JAMES COOK UNIVERSITY AUSTRALIA

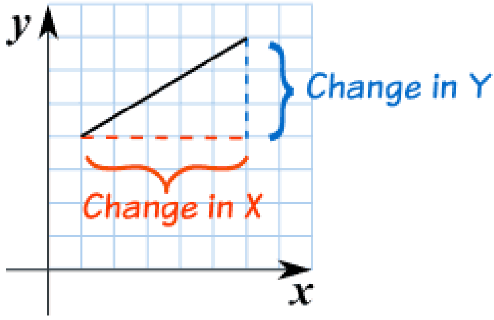
Volcanic Hot Spots and Continental Drift

Start by showing a model of how the tectonic plate moves above a hot spot, resulting in the formation of an island chain.

1. Have the students make a prediction about how far the tectonic plate they are currently standing on moves in a year. (Answer: Approximately 10cm per year.)
2. Direct students to the map.
   The map shows degrees longitude on the x-axis – imagine lines running upwards at 150°, 160°, 170° etc. The lines of longitude are written on the y-axis – imagine horizontal lines running along at 20°, 30° and so on. The Hawaiian chain of islands in the Pacific Ocean is shown on the map. The names of each island in the chain are written on the map. The active volcano Kiluaea is located on the island known as the Big Island of Hawaii at the bottom at around 155° longitude. Here's an interesting side point. The Big Island of Hawaii is at about latitude 19° above the equator and Townsville is at about latitude 19° below the equator. The red scale is set so that 3cm = 1000km.
3. Look at the scale shown on this map. This is a scale you can use to match up with your ruler measurements to work out actual distances between the islands. The map should be scaled so that 3cm is 1000km. So if the distance you measure between two islands using a ruler is 6 cm how far apart are they really? They will be 2000 km.
4. Ask students to measure the actual distance between *Hawaii* and *Kauai* Islands (519 km). Ask students to measure the actual distance between *Hawaii* and *Laysan* Islands (1818 km). Direct students to Table 1 which shows the age of the rock on each island in millions of years, abbreviated to My, and the distance each island is from the Big Island of Hawaii. Have them fill in the missing values they measured.
5. Ask students to get out highlighter pen. Which island is the oldest – highlight it on the map. Which is the youngest – highlight it on the map. Is this its true age? Of course not, but we use that as the starting point on the time line and give it an age of zero My so all the other islands' ages are in comparison to that one.
6. Split students into two groups, and have them plot the points appropriate to their group (slope 1 vs slope 2).

7. Ask students to use the information in the table and the graph paper provided to plot Age of island versus distance of each island.
8. Ask students to inspect the scatterplot. Are there any trends? Could you make straight lines out of any of the points? Assist students to draw the line of best fit:
    - The **line of best fit** is drawn so that the points are evenly distributed on either side of the line. There are various methods for drawing this 'precisely', but you will only be expected to draw the line 'by eye'.
    - When drawing the line of best fit, use a transparent ruler so you can see how the line fits between all the points before you draw it.
    - You may be asked to comment on the nature of the relationship between the two variables. This means you will be expected to say whether there is positive, negative or no relationship. Using terms such as 'strong', 'moderate' or 'weak' will give a clearer indication of the strength of the relationship.
    - For example if it is clear that y increases as x increases. Then we can say that, the relationship between the variables is positive.
    - If most of the points sit very close to the line we can say that the association between the two variables is strong.
    - On the other hand if the points are a long way from the line then the relationship is not very strong.
    - And if it looks like a blob rather than points along a straight line then we can say that there is not much of an association between the two variables.
9. Assist students in working out the slope of the line they have drawn:
    - A slope is the steepness of a line. Think of a set of stairs, they are pretty steep, but a wheelchair ramp rise much more gradually so that is a small slope. You can calculate how steep a slope is using the rise over run method. Pick any two points on a straight line. Look at how much the y value changes (the rise) and how much the x value changes (the run). Divide the rise by the run and you have a number that tells you how steep the slope is.
    - To find the slope, divide the **change in vertical height** **(the rise**) by the **change in horizontal distance** **(the run).** The demonstrator will help you do this.

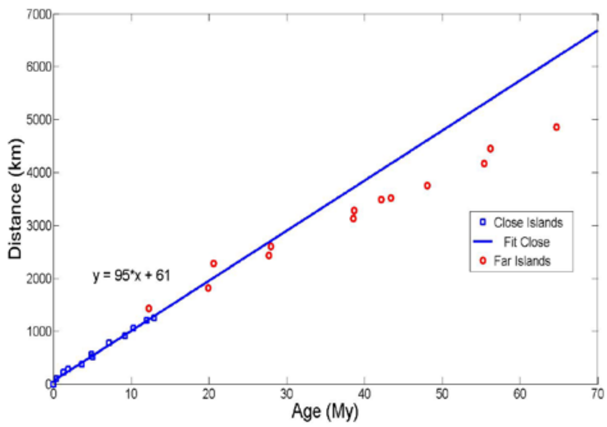
Slope = $\dfrac{\text{Change in Y}}{\text{Change in X}}$

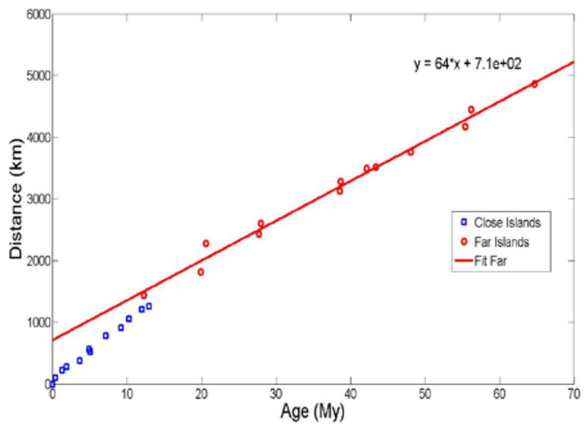


10. Have the students predict from the diagram where the change in speed occurs. They will then answer Questions 4-7 and are expected to realize that the time at which the slopes change by looking at the plot is very different from the time at which the direction changes. Have the geologist discuss this.

Answers

1. There should be a positive relationship between the age and the distance, as the distance from the youngest island increases, the age of the rock increases. So this means the islands that are furthest from The Big Island of Hawaii are the oldest.
2. The speed is worked out by calculating the rise/run for each straight line.
3. The slope/speed is approximately 100km/My = 10cm/year (Group A), or 65km/My = 6.5cm/year (Group B)
4. It is expected that they would choose the change in direction.
5. 12-13 My
6. Daikakuji, ~40My
7. The two changes occur at different times and are not consistent.





Optional Game: Sweet Decay

The students will simulate radioactive decay where radioactive Element A (marked side up/heads) decays and turns into stable Element B (marked side down/tails) which cannot decay.

Materials:

- 5 x Cups of 100 MnMs (marked on one side); or pennies/coins – label these "testing cup"
- 5 empty cups
- 5 sheets of paper towel (for MnM version)

Steps:

1. Hand out cups to each group.
2. Students toss contents of cup out (onto paper towel if MnMs).
3. Students remove those with marked side down/tails to the empty cup which is set aside.
4. Students count the number of remaining radioactive elements. Record in the table.
5. Return only the radioactive (marked side up/heads) to the testing cup.
6. Students make a prediction about how many will be still radioactive in the next round.
7. Students repeat Steps 1 -3.
8. Continue until there are no radioactive elements left.

As the game progresses, ask:

1. Do your predictions match what is being observed?
2. (After two or three "half-lives") What is happening to the number of radioactive elements remaining?
3. Are the same number of elements being removed each time we toss the cup?
4. (At the end) At which round were half the number of radioactive elements returned to the cup?
5. And then at which round were there half as many again remaining?
6. What might we mean by the term half-life?
7. If we assume that each round represents the same number of years have gone by e.g. 10 years then what is the half-life of this radioactive element?

8. If you started with a sample of 600 radioactive elements, how many would remain un-decayed after three half-lives?
9. How does the amount of radioactive element present at the start affect the number that decay? Does it affect the half-life?
10. Is there any way to predict when a specific MnM/coin lands marked side down/tails or 'decayed'.

Answers:

1. We would expect that around half will be removed each time, but this may not always happen. The predictions will not always match because we need to have a very large number of tests to be sure that the experimental results match theoretical results of 50/50.
2. The numbers that are removed should decrease with every round. But they should be around half.
3. There should be around half at round 2, then at round 3.
4. The half-life would be 10 years.
5. After three rounds 75 should be left.
6. The number of radioactive elements left at the end will depend on how much was present to start. But the half-life will always be the same.
7. Predicting whether an element decays or not is up to chance. We can never be sure what will happen to a specific element. This is like gambling/lottery tickets. But the amount of starting material will determine how much of the radioactive element is left over time.

Toss	Number of radioactive nuclei	Prediction for Next Toss
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		