

Relative Dating

ESSENTIAL QUESTION

How are the relative ages of rock measured?

By the end of this lesson, you should be able to summarize how scientists measure the relative ages of rock layers and identify gaps in the rock record.

Studying these rock layers can tell scientists a great deal about the order in which the different layers formed.

Lesson Labs

- Quick Labs**
- Layers of Sedimentary Rock
 - Ordering Rock Layers
- Exploration Lab**
- Earth's History

Engage Your Brain

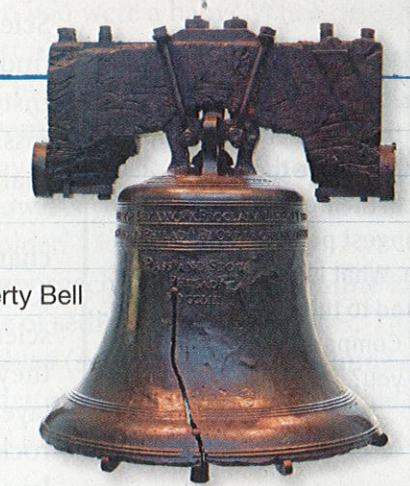
1 Describe Fill in each blank with the word or phrase that you think completes the following sentences.

An example of something young is _____

An example of something old is _____

An example of something that is horizontal is _____

An example of something older than you is _____



The Liberty Bell

2 Explain Which came first, the bell or the crack in the bell? How do you know?

Active Reading

3 Synthesize You can often define an unknown word if you know the meaning of its word parts. Use the word parts below to make an educated guess about the meaning of the word *superposition*, when used to describe layers of rock.

Word part	Meaning
<i>super-</i>	above
<i>-position</i>	specific place

superposition: _____

Vocabulary Terms

- relative dating
- superposition
- unconformity
- fossil
- geologic column

4 Apply As you learn the definition of each vocabulary term in this lesson, make your own definition or sketch to help you remember the meaning of the term.

Who's First?

What is relative dating?

Imagine that you are a detective at a crime scene. You must figure out the order of events that took place before you arrived. Scientists have the same goal when studying Earth. They try to find out the order in which events happened during Earth's history. Instead of using fingerprints and witnesses, scientists use rocks and fossils. Determining whether an object or event is older or younger than other objects or events is called **relative dating**.

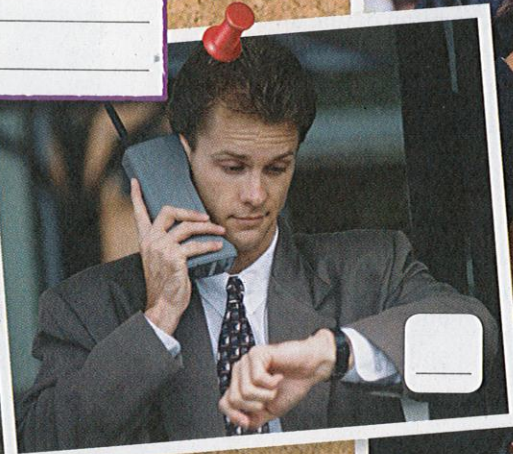
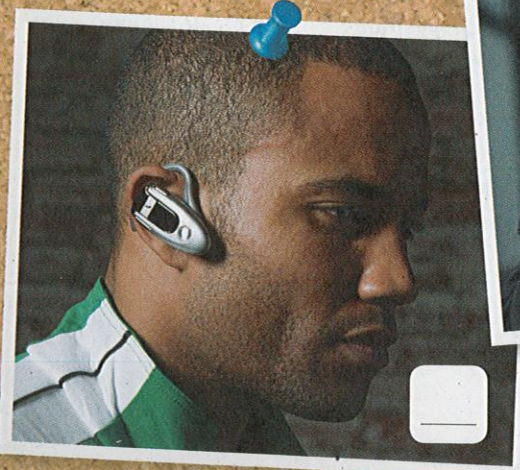
The telephones shown below show how technologies have changed over time. Layers of rock also show how certain things took place in the past. Using different pieces of information, scientists can find the order in which rock layers formed. Once they know the order, a relative age can be determined for each rock layer. Keep in mind, however, that this does not give scientists a rock's age in years. It only allows scientists to find out what rock layer is older or younger than another rock layer.

Think Outside the Book Inquiry

5 Model In groups of 6–10 people, form a line. Place the oldest person in the front of the line and the youngest person at the end of the line. What is your relative age compared to the person in front of you? Compared to the person behind you?

Visualize It!

6 Explain Use the numbers 1, 2, and 3 to rate these telephones from oldest (1) to youngest (3). Explain your choices. Does this tell you the years that the telephones were made?



How these telephones look is a clue to their relative ages.

How are undisturbed rock layers dated?

To find the relative ages of rocks, scientists study the layers in sedimentary rocks. Sedimentary rocks form when new sediments are deposited on top of older rock. As more sediment is added, it is compressed and hardens into rock layers.

Scientists know that gravity causes sediment to be deposited in layers that are horizontal (hohr•ih•ZAHN•tuhl). Over time, different layers of sediment pile up on Earth's surface. Younger layers pile on top of older ones. If left undisturbed, the sediment will remain in horizontal layers. Scientists use the order of these layers to date the rock of each layer.

Active Reading 7 Explain Why does gravity cause layers of sediment to be horizontal?

Using Superposition

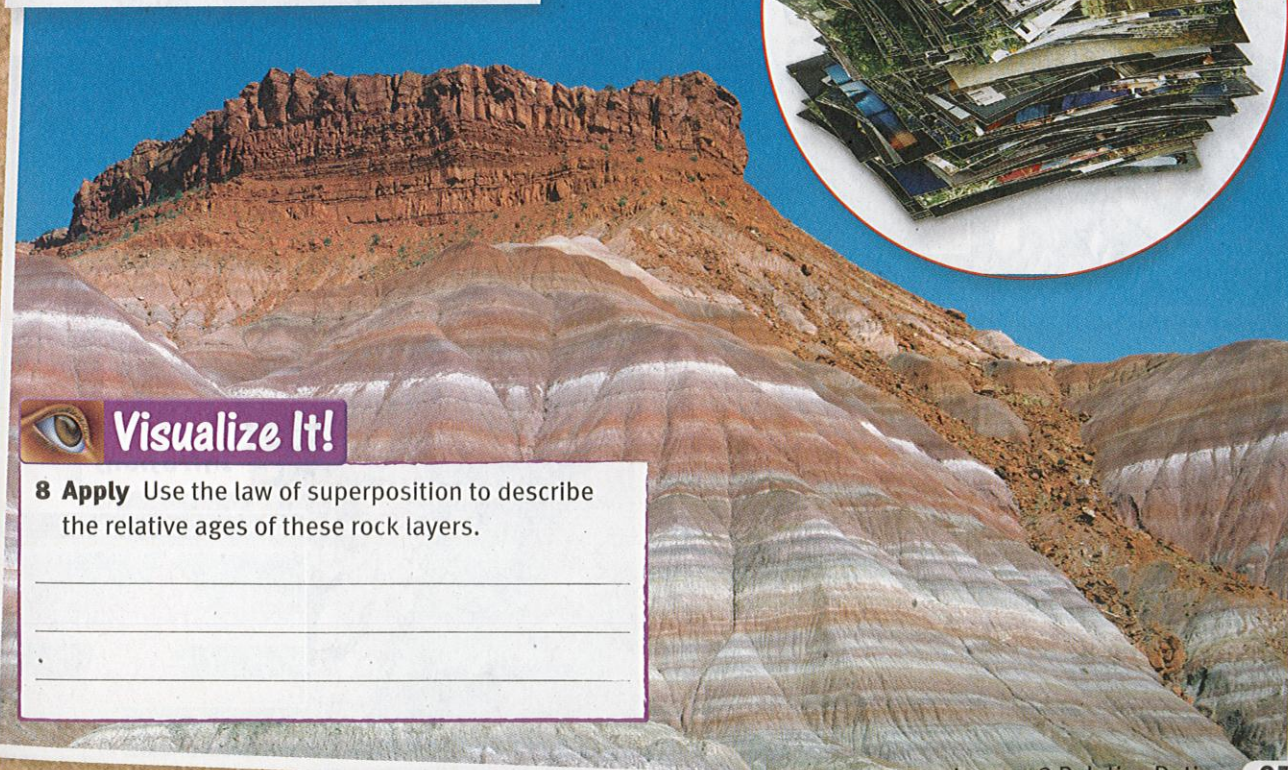
Suppose that you have a brother who takes pictures of your family and piles them in a box. Over time, he adds new pictures to the top of the pile. Where are the oldest pictures—the ones taken when you were a baby? Where are the most recent pictures—the ones taken last week? The oldest pictures will be at the bottom of the pile. The youngest pictures will be at the top of the pile. Layers of rock are like the photographs shown below. As you go from top to bottom, the layers get older.

This approach is used to determine the relative age of sedimentary rock layers. The law of **superposition** (soo•per•puh•ZISH•uhn) is the principle that states that younger rocks lie above older rocks if the layers have not been disturbed.

Rock layers are like photographs that have been put in a pile over time.

Visualize It!

8 Apply Use the law of superposition to describe the relative ages of these rock layers.



How Disturbing!

How are sedimentary rock layers disturbed?

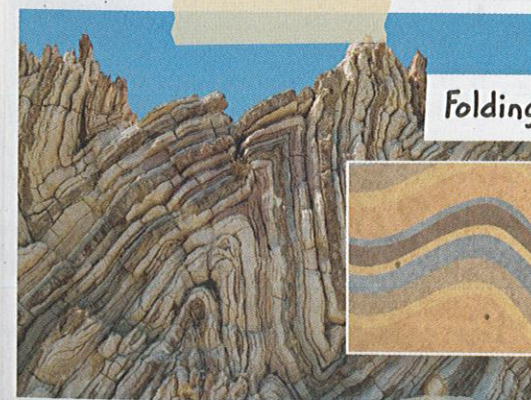
If rock layers are not horizontal, then something disturbed them after they formed. Forces in Earth can disturb rock layers so much that older layers end up on top of younger layers. Some of the ways that rock layers can be disturbed are shown below and on the next page.

By Tilting and Folding

Tilting happens when Earth's forces move rock layers up or down unevenly. The layers become slanted. *Folding* is the bending of rocks that can happen when rock layers are squeezed together. The bending is from stress on the rock. Folding can cause rock layers to be turned over by so much that older layers end up on top of younger layers.



Tilting



Folding

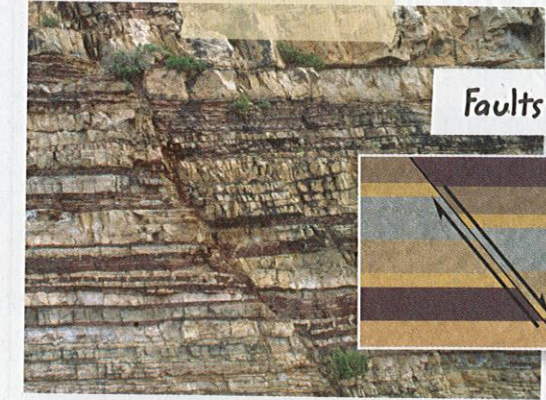
By Faults and Intrusions

Scientists often find features that cut across existing layers of rock. A *fault* is a break or crack in Earth's crust where rocks can move. An *intrusion* (in•TROO•zhuhn) is igneous rock that forms when magma is injected into rock and then cools and becomes hard.

