

Hawaiian Islands: Born of Fire

Next Generation Science Standards:

- 4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.
- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electric currents.
- 5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Hawai'i Content and Performance Standards III:

- SC.4.8.1 Describe how slow processes sometimes shape and reshape the surface of the Earth.
- SC.4.8.2 Describe how fast processes (e.g., volcanoes, earthquakes) sometimes shape and reshape the surface of the Earth.
- SC.5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.
- SC.5.6.1 Identify different forms of energy (e.g., thermal, electrical, nuclear, light, sound) and how they change and transfer energy from one form to another.
- SC.5.6.2 Describe ways that heat can be transferred from one object to another.

Description:

This lesson introduces students to hot spot theory and how it relates to plate tectonics. It also compares and contrasts composite and shield volcanoes and introduces students to the theory behind the formation of the Hawaiian Islands. Students will learn how to classify Hawaiian volcanoes according to their activity and location as active, dormant and extinct.

Duration: 60 minutes

Objectives: At the end of this lesson, the students will be able to:

- Describe the theory of geological processes that created the Hawaiian archipelago while demonstrating an understanding of terms and concepts associated with hotspot theory and plate tectonics.

Background:

The Earth's geology is in a constant state of flux. Hawaiian geology is the same, undergoing a constant cycle of formation, transformation, and destruction. Because Hawaiian volcanoes are formed in the middle of the Pacific Plate and not on the edge, the plate tectonic theory by itself doesn't explain their origin. Hawaiian volcanoes are instead explained by the hot spot theory.

The majority of the Earth's volcanoes are composite volcanoes, produced by heat and pressure where the Earth's plate boundaries collide. The Hawaiian Islands, on the other hand, are located right in the middle of the Pacific plate. They are called shield volcanoes, formed as the giant Pacific plate moves slowly but steadily over a hot spot of magma from deep within the Earth. The volcanoes of Hawai'i are going through a process of activity, dormancy, and eventually extinction as they move further and further from this hot spot.

There are two main types of volcanoes: composite and shield. Composite volcanoes are most often created around the edges of plate boundaries. They are characterized by their thick lava, where gas bubbles aren't able to escape. Instead, the gases build up and eventually explode out violently. Composite volcanoes look like tall, steep cones. Shield volcanoes have more fluid lava which causes them to erupt more gently. The thinner lava of shield volcanoes allows gases to constantly escape, never resulting in a violent explosion. Rather than one major eruption, we have countless smaller eruptions which build their characteristic broad, gentle slopes resembling a warrior's shield. The Hawaiian Islands are all classified as shield volcanoes.

Hawaiian shield volcanoes are formed by lava flowing on the ocean floor and building layer upon layer into great volcanoes. The hot spot theory explains that magma from the upper mantle rises through a channel into a magma chamber called a hot spot. Because magma is less dense than the surrounding rock, it rises to the surface. The Hawaiian hot spot has been continuously active for over 80 million years! The volcanoes are being formed on the Pacific plate, which moves at a rate of about 4 in. per year to the northwest. Therefore, the oldest Hawaiian volcanoes are located far to the northwest and the youngest island is directly over the hot spot. Although you may think there are only 8 major islands as Hawai'i, there are really 132 islands including all the atolls and undersea volcanoes extending to the western Aleutian Islands.

The proximity to the hot spot determines whether a volcano is classified as active (currently active or dormant) or extinct. Extinct means that a volcano is completely done erupting. The volcanoes northwest of West Maui are all considered extinct because they have moved further and further from the hot spot and would never erupt again. There are volcanoes on the Big Island and on Maui that are classified as active. Active means that they are either currently erupting or dormant. Dormant means that there has been recent activity (but is not currently erupting) and it is likely to erupt again soon in the near future. Today, there is a new volcano forming directly above the hot spot named Lō'ihi, which is located about 20 miles southeast of Hawai'i Island. The cycle of creation and extinction of Hawaiian volcanoes will continue.

Vocabulary:

Active: Either currently erupting, or dormant (not currently erupting).

Caldera: A crater formed when the summit of a volcano collapses.

Cinder cone: Volcanic cones formed along the rift zone built from lava cinders.

Composite volcano (Stratovolcano): Explosive volcanoes with steep slopes formed by viscous, thick lavas that tend to pile up near a vent.

Dormant: A volcano that is inactive or resting, but is likely to erupt again in the near future.

Extinct: A volcano that has stopped erupting and there is no chance of erupting again.

Hot spot: A source of heat from deep within the Earth's mantle that continually generates new magma.

Lava: Magma that has reached the surface of the Earth.

Magma: Molten rock containing dissolved gasses beneath the Earth's surface.

Rift zone: Fractures in a volcano's surface from which molten lava can emerge.

Shield volcano: A type of volcano built almost entirely of fluid lava flows. Flow after flow pours out in all directions from a central summit vent, or group of vents, building a broad, gently sloping cone, with a profile like that of a warrior's shield.

Materials Needed:

Hot Spot Worksheet (included)

Comparing the Islands Worksheet (included)

Procedure:

Step 1: Relate Volcanology to Bubbles in Soda

Where do bubbles go when you pour a soda into a glass? = They go to the top, to try to escape! They are lighter than the soda so they rise.

- Has anyone seen what happens after a soda is dropped or accidentally shaken? = It explodes!
- Why would this happen? = The dissolved gas, is under pressure in the soda, and is released when the soda is opened.
- Relate the example of pressure in a soda bottle to that of a volcanic eruption. = When the pressure inside a volcano builds up to a certain point, it can also cause an explosion or eruption.
- When a volcano erupts the pressure that has built up from the incredible heat of the magma is released.

Step 2: Composite Volcanoes

Ask students to take notes as you write on the board the features of different volcanoes. Features of composite volcanoes (also known as a stratovolcano):

- Explosive, violent eruptions
- Viscous or very thick lava
- Steep slopes

Check for understanding by discussing the following questions:

- Where do you think we would find these explosive volcanoes? = Near the edges of the tectonic plate boundaries.
- Hawai'i is found on the edge of which plate? = (Trick question!) It is found in the middle of the Pacific Plate.
- Are all volcanic eruptions explosive? = No.
- Why could this be?
- Is Haleakalā a Composite volcano? = No.
- If Haleakalā is not a composite volcano what kind is it? = Shield volcano.
- Does anyone know of a Hawaiian volcano erupting today? = Mauna Loa

Step 3: Shield Volcanoes

Explain that Hawaiian volcanoes are classified as shield volcanoes. Features of shield volcanoes:

- Gentle eruptions
- Less viscous, not as thick, but more fluid and thinner lava
- Broad shape with gentle slopes resembling a warrior's shield

Step 4: Introduce Hot Spot Theory

Let's learn about how the Hawaiian Islands have formed.

- What could form a volcano in the middle of the Pacific plate? = A hot spot (magma chamber)
- What brings this magma to the surface? = Because magma is less dense than the surrounding rock, it rises to the surface.
- Discuss how the volcanoes are being formed on the Pacific plate, which moves at a rate of about 4 in. per year to the northwest. Therefore, the oldest Hawaiian volcanoes are located far to the northwest and the youngest island is directly over the hot spot. Although you may think there are only 8 major islands as Hawai'i, there are really 132 islands including all the atolls and undersea volcanoes extending to the western Aleutian Islands.
- Hand out Hot Spot worksheet and instruct students to color:
 - Mantle = orange
 - Shield volcano = green
 - Hot spot = red
 - Composite volcano = blue
 - Pacific plate = brown
 - Magma from converging plates = yellow
 - Continental plate = black

- Point out the hot spot. Point out the mantle. = The mantle is where the hot spot gets its magma.
- Is the hot spot moving? = No, the plate is moving to the northwest.
- Point out that Hawai'i shield volcanoes are building under the ocean a long time before they ever emerge above sea level.

Step 5: Thermal Energy Transfer

- What do we call the type of energy that comes from heat? = Thermal.
- Is magma a form of energy? = Yes, magma is a form of thermal energy.
- When magma reaches the surface of the Earth where does this energy go? = It is transferred to the surrounding environment.
- When magma reaches the surface of the Earth what do we call it? = Lava.
- What happens to things that the lava touches? = They get hot.
- What does this do to the lava? = It cools (as it transfers its heat to everything it touches) and eventually turns to rock.
- What if this happens over and over and over for a million years? = A volcano is formed.

Step 6: Comparing Islands Worksheet

Hand out the Comparing the Islands Worksheet.

1. Cut off instructions and set aside. Then follow step 1. (Below are the answers) Show students a map of the Hawaiian Islands if needed.
2. Smallest to largest = Kaho'olawe, Ni'ihau, Lana'i, Moloka'i, Kauai, O'ahu, Maui, and Hawai'i
3. East to West = Hawai'i, Maui, Kaho'olawe, Moloka'i, Lana'i, O'ahu, Kaua'i, Ni'ihau
4. North to South = Kaua'i, Ni'ihau, O'ahu, Moloka'i, Maui, Lana'i, Kaho'olawe, and Hawai'i
5. Young to old = Is this familiar? (Same as East to West answer).

