Geologic Time

Analyzing the Rock and Fossil Records

Before You Read

What do you think? Read the three statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	Older rocks are always located below younger rocks.	
	Relative age means that scientists are relatively sure of the age.	
	Fossils are pieces of dead organisms.	

Read to Learn

What is the basis for understanding Earth's past?

Today, scientists know that Earth's history started about 4.6 billion years ago. But early studies and ideas of geology and Earth history did not consider that Earth is very old. Scientists described what they saw in terms of what they experienced in their everyday lives. For example, some early scientists explained Earth's history as a series of disastrous events that occurred over short periods of time. They called this idea catastrophism (kuh TAS truh fih zum). An important idea was set forth during the late 1700s that caused scientists to change their view of Earth's history.

Principle of Uniformitarianism In the 1700s, James Hutton rejected catastrophism. Hutton was a naturalist and farmer in Scotland. He noticed that the landscape on his farm changed over the years. Hutton thought that the processes responsible for changing the landscape on his farm could also change Earth's surface. For example, Hutton thought that erosion caused by streams could also wear down mountains. He realized that these processes would take a long time to change Earth's surface. Hutton proposed that Earth was much older than a few thousand years.

Key Concept

- How can rocks and fossils be used to determine the order of past events?

Mark the Text

Identify Main Ideas
Highlight each head and the details that support it. Use the highlighted information to review the lesson.

Scientific Vocabulary

geology
(noun) the science and study of the planet Earth

Academic Vocabulary

processes
(noun) a series of actions or operations that lead to an end result

Academic Vocabulary

uniform
(adjective) staying the same all the time

Scientific Vocabulary

glacier
(noun) a large mass of ice that moves slowly over land

Hutton's ideas became part of the principle of uniformitarianism (yew nuh for muh TER ee uh nih zum). *The principle of* **uniformitarianism** *states that geologic processes that occur today are similar to those that have occurred in the past*. According to this view, Earth's surface is constantly being reshaped in a steady, uniform manner. For example, when a glacier melts, the rock material that is contained in the glacial ice gets deposited. The physical characteristics of this material is very distinct. The material is unsorted and contains many different sizes of sediment. Many of the rocks have scratches on them. This material can be recognized anywhere. Today, there are rock layers that are made of the same type of rocks and sediment. Because they are so similar in appearance, uniformitarianism tells us that these rock layers were once material that was deposited by glaciers.

Because of uniformitarianism, scientists can learn about Earth's past by studying the present. One way to do this is by studying the order in which geologic events occurred using a method called relative-age dating. This does not allow scientists to determine the **absolute age,** *or the actual age* of the events. But it gives scientists a clearer understanding about Earth's history.

What is relative-age dating?

Suppose you have just remembered where you left the money that you have been looking for. It is in the pocket of the pants you wore to the movies last Saturday. Now imagine that the pants are in your pile of dirty laundry. How can you tell where your money is? It turns out that there is some order to your pile of clothes. Every time you add clothes to the pile, you place them on top. The clothes from last Saturday are on the bottom. That is where your money is!

Academic Vocabulary

formation
(noun) something that is formed or created

Relative Age There is order in a rock formation just as there is order in a pile of clothes. In many rock formations, the oldest rocks are in the bottom layer and the youngest rocks are in the top layer.

If you have brothers and sisters, you might describe your age by saying, "I'm older than my sister and younger than my brother." This tells how your age relates to others in your family. It is your relative age. In geology, **relative age** *is the age of rocks and geologic features compared with other rocks and geologic features nearby*.

The Principles of Relative-Age Dating Long ago, a man named Nicolaus Steno developed a set of principles to compare the ages of rock layers. Called Steno's principles, they help geologists organize rocks according to their relative ages. They are superposition, original horizontality, lateral continuity, and cross-cutting relationships. Modern geologists have added a fifth principle, the principle of inclusions. So today, there are 5 principles used in relative-age dating. Let's review.

- Your pile of dirty clothes demonstrates the first principle of relative-age dating—superposition. **Superposition** *is the principle that in undisturbed rock layers, the oldest rocks are on the bottom*. Forces do sometimes disturb rock layers after they are deposited. But if no disturbance takes place, each layer of rocks is younger than the layer below it.
- The second principle of relative-age dating is called original horizontality. According to the principle of **original horizontality,** *most rock-forming materials are deposited in horizontal layers.* Sometimes rock layers are deformed or disturbed after they form. For example, the layers might be tilted or folded. When you see rocks that are tilted, remember that all layers were originally deposited horizontally.
- **Lateral continuity** *is the principle that sediments are deposited in large, flat sheets.* The sheets, or layers, continue in all lateral directions until they thin out or until they meet a barrier. This principle is called the principle of lateral continuity. For example, a river might erode the layers, but the order of the layers does not change. This principle helps geologists recognize the same rock layers on either side of a large river or canyon.
- Sometimes forces within Earth cause rock formations to break, or fracture. When rocks move along a fracture line, the fracture is called a fault. According to the principle of **cross-cutting relationships,** *if one geologic feature cuts across another feature, the feature that it cuts across is older.* Imagine several rock layers that have been intruded by an igneous intrusion. Then the layers and the intrusion are cut by a fault. What are the relative ages? You can conclude that the rock layers are the oldest, followed by the intrusion and then the fault. The fault is the youngest because it cuts both the rock layers and the intrusion.

Scientific Vocabulary

disturb
(verb) to change the position or order of something

Academic Vocabulary

horizontal
(adjective) flat and level

Word Origin

lateral
from Latin *lateralis,* means "belonging to the side"

Science Use v. Common Use

intrusion
Science Use the entry of magma into or between rock formations; the igneous rock formed

Common Use the act of intruding

Scientific Vocabulary
magma
(noun) molten rock inside Earth

- Sometimes, when rocks form, they contain pieces of other rocks. This can happen when part of an existing rock breaks off and falls into soft sediment or flowing magma. When the sediment or the magma becomes rock, the broken piece of rock becomes a part of it. *A piece of an older rock that becomes part of a new rock is called an* **inclusion.** According to the principle of inclusions, if one rock contains pieces of another rock, the rock containing the pieces is younger than the pieces.

What can the fossil record tell us about Earth's history?

Word Origin
fossil
from Latin *fossils,* means "dug up"

Scientific Vocabulary
ancient
(adjective) very old

Did you know that rocks themselves can contain clues about their relative ages? Some of the most obvious clues found in rocks are fossils. **Fossils** *are the preserved remains or evidence of ancient living things.* When many people think of fossils, they think of dinosaur fossils. Many dinosaurs were large animals. Their large bones remained after they died. Not all fossils are large enough for you to see. Some fossils can be seen only by using a microscope. These tiny fossils are called microfossils. Some microfossils are about the size of a speck of dust. Yet, they can all be used to help scientists interpret Earth's history.

The Fossil Record While studying the fossils in rock layers, early geologists recognized three things. First, fossils found in the oldest layers of rock are of relatively simple organisms. Fossils of more complex organisms appear in younger layers of rock. Second, there were a few times when many types of fossils that appear in one rock layer did not appear in the younger rock layers right above it. These sudden disappearances in the fossil record of many types of organisms mark **mass extinctions**—*times when many species on Earth died or became extinct within a relatively short period of time.* And finally, fossils and the rocks they are within can be used to determine what the environment of an area was like long ago.

Word Origin
extinct
from Latin *extinctus,* means "dying out"

Ancient Environments Scientists use the principle of uniformitarianism to learn about ancient organisms and the environments in which they lived. They compare fossils of ancient organisms with organisms living today. For example, a trilobite fossil and a horseshoe crab look alike. Horseshoe crabs today live in shallow water on the ocean floor. Partly because trilobite fossils look like horseshoe crabs, scientists infer that trilobites also lived in shallow ocean water.

Shallow Seas Today, Earth's continents are mostly above sea level. Many times in the past, the sea level rose and flooded Earth's continents. For example, a shallow ocean covered much of North America about 450 million years ago. Fossils of organisms that lived in that shallow ocean help scientists reconstruct what the seafloor looked like in the past.

Past Climates Fossils also help scientists learn about past climate changes. For example, fossils of ferns and other tropical plants indicate that much of Earth was very warm 100 million years ago. Tropical swamps and forests covered much of the land. Dinosaurs lived on Earth during this period.

Millions of years later, the swamps and forests were gone. In some of these areas, coarse grasses grew. Huge sheets of ice formed as the climate cooled. This ice spread over parts of North America, Europe, and Asia. Organisms that adapted to the cold climate survived. Fossils of organisms, such as the woolly mammoth, help scientists learn about this cold time in Earth's history.

Academic Vocabulary

indicate
(verb) to be a sign of; to point to

Scientific Vocabulary

adapt
(verb) to change in order to succeed in a new situation

After You Read

Reread the statements at the beginning of the lesson. Fill in the *After* column with an A if you agree with the statement or a D if you disagree. Did you change your mind?