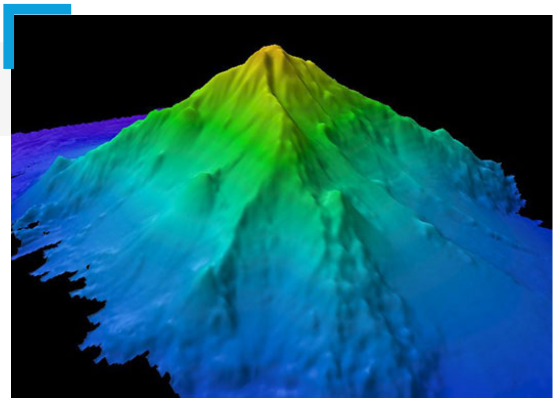
Investigation: Formation of Seamounts and Island Chains

Overview



Kahalewai seamount mapped during the Mountains in the Deep: Exploring the Central Pacific Basin expedition. *Image courtesy of NOAA Ocean Exploration.*

TOPIC: Seamounts and Island Chains

FOCUS: Students analyze data and images to make sense of the processes that form seamounts and island chains.

GRADE LEVEL: 6th-8th Earth Science

TIME NEEDED: Two 45-50 minute class periods (plus additional time for optional extension)

PHENOMENON (DRIVING QUESTION) How do seamounts and island chains form in the middle of the ocean?

OBJECTIVES/ LEARNING OUTCOMES: Students will:

- Develop and use a model to explain how the distribution of seamounts and island chains provides evidence of past and current tectonic processes.
- Analyze and interpret data to assess patterns in the formation of seamounts and island chains.

Performance Expectation (PEs)
MS-ESS2-3 (PE)

Disciplinary Core Ideas (DCIs)
MS-ESS1.C: The History of Planet Earth
MS -ESS2.B: Plate Tectonics and Large Scale System Interactions

Crosscutting Concepts (CCs)
Patterns
Systems and System Models

Science & Engineering Practices (SEPs)
Analyzing and Interpreting Data
Developing and Using Models
Obtaining, Evaluating, and Communicating Information

COMMON CORE CONNECTIONS
ELA-LITERACY.RST.6-8.4; 8.7; 8.9

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS
Principle 1: FC b

Overview cont.

MATERIALS

Student Handouts

One per group, print or share digital copies

- Hawaiian Map and Data Table
- Alaskan Map and Data Table

One per student, print or share digital copies

- Shaving Cream Seamount Graphic Organizer
- Seamount/Island Chain Model Template

Seamount Investigation Demo (teacher demonstration or small group activity)

Materials for one set-up:

- Foamy regular shaving cream
- Large grease splatter screen/guard

EQUIPMENT:

- Computer and projector for class viewing of videos and slides or online sharing capability
- White board and dry erase marker or online platform to record class findings
- Student notebooks for students to record their observations, questions, and explanations
- *Optional: Student laptops or tablets for extensions and/or additional research*

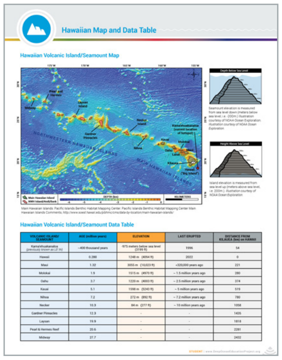
SET-UP INSTRUCTIONS:

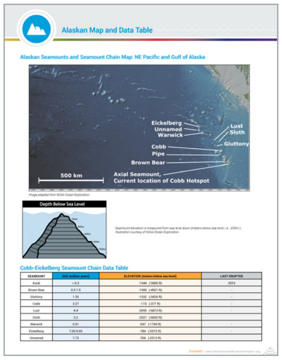
For online learning:

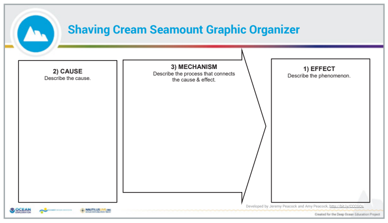
- Share links or digital copies of all materials listed above with students using a preferred online platform.

