O-18 Isotopes & Glaciation

Teacher Guide

Credits: Jennifer C. Field

Objectives:

Students will learn the method of using Oxygen isotopes in the determination of paleoclimate. Students will create a model that demonstrates the differential evaporation and deposition of Oxygen isotopes and explain their role in the dating process.

Additional Resources

- *Introducing the International Ocean Discovery Program* https://www.youtube.com/watch?v=0nydKlpZdIU&list=PLroDmZEKRHPMCtFMzjx-Zg7plqnIqWMjI&index=2&t=242s
- *How Science Works* https://www.youtube.com/watch?v=i9tsdAQBcfM&list=PLroDmZEKRHPMCtFMzjx-Zg7plqnIqWMjI&index=3&t=0s
- "*Microfossils Making Macro Impacts*" joidesresoluution.org https://joidesresolution.org/microfossils-making-macro-impacts/
- "*Paleoclimates*" University of Michigan. Globalchange.umich.edu http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/paleoclimate/index.html
- *PNN Special Report Life on Board* *https://www.youtube.com/watch?v=n0bcIoALDFg&list=PLroDmZEKRHPMCtFMzjx-Zg7plqnIqWMjI&index=4&t=341s*

Activity Summary

Students will watch a short (8 minute) video about how seafloor cores are collected and analyzed using basic chemistry principles. They will then answer questions about Foraminifera and how these organisms help scientists study paleoclimate. Students will then be asked to interpret a graph and create a comic strip (or CER) based on their understanding of the water cycle, and how benthic Foraminifera store Oxygen isotopes which indicate the climate during the time of their deposition.

Next Generation Science Standards

HS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics
Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
HS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Target Audience:

8-12 Environmental Science/Environmental Chemistry

Time Required:

One 55-60 minute class period

Materials Needed:

- Device to watch Youtube video : Using Chemistry to Discover Earth's Secrets
  - https://youtu.be/QLCFEPdq3yw
- White paper for comic strip
- Colored pencils or markers
- Ruler
- Printed copies of Student Lesson

Activity Description

Name_____
Date _____

Watch the following video:
Using Chemistry to Discover the Earth's Secrets
https://youtu.be/QLCFEPdq3yw

1. What are Foraminifera?

Foraminifera are single celled heterotrophic organisms that live in the ocean

2. From what are the shells of Foraminifera made?

The shells are made for Calcium Carbonate - $CaCO_3$

3. What are benthic Foraminifera?

Benthic Foraminifera live on the bottom of the ocean

4. How does oxygen from the ocean get into benthic Foraminifera?

The benthic foraminifera undergo cellular respiration and incorporate Oxygen from the water. This Oxygen is then also incorporated into the carbonate in their shells.

Review:

Chemistry is a branch of science that helps us to understand how the world works. Did you know that scientists can use chemistry to determine how the climate has changed through time? It's true! By using isotopes, scientists can start to recreate past glacial cycles.

Isotopes are different variations of atoms. You may be familiar with the Periodic Table of the Elements. On it, you can find the mass of each element in atomic mass units (amu). You may notice that the number is a decimal. This is because it is the weighted average

of all of the masses of any type of isotope found for each element. But what is an isotope?

Isotopes vary by having more or fewer neutrons in the nucleus than the most common form of the element. Because neutrons add mass to the atom, these atoms weigh more if there are more neutrons or less if there are fewer neutrons.

Oxygen is a good example. Most oxygen atoms have 8 protons and 8 neutrons for a mass of 16 amu. On the periodic table, Oxygen looks like this:

8 O Oxygen 16.00	^{16}O	
	Number of protons	8
	Number of neutrons	8
	Number of electrons	8
	Atomic mass	16

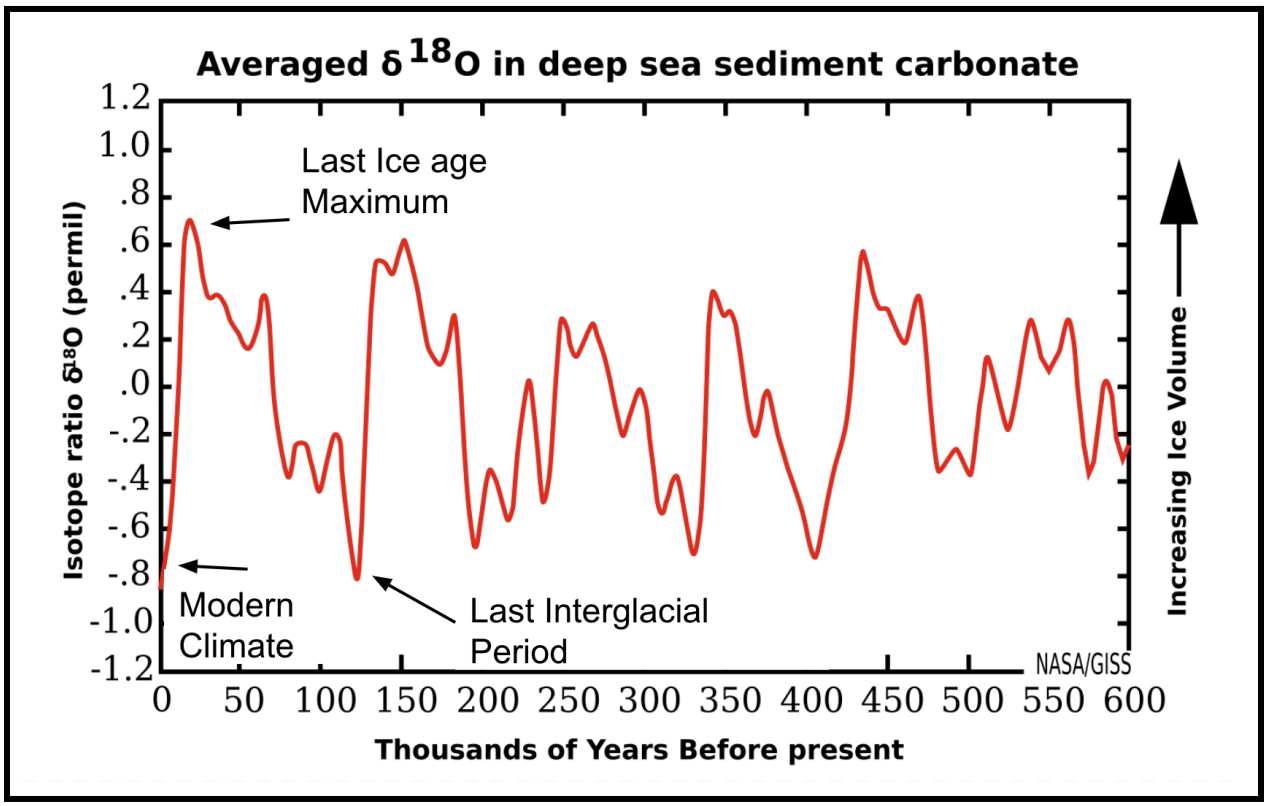
But, there is also another form of Oxygen that is much less common, it has more neutrons and has a mass of 18 amu. It is written Oxygen-18 or ^{18}O and is referred to as “heavy” oxygen.

Using the table above as a guide, fill in this table for the Oxygen-18 isotope:

8 O Oxygen 18	^{18}O	
	Number of protons	8
	Number of neutrons	10
	Number of electrons	8
	Atomic mass	18

This “Heavy Oxygen” helps determine the paleoclimate, or the ancient climate, during the deposition of ocean sediments.

Review the graph:



Schmidt, G.A. 1999. Forward modeling and interpretation of carbonate proxy data using oxygen isotope tracers in a global ocean model. Paleoceanography 14, 482-497.

1. On the left Y-axis is the ratio of Oxygen-18 to Oxygen-16, or the Delta ^{18}O ($\delta^{18}O$). What is the right Y-axis measuring?

The right Y-axis is measuring Increasing Ice Volume

2. What is the correlation between $\delta^{18}O$ and the volume of ice?

As the volume of ice increases, the $\delta^{18}O$ also increases

3. Use your knowledge of cellular respiration, the water cycle, and Oxygen-18, to create a comic strip that shows the relationship between benthic Foraminifera, the dead algae they eat and the Oxygen-18 levels in the shells of fossilized Foraminifera.

Answers will vary