SECTION 1

READING WARM-UP

Understanding Rock

Terms to Learn

rock
rock cycle
magma
composition
texture
igneous rock
sedimentary rock
metamorphic rock

What You'll Do

- Describe two ways rocks were used by early humans, and describe two ways they are used today.
- Describe how each type of rock changes into another as it moves through the rock cycle.
- List two characteristics of rock that are used to help classify it.

The Earth's crust is made up mostly of rock. But what exactly is rock? **Rock** is simply a solid mixture of crystals of one or more minerals. However, some types of rock, such as coal, are made of organic materials. Rocks come in all sizes—from pebbles to formations thousands of kilometers long!

The Value of Rock

Rock has been an important natural resource as long as humans have existed. Early humans used rocks as hammers to make other tools. They discovered that they could make arrowheads, spear points, knives, and scrapers by carefully hammering flint, chert, and obsidian rocks. See **Figure 1.** These rocks were shaped to form extremely sharp edges and points. Even today, obsidian is used to form special scalpels, as shown in **Figure 2.**

Rock has also been used for centuries to make buildings, roads, and monuments. **Figure 3** shows some inventive uses of rock by both ancient and modern civilizations. Buildings have been made out of marble, granite, sandstone, limestone, and slate. Modern buildings also use concrete, in which rock is an important ingredient. Concrete is one of the most common building materials used today.

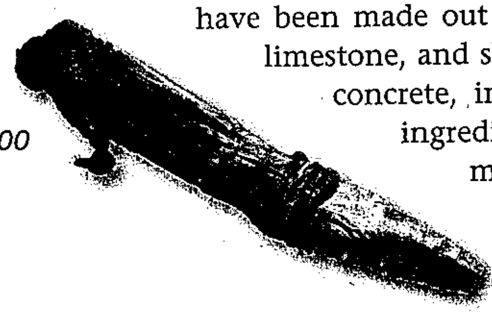


Figure 1 *This stone tool was made and used more than 5,000 years ago.*

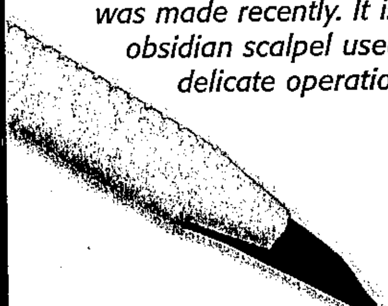
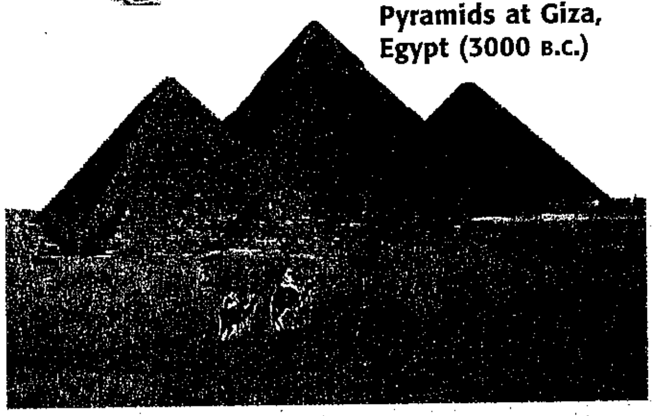


Figure 2 *This stone tool was made recently. It is an obsidian scalpel used in delicate operations.*

Figure 3 *These photos show a few samples of structures built with rock. On this page are structures built by ancient civilizations. On the facing page are some more-modern examples.*



Pyramids at Giza, Egypt (3000 B.C.)

Machu Picchu, Peru (A.D. 600)

Humans have a long history with rock. Certain types of rock have helped us to survive and to develop both our ancient and modern civilizations. Rock is also very important to scientists. The study of rocks helps answer questions about the history of the Earth and our solar system. Rocks provide a record of what the Earth and other planets were like before recorded history.

The fossils some rocks contain also provide clues about life-forms that lived billions of years ago, long before dinosaurs walked the Earth. **Figure 4** shows how rocks can capture evidence of life that became extinct long ago. Without such fossils, scientists would know very little about the history of life on Earth. The answers we get from studying rocks often cause us to ask even more questions!

BRAIN FOOD

Some meteorites are actually rocks that come from other planets. Below is a microscopic view of a meteorite that came from Mars. The tiny structures may indicate that microscopic life once existed on Mars.

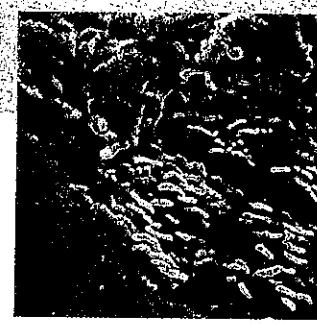
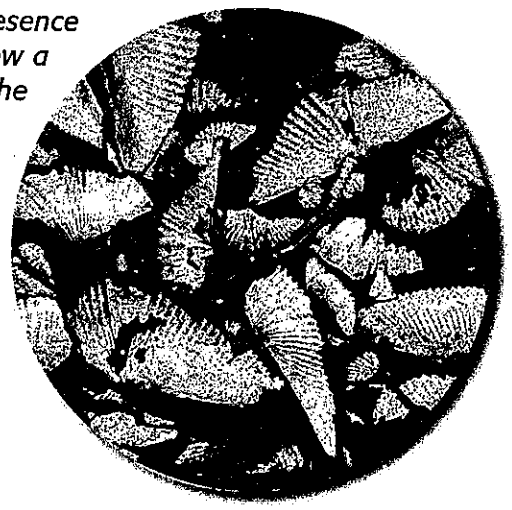
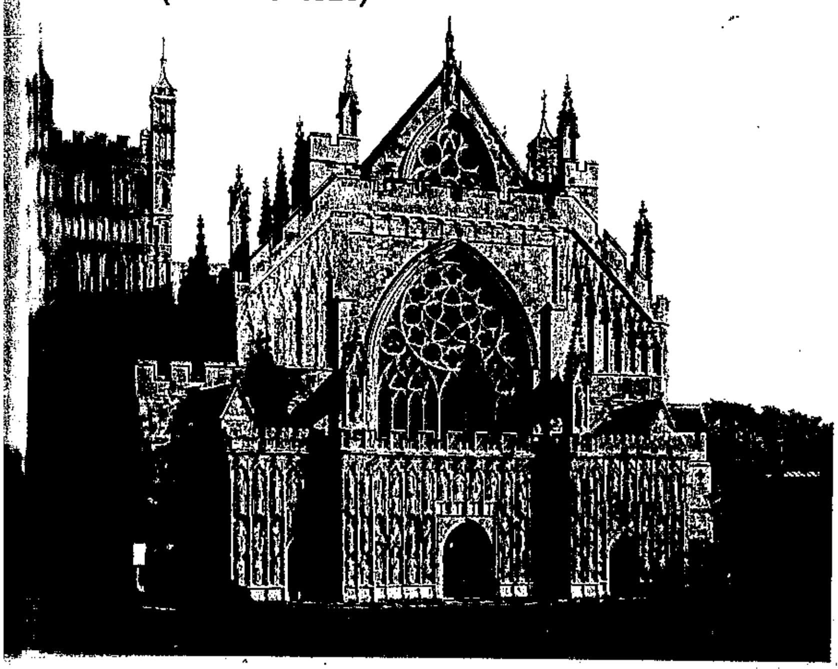


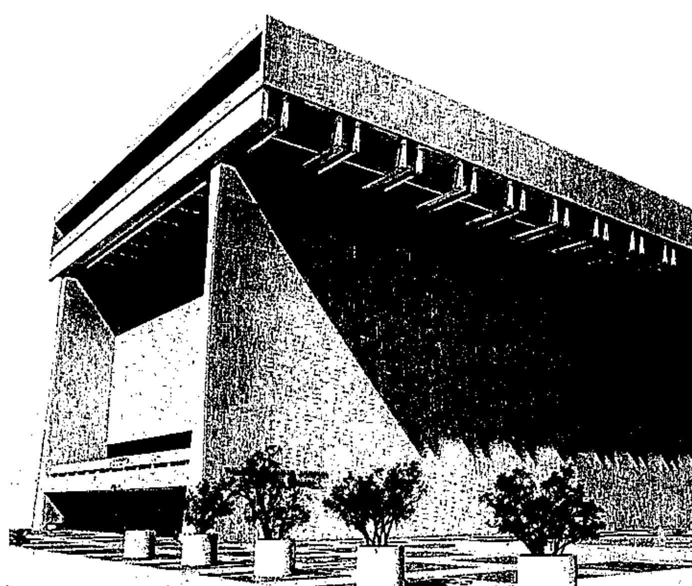
Figure 4 *These fossils were found on a mountaintop. Their presence indicates that what is now a mountaintop was once the bottom of a shallow sea.*



Exeter Cathedral, Exeter, England (A.D. 1120–1520)

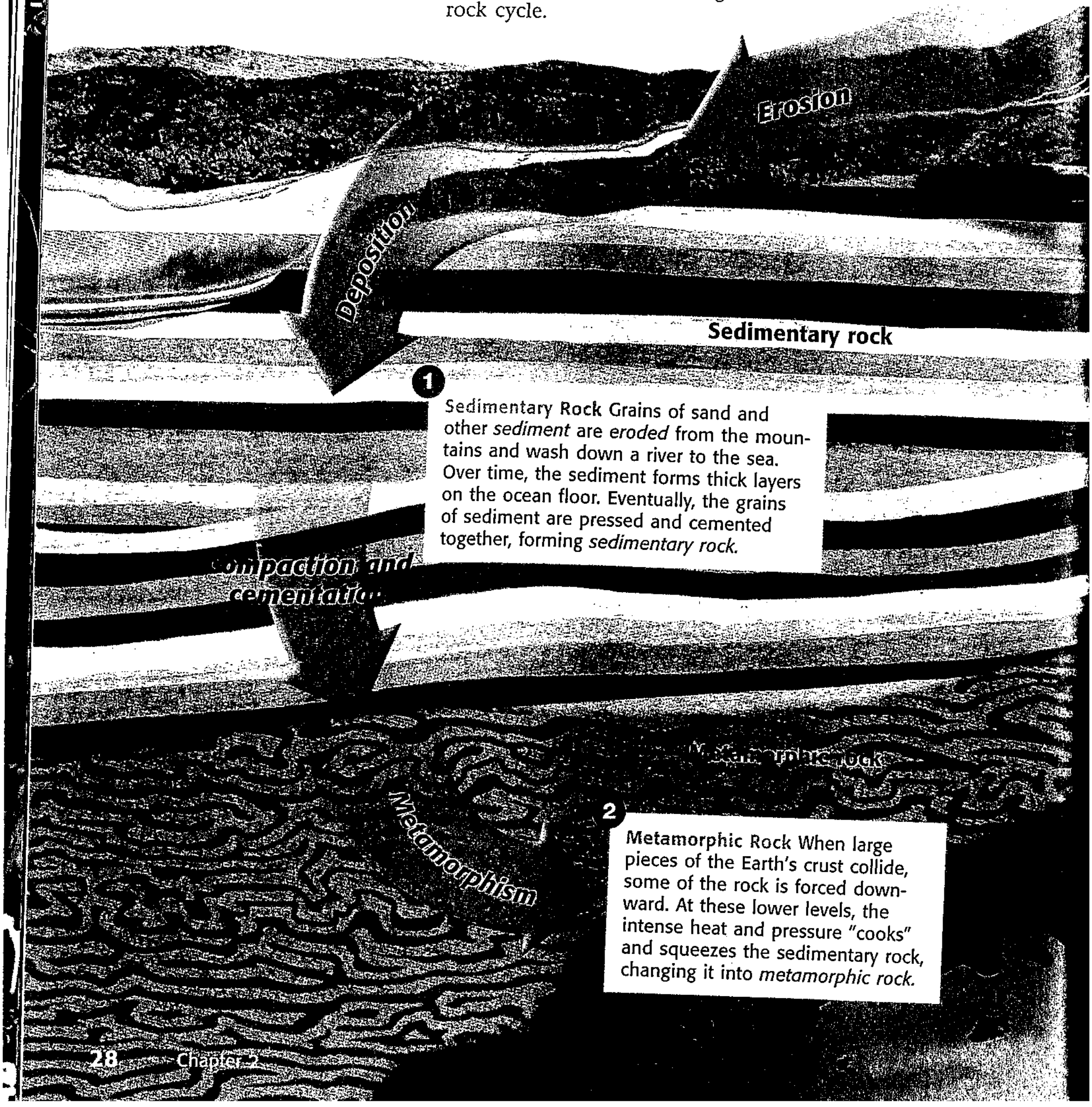


LBJ Library, Austin, Texas (1972)



