Points to Consider

- If you were interested in learning about Earth's history, which type of rocks would give you the most information?
- Could a younger layer of sedimentary rock ever be found under an older layer? How do you think this could happen?
- Could a sedimentary rock form only by compaction from intense pressure?

4.4 Metamorphic Rocks

Lesson Objectives

- Describe how metamorphic rocks are formed.
- Describe the properties of some common metamorphic rocks.
- Relate some common uses of metamorphic rocks.

Introduction

In this lesson you will learn about metamorphic rocks, how they form, and some of their common uses. **Figure** 4.22 shows a large outcrop of metamorphic rocks. Notice the platy layers that run from left to right within the rock. It looks as though you could easily break off layers from the front surface of the outcrop. This layering is a result of the process of metamorphism. Metamorphism is the changing of rocks by heat and pressure. During this process, rocks change either physically and/or chemically. They change so much that they become an entirely new rock.

Metamorphism

Metamorphic rocks start off as igneous, sedimentary, or other metamorphic rocks. These rocks are changed when heat or pressure alters the existing rock's physical or chemical make up. One ways rocks may change during metamorphism is by rearrangement of their mineral crystals. When heat and pressure change the environment of a rock, the crystals may respond by rearranging their structure. They will form new minerals that are more **stable** in the new environment. Extreme pressure may also lead to the formation of **foliation**, or flat layers in rocks that form as the rocks are squeezed by pressure. Foliation normally forms when pressure was exerted on a rock from one direction. If pressure is exerted from all directions, then the rock usually does not show foliation.

There are two main types of metamorphism:

1. Contact metamorphism—occurs when magma contacts a rock, changing it by extreme heat (**Figure** 4.23).

Figure 4.22: The platy layers in this large outcrop of metamorphic rock show the effects of pressure on rocks during metamorphism.

2. Regional metamorphism—occurs when great masses of rock change over a wide area due to pressure deep within the earth or through extreme pressure from rock layers on top of it.

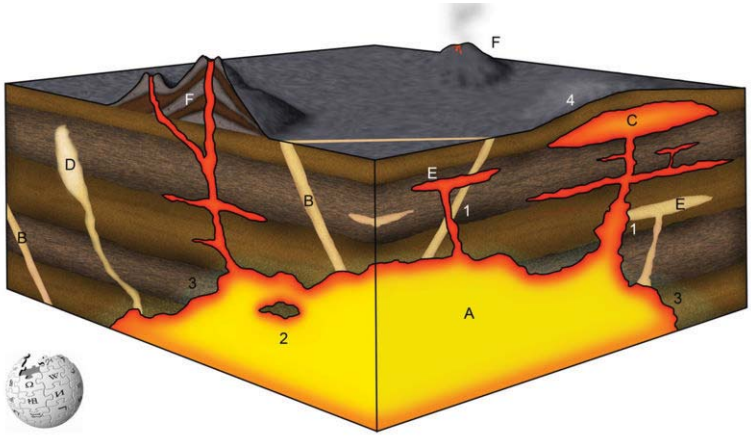

Figure 4.23: This diagram shows hot magma within the earth contacting various rock layers. This is an example of contact metamorphism.

It is important to note that metamorphism does not cause complete melting of the initial rock. It only causes changes to a rock by heat or pressure. The rearrangement of the mineral crystals is the most common way that we notice these changes. **Table** 4.3 shows some common metamorphic rocks and the original rocks that they come from.

Table 4.3: **Common Metamorphic Rocks**

Picture	Rock Name	Type of Metamorphic Rock	Comments
	Slate	Foliated	Metamorphism of shale
	Phyllite	Foliated	Metamorphism of slate, but under greater heat and pressure than slate
	Schist	Foliated	Often derived from metamorphism of claystone or shale; metamorphosed under more heat and pressure than phyllite
	Gneiss	Foliated	Metamorphism of various different rocks, under extreme conditions of heat and pressure
	Hornfels	Non-foliated	Contact metamorphism of various different rock types

Table 4.3: (continued)

Picture	Rock Name	Type of Metamorphic Rock	Comments
	Quartzite	Non-foliated	Metamorphism of sandstone
	Marble	Non-foliated	Metamorphism of limestone
	Metaconglomerate	Non-foliated	Metamorphism of conglomerate

Hornfels, with its alternating bands of dark and light crystals is a good example of how minerals rearrange themselves during metamorphism. In this case, the minerals separated by density and became banded. Gneiss forms by regional metamorphism from both high temperature and pressure.

Quartzite and marble are the most commonly used metamorphic rocks. They are frequently chosen for building materials and artwork. Marble is used for statues and decorative items like vases (**Figure** 4.24). Ground up marble is also a component of toothpaste, plastics, and paper. Quartzite is very hard and is often crushed and used in building railroad tracks (**Figure** 4.25). Schist and slate are sometimes used as building and landscape materials.

Lesson Summary

- Metamorphic rocks form when heat and pressure transform an existing rock into a new rock.
- Contact metamorphism occurs when hot magma transforms rock that it contacts.
- Regional metamorphism transforms large areas of existing rocks under the tremendous heat and pressure created by tectonic forces.

Figure 4.24: Marble is used for decorative items and in art.

Figure 4.25: Crushed quartzite is sometimes placed under railroad tracks because it is very hard and durable.

Review Questions

1. Why do the minerals in a rock sometimes rearrange themselves when exposed to heat or pressure?
2. What is foliation in metamorphic rocks?
3. Describe the different conditions that lead to foliated versus non-foliated metamorphic rocks.
4. List and describe the two main types of metamorphism.
5. How can metamorphic rocks be a clue to how they were formed?
6. Suppose a phyllite sample was metamorphosed again. How might it look different after this second round of metamorphism.

Vocabulary

stable Steady and not likely to change significantly any more.

contact metamorphism Results from temperature increases when a body of magma contacts a cooler existing rock.

regional metamorphism Occurs when great masses of rock change over a wide area due to pressure.

foliation Property of some metamorphic rocks in which flat layers are formed; seen as evidence of squeezing by pressure.

Points to Consider

- What type of plate boundary would produce the most intense metamorphism of rock?
- Do you think new minerals could form when an existing rock is metamorphosed?

Image Sources

(1) http://en.wikipedia.org/wiki/Diorite. GNU-FDL.

(2) http://en.wikipedia.org/wiki/Image:Perpendicularly-fused_Metamorphosed_Sedimentary_Layers.jpg. GNU-FDL.

(3) *The Rock Cycle.*. GNU-FDL.

(4) http://en.wikipedia.org/wiki/Lava. GNU-FDL.