Oxygen Isotopes Reveal Ancient Climates

STUDENT NAME: .....

STUDENT ACTIVITY

SCIENTIFIC OCEAN DRILLING

Objective(s)/Outcome(s)

Students will be able to:

1. analyze data taken from microfossils in seafloor cores to describe patterns in climate fluctuation during the last 150,000 years of Earth's history.
2. Evaluate how past climate data can be used to predict future climate change patterns.

Materials

Per Group

- Computer with internet access

Per Student

- Graphing supplies or program

Background

Ocean sediment cores are cylinders of mud, sand, and rock that scientists drill from the ocean floor to learn about Earth's past, including climate. These cores contain tiny organisms, like foraminifera (also known as forams), which are small marine creatures with hard shells made of calcium carbonate. When foraminifera die, their shells sink to the ocean floor and get buried in the sediment. Scientists can look at these shells to understand past climate conditions. The oxygen in the shells can appear as two different isotopes: oxygen-16 (^{16}O) and oxygen-18 (^{18}O). When the water is warmer, there is more of the lighter oxygen-16 in the shells, and when the water is colder, there is more of the heavier oxygen-18. By measuring the ratio of these isotopes in foraminifera shells, scientists can figure out the temperature of the ocean when the organisms lived, giving them clues about past climate.

In addition to studying oxygen isotopes, scientists also examine the type of sediment in the core to learn more about Earth's climate. Sediment types can tell us if the climate was dry or wet, hot or cold. For example, if the core has a lot of land-based sediment, it may indicate higher rates of erosion, which is often associated with more rain or ice melting. By combining information from both the oxygen isotopes in foraminifera shells and the types of sediment layers, scientists can create a picture of Earth's past climate. This helps us understand how the climate has changed over thousands or even millions of years, and how factors like temperature and rainfall have impacted life on Earth.

Activity

Part 1

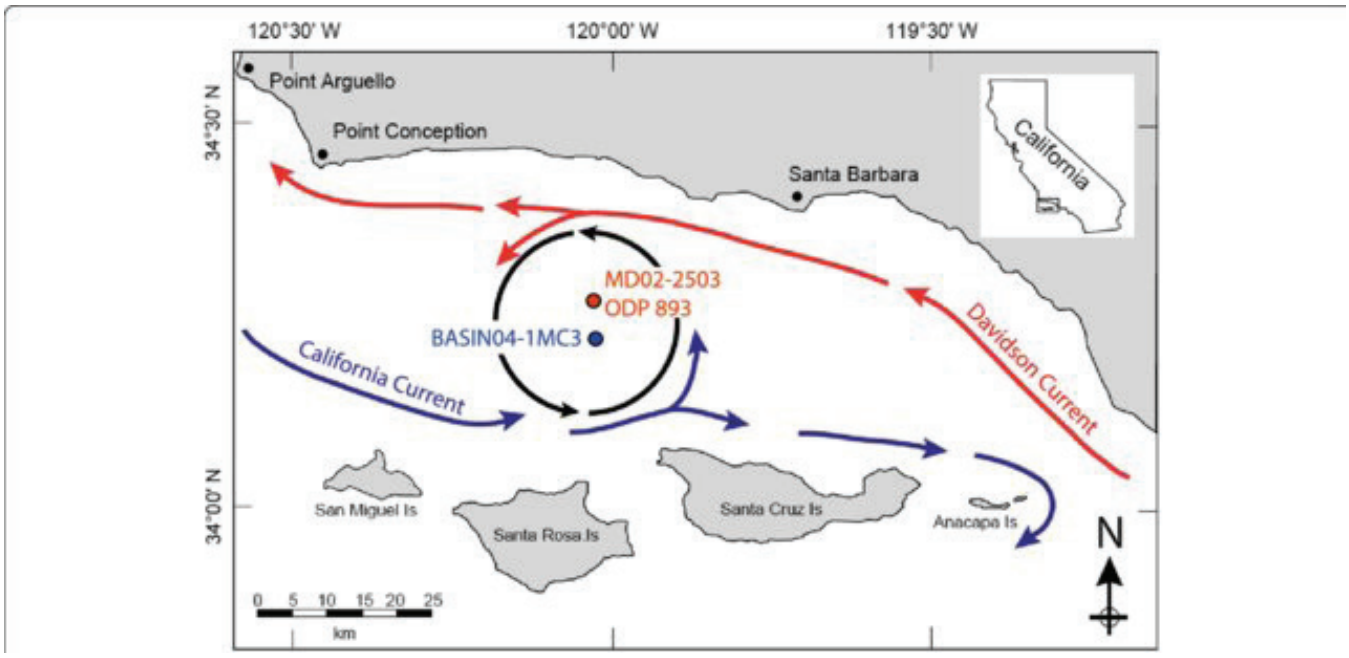
1. Look at the data in Table 1. This data is determined by equipment that can measure the amount of each oxygen isotope within foraminifera fossils within an ocean sediment core.

    a. This data was taken from Core 893A during Expedition 146.

    b. Look at a map of the location from which this core was taken (Figure 1).

STUDENT NAME: .....

FIGURE 1: LOCATION OF CORE 893A FROM ODP EXPEDITION 146.



Credit: Beaufort & Grelaud, 2017, **CC BY 4.0**

c. Describe how the core's location may have influenced the sediment that accumulated there. Consider all the information on the map, from distance to land to water currents.

d. Name two more pieces of information you would like to know about the location of the core that would help you in determining the environmental conditions that affected sedimentation.

2. Graph the data in the first two columns of Table 1.

a. Note that the years are not evenly spaced.

b. Carefully consider what type of graph to make.

3. On your graph, note at least three areas on the graph that show distinctly different data or trends.

a. On Table 1, mark these points, noting the depth at which the data was taken.

b. Go to the **database of ocean sediment core images** to view the core from which the data were taken (Core 893A, Expedition 146).

c. Go to the segments of the core that contain the depths you marked on Table 1.

d. Describe each of the segments you view, noting any trends in their appearance.

STUDENT NAME: .....

Analysis

1. Look at your graph and describe what you see. What overall pattern do you observe?

2. During what three times can you find the highest ^{18}O : ^{16}O ratios?

3. Describe any trends you saw in the appearance of the cores given what you know about their oxygen ratio content.

Synthesis

1. What might the climate have been like for the three times you noted on your graph in analysis question #1 and the cores sections you observed that match with these times? Do these two pieces of data seem to support the same conclusions? (Think about the hydrological cycle, snow and the formation of large land ice sheets like those covering Greenland and the Antarctic continent. Also, consider how much runoff is coming from the land and going into the oceans.)

2. Do some additional research: when are known periods of glaciation in North America during the last 160,000 years? Do these align with your graphed data in any way? Do they support the claim that oxygen isotopes are a useful way to study the history of climate change?

STUDENT NAME: .....

3. Based on the trends you see on your graph, predict and explain what will happen to ^{18}O : ^{16}O ratios as modern global warming continues. (CAUTION: Oxygen isotopes are simply a record, not a cause of climate change.)

Extensions

1. Read and discuss "**Fossil Thermometers for Earth's Climate**" by Lear et al. Summarize what the article is saying.

2. Research and describe modern and/or fossil foraminifera (the organisms used in the oxygen isotope studies that generated the data that you graphed).

STUDENT NAME: .....

HANDOUT

TABLE 1. OXYGEN ISOTOPE RATIOS OVER THE LAST 157,000 YEARS

Age (years)	$^{18}O : {}^{16}O$ Ratio	Depth in Core (meters below seafloor, mbsf)
2,012	2.20	3.54
6,345	2.40	10.47
8,325	2.50	13.53
11,277	3.08	18.02
14,897	3.13	22.28
15,748	3.62	24.70
18,142	4.07	28.23
19,971	3.75	30.91
21,871	3.95	33.68
30,414	3.48	45.28
42,452	3.05	62.01
50,388	3.09	73.04
57,013	3.23	81.02
59,872	4.02	84.41
61,551	4.12	86.40
67,682	3.59	93.00
73,751	3.40	98.68
83,977	3.01	108.25
94,248	3.00	120.33
101,995	2.75	127.58
108,684	2.4	133.84
124,202	2.22	150.94
131,125	3.71	161.45
134,718	3.93	165.44
143,274	3.70	174.94
149,011	3.85	181.31
154,360	3.82	187.25
156,819	3.46	189.98

Data sampled from: Kennett 1995