10.4 Metamorphic Rock

The changing of one type of rock to another by heat, pressure, and chemical processes is called **metamorphism.** Most metamorphic rock forms deep beneath the surface of the earth. All metamorphic rock is formed from existing igneous, sedimentary, or metamorphic rock.

Section Objectives

- **Distinguish between regional and contact metamorphism.**
- **Distinguish between foliated and unfoliated metamorphic rocks and give an example of each.**

Formation of Metamorphic Rocks

During metamorphism, heat, pressure, and hot fluids can cause certain minerals to change into other chemicals. Minerals may also change in size or shape or separate into parallel bands that give the rock a layered appearance. Hot fluids from magma may circulate through the rock, changing the mineral composition by dissolving some materials and adding others. All of these changes are part of metamorphism. Two types of metamorphism occur in the crust of the earth. One type of metamorphism occurs when rocks come into direct contact with magma. The other type occurs due to the heat and pressure created by tectonic activity.

When hot magma pushes through existing rock, the heat from the magma can change the structure and mineral composition of the surrounding rock. This type of metamorphism is called **contact metamorphism** because only rocks near or actually touching the hot magma are metamorphosed by its heat. Hot chemical fluids working through fractures may also cause changes in the surrounding rock during contact metamorphism.

Metamorphism sometimes occurs over an area of thousands of square kilometers during periods of tectonic activity. This type of metamorphism is called **regional metamorphism.** The movement of one tectonic plate against another creates tremendous heat and pressure in the rocks at the plate edges. This heat and pressure causes chemical changes in the minerals of the rock. Most metamorphic rock is formed by regional metamorphism. However, volcanism and magma movement often accompany tectonic activity. Thus, rocks formed by contact metamorphism often are found where regional metamorphism has occurred.

Classification of Metamorphic Rocks

Metamorphic rocks are classified according to their structure. Metamorphic rocks have either a **foliated** structure or an **unfoliated** structure. Rocks with a foliated structure have visible parallel bands. Rocks without visible bands are unfoliated.

Foliated Rocks

Foliated rocks can form in one of two ways. Extreme pressure may flatten the mineral crystals in the original rock and push them into parallel bands. Foliation also occurs as minerals of different densities separate into bands, producing a series of alternating dark and light bands.

INVESTIGATE!

To learn more about classifying rocks, try the In-Depth Investigation on pages 192–193.

Common metamorphic rocks with foliated structure include slate, schist, and gneiss. Slate, shown in Figure 10–11, is formed by pressure acting on the sedimentary rock shale, which contains clay minerals of a flaky consistency. The fine-grained minerals in slate are compressed into thin layers, which split easily into flat sheets. Flat sheets of slate are often used for building materials, such as roof tiles or walkway stones.

A greater amount of heat and pressure change slate into the coarser-grained metamorphic rock known as *schist,* shown in Figure 10–11. Deep underground, intense heat and pressure cause the elements in schist to change to very coarse-grained minerals separated into bands of different densities. This greatly metamorphosed rock with bands of light and dark minerals is *gneiss,* which you can also see in Figure 10–11.

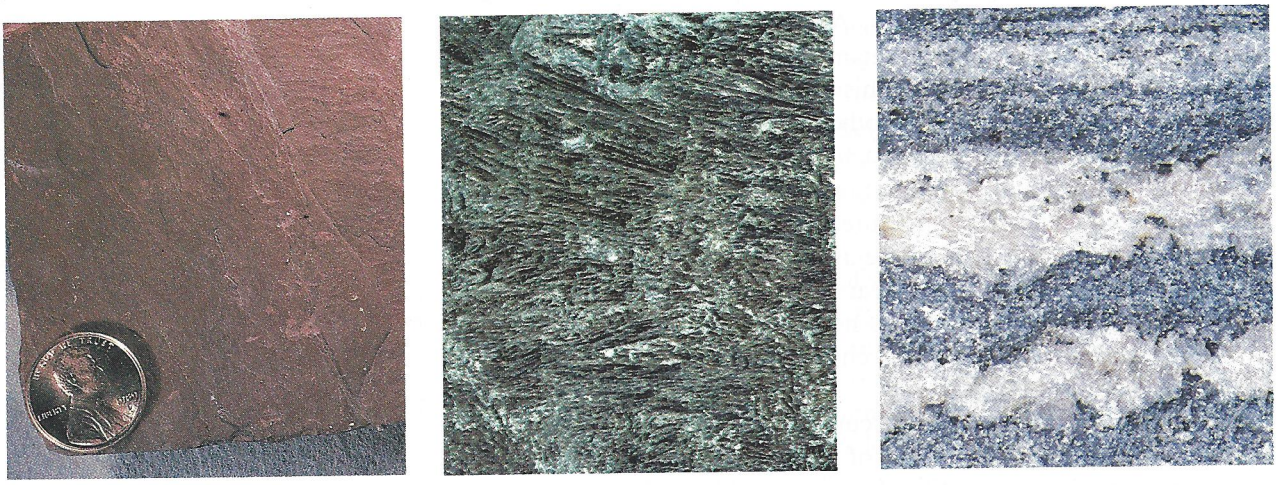


Figure 10–11. Increasing heat and pressure change slate (left) into the metamorphic rocks schist (center) and gneiss (right), which shows definite foliation.

Unfoliated Rocks

Unfoliated metamorphic rocks do not have bands of crystals. One common unfoliated rock is quartzite, the result of metamorphism of the sedimentary rock sandstone. During metamorphism, the sandstone is compacted so tightly that the spaces between the particles

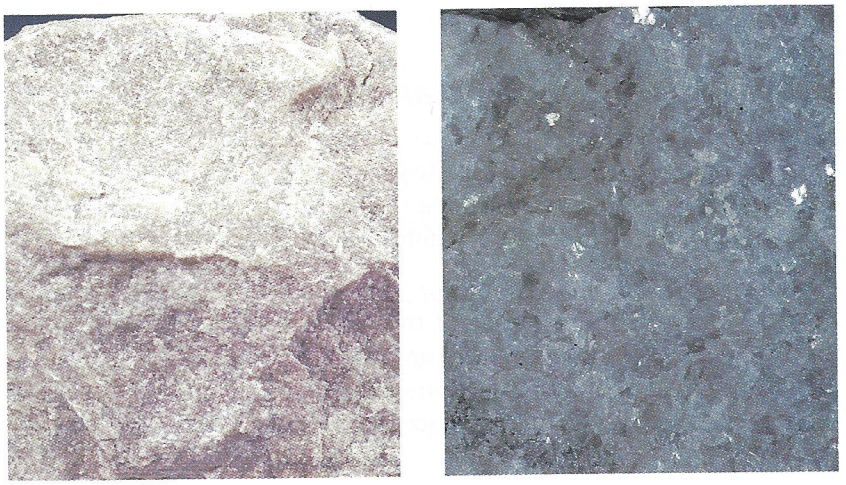


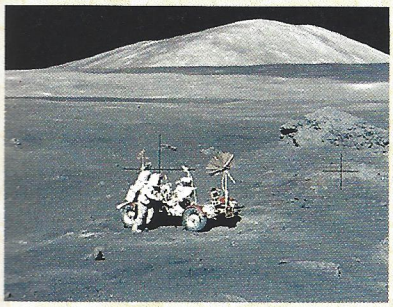
Figure 10–12. Unfoliated metamorphic rocks do not have defined bands of crystals, as shown by these samples of quartzite (left) and marble (right).

EarthBeat

Moon Rocks

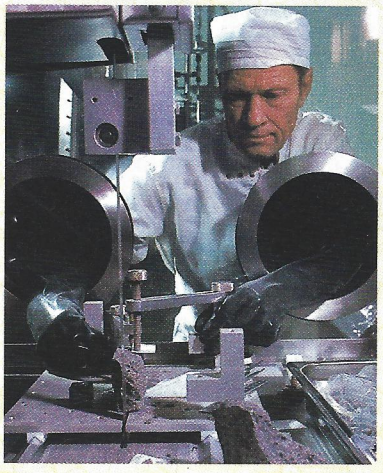
NASA's Apollo moon missions have brought almost 400 kg of lunar rocks back to earth. Soon after the *Apollo 11* astronauts set foot on the moon in 1969, they began to fill two boxes with brown and gray moon rocks. Later expeditions included vehicles that allowed a total of about 2,000 specimens to be collected.

Geologists discovered that moon rocks are similar to earth rocks in composition and in the way they were formed. Geologists use their knowledge of earth rocks to analyze the moon rocks and learn about the geological history of the moon.



Much of the rock matter brought back from the moon was in a powdery form. This pulverized rock, called *regolith,* covers much of the surface of the moon. Rock-dating methods indicate that regolith is among the oldest of the moon rocks. From this information, geologists concluded that during the first billion years of the moon's existence, a shower of meteorites pulverized most of the then-existing moon rocks.

The solid rocks on the moon are of two types—highland rocks and mare rocks. The highland rocks are igneous rocks high in plagioclase feldspar content.



Mare (Latin for "sea") refers to dark areas on the moon. Mare rock formed after meteor showers made craters on the moon. Lava from within the moon poured onto the crater floors, covering wide areas of the lunar surface. The lava then cooled and hardened into basalt about 4 billion years ago.

Is mare rock igneous, metamorphic, or sedimentary? Explain your answer.

disappear. Because quartzite is very hard and durable, it remains to form a large part of many hills and mountains after weaker rocks have been worn away. Marble, the beautiful building stone used for monuments and statues, is a metamorphic rock formed from the compression of limestone.

Section 10.4 Review

1. Which kind of metamorphism affects only those rocks near or actually touching the hot magma?
2. What is a foliated structure? In what two ways do rocks get a foliated structure?
3. What is an unfoliated structure? Explain how quartzite gets its unfoliated structure.
4. The metamorphic rock phyllite breaks into flat sheets. Is phyllite foliated or unfoliated? Explain your answer.