Section 3

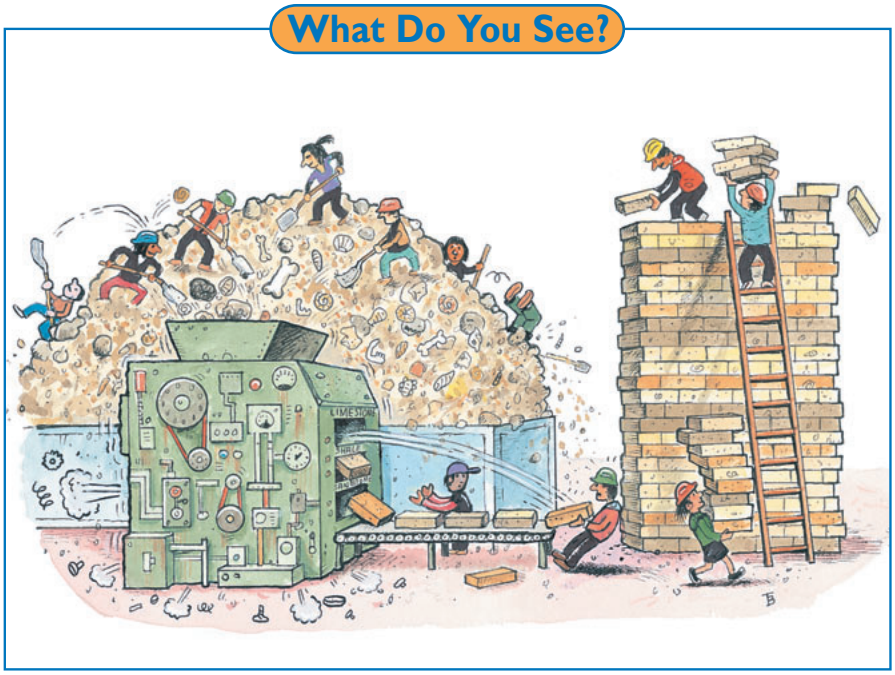
Sedimentary Rocks and the Geologic History of Your Community

Learning Outcomes

In this section, you will

- **Identify** and **classify** several sedimentary rocks.
- **Describe** how the three main types of sedimentary rocks form.
- **Determine** that sedimentary rocks are divided into groups based on how they form.
- **Infer** the environment in which sediment was deposited when you are given a sedimentary rock.
- **Recognize** that classification helps scientists organize the natural world into smaller, workable components.

What Do You See?



Think About It

Sedimentary rocks, which are made of sediment, cover about three fourths of Earth's land surface.

- **How does sediment "turn into" sedimentary rock?**
- **What are some of the distinguishing features of sedimentary rocks?**

Record your ideas about these questions in your *Geo* log. Include a quick sketch. Be prepared to discuss your responses with your small group and the class.

Investigate

In this *Investigate*, you will run models that show how sedimentary rocks are formed. You will then examine samples of actual sedimentary rocks. Finally, you will use a geologic map to identify and locate sedimentary rocks in your area.

Part A: Making Models of Sedimentary Rocks

Clean up spills immediately. Take care not to get sediments into your eyes. Wash your hands after you have completed this part of the *Investigate*.

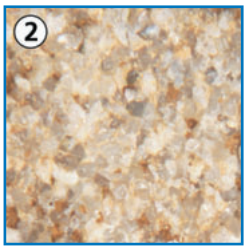
1. Mudstone
   - Spread some wet mud in a pan.
   - Set it out in the sunlight undisturbed until all the moisture has evaporated from the mud.
2. Rock salt
   - Add salt to a container of warm water until salt will no longer dissolve.
   - Pour a few millimeters of the water into a shallow plate, dish, or pan.
   - Let the water evaporate overnight. Do not disturb the setup until all the water has evaporated.
3. Sandstone
   - Make a mixture that is half water and half white craft glue.
   - Combine this mixture with a handful of sand in a small container. Pour off any excess liquid.
   - Line a small bowl or beaker with wax paper and pour in the sandy mixture.
   - Let it stand undisturbed until all the water has evaporated, which may take several days.
4. Conglomerate
   - Make a mixture that is half water and half white craft glue.
   - Combine this mixture with a handful of sand, gravel, and clay in a small container. Pour off any excess liquid.
   - Line a small bowl or beaker with wax paper and pour in the mixture.
   - Let it stand undisturbed until all the water has evaporated, which may take several days.
5. Sediment deposition
   - Pour a mixture of clay, silt, sand, and gravel into a clear, sturdy container filled with water.
   - Close and shake the container, then let it stand.
   - Observe the container over the next several days.

