# ICE CORE DATA Worksheet

You have 4 layers of ice. Each layer of ice represents 1000 years of accumulation. There are 3 pieces of information associated with each layer that you need to record on this sheet: a. AGE b. CO2 c. ISOTOPE PROXY DATA. The age of each layer is found on a label on the outside of the core – CAREFUL don’t mix up the top and bottom of the core! CO2 concentration data can be found on small piece of paper and isotope data (used by scientists as a proxy for temperature) is represented by a special proxy (colored marbles).

FIRST DATA POINT

a. AGE RANGE (Years Before Present)= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. CO2 (1000-year average concentration of CO2) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(PPMV)

# of green marbles =

# of purple marbles =

# of orange marbles =

c. Temperature Proxy (deuterium/hydrogen ratio of ice relative to the standard) δD = - \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ (‰)

SECOND DATA POINT

a. AGE RANGE (Years Before Present)= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. CO2 (1000-year average concentration of CO2) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(PPMV)

# of green marbles =

# of purple marbles =

# of orange marbles =

c. Temperature Proxy (deuterium/hydrogen ratio of ice relative to the standard) δD = - \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ (‰)

THIRD DATA POINT

a. AGE RANGE (Years Before Present)= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. CO2 (1000-year average concentration of CO2) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(PPMV)

# of green marbles =

# of purple marbles =

# of orange marbles =

c. Temperature Proxy (deuterium/hydrogen ratio of ice relative to the standard) δD = - \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ (‰)

FOURTH DATA POINT

a. AGE RANGE (Years Before Present)= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. CO2 (1000-year average concentration of CO2) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(PPMV)

# of green marbles =

# of purple marbles =

# of orange marbles =

c. Temperature Proxy (deuterium/hydrogen ratio of ice relative to the standard) δD = - \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ (‰)

# PROXY Worksheet

In this exercise colored marbles are a proxy for isotope data expressed in delta notation. Because we don’t have access to a mass spectrometer this lab uses a proxy (marbles) for a proxy (isotopes)! The ratio of heavy vs. light (D/H) hydrogen isotopes in the water molecules that make up ice varies along with changes in local temperature. Deuterium is so rare that the D/H ratio of ice is a very small number and isotope ratios of environmental samples need to be compared to a standard to make sense, therefore isotope data is expressed using delta notation. D values of hydrogen isotopes in ice cores are three digit negative values. Large green marbles represent the 100s digit, small purple marbles represent the 10s digit, and small orange marble represent the 1s digit.

Instructions:

1. You will be given a handful of marbles.
2. Place the colored marbles in the matching square below.
3. Write down the number of marbles in each colored box.

# of green marbles =

# of purple marbles =

# of orange marbles =

4. Translate the marbles into a negative number such as **-393** and write your answer here

 δD = - \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ (‰)

-Why is the “delta” value negative? Because the D/H ratio of the any sample is always compared to a standard for reference. For water isotopes, the standard is Vienna Standard Mean Ocean Water (VSMOW). The “delta” δ value of mean ocean water (VSMOW) is zero. The ocean has more deuterium than most natural substances – so most samples have a negative value according to “delta” notation because they are depleted in deuterium relative to the standard.



-Why are the units per mil (‰)? The answer is simple! Convenience (otherwise we would have to work with very small numbers, which is annoying).

# Pre Lab Survey

Please fill out this survey to help improve the lab. This survey is anonymous and will NOT influence your grades. It is OK to guess the correct answer. The information you provide will help science educators understand if this lab is effective.

1. **Approximately how many years ago was the Last Glacial Maximum (when ice sheets last extended the farthest)? Circle one.**
	1. ~230 years ago (American Revolution)
	2. ~2030 years ago (Cleopatra ruled Egypt)
	3. ~20,000 years ago (Human settlement of the Americas)
	4. ~230,000,000 years ago (First dinosaurs)
2. **What are isotopes?**
3. **What is the relationship between CO2 and temperature? Circle one.**
	1. As CO2 increases, temperature increases
	2. As CO2 increases, temperature decreases
	3. CO2 and temperature are not linked
4. **How are modern CO2 levels since the Industrial Revolution different than CO2 levels during the past 800,000 years? Circle all that apply.**
	1. Atmospheric CO2 has changed at a faster rate since the Industrial Revolution compare to the 800,000 years prior.
	2. The concentration of atmospheric CO2 today exceeds the glacial-interglacial variance by 100ppm (100% of the prior natural variance).
	3. The modern concentration of atmospheric CO2 is not different than the past 800,000 years.
5. **Please tell us how much do you know about the following topics.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Do you know . . .** | **Definitely Not****(1)** | **Sort of****(2)** | **Pretty Much****(3)** | **Yes, Definitely****(4)** |
| How scientists study Earth’s past climate? |  |  |  |  |
| What a proxy is? |  |  |  |  |
| About different timescales? |  |  |  |  |
| How temperature and CO2 were different in the past? |  |  |  |  |

# Post Lab Survey (Front and Back!)

Please fill out this survey to help improve the lab. This survey is anonymous and will NOT influence your grades. It is OK to guess the correct answer. The information you provide will help science educators understand if this lab is effective.

1. **Approximately how many years ago was the Last Glacial Maximum (when ice sheets last extended the farthest)? Circle one.**
	1. ~230 years ago (American Revolution)
	2. ~2030 years ago (Cleopatra ruled Egypt)
	3. ~20,000 years ago (Human settlement of the Americas)
	4. ~230,000,000 years ago (First dinosaurs)
2. **What are isotopes?**
3. **Which δDice value represents a colder temperature? Circle one.**
	1. δDice = -442‰
	2. δDice = -397‰
4. **What is the relationship between CO2 and temperature? Circle one.**
	1. As CO2 increases, temperature increases
	2. As CO2 increases, temperature decreases
	3. CO2 and temperature are not linked
5. **How are modern CO2 levels since the Industrial Revolution different than CO2 levels during the past 800,000 years? Circle all that apply.**
	1. Atmospheric CO2 has changed at a faster rate since the Industrial Revolution compare to the 800,000 years prior.
	2. The concentration of atmospheric CO2 today exceeds the glacial-interglacial variance by 100ppm (100% of the prior natural variance).
	3. The modern concentration of atmospheric CO2 is not different than the past 800,000 years.
6. **Please tell us how much do you know about the following topics.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Do you know . . .** | **Definitely Not****(1)** | **Sort of****(2)** | **Pretty Much****(3)** | **Yes, Definitely****(4)** |
| How scientists study Earth’s past climate? |  |  |  |  |
| What a proxy is? |  |  |  |  |
| About different timescales? |  |  |  |  |
| How temperature and CO2 were different in the past? |  |  |  |  |

1. **What would you say was the most important thing you learned from this lab?**
2. **Is there anything about the lab you found confusing?**

Thanks for filling out this survey!