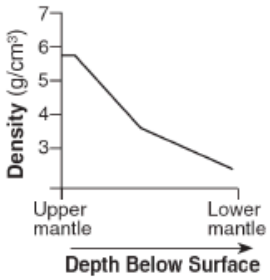
WARM UP

1.) What caused the interior of Earth to separate into layers?
   a.) a decrease in the rate of rotation of Earth
   b.) the gravitational pull on materials of varying densities
   c.) variations in heating by the Sun due to Earth's tilt
   d.) collisions with meteors and comets

2.) Which of the following is **not** a likely result of tectonic plate movement?
   a.) Mountain building
   b.) Earthquakes
   c.) Formation of volcanic islands
   d.) Changes in the phases of the Moon

3.) Which graph best shows the inferred density of Earth's interior as depth increases from the **upper mantle** to the **lower mantle**?

A)


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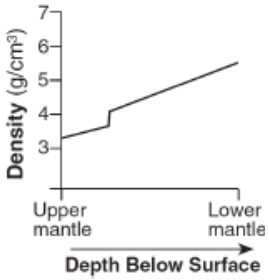

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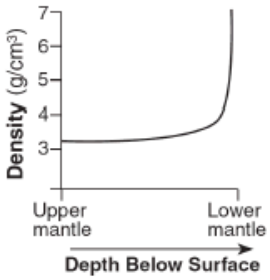
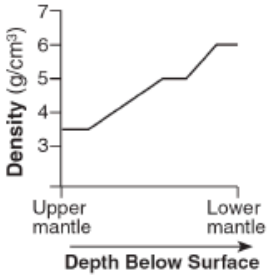


D)


OBJECTIVE

SWBAT analyze spatial and temporal data from the Hawaiian Island chain to calculate plate motion rate and direction. (HS-ESS2-1)

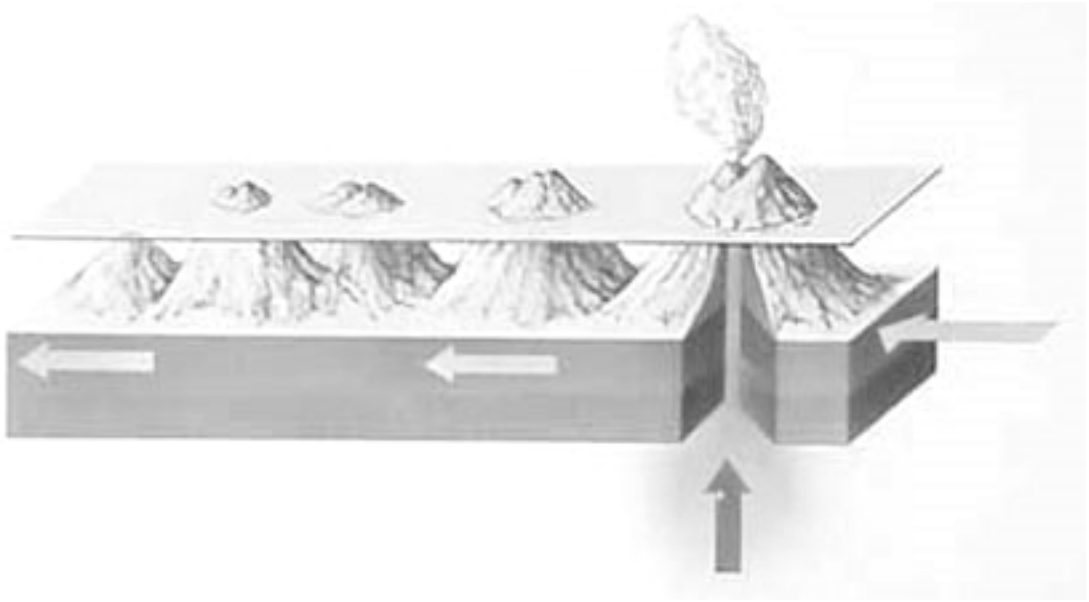
SWBAT use evidence from volcanic age patterns to explain how a stationary hotspot and a moving lithospheric plate produce a chain of volcanoes. (HS-ESS1-5)

Criteria For Success (CFS)

Students will receive a minimum score of an 80% on the lab rubric

Plate tectonics has been an accepted theory since the 1960s. According to this theory, the crust of the Earth is composed of plates that move over the asthenosphere. There are two basic types of plates: heavy, thin, and dense **oceanic plates**, which are primarily composed of basalt; and thick, lighter, **continental plates** which are comprised of silicate rocks (granite).

Movement of the Pacific Plate over the Hawaiian Hot Spot



The idea behind plate tectonics is that the crustal plates are moving with respect to one another over geologic time. The rates of movement of crustal plates can be determined by using data from the plate margins along the mid-ocean ridges, or at magma plumes known as "**hotspots**" where the distance and age can be measured. The Hawaiian Islands are volcanic islands that are produced as superheated molten material rises upward from deep within the mantle. As the molten material breaks through weak places in the crustal plate, a new "island" will form (see picture above).

Video Question:

How can a single hot spot create a chain of multiple volcanoes?

_____

_____

_____

Will all the volcanoes be active at the same time? Why or why not?

_____

_____

_____

Procedure:

1. **Temporal Scale:** Use Map 1 to find the absolute ages of lava in bold black numbers. These represent millions of years before the present. Calculate the age difference between the islands and enter the data in the table.
2. **Spatial Scale:** Measure the distance between the "dots" of each circle using the scale on the diagram. Enter the data in the data table.
3. Convert the distance from kilometers to "land" or "real" centimeters (**NOT what you could measure on the map**!) by multiplying the distance in km by 100,000 (which is the number of cm in 1 km. HINT: This will be a big number! Enter the data in the data table.
4. Hawaii contains an active volcano, Mauna Loa, so the lava on it is very young. (0.01 million years old). The lava on Kauai Island is 5.1 million years old. Kauai Island was once an active volcano, standing where Hawaii stands today.
5. Figure the rate in centimeters per year using the distances from Hawaii to each of the three dated lavas on the map and the following rate equation.

$$\text{Rate of Movement} = \frac{\text{Land Distance (cm)}}{\text{Difference in Age (years)}}$$

Note: Round your rate of movement answers to the nearest tenth (0.1 cm/year)

ISLANDS	Difference in Age (years)	Distance (km)	Land Distance (cm)	Rate of Movement (cm/year)
Hawaii – Maui				
Maui – Molokai				
Molokai – Oahu				
Oahu – Kauai				

Analysis: Please write all responses neatly and in complete sentences.

1.) In which direction was the crustal plate moving when the Hawaiian Islands were formed? Explain how you can tell.

_____

_____

_____

_____

2.) According to your data, did the crustal plate always move at the same speed? Explain how you know.

_____

_____

_____

_____

3.) Put the steps in order to explain why a "hotspot" can produce a chain of islands in the Pacific Ocean instead of just one big island.

