LAB 7

Lab Handout

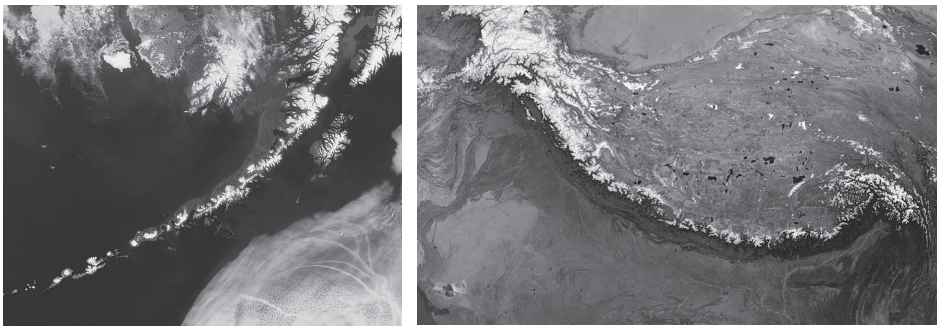
Lab 7. Formation of Geologic Features: How Can We Explain the Growth of the Hawaiian Archipelago Over the Past 100 Million Years?

Introduction

Scientists use the theory of plate tectonics to explain current and past movements of the rocks at Earth's surface and the origin of many geologic features such as those shown in Figure L7.1. The theory of plate tectonics indicates that the lithosphere is broken into several plates that are in constant motion. Multiple lines of evidence support this theory. This evidence includes, but is not limited to, the location of earthquakes, chains of volcanoes (see Figure L7.1A), and non-volcanic mountain ranges (see Figure L7.1b) around the globe; how land under massive loads (such as lakes or ice sheets) can bend and even flow; the existence of mid-oceanic ridges; and the age of rocks near these ridges.

FIGURE L7.1

(a) The Aleutian archipelago, a chain of volcanic islands in Alaska; (b) the Himalayas, a nonvolcanic mountain range in Asia separating the plains of the Indian subcontinent from the Tibetan plateau



a **b**

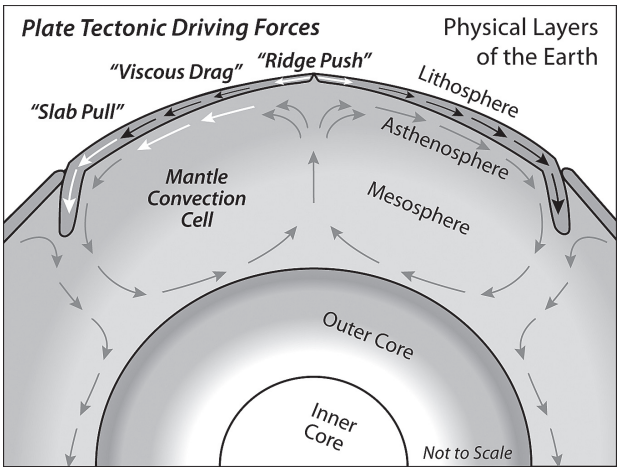
The plates are composed of oceanic and continental lithosphere. The plates move because they are located on top of giant convection cells in the mantle (see Figure L7.2). These currents bring matter from the hot inner mantle near the outer core up to the cooler surface and return cooler matter back to the inner mantle. The convection cells are driven by the energy that is released when isotopes deep within the interior of the Earth go through radioactive decay. The movement of matter in the mantle produces forces, which include viscous drag, slab pull, and ridge push, that together slowly move each of the plates across Earth's surface in a specific direction. The plates carry the continents, create

or destroy ocean basins, form mountain ranges and plateaus, and produce earthquakes or volcanoes as they move.

Many interesting Earth surface features, such as the ones shown in Figure L7.1, are the result of either constructive or destructive geologic processes that occur along plate boundaries. There are three main types of plate boundaries (see Figure L7.3): *convergent boundaries* result when two plates collide with each other, *divergent boundaries* result when two plates move away from each other, and *transform boundaries* occur when plates slide past each other. We can explain many of the geologic features we see on Earth's surface when we understand how plates move and interact with each other over time.