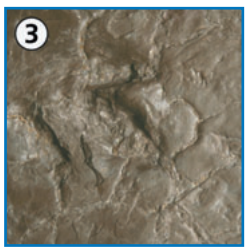
a) Describe what you observe immediately, by the end of class, and over the next several days.

6. Examine the rock samples that you made. These samples are models of sedimentary rocks.

a) Sketch and label a diagram of each sedimentary rock that you made.

Part B: Observing Sedimentary Rocks





1. Examine the photographs of the sedimentary rocks shown, or a set of sedimentary rock samples that you are provided. Common sedimentary rocks include limestone, dolomite, mudstone, sandstone, siltstone, shale, conglomerate, rock salt, and coal. Carefully observe and describe the rock samples.

a) Make a data table to record your descriptions of each sedimentary rock. Note any distinguishing features.

b) The three major sedimentary rock types are described below. Based on your descriptions, determine the sedimentary rock type of each rock sample.

Sedimentary Rock Type	Description
Clastic	Fragments of rocks and minerals that have been physically transported and deposited and then converted into rock.
Organic	Remains of plants and animals that have been converted into rock.
Chemical	Direct precipitation of minerals from a solution.

Part C: Sedimentary Rocks of Your Community

1. Examine the legend of a geologic map of your community, local area, or state. A geologic map of southern Florida is shown on the following page. A geologic map shows the distribution of *bedrock* at Earth's surface. The bedrock shown on the map might be exposed at the surface, or it could be covered by a thin layer of soil or very recent sediment. Every geologic map has a legend that shows the kinds of bedrock that are present in the map area. The legend also shows the rock bodies or *rock units* that these rocks belong to, and their geologic age. You will learn more about rock units in a later section of this chapter.

   Working with your group, interpret the data on the geologic map by answering the following questions:

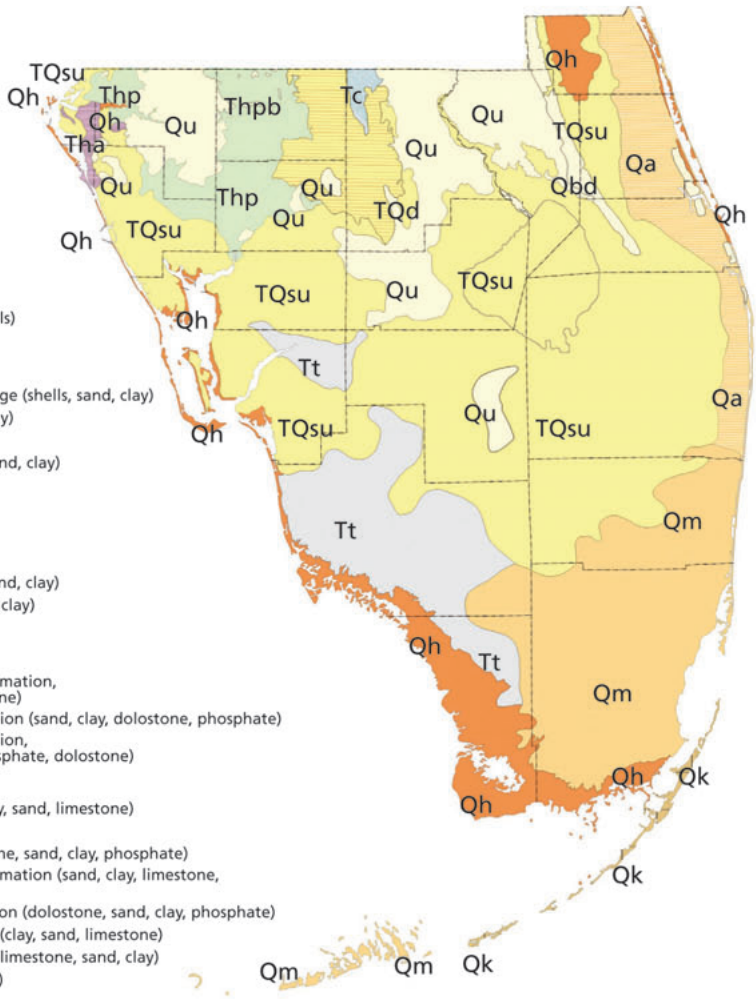
   a) Are any sedimentary rocks described in the legend? If so, write down the rock types, the names of the rock units they belong to, and their locations.

   b) What are the most common sedimentary rocks in your area?

   c) Which is the oldest sedimentary rock unit?

   d) Which is the youngest sedimentary rock unit?

