Secrets of the Sediments - Student Page

Using Marine Sediments to Study Global Climate Change

Summary

During this activity, you 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

You will be able to:

- graph data from sediments
- interpret that data
- draw conclusions from your data

Before You Begin

1. Think about these questions and record your answers on your own paper.
   a. What is climate?
   b. How would you describe the climate in your city, town or village?
   c. Does climate have any direct effects on your life? Does climate change? Talk to your parents and grandparents about any climate changes they recall.
2. Brainstorm and record some ideas for this essential question:
   a. How can we study global climate changes?
   b. What pieces of evidence can we look for to see how the Earth's climate has changed over the planet's long history?

Vocabulary

stable isotope
core
sediment
microfossil

Materials

- Graph paper
- Rulers

Background

The *JOIDES Resolution* (JR) is a ship that travels the world coring rock and sediments from the bottom of the ocean. When sediment cores are removed from the ocean floor, they undergo a variety of processes including visual descriptions, studies of microfossils, analysis for paleomagnetism, determination of sedimentation rates, and chemical studies of sediments including stable oxygen isotopes and carbonates.

Activities

1. Isotopes are atoms with the same number of protons, but different numbers of neutrons; the more neutrons, the heavier the isotope. Unstable isotopes, like uranium, decay over time and geologists can use them for age determination and dating. Stable isotopes do not decay and can therefore provide indirect records or proxies of past climate change. Oxygen occurs in three stable isotopes: oxygen-16 (^{16}O), oxygen-17 (^{17}O), and oxygen-18 (^{18}O). Which isotope is heavier?
2. Water's chemical composition is H_2O. The oxygen in water is usually ^{16}O but sometimes ^{18}O. ^{17}O is very rare. In terms of the hydrological cycle and evaporation, which oxygen isotope would evaporate first? Why?
3. Calcareous microfossils use oxygen from the water as one component of their carbonate ($CaCO_3$) shells, and are a good indicator of the oxygen chemistry of the water when they were alive. Table 1 shows the ^{18}O:^{16}O ratios and the ages of marine microfossils found in the Santa Barbara sediment core. Plot the ^{18}O:^{16}O ratio vs. sediment age and connect the points on a sheet of graph paper.

Table 1

Age (in thousands of years)	^{18}O:^{16}O Ratio
2	2.2
6	2.4
8	2.5
11	3.1
13	3.5
15	3.1
16	3.6
18	4.1
20	3.8
21	4.0
30	3.5
42	3.0
50	3.1
57	3.3
58	3.4
62	4.2
68	3.6
74	3.4
82	3.0
94	3.0
102	2.8
109	2.4
124	2.2
131	3.7
136	3.9
144	3.7
149	3.9
150	3.8
157	3.5

Table adapted from Kennett, 1995

4. Analysis
   a. Look at the graph and describe what you see.
   b. During what three ages or time periods can you find the highest ^{18}O:^{16}O ratios?
   c. Identify and list the time periods with the lowest ^{18}O ratios.
   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.)
   e. Predict and explain what will happen to the ^{18}O:^{16}O ratios as global warming continues. (CAUTION: Oxygen isotopes are simply a record, not a cause of climate change.)
   f. Do you think the levels of ^{18}O can also indicate the amount of ice found on land? Explain.

Extensions

1. Read and discuss "Fossil Thermometers for Earth's Climate" by Lear et al., from the ODP Highlights (*www.oceandrilling.org/greatest_hits2/*).
2. Research and examine global temperatures for the past 160,000 years and see how temperatures relate to the ^{18}O:^{16}O ratios for the glacial and non-glacial periods.
3. Research and describe modern and/or fossil foraminifera, the organisms used in oxygen isotope studies.
4. Would you expect high or low ^{18}O:^{16}O ratios in ice cores? Investigate and track down an answer.

References

Kennett, James, 1995. Latest Quaternary Benthic Oxygen and Carbon Isotope Stratigraphy: Hole 893A, Santa Barbara, California. *Proceedings of the Ocean Drilling Program Scientific Results*, v. 146, 16pp.

The Secrets of the Sediments - Teacher's Guide is available for download at *www.oceanleadership.org/education/deep-earth-academy/educators/classroom-activities/*

Activity written on the School of Rock Expedition by Ramona Smith, 11/2005 (for more information contact: *learning@oceanleadership.org*)