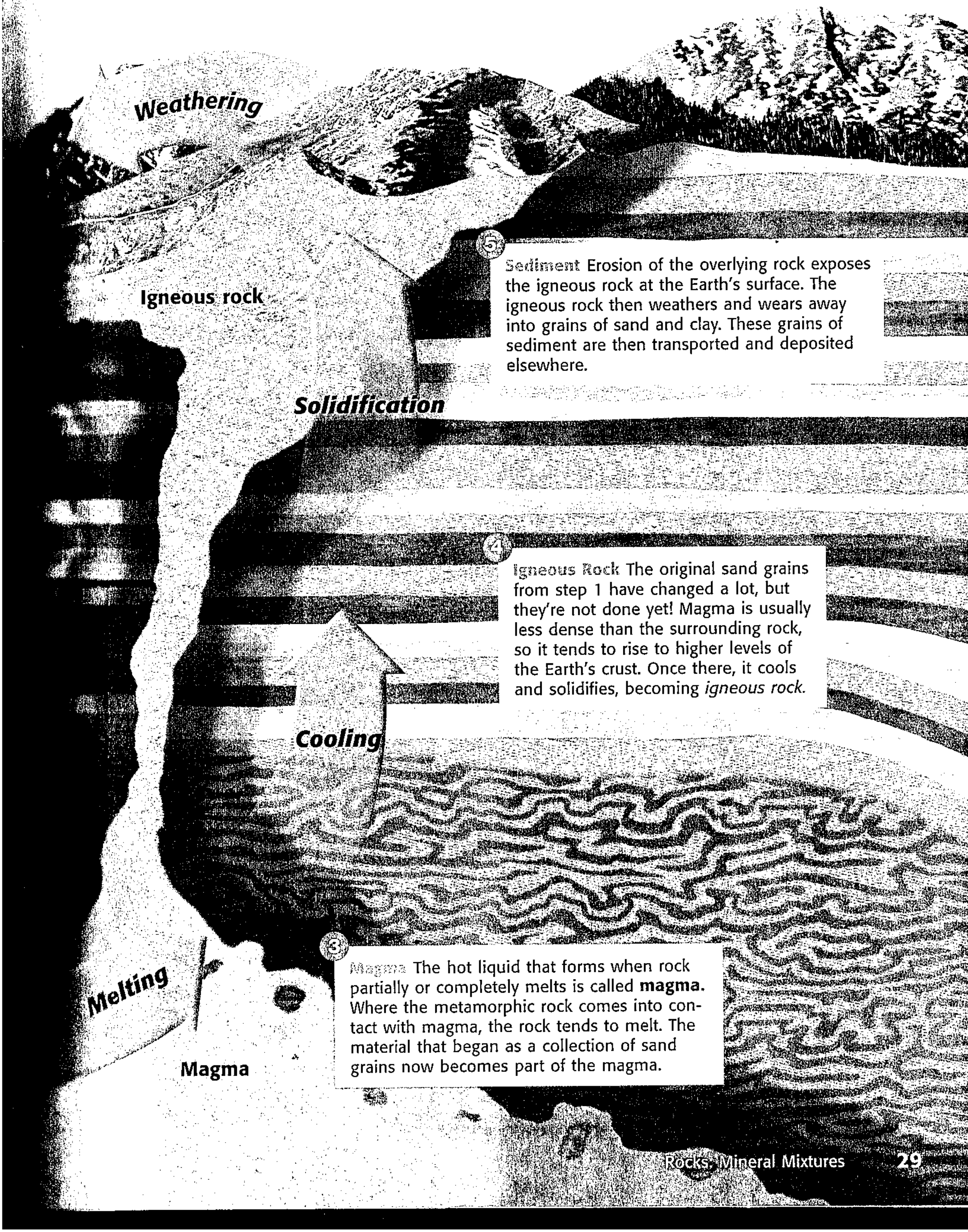
The Rock Cycle

The rocks in the Earth's crust are constantly changing. Rock changes its shape and composition in a variety of ways. The way rock forms determines what type of rock it is. The three main types of rock are *igneous, sedimentary,* and *metamorphic.* Each type of rock is a part of the *rock cycle.* The **rock cycle** is the process by which one rock type changes into another. Follow this diagram to see one way sand grains can change as they travel through the rock cycle.



1 Sedimentary Rock Grains of sand and other *sediment* are *eroded* from the mountains and wash down a river to the sea. Over time, the sediment forms thick layers on the ocean floor. Eventually, the grains of sediment are pressed and cemented together, forming *sedimentary rock.*

2 Metamorphic Rock When large pieces of the Earth's crust collide, some of the rock is forced downward. At these lower levels, the intense heat and pressure "cooks" and squeezes the sedimentary rock, changing it into *metamorphic rock.*



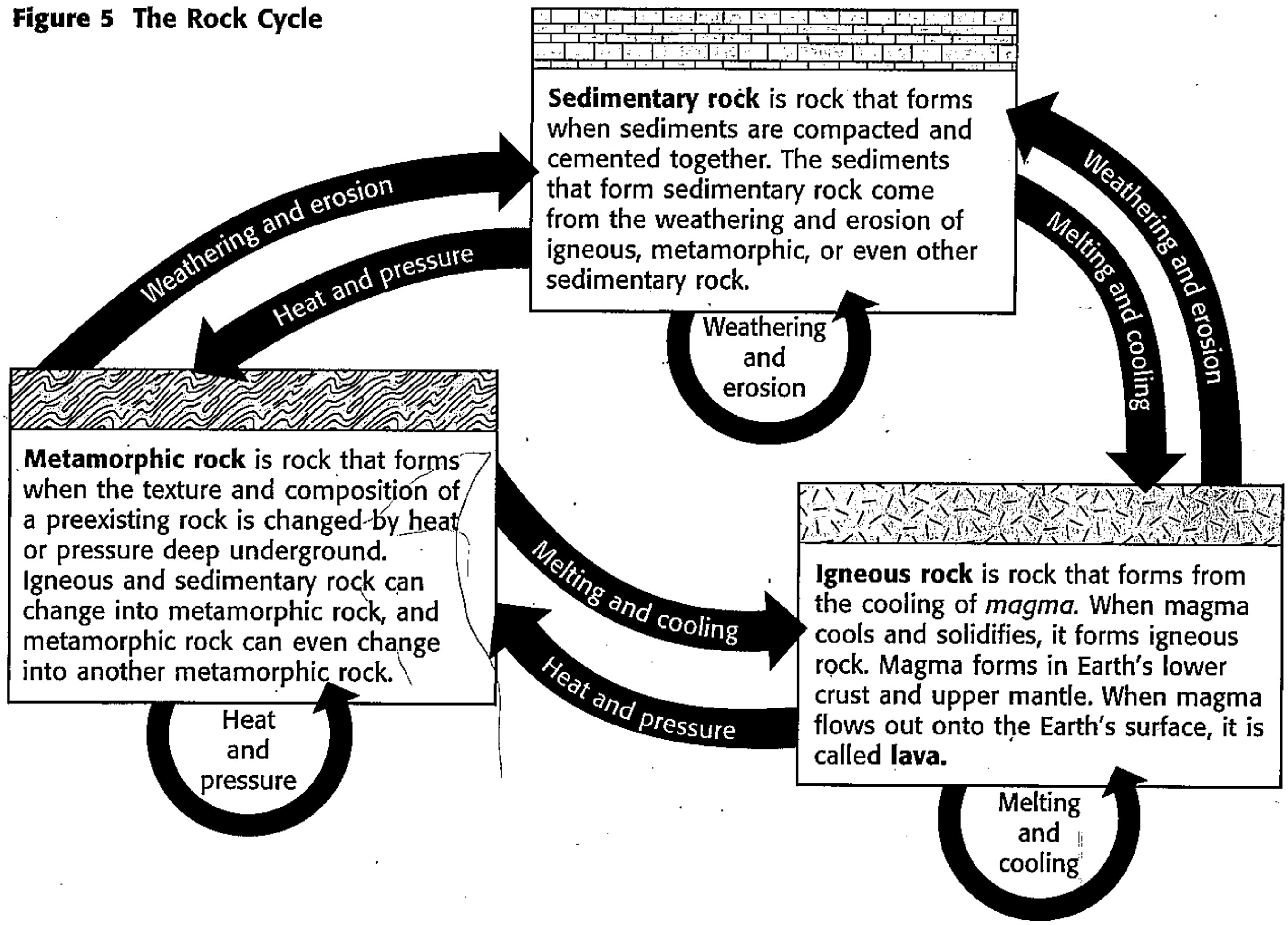
5 **Sediment** Erosion of the overlying rock exposes the igneous rock at the Earth's surface. The igneous rock then weathers and wears away into grains of sand and clay. These grains of sediment are then transported and deposited elsewhere.

4 **Igneous Rock** The original sand grains from step 1 have changed a lot, but they're not done yet! Magma is usually less dense than the surrounding rock, so it tends to rise to higher levels of the Earth's crust. Once there, it cools and solidifies, becoming *igneous rock.*

3 **Magma** The hot liquid that forms when rock partially or completely melts is called **magma.** Where the metamorphic rock comes into contact with magma, the rock tends to melt. The material that began as a collection of sand grains now becomes part of the magma.

Now that you know something about the natural processes that make the three major rock types, you can see that each type of rock can become any other type of rock. This is why it is called a cycle—there is no beginning or end. All rocks are at some stage of the rock cycle and can change into a different rock type. **Figure 5** shows how the three types of rock change form.

Figure 5 The Rock Cycle



APPLY

Classifying Objects

Geologists sometimes use food examples to describe geologic processes. For example, when you tap a block of gelatin, it shakes much like the ground shakes during an earthquake. Melting and solidifying chocolate chips models the formation of magma and igneous rocks. Think of a way that food can be used to describe the formation of sedimentary and metamorphic rocks. What do you think are the strengths and weaknesses of using food to describe geologic processes? Explain.