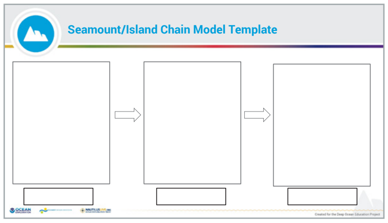
For in-person instruction:

- Cue up all videos and slides for student viewing.
- *If projecting these for the class is not an option, print or share digital copies with students.*









Educator Guide

Background

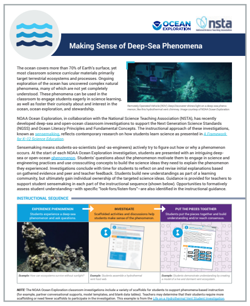
Thousands of seamounts have been discovered worldwide. One of the longest of these chains is known as the Cobb-Eickelberg chain and was explored during the NOAA Ocean Exploration Expedition: Exploring Alaska's Seamounts. What formed these underwater mountains (some of which were once islands)? Why are they arranged in chains? Seamounts and island chains are the products of underwater volcanoes and may have several origins.

Scientists hypothesize the seamounts in the Cobb-Eickelberg chain were produced by eruptions of the Cobb Hotspot, a source of magma from within the Earth's mantle. While the location of this hotspot has basically remained the same, the overlying Pacific Plate has been moving to the northwest. The volcanoes produced by the hotspot are aligned in the same direction the plate moves. Axial Volcano is currently active and the most recent volcano produced by the Cobb Hotspot.

The Hawaiian Islands and seamounts are also an example of plate motion over an underlying hotspot. The Hawaiian-Emperor Seamount chain is evidence that the Hawaiian Hotspot has been active for at least 80 million years. This hotspot provides magma for an active eruption on the Big Island of Hawaii and produces eruptions on the seamount Kama'ehuakanaloa, which may eventually become the newest Hawaiian island.

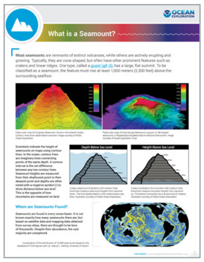
Educator Note

- Students should be familiar with convection currents and plate tectonics.
- A variety of student interaction techniques and examples of student questions are provided throughout this activity to engage students in the process of sensemaking to move their learning forward.
- Learn more about the instructional strategies and tools included in the NOAA Ocean Exploration student investigations.

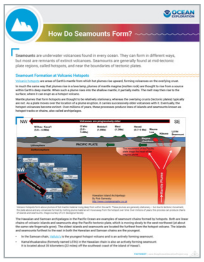


FOR MORE INFORMATION:

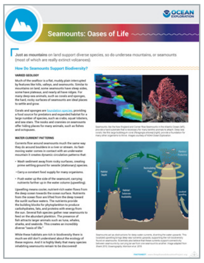
- *What is a Seamount?* Fact Sheet



- *How Do Seamounts Form?* Fact Sheet



- *Seamounts: Oases of Life* Fact Sheet

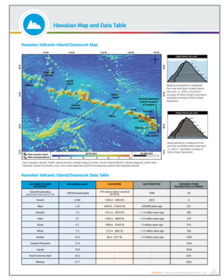


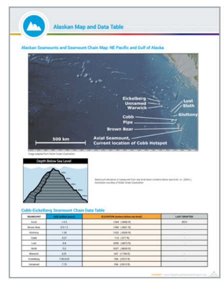
Educator Guide cont.

Experience the Phenomenon

Begin by telling students you are sharing an interesting phenomenon with them, and ask them to make a T-chart on a sheet of paper or small whiteboards with one column labeled "I Notice..." where they will write down their *observations* and a second column labeled "I Wonder...." where they will put their *questions*.

Tell students they will be looking at data related to two different seamount/island chains found in the Pacific Ocean. Ask them to share what they know about seamounts and islands.