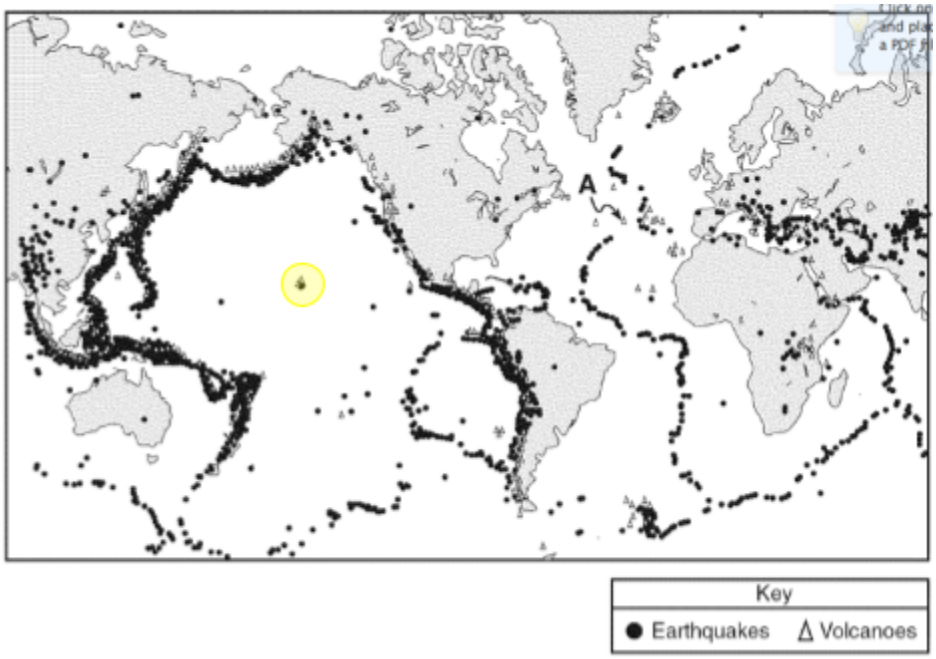
Step (1 - 4)	**Description**
	The plate moves, carrying the volcano away from the hotspot.
	Magma rises up and vents on the surface, forming a volcano on the crust
	The older volcano is now disconnected from the hotspot and has become extinct.
	A new volcano starts to form over the hotspot.

Practice:

1.) Approximately what are the coordinates of the Hawaii Hot Spot?
   a.) 50° N, 120° W
   b.) 25° N, 158° E
   c.) 25° N, 158° W
   d.) 25° S, 158° E

2.) On which plate is the Hawaii Hot Spot located?
   a.) South American
   b.) Antarctic
   c.) Nazca
   d.) Pacific

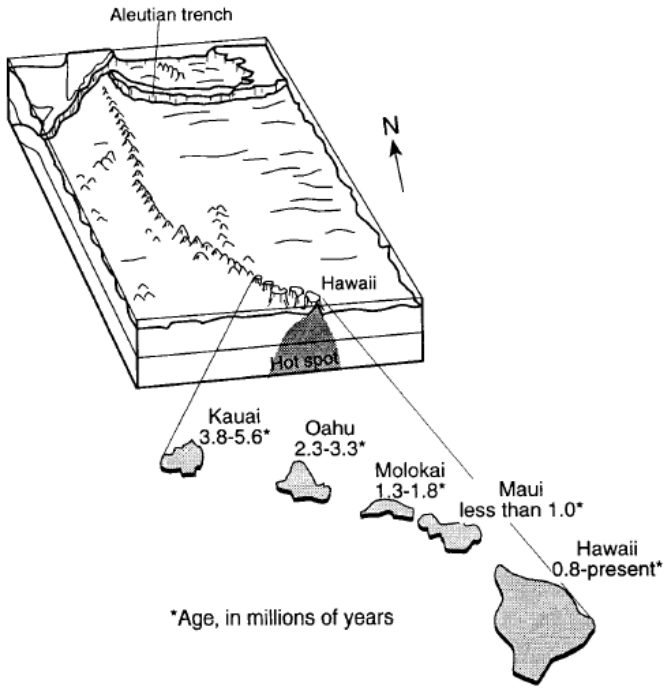
The map shows major earthquakes and volcanic activity occurring from 1996 through 2000. The Hawaii Islands are highlighted in yellow on the map.



3.) Identify the source of the magma for the volcanic activity in Hawaii.