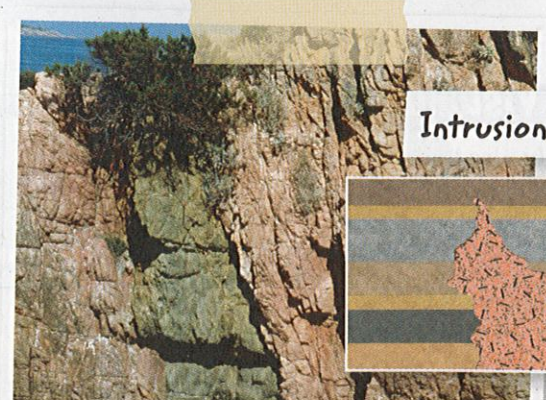
Folding, tilting, faults, and intrusions can make finding out the relative ages of rock layers difficult. This can be even more complicated when a layer of rock is missing. Scientists call this missing layer of rock an *unconformity*.



9 Describe Write a caption for this group of images.



Faults



Intrusions

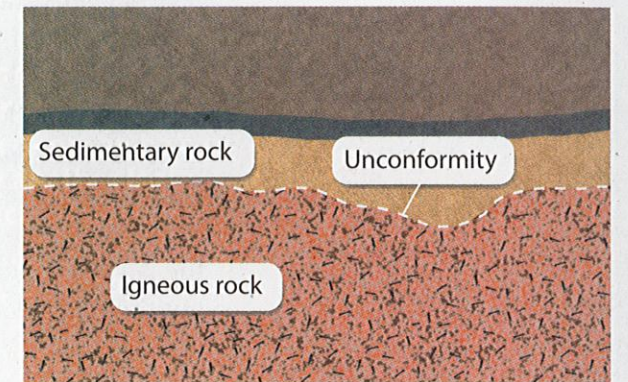
By Unconformities

A missing layer of rock forms a gap in Earth's geologic history, also called the geologic record. An *unconformity* (uhn•kuhn•FAWR•mih•tee) is a break in the geologic record that is made when rock layers are eroded or when sediment is not deposited for a long period of time. When scientists find an unconformity, they must question if the "missing layer" was simply never present or if it was removed. Two examples of unconformities are shown below.



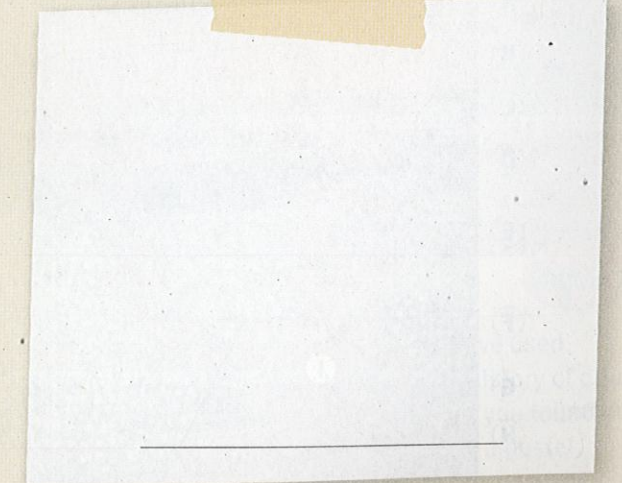
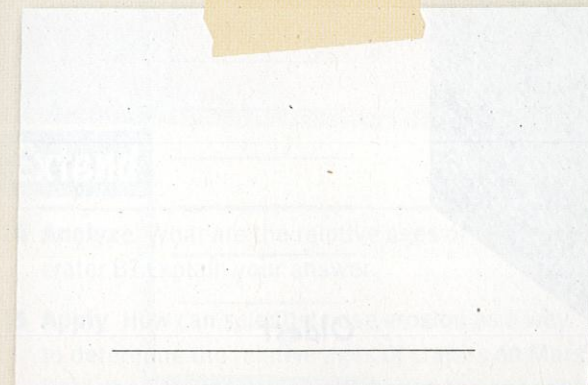
An unconformity can happen between horizontal layers and layers that are tilted or folded. The older layers were tilted or folded and then eroded before horizontal layers formed above them.

Active Reading 10 Describe What are two ways that a rock layer can cause a gap in the geologic record?



An unconformity can also happen when igneous or metamorphic rocks are exposed at Earth's surface and become eroded. Later, deposited sediment causes the eroded surface to become buried under sedimentary rock.

11 Illustrate Choose two of the following: tilting, folding, fault, intrusion, and an unconformity. Draw and label each one.



I'm Cutting In!

Active Reading

- 12 Identify** As you read, underline the law of crosscutting relationships.

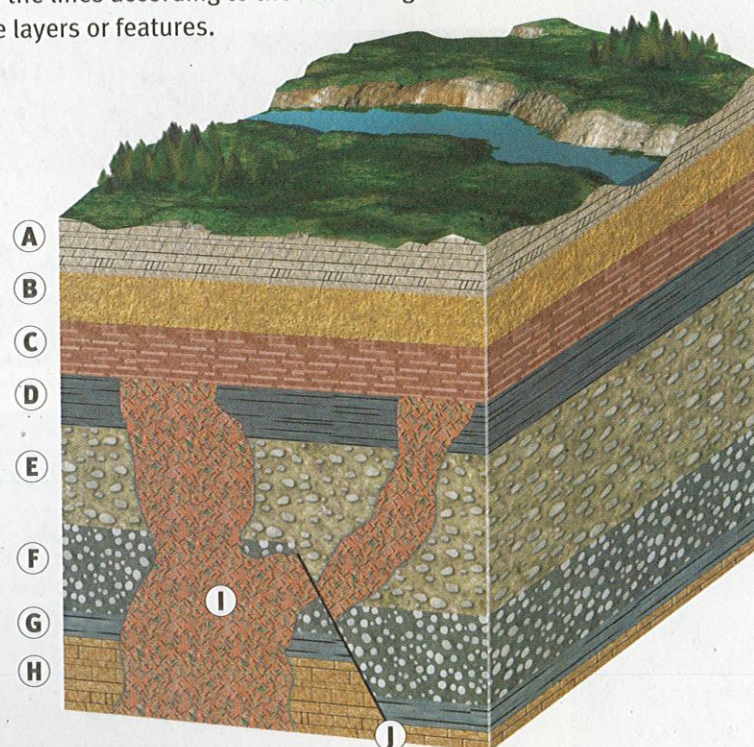
How are rock layers ordered?

Often, the order of rock layers is affected by more than one thing. Finding out what happened to form a group of rock layers is like piecing together a jigsaw puzzle. The law of superposition helps scientists to do this.

The idea that layers of rock have to be in place before anything can disturb them is also used. The law of crosscutting relationships states that a fault or a body of rock, such as an intrusion, must be younger than any feature or layer of rock that the fault or rock body cuts through. For example, if a fault has broken a rock layer, the fault is younger than the rock layer. If a fault has broken through igneous rock, the igneous rock must have been in place, and cool, before it could have been broken. The same is true for an unconformity. Look at the image below and use the laws of superposition and crosscutting relationships to figure out the relative ages of the rock layers and features.

Visualize It!

- 13 Analyze** What is the order in which layers and features A through J formed? Fill in the lines according to the relative ages of the layers or features.



Youngest

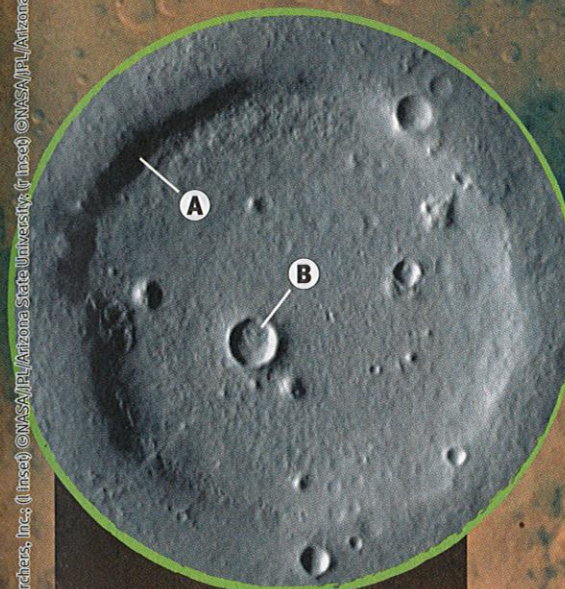
Oldest

Why It Matters

Dating Mars

WEIRD
SCIENCE

NASA's *Mars Odyssey* orbiter and the *Hubble Space Telescope* have produced a large collection of images of the surface of Mars. These are studied to find the relative ages of features on Mars, using the laws of superposition and crosscutting relationships. Here are two examples of crosscutting relationships.



