF ROCKS IN THE WILD (ALMOST)

The rock garden out the northeast door from Deike includes some nice large rock specimens that present a good opportunity to practice your rock identification skills.



1. Texture: Name:	Mineralogy:
2. Texture: Name:	Mineralogy:
3. Texture: Name:	Mineralogy:
4. Texture: Name:	Mineralogy:
5. Texture: Name:	Mineralogy:
6. Texture: Name:	Mineralogy:
7. Texture: Name:	Mineralogy:
8. Texture: Name:	Mineralogy: