Section 2

The Relative Age of Rocks

Reading Preview

Key Concepts

- What is the law of superposition?
- How do geologists determine the relative age of rocks?
- How are index fossils useful to geologists?

Key Terms

- relative age • absolute age
- law of superposition
- extrusion • intrusion • fault
- unconformity • index fossil

Target Reading Skill

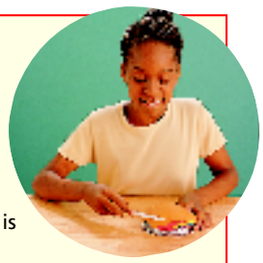
Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write answers to your questions.

Relative Age

Question	Answer
What does the position of rock layers reveal?	The position of rock layers shows . . .

Lab zone Discover Activity

Which Layer Is the Oldest?



1. Make a stack of different-colored layers of clay. Each layer should be about the size and thickness of a pancake. If these flat layers are sediments, which layer of sediment was deposited first? (*Hint:* This is the oldest layer.)
2. Now form the stack into a dome by pressing it over a small rounded object, such as a small bowl. With a cheese-slicer or plastic knife, carefully cut off the top of the dome. Look at the layers that you have exposed. Which layer is the oldest?

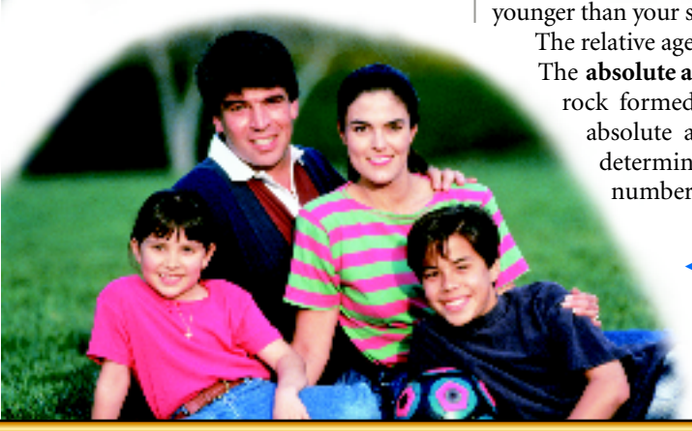
Think It Over

Inferring If you press the stack into a small bowl and trim away the clay that sticks above the edge, where will you find the oldest layer?

As sedimentary rock forms, the remains of organisms in the sediment may become fossils. Millions of years later, if you split open the rock, you might see the petrified bones of an extinct reptile or insect.

Your first question about a new fossil might be, "What is it?" Your next question would probably be, "How old is it?" Geologists have two ways to express the age of a rock and any fossil it contains. The **relative age** of a rock is its age compared to the ages of other rocks. You have probably used the idea of relative age when comparing your age with someone else's age. For example, if you say that you are older than your brother but younger than your sister, you are describing your relative age.

The relative age of a rock does not provide its absolute age. The **absolute age** of a rock is the number of years since the rock formed. It may be impossible to know a rock's absolute age exactly. But sometimes geologists can determine a rock's absolute age to within a certain number of years.



◀ **The age of each family member could be given as relative age or absolute age.**

Lab zone Discover Activity

Skills Focus inferring L2

Materials 4 to 5 different colors of modeling compound, small bowl, cheese slicer or plastic knife

Time 10 minutes

Tips When students begin cutting off the top of the dome, advise them not to cut all the way to the bowl; have them leave one layer covering the bowl.

Expected Outcome The oldest layer is the bottom layer when the layers are flat. When the layers are pressed over the bowl and the top of the dome is cut off, the oldest layer is in the center of the dome, even if it rises above the other layers.

Think It Over The oldest layer is found on the outside ring, touching the bowl.

Section 2

The Relative Age of Rocks

Objectives

After this lesson, students will be able to

G.4.2.1 State the law of superposition.

G.4.2.2 Describe how geologists determine the relative age of rocks.

G.4.2.3 Explain how index fossils are useful to geologists.

Target Reading Skill

Asking Questions Explain that changing a heading into a question helps students anticipate the ideas, facts, and events they are about to read.

Answers

Possible questions and answers:

What does the position of rock layers reveal? *(The oldest layers—and the oldest fossils—are at the bottom.)* **How do geologists determine the relative age of a rock?** *(The position of rock layers, extrusions and intrusions of igneous rock, faults, and gaps in the geologic record)* **How are fossils used to date rocks?** *(The age of an index fossil tells the age of the rock layer in which it occurs.)*

All in One Teaching Resources

- Transparency G35

Preteach

Build Background Knowledge L1

How Sediments Are Deposited

Ask: **What happens to the sediment load carried to an ocean by a river?** *(Some is deposited on beaches and some on the ocean floor.)* Explain that this sediment can harden over time into layers of rock.

Instruct

The Position of Rock Layers

A Trip Through Geologic Time

Show the Video Field Trip to let students experience the geology of the Grand Canyon. Discussion question: **How does the evidence found in the Grand Canyon's layers help scientists re-create the geologic history of the region?** *(The rock layers of the Grand Canyon follow the law of superposition. The oldest rock is at the bottom, and the most recent layers are near the top.)*

Teach Key Concepts L1

The Law of Superposition

Focus Remind students that, as a noun, *relative* means a family member. But as an adjective, *relative* is used as a means of comparison.

Teach Have students recall the Discover Activity in which they made flat layers from modeling clay. Ask: **How was your model like the illustration of the Grand Canyon you see in Figure 5?** *(The oldest layer is on the bottom.)* **How do scientists use this concept to determine the relative ages of rocks?** *(In horizontal sedimentary rock layers, the oldest layer is at the bottom. Each higher layer is younger than the layers below it.)* **What is this principle called?** *(The law of superposition)*

Apply Have students examine the layers of rock in the illustration. Ask: **Why couldn't the Hermit Shale layer be older than the Supai Sandstone layer?** *(Because the Hermit Shale lies above the Supai Sandstone, the sedimentary rock must have been formed more recently.)* **learning modality: visual**

All in One Teaching Resources

- Transparency G36

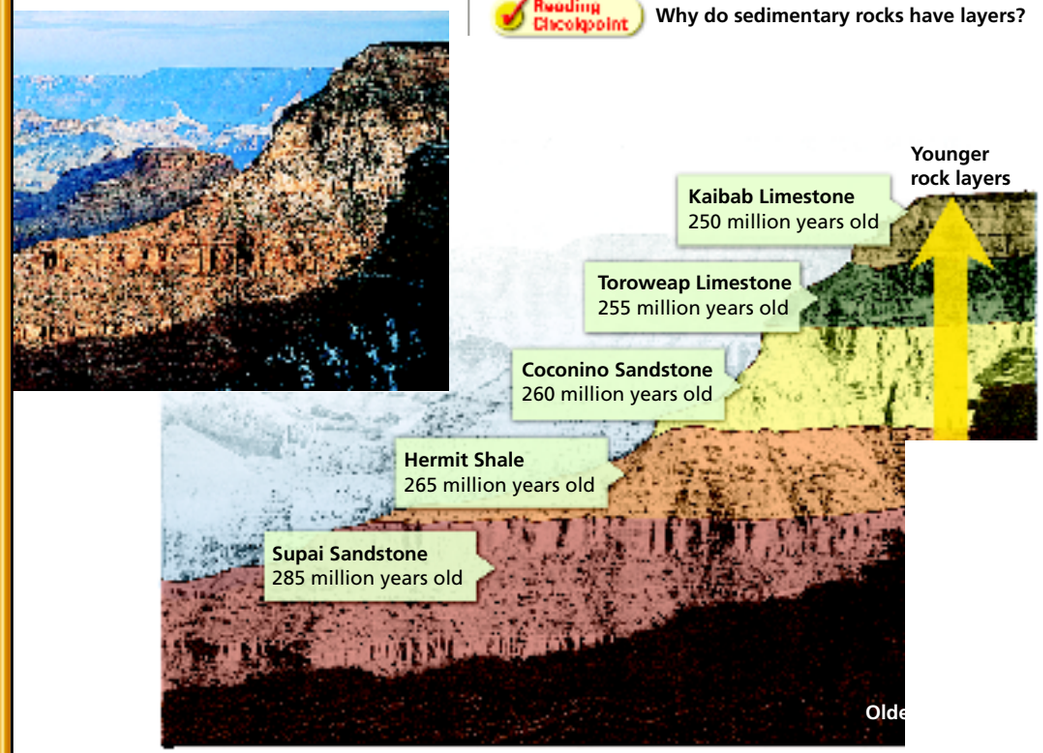
Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *The Relative Age of Rocks*

Student Edition on Audio CD

FIGURE 5
The Grand Canyon
More than a dozen rock layers make up the walls of the Grand Canyon. You can see five layers clearly in the photograph. **Applying Concepts** *In which labeled layers would you find the oldest fossils? Explain.*



The Position of Rock Layers

Have you ever seen rock layers of different colors on a cliff beside a road? What are these layers, and how did they form? The sediment that forms sedimentary rocks is deposited in flat layers one on top of the other. Over time, the sediment hardens and changes into sedimentary rock. These rock layers provide a record of Earth's geologic history.

It can be difficult to determine the absolute age of a rock. So geologists use a method to find a rock's relative age. Geologists use the **law of superposition** to determine the relative ages of sedimentary rock layers. **According to the law of superposition, in horizontal sedimentary rock layers the oldest layer is at the bottom. Each higher layer is younger than the layers below it.**

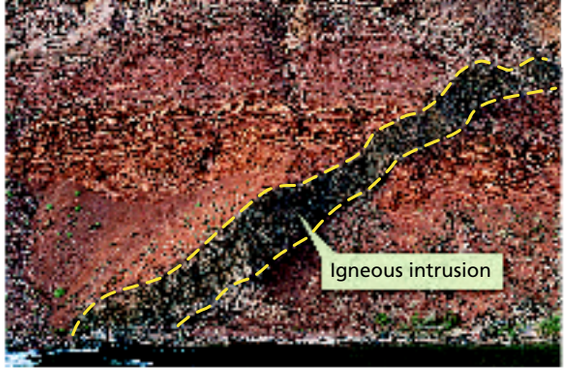
The walls of the Grand Canyon in Arizona illustrate the law of superposition. You can see some of the rock layers found in the Grand Canyon in Figure 5. The deeper down you go in the Grand Canyon, the older the rocks.

Reading Checkpoint **Why do sedimentary rocks have layers?**

Differentiated Instruction

Special Needs L1

Relative and Absolute Ages Clarify the meaning of *relative age* and *absolute age* by writing the following statements about children in a family on the board: "Anthony is the youngest." *(Relative)* "Melony is 4 years old." *(Absolute)* "Michael is older than Shatiqua." *(Relative)* "Ashley is older than Melony but younger than Shatiqua." *(Relative)* Help students place the children in order from youngest to oldest. *(Michael, Shatiqua, Ashley, Melony, Anthony)* Ask: **How does this example model how scientists determine the ages of rock layers?** *(Scientists are able to fill in gaps in the geologic record by comparing the ages of rocks.)* **learning modality: logical/mathematical**



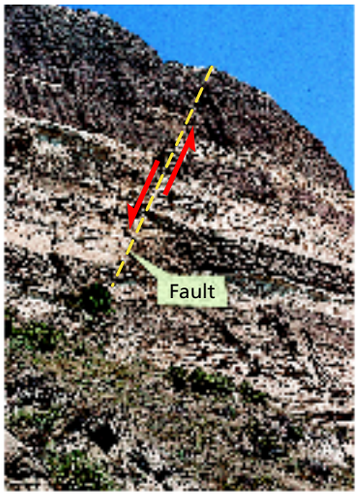


FIGURE 6
Intrusions and Faults
Intrusions and faults give clues to the relative ages of rocks. An intrusion (left) cuts through rock layers. Rock layers are broken and shifted along a fault (right).