Distribute the maps and data tables for the Hawaiian Map and Data Table and the Alaskan Map and Data Table to each group. Ask students, *"What patterns do you observe in the data presented in the maps and tables?"* Have students record their observations and questions on their T-charts. Ask students to share their observations with a partner as you circulate and listen to their observations. Encourage students to focus on observations vs. inferences. For example, ask students, *"What do you see that makes you say that?"*

Using a medium where all students can see, create a three column "Notice/Wonder/Investigate" class chart. Ask students to reference their "Notice/Wonder" T-charts to share and visibly record their thoughts on the map/data sets with the class.

Suggested teacher prompts:

- *How does the data change over time?*
- *What questions could you ask to help explain the patterns in the data you observed?*

Student observations and questions may include:

- *The islands all seem to be in a line.*
- *The Alaskan seamount chain is close to a plate boundary.*
- *Why are the oldest islands the furthest away from the hotspots in both island/seamount chains?*
- *We have learned that volcanic activity is associated with plate boundaries but, where is the magma coming from?*
- *Why are some of the mountains still active volcanoes and others aren't?*
- *What is a hotspot? Does this "hotspot" have something to do with the islands/seamounts being in a chain?*

TEACHER NOTE

Seamounts do not necessarily erupt sequentially, and the freshest rock material is not always sampled. For example, the big island of Hawaii has been active for 5 million years. Fresh zero age rocks could be found today, but a short distance away, there could be rocks that are 5 million years old. Magma volumes are also not consistent. So age and height of seamounts are not automatically connected.

Educator Guide cont.

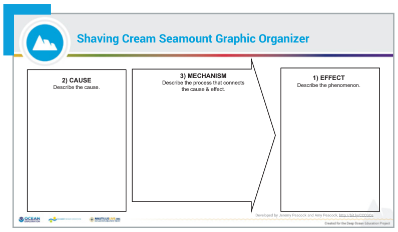
Investigate

Lead a discussion to identify some patterns/similarities in the students' questions. Point out that many students have questions about why the oldest volcanoes have not erupted in long periods of time, and that the age of the islands and seamounts within the chain increase the further away they are from the active volcano. Also, note that some students suggested the volcanic activity is probably connected to the hotspots that are identified on the map.

Guide students in identifying investigations they could conduct to answer their questions. Record these ideas in the "Investigate" column of the chart you created for the class. Since some of these questions could be answered by students looking up information about hotspots and plate tectonics, facilitate a discussion about what sources would be considered reliable. Ask students if they can identify agencies that could provide reliable information and put the suggestions under the "Investigate" column.

Suggested prompts include:

- *What could we do to answer some of the questions you've listed?*
- *It seems like many of you have questions about why the seamounts/islands appear to be in a line. How can we find out more about that?*
- *It looks like there might be some questions about why some of the islands or seamounts are active volcanoes and some are not. How can we learn more about this?*
- *How should we go about doing this research? With so much information on the internet, what kind of sources should we search to get reliable information?*



Tell students they will now be conducting an investigation to gather evidence that will help them make sense of the patterns they observed on the maps and data tables.

Activity: Shaving Cream Seamounts Demonstration

This activity can be conducted as a teacher demonstration or as a small group of three or four students. For distance learning, consider videotaping the demonstration and uploading it to your learning platform.

- Use a grease splatter screen and foaming shaving cream for this activity.
- Ask the students to think about what the grease splatter screen and the shaving cream represent in this model (plate, magma, and/or hotspot)
- Demonstrate the procedure to the students.
  a. Hold the screen *above* the nozzle of the can of shaving cream. Keeping the can in place, gently release a small squirt of shaving cream to produce a small mound on the top of the screen.
  b. Slowly move the screen in one direction (simulating plate movement), and squirt a series of consecutive mounds. Make 4 or more mounds. *Be sure to practice this in advance!*
- Now, using the screen and shaving cream, have the students reference the Hawaiian Map and Data Table to recreate the pattern of the seamounts.
- When all groups have successfully completed the activity or seen it demonstrated, provide them with the Shaving Cream Seamount Graphic Organizer. Have each student complete this and share their thinking within their group.

