Chapter 7

The Ocean on Top of a Mountain

Topics

- Geological dating
- Burgess Shale
- Mountain formation

Reading Strategy

- Finding the meaning of new words

Lesson Objectives: Connecting to National Standards

The following list shows the *Next Generation Science Standards* (*NGSS*) and *Common Core State Standards* (*CCSS*) supported by this activity.

NGSS: *Science and Engineering Practices*

- Developing and Using Models
- Constructing Explanations and Designing Solutions

NGSS: *Disciplinary Core Idea*

- **ESS1.C.** The History of Planet Earth

NGSS: *Crosscutting Concepts*

- Systems and System Models
- Patterns

CCSS: *Literacy in Science and Technical Subjects*

- **CCSS.ELA-Literacy.RST.6-8.4.** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.
- **CCSS.ELA-Literacy.WHST.6-8.2.** Write informative/explanatory texts, including the narration of historical events, scientific procedure /experiments, or technical processes.
- **CCSS.ELA-Literacy.WHST.6-8.2.c.** Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.

Background

Landforms develop and change over time, but they retain traces of their earlier structures. Geologists use those traces to piece together the story of the Earth's past. In this chapter, students will simulate the "life" of a mountain and then think about what traces of each stage of the mountain's life are present at the end of the simulation. Then they will read about the Burgess Shale and how scientists used the clues in the mountain to date the fossils and determine how marine fossils ended up near the top of a group of mountains.

SAFETY NOTE
Scissors and even shells could potentially cut someone. Use your good sense with these items. Have students wash hands after handling shells if the shells haven't been sanitized.

Materials (Per Group)

- 7–10 small shells (can be reused)
- 7–10 small shells that have been colored with a permanent marker (can be reused)
- 7–10 dried beans (can be reused)
- Colored construction paper (four colors, one or two sheets of each)
- Scissors
- Roll of tape or glue dots

Student Pages

- The Story of a Mountain (lab sheet)
- "Dating the Burgess Shale" (article)
- Reading the Rocks at the Grand Canyon (thinking visually)

Exploration/Pre-Reading

Before class, gather the materials for each group. You will need to color or dye some of the small shells to differentiate them. Begin by dividing students into groups of four. Groups can work through the simulation at their own pace.

Introduce the Reading. Tell students that they are going to read an article that will take them all the way back to the Cambrian era to explore a famous group of ocean fossils found on a mountain. The Royal Ontario Museum and the Yoho National Park (both in Canada) each have two- to three-minute videos that introduce the Burgess Shale. You could show one of them to set the stage for the article.

Reading Strategy: Finding the Meaning of New Words

Note that this strategy was first introduced in Chapter 5 (p. 45). If you have not used Chapter 5, introduce the strategy according to the instructions found on page 48 instead.

If your students have already been introduced to the strategy, begin by asking them if they can remember some of the ways that science books give definitions of new words. List their answers on the board and add any they may have forgotten (see Table 2.1, p. 16).

Next, explain that not all words are defined in the text. Sometimes a writer uses a word and doesn't give the definition. In those cases, you try to figure out a "good enough" definition. Post the following sentences:

An Anomalocaris *was also on the hunt. It reached down with its strong, armored tentacles and grabbed the trilobite. The* Anomalocaris *tried to shove the struggling trilobite into its mouth.*

Ask students what they think an *Anomalocaris* and a trilobite might be, and have them give the clues they are using. Here are some possible answers:

- *Anomalocaris* is some kind of animal because it is hunting.
- It might be like an octopus because it has tentacles. (*Note*: It's not actually related, but that is a reasonable guess based on the clues in the passage).
- *Anomalocaris* is a scientific name because it is in italics.
- Trilobites are something the *Anomalocaris* eats, because it is being shoved into the *Anomalocaris*'s mouth.
- Trilobites are also animals because this one is described as "struggling."

At this point, students probably don't have a clear picture of what an *Anomalocaris* is, but they know *enough* to keep reading. Ultimately, this article isn't about an *Anomalocaris*—it's about dating a fossil find. Therefore, the clues above tell them *enough* to understand the point of the article.

Note that there may be other words in the passage that students don't know, such as tentacles. See if they can figure out enough to keep reading (in this case, that tentacles are something an *Anomalocaris* has that lets it grab another animal). It can be very freeing to students to realize they don't really have to know a word completely to understand *enough*.

Journal Question

Do you ever have trouble remembering the meaning of a new word after you read it? What could you do while reading to help you keep up with the new words you are learning?

> ***FIND OUT MORE***
> To learn more about the Burgess Shale, check out the Burgess Shale pages from the Royal Ontario Museum at *http://burgess-shale.rom.on.ca/en* or the book
> - Morris, S. C. 1999. *The crucible of creation: The Burgess Shale and the rise of animals.* Oxford: Oxford University Press.

Application/Post-Reading

- Thinking Visually: Reading the Rocks at the Grand Canyon
- Writing Prompt: Write a paragraph that explains the difference between an absolute age and a relative age. Give an example of each from geology and then give an example of how you could describe how long you've been alive using a relative age and an absolute age.
  - Prewriting questions: What science words will you need? What writing words could you use? (compare and contrast words such as similarly, in contrast, however, etc.). You may need to help students brainstorm ways to give their relative age (older than one sibling, younger than another; older than the iPad, younger than cell phones, etc.).
  - Key Evaluation Point: Relative ages tell how old things are in comparison to each other, whereas absolute ages give dates for when a rock (or person!) was formed.

The Story of a Mountain

Decide which group member will hold each job. Write your job title at the top of your paper.

Jobs

Narrator: Reads the story that describes what happens to your model

Builder: Builds the land up

Eroder: Erodes and weathers your land

Fossilizer: Leaves traces of life

Work through the story below, with each group member doing their part. Answer the questions on your own paper.

Narrator: Once upon a time, there was an ancient ocean.

(**Builder**—*Lay one color of paper on the table to represent the ocean floor.*)

Narrator: Lots of different kinds of animals with shells lived in the ocean. When they died, their shells collected on the bottom.

(**Fossilizer**—*Sprinkle shells over the paper and tape them down.*)

Narrator: After several million years, the tectonic plate holding the ocean shifted. The water in this part of the ocean became shallower. Coarse rocks washed into the ocean and covered up the old ocean floor.

(**Builder**—*Place a different color of paper on top of the shells to represent the rock layer.*)

Narrator: At this time, there were some special animals living in the shallow edge of the ocean. They only existed for a few thousand years and then died out.

(**Fossilizer**—*Tape the colored shells onto the second paper.*)

Narrator: Early in Earth's history, there were many more volcanoes than there are now. One erupted near here, and lava covered what was left of the water in this area.

(**Builder**—*Add a third layer of paper to the pile to represent the lava layer.*)

Narrator: The lava filled up the ocean so it became land. Small land animals lived there. Some of their skeletons were preserved in the rock.

(**Fossilizer**—*Tape the beans onto the lava layer.*)

Narrator: An ice age hit. A big glacier slid across this area, stripping off some of the rock as it came through.

(**Eroder**—*Cut off half of the paper that was just put down, including any beans that are on it.*)

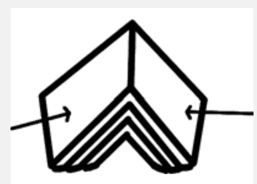
Narrator: Over the next several million years, bits of dirt and rock from a nearby mountain washed down in rainstorms over this area. Layers of sediment formed over the lava. Pressure converted the sediment into sedimentary rock.

(**Builder**—*Cover the top layer with the last piece of paper.*)

Everyone: *Pause to do the following on your own paper:*

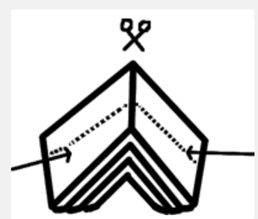
1. Draw your landscape. Label the colors for each layer and where to find each type of fossil (shells, colored shells, beans).
2. Draw a squiggly line to show where some of the rock is "missing" due to the glacier. Here, the two layers that are next to each other don't follow each other exactly in time. Geologists call this an unconformity. Write "unconformity" next to your squiggly line.
3. Label the layer that holds the *oldest* rock and the *oldest* fossils.

Narrator: The tectonic plates are on the move. Two plates have collided, and this part of the Earth was squished.