Geologic Map of the State of Florida—Southern Peninsula



Quaternary Holocene
- Qh — Holocene sediments (sand, clay, organics)

Pleistocene/Holocene
- Qal — Alluvium (sand, clay, organics)
- Qbd — Beach Ridge and Dune (sand)
- Qu — Undifferentiated sediments (sand, clay, organics)

Pleistocene
- Qa — Anastasia Formation (limestone, coquina, sand)
- Qk — Key Largo Limestone (limestone)
- Qm — Miami Limestone (limestone, sand)
- Qrt — Trail Ridge sands (sand, heavy minerals)

Tertiary/Quaternary Pliocene/Pleistocene
- TQsu — Shelly sediments of Plio-Pleistocene age (shells, sand, clay)
- TQu — Undifferentiated sediments (sand, clay)
- TQd — Dunes (sand)
- TQuc — Reworked Cypresshead sediments (sand, clay)

Tertiary Pliocene
- Tc — Cypresshead Formation (sand, clay)
- Tci — Citronelle Formation (sand, clay)
- Tmc — Miccosukee Formation (sand, clay)
- Tic — Intracoastal Formation (limestone, sand, clay)
- Tt — Tamiami Formation (limestone, sand, clay)
- Tjb — Jackson Bluff Formation (clay, sand)

Miocene/Pliocene
- Thcc — Hawthorn Group, Coosawhatchie Formation, Charlton Member (clay, sand, limestone)
- Thp — Hawthorn Group, Peace River Formation (sand, clay, dolostone, phosphate)
- Thpb — Hawthorn Group, Peace River Formation, Bone Valley Member (sand, clay, phosphate, dolostone)

Miocene
- Trm — Residuum on Miocene sediments (clay, sand, limestone)
- Tab — Alum Bluff Group (clay, sand)
- Th — Hawthorn Group (dolostone, limestone, sand, clay, phosphate)
- Thc — Hawthorn Group, Coosawhatchie Formation (sand, clay, limestone, dolostone, phosphate)
- Ths — Hawthorn Group, Statenville Formation (dolostone, sand, clay, phosphate)
- Tht — Hawthorn Group, Torreya Formation (clay, sand, limestone)
- Tch — Chatahoochee Formaton (dolostone, limestone, sand, clay)
- Tsmk — St. Marks Formation (limestone, sand)

Oligocene/Miocene
- Tha — Hawthorn Group, Arcadia Formation (dolostone, limestone, sand, clay, phosphate)
- That — Hawthorn Group, Arcadia Formation, Tampa Member (limestone, dolostone, sand, clay)

Oligocene
- Tro — Residuum on Oligocene sediments (clay, sand, limestone)
- Ts — Suwannee Limestone (limestone)
- Tsm — Suwannee Limestone-Marianna Limestone undifferentiated (limestone)

Eocene
- Tre — Residuum on Eocene sediments (clay, sand, limestone)
- To — Ocala Limestone (limestone, dolostone)
- Tap — Avon Park Formation (limestone, dolostone)

Digging Deeper

SEDIMENTARY ROCKS IN EARTH'S CRUST

Distribution of Sedimentary Rock

In the *Investigate*, you looked at several models. You simulated ways in which sedimentary rocks form. You then looked at actual sedimentary rocks. Next, you used a geologic map of your region. You identified and located sedimentary rocks in your area.

Except for a thin layer of soil and very young **sediments** at Earth's surface, Earth's crust is made of solid **bedrock**. Sediments are loose materials that have not been formed into rocks. The crust consists of a very wide range of rock types. However, **sedimentary rocks** are by far the most common type in the upper crust. If you could somehow take off the thin layer of soil and sediment from the top of the crust and look at the exposed bedrock, about three fourths of it would be sedimentary rock. Over large areas of the continents, sedimentary rocks form layers, called **strata**. (See *Figure 1*.)

Figure 1 The Grand Canyon is a striking example of layering in sedimentary rocks.

Sedimentary layers may be found near an ocean. This means that the area was most likely below sea level in the past. Sedimentary layers may also be found in the middle of a continent. This may mean one of two things. The area might have been low relative to nearby mountain ranges. The sediments to cover the low area came from the mountains. The other possibility is that the area was covered by a shallow sea in the past.

Geo Words

sediment: solid fragments or particles that are transported and deposited by wind, water, or ice.

bedrock: solid rock that is connected continuously down into Earth's crust, rather than existing as separate pieces or masses surrounded by loose materials.

sedimentary rock: a rock, usually layered, that results from the consolidation or lithification of sediment, for example a clastic rock, such as sandstone, a chemical rock, such as rock salt, or an organic rock, such as coal.

strata (plural of stratum): layers of rock, visually separable from other layers above and below.

Geo Words

clastic sedimentary rock: a sedimentary rock made up mostly of fragments derived from preexisting rocks and transported mechanically to their places of deposition.

clast: an individual fragment of sediment produced by the physical disintegration of a larger rock mass.

precipitation: the process of forming solid mineral constituents from a solution by evaporation.

chemical sedimentary rock: a sedimentary rock formed by direct chemical precipitation of minerals from a solution.

Clastic Sedimentary Rocks

Clastic sedimentary rocks are made of fragments, called **clasts**. The clasts are eroded from other rocks. Conglomerate, sandstone, siltstone, mudstone, claystone, and shale are clastic sedimentary rocks. Clasts are classified according to their size. The smallest clasts are too small to see without a microscope. They are called clay. Clasts with sizes between clay and sand are called silt. Claystone consists of clay-sized particles. Siltstone consists of silt-sized particles. Mudstone consists of a mixture of silt-sized and clay-sized particles. When a claystone or mudstone breaks into small, flat chips, it is often called a shale. Sandstone is made of sand-sized particles. Conglomerate is made of gravel-sized particles. The size of the particles ranges from small pebbles to large boulders. The particle size usually reflects the strength of the medium that carried the sediment. Pieces of gravel are much larger than tiny clay particles. Therefore, faster flows of water are needed to move them from where they originate to where they are deposited.

Chemical Sedimentary Rocks

Sometimes, water cannot hold all of the material that is dissolved in it. When this occurs, some of the material comes out of the solution as solids. This process is called **precipitation**. It can happen when some or all of the water evaporates. It can also happen when the water is cooled. **Chemical sedimentary rocks** consist of materials that have precipitated from ocean water or lake water. (See *Figure 2*.)

Figure 2 Evaporation of rainwater produces salt flats, as in Death Valley.

In *Part A* of the *Investigate*, you ran a model of the deposition of a chemical sediment. You did this by allowing a saturated saltwater solution to dry. The salt crystals that formed precipitated out of the solution. Limestone is the most common chemical sedimentary rock. It consists of the mineral calcite. This is a calcium carbonate mineral with the formula $CaCO_3$. Some of the calcium carbonate is precipitated directly out of seawater. Some is precipitated by marine animals to make their shells. Dolomite is another common chemical sedimentary rock. It consists of the mineral dolomite. (The mineral and the rock have the same name.) Its chemical formula is $CaMg(CO_3)_2$. Gypsum ($CaSO_4 \cdot 2H_2O$)

and halite (NaCl) are also precipitated out of solution. They are also called rock salt. They form when solvent evaporates. The concentration of the solution then increases. At some point, the concentration is enough for the rock salt to precipitate out of solution. Areas with arid (dry) climates are where intense evaporation is most likely to occur.

Organic Sedimentary Rocks

Organic sedimentary rocks are made of organic materials. Coal is the best example. Coal forms when plants in swamps with a lot of vegetation die and are buried by the remains of later plants. The plant material becomes compacted. Over time, the weight of overlying sediment turns the vegetation into rock. The first material to form is called peat. Peat is shown in *Figure 3*. It has not yet been buried deeply. Peat is used by humans for fuel and for agriculture. With time and greater compaction, peat is converted to lignite ("brown coal"). With further compaction, bituminous coal ("soft coal") forms. Approximately 35 m of original plant matter is compacted to form 30 cm of bituminous coal. The most deeply buried coal is called anthracite ("hard coal").

Figure 3 In Ireland, peat harvested from bogs is often used as a source of fuel.

Sedimentary Environments

Sedimentary rocks are formed from sediments that are deposited in various places at Earth's surface. For example, limestone is usually deposited in a shallow ocean. Sandstone can also be deposited in a shallow ocean. However, it can form in a beach, desert, or river as well. Coal is usually formed in swamps. A sedimentary rock can therefore tell you something about the environment in the past. Each rock "tells a story" about the geologic environment in which it formed. However, it may not be easy to read that story.

Geo Words

organic sedimentary rock: a sedimentary rock consisting mainly of the remains of organisms.

Geo Words

compaction: the reduction in bulk volume or thickness of fine-grained sediments due to increasing weight of overlying material that is continually being deposited.

cementation: the process by which sediments are converted into rock by the precipitation of a mineral "cement" among the grains of sediment.