TEACHER NOTE

Students will need an opportunity to practice creating a seamount chain on the screen.

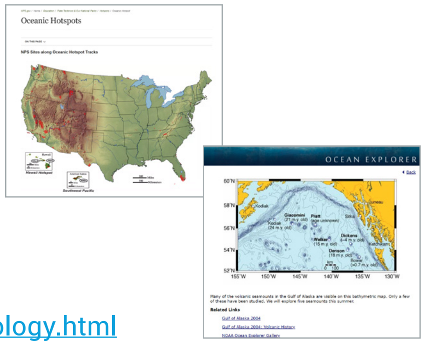
- Share this graphic organizer in a way that the whole class can see it, allowing students to share their thinking and complete a class graphic organizer for consensus.

Educator Guide cont.

Investigate cont.

Redirect students to the original class "Notice/Wonder/Investigate" chart. Identify the questions that students posed that have been answered to this point. Add the additional questions that have surfaced as a result of the seamount demonstration. Tell students that they will now work to gather evidence that explains where the magma that formed the hotspots comes from, and what mechanism is "driving" the seafloor to move over the hotspot. Tell students to add the evidence to their individual graphic organizer.

Students can move through each of the additional resources individually or in pairs. Student groups might also be divided to "jigsaw" each of the additional resources and come back together to share their findings.



Readings

Hawaii Resources:

- https://www.nps.gov/subjects/geology/plate-tectonics-oceanic-hotspots.htm
- https://pubs.usgs.gov/gip/dynamic/hotspots.html

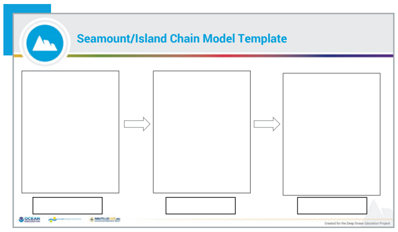
Alaska Resources:

- https://oceanexplorer.noaa.gov/explorations/04alaska/background/volcanic/media/gofae03_map.html
- https://oceanexplorer.noaa.gov/explorations/02alaska/background/geology/geology.html

TEACHER NOTE

Optional: Use these Plates on the Move and Plate Motion simulations as additional resources for student engagement and review of tectonic processes.

Put the Pieces Together



Ask students to draw a model explaining how seamount chains form using everything they have learned. Remind them to identify the components and the relationships between those components in order to make their thinking as visible as possible. Provide students with the Seamount/Island Chain Model Template, allowing them to modify as needed.

Allow time for students to create their models individually and then share and explain their models in small groups. Give students time to identify the similarities and differences between all the models that were shared. Have the students create a group model that best represents their group's thinking.

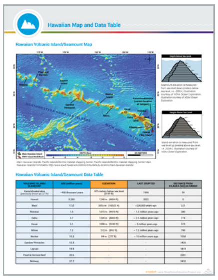
Conduct a gallery walk, with one student being a spokesperson for each group. The members who rotate will identify similarities and differences between their model and the other groups', and provide feedback to the other groups.

After rotating to all the groups, have students return to their original group and make revisions to their model template based on their feedback and observations.

Ask students to finalize their models and write a short summary explaining the processes that form seamounts and island chains.

Educator Guide cont.

Extension



- Using the Hawaiian Map and Data Table, have students calculate the Pacific Plate's approximate velocity. You may need to help students deal with large numbers and decimal places.

  The basic calculation is velocity = distance ÷ time, which in the case of Midway is 2,432 km ÷ 27,700,000 yr = 0.0000877 km/yr = 0.0877 m/yr = 8.77 cm/yr. The same calculation for Nihoa is 780 km ÷ 7,200,000 yr = 10.8 cm/yr.

Scientific Terms

Tectonic processes: Processes related to the interaction between, or deformation of, rigid plates forming the crust of the Earth.

Seamount: An undersea mountain-like formation often created by volcanic activity with a peak that does not rise to the ocean surface.