FIGURE L7.2

Convection cells in the mantle



Earth's surface is still being shaped and reshaped because of the movement of plates. One example of this phenomenon is the Hawaiian Islands. The Hawaiian Islands is an archipelago in the northern part of the Pacific Ocean that consists of eight major islands, several atolls, and numerous smaller islets. It extends from the island of Hawaii over 2,400 kilometers to the Kure Atoll. Each island is made up of one or more volcanoes (see Figure L7.4). The island of Hawaii, for instance, is made up of five different volcanoes. Two of the volcanoes found on the island of Hawaii are called Mauna Loa and Kilauea. Mauna Loa is the largest active volcano on Earth, and Kilauea is one of the most productive volcanoes in terms of how much lava erupts from it each year.

FIGURE L7.3

The three types of plate boundaries

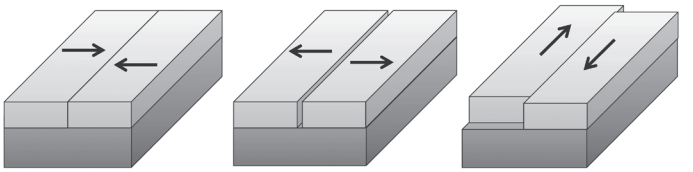
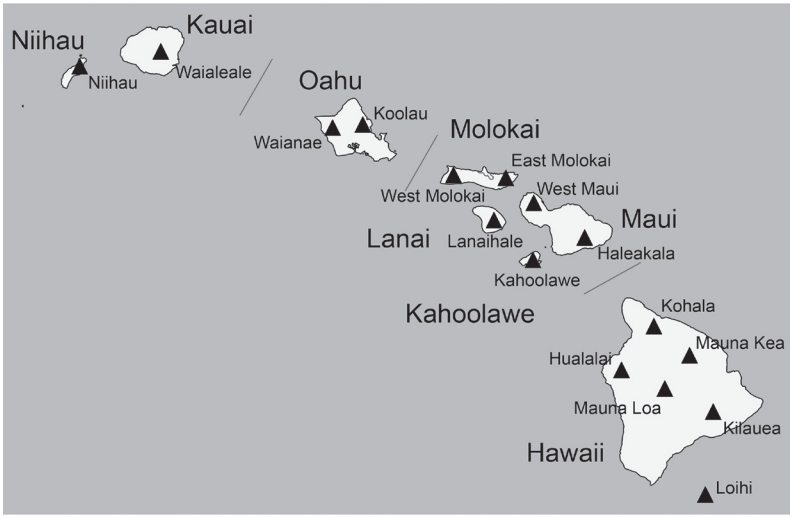


FIGURE L7.4

The Hawaiian archipelago and some of its volcanoes



The number of islands in the Hawaiian archipelago has slowly increased over the last 100 million years. In this investigation, you will attempt to explain why these islands

are in the middle of the Pacific Ocean, why they form a chain instead of some other shape, why some of the islands are bigger than other ones, and why the number of islands in the archipelago has slowly increased over time.

Your Task

Develop a conceptual model that you can use to explain how the Hawaiian archipelago formed over the last 100 million years. Your conceptual model must be based on what we know about patterns, systems and system models, and the movement of Earth's plates over time. You should be able to use your conceptual model to predict when and where you will see a new island appear in the Hawaiian archipelago.

The guiding question of this investigation is, ***How can we explain the growth of the Hawaiian archipelago over the past 100 million years?***

Materials

You will use a computer with Excel or other spreadsheet application during your investigation. You will also use the following resources:

- *Natural Hazards Viewer* online interactive map, available at *http://maps.ngdc.noaa.gov/viewers/hazards*
- Ages of Volcanoes in Hawaiian Islands Excel file; your teacher will tell you how to access the Excel file.