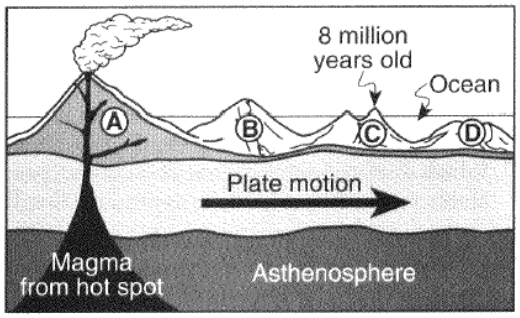
_____

The block diagram below shows the bedrock age as measured by radioactive dating and the present location of part of the Hawaiian Island chain. These volcanic islands may have formed as the Pacific Plate moved over a mantle hot spot.



4.) The diagram provides evidence that the Pacific Crustal Plate was moving toward the
   a.) South
   b.) East
   c.) Southwest
   d.) Northwest

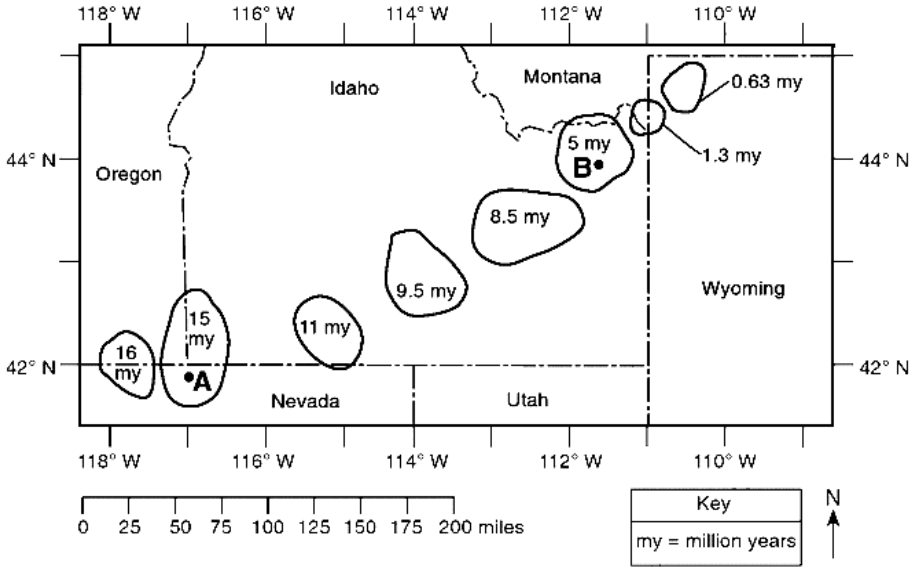
The cross section below shows the direction of movement of an oceanic plate over a mantle hot spot, resulting in the formation of a chain of volcanoes labeled A, B, C, and D. The geologic age of volcano C is shown.



5.) What are the most likely geologic ages of volcanoes B and D?
   a.) B is 5 million years old and D is 12 million years old
   b.) B is 2 million years old and D is 6 million years old
   c.) B is 9 million years old and D is 9 million years old
   d.) B is 10 million years old and D is 4 million years old

Base your answer to question 6 on the map and the passage. The map shows the outlines and ages of several calderas created as a result of volcanic activity over the last 16 million years as the North American Plate moved over the Yellowstone Hotspot. A and B represent locations within the calderas.

Yellowstone Volcanic Calderas



The Yellowstone Hot Spot has interacted with the North American Plate, causing widespread outpourings of basalt that buried about 200,000 square miles under layers of lava flows that are a half mile or more thick. Some of the basaltic magma produced by the hot spot accumulates near the base of the plate, where it melts the crust above. The melted crust, in turn, rises closer to the surface to form large reservoirs of potentially explosive rhyolite magma. Catastrophic eruptions have partly emptied some of these reservoirs, causing their roofs to collapse. The resulting craters, some of which are more than 30 miles across, are known as volcanic calderas.

6.) Calculate, in miles per million years, the rate at which the North American Plate has moved over the Yellowstone Hot Spot between point A and point B.