Determining Relative Age

There are other clues besides the position of rock layers to the relative ages of rocks. **To determine relative age, geologists also study extrusions and intrusions of igneous rock, faults, and gaps in the geologic record.**

Clues From Igneous Rock Igneous rock forms when magma or lava hardens. Magma is molten material beneath Earth's surface. Magma that flows onto the surface is called lava.

Lava that hardens on the surface is called an **extrusion.** An extrusion is always younger than the extrusion below it.

Beneath the surface, magma may push into bodies of rock. There, the magma cools and hardens into a mass of igneous rock called an **intrusion.** An intrusion is always younger than the rock layers around and beneath it. Figure 6 shows an intrusion. Geologists study where intrusions and extrusions formed in relation to other rock layers. This helps geologists understand the relative ages of the different types of rock.

Clues From Faults More clues come from the study of faults. A **fault** is a break in Earth's crust. Forces inside Earth cause movement of the rock on opposite sides of a fault.

A fault is always younger than the rock it cuts through. To determine the relative age of a fault, geologists find the relative age of the youngest layer cut by the fault.

Movements along faults can make it harder for geologists to determine the relative ages of rock layers. You can see in Figure 6 how the rock layers no longer line up because of movement along the fault.

Lab zone Try This Activity

Sampling a Sandwich

Your teacher will give you a sandwich that represents rock layers in Earth's crust.

1. Use a round, hollow, uncooked noodle as a coring tool. Push the noodle through the layers of the sandwich.
2. Pull the noodle out of the sandwich. Break the noodle gently to remove your core sample.
3. Draw a picture of what you see in each layer of the core.

Making Models Which layer of your sandwich is the "oldest"? The "youngest"? Why do you think scientists study core samples?

Lab zone Try This Activity

Skills Focus making models L2

Materials cylindrical pasta noodle about 1.5 cm in diameter, sandwich of different soft cheeses and meats

Time 15 minutes

Tips One sandwich can be used for several samples. Explain that geologists use drills to cut through rock layers and bring core samples to the surface to study.

Expected Outcome The oldest is the bottom; the youngest is the top. Core samples provide information about layers of rock.

Extend Ask: **If these were layers of sedimentary rock, why couldn't layer 4 be younger than layer 3?** *(The sediment that formed layer 3 could not have been deposited underneath the hardened rock of layer 4.)* **learning modality: kinesthetic**

Determining Relative Age

Teach Key Concepts L1

Clues to Determine Relative Age

Focus Review the definition of relative age.

Teach Ask: **How do geologists use extrusions and intrusions to determine relative age?** *(They are always younger than the rocks beneath and surrounding them.)* **Are faults younger or older than the rock they cut through?** *(Younger)* **What might cause a gap in the geologic record?** *(Erosion might wear away a layer of rock. When a new layer forms, the layer that was originally there was lost.)*

Apply Ask: **How are faults, intrusions, and extrusions similar?** *(They are all younger than the rocks they push into or disturb.)* **learning modality: verbal**

Lab zone Build Inquiry L2

Comparing Rock Samples

Materials hand lens, samples of granite, basalt, sandstone, and shale

Time 15 minutes

Focus Ask students to recall the origins of sedimentary and igneous rocks.

Teach Label the samples: **Granite—forms intrusions, Basalt—forms extrusions, Sandstone—formed mainly of sandy sediment,** and **Shale—formed mainly of muddy sediment.** Have students examine the samples and write descriptions of them, including textures and grain size.

Apply Ask: **Which of the rocks would occur as a layer?** *(Basalt, sandstone, and shale)* **Which rock would cut across other rock layers?** *(Granite)* **learning modality: kinesthetic**

Monitor Progress L2

Drawing Have students draw several sedimentary rock layers; add and label an intrusion, extrusion, and a fault; then label the layers from oldest to youngest.

Answers

Figure 5 The Supai Sandstone; the oldest layer is at the bottom.

Reading Checkpoint The sediment that forms sedimentary rocks is deposited in flat layers one on top of the other.

Using Fossils to Date Rocks

Teach Key Concepts L1

Index Fossils

Focus Review the difference between absolute age and relative age.

Teach Ask: **Is an index fossil used to determine absolute age or relative age? Explain.** *(Relative age—the index fossil is compared to other fossils in other locations.)* **How does an index fossil help date rocks?** *(Rock layers that contain the same index fossil are about the same age.)*

Apply Pose this problem to students: **Suppose two rock layers in two different locations contain fossils of a dinosaur that lived only during the Jurassic Period. What can you conclude about the rock layers?** *(They must have been formed at about the same time during the Jurassic Period.)* **learning modality: logical/mathematical**

Lab zone **Build Inquiry** L3

Modeling Index Fossils

Materials newspapers, common classroom objects such as pencils, erasers, paper clips, and buttons

Time 20 minutes

Focus Review the definition of an index fossil.

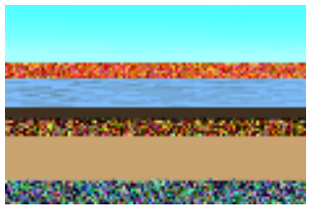
Teach Create a model of several locations by using layers of newspapers. Place common objects between sections of a newspaper, labeling the layers A, B, C, and D. Use one object, such as a button, to represent an index fossil. Give each group of students one newspaper pile, and have them remove the layers, recording the "fossils" found. After groups have examined the layers, record their observations on the board. Have them determine which of the "fossils" can be used as an index fossil by its distribution and location.

Apply Ask: **How were you able to determine which fossil is an index fossil?** *(The fossil was found in several stacks of newspapers in the same layer, but not in any other layers.)* **learning modality: kinesthetic**

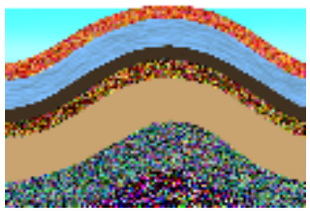
All in One **Teaching Resources**

- Transparencies G37, G38

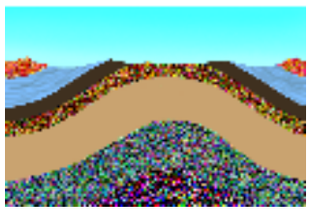
FIGURE 7
Unconformity
An unconformity occurs where erosion wears away layers of sedimentary rock. Other rock layers then form on top.
Sequencing *What two processes must take place before an unconformity can form?*



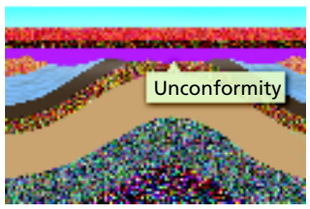
1 Sedimentary rocks form in horizontal layers.



2 Folding tilts the rock layers.



3 The surface is eroded.



4 New sediment is deposited, forming rock layers above the unconformity.

Gaps in the Geologic Record The geologic record of sedimentary rock layers is not always complete. Deposition slowly builds layer upon layer of sedimentary rock. But some of these layers may erode away, exposing an older rock surface. Then deposition begins again, building new rock layers.

The surface where new rock layers meet a much older rock surface beneath them is called an **unconformity**. An unconformity is a gap in the geologic record. An unconformity shows where some rock layers have been lost because of erosion. Figure 7 shows how an unconformity forms.

Reading Checkpoint **What is an unconformity?**

Using Fossils to Date Rocks

To date rock layers, geologists first give a relative age to a layer of rock at one location. Then they can give the same age to matching layers of rock at other locations.