(**Builder**—*Press the two sides of your model together until it folds up in the middle to form a mountain. Make a tight crease across the top of the "mountain" to make a fold that will stay.*)

Narrator: A mountain has formed! And almost immediately, a river forms, because water runs off the mountain when it rains. The movement of the water gradually wears down a valley in the middle of the mountain range.



(**Eroder**—*Use the scissors to cut across the middle of the crease at the top of the mountain. The cut should go through all the layers. Separate the two sides of the mountain so that you can see the inside.*)

Everyone: *Pause to do the following on your own paper:*

4. Imagine you are on a raft on the river at the bottom of the valley. Draw what you would see looking up at one side of the mountain. Label the oldest and youngest layers, and the position of each group of fossils.

Narrator: The weather patterns in the area mean that erosion is worse in one area of the mountain. It happens to be the same place that the glacier went through millions of years before.

(**Eroder**—*Cut away part of the top layer of paper over the spot where you have an unconformity. You should now be able to see the layer with the colored shells.*)

Everyone: *Answer the following on your own paper:*

5. Imagine you are hiking this mountain with your friend and see one of the colored shells. She asks, "How did a fossil shell get on top of a mountain?" What do you tell her?

REMEMBER YOUR CODES

! This is important.

✓ I knew that.

X This is different from what I thought.

? I don't understand.

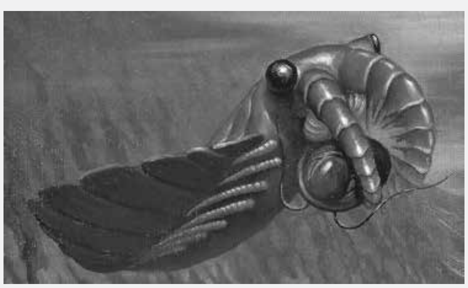
Dating the Burgess Shale

In the mud at the bottom of a tropical ocean, by the base of an underwater cliff, a squishy worm wiggled in its burrow. The wiggle was a mistake, though, because a trilobite was hunting nearby. The trilobite snatched the worm from its burrow and began to eat.

A shadow passed overhead. An *Anomalocaris* was also on the hunt. It reached down with its strong, armored tentacles and grabbed the trilobite. The *Anomalocaris* tried to shove the struggling trilobite into its mouth. But it was too slow.

Something disturbed the mud at the top of the cliff above them. Mud poured down in an underwater landslide, and everything, including the *Anomalocaris,* the trilobite, and the burrowing worm, was instantly smothered.

Artist's representation of *Anomalocaris* with a trilobite



Fast Forward

Half a million years later, Charles Walcott, his wife Helena, and their 13-year-old son were walking through the Canadian Rocky Mountains. Walcott was a paleontologist, and they were on their way home from a fossil hunt. They stopped by a ridge between two peaks and broke open a rock. Walcott knew they had found something special. Usually, only the hard parts of animals become fossils. But here was the fossil of a squishy worm. Walcott looked around. The rocks had fossils of trilobites, *Anomalocaris,* and other animals with hard parts. But they were also full of the fossils of animals with soft bodies. He named the area the Burgess Shale. As soon as possible, he came back with a team to excavate the area.

Location of the Burgess Shale

To understand the fossils coming out of the Burgess Shale, scientists needed to know the story of the place where they were found. How old were the rocks and the fossils they contained?

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Reading the Rock

The Burgess Shale fossils are preserved in sedimentary rock. It formed when layers of mud were compressed into rock. If an area of sedimentary rock hasn't been moved, then the oldest layers are at the bottom and

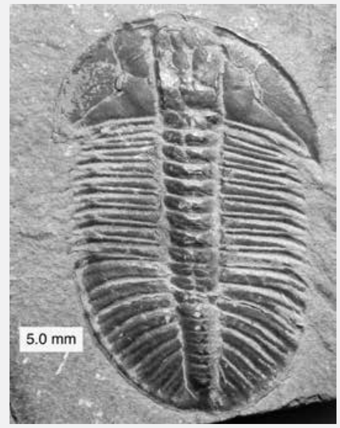
the most recent layer is on top. By comparing layers, you can tell which rocks and fossils are older, but you can't tell exactly how old each layer is.

