HOT SPOT ACTIVITY

Ages:
12–18 years

Duration:
30 minutes

Materials:
Per pair of students
- **Ruler**
- **Calculator**
- **Map of Hawaiian-Emperor Island chain**
- **Table of Island ages**

OVERVIEW —

The students will measure the distances of islands, convert and graph their data to determine the speed of the Pacific Plate.
Modified from an existing activity by Alison Henning, Rice University, and from
http://www.soest.hawaii.edu/GG/HCV/haw_formation.html

OBJECTIVE —

The students will:
- Measure and convert distances on a map
- Graph data
- Analyze data to determine the speed of the Pacific Plate

BEFORE YOU START: *The students should be familiar with graphing and with the concept of a hot spot and plate tectonics.*

ACTIVITY —

Invite the students to suggest methods of determining how fast a tectonic plate is moving.

Share with the students that a useful mechanism is to measure the ages of different islands formed from a hot spot, and take the ratio of the distance to the age, to determine the rate of speed of the plate.

Give the students the following instructions

1. Using a ruler and the map provided, measure the distance between the first volcano (Kilauea) and the other island volcanos.
2. Convert the measurements into kilometers, using the scale on the map.
3. Record the distance on the table "Age of the Hawaiian Islands and Outer Seamounts."
4. Create a graph with distance in kilometers on the "Y" axis and age in millions of years on the "X" axis, and plot your data.
5. Draw a line to represent the best fit of your data.
6. The slope of the line will give you the speed of the plate, in kilometers per millions of years.
7. Extension: Convert the speed from km/millions of years to centimeters per year.

Questions for Class Discussion

Do you see a trend in the data? If so, how can this trend be explained?

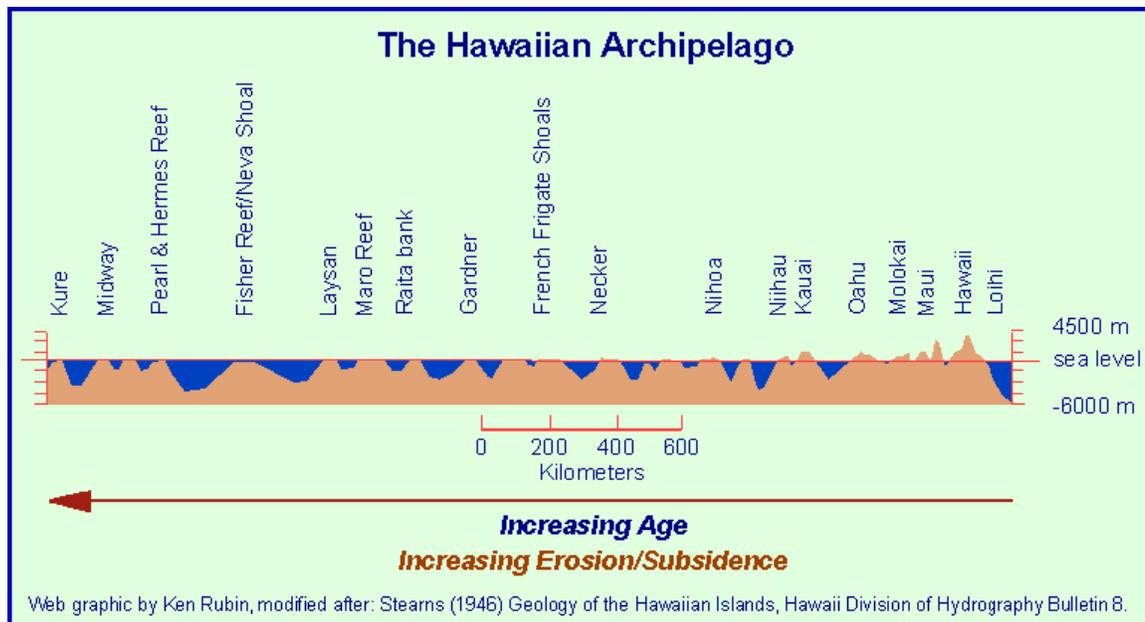Are these data consistent with the "hot spot" hypothesis?

