EXERCISE 2

Common Rocks

To an Earth scientist, rocks represent much more than usable substances. They are the materials of the Earth; understanding their origin and how they change allows us to begin to understand Earth and its processes. It is often said that "the history of Earth is written in the rocks"—we just have to be smart enough to read the "words."

In this exercise, you will investigate some of the common rocks that are found on and near Earth's surface. The criteria used to classify a rock as being of either igneous, sedimentary, or metamorphic origin are examined, as well as the procedure for identifying rocks within each of these three families.

Objectives

After you have completed this exercise, you should be able to:

1. Examine a rock and determine if it is an igneous, sedimentary, or metamorphic rock.
2. List and define the terms used to describe the textures of igneous, sedimentary, and metamorphic rocks.
3. Name the dominant mineral(s) found in the most common igneous, sedimentary, and metamorphic rocks.
4. Use a classification key to identify a rock.
5. Recognize and name some of the common rocks by sight.

Materials

metric ruler
hand lens

Materials Supplied by Your Instructor

igneous rocks
sedimentary rocks
dilute hydrochloric acid
streak plate
metamorphic rocks
hand lens or binocular microscope
glass plate
copper penny

Terms

rock
rock cycle
igneous rock
magma
sedimentary rock
weathering
sediment
lithification
metamorphic rock
composition
detrital material
chemical material
foliation
texture

Introduction

Most **rocks** are aggregates (mixtures) of minerals. However, there are some rocks that are composed essentially of one mineral found in large impure quantities. The rock limestone, consisting almost entirely of the mineral calcite, is a good example.

Rocks are classified into three types, based on the processes that formed them. One of the most useful devices for understanding rock types and the geologic processes that transform one rock type into another is the **rock cycle**. The cycle, shown in Figure 2.1, illustrates the various Earth materials and uses arrows to indicate chemical and physical processes. As you examine the rock cycle and read the following definitions, notice the references to the origin of each rock type.

The three types of rock are igneous, sedimentary, and metamorphic.

Igneous Igneous rocks (Figures 2.2–2.9) are the solidified products of once molten material called **magma**. The distinguishing feature of most igneous rocks is an interlocking arrangement of mineral crystals that forms as the molten material cools and crystals grow. *Intrusive* igneous rocks form below the surface of Earth, while those that form at the surface from lava are termed *extrusive*.

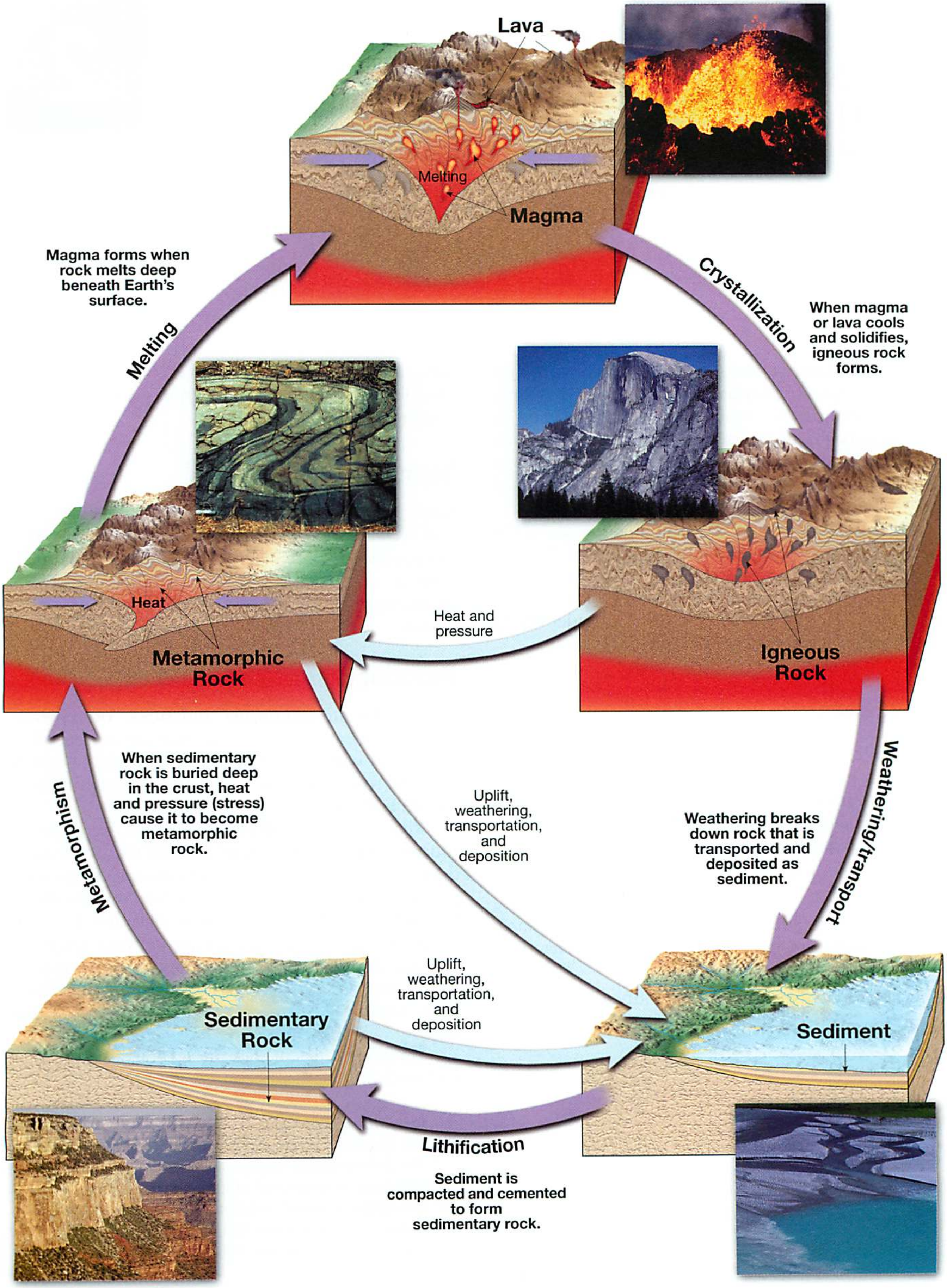


Figure 2.1 The rock cycle illustrating the role of the various geologic processes that act to transform one rock type into another.

Sedimentary These rocks (Figures 2.10–2.17) form at or near Earth's surface from the accumulated products of **weathering**, called **sediment**. These products may be solid particles or material that was formerly dissolved and then precipitated by either inorganic or organic processes. The process of **lithification** transforms the sediment into hard rock. Since sedimentary rocks form at, or very near. Earth's surface, they often contain organic matter, or fossils, or both. The layering (or bedding) that develops as sediment is sorted by, and settled out from, a transporting material (usually water or air) helps make sedimentary rocks recognizable.

Metamorphic These rocks (Figures 2.18–2.25) form below Earth's surface where high temperatures, pressures, and/or chemical fluids change preexisting rocks without melting them.

Minerals are identified by using their physical and chemical properties. However, rock types and the names of individual rocks are determined by describing their *textures* and *compositions*. The key to success in rock identification lies in learning to accurately determine and describe these properties.

Texture refers to the shape, arrangement, and size of mineral grains in a rock. The shape and arrangement of mineral grains help determine the type (igneous, sedimentary, or metamorphic) of rock. Mineral grain size is often used to separate rocks within a particular type. Each rock type uses different terms to describe its textures.

Composition refers to the minerals that are found in a rock. Often the larger mineral grains can be identified by sight or by using their physical properties. In some cases, small mineral grains may require the use of a hand lens or microscope. Occasionally, very small grains cannot be identified with the normal magnification of a microscope. Practice and increased familiarity with the minerals will make this assessment easier.

Comparing Igneous, Sedimentary, and Metamorphic Rocks

One of the first steps in the identification of rocks is to determine the rock type. Each of the three rock types has a somewhat unique appearance that helps to distinguish one type from the other.

Examine the specimens of the three rock types supplied by your instructor, as well as the photographs of the rocks in Figures 2.2–2.25. Then answer the following questions.

1. Which two of the three rock types appear to be made primarily of intergrown crystals?

   ____________ rocks and ____________ rocks

2. Which one of the two rock types you listed in question 1 has the mineral crystals aligned or arranged so that they are oriented in the same direction in a linear, linelike manner?

   ____

3. Which one of the two rock types you listed in question 1 has the mineral crystals in most of the rocks arranged in a dense interlocking mass with no alignment?

   ____

4. Of the three rock types, (igneous, sedimentary, metamorphic) rocks often contain haphazardly arranged pieces or fragments, rather than crystals. Circle your answer.

Igneous Rock Identification

Igneous rocks form from the cooling and crystallization of magma. The interlocking network of mineral crystals that develop as the molten material cools gives most igneous rocks their distinctive crystalline appearance.

Textures of Igneous Rocks

The rate of cooling of the magma determines the size of the interlocking crystals found in igneous rocks. The slower the cooling rate, the larger the mineral crystals. The five principal textures of igneous rocks are:

Coarse Grained (or *phaneritic*) The majority of mineral crystals are of a uniform size and large enough to be identifiable without a microscope. This texture occurs when magma cools slowly inside Earth.

Fine Grained (or *aphanitic*) Very small crystals, which are generally not identifiable without strong magnification, develop when molten material cools quickly on, or very near, the surface of Earth.

Porphyritic Two very contrasting sizes of crystals are caused by magma having two different rates of cooling. The larger crystals are termed *phenocrysts;* and the smaller, surrounding crystals are termed *groundmass* (or *matrix*).

Glassy No mineral crystals develop because of very rapid cooling. This lack of crystals causes the rock to have a glassy appearance. In some cases, rapidly escaping gases may produce a frothy appearance similar to spun glass.

Fragmental The rock contains broken, angular fragments of rocky materials produced during an explosive volcanic eruption.

Examine the igneous rock photographs in Figures 2.2–2.9. Then answer the following questions.

5. The igneous rock illustrated in Figure 2.2 is made of large mineral crystals that are all about the same size. The rock formed from magma that cooled (slowly, rapidly) (inside, on the surface of) Earth. Circle your answers.

Igneous Rocks

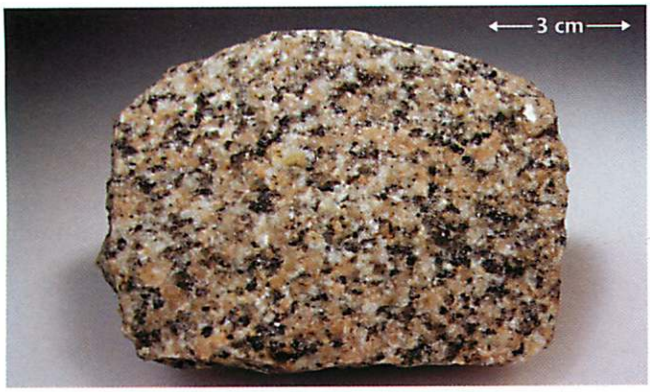


Figure 2.2 Granite, a common coarse-grained, intrusive igneous rock.

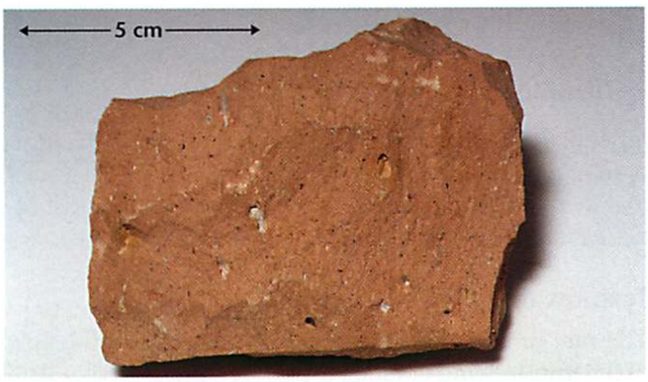


Figure 2.3 Rhyolite, a fine-grained, extrusive rock.