Certain fossils, called index fossils, help geologists match rock layers. To be useful as an **index fossil,** a fossil must be widely distributed and represent a type of organism that existed only briefly. A fossil is considered widely distributed if it occurs in many different areas. Geologists look for index fossils in layers of rock. **Index fossils are useful because they tell the relative ages of the rock layers in which they occur.**

Geologists use particular types of organisms as index fossils—for example, certain types of ammonites. Ammonites (AM uh nyts) were a group of hard-shelled animals. Ammonites evolved in shallow seas more than 500 million years ago and became extinct about 65 million years ago.

Ammonite fossils make good index fossils for two reasons. First, they are widely distributed. Second, many different types of ammonites evolved and then became extinct after a few million years.

Geologists can identify the different types of ammonites through differences in the structure of their shells. Based on these differences, geologists can identify the rock layers in which a particular type of ammonite fossil occurs.

You can use index fossils to match rock layers. Look at Figure 8, which shows rock layers from four different locations. Notice that two of the fossils are found in only one of these rock layers. These are the index fossils.

Reading Checkpoint **What characteristics must a fossil have to be useful as an index fossil?**

Differentiated Instruction

Less Proficient Readers L1
Understanding Causes of Unconformities Pair students with more proficient readers. Refer them to Figure 7, and write the questions that follow on the board. Ask them to draw on previous knowledge to give detailed answers. Encourage them to use the table of contents and index to locate information in other parts of the textbook. Questions: **What process could have made the sedimentary layers?** *(Deposition from water, wind, waves, or glaciers)* **What could have caused the folding of the layers?** *(Forces from inside Earth can cause movement.)* **What could have caused the wearing away of the surface?** *(Chemical or mechanical weathering, and then erosion by water, wind, waves, or glaciers)* **learning modality: visual**

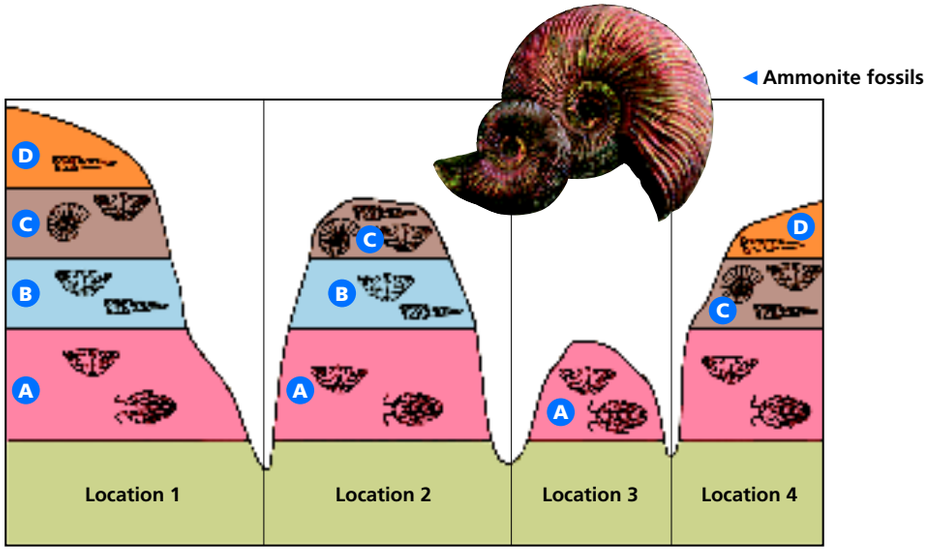


FIGURE 8
Using Index Fossils
Scientists use index fossils to match up rock layers at locations that may be far apart. The ammonites in layer C are index fossils. **Interpreting Diagrams** *Can you find another index fossil in the diagram? (Hint: Look for a fossil that occurs in only one time period, but in several different locations.)*

Go Online active art

For: Index Fossil activities
Visit: PHSchool.com
Web Code: cfp-2042

Section 2 Assessment

Target Reading Skill **Asking Questions** Use the answers to the questions you wrote about the headings to help you answer the questions below.

