

Secrets of the Sediments - Teacher Guide

Using Marine Sediments to Study Global Climate Change

Summary

During this activity, students will graph and analyze data from sediments collected off the coast of Santa Barbara, California to determine whether this information can be used to study historical climate change.

Learning Objectives

- Students will construct a graph showing the relationship between $^{18}\text{O}:^{16}\text{O}$ ratios in marine sediments and the age of the sediments.
- Students will interpret their graphs, looking for relationships between higher levels of ^{18}O during glacial periods.

National Science Education Standards

Grades 5-8

Standard D: Earth and Space Science

- Earth's History

Grades 9-12

Standard A: Science as Inquiry

- Evidence, models and explanation

Standard B: Physical Science

- Structure and properties of matter
- Interactions of energy and matter

Standard D: Earth and Space Science

- Energy in the Earth System
- Geochemical Cycles

Ocean Literacy Principles

1. The Earth has one big ocean with many features.
5. The ocean supports a great diversity of life and ecosystems.
7. The ocean is largely unexplored.

Target Grade: 7-12

Time: 1 Class Period

Materials

- Student Guides
- Rulers
- Graph paper
- Pencils
- Optional article, "Fossil Thermometers for Earth's Climate"

Background

The JOIDES Resolution travels the world sampling rock and sediment by obtaining cores from the bottom of the ocean. When the cores are removed from the ocean floor and brought onboard, they undergo a variety of analyses. Measurements like oxygen isotope ratios in sediment microfossils can be used to help scientists better understand the history of global climate change. Isotopes are atoms that have a different number of neutrons in their nucleus. For example, an oxygen-16 (^{16}O) isotope has 8 neutrons and oxygen-18 (^{18}O) would have 10 neutrons. Therefore, oxygen-18 is slightly heavier and oxygen-16 is slightly lighter. Water's chemical composition is H_2O — with either ^{16}O or ^{18}O .

The data presented in this activity shows the ratio of $^{18}\text{O}:^{16}\text{O}$ in marine microfossils found in ocean sediments off the California coast and the age of the fossils/sediments. Microfossils use oxygen from the water to create their carbonate (CaCO_3) shells, and are therefore good indicators or proxies of the water chemistry and oxygen isotopes when they were alive.

^{16}O , because it is lighter, is evaporated more easily. During glacial periods, the ^{16}O becomes "locked-up" in the glacial ice while ^{18}O remains in ocean waters causing the microfossils to become enriched in ^{18}O as well. During non-glacial periods, the $^{18}\text{O}:^{16}\text{O}$ is closer to 1, and this ratio is again reflected in the chemistry of the microfossil shells.

What To Do

1. Start by introducing the *JOIDES Resolution*. Discuss the questions listed in “Before You Begin” on the Student Page and review or introduce isotopes.
2. Allow the students to plot the data in Table 1. Their graphs should look something like the one shown below.
3. The “Analysis” questions can be completed individually, in small groups, or as a whole-class discussion.
4. Analysis

- a. Look at the graph and describe what you see.

The highest ratio of ^{18}O to ^{16}O fluctuates over time.

- b. During what three ages or time periods can you find the highest ^{18}O : ^{16}O ratios?

The highest ^{18}O : ^{16}O ratios are approximately: 20,000 years ago, 65,000 years ago and 135,000 years ago.

- c. Identify and list the time periods with the lowest ^{18}O ratios.

The lowest ^{18}O : ^{16}O ratios are approximately: today, 42,000 years ago, and 125,000 years ago.

- d. Why do you think this pattern occurred? What might have been happening geologically? Climatologically? (Think about the hydrological cycle, snow and the formation of large ice sheets like those covering Greenland and the Antarctic continent.)

Glaciers were melting (retreating) and growing larger (advancing); the atmosphere was warming and cooling.

- e. Predict and explain what will happen to ^{18}O : ^{16}O ratios as global warming continues. (CAUTION: Oxygen isotopes are simply a record, not a cause of climate change.)

^{18}O : ^{16}O ratios will move closer to 1:1 as more water melts from the ice caps and enters the oceans.

- f. Do you think the levels of ^{18}O can also indicate the amount of ice found on land? Explain.

Yes. If there are high ^{18}O : ^{16}O ratios, we can assume that there are larger amounts of ice on land, as the ^{16}O would be “locked up” in the glacial ice.

^{18}O : ^{16}O ratio vs Age of Sediments