Step 7: Explain active and extinct and dormant

Explain that the proximity to the hot spot determines whether a volcano is classified as active (currently active or dormant) or extinct. Extinct means that a volcano is completely done erupting. The volcanoes to the northwest of West Maui are all considered extinct because they have moved further and further from the hot spot and would never erupt again. There are volcanoes on the Big Island and on Maui that are classified as active. Active means that they are either currently erupting or dormant. Dormant means that there has been recent activity (but is not currently erupting) and it is likely to erupt again soon in the near future. Haleakalā is considered to be dormant.

Step 8: Conclusion

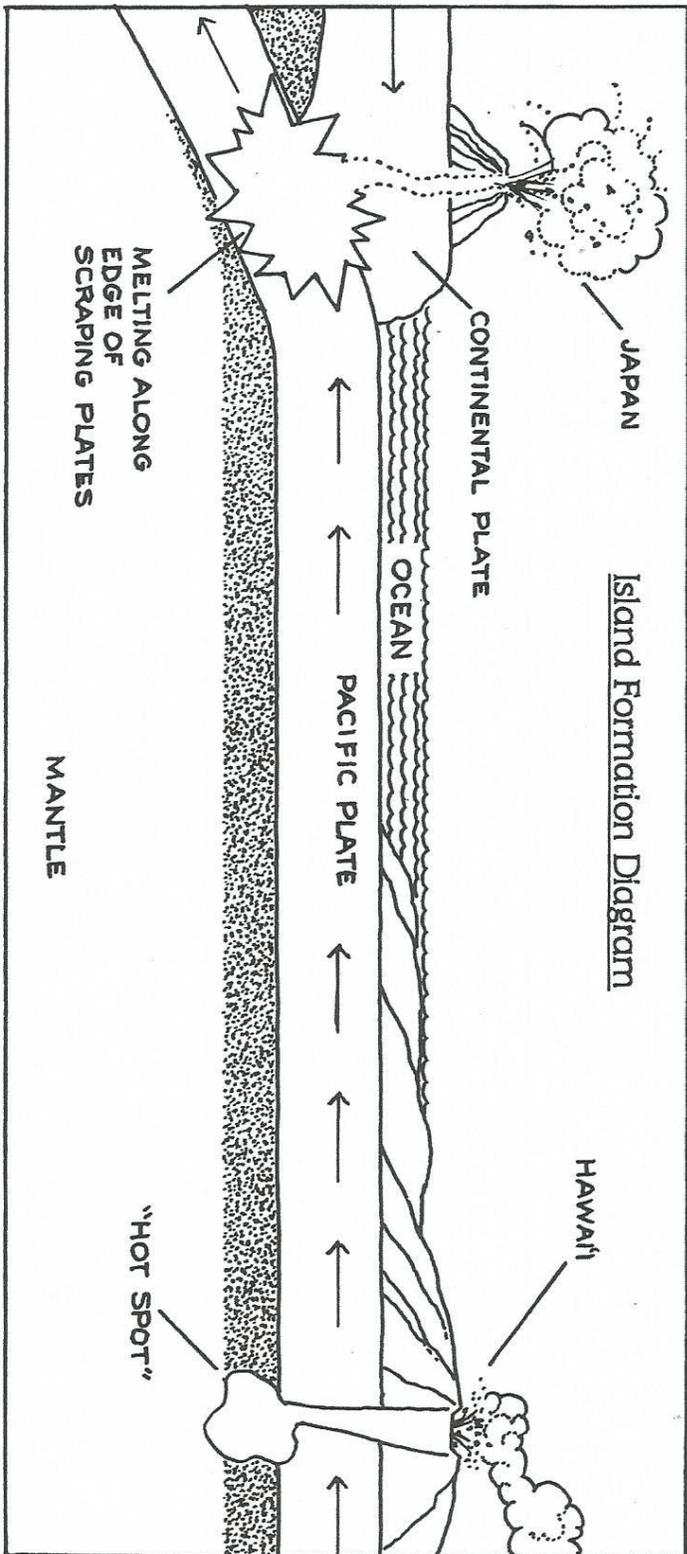
The Hawaiian Islands are only the tops of great mountains that reach deep into the sea. This chain of shield volcanoes has been built up by repeated eruptions of magma from a hot spot deep within the mantle of the Earth over millions of years. The movement of the Pacific Plate to the northwest over this hot spot has formed the chain of islands known as Hawai'i.

References:

Adapted from Mattox, S. (1994). *A teacher's guide to the geology of Hawaii Volcanoes National Park*. (Activity 3.4). Honolulu, HI: Hawai'i Natural History Association.

