1.3.2 Sedimentary Rock

Unlike the earth's crust, which is dominated by igneous and metamorphic rock, the most common rock visible on the earth's surface is sedimentary rock. After igneous rock develops from cooled magma, it is often exposed to the atmosphere and hydrosphere. This exposure to wind and water causes fragments of the rock to loosen and break away into tiny particles called sediments. Sediments are particles of minerals, rock fragments, shells, leaves, and the remains of once-living things. Different sediments have different textures—from very coarse to very fine. Some examples of sediments include gravel, sand, silt, and mud.

Sediments form in a variety of ways. Water from rain or runoff soaks into pores of rocks. When the water freezes, the pores crack open and portions of the rock fall away, creating sediments. Acids dissolved in rainwater also break down rocks into tiny fragments. Another way that sediments form is when rocks are exposed to the heat of the sun, which causes rock molecules to expand and contract. This molecular movement can create cracks in rocks until at some point, fragments and particles completely separate from the original rock. Water, wind, or ice carry these fragments, along with organic sediments, away and deposit them. When sediments collect, sedimentary rock can form.

Sedimentary rock is rock formed from sediments that have been compacted and cemented together. The process that transforms layers of rock fragments into sedimentary rock is called lithification, which means "to turn into stone." Lithification occurs by two processes: compaction and cementation.

Many deposits of small pieces of earth collect on top of each other to form layers called strata. The weight of the upper layers

**TRY THIS**

**Shifting Sediments**

Fill a clear jar with sand, gravel, mud, large pebbles, and clay. Add 50 mL of Epsom salt. Add water until there is only about 5 cm of space left at the top. Place the lid on the jar and shake for several seconds. When all is thoroughly mixed, place the jar on a flat surface and allow it to sit undisturbed overnight. The next day, observe how the layers have settled. Carefully pour the water out and let the layers dry completely. The Epsom salt (magnesium and sulfur) acts as glue to hold the "rock" together.
puts tremendous pressure on the bottom layers, compressing the sediments together until the bottom layers slowly turn into hard rock. During this compaction, as the sediments are pushed together, inner pore spaces become smaller and some of the water is squeezed out. The remaining water surrounding the sediments can contain dissolved minerals, which later recrystallize as new minerals in the pore spaces.

Cementation occurs following compaction and recrystallization. In cementation, the crystals interlock and connect the sediment grains. This process essentially glues the sediments together. The resulting strata layers range in varying degrees of thickness and color, which helps to easily distinguish the incorporated sedimentary rock. This visible stratification, or layering, of sedimentary rock gives geologists clues about how rocks formed. Most sedimentary layers are deposited in a nearly horizontal position. However, there are times when scientists examine a rock layer that is folded or tilted. Scientists then assume this folding or tilting is a result of a disturbance in the earth’s crust.

Sedimentary rock is classified into three main groups: clastic, chemical, and carbonate, or organic. Geologists classify sedimentary rock depending on how it is formed. The most common sedimentary rock, **clastic rock** (from the Greek word *klastos*, meaning “broken into pieces”), is made of separate rock particles and fragments
that were eroded from an older rock. These fragments come together by wind, water, or ice to form a new rock by compaction and cementation.

Clastic sedimentary rock is further classified by the sediment size from which it forms. A conglomerate rock is a clastic rock composed of rounded, gravel-sized rock fragments usually larger than 2 mm in diameter. Conglomerate rock forms where sediments are deposited, such as at the mouths of rivers and along beaches. Individual rock fragments can be seen in conglomerate rock. These rock fragments are usually cemented together by tiny mineral particles that form what is called a clastic matrix.

Breccia is a type of clastic rock composed of sharp-cornered, angular fragments larger than 2 mm in diameter that are cemented together with carbonate, silica, or silt material. Breccia often forms at the base of a steep cliff where rockslides have occurred.

Sandstone is a clastic rock composed of rounded, sand-sized grains usually between 0.063 mm and 2 mm in diameter. This clastic rock is the second most common sedimentary rock. It comprises 10%–20% of the sedimentary rock in the earth’s crust. Sandstone has many pores through which water can easily move. One of the most common minerals in sandstone is quartz, which can comprise 90% of the rock.

Shale is a clastic rock that forms in flat layers composed of silt- and clay-sized grains smaller than 0.004 mm in diameter. These layers are brittle and can be easily broken apart into flat pieces. Many of the particles are so small that they are barely visible without a microscope. Some geologists chew the sediments to estimate the size of their particles. (Silt is gritty, and clay is smooth.) Shale is the most abundant sedimentary rock, accounting for roughly 70% of sedimentary rock. These clastic rocks are often found with layers of sandstone or limestone. They typically form in environments where mud, silts, and other sediments were deposited by gentle transporting water currents. These sediments are then compacted in areas such as the ocean floor, basins of shallow seas, and river floodplains.
Chemical sedimentary rock is divided into two groups: allochemicals and orthochemicals. Examples of allochemicals include some limestone and chert. Examples of orthochemicals include bedded deposits of halite, gypsum, anhydrite, and banded iron formations. These sedimentary rocks do not form from separate rock pieces. They are composed of minerals that were once dissolved in water. Their structure is made up of interlocking crystals that result in a small, fine grain. As the water evaporates, the minerals that are left behind build up into rock masses. For example, some chemical sedimentary rock forms when dissolved salts in a body of water are deposited and the water evaporates away. Rock salt and gypsum are two examples of chemical sedimentary rock.

Carbonate sedimentary rock is composed of organic materials from decaying organisms. Coal, for example, is an organic sedimentary rock made of carbon from ancient plant remains. Other carbonate sedimentary rock is composed of the skeletal remains of marine creatures. Given that the skeletons are mineral and not technically organic, they are sometimes termed *biochemical*.

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**Bible Connection**

The Importance of Salt
Salt is mentioned in at least 36 places in the Bible. It was crucial in ancient cultures as a seasoning, preservative, disinfectant, component of ceremonial offerings, or as a unit of exchange. Salt was a necessity of life, both literally and metaphorically. In Matthew 5, Jesus uses salt as a metaphor, suggesting the children of God should preserve themselves from impurities just as salt preserves food.

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**FYI**

Too Much Salt?
The Dead Sea in Israel is highly concentrated with various salts that allow individuals to easily float. On the western shore near Ein Gedi, one can find pebbles cemented with halite.

Dead Sea Composition

- 51% Magnesium chloride - MgCl₂
- 30% Sodium chloride - NaCl
- 14% Calcium chloride - CaCl₂
- 5% Potassium chloride - KCl

Composition of Most Oceans and Seas

- 97% Sodium chloride - NaCl
- 3% Other components

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An example of a biochemical rock is limestone, which forms from the mineral calcite. Limestone deposits often develop from the shells of clams, plankton, and other aquatic creatures. Chalk is a fine-grained limestone made of microscopic shells, fragments of larger shells, and calcite. It is soft enough to write with because chalk particles are tiny and rather loosely packed.

Some limestone is created entirely by chemical processes instead of organic processes. For example, as rainwater lands on the earth, it has the opportunity to enter caves through the cracks in rocks. The rainwater will then pass through organic material and incorporate carbon dioxide gas along the way, creating carbonic acid. This weak acid passes through joints and cracks in limestone. The mineral calcite is dissolved from the limestone rock. This process is what forms a cave. When the water that holds the dissolved rock is exposed to the air in the cave, it releases the carbon dioxide gas, much like a fizzy drink does when it is first opened. As the carbon dioxide is released, calcite is redeposited on cave walls, ceilings, and floors. This redeposited mineral will build up after countless water drops complete the chemical process, eventually forming a stalactite. If the water that drops to the floor of the cave still contains some dissolved calcite, it can deposit more dissolved calcite there, forming a stalagmite.

By analyzing and interpreting the sedimentary rock record, scientists attempt to date and document many of the significant events that have occurred in Earth’s history. This record provides information on ancient geography. A map of the distribution of sediments that formed in shallow oceans bordering rising mountains or in deep, subsiding ocean trenches will indicate past relationships between seas and landmasses.
An accurate interpretation allows scientists to form conclusions about the evolution of mountain systems, continental blocks, and ocean basins. Some scientists also attempt to draw conclusions about the origin and evolution of the atmosphere and hydrosphere. Other scientists examine the sedimentary rock record containing fossils of once-living creatures in an attempt to document the theory of evolutionary advancement from simple to complex organisms in the plant and animal kingdoms.

It is also important to understand the economic significance of sedimentary rock. For example, sedimentary rock essentially contains the world’s entire supply of oil and natural gas, coal, phosphates, salt deposits, groundwater, and other natural resources. As good stewards, humanity is responsible for taking care of and preserving the many gifts God has entrusted to people.

LESSON REVIEW
1. How does compaction and cementation form layers of rock?
2. What are the three types of clastic sedimentary rock? How do they differ?
3. How are the three types of sedimentary rock formed?
4. Would it be more likely to find fossils in an igneous rock or a sedimentary rock? Why?
5. Describe the major types of clastic sedimentary rock.
6. Assume that the volume of a layer of mud will decrease by 40% during deposition and compaction. If the original sediment layer is 50 cm thick, what will be the thickness of the shale layer after compaction?