Safety Precautions

Follow all normal lab safety rules.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

The first step in the development of your conceptual model is to learn as much as you can about the geologic activity around the Hawaiian archipelago. You can use the *Natural Hazards Viewer* interactive map to determine the location of any plate boundaries around the islands, the location of volcanoes on and around each island, and the occurrence and magnitude of earthquakes in the area. As you use the *Natural Hazards Viewer*, be sure to consider the following questions:

- What are the boundaries and the components of the system you are studying?
- How do the components of this system interact with each other?
- How can you quantitatively describe changes within the system over time?
- What scale or scales should you use to when you take your measurements?

- What is going on at the unobservable level that could cause the things that you observe?

The second step in the development of your conceptual model is to learn more about the characteristics of the volcanoes in the Hawaiian archipelago. You can use the Excel file called Ages of Volcanoes in Hawaiian Islands to determine which volcanoes are active and which are dormant, the distances between the volcanoes, and the age of each volcano. As you analyze the data in this Excel file, be sure to consider the following questions:

- What types of patterns could you look for in your data?
- How could you use mathematics to describe a relationship between two variables?
- What could be causing the pattern that you observe?
- What graphs could you create in Excel to help you make sense of the data?

Once you have learned as much as you can about Hawaiian archipelago system, your group can begin to develop your conceptual model. A conceptual model is an idea or set of ideas that explains what causes a particular phenomenon in nature. People often use words, images, and arrows to describe a conceptual model. Your conceptual model needs to be able to explain the origin of the Hawaiian archipelago. It also needs to be able to explain

- why the islands form a chain and not some other shape,
- why the number of islands has increased over the last 100 million years,
- why some islands are bigger than other ones, and
- what will likely happen to the Hawaiian archipelago over the next 100 million years.

The last step in your investigation will be to generate the evidence you to need to convince others that your model is valid and acceptable. To accomplish this goal, you can attempt to show how using a different version of your model or making a specific change to a portion of your model would make your model inconsistent with what we know about the islands in the Hawaiian archipelago. Scientists often make comparisons between different versions of a model in this manner to show that a model they have developed is valid or acceptable. You can also use the *Natural Hazards Viewer* to identify other chains of volcanoes that are similar to ones found in the Hawaiian archipelago. You can then determine if you are able to use your model to explain the formation of other chains of volcanoes. If you are able to show how your conceptual model explains the formation of the Hawaiian archipelago better than other models or that you can use your conceptual model to explain many different phenomena, then you should be able to convince others that it is valid or acceptable.

LAB 7

Connections to the Nature of Scientific Knowledge and Scientific Inquiry

As you work through your investigation, be sure to think about

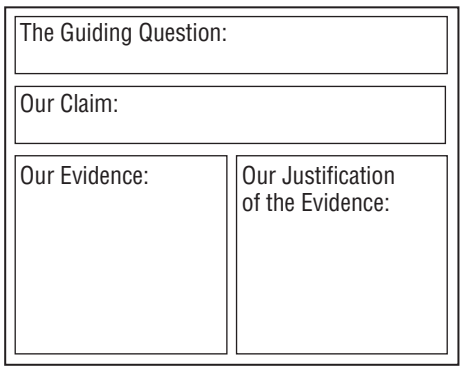
- the use of models as tools for reasoning about natural phenomena in science, and
- the assumptions made by scientists about order and consistency in nature.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a claim, evidence to support your claim, and a justification of the evidence. The *claim* is your group's answer to the guiding question. The *evidence* is an analysis and interpretation of your data. Finally, the *justification* of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L7.5.

FIGURE L7.5

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One or two members of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the other arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group's argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.

Critiques of our initial argument and suggestions for improvement:

If you are critiquing your classmates' arguments, your goal is to look for mistakes in their arguments and offer suggestions for improvement so these mistakes can be fixed. You should look for ways to make your initial argument stronger by looking for things that the other groups did well. You can keep track of interesting ideas that you see and hear during the argumentation in the space below. You can also use this space to keep track of any questions that you will need to discuss with your team.

Interesting ideas from other groups or questions to take back to my group:

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer for the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. You should write your report using a word processing application (such as Word, Pages, or Google Docs), if possible, to make it easier for you to edit and revise it later. You should embed any diagrams, figures, or tables into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid.