

Session 5.

When Continents Collide

From the volcanoes that encircle the Pacific Ocean in the “ring of fire” to the peaks of the Himalayas at the “top of the world,” mountains are perhaps Earth’s most dramatic landforms. Can we find a pattern in how and where mountains form? In this session, we build upon our understanding of plate tectonics to take a closer look at the connection between plate boundaries and mountain formation. In the process, we continue our exploration of rocks and the stories they can tell.

The Video

The video opens with a mystery: How is it possible that marine fossils are found on the world’s highest continental mountain, Mount Everest? To answer this question, we join geologist Dr. Keith Klepeis on a forensic rock investigation in Vermont. He helps us examine some of the features in rocks that provide evidence of the geological history of a location. From this evidence, we reconstruct the events that led to the formation of the Appalachian Mountains. We then apply this understanding to the formation of other mountain ranges, and in doing so solve our marine fossil mystery.

Throughout the video, we watch children being interviewed as they explore their ideas about the forces that can fold rock, how mountains form, and our Mount Everest marine fossil mystery. We visit science consultant Duke Dawson and the fifth graders at The Goddard School of Science and Technology in Worcester, Massachusetts as they construct a model for mountain building. We listen as they discuss their ideas about the different shapes that characterize the Earth’s surface, called landforms, and the forces that sculpt them. We observe them grappling with the question of how mountains form, and follow their work as they manipulate dough and wood models representing colliding continents.

Learning Goals

During this session, you will build understandings to help you:

- Relate plate tectonics to the formation of mountains
- Describe two ways that mountains can form at convergent plate boundaries

On-Site Activities

Getting Ready (60 minutes)

Activity One—Problem Set and Reading Discussion (20 minutes)

1. In small groups, review the questions from the problem set for Session 4. You will discuss the question about mountain formation again after viewing the video.
2. With a partner, review and discuss each other's concept maps for volcanoes.
3. Next, think about what you know about mountains. Discuss how or where this topic might connect to your map.
4. Session 4's homework asked you to read the article "Some Comments on Children's Ideas About Earth Structure, Volcanoes, Earthquakes, and Plates" and to identify several of the children's ideas about tectonic plates, volcanoes, and earthquakes that compare to your own or are prevalent among your students, and then to describe a teaching strategy that could be used to challenge each of these ideas. As a whole group, discuss these ideas and strategies.

Activity Two—Models of Plate Convergence (20 minutes)

1. To prepare for today's session, you were asked to apply what you learned about plate tectonics in Session 4 to construct a model of what happens at a convergent plate boundary where oceanic crust meets continental crust. You were asked to write an explanation of what is happening in your model. In your small group, take turns manipulating each model and sharing your written explanations, focusing on the process of mountain building.
2. With your group, decide which model most accurately represents the details of this type of plate convergence. As needed, write a new explanation based on this model, reflecting any revisions that might be made to make the model more accurate.
3. Reconvene as a whole group and share the models chosen by each small group. From these models, generate a list of statements that best describe the details of mountain building at this type of convergent plate boundary. You'll refer to this list again after viewing the video.

Facilitators: Distribute the playdough and waxed paper to the group.

Activity Three—Colliding Continents (20 minutes)

1. Rejoin your partner. Use the playdough to make two layered slabs that will represent continents. For each slab, start with a base layer approximately 10 cm x 10 cm in dimension. Add at least three different colored layers on top of each base. Each layer should be about 1cm thick. The number and order of layers need not be the same in each slab. Use a plastic knife to cut each slab in half. If you wish, you can vary the shapes of your half-slabs slightly to make them more realistic representations of continents. Put one continent made from each original slab aside for use after viewing the video.
2. Place a piece of waxed paper about 40 cm long on a flat surface. Cut two pieces of waxed paper to be slightly larger than each of your continents. Place these two pieces at opposite ends of the larger piece of waxed paper. Then, place a continent onto each of the smaller pieces. You now have continents that are ready to collide!
3. Before you enact a collision, discuss your model with your partner.
 - What do the layers in your continents tell you about their histories?
 - Would you expect layering to be the same in different continents? Why or why not?
 - What do the smaller pieces of waxed paper represent? The larger piece?
 - What do you think might happen if real continents were to collide?
 - How can you use these materials to model this?

On-Site Activities, cont'd.

Use your materials to model a collision between continents. Make a sketch of the outcome. Using what you know about plate tectonics, write an explanation that accounts for the outcome. Do you think your model is realistic? What geological evidence on Earth's surface would help you find out? Where would you look for this evidence? You'll revisit your model and explanation after viewing the video.

Viewing the Program (60 minutes)

As you view the video, think about the following focus questions:

1. How can a marine fossil appear on Mount Everest, the tallest continental mountain?
2. How is the model of plate convergence you built and brought to today's session the same as, and different from, the model the fifth-grade students in the featured classroom are using to think about plate convergence?
3. In the science studio, Siddarth and Megan express their ideas about the kinds of forces that can bend rock. Listen for their ideas about how this can happen. How do their ideas compare to yours?

Going Further (60 minutes)

1. With a partner, spend a few minutes discussing the video:
 - What, if anything, surprised you?
 - How has your thinking about the characteristics of rock changed?
 - What forces can cause large masses of rock to fold, flow, bend, and break?
 - And what forces *cannot* cause this to happen?
2. Revisit the Problem Set you prepared for Session 4. With your partner, review your explanation of the ways that mountains can form. How has your thinking changed? What patterns, if any, are there to the formation of mountains? Together, write a new explanation of the ways that mountains can form. Discuss how this knowledge informs your understanding of how marine fossils can appear on the heights of Mount Everest.
3. What important ideas about plate tectonics and the history of mountain building on the Earth's surface were revealed in Dr. Keith Klepeis's description of how the Appalachian Mountains formed? Discuss these ideas with your partner. Recall the two different rock formations examined in the video.
 - What did the layers reveal about each formation?
 - How could two different patterns be a part of the same mountain-building event?
 - Of the three types of rock highlighted in this course, which do you think are the most useful in reconstructing geological events? Why?

Note: See the *Earth and Space Science* Web site to learn more about how the Appalachians formed (A Closer Look: The Appalachian Mountains) at www.learner.org/channel/courses/essential/earthspace/session5.

On-Site Activities, cont'd.

4. Return to your playdough model of a collision between continents. Apply your understandings of how the Appalachians and Himalayas formed to critique your model for its accuracy. Use the materials you set aside to create a new model, reflecting what you've learned. If you could improve something about this model (e.g., the materials or the procedures) to help others learn about this example of mountain building, what would it be?
5. Reconvene your small group. Refer to the model that you chose during Activity Two as the best representation of what happens when oceanic crust meets continental crust at convergent plate boundaries. Compare it to your playdough model. Both of these models portray mountain-building events at convergent plate boundaries. What makes the second model different from the first? Use what you understand about the nature of plates and plate tectonics to account for the differences.
6. Finally, as a whole group, revisit your list of statements from Activity Two that describe the details of mountain building when oceanic crust converges with continental crust. Together, generate a list of statements that describe the details of mountain building when two plates carrying continental crust collide. The two lists should allow you to compare and contrast these two mountain-building events. Individuals may wish to record each list and make sketches to keep as part of their own class materials. Finish this session by considering the following questions:
 - Where on Earth would you expect to find additional examples of these two types of mountain-building events?
 - What plate convergence scenario have we left out?
 - What do you think might happen at this type of convergent plate boundary?
 - Where on Earth's surface might you look for evidence of its existence?

Between Sessions

Homework (* = required)

* Reading Assignment

Broadstock, M.J. "Children's Understanding of Earth Systems Phenomena in Taiwan." The Third International Seminar on Misconceptions and Educational Strategies on Science and Mathematics, Misconceptions Trust, Ithaca, NY: 1993.

Think about the ideas in the article that you think are most useful in teaching about mountains.

* Problem Set

(Suggested answers are listed in the Appendix.)

1. Is it possible for more than one type of mountain-building event to occur at a single convergent plate boundary? For this session, you created two models. One portrayed a collision between a plate carrying oceanic crust and a plate carrying continental crust, and the other portrayed a collision between two plates carrying continental crust. Use what you understand about plate tectonics to construct a scenario where one collision is followed by the other. What are the possibilities that this has happened during Earth's history? What geological evidence would you look for?
2. One of the rocks that Dr. Klepeis investigated at Clay Point in Vermont was a metamorphic rock. Make a chart comparing the characteristics of sedimentary, igneous, and metamorphic rocks and the processes that form them. Be sure to bring this chart to the next session.

Note: See the *Earth and Space Science* Web site to learn more about metamorphic rocks (A Closer Look: Metamorphic Rocks) at www.learner.org/channel/courses/essential/earthspace/session5.

3. At this point in the course, we have discussed the three main types of rocks found on Earth. Over immense time scales, rock can change from one type to another. The "engine" of plate tectonics can be envisioned as a giant conveyor belt that recycles Earth's materials as the matter that makes up rocks is redistributed and transformed from one rock type to another. The relationship between igneous, sedimentary, and metamorphic rocks is known as the rock cycle. Using only course materials, make a diagram that represents how you think this cycle works. After creating your diagram, consult another resource (e.g., your college-level textbook or the Web) and study how the rock cycle is depicted. Create a second diagram that integrates any new information from the resource that you used. Write a few sentences explaining the processes represented in your final diagram.

* Ongoing Concept Mapping

Develop a concept map around the concept of "mountains." Reflect on the content of the video and the site investigation activities to identify major concepts that could be included in your map. Provide as many details and connections as you can for each concept. Be sure to incorporate what you have learned about the tectonic processes involved in mountain formation.

Guided Journal Entry

During this session, the Himalayas were examined as an example of mountain formation on land. In Session 4, an underwater example was featured: the seamounts of the Hawaiian-Emperor Seamount Chain. Both of these examples represent the tallest mountains of their kind. What else do these two examples of mountain building have in common? What distinguishes them? In your journal entry, compare and contrast mountain formation as it applies to the Himalayas and the Hawaiian-Emperor Seamount Chain. How are both evidence of plate tectonics?

Between Sessions, cont'd.

Guided Channel-Talk Posting

It is likely that many of your students can tell you about the tallest mountain on Earth: Mt. Everest. What do you think they know about how mountains form? Devise a set of interview questions that will help uncover their ideas. Ask several students these questions (or if school is not in session, ask several people you know). Share their answers with your colleagues in this Channel-Talk posting. What seem to be common but inaccurate ideas about how mountains form? What strategies do you think might help build more accurate scientific understandings? Be sure to share any experiences you've had.

Suggestions for Textbook Reading

- Mountains and mountain belts
- Causes and processes of mountain building
- Metamorphic rock
- Metamorphic settings
- Mountains and rock deformation
- Faulting and folding of rock
- Processes of metamorphism
- Classification of metamorphic rock

* Preparing for the Next Session

For "Getting Ready"

1. Our hosts, Britt and Joe, pose an interesting question at the end of this session's program: If most mountains around the world form in the same way, why do they look different? Brainstorm and list ideas for their differences in appearance.
2. In this session, we focused on how mountains form. But mountains are only one kind of landform. What are some other kinds of landforms? Make a list of other landforms. How do they form? Choose one type of landform, and write a description of how it might have formed.

Materials Needed for Next Time

Facilitator:

- Magnifying glass (1 per pair)
- Plastic container with lid (1 per pair)
- Waxed paper (80 cm per pair)
- Broadsheet newsprint paper (18-in.x 24-in.) (1 sheet per pair)
- Sand (1/4 cup per pair)
- Ice cubes (approximately 2 per pair)

All participants:

- Your rocks, unanswered questions, and classification schemes from Session 2
- Your responses to items one and two from For "Getting Ready"

Graduate Credit Activities

Continue your work on the annotated bibliography and action research project.