The Nitty-Gritty on Rock Classification

You now know that scientists classify all rock into three main types based on how they formed. But did you know that each type of rock is divided into even smaller groups? These smaller groups are also based on differences in the way rocks form. For example, all igneous rock forms when hot liquid cools and solidifies. But some igneous rocks form when lava cools on the Earth's surface, while others form when magma cools deep beneath the surface. Therefore, igneous rock is divided into two smaller groups, depending on how and where it forms. In the same way, sedimentary and metamorphic rocks are also divided into smaller groups. How do Earth scientists know how to classify different rocks? They study them in detail using two important criteria—*composition* and *texture.*

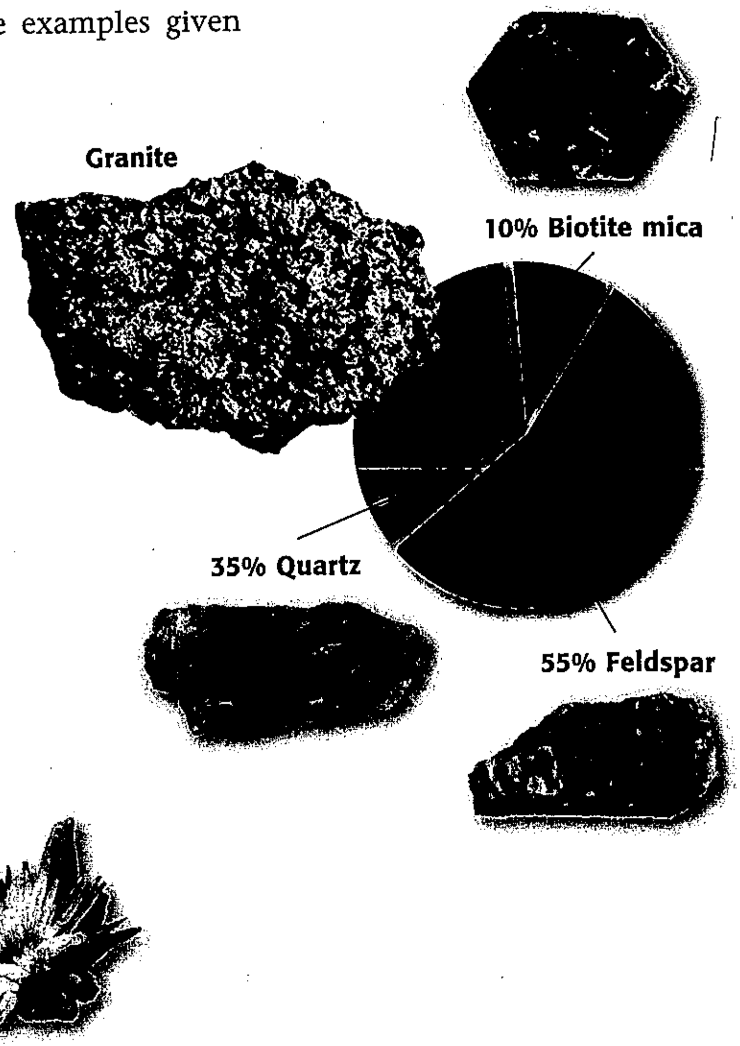
MATH BREAK

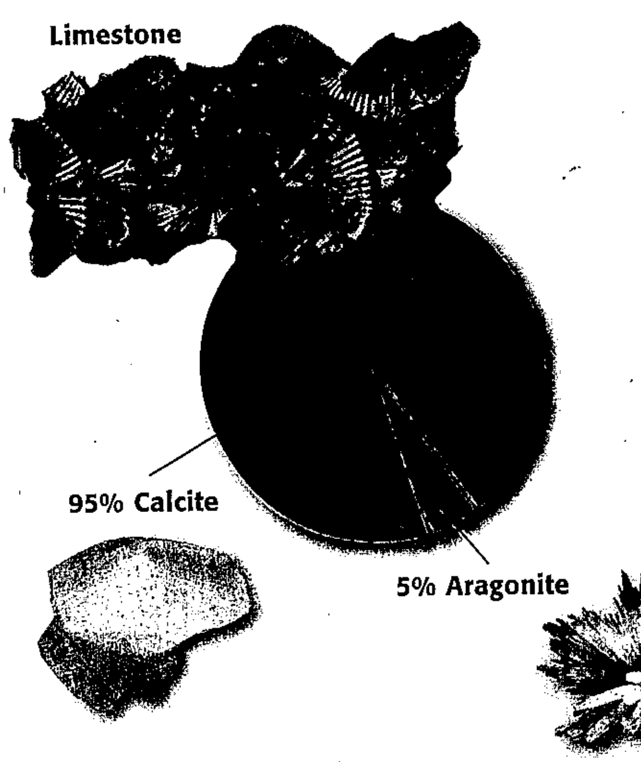
What's in It?

Assume that a granite rock you are studying is made of 30 percent quartz, 55 percent feldspar, and the rest biotite mica. What percentage of the rock is biotite mica?

Composition The minerals a rock is made of determine the **composition** of the rock. For example, a rock that is made up mostly of the mineral quartz will have a composition very similar to quartz. A rock that is made of 50 percent quartz and 50 percent feldspar will have a very different overall composition. Use this idea to compare the examples given in **Figure 6.**

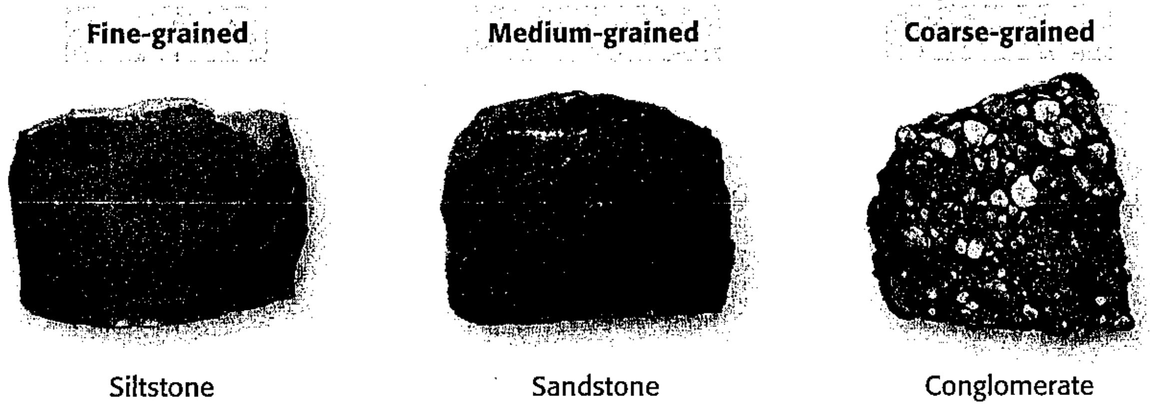
Figure 6 *The overall composition of a rock depends on the minerals it contains.*





Texture The **texture** of a rock is determined by the sizes, shapes, and positions of the grains of which it is made. Rocks that are made entirely of small grains, such as silt or clay particles, are said to have a *fine-grained* texture. Rocks that are made of large grains, such as pebbles, are said to have a *coarse-grained* texture. Rocks that have a texture between fine- and coarse-grained are said to have a *medium-grained* texture. Examples of these textures are shown in **Figure 7.**

Figure 7 *These three sedimentary rocks are made up of grains of different sizes. Can you see the differences in their textures?*



Each rock type has a different kind of texture that can provide good clues to how and where the rock formed. For example, the rock shown in **Figure 8** has a texture that reflects how it formed. Both texture and composition are important characteristics that scientists use to understand the origin and history of rocks. Keep these characteristics in mind as you continue reading through this chapter.

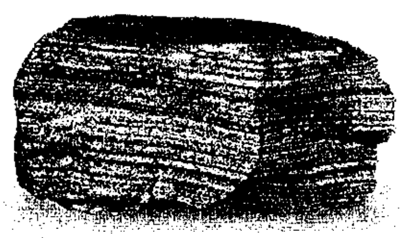


Figure 8 *This layered sandstone formed at the bottom of a river. The sediments from which it is made were deposited in layers.*

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SECTION REVIEW

1. List two ways rock is important to humans today.
2. What are the three major rock types, and how can they change from one type to another type?
3. How is lava different from magma?
4. **Comparing Concepts** Explain the difference between texture and composition.

SECTION 2

READING WARM-UP

Terms to Learn

intrusive
extrusive

What You'll Do

- Explain how the cooling rate of magma affects the properties of igneous rock.
- Distinguish between igneous rock that cools deep within the crust and igneous rock that cools at the surface.
- Identify common igneous rock formations.

Igneous Rock

The word *igneous* comes from the Latin word for "fire." Magma cools into various types of igneous rock depending on the composition of the magma and the amount of time it takes the magma to cool and solidify. Like all other rock, igneous rock is classified according to its composition and texture.

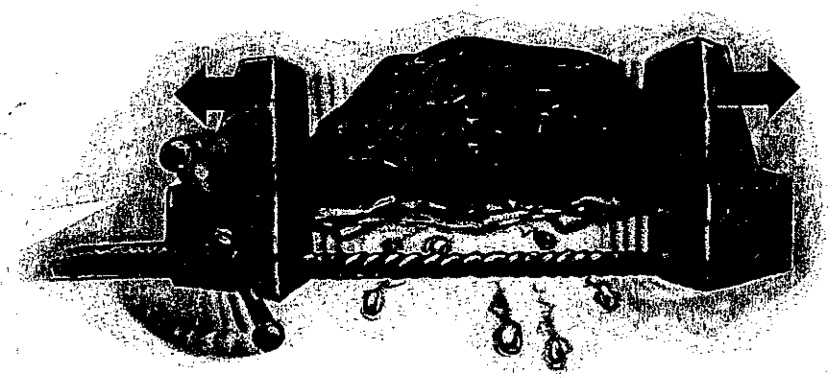
Origins of Igneous Rock

Magma and lava solidify in much the same way that water freezes. When magma or lava cools down enough, it solidifies, or "freezes," to form igneous rock. One difference between water freezing and magma freezing is that water freezes at 0°C and magma and lava freeze at between 700°C and 1,250°C.

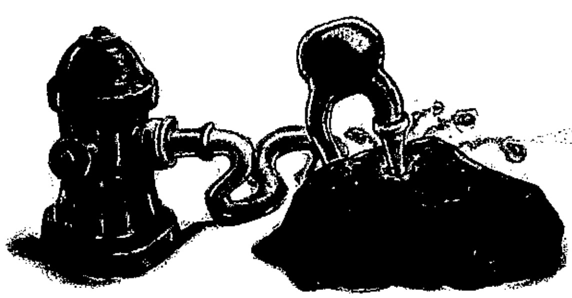
There are three ways magma can form: when rock is heated, when pressure is released, or when rock changes composition. To see how this can happen, follow along with **Figure 9.**

Figure 9 *There are three ways a rock can melt.*

Temperature An increase in temperature deep within the Earth's crust can cause the minerals in a rock to melt. Different minerals melt at different temperatures. So depending on how hot a rock gets, some of the minerals can melt while other minerals remain solid.



Pressure The high pressure deep within the Earth forces minerals to stay in the solid state, when otherwise they would melt from the intense heat. When hot rocks rise to shallow depths, the pressure is finally released and the minerals can melt.



Composition Sometimes fluids like water and carbon dioxide enter a rock that is close to its melting point. When these fluids combine with the rock, they can lower the melting point of the rock enough for it to melt and form magma.

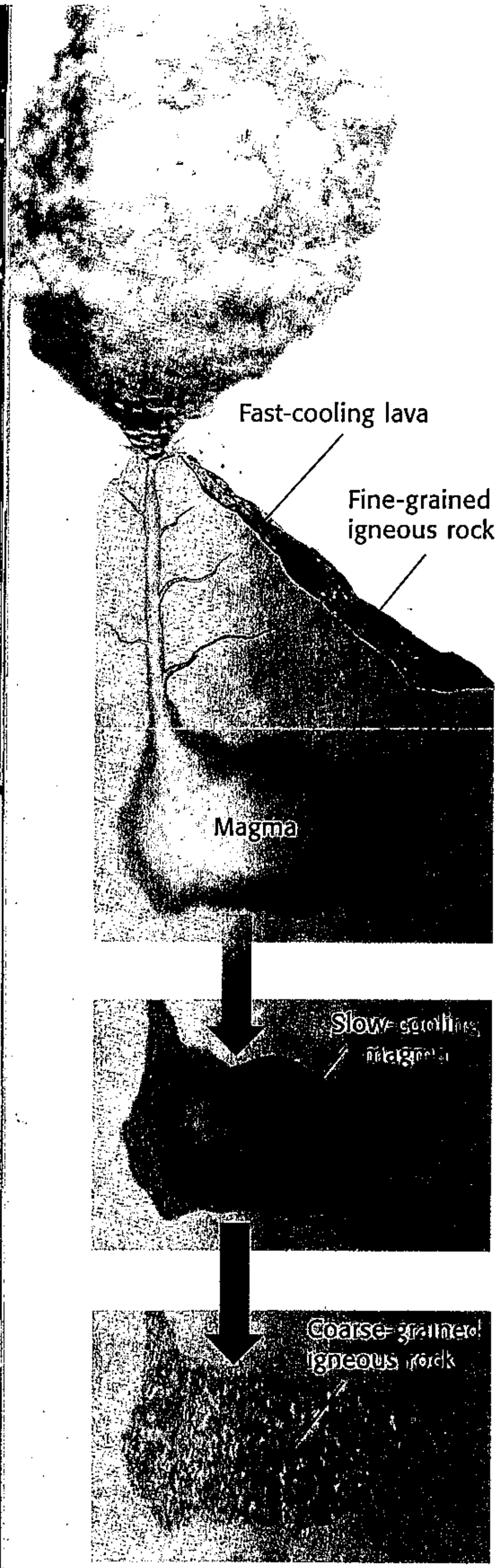


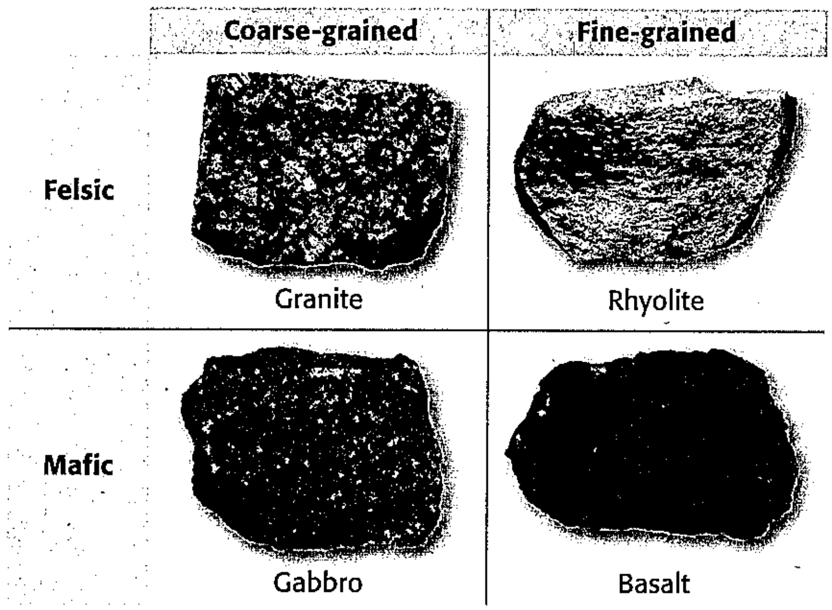
Figure 11 *The amount of time it takes for magma or lava to cool determines the texture of igneous rock.*

Composition and Texture of Igneous Rock

Look at the rocks in **Figure 10.** All of these are igneous rocks, even though they look very different from one another. These rocks differ from one another in what they are made of and how fast they cooled.

The light-colored rocks are not only lighter in color but also less dense. They are rich in elements such as silicon, aluminum, sodium, and potassium. These lightweight rocks are called *felsic.* The darker rocks are denser than the felsic rocks. These rocks are rich in iron, magnesium, and calcium and are called *mafic.*

Figure 10 *Light-colored igneous rock generally has a felsic composition. Dark-colored igneous rock generally has a mafic composition.*



Now look at **Figure 11.** This illustration shows what happens to magma when it cools at different rates. The longer it takes for the magma or lava to cool, the more time mineral crystals have to grow. And the more time the crystals have to grow, the coarser the texture of the resulting igneous rock.

Self-Check

Rank the rocks shown in Figure 10 by how fast they cooled. Hint: Pay attention to their texture. *(See page 216 to check your answer.)*

Igneous Rock Formations

You have probably seen igneous rock formations that were caused by lava cooling on the Earth's surface. But not all magma reaches the surface. Some magma cools and solidifies deep within the Earth's crust.

Intrusive Igneous Rock When magma cools beneath the Earth's surface, the resulting rock is called **intrusive.** Intrusive rock usually has a coarse-grained texture. This is because it is well insulated by the surrounding rock and thus cools very slowly.

Intrusive rock formations are named for their size and the way in which they intrude, or push into, the surrounding rock. *Plutons* are large, balloon-shaped intrusive formations that result when magma cools at great depths. **Figure 12** shows an example of an intrusive formation that has been exposed on the Earth's surface. Some common intrusive rock formations are shown in **Figure 13.**

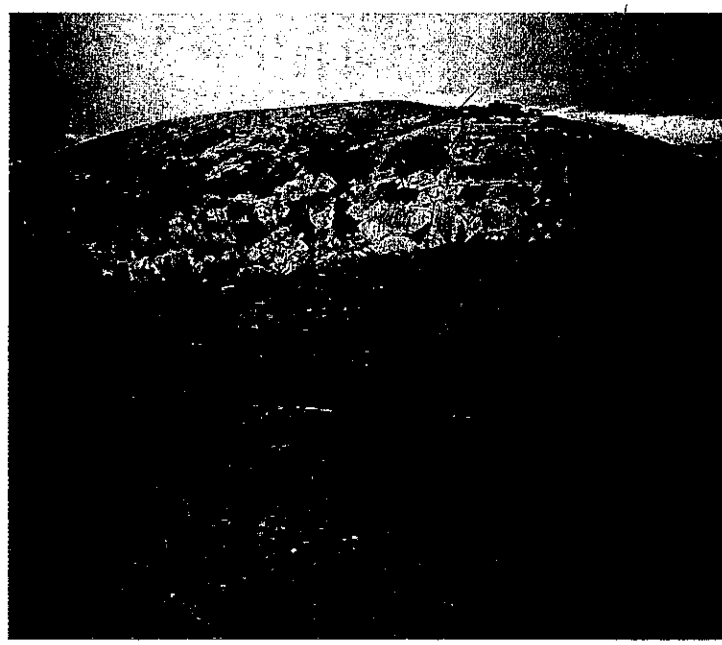


Figure 12 *Enchanted Rock, near Llano, Texas, is an exposed pluton made of granite.*

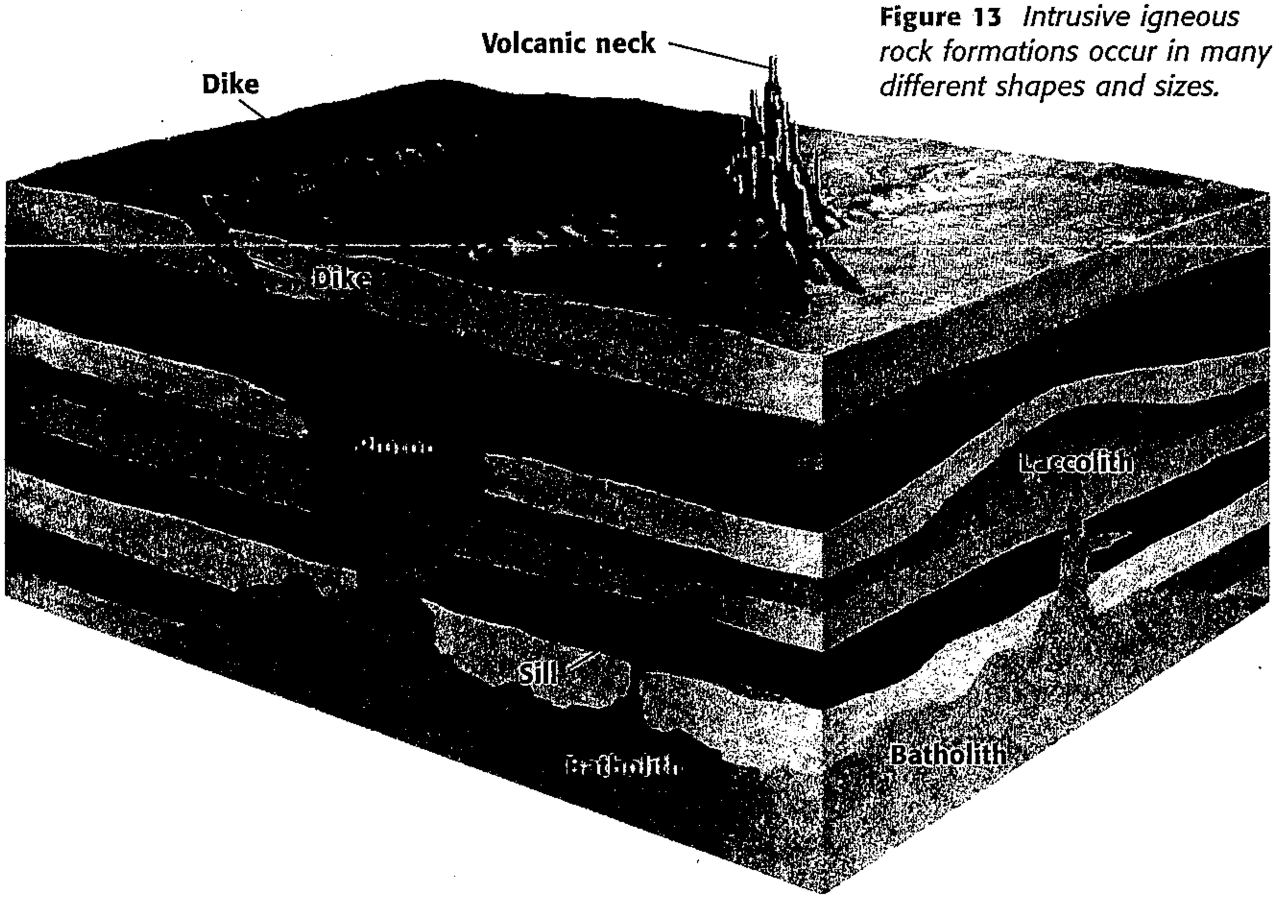
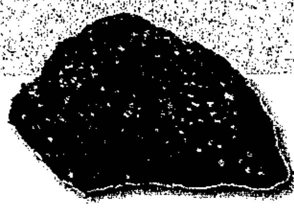


Figure 13 *Intrusive igneous rock formations occur in many different shapes and sizes.*

BRAIN FOOD

Violent volcanic eruptions sometimes produce a porous rock called pumice. Pumice is full of small holes once filled with trapped gases. Depending on how much space is taken up by these holes, some types of pumice can even float!



Extrusive Igneous Rock Igneous rock that forms on the Earth's surface is called **extrusive.** Most volcanic rock is extrusive. Extrusive rock cools quickly on the surface and contains either very small crystals or none at all.

When lava erupts from a volcano, a formation called a *lava flow* is made. You can see an active lava flow in **Figure 14.** But lava does not always come from volcanoes. Sometimes lava erupts from long cracks in the Earth's surface called *fissures.* When a large amount of lava flows out of a fissure, it can cover a vast area, forming a plain called a *lava plateau.* Pre-existing landforms are often buried by extrusive igneous rock formations.

Figure 14 *Below is an active lava flow. When exposed to surface conditions, lava quickly cools and solidifies, forming a fine-grained igneous rock.*

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SECTION REVIEW

1. What two properties are used to classify igneous rock?
2. How does the cooling rate of lava or magma affect the texture of an igneous rock?
3. **Interpreting Illustrations** Use the diagram in Figure 13 to compare a sill with a dike. What makes them different from each other?

SECTION 3

READING WARM-UP

Terms to Learn

strata
stratification

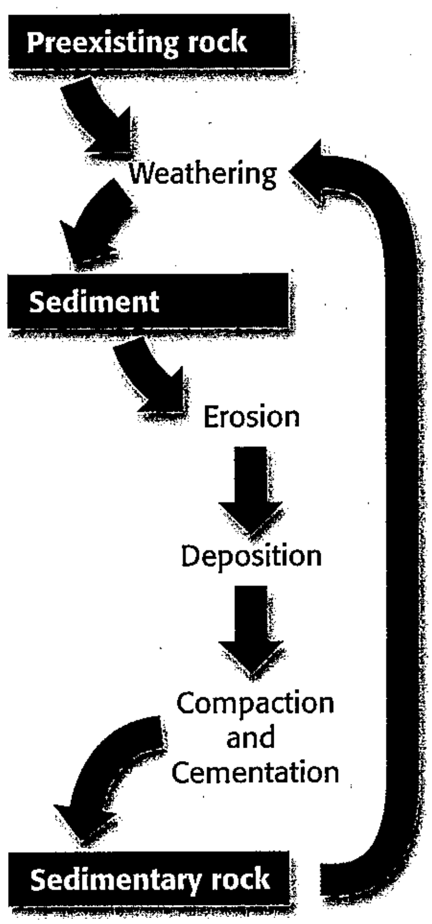
What You'll Do

- Describe how the three types of sedimentary rock form.
- Explain how sedimentary rocks record Earth's history.

Sedimentary Rock

Wind, water, ice, sunlight, and gravity all cause rock to *weather* into fragments. **Figure 15** shows how some sedimentary rocks form. Through the process of erosion, rock fragments, called sediment, are transported from one place to another. Eventually the sediment is deposited in layers. Sedimentary rock then forms as sediments become compacted and cemented together.

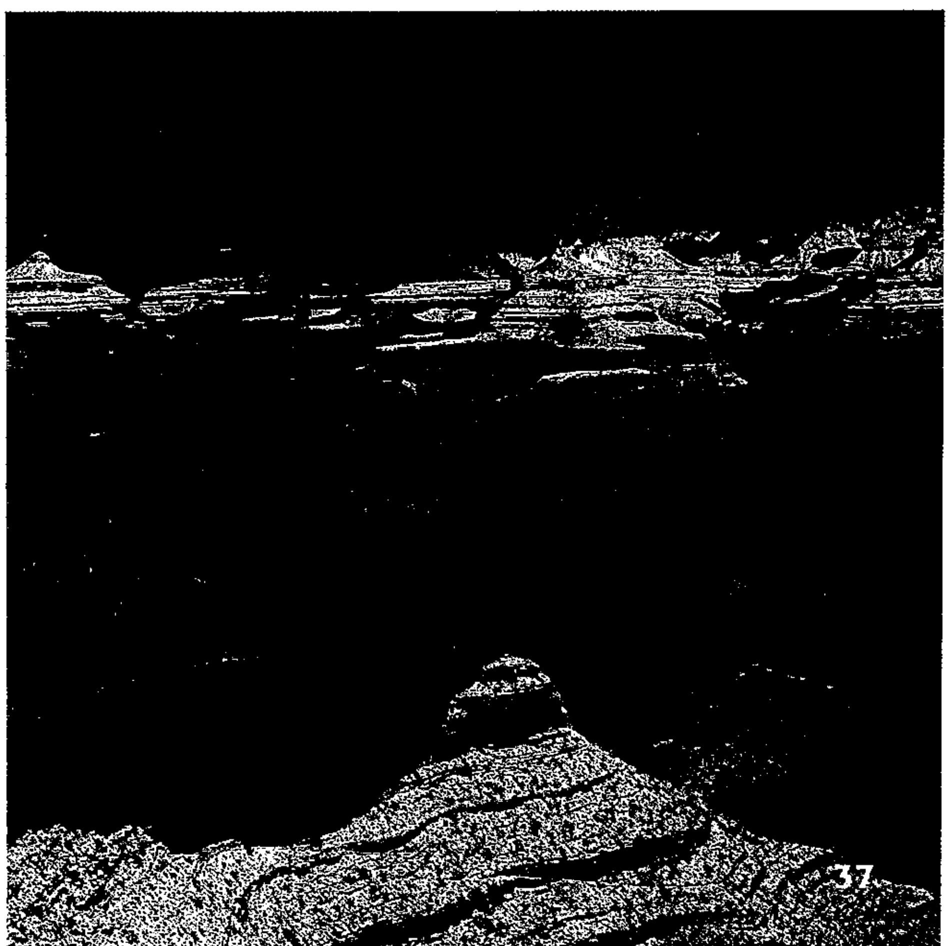
Figure 15 A Sedimentary Rock Cycle



Origins of Sedimentary Rock

As new layers of sediment are deposited, the layers eventually become compressed, or compacted. Dissolved minerals separate out of the water to form a natural glue that binds the sediments together into sedimentary rock. Sedimentary rock forms at or near the Earth's surface, without the heat and pressure involved in the formation of igneous and metamorphic rocks. The physical features of sedimentary rock tell part of its history. The most noticeable feature of sedimentary rock is its layers, or **strata.** Road cuts and construction zones are good places to observe sedimentary rock formations, and as you can see in **Figure 16,** canyons carved by rivers provide some spectacular views.

Figure 16 *Millions of years of erosion by the Colorado River have revealed the rock strata in the walls of the Grand Canyon.*



Composition of Sedimentary Rock

Sedimentary rock is also classified by the way it forms. There are three main categories of sedimentary rock—clastic, chemical, and organic. *Clastic* sedimentary rock forms when rock or mineral fragments, called clasts, stick together. *Chemical* sedimentary rock forms when minerals crystallize out of a solution, such as sea water, to become rock. *Organic* sedimentary rock forms from the remains of organisms.

Clastic Sedimentary Rock Clastic sedimentary rock is made of fragments of other rocks and minerals. As you can see in **Figure 17,** the size and shape of the rock fragments that make up clastic sedimentary rock influence their names.

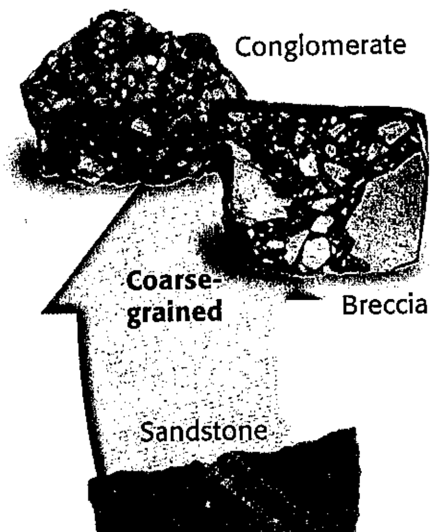
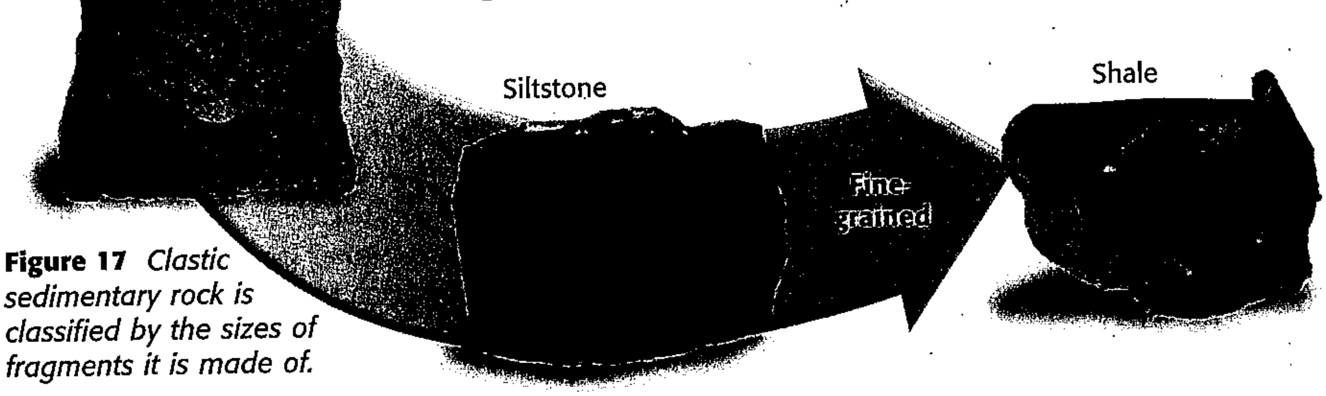



Figure 17 *Clastic sedimentary rock is classified by the sizes of fragments it is made of.*

Chemical Sedimentary Rock Chemical sedimentary rock forms from *solutions* of minerals and water. As rainwater slowly makes its way to the ocean, it dissolves some of the rock material it passes through. Some of this dissolved material eventually forms the minerals that make up chemical sedimentary rock. One type of chemical sedimentary rock, chemical limestone, is made of calcium carbonate ($CaCO_3$), or the mineral calcite. It forms when calcium and carbonate become so concentrated in the sea water that calcite crystallizes out of the sea water solution, as shown in **Figure 18.**