_____ **miles/million years**

7.) Yellowstone is a much more dangerous hot spot than Hawaii because there is a larger pool of magma under the crust. Based on your knowledge of continental and oceanic crust, why do you think that is?

_____

_____

Exit Ticket Grade

_____/_____

Name: _____

Date: _____

Class: _____

OBJECTIVE

SWBAT analyze spatial and temporal data from the Hawaiian Island chain to calculate plate motion rate and direction.

(NOVICE) 1 2 3 4 5 (MASTERY)

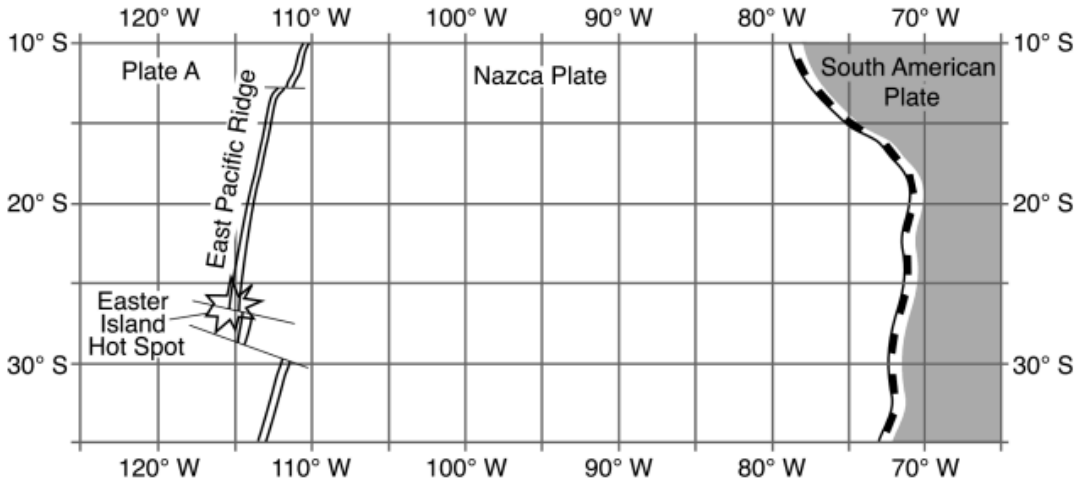
SWBAT use evidence from volcanic age patterns to explain how a stationary hotspot and a moving lithospheric plate produce a chain of volcanoes.

(NOVICE) 1 2 3 4 5 (MASTERY)

Exit Ticket

The map shows a portion of the Nazca Plate under the southeastern Pacific Ocean. Plate A represents another tectonic plate. The table shows some data for islands and seamounts (undersea volcanoes that do not rise above the ocean surface) that originally formed at the Easter Island Hot Spot.