Checking Up

1. What does the presence of sedimentary rock layers reveal about sea level or past topography in a region?
2. Why is gravel more likely to be found on a river bottom than on a lake bottom?
3. The top of Mt. Everest is made of limestone. What does this suggest about how the topography of that area has changed through time?
4. Rock salt is mined throughout the Great Lakes region. What does this suggest about the past climate of this area?

Sedimentary Rocks and Climate

Sedimentary rocks can tell you about past climates. For example, sandstone that was deposited as desert sand dunes records a time when the area was dry. Protective vegetation would have been lacking. Limestones suggest deposition in warm, shallow oceans. Coal forms in tropical to subtropical climates. Ancient coal is found in Antarctica. This suggests that the climate has changed over time in the Antarctic.

How Sediment Becomes Rock

In many places, sediments are deposited for a long time. They become buried deep below Earth's surface. The pressure on the sediment increases. As a result, the particles are pressed together. This process is called **compaction.** Water solutions from deep in Earth can filter up through the pore spaces of the sediment. Materials precipitate from these solutions. They are deposited around the sediment particles. The material acts like a cement. This process is called **cementation.** Compaction and cementation cause the sediment to turn into a solid sedimentary rock. In *Part A* of the *Investigate*, your mixture of glue and water modeled the natural cementation process. Clastic sediments usually turn into solid rock deep under the surface. This usually occurs after many hundreds, or even thousands, of meters of burial. On the other hand, chemical sediments can become sedimentary rocks with very shallow burial. They can form from meters to a few hundreds of meters below the surface.

Classifying Sedimentary Rocks

Sediments are deposited in many different environments. As a result, there are many different types of sedimentary rocks. Scientists have developed a classification system for these rocks. They have grouped them by features they find important. It helps them discuss the different types of rocks with each other.

You looked at the sedimentary rocks in the *Investigate.* You thought about how to put them into groups. Each person that makes a classification system decides on which features to use. For example, you might have chosen color, texture, roundness of grains, or other features. Did you find differences among your group members or between groups? If you did, you experienced exactly what geologists did. In this section, you read that the rocks can be classified as clastic, chemical, and organic. It is about the simplest scheme that can be used. There are much more detailed systems. However, they all use two main features. These are the composition and size of the sediment particles.

Think About It Again

At the beginning of this section, you were asked the following:

- **How does sediment "turn into" sedimentary rock?**
- **What are some of the distinguishing features of sedimentary rocks?**

Record your ideas about these questions now. Refer to the three main types of sedimentary rocks in your answer.

Reflecting on the Section and the Challenge

Your exhibit should help visitors understand the processes that formed sedimentary rocks in your region. You might want to have people make models of sedimentary rocks as you did in the *Investigate*, or have them observe samples of the common sedimentary rocks in your region. They could then use a geologic map of your state to see where these rocks are located and how old they are. This information will help visitors to understand the geologic history of the local area and region.

Understanding and Applying

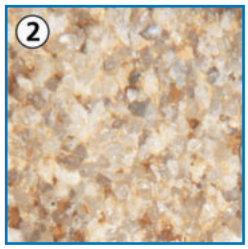
1. In your own words, explain how the three main types of sedimentary rocks form.
2. From your knowledge of sedimentary rocks, label the following interpretations of depositional environments as true or false. Explain your answers.
   a) Coal and peat form from the same material.
   b) Limestone indicates that a shallow sea once covered an area.
   c) The presence of sandstone indicates that the area was once a shoreline.
   d) Rock salt indicates that a region once had an arid climate.
   e) Claystone is deposited by fast-flowing streams.

3. Look at the three rock samples shown in the photographs or the rock samples provided to you by your teacher.

   a) What is the name of each of the sedimentary rocks?

   b) Describe a possible depositional environment in which each formed.

   c) How did the models you made help you identify these rocks?



4. ***Preparing for the Chapter Challenge***

   One strategy to engage visitors at your exhibit might be to have them take a short interactive quiz at a kiosk before and after they tour your exhibit. For example, you could have them identify the sedimentary rocks in your region. They could also be quizzed on the ages of the rocks. (You can use a geologic map of your state to find this information to make your quiz.) Your quiz could also have visitors match the type of environment in which each sedimentary rock might have formed with the type of rock. This evidence from the sedimentary record will help visitors understand how the geologic history of your region has changed over time.

Inquiring Further

1. **Sedimentary rocks and energy resources**

   What sedimentary environments lead to the formation of oil and natural gas? Investigate the types of rocks associated with the successful mining of oil and natural gas.

2. **Sedimentary rocks in the making**

   Where are Earth's largest sedimentary basins? How thick are the sediments in those basins? Where are some of the largest chemical sedimentary deposits forming today?