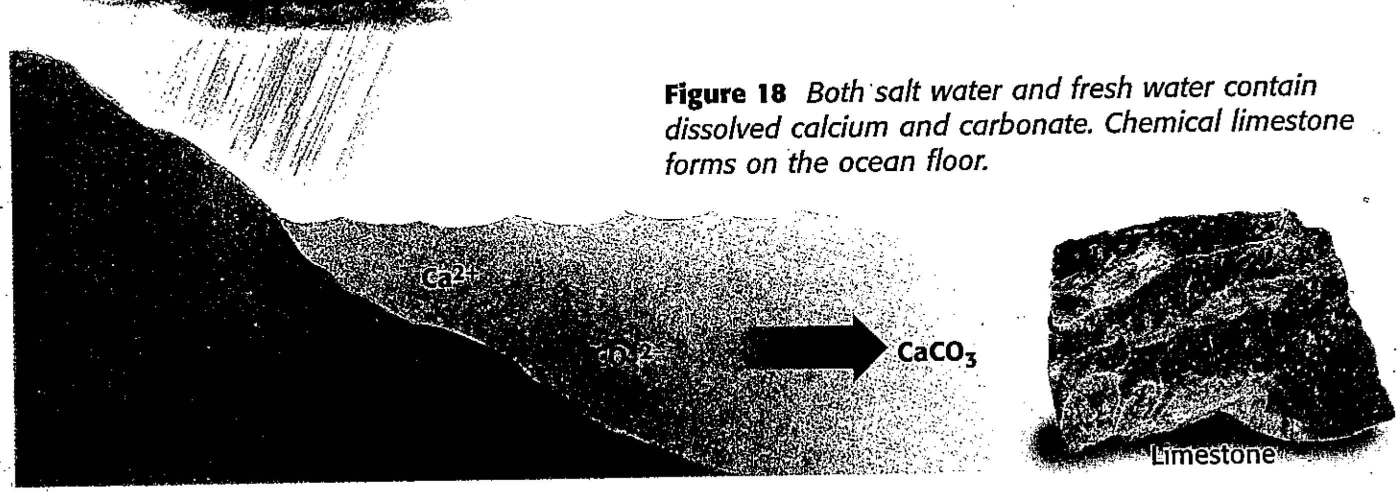



Figure 18 *Both salt water and fresh water contain dissolved calcium and carbonate. Chemical limestone forms on the ocean floor.*

Organic Sedimentary Rock

Most limestone forms from the remains of animals that once lived in the ocean. This organic material consists of shells or skeletons, which are made of calcium carbonate that the animals get from sea water.

For example, some limestone is made of the skeletons of tiny organisms called coral. Coral are very small, but they live in huge colonies, as shown in **Figure 19.** Over time, the remains of these sea animals accumulate on the ocean floor. These animal remains eventually become cemented together to form *fossiliferous* (FAHS uhl IF uhr uhs) *limestone.*

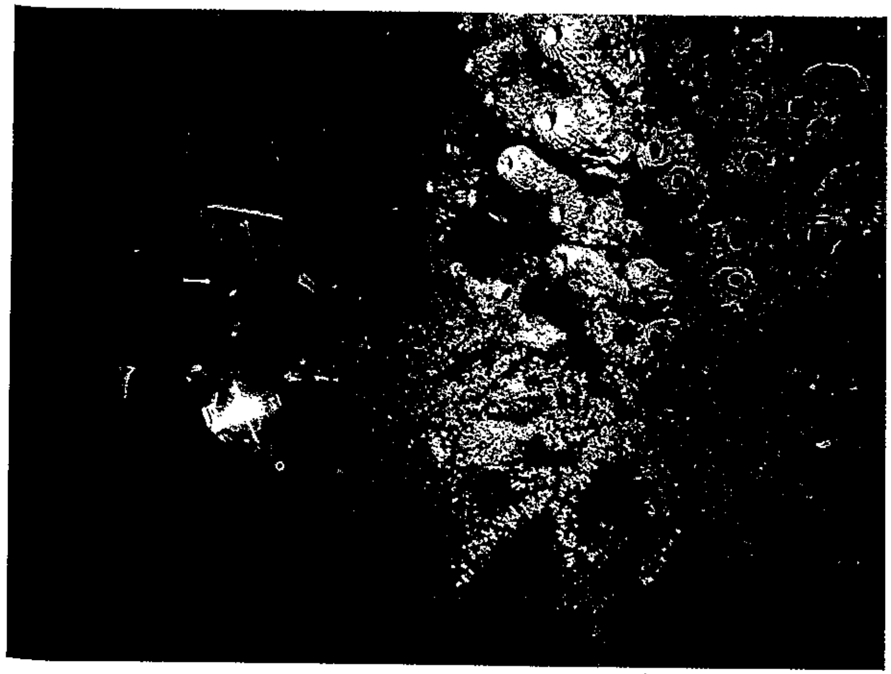


Figure 19 *Sea animals called coral create huge deposits of limestone. As they die, their skeletons accumulate on the ocean floor.*

Fossils are the remains or traces of plants and animals that have been preserved in sedimentary rock. Fossils have given us enormous amounts of information about ancient life-forms and how they lived. Most fossils come from animals that lived in the oceans. Another type of organic limestone, shown in **Figure 20,** forms from organisms that leave their shells in the mud on the ocean floor.

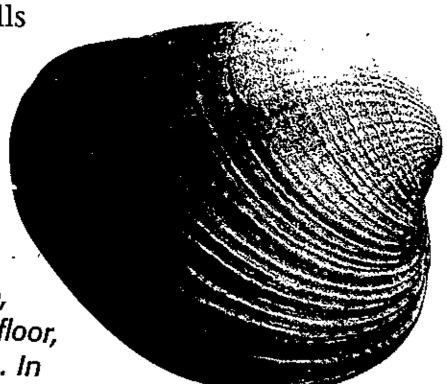
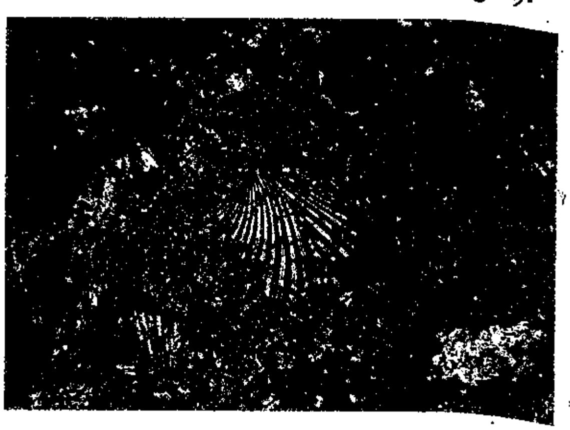
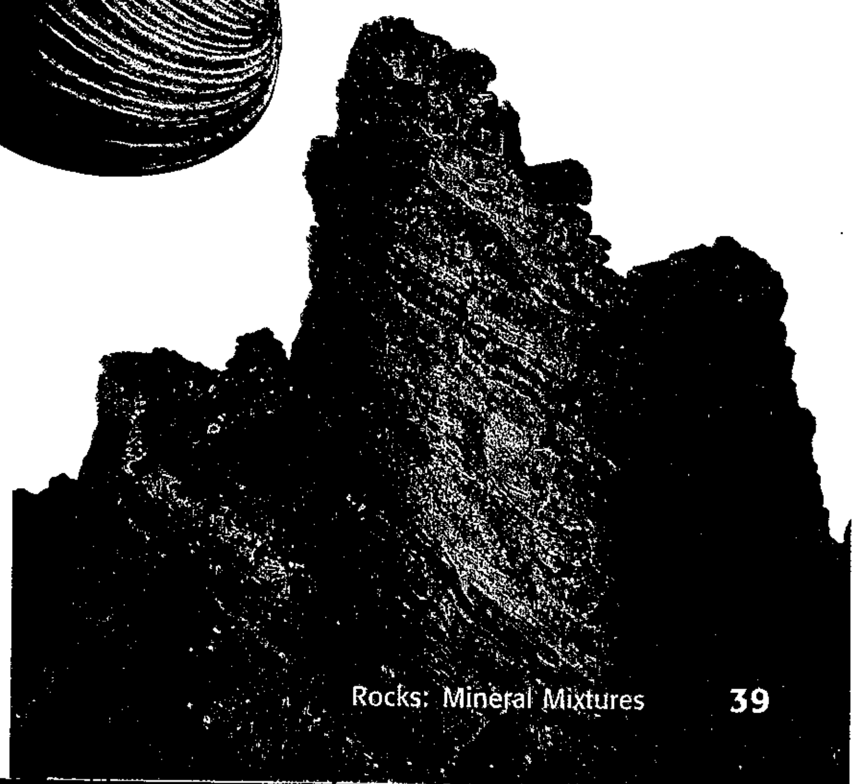


Figure 20 *Shellfish, such as clams (above right), get the calcium for their shells from sea water. When these organisms die, their shells collect on the ocean floor, eventually becoming rock (below). In time, huge rock formations result (right).*





Sedimentary Rock Structures

Many sedimentary rock features can tell you about the way the rock formed. The most characteristic feature of sedimentary rock is **stratification,** or layering. Strata differ from one another depending on the kind, size, and color of their sediment. The rate of deposition can also affect the thickness of the layers. Sedimentary rocks sometimes record the motion of wind and water waves on lakes, seas, rivers, and sand dunes. Some of these features are shown in **Figures 21** and **22.**

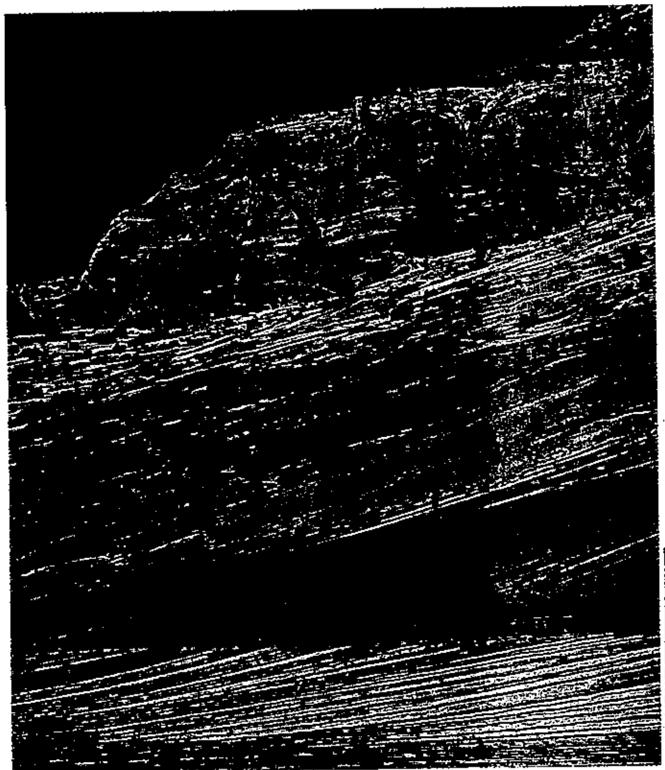


Figure 21 *Wind caused these slanted deposits, called* cross-beds, *but water can also cause them.*

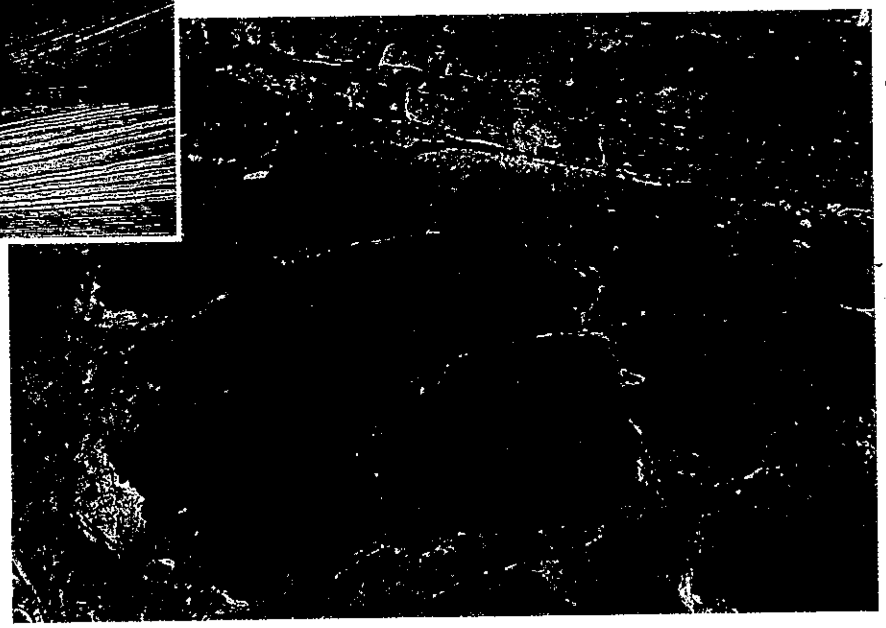


Figure 22 *These* ripple marks *were made by flowing water and were preserved when the sediments became sedimentary rock. Ripple marks can also form from the action of wind.*

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SECTION REVIEW

1. Describe the process by which clastic sedimentary rock forms.
2. List three sedimentary rock structures, and explain how they record geologic processes.
3. **Analyzing Relationships** Both clastic and chemical sedimentary rocks are classified according to texture and composition. Which property is more important for each sedimentary rock type? Explain.

SECTION 4

READING WARM-UP

Terms to Learn

foliated
nonfoliated

What You'll Do

- Describe two ways a rock can undergo metamorphism.
- Explain how the mineral composition of rocks changes as they undergo metamorphism.
- Describe the difference between foliated and nonfoliated metamorphic rock.

Metamorphic Rock

The word *metamorphic* comes from *meta,* meaning "changed," and *morphos,* meaning "shape." Remember, metamorphic rocks are those in which the structure, texture, or composition of the rock has changed. Rock can undergo metamorphism by heat or pressure acting alone or by a combination of the two. All three types of rock—igneous, sedimentary, and even metamorphic—can change into metamorphic rock.

Origins of Metamorphic Rock

The texture or mineral composition of a rock can change when its surroundings change. If the temperature or pressure of the new environment is different from the one the rock formed in, the rock will undergo metamorphism.

Most metamorphic change is caused by increased pressure that takes place at depths greater than 2 km. At depths greater than 16 km, the pressure can be more than 4,000 times the pressure of the atmosphere! Look at **Figure 23.** This rock, called garnet schist, formed at a depth of about 30 km. At this depth, some of the crystals the rock is made of change as a result of the extreme pressure. Other types of schist form at much shallower depths.

The temperature at which metamorphism occurs ranges from 50°C to 1,000°C. At temperatures higher than 1,000°C, most rocks will melt. Metamorphism does not melt rock—when rock melts, it becomes magma and then igneous rock. In **Figure 24** you can see that this rock was deformed by intense pressure.

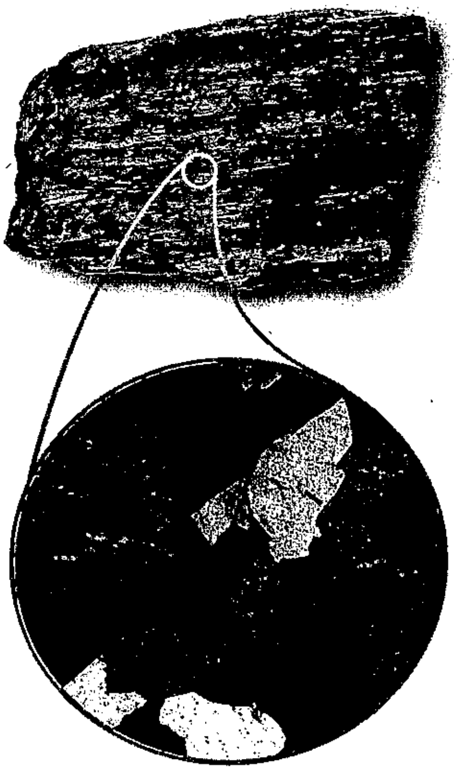


Figure 23 *At top is a metamorphic rock called garnet schist. At bottom is a microscopic view of a thin slice of a garnet schist.*

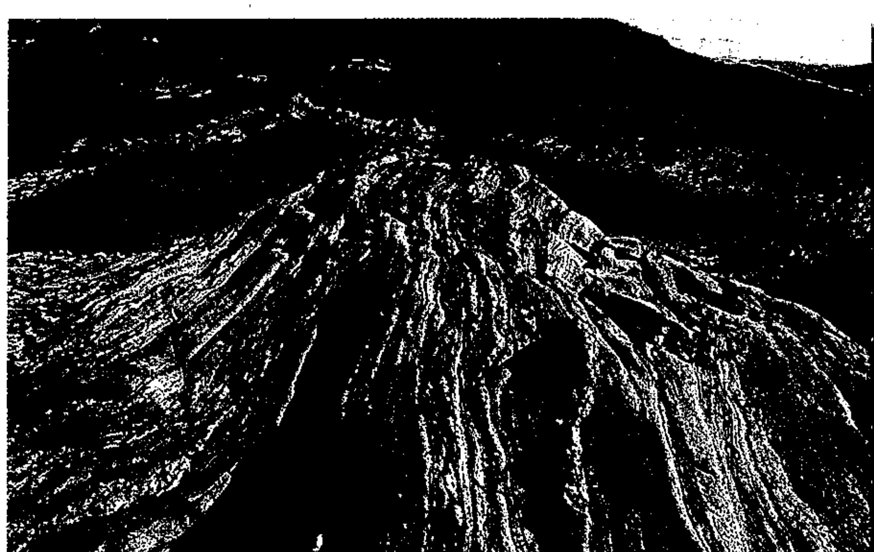


Figure 24 *In this outcrop, you can see an example of how sedimentary rock was deformed as it underwent metamorphism.*

QuickLab

Stretching Out

1. Draw your version of a granite rock on a **piece of paper** with a **black-ink pen.** Be sure to include the outline of the rock, and fill it in with different crystal shapes.
2. Mash some **plastic play putty** over the "granite," and slowly peel it off.
3. After making sure that the outline of your "granite" has been transferred to the putty, push and pull on the putty. What happened to the "crystals"? What happened to the "granite"?

TRY at HOME

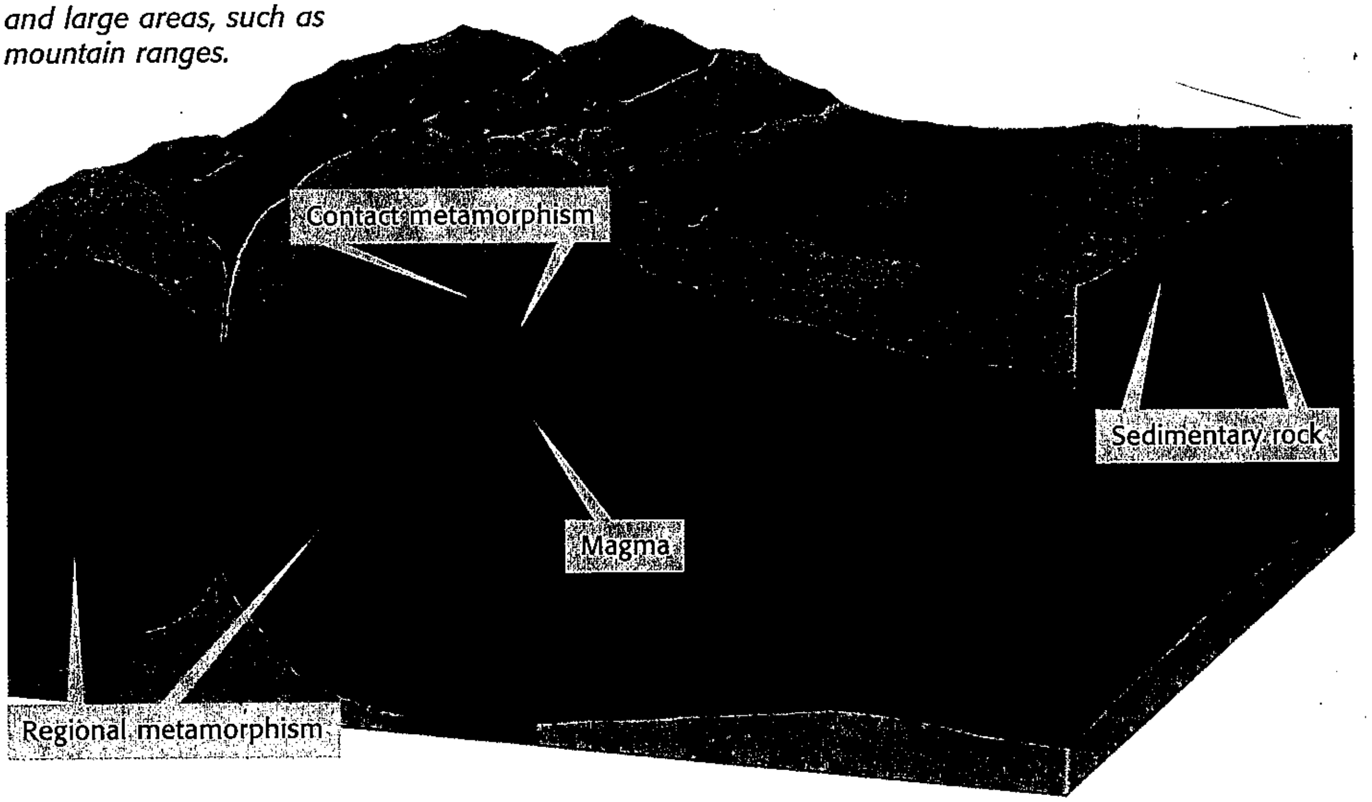
Contact Metamorphism One way rock can undergo metamorphism is by coming into contact with magma. When magma moves through the crust, it heats the surrounding rock and "cooks" it. As a result, the magma changes some of the minerals in the surrounding rock into other minerals. The greatest change takes place where magma comes into direct contact with the surrounding rock. The effect of heat gradually lessens with distance from the magma. As you can see in **Figure 25,** *contact metamorphism* only happens next to igneous intrusions.

Regional Metamorphism When enormous pressure builds up in rock that is deeply buried under other rock formations, or when large pieces of the Earth's crust collide with each other, *regional metamorphism* occurs. The pressure and increased temperature that exist under these conditions cause rock to become deformed and chemically changed. This kind of metamorphic rock is underneath most continental rock formations.

Self-Check

How could a rock undergo both contact and regional metamorphism? *(See page 216 to check your answer.)*

Figure 25 *Metamorphism occurs over small areas, such as next to bodies of magma, and large areas, such as mountain ranges.*



Composition of Metamorphic Rock

When conditions within the Earth's crust change because of collisions between continents or the intrusion of magma, the temperature and pressure of the existing rock change. Minerals that were present in the rock when it formed may no longer be stable in the new environment. The original minerals change into minerals that are more stable in the new temperature and pressure conditions. Look at **Figure 26** to see an example of how this happens.

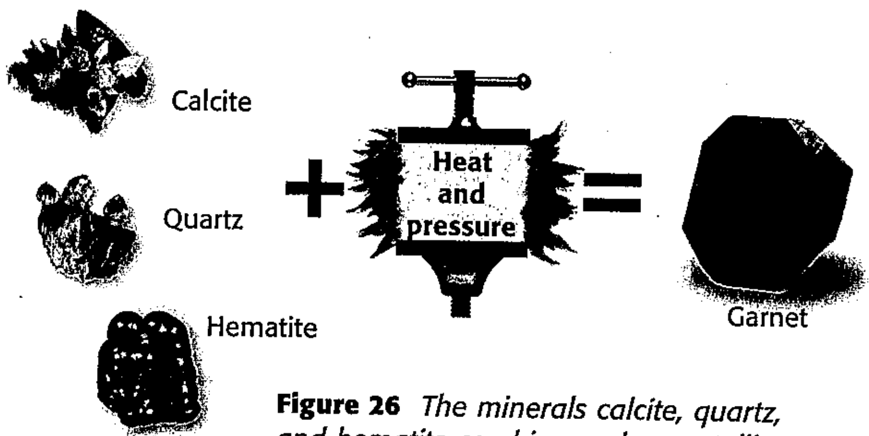
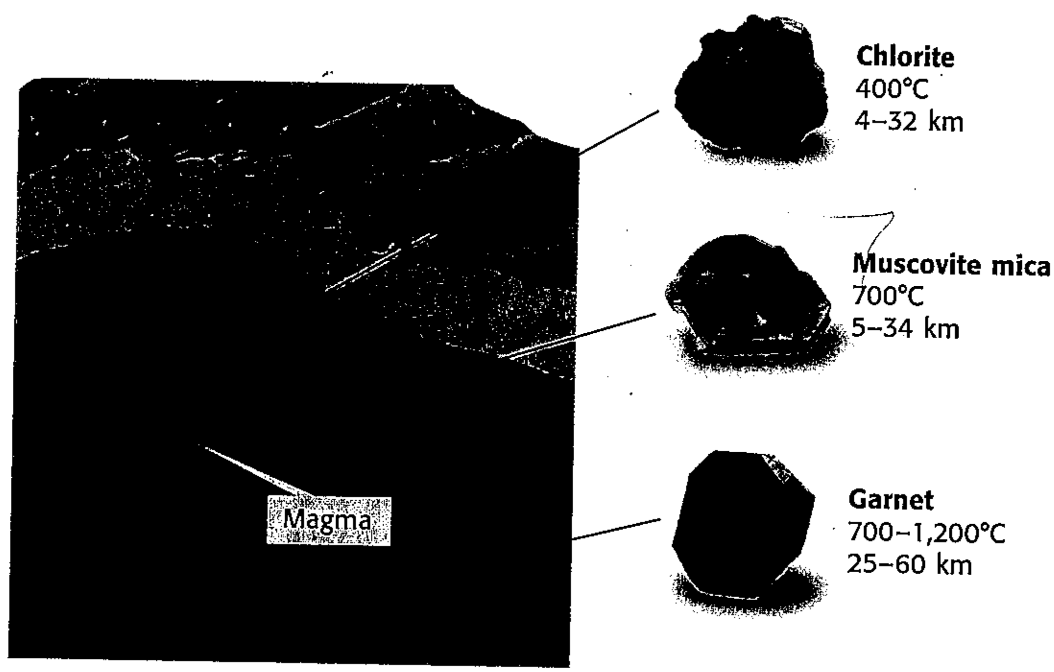


Figure 26 *The minerals calcite, quartz, and hematite combine and recrystallize to form the metamorphic mineral garnet.*

Many of these new minerals occur only in metamorphic rock. As shown in **Figure 27,** some metamorphic minerals form only within a specific range of temperature and pressure conditions. When scientists observe these metamorphic minerals in a rock, they can estimate the temperature and depth (pressure) at which recently exposed rock underwent metamorphism.

Figure 27 *Scientists can understand a metamorphic rock's history by observing the minerals it contains. For example, metamorphic rock containing garnet formed at a greater depth than one that contains only chlorite.*



Activity

Did you know that you have a birthstone? Birthstones are gemstones, or mineral crystals. For each month of the year, there are one or two different birthstones. Find out which birthstone or birthstones you have by doing research in your school library or on the Internet. The names of birthstones are not usually the same as their actual mineral names. In what kind of rock would you likely find your birthstone? Why?

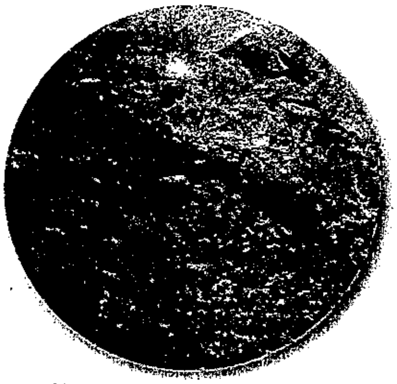
Textures of Metamorphic Rock

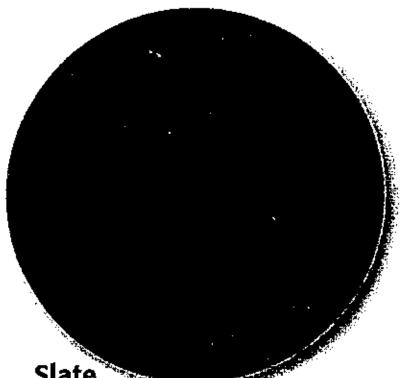
As you know, texture helps to classify igneous and sedimentary rock. The same is true of metamorphic rock. All metamorphic rock has one of two textures—*foliated* or *nonfoliated.* **Foliated** metamorphic rock consists of minerals that are aligned and look almost like pages in a book. **Nonfoliated** metamorphic rock does not appear to have any regular pattern. Let's take a closer look at each of these types of metamorphic rock to find out how they form.

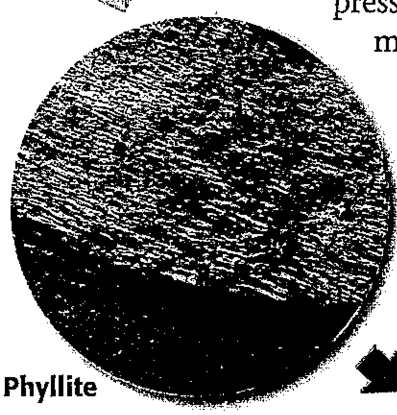
Foliated Metamorphic Rock Foliated metamorphic rock contains mineral grains that are aligned by pressure. Strongly foliated rocks usually contain flat minerals, like biotite mica. Look at **Figure 28.** Shale consists of layers of clay minerals. When subjected to slight heat and pressure, the clay minerals change into mica minerals and the shale becomes a fine-grained, foliated metamorphic rock called slate.

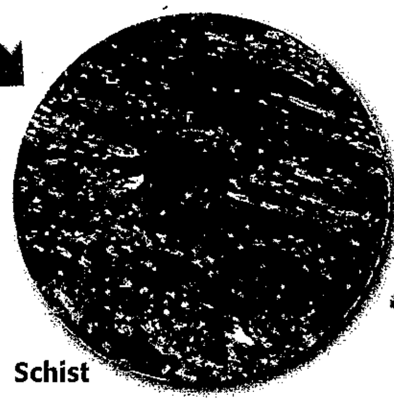
Metamorphic rocks can become other metamorphic rocks if the environment changes again. With additional heat and pressure, slate can change into phyllite, another metamorphic rock. When phyllite is exposed to additional heat and pressure, it can change into a metamorphic rock called schist.

As the degree of metamorphism increases, the arrangement of minerals in the rock changes. With additional heat and pressure, coarse-grained minerals separate into bands in a metamorphic rock called *gneiss* (pronounced "nice").









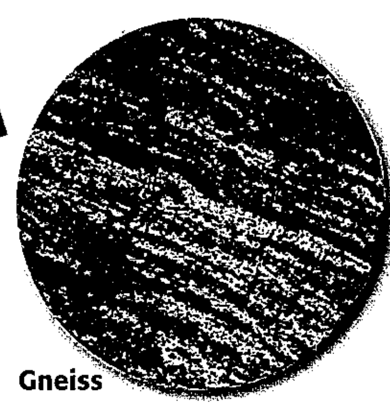


Figure 28 *The effects of metamorphism depend on the heat and pressure applied to the rock. Here you can see what happens to shale when it is exposed to more and more heat and pressure.*

LabBook

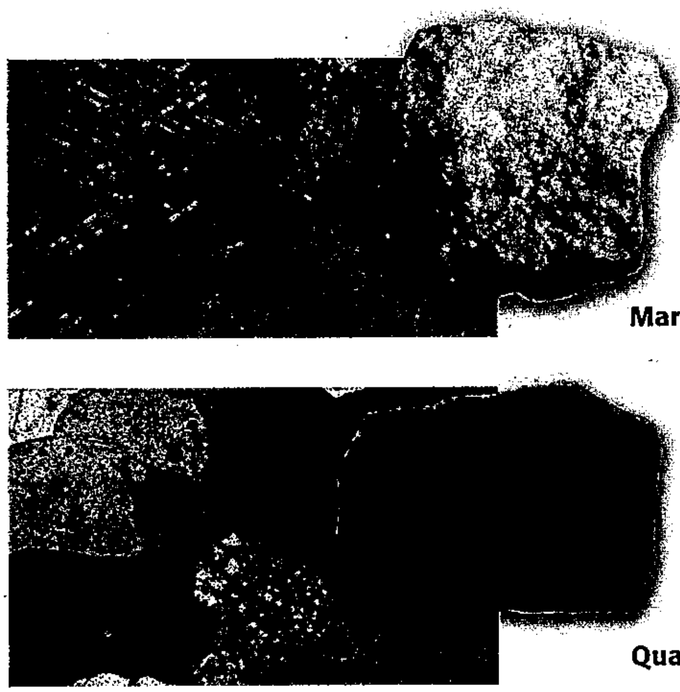
Wouldn't it be "gneiss" to make your own foliated rock? Turn to page 181 in your LabBook to find out how.

Nonfoliated Metamorphic Rock Nonfoliated metamorphic rocks are shown in **Figure 29.** Do you notice anything missing? The lack of aligned mineral grains makes them nonfoliated. They are rocks commonly made of only one, or just a few, minerals.

Sandstone is a sedimentary rock made of distinct quartz sand grains. But when sandstone is subjected to the heat and pressure of metamorphism, the spaces between the sand grains disappear as they recrystallize, forming quartzite. Quartzite has a shiny, glittery appearance. It is still made of quartz, but the mineral grains are larger. When limestone undergoes metamorphism, the same process happens to the mineral calcite, and the limestone becomes marble. Marble has larger calcite crystals than limestone. You have probably seen marble in buildings and statues.

Biology CONNECTION

The term *metamorphosis* means "change in form." When certain animals undergo a dramatic change in the shape of their body, they are said to have undergone a metamorphosis. As part of their natural life cycle, moths and butterflies go through four stages of life. After they hatch from an egg, they are in the larval stage in the form of a caterpillar. In the next stage they build a cocoon or become a chrysalis. This is called the pupal stage. They finally emerge into the adult stage of their life, complete with wings, antennae, and legs!



Marble

Quartzite

Figure 29 *Marble and quartzite are nonfoliated metamorphic rocks. As you can see in the microscopic views, none of the mineral crystals are aligned.*

SECTION REVIEW

1. What environmental factors cause rock to undergo metamorphism?
2. What is the difference between foliated and nonfoliated metamorphic rock?
3. **Making Inferences** If you had two metamorphic rocks, one with garnet crystals and the other with chlorite crystals, which one would have formed at a deeper level in the Earth's crust? Explain.

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