Adapted from 'Ōhi'a Project. (1989). *Hot spot! An environmental education guidebook for Hawai'i*. (pp. 4.5-4.12). Honolulu, HI: Bernice Pauahi Bishop Museum and Moanalua Gardens Foundation.

Hot Spot Worksheet



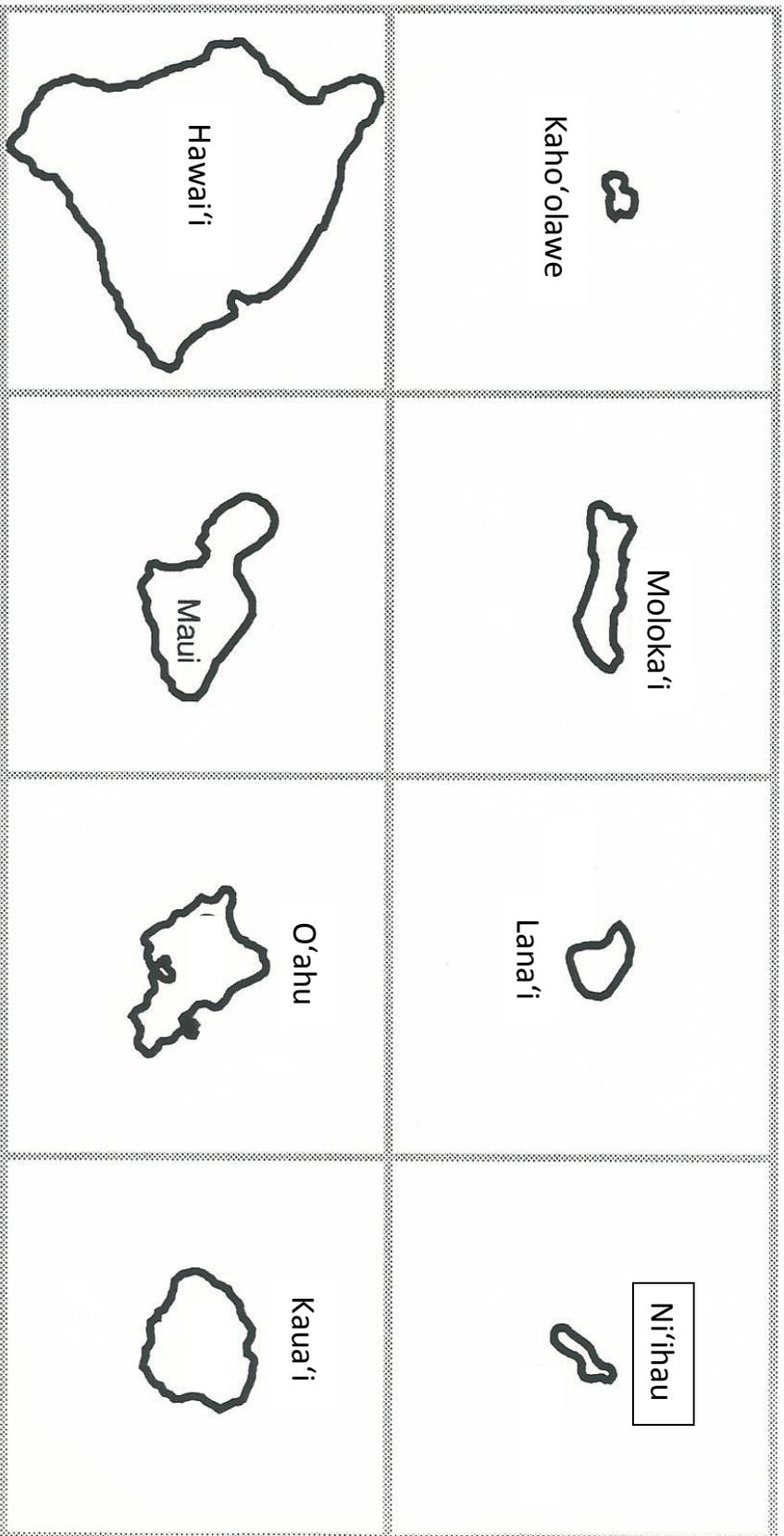
Color the diagram as follows:

- Shield volcano = green
- Composite volcano = blue
- Pacific plate = brown

- Mantle = orange
- Hot spot = red
- Magma from converging plates = yellow
- Continental plate = black

Explain how the Hawaiian Islands were formed.

Comparing the Islands



Directions:

1. Cut out the squares along the gray lines.
2. Arrange the islands from smallest to largest.
3. Arrange the islands from east to west.
4. Arrange the islands from north to south.
5. Arrange the islands from young to old.