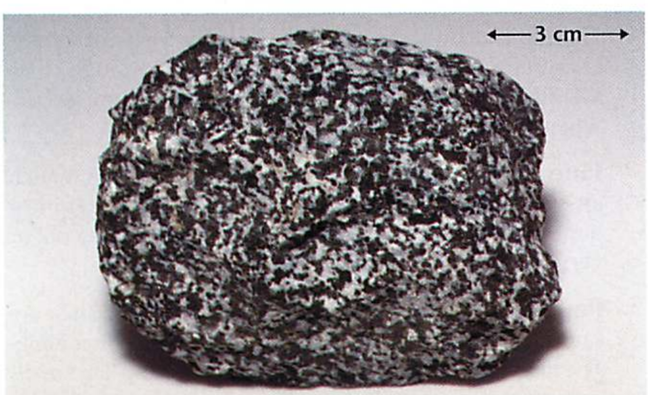


Figure 2.4 Diorite, a coarse-grained igneous rock.

Figure 2.5 Andesite porphry, an igneous rock with a porphyritic texture.

Figure 2.6 Basalt, a fine-grained igneous rock.

Figure 2.7 Gabbro, a coarse-grained, intrusive igneous rock.

Figure 2.8 Obsidian, an igneous rock with a glassy texture.

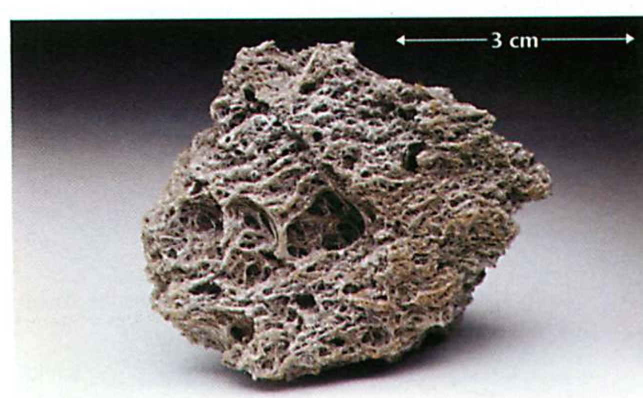


Figure 2.9 Pumice, a glassy rock containing numerous tiny voids.

Figure 2.10 Conglomerate, a detrital sedimentary rock.

Figure 2.11 Sandstone, a common detrital sedimentary rock.

Figure 2.12 Shale, a detrital sedimentary rock composed of very fine grains.

Figure 2.13 Breccia, a detrital sedimentary rock containing large, angular fragments.

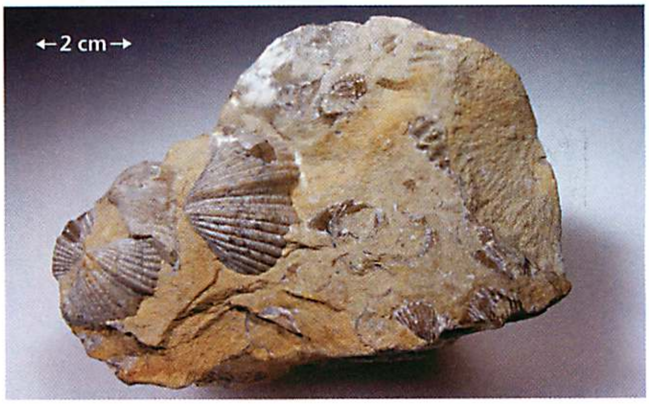


Figure 2.14 Fossiliferous limestone, a biochemical sedimentary rock.

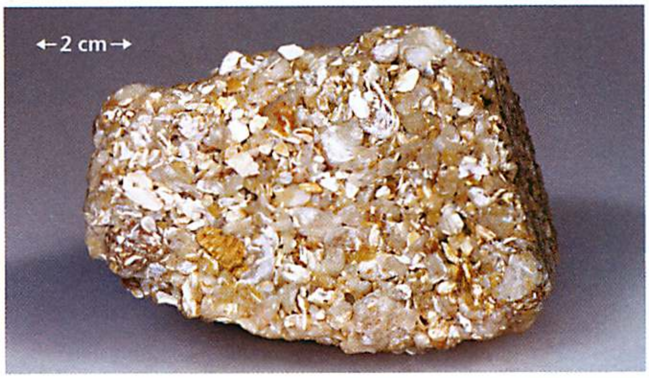


Figure 2.15 Coquina, a biochemical limestone consisting of visible shells and shell fragments, loosely cemented.

Figure 2.16 Rock salt, a chemical sedimentary rock formed as water evaporates.

Figure 2.17 Bituminous coal, a sedimentary rock composed of altered plant remains.

Metamorphic Rocks

Figure 2.18 Slate, a fine-grained, foliated metamorphic rock.

Figure 2.19 Phyllite, a foliated metamorphic rock with barely visible grains.

Figure 2.20 Schist, a foliated metamorphic rock with visible grains (variety: garnet-mica schist).

Figure 2.21 Gneiss, a foliated-banded metamorphic rock that often forms during intensive metamorphism.

Figure 2.22 Schist, variety mica schist.

Figure 2.23 Marble, a nonfoliated metamorphic rock that forms from the metamorphism of the sedimentary rock limestone.

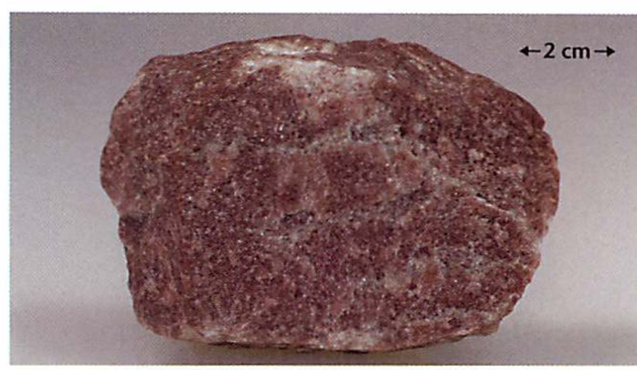


Figure 2.24 Quartzite, a nonfoliated metamorphic rock composed of fused quartz grains.

Figure 2.25 Anthracite coal, often called hard coal, forms from the metamorphism of bituminous coal.

6. The rock shown in Figure 2.6 is made of mineral crystals that are all small and not identifiable without a microscope. The rock formed from magma that cooled (slowly, rapidly) (inside, on/near the surface of) Earth. Circle your answers.
7. The igneous rock in Figure 2.5 has a porphyritic texture. The large crystals are called ________, and the surrounding, smaller crystals are called ________.
8. The rocks in Figures 2.2 and 2.3 have nearly the same mineral composition. What fact about the mineral crystals in the rocks makes their appearances so different? What caused this difference?

____

____

Select a coarse-grained rock from the igneous rock specimens supplied by your instructor and examine the mineral crystals closely using a hand lens or microscope.

9. Sketch a diagram showing the arrangement of the mineral crystals in the igneous rock specimen you examined in the space provided below. Indicate the scale of your sketch by writing the appropriate length within the ( ) provided on the bar scale.

Sketch:

0 ( ) cm

Scale

Composition of Igneous Rocks

The specific mineral composition of an igneous rock is ultimately determined by the chemical composition of the magma from which it crystallized. However, the minerals found in igneous rocks can be arranged into four groups. Each group can be identified by observing the proportion of dark-colored minerals compared to light-colored minerals. The four groups are

Felsic (or *granitic*) Composed mainly of the light-colored minerals quartz and potassium feldspars. Dark-colored minerals account for less than 15% of the minerals in rocks found in this group.

Intermediate (or *andesitic*) A mixture of both light-colored and dark-colored minerals. Dark minerals comprise about 15% to 45% of these rocks.

Mafic (or *basaltic*) Dark-colored minerals such as pyroxene and olivine account for over 45% of the composition of these rocks.

Ultramafic Composed almost entirely of the dark-colored minerals pyroxene and olivine, these rocks are rarely observed on Earth's surface. However, the ultramafic rock peridotite is believed to be a major constituent of Earth's upper mantle.

10. Estimate the percentage of dark minerals contained in the igneous rock in Figure 2.4. (You may find the color index at the top of Figure 2.26, *Igneous & Rock Identification Key,* helpful.) The rock's color is (light, medium, dark, very dark). Circle your answer.
11. The rocks shown in Figures 2.3 and 2.6 have the same texture. What fact about the mineral crystals makes their appearances so different?

____

Using an Igneous Rock Identification Key

The name of an igneous rock can be found by first determining its texture and color (an indication of mineral composition), identifying visible mineral grains, and then using an igneous rock identification key such as the one shown in Figure 2.26 to determine the name.

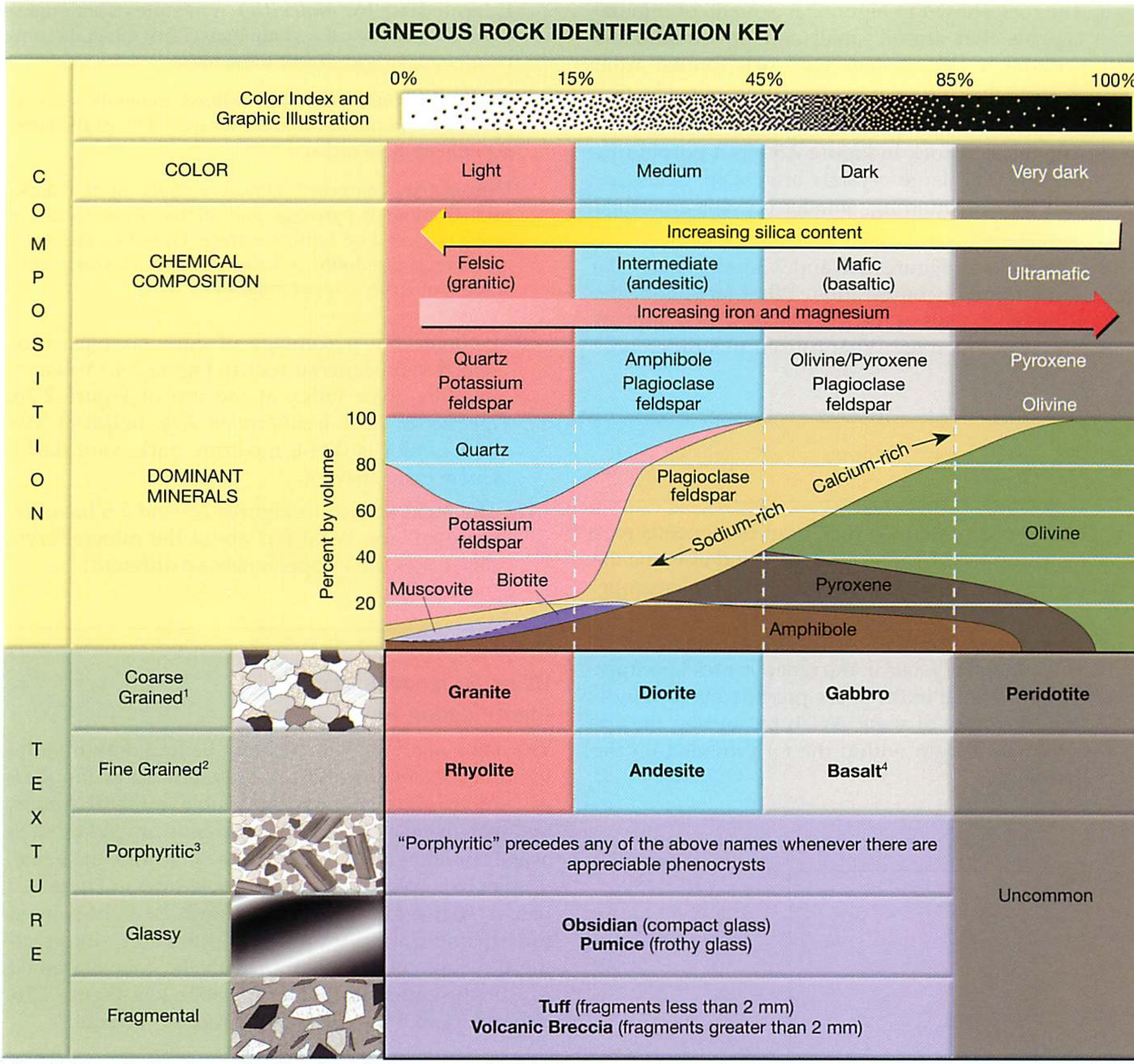
For example, the igneous rock shown in Figure 2.2 has a coarse-grained texture and is light-colored (quartz and potassium feldspar dominant). Intersecting the light-colored column with the coarse-grained row on the igneous rock identification key, Figure 2.26, determines that the name of the rock is "granite."

12. Place each of the igneous rocks supplied by your instructor on a numbered piece of paper. Then complete the igneous rock identification chart, Figure 2.27, for each rock. Use the igneous rock identification key, Figure 2.26, to determine each specimen's name.

Sedimentary Rock Identification

Sedimentary rocks, Figures 2.10–2.17, form from the accumulated products of weathering called *sediment*. Sedimentary rocks can be made of either, or a combination of, detrital or chemical material.

Detrital material consists of mineral grains or rock fragments derived from the process of mechanical weathering that are transported and deposited as solid particles (sediment). Rocks formed in this manner are called *detrital sedimentary rocks*. The mineral pieces that make



[1] Also called phaneritic. Crystals generally 1-10 mm (1 cm). The term pegmatite is added to the rock name when crystals are greater than 1 cm; e.g. granite-pegmatite.

[2] Also called aphanitic. Crystals generally less than 1 mm.

[3] For example, a granite with phenocrysts is called porphyritic granite.

[4] Basalt with a cinder-like appearance that develops from gas bubbles trapped in cooling lava (a texture referred to as vesicular) is called scoria.

Figure 2.26 Igneous rock identification key. Color, with associated mineral composition, is shown along the top axis. Each rock in a column has the color and composition indicated at the top of the column. Texture is shown along the left side of the key. Each rock in a row has the texture indicated for that row. To determine the name of a rock, intersect the appropriate column (color and mineral composition) with the appropriate row (texture) and read the name at the place of intersection.

up a detrital sedimentary rock are called *grains* (or *fragments* if they are pieces of rock). The identification of a detrital sedimentary rock is determined primarily by the size of the grains or fragments. Mineral composition of the rock is a secondary concern.

Chemical material was previously dissolved in water and later precipitated by either inorganic or organic processes. Rocks formed in this manner are called *chemical sedimentary rocks.* If the material is the result of the life processes of water-dwelling organisms—for example, the formation of a shell—it is said to be of biochemical origin. Mineral composition is the primary consideration in the identification of chemical sedimentary rocks.

Sedimentary rocks come in many varieties that have formed in many different ways. For the purpose of examination, this investigation divides the sedimentary rocks into the two groups, *detrital* and *chemical,* based upon the type of material found in the rock.

Specimen Number	Texture	Color (light-intermediate-dark)	Dominant Minerals	Rock Name

Figure 2.27 Igneous rock identification chart.

Examining Sedimentary Rocks

Examine the sedimentary rock specimens supplied by your instructor. Separate those that are made of pieces or fragments of mineral, rock material, or both. They are the detrital sedimentary rocks. Do *not* include any rocks that have abundant shells or shell fragments. You may find the photographs of the detrital sedimentary rocks in Figures 2.10–2.13 helpful. The remaining sedimentary rocks, those with shells or shell fragments and those that consist of crystals, are the chemical rocks.

Pick up each detrital rock specimen and rub your finger over it to feel the size of the grains or fragments.

13. How many of your detrital specimens feel rough like sand? How many feel smooth like mud or clay?

_______ specimens feel rough and _______ feel smooth.

Use a hand lens or microscope to examine the grains or fragments of several coarse detrital rock specimens. Notice that they are not crystals.

14. Sketch the magnified pieces and surrounding material, called *cement* (or *matrix*), of a coarse detrital rock in the space provided on the following page. Indicate the scale of your sketch by writing the appropriate length within the ( ) provided on the bar scale.

Sketch:

0 ( ) cm

Scale

a. Observe the material surrounding the grains or fragments in the rock specimen closely with a hand lens or microscope. The material is (course, fine). Circle your answer.

b. Write a brief description of the detrital rock specimen you have examined.

____

____

Two of the minerals that often comprise the grains of detrital sedimentary rocks are quartz, a hard (hardness = 7) mineral with a glassy luster, and clay, a soft, fine mineral that consists of microscopic platy particles. The difference in appearance and hardness of quartz and clay is helpful in distinguishing them.

15. How many of your detrital specimens are made of quartz, and how many appear to be made of clay?

_______ specimens have quartz grains and

_______ have clay grains.

As a result of their method of formation, many chemical sedimentary rocks are fine-to-coarse crystalline, while others consist of shells or shell fragments.

16. How many of your chemical sedimentary rocks are crystalline, and how many contain abundant shells or shell fragments?

_______ specimens are crystalline and

_______ contain shells or shell fragments.

Limestones, Figures 2.14 and 2.15, are the most abundant chemical sedimentary rocks. They have several origins and many different varieties; however, one thing that all limestones have in common is that they are made of the calcium carbonate mineral called *calcite*. Calcite can precipitate directly from the sea to form limestone or can be used by marine organisms to make shells. After the organisms die, the shells become sediment and eventually the sedimentary rock limestone.

Calcite is a mineral that reacts with dilute hydrochloric acid and effervesces (fizzes) as carbon dioxide gas is released. Most limestones react readily when a small drop of acid is placed on them, thus providing a good test for identifying the rock. Many limestones also contain fragments of seashells, which also aid in their identification.

17. Follow the directions of your instructor to test the specified sedimentary rock(s) with the dilute hydrochloric acid provided and observe the results. [*Note:* Several detrital sedimentary rocks have calcite surrounding their grains or fragments (calcite cement) that will effervesce with acid and give a *false* test for limestone. Observe the acid reaction closely.]

Using a Sedimentary Rock Identification Key

The sedimentary rock identification key in Figure 2.28 divides the sedimentary rocks into detrital and chemical types. Notice that the primary subdivisions for the detrital rocks are based upon grain size, whereas composition is used to subdivide the chemical rocks.

Detrital Sedimentary Rocks

Texture (particle size)	Sediment Name	Rock Name
Coarse (over 2 mm)	Gravel (rounded particles)	**Conglomerate**
	Gravel (angular particles)	**Breccia**
Medium (1/16 to 2 mm)	Sand (if abundant feldspar is present the rock is called **Arkose**)	**Sandstone**
Fine (1/16 to 1/256 mm)	Mud	**Siltstone**
Very fine (less than 1/256 mm)	Mud	**Shale**

Chemical Sedimentary Rocks

Composition	Texture	Rock Name	
Calcite, $CaCO_3$ (effervesces in HCl)	Fine to coarse crystalline	**Crystalline Limestone**	
		Travertine	
	Visible shells and shell fragments loosely cemented	**Coquina**	**Biochemical Limestone**
	Various size shells and shell fragments cemented with calcite cement	**Fossiliferous Limestone**	
	Microscopic shells and clay	**Chalk**	
Quartz, SiO_2	Very fine crystalline	**Chert** (light colored) **Flint** (dark colored)	
Gypsum $CaSO_4 \cdot 2H_2O$	Fine to coarse crystalline	**Rock Gypsum**	
Halite, NaCl	Fine to coarse crystalline	**Rock Salt**	
Altered plant fragments	Fine-grained organic matter	**Bituminous Coal**	

Figure 2.28 Sedimentary rock identification key. Sedimentary rocks are divided into two groups, detrital and chemical, depending upon the type of material that composes them. Detrital rocks are further subdivided by the size of their grains, while the subdivision of the chemical rocks is determined by composition.

Specimen Number	Detrital or Chemical	Texture (grain size)	Sediment Name or Composition	Rock Name

Figure 2.29 Sedimentary rock identification chart.

18. Place each of the sedimentary rocks supplied by your instructor on a numbered piece of paper. Then complete the sedimentary rock identification chart, Figure 2.29, for each rock. Use the sedimentary rock identification key, Figure 2.28, to determine each specimen's name.

Sedimentary Rocks and Environments

Sedimentary rocks are extremely important in the study of Earth's history. Particle size and the materials from which they are made often suggest something about the place, or environment, in which the rock formed. The fossils that often are found in a sedimentary rock also provide information about the rock's history.

Reexamine the sedimentary rocks and think of them as representing a "place" on Earth where the sediment was deposited.

19. Figure 2.11 is the rock sandstone that formed from sand. Where on Earth do you find sand, the primary material of sandstone, being deposited today?

____

Figure 2.30 shows a few generalized environments (places) where sediment accumulates. Often, an environment is characterized by the type of sediment and life forms associated with it.

20. Use Figure 2.30 to name the environment(s) where, in the past, the sediment for the following sedimentary rocks may have been deposited.

	ORIGINAL SEDIMENT	ENVIRONMENT(S)
Sandstone:	(sand)	____________
Shale:	(mud)	____________
Limestone:	(coral, shells)	____________

Metamorphic Rock Identification

Metamorphic rocks were previously igneous, sedimentary, or other metamorphic rocks that were changed by any combination of heat, pressure, and chemical fluids during the process of **metamorphism.** They are most often located beneath sedimentary rocks on the continents and in the cores of mountains.

During metamorphism new minerals may form, and/or existing minerals can grow larger as metamorphism becomes more intense. Frequently, mineral crystals that are elongated (like hornblende) or have a sheet structure (like the micas—biotite and muscovite) become oriented perpendicular to compressional forces. The resulting parallel, linear alignment of mineral crystals perpendicular to compressional forces (differential stress) is called **foliation** (Figure 2.31). Foliation is unique to many metamorphic rocks and gives them a layered or banded appearance.

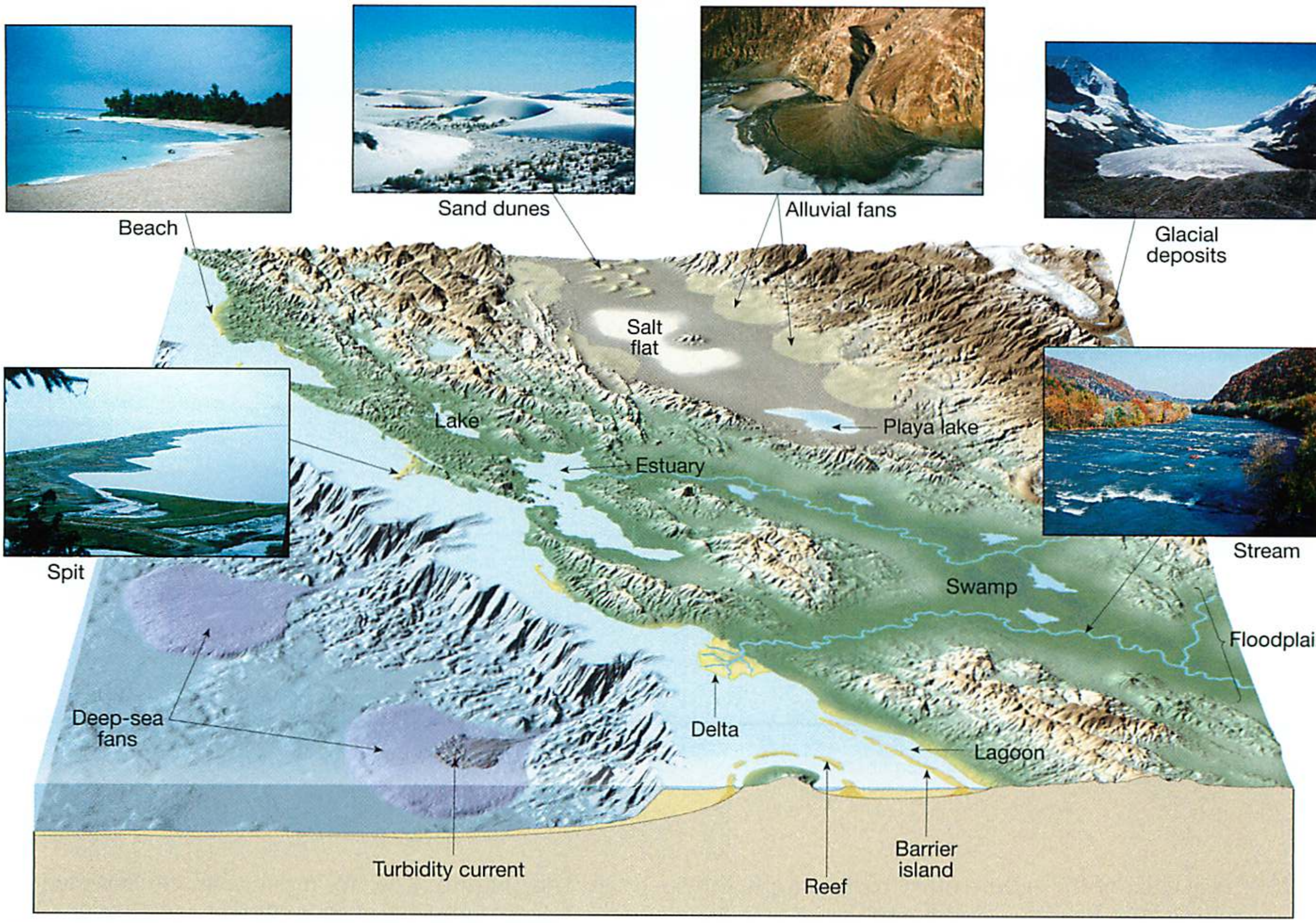


Figure 2.30 Generalized illustration of sedimentary environments. Although many environments exist on both the land and in the sea, only some of the most important are represented in this idealized diagram. (Photos by E. J. Tarbuck, except alluvial fan, by Marli Miller)

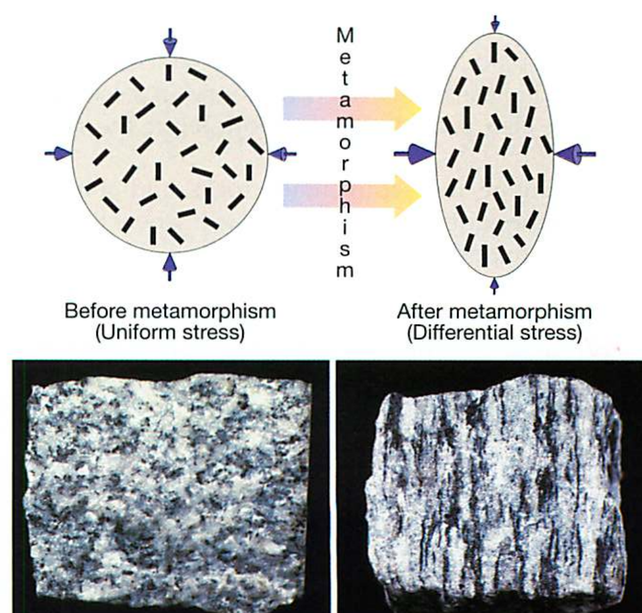


Figure 2.31 Under directed pressure, planar minerals, such as the micas, become reoriented or recrystallized so that their surfaces are aligned at right angles to the stress. The resulting planar orientation of mineral grains is called **foliation** and gives the rock a foliated texture. If the coarse-grained igneous rock (granite) on the left underwent intense metamorphism, it could end up closely resembling the metamorphic rock on the right (gneiss). (Photos by E. J. Tarbuck)

Metamorphic rocks are divided into two groups based on texture—foliated and nonfoliated. These textural divisions provide the basis for the identification of metamorphic rocks.

Foliated Metamorphic Rocks

The mineral crystals in foliated metamorphic rocks are either elongated or have a sheet structure and are arranged in a parallel or "layered" manner. *During metamorphism, increased heat and pressure can cause the mineral crystals to become larger and the foliation more obvious.* (Figure 2.32) The metamorphic rocks in Figures 2.18–2.22 exhibit foliated textures.

21. From the rocks illustrated in Figures 2.18 and 2.20, the (slate, schist) resulted from more intensive heat and pressure. Circle your answer.
22. From the metamorphic rocks in Figures 2.19 and 2.21, the (phyllite, gneiss) shows the minerals separated into light and dark bands. Circle your answer. (The foliated-banded texture of the rock that you have selected often results from the most intensive heat and pressure during metamorphism.)

Select several of the foliated metamorphic rock specimens supplied by your instructor that have large crystals and examine them with a hand lens or microscope.

23. Sketch the appearance of the magnified crystals of one foliated metamorphic rock in the space provided below. Indicate the scale of your sketch by writing the appropriate length within the ( ) provided on the bar scale.

Sketch:

0 ( ) cm

Scale

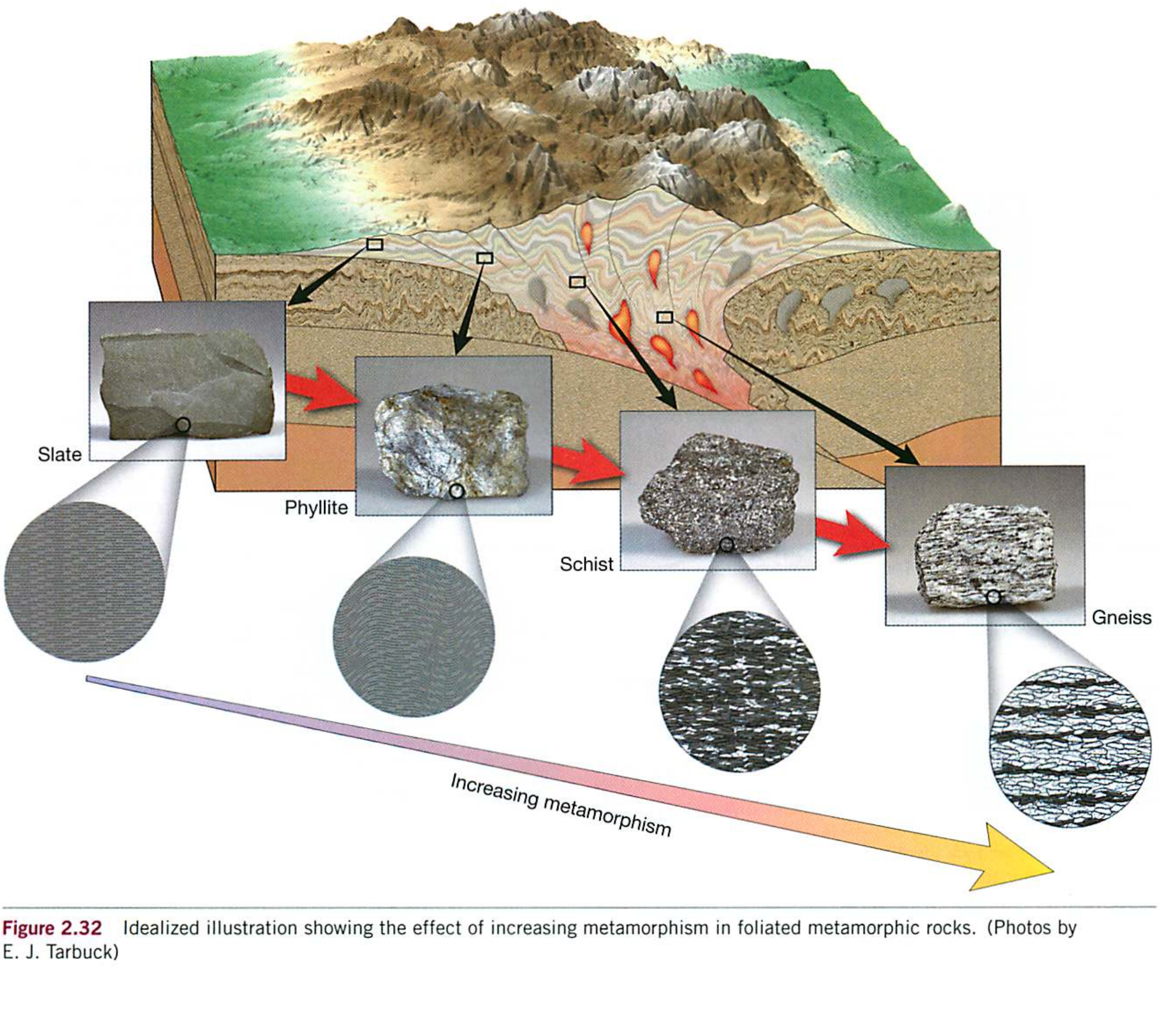


Figure 2.32 Idealized illustration showing the effect of increasing metamorphism in foliated metamorphic rocks. (Photos by E. J. Tarbuck)

Notes and calculations.

Common Rocks

Date Due: ______________________

Name: ______________________

Date: ______________________

Class: ______________________

After you have finished Exercise 2, complete the following questions. You may have to refer to the exercise for assistance or to locate specific answers. Be prepared to submit this summary/report to your instructor at the designated time.

1. Write a brief definition of each of the three rock types.

   Igneous rocks: ______________________

   Sedimentary rocks: ______________________

   Metamorphic rocks: ______________________

2. What unique factor about the arrangement of mineral crystals occurs in many metamorphic rocks?

3. Describe the procedure you would follow to determine the name of a specific igneous rock.

4. Describe the basic difference between detrital and chemical sedimentary rocks.

5. List the *texture* and mineral *composition* of each of the following rocks.

	TEXTURE	MINERAL COMPOSITION
Granite:		
Marble:		
Sandstone:		

6. What are two possible environments for the origin of the sedimentary rock sandstone?

7. Of the three rock types, which one is most likely to contain fossils? Explain the reason for your choice.

8. What factor determines the size of the crystals in igneous rocks?

9. What is a good chemical test to determine the primary mineral in limestone?

10. What factor(s) determine(s) the size of crystals in metamorphic rocks?

11. If the sedimentary rock limestone is subjected to metamorphism, what metamorphic rock will likely form?

____

12. With reference to the rock cycle, describe the processes and changes that an igneous rock will undergo as it is changed first to a sedimentary rock, which then becomes a metamorphic rock.

____

____

____

13. Select two igneous, two sedimentary, and two metamorphic rocks that you identified, and write a brief description of each.

Rock type: ______________________________

Rock name: ______________________________

Description: ______________________________

____

____

Rock type: ______________________________

Rock name: ______________________________

Description: ______________________________

____

____

Rock type: ______________________________

Rock name: ______________________________

Description: ______________________________

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Rock type: ______________________________

Rock name: ______________________________

Description: ______________________________

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Rock type: ______________________________

Rock name: ______________________________

Description: ______________________________

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____

Rock type: ______________________________

Rock name: ______________________________

Description: ______________________________

____

____

14. Referring to Figure 2.35, list each rock's name and write a brief description of each.

A: ______________________________

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____

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B: ______________________________

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____

____

C: ______________________________

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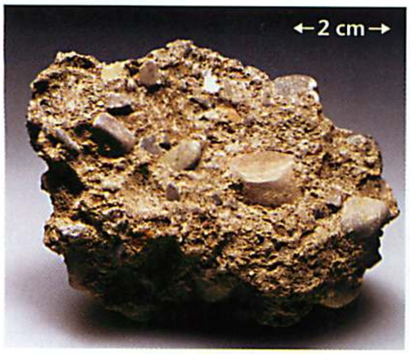
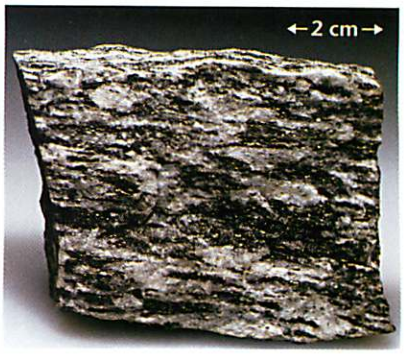


A.

B.



C.

Figure 2.35 Three rock specimens for use with question 14.