Session 4.

The Engine That Drives the Earth

What do the lush, tropical islands of Hawaii have in common with the barren, cool summits of the Cascade Mountains in the northwestern United States? Both provide dramatic evidence of plate tectonics in the form of volcanoes and earthquakes. In this session, we investigate how these phenomena are connected to the movement of plates. As we examine what happens at and between plate boundaries, our focus shifts to the mechanisms deep within the Earth that drive what we observe at its surface.

The Video

The beautiful islands of Hawaii harbor a mystery. Evidence found on each of the eight major islands indicates that they all grew from the sea floor by volcanic eruptions. Yet, when visiting Hawaii today, we can see that only one of the islands is home to an active volcano. What happened? What shut down the other Hawaiian volcanoes? And what does this tell us about how the Earth functions?

We join volcanologists Dr. Dave Sherrod and Dr. Chuck Blay to investigate the nature of volcanoes and volcanic eruptions. Our hosts, Britt and Joe, along with geophysicist Dr. Michael Manga, invite us to use everyday items like a can of soda to understand the forces involved. Our focus shifts to examine how tectonic plates move relative to one another and what happens when plates interact at their boundaries. Geologist Dr. Keith Klepeis describes one famous example—the San Andreas Fault in California—as we consider the causes and effects of earthquakes. Then, the mystery of the extinction of the Hawaiian volcanoes is unraveled as our scientists weigh evidence supporting the hotspot story of Hawaii's formation. Finally, Dr. Andy Kurtz introduces us to Hawaii's newest volcano, which is still underwater. These explorations ultimately lead us to theorize about the mechanisms of plate movement.

During the program, interviews with students uncover their ideas about volcanoes. We visit Ariel Owen's sixth graders at the Foothills Middle School in Walnut Creek, California, and listen in as they discover the connections between plate boundaries and the occurrence of volcanoes and earthquakes using a computer-based curriculum.

Learning Goals

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

- Compare and contrast different types of volcanoes and volcanic eruptions
- Relate the occurrence of volcanoes and earthquakes to the location of plate boundaries
- Describe the nature of plate boundaries and how plates move relative to one another
- Appreciate how knowledge of volcanoes and earthquakes can inform our understandings of the mechanisms underlying plate tectonics

On-Site Activities

Getting Ready (60 minutes)

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

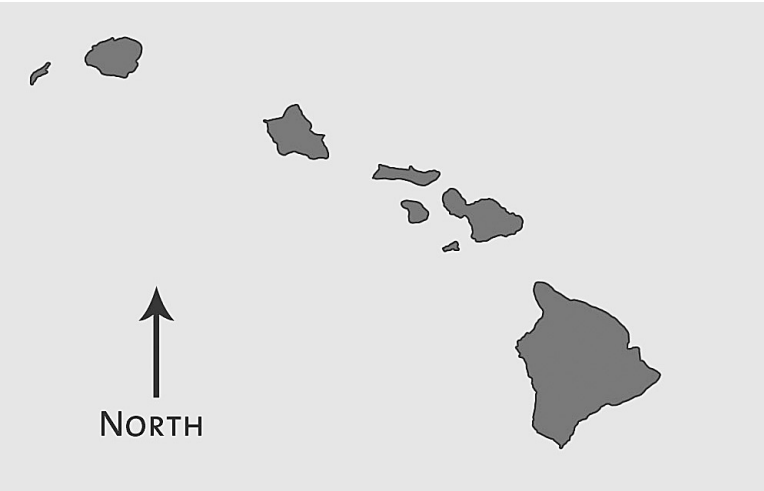
1. Working in small groups, review the questions from the problem set for Session 3.
2. With a partner, review and discuss each other's concept maps for Earth's interior.
3. Next, think about what you know about volcanoes. Discuss how or where this topic might connect to your map.
4. Session 3's homework asked you read the article titled "The Earth's Mantle Is Solid: Teacher's Misconceptions About the Earth and Plate Tectonics," to identify two teacher ideas that compare to your own or are prevalent among your students, and to define a question about the related content and try to answer it. Each group member should share the ideas identified from the reading and the accompanying content questions. As a whole group, discuss answers related to the content questions.

Activity Two—The Nature of Volcanoes (15 minutes)

1. To prepare for today's session, you were asked to draw a sketch of what you think a volcano looks like and to consider the following questions: What is a volcano, and how and where do they form? Share your work with your partner.
2. Next, discuss the following questions and record your ideas:
   - What causes volcanoes to erupt?
   - What happens during a volcanic eruption?
   - Are there different types of volcanoes, and if so, do they erupt in different ways?
   - What do volcanoes reveal about tectonic plates and the mechanisms driving their movement?

Activity Three—Hawaii, Land of Volcanoes (10 minutes)

Hawaii is home to the largest volcano on Earth: Mauna Loa. All of the Hawaiian Islands are volcanic in origin. There are volcanoes on each of the islands of Hawaii, yet only the southernmost island—the "big island," Hawaii—has *active* volcanoes. Using the diagram below as a reference, create a drawing with your partner that illustrates 1) how you think the islands of Hawaii formed and 2) why only one island contains active volcanoes. Create a brief written explanation to accompany your drawing.



On-Site Activities, cont'd.

Activity Four—Tectonic Plates and Their Boundaries (15 minutes)

In past sessions, you have observed that the Earth's surface is broken into distinct pieces called "plates." You may recall that each plate consists of a slab of oceanic crust, continental crust, or both, fused to a corresponding slab of rigid mantle—collectively referred to as the lithosphere. You may also recall that these plates move in relation to each other on top of another layer within the mantle called the asthenosphere, which is a partially molten layer of rock that flows. As plates move, their boundaries, or edges, interact with each other.

1. Reconvene your group. Together, look at World Map #1 (at the end of this session's materials), which identifies the plates and plate boundaries. Observe where the plate boundaries lie and write a brief description of your observations.
2. Next, look at World Map #2 (at the end of this session's materials). In this map, the oceans have been removed. What geologic features do you notice? Do any features seem to correspond with the boundaries of the plates? Compare the two world maps. What patterns exist between geologic features and plate boundaries? Record your ideas.
3. These two maps show how tectonic plates are arranged relative to one another. But what drives the movement of tectonic plates? Can you find a global pattern to plate arrangement and movement that suggests an underlying mechanism? As a group, discuss and record your theories about what drives plate movement.

Viewing the Program (60 minutes)

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

1. How can volcanoes and earthquakes help us understand what is driving plate tectonics?
2. The students in Ariel's sixth-grade class are trying to understand the connection between plate boundaries and the occurrence of volcanoes and earthquakes. As you watch the featured classroom, think about this question: Can earthquakes occur in places other than near volcanoes or plate boundaries?
3. The elementary school students interviewed seem to have similar ideas about what causes a volcano to erupt. Listen for their ideas. Do you agree or disagree?

Going Further (60 minutes)

1. In your group, spend a few minutes discussing the video. Did anything surprise you? Refer to your initial volcano sketch, definition, and explanations considered during Activity Two in Getting Ready. How have your ideas about volcanoes changed? Together, revise your explanations of how volcanoes form, why volcanoes erupt, and what happens during volcanic eruptions.
2. With your group, revisit the drawings and explanations you and your partner created of Hawaii's formation during Activity Three of Getting Ready. Discuss any changes you would make to reflect new understandings of plate tectonics. Next, revisit your initial ideas about where volcanoes form. If you could suggest a general rule for where volcanoes form, what would it be? Would the volcanoes of Hawaii be an exception to this rule? Why or why not?
3. Discuss the following questions with your group:
   - Why are earthquakes associated with volcanic eruptions and plate boundaries?
   - Can earthquakes occur in places other than near volcanoes or plate boundaries?
   - If so, how might these earthquakes differ from earthquakes that occur near volcanoes and plate boundaries?

On-Site Activities, cont'd.

4. Rejoin your partner. Refer to the two world maps you used during Activity Four in Getting Ready, and revisit your group's observations and ideas about the occurrence of geologic features in relation to plate boundaries. The video examined three different types of boundaries: convergent, divergent, and transform. Looking back at the world maps, see if you can locate the "ring of fire." Which kind of plate boundary is associated with it?
5. Today's session focused on geologic features and events associated with plate movement. With your partner, revisit your group's initial theories about what causes the plates to move. What evidence do volcanoes and earthquakes provide for a mechanism for plate movement? Is there a global pattern to plate arrangement and movement that suggests what causes them to move? Revise your ideas and create one or two general statements that reflect your understanding of what drives plate movement.

Between Sessions

Homework (* = required)

* Reading Assignment

Sharpe, J., Mackintoch, M., and Seedhouse, P. "Some Comments on Children's Ideas About Earth Structure, Volcanoes, Earthquakes, and Plates." *Teaching Earth Sciences* 20, no. 1 (1995): 28–30.

As you read, identify several children's ideas about tectonic plates, volcanoes, and earthquakes that compare to your own or are prevalent among your students. Describe a teaching strategy that you could use to challenge each of these ideas.

* Problem Set

(Suggested answers are listed in the Appendix.)

1. The oldest oceanic crust is about 200 million years old. The average age of continental crust is about 2 billion years old. Why is this? What does this tell us about the differences between plates topped by continental crust and plates topped by oceanic crust? How do the two types of plates interact?
2. Early in the video for Session 4, two types of volcanoes are compared. Scientists actually recognize several kinds of volcanoes. Research the different types of volcanoes and create a chart that outlines their general characteristics and differences.

Note: See the *Earth and Space Science* Web site to learn more about volcanoes (A Closer Look: Volcanoes) at www.learner.org/channel/courses/essential/earthspace/session4.

3. In the video, Dr. Dave Sherrod suggests that Earth's internal heat contributes to plate movement by generating convection currents. A convection current can be described as a current of hot, bouyant material that rises up through the mantle, cools, becomes dense and sinks back down. Other scientists suggest a more physical "push-pull" tectonic plate model, where subducting slabs pull plates down and spreading ridges push plates apart in a manner analogous to a conveyor belt. Could both of these ideas be accurate? Explain your answer.

Between Sessions, cont'd.

* Ongoing Concept Mapping

Develop a concept map for the concept "volcanoes." Reflect on the video and other session activities to identify key concepts to include in your map. Be sure to incorporate what you have learned about the connection between volcanoes and earthquakes and plate boundaries.

Guided Journal Entry

In Sessions 2, 3, and 4, we explored a theory that revolutionized the scientific community's understanding of geology: plate tectonics. Why is it considered to be a "unifying theory"? In your journal, write a few paragraphs explaining why you think the theory of plate tectonics offers a consistent and coherent explanation of how the Earth works. Give specific examples of geologic features and events that support your argument and describe the relationships among them.

Guided Channel-Talk Posting

Most scientific theories are built from observation. This is true both for scientists and elementary school students. The theory of plate tectonics has been built from observations of local phenomena (e.g., volcanoes and earthquakes) that indicate patterns at a global scale. Yet many students do not live in places where such observable phenomena occur. And, it's hard to appreciate the global patterns that exist (e.g., at plate boundaries) without simply displaying the information. In the video, the WISE computer-based curriculum represents one way of helping students make connections on their own, using data observed by scientists. What ideas do you have for introducing plate tectonics to students so that they can learn from observation? Discuss this in your Channel-Talk posting. Be sure to share any related experiences you've had in your classroom.

Suggestions for Textbook Reading

- Types of volcanoes and volcanic eruptions
- Faults and earthquakes
- Types of plate boundaries
- Geologic features and events associated with plate boundaries
- Mechanisms of plate movement
- Mantle plumes and hotspots
- Plate tectonic links to volcanoes and earthquakes

* Preparing for the Next Session

For "Getting Ready"

Recall the ways that tectonic plates interact, and reflect further upon what happens at the convergent plate boundaries examined in this session. Design and construct a working model of two plates converging at a subduction zone, and write an explanation of what is happening in your model.

Materials Needed for Next Time

Facilitator:

- Playdough in three different colors (1/2 cup in volume of each color per pair)
- Waxed paper (about 80 cm in length per pair)

All participants:

- Your model of a convergent plate boundary and written explanation of how it works

Graduate Credit Activities

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

World Maps

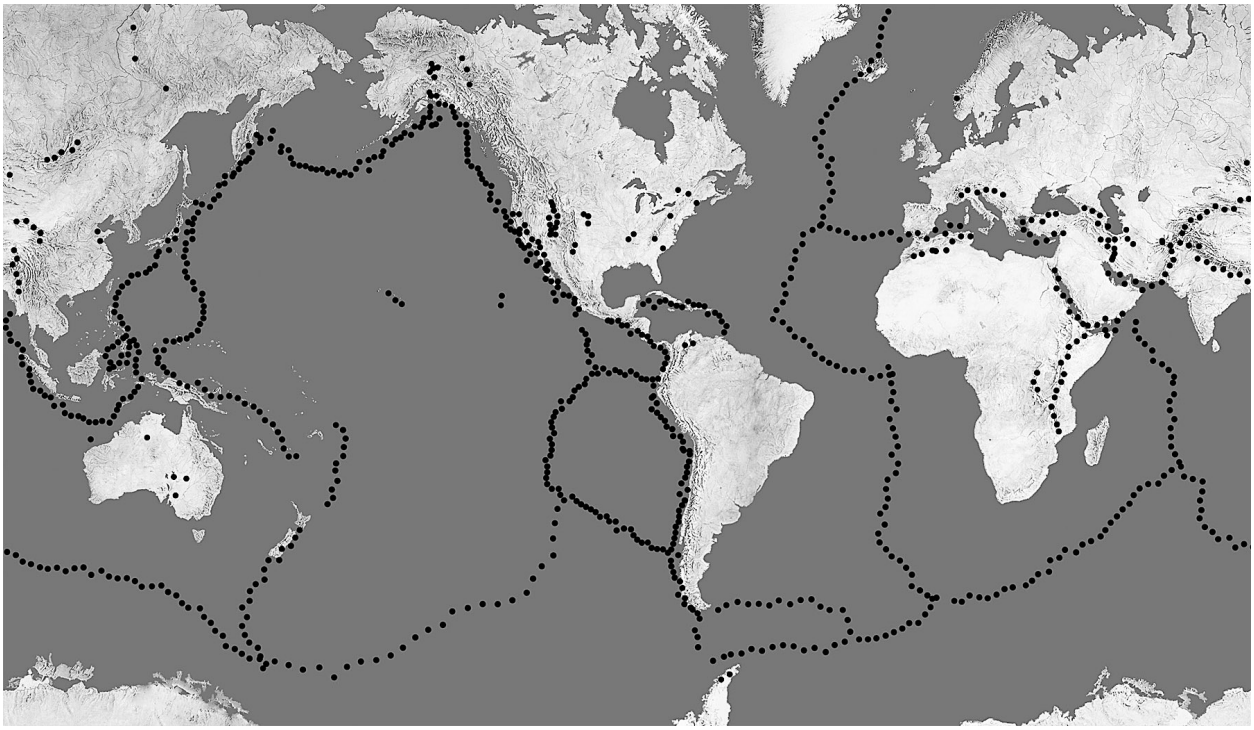


Figure 1: World Map #1
(world with plate boundaries indicated)

World Maps, cont'd.

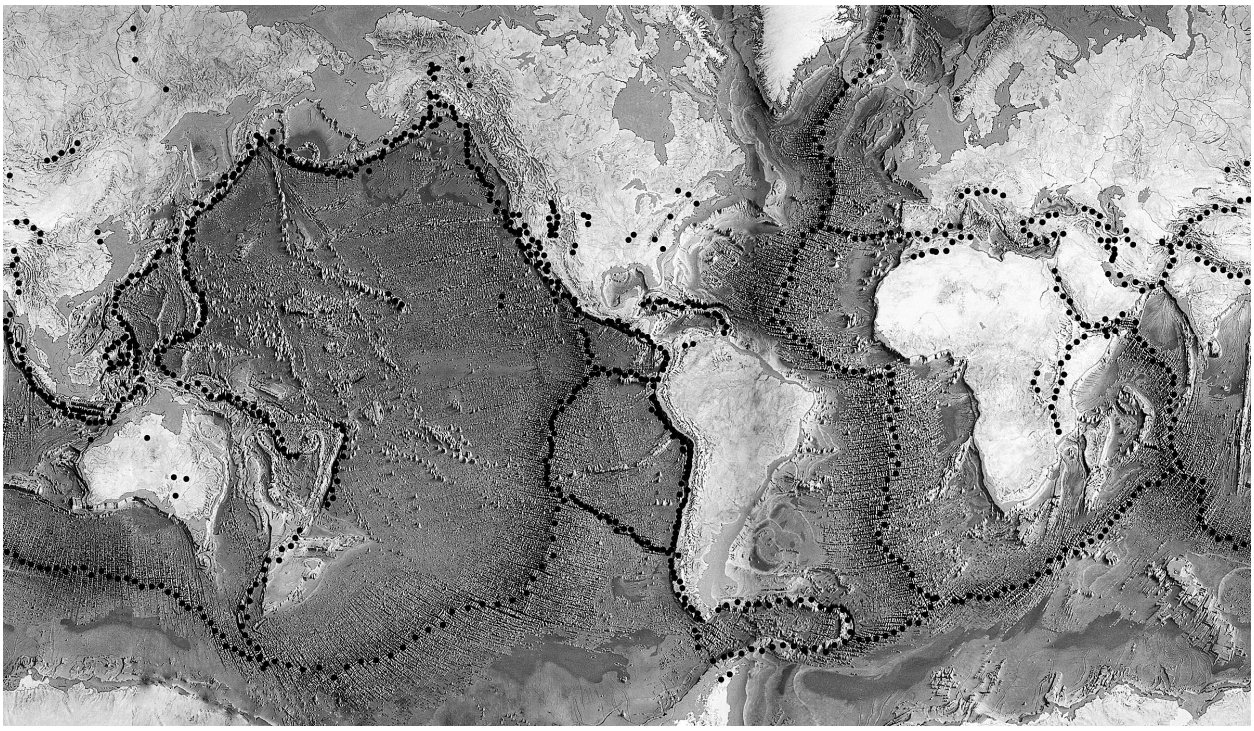


Figure 2: World Map#2
(world with oceans removed with or without plate boundaries)

Notes