The oldest layers are at the bottom.

The rocks of the Burgess Shale have been moved by plate tectonics. A huge section of rock was shoved up and across North America as two plates collided, forming the Rocky Mountains. So the layers of the Burgess Shale are located partway up a mountain. However, within the slab of rock that was moved, the sedimentary layers go from oldest to youngest.

The fossils themselves can also provide clues to their age. Some fossils are found all over the world but only within a short range of time. For example, there are many fossils of the trilobite *Elrathina* found in North America. They all come from rocks formed during the Middle Cambrian period. Therefore, when new fossils of *Elrathina* show up, scientists can make a good guess that those rocks are also from the Middle Cambrian. Fossils that help determine the age of rocks are called index fossils. *Elrathina* is one of several index fossils found in the Burgess Shale.

Trilobite fossil from the Burgess Shale



Making a Date

Sedimentary rock layers and index fossils help scientists determine if rocks are younger, older, or about the same age as other rocks. This is called a relative age. But to find out how many years old a fossil is, called the absolute age, scientists need an igneous rock. Igneous rocks contain small amounts of radioactive atoms. Radioactive atoms are unstable and break apart. Fortunately, they break apart at a steady, predictable pace. Scientists can test for how much radioactive material is left and figure out how long ago the rock formed. It's as if you bought a pack of gum and chewed one piece each day. You could figure out what day you bought the pack by looking at how many pieces were missing.

There are no layers of igneous rock in direct contact with the layers of the Burgess Shale. However, there are igneous layers some distance above and below the shale. The lower layer dates to 542 million years ago. The upper layer dates to 488

million years ago. So the Burgess Shale must be between 488 million and 542 million years old. By comparing the index fossils and sedimentary layers to other places where similar fossils and sedimentary layers have been found, geologists estimate that the Burgess Shale was formed between 505 million and 510 million years ago.

Life in the Cambrian Period

That date places the fossils firmly within the Cambrian period. Somehow, the mudslides from the underwater cliff had preserved soft and hard-bodied animals in more detail than anyone had seen before. These amazing fossils revolutionized our understanding of life during the Cambrian. The Burgess Shale is so rich in fossils that even after a hundred years of excavation, there are still more fossils, and more clues to life in the Cambrian, to be found.

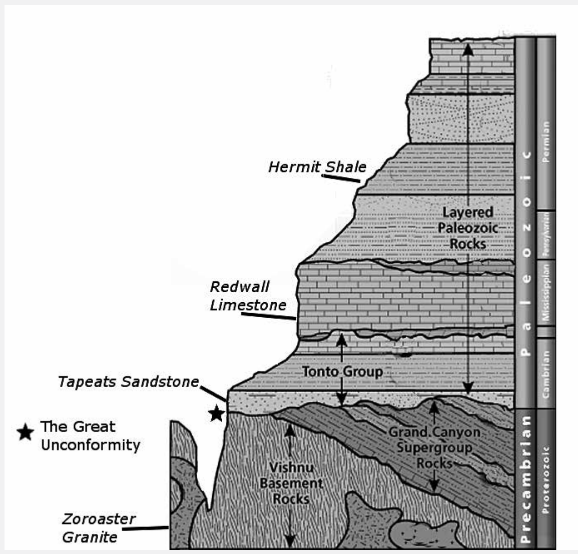
THE BIG QUESTION

List three kinds of evidence from the article that scientists use to determine the age of layers of rock.

Reading the Rocks at the Grand Canyon

The diagram below shows the layers of rock that are exposed along the sides of the Grand Canyon in Arizona. Although all of the layers have names, only a few are labeled here. Use the diagram below to answer the questions.

Layers of the Grand Canyon



1. Four layers are listed in italics. Name those layers in order from youngest to oldest.

2. Considering the label "Great Unconformity," what can you tell about the rock layer just below the Tapeats Sandstone?

3. The layers below the Great Unconformity are tilted. What kind of forces could have caused them to tilt?

4. The Zoroaster Granite formed when magma pressed upward into the Vishnu Basement Rocks and then cooled into rock. Which must be older, the Zoroaster Granite or the Vishnu Basement Rocks?