

Clocking Tectonic Plates

The speed at which tectonic plates move can be measured by several techniques. Global Positioning System receivers anchored to bedrock can track today's movement, but how can you learn about earlier movement?

Chains of volcanoes can be created when a tectonic plate moves over a spot of hot rising mantle. The distance between the volcanoes depends on how fast the plate moved. When combined with the known age of each volcano (by radioactive dating), you can plot the past speed and direction of a plate.

Questions

How fast, and in what direction, has the Pacific Plate been moving?

Prediction

Write a prediction based on the question asked above.

INQUIRY SKILLS

- | | | |
|---|---|--|
| <input type="radio"/> Questioning | <input checked="" type="radio"/> Conducting | <input checked="" type="radio"/> Evaluating |
| <input type="radio"/> Hypothesizing | <input checked="" type="radio"/> Recording | <input type="radio"/> Synthesizing |
| <input checked="" type="radio"/> Predicting | <input checked="" type="radio"/> Analyzing | <input checked="" type="radio"/> Communicating |
| <input type="radio"/> Planning | | |

Experimental Design

You will measure the distance between the volcanoes in the Hawaiian Islands and combine this with the known age of the islands to calculate the historical movement of the Pacific Plate.

Materials

- ruler, marked in millimetres
- calculator
- scale map of the Hawaiian Islands (Figure 1)

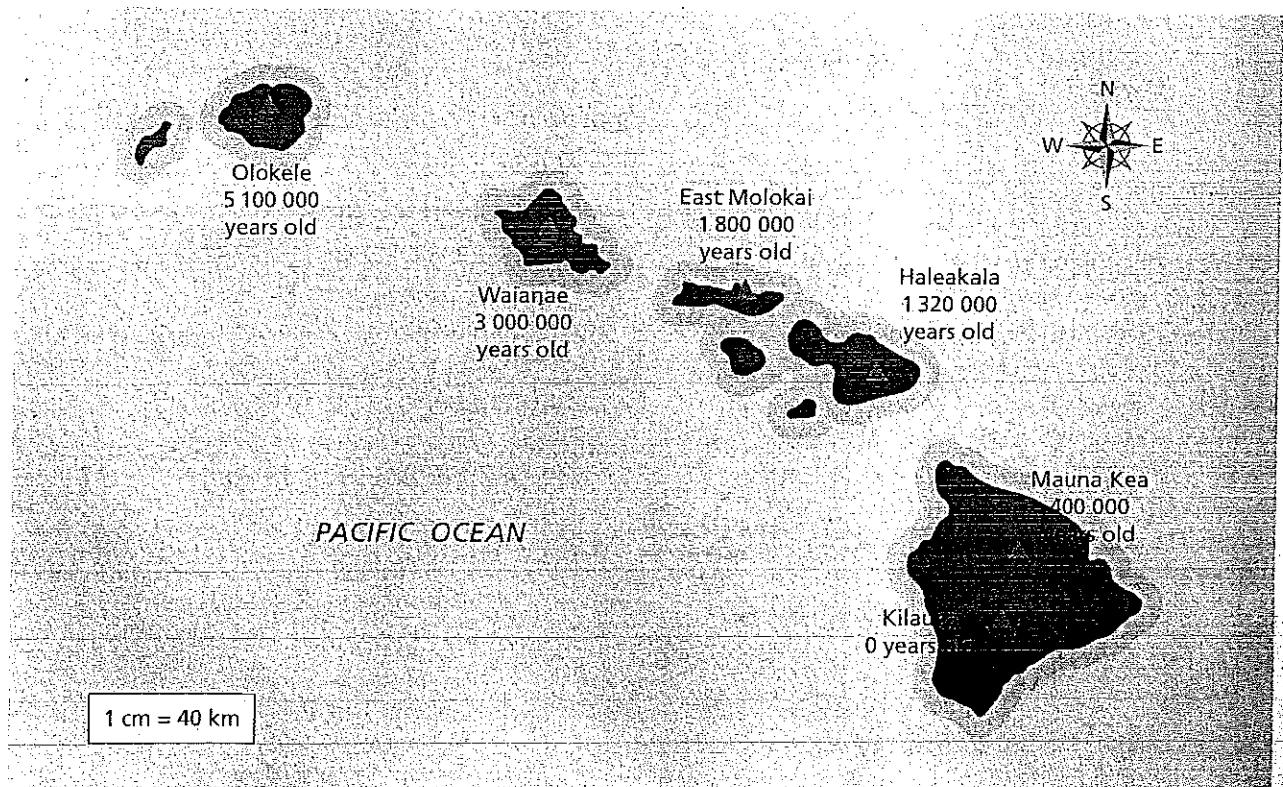


Figure 1 The Hawaiian Islands

Procedure

1. Copy Table 1 into your notebook.

Table 1

Volcano	Distance to next volcano (km)	Time until next volcano (yr)	Speed (cm/yr)
Olokele			
Waianae			
East Molokai			
Haleakala			
Mauna Kea			
Kilauea	0	0	0

2. Using the scale map provided in Figure 1, measure the distance between Olokele and Waianae. Measure from the centre of each volcano, marked by a triangle. Record the distances in centimetres, to one decimal place. Measure the distances between each of the remaining volcanoes.
3. Convert your measurements to kilometres using the scale shown on the map. Record this value in the table.
4. Calculate the difference between the ages of the volcanoes. How many years passed between the formation of each island in the chain? Record these values in the table.
5. Calculate the speed at which the plate moved between the formation of each island using the equation

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

A sample calculation has been done for you.
Sample calculation:

$$\text{distance} = 50 \text{ km, time} = 400\,000 \text{ yr}$$

$$\begin{aligned} \text{speed} &= \frac{50 \text{ km}}{400\,000 \text{ yr}} \\ &= 0.000125 \text{ km/yr} \end{aligned}$$

6. Convert the speed to centimetres per year. Remember that 1 km = 100 000 cm. Record this value in the table.

Sample calculation:

$$\begin{aligned} \text{cm/yr} &= \text{km/yr} \times \frac{100\,000 \text{ cm}}{1 \text{ km}} \\ &= 0.000125 \text{ km/yr} \times \frac{100\,000 \text{ cm}}{1 \text{ km}} \\ &= 12.5 \text{ cm/yr} \end{aligned}$$

Conclusion

Complete the following items to answer the question posed at the beginning of the investigation

Analysis

- (a) Which volcano is the oldest? Which is the youngest?
- (b) When was the Pacific Plate moving the fastest? The slowest?
- (c) Explain how you could calculate the average speed of the Pacific Plate over the past five million years, then calculate the value.
- (d) In what direction is the Pacific Plate moving? Explain how you know.

Evaluation

- (e) Identify possible sources of error.
- (f) Evaluate carefully how you measured the distance between volcanoes. How does the method or accuracy of this measurement affect the calculation of the distance and speed?
- (g) If the distance between volcanoes is measured in kilometres, why is speed given in cm/yr?
- (h) What major assumption is made about the spot of rising mantle when plate speed is calculated this way? If this assumption is incorrect, how might this change your results?

To perform this investigation with an interactive map of the Hawaiian Islands, go to

www.science.nelson.com