Examine the rate of movement of the plates. What happens about 40 million years ago? What might have caused this?

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BACKGROUND —

The Hawaiian-Emperor Island Chains are volcanic in origin. Each island is made up of at least one primary volcano, although many islands are composites of more than one. The Big Island, for instance, is constructed of 5 major volcanoes: Kilauea, Mauna Loa, Mauna Kea, Hualalai and Kohala. Mauna Loa is the largest active volcano on Earth. Kilauea is presently one of the most productive volcanoes on Earth (in terms of how much lava it erupts each year). The primary volcanoes are known as a *shield volcanoes*, which are gently sloping mountains produced from a large number of generally very fluid lava flows.

Hawaiian volcanoes primarily erupt a type of rock known as *basalt*. When molten, basalt produces liquids of relatively high fluidity, compared to volcanoes that erupt more silica rich magma types such as andesite, dacite or rhyolite. The fluidity of molten basalt favors the formation of lava flows, which is why the Hawaiian volcanoes generally have gentle sloping sides. In contrast, lavas with higher silica content are more viscous and commonly produce either thicker, shorter lava flows, thick blocky deposits and/or thick beds of ash that fall from the sky following explosive eruptions. These other types of volcanoes (common outside of Hawaii) are typically steeper sided.

The Hawaiian volcanoes were produced by the Hawaiian *hot spot*, which is presently under the Big Island of Hawaii. The image below shows the islands of the Hawaiian chain and the intervening shallows, banks and reefs along a line from southeast to northwest. In general, when you move along the island chain from southeast (Hawaii) to northwest (Kure), the volcanoes become older and older.

The Hawaiian Archipelago

Web graphic by Ken Rubin, modified after: Stearns (1946) Geology of the Hawaiian Islands, Hawaii Division of Hydrography Bulletin 8.

The age trend of the volcanoes is thought to be due to the way in which the islands are built on the moving sea floor of the North Pacific Ocean: the Pacific Ocean is mostly floored by a single tectonic plate (known as the "Pacific Plate") that is moving over the layer in the Earth known as the *asthenosphere*. This movement takes it to the northwest compared to the layers below it at a rate of 5 to 10 cm/yr (the rate depends on where you are on it). As the plate moves over a fixed spot deeper in the Earth where magma (molten lava) forms, a new volcano can punch through this plate and create an island. The Hawaiian Islands are believed to be formed from one such 'hot spot'. As the plate moves away, the volcano stops erupting and a new one is formed in its place. With time, the volcanoes keep drifting westward and getting older relative to the one active volcano that is over the hot spot. As they age, the crust upon which they sit cools and subsides. This, combined with erosion of the islands once active volcanism stops, leads to a shrinking of the islands with age and their eventual submergence below the ocean surface.
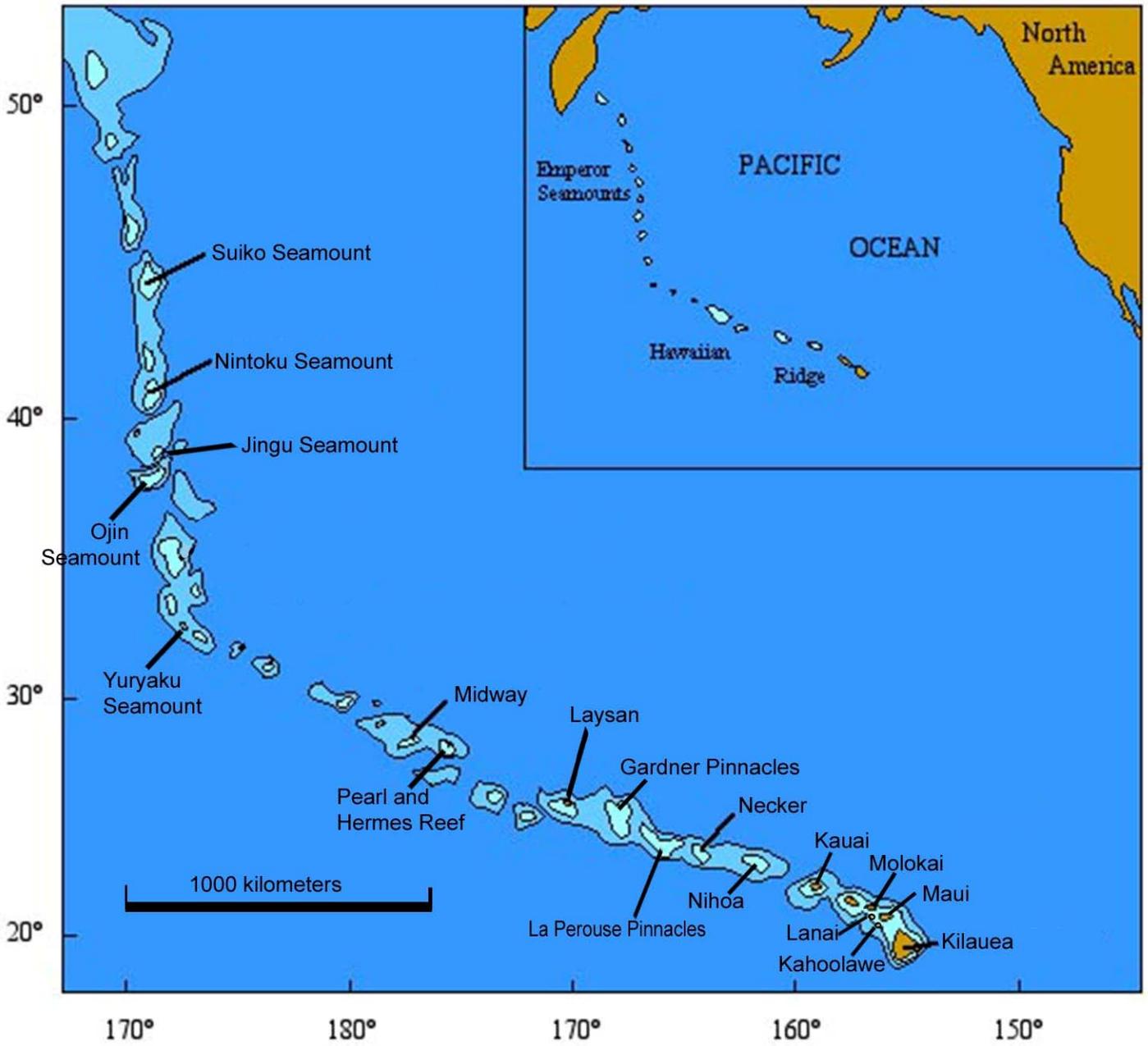
Label	Location
50°	
Suiko Seamount	
Nintoku Seamount	
40°	
Jingu Seamount	
Ojin Seamount	
Yuryaku Seamount	
30°	Midway
	Laysan
Pearl and Hermes Reef	Gardner Pinnacles
	Necker
	Kauai, Molokai
	Maui
20°	Nihoa, Lanai, Kilauea
La Perouse Pinnacles	Kahoolawe

1000 kilometers

170°   180°   170°   160°   150°

Emperor Seamounts

PACIFIC

OCEAN

North America

Hawaiian Ridge

Age of the Hawaiian Islands and outer seamounts

Volcano Name	Distance from Kilauea along trend of chain (km)	Best K-Ar age (in millions of year)s
Kilauea	0	0-0.4
Kahoolawe		> 1.03 ± 0.18
Maui		1.32 ± 0.04
Lanai		1.28 ± 0.04
Molokai		1.76 ± 0.04
Kauai		5.1 ± 0.20
Nihoa		7.2 ± 0.3
Necker		10.3 ± 0.4
La Perouse Pinnacles		12.0 ± 0.4
Gardner Pinnacles		12.3 ± 1.0
Laysan		19.9 ± 0.3
Pearl and Hermes Reef		20.6 ± 2.7
Midway		27.7 ± 0.6
Yuryaku		43.4 ± 1.6
Ojin		55.2 ± 0.7
Jingu		55.4 ± 0.9
Nintoku		56.2 ± 0.6
Suiko		59.6 ± 0.6