Geologic hotspot: A hotspot is a large plume of hot mantle material rising through the sea floor from deep within the Earth.

Assessment

Opportunities for formative assessment are embedded throughout the lesson. The student models and explanations that are developed at the end of the lesson could be used as an opportunity for summative assessment of learning.

LOOK FORS:

The following components should be included in students' final explanations.

- A hotspot is a large plume of hot mantle material rising through the seafloor from deep within the Earth.
- Hotspots provide magma for active eruptions which may eventually become new islands.
- Eruptions can be caused by subduction processes or plate motion over an underlying hotspot.
- Seamounts can form as a plate moves over a hotspot.
- Seamounts produced by a hotspot are aligned in the same direction the plate moves.
- Seamounts are progressively older the further they are away from the largest and most active volcano.
- Old islands formed within a seamount chain could get smaller with age (and are farther away from the hotspot).

Seamounts

Page 1:
- Seamount (image): https://oceanexplorer.noaa.gov/facts/seamounts.html

Page 2:
- Hawaiian Map and Data Table (pdf): https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf
- Alaskan Map and Data Table (pdf): https://oceanexplorer.noaa.gov/edu/materials/alaskan-map-data-table.pdf
- Shaving Cream Seamount Graphic Organizer (pdf): https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf
- Seamount/Island Chain Model Template (pdf): https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf

Page 3:
- NOAA Ocean Exploration Expedition: Exploring Alaska's Seamounts (webpage): https://oceanexplorer.noaa.gov/explorations/02alaska/welcome.html
- Making Sense of Deep-Sea Phenomena (pdf): https://oceanexplorer.noaa.gov/edu/materials/NOAA-NSTA-sensemaking-phenomenon.pdf
- What is a Seamount? (fact sheet): https://oceanexplorer.noaa.gov/edu/materials/what-is-a-seamount-fact-sheet.pdf
- How Do Seamounts Form? (fact sheet): https://oceanexplorer.noaa.gov/edu/materials/how-seamounts-form-fact-sheet.pdf
- Seamounts: Oases of Life (fact sheet): https://oceanexplorer.noaa.gov/edu/materials/seamounts-oases-of-life-fact-sheet.pdf

Page 4:
- Hawaiian Map and Data Table (pdf): https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf
- Alaskan Map and Data Table (pdf): https://oceanexplorer.noaa.gov/edu/materials/alaskan-map-data-table.pdf

Page 5:
- Hawaiian Map and Data Table (pdf): https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf
- Shaving Cream Seamount Graphic Organizer (pdf): https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf

Page 6:
- Oceanic Hotspots (website): https://www.nps.gov/subjects/geology/plate-tectonics-oceanic-hotspots.htm
- Hotspots (website): https://pubs.usgs.gov/gip/dynamic/hotspots.html
- Gulf of Alaska (website): https://oceanexplorer.noaa.gov/explorations/04alaska/background/volcanic/media/gofae03_map.html
- Volcanic History of Seamounts in the Gulf of Alaska (website): https://oceanexplorer.noaa.gov/explorations/02alaska/background/geology/geology.html
- Plates on the Move Game (website): https://www.amnh.org/explore/ology/earth/plates-on-the-move2/game
- Plate Motion (website): https://sepuplhs.org/middle/third-edition/simulations/plate_motion_sim.html
- Seamount/Island Chain Model Template (pdf): https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf

Page 7:
- Hawaiian Map and Data Table (pdf): https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf

Partners

NOAA OCEAN EXPLORATION

SCHMIDT OCEAN INSTITUTE

NAUTILUSLIVE.ORG OCEAN EXPLORATION TRUST

Created in cooperation with the National Marine Sanctuary Foundation under federal award NA19OAR0110405 for the Deep Ocean Education Project.

Information and Feedback

We value your feedback on this activity, including how you use it in your formal/informal education settings. Please send your comments to: **oceanexeducation@noaa.gov**. If reproducing this activity, please cite NOAA as the source, and provide the following URL: https://oceanexplorer.noaa.gov.