Crater in a Crater
A crater (A) can be cut by another crater (B) that formed from a later impact.



The Crater Came First
A crater can be cut by another feature, such as a fracture.

Hellas Crater

The many craters on Mars are studied to determine relative ages of features. This is Hellas Impact Basin, which is almost 2100 km wide.

Extend

- 14 Analyze** What are the relative ages of crater A and crater B? Explain your answer.
- 15 Apply** How can scientists use erosion as a way to determine the relative ages of craters on Mars? Describe how erosion could change the appearance of a crater over time.

- 16 Research** Find out how scientists have used relative dating to study the geologic history of other planets, such as Venus. Present what you found out by drawing a graphic novel or making a poster.

Inquiry

So Far Away

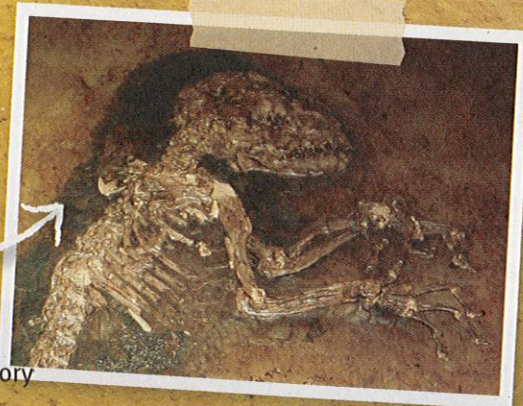
How are fossils used to determine relative ages of rocks?

Fossils are the traces or remains of an organism that lived long ago, most commonly preserved in sedimentary rock. Fossil forms of plants and animals show change over time, as they evolve. Scientists can classify fossilized (FAHS•uh•lyzd) organisms based on these changes. Then they can use that classification of fossils to find the relative ages of the rocks in which the fossils are found. Rock that contains fossils of organisms similar to those that live today is most likely younger than rock that contains fossils of ancient organisms. For example, fossilized remains of a 47 million-year-old primate are shown below. Rock that contains these fossils is younger than rock that contains the fossils of a dinosaur that lived over 200 million years ago.

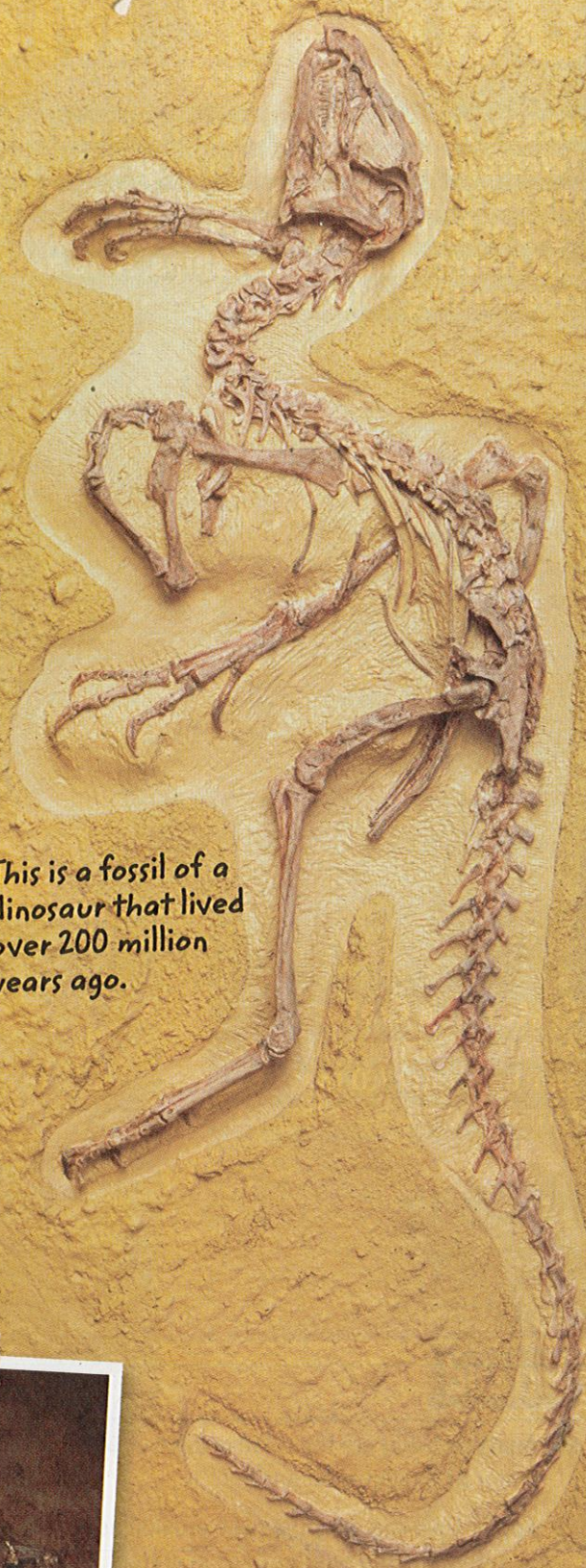
Inquiry

17 Explain In general, would fossils of species that did not change noticeably over time be useful in determining the relative ages of rocks? Explain.

This is a fossil of a primate that lived about 47 million years ago.



This is a fossil of a dinosaur that lived over 200 million years ago.



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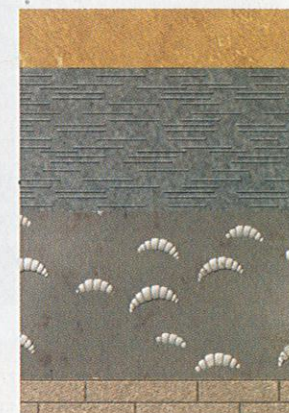
How are geologic columns used to compare relative ages of rocks?

Relative dating can also be done by comparing the relative ages of rock layers in different areas. The comparison is done using a geologic column. A **geologic column** is an ordered arrangement of rock layers that is based on the relative ages of the rocks, with the oldest rocks at the bottom of the column. It is made by piecing together different rock sequences from different areas. A geologic column represents an ideal image of a rock layer sequence that doesn't actually exist in any one place on Earth.

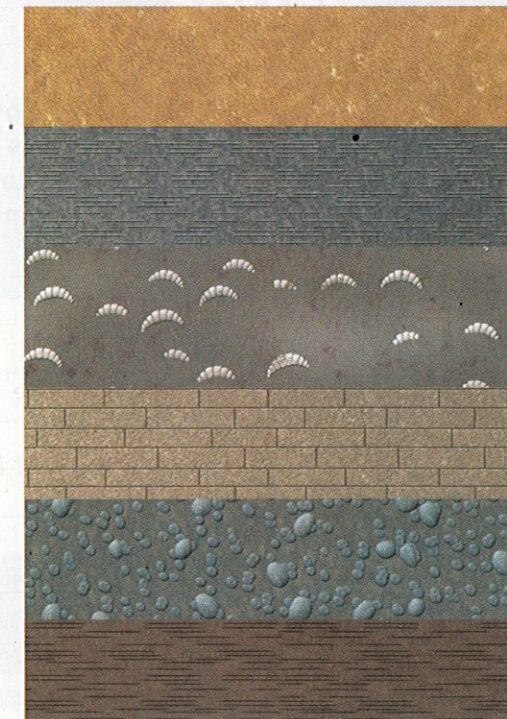
The rock sequences shown below represent rock layers from different outcrops at different locations. Each has certain rock layers that are common to layers in the geologic column, shown in the middle. Scientists can compare a rock layer with a similar layer in a geologic column that has the same fossils or that has the same relative position. If the two layers match, then they probably formed around the same time.

Visualize It!

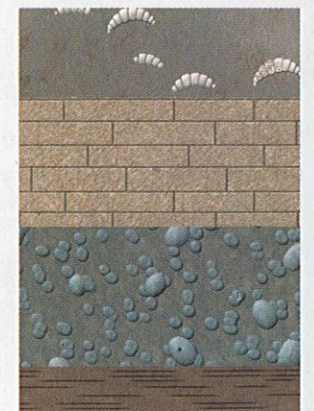
19 Identify Draw lines from the top and bottom of each outcrop to their matching positions in the geologic column.



Outcrop 1



Rock layers from different outcrops can be compared to a geologic column.



Outcrop 2

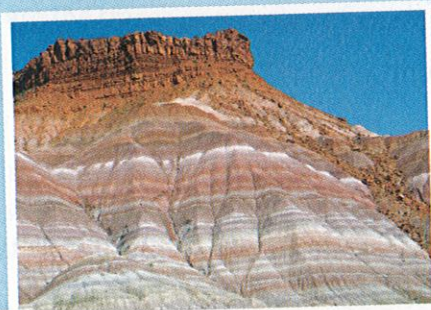
Active Reading

18 Identify As you read, underline the description of how rock layers are ordered in a geologic column.

Visual Summary

To complete this summary, circle the correct words. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

If undisturbed, sedimentary rock exists as horizontal layers.



20 For undisturbed rock layers, younger rocks are above/below older rocks.

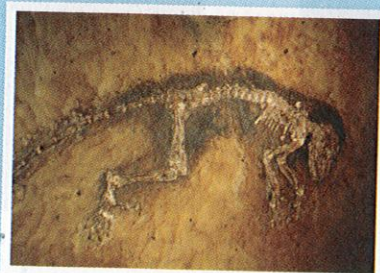
Forces in Earth can cause horizontal layers of rock to be disturbed.



21 This photo shows folding/tilting.

Relative Dating

Fossils can be used to determine the relative ages of rock layers.



22 In undisturbed rock layers, fossils of a more recent organism will be in rock that is above/below rock containing fossils of older organisms.

Rock layers from different areas can be compared to a geologic column.



23 In geologic columns, the oldest rock layers are at the bottom/top.

24 **Apply** How might the law of superposition relate to a stack of magazines that you have been saving over the past few years?

Lesson Review

Lesson 2

Vocabulary

In your own words, define the following terms.

1 relative dating

2 unconformity

Key Concepts

3 **Describe** How are sedimentary rock layers deposited?

4 **List** Name five ways that the order of rock layers can be disturbed.

5 **Explain** How are the laws of superposition and crosscutting relationships used to determine the relative ages of rocks?

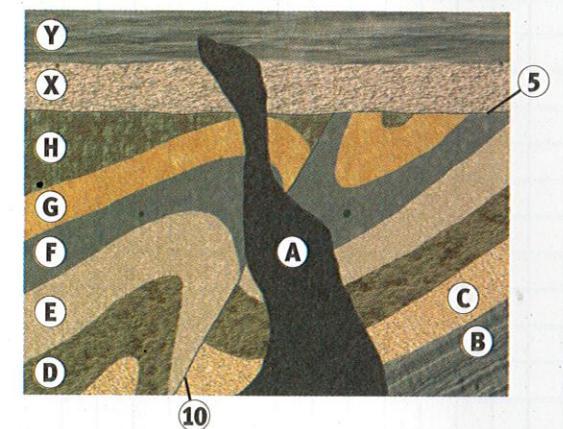
6 **Explain** How can fossils be used to determine the relative ages of rock layers?

7 **Describe** How is the geologic column used in relative dating?

Critical Thinking

8 **Justify** Does the law of crosscutting relationships involve sedimentary rock only? Why or why not?

Use this image to answer the following questions.



9 **Analyze** Is intrusion A younger or older than layer X? Explain.

10 **Analyze** What feature is marked by 5?

11 **Analyze** Other than intrusion and faulting, what happened in layers B, C, D, E, F, G, and H?