Southeastern Pacific Ocean

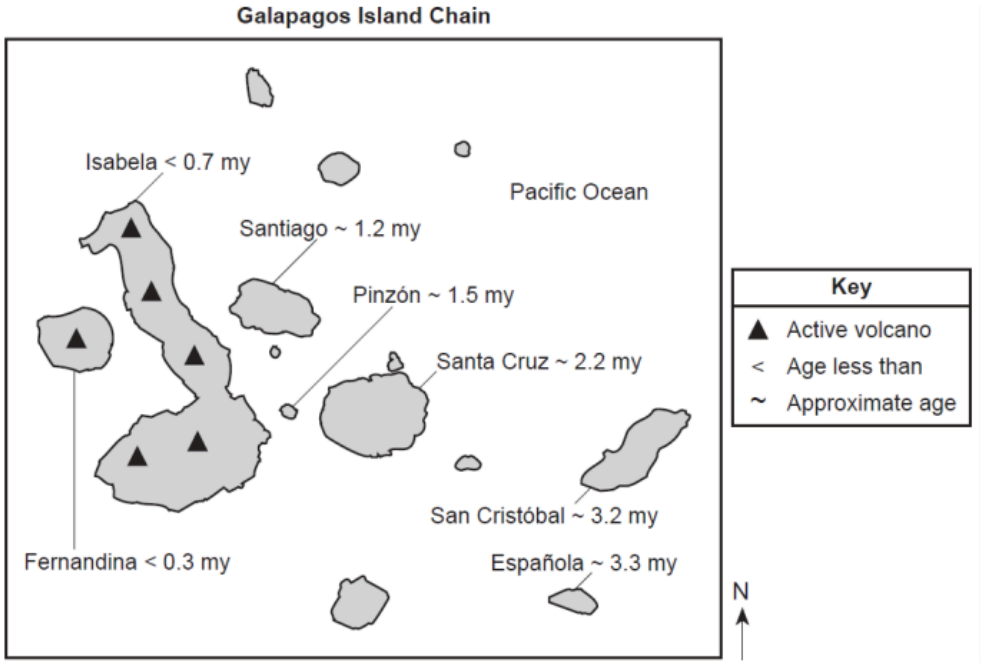


Islands and Seamounts Formed By the Easter Island Hot Spot

Name	Island or Seamount	Latitude (°S)	Longitude (°W)	Distance from East Pacific Ridge (km)	Age of Oceanic Bedrock (million years)
Easter Island	island	27	109	360	0.3
Sala y Gomez	island	26	105	750	1.7
GS57202-70	seamount	25	98	1500	7.9
18DS	seamount	26	93	2000	11.5
17DS	seamount	25	88	2500	14.9
12DS	seamount	23	83	3100	22.0

1.) On the map, plot with **X**s the location of the six islands and seamounts formed by the Easter Island Hot Spot.

2.) Identify the name of Tectonic Plate A. _____ Plate



3.) Based on the age of the bedrock of the Galapagos Islands, in which direction does the tectonic plate containing the islands appear to be moving away from the Galapagos Hot Spot?