Reviewing Key Concepts

1. **a.** **Defining** In your own words, define the terms *relative age* and *absolute age*.
   b. **Explaining** What is the law of superposition?
   c. **Inferring** A geologist finds a cliff where the edges of several different rock layers can be seen. Which layer is the oldest? Explain.
2. **a.** **Reviewing** Besides the law of superposition, what are three types of clues to the relative age of rock layers?
   b. **Comparing and Contrasting** Compare and contrast extrusions and intrusions.
   c. **Sequencing** An intrusion crosses an extrusion. Which layer is the older? Explain.
3. **a.** **Defining** What is an index fossil?
   b. **Applying Concepts** The fossil record shows that horseshoe crabs have existed with very little change for about 200 million years. Would horseshoe crabs be useful as an index fossil? Explain why or why not.

Lab zone At-Home Activity

Drawer to the Past Collect ten items out of a drawer full of odds and ends such as keys, coins, receipts, photographs, and souvenirs. Have your family members put them in order from oldest to newest. What clues will you use to determine their relative ages? How can you determine the oldest object of all? List the ten items in order of their relative age. Do you know the absolute age of any of the items?

Lab zone At Home Activity

Drawer to the Past L2 Encourage students to carry out the activity at home and then bring a list of the ten items to class. Clues used to determine relative ages might include the memories of family members and the condition of an item. Some items, such as coins, may contain dates that indicate an absolute age.

Lab zone Chapter Project

Keep Students on Track Point students toward research materials that will provide information about their chosen time periods, and encourage them to keep a bibliography of their sources. Tell students to keep in mind the pictures and facts they will need for the class timeline and travel brochure.

Go Online active art

For: Index Fossil activities
Visit: PHSchool.com
Web Code: cfp-2042

Students can interact with the art of index fossils online.

Monitor Progress L2

Answers
Figure 7 Erosion and deposition
Figure 8 The trilobites in Layer A

Reading Checkpoint A gap in the geological record

Reading Checkpoint It must be widely distributed, and it must have existed for only a brief period of time.

Assess

Reviewing Key Concepts

1. a. Relative age states whether a rock is younger or older than another rock. Absolute age is a rock's age in years. **b.** In horizontal layers of sedimentary rock, the oldest layer is at the bottom, and each higher layer is younger than the layer below it. **c.** The bottom; it was the first to be formed by deposits.
2. a. Igneous rock intrusions and extrusions, faults, and unconformities **b.** Both form from molten material. Lava that hardens on the surface is an extrusion. Magma that cools below the surface is an intrusion. **c.** The extrusion; intrusions are always younger than the rock layers through which they pass.
3. a. A fossil that is used to determine the relative age of rocks **b.** No. They have existed with little change for a long time.

Reteach L1

With the class, make a drawing that includes sedimentary rock layers, an unconformity, a fault, an intrusion, an extrusion, and several index fossils. Discuss the relative ages of each layer.

All in One Teaching Resources

- Section Summary: *The Relative Age of Rocks*
- Review and Reinforce: *The Relative Age of Rocks*
- Enrich: *The Relative Age of Rocks*

Finding Clues to Rock Layers

L2

Prepare for Inquiry

Key Concept

Index fossils as well as intrusions and extrusions can be used to determine the relative ages of rock layers.

Skills Objectives

Students will be able to

- Interpret data about various fossils found in rock layers
- Draw conclusions about the relative ages of rock layers

Class Time 30 minutes

All in One Teaching Resources

- LabWorksheet: *Finding Clues to Rock Layers*

Guide Inquiry

Introduce the Procedure

Allow students time to read through the entire procedure. Then ask: **Where can you find out what kinds of fossils are in the different rock layers?** *(In the key to symbols)* **What kind of fossils do geologists use to match rock layers?** *(Index fossils)*

Analyze and Conclude

1. Fossils of marine animals in layers A and B indicate a marine environment. Dinosaur tracks and a leaf suggest that a land environment created layer D.