a.) Northeast
b.) Southeast
c.) Northwest
d.) Southwest

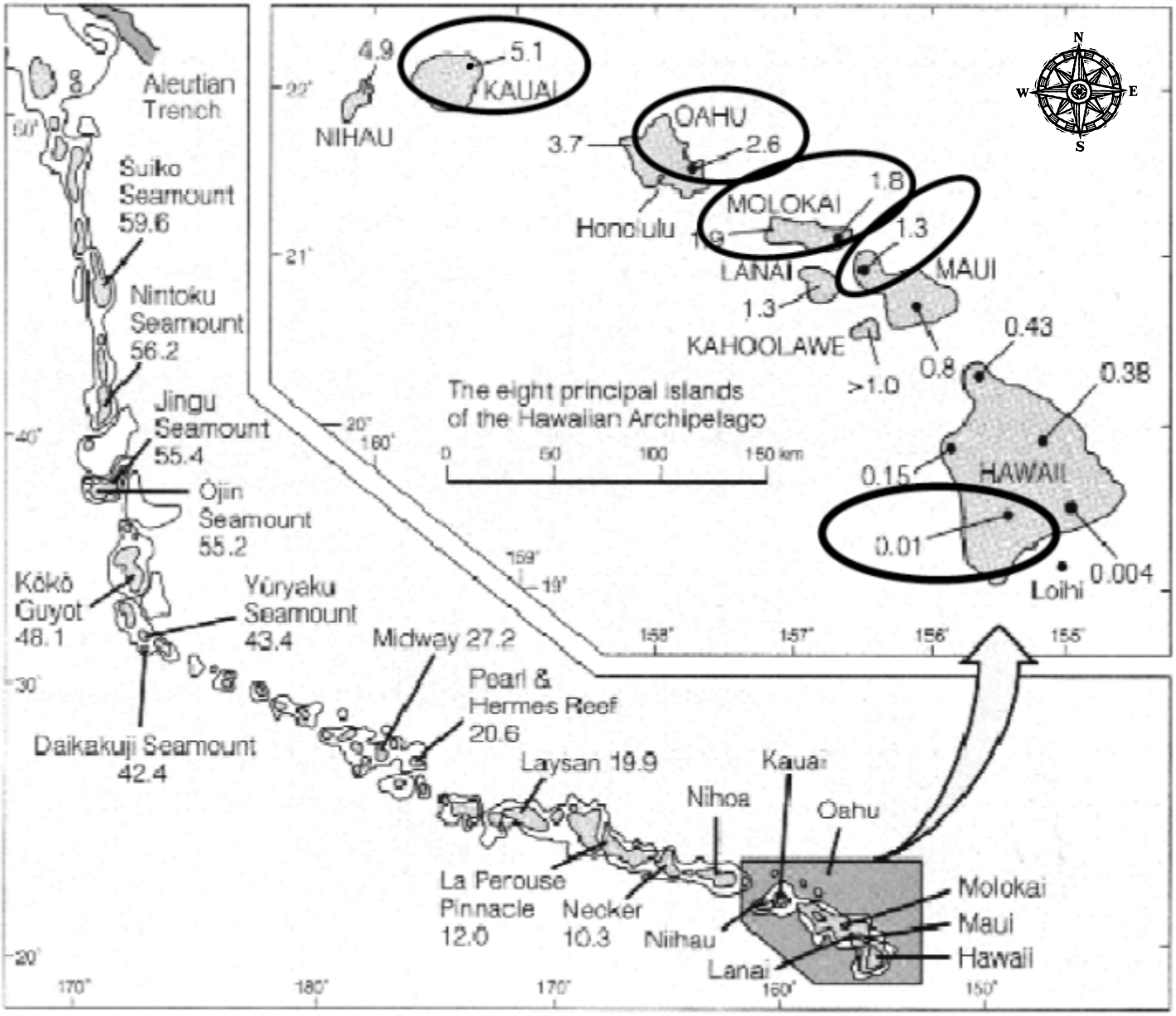
4.) San Cristóbal is one of the easternmost Galápagos Islands, far from the active volcanoes on Isabela and Fernandina. Which statement best explains why residents of San Cristóbal do not prepare for volcanic eruptions like residents on those islands?

a.) The island is too small for magma to rise beneath it.
b.) San Cristóbal has already moved away from the hotspot.
c.) San Cristóbal's volcanoes only erupt underwater.
d.) The island is protected by nearby volcanoes on Isabela and Fernandina.

5.) A new volcanic island begins forming just west of Fernandina, directly above the Galápagos Hotspot. If the plate continues moving in the same direction, what will happen to this island over the next few million years?

a.) It will remain directly above the hotspot and keep erupting.
b.) It will slowly move away from the hotspot and eventually become inactive.
c.) It will move toward San Cristóbal and merge with it.
d.) It will sink into the ocean immediately after forming.

MAP 1


Aleutian Trench
Suiko Seamount 59.6
Nintoku Seamount 56.2
Jingu Seamount 55.4
Ojin Seamount 55.2
Kōkō Guyot 48.1
Yūryaku Seamount 43.4
Daikakuji Seamount 42.4
Midway 27.2
Pearl & Hermes Reef 20.6
Laysan 19.9
Nihoa
Kauai
Oahu
Molokai
Maui
Hawaii
Lanai
Niihau
Necker 10.3
La Perouse Pinnacle 12.0
NIHAU 4.9
KAUAI 5.1
OAHU 3.7 2.6
Honolulu
MOLOKAI 1.8
LANAI 1.3
MAUI 1.3
KAHOOLAWE >1.0
0.8
0.43
0.38
HAWAII
0.15
0.01
0.004
Loihi
The eight principal islands of the Hawaiian Archipelago
0 50 100 150 km
N
W
E
S