2. According to the law of superposition, layer A is the oldest because it is below all other layers.

3. According to the law of superposition, layer G formed most recently because it is above all other layers.

4. Layers C and E are extrusions of igneous rock, in which fossils can't form.

5. Dinosaur, plant, and bird fossils

6. Layer B

7. Rock layers that are missing from the sequence at Site 2 provide clues of an unconformity. Layers E and D are missing between layers X and Y, which suggests that the boundary between Y and X is an unconformity. Layer A is also missing, which suggests that there is an unconformity below W.

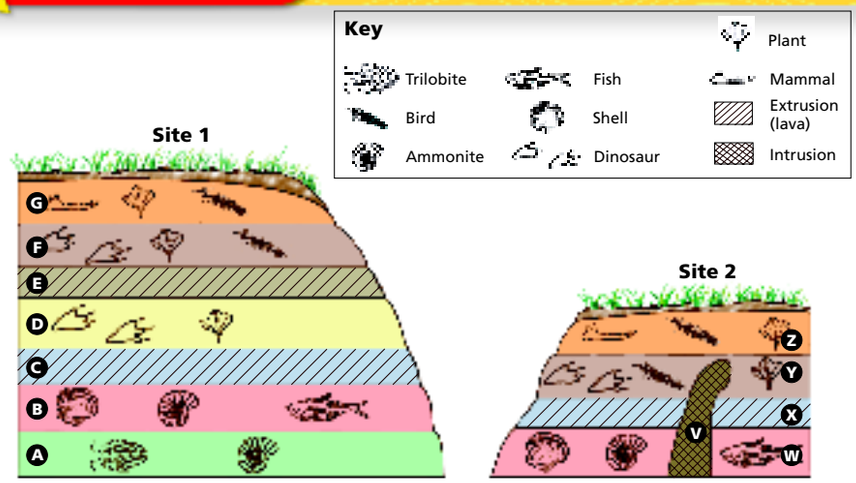
8. Layer Y is older because an intrusion is always younger than the layer through which it passes.

9. The environment most likely started out as an ocean environment. Volcanic extrusions covered the environment over many years, eventually creating a swamplike environment in which dinosaurs lived.

Extend Inquiry

More to Explore Because faults can occur only after rock layers have formed, any layers the fault cuts across would be older than the fault. Encourage students to test one another with their sketches.

Lab zone Skills Lab



Finding Clues to Rock Layers

Problem

How can you use fossils and geologic features to interpret the relative ages of rock layers?

Skills Focus

interpreting data, drawing conclusions

Procedure

1. Study the rock layers at Sites 1 and 2. Write down the similarities and differences between the layers at the two sites.
2. List the kinds of fossils that are found in each rock layer of Sites 1 and 2.

Analyze and Conclude

Site 1

1. **Interpreting Data** What "fossil clues" in layers A and B indicate the kind of environment that existed when these rock layers were formed? How did the environment change in layer D?
2. **Drawing Conclusions** Which layer is the oldest? How do you know?
3. **Drawing Conclusions** Which of the layers formed most recently? How do you know?
4. **Inferring** Why are there no fossils in layers C and E?
5. **Observing** What kind of fossils are found in layer F?

Site 2

6. **Inferring** Which layer at Site 1 might have formed at the same time as layer W at Site 2?
7. **Interpreting Data** What clues show an unconformity or gap in the horizontal rock layers? Which rock layers are missing? What might have happened to these rock layers?
8. **Drawing Conclusions** Which is older, intrusion V or layer Y? How do you know?
9. **Communicating** Write a journal entry describing how the environment at Site 2 changed over time. Starting with the earliest layer, describe the types of organisms, their environment, and how the environment changed.

More to Explore

Draw a sketch similar to Site 2 and include a fault that cuts across the intrusion. Have a partner then identify the relative age of the fault, the intrusion, and the layers cut by the fault.