The Scale of Past Climate Events

STUDENT NAME: ....

STUDENT ACTIVITY

SCIENTIFIC OCEAN DRILLING

Objective(s)/Outcome(s)

Students will be able to analyze oxygen isotope data from sediment cores to understand the occurrence of Heinrich Events.

Materials

- Handouts A–D
- Computer or tablet with internet access

Background

Heinrich Events are natural phenomena in which large groups of icebergs break off from the Laurentide Ice Sheet and enter the Hudson Strait into the North Atlantic (Figure 1A). First described by marine geologist Hartmut Heinrich, they have occurred multiple times over the past 640,000 years. The icebergs contained rock debris that had been eroded by the glaciers, and as they melted, this material was dropped to the sea floor as ice rafted debris (abbreviated to "IRD" or referred to as dropstones) forming deposits called Heinrich layers. Multiple mechanisms for Heinrich Events have been proposed but most scientists settle on rapid climatic oscillations which destabilize the Laurentide Ice Sheet and other northern hemisphere ice sheets (Figure 1B).

FIGURE 1A. MAP OF LABRADOR SEA AND SURROUNDING BODIES OF WATER.

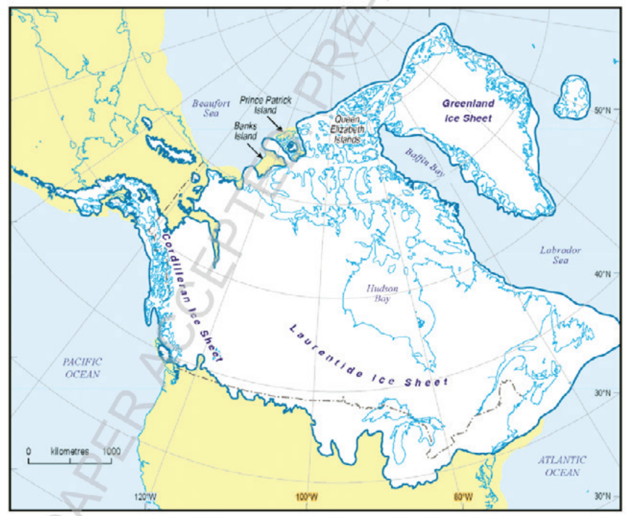

FIGURE 1B. REVISED RECONSTRUCTION OF THE NORTH AMERICAN ICE SHEETS AT 21.8 KA

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In marine sediment cores, like those collected during Deep Sea Drilling Project (DPSP) Leg 94, these events can be identified by recognizing large fractions of lithic fragments—portions of rocks of continental origin that end up in the ocean. Due to the large size of the IRD, they cannot be transported by ocean currents and can be interpreted as having been carried by icebergs or sea ice which broke off glaciers or ice shelves, and dumped debris onto the sea floor as the icebergs melted. The presence of IRD in these sediment cores can be interpreted as indicating a Heinrich Event.

Activity

Part A

1. Using the maps above as a guide, identify the following on the map on Handout A:
   a. Hudson Strait.
   b. Laurentide Ice Sheet margin.
   c. Deep Sea Drilling Project Leg 94 Site 609.
   d. A possible path for icebergs to travel between Hudson Strait and Site 609. It may help to research ocean currents in this area.
2. Retrieve the large images of Site 609 (either digital or printed).
   a. Looking at each core in order to identify IRD present in the cores. Zooming in on the images can help in the identification of IRD:
      i. **Core * images**
      ii. **Core A images**
      iii. **Core B images**
      iv. **Core C images**
   b. Complete the data table on Handout B. Measure the size in centimeters (cm) and its location within the core (be sure the document is at 100% magnification when you take measurements). If you need more rows, add them as needed.

Part B

1. Read Handout C to learn about how oxygen isotopes ratios were measured in cores taken during the Greenland Ice Sheet Project 2 (GISP2).
2. Analyze the graph on Handout D-1. Fold your paper so you cannot see Handout D-2.

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a. The graph on Handout D-1 is the record of ^{18}O values from GISP2 with ages on the y-axis and change in percent of heavy oxygen on the x-axis (note the direction of the scale on this axis).

b. Using the information from Handout C, mark 5 possible Heinrich events on the graph. Use a pencil to draw a dotted horizontal line to mark the beginning and end of each proposed event.

Part C

1. Unfold Handout D so both graphs are visible. Make observations of the two graphs.

a. The graph on Handout D-2 shows the percentage of IRD along the length of the same core used to make the graph of the heavy oxygen isotope.

b. Adjust the lines for the Heinrich Events as needed to reflect this new data.

Analysis

1. Compare the data on the GISP2 core graph and the IRD graph. Is there a relationship between the two data sets? Explain your answer, using the graphs as evidence.

2. Table 1 shows the accepted dates of Heinrich Events, based on many lines of evidence. Use a highlighter to shade in these events on the GISP2 core graph and the IRD graph. How did your predictions compare to the known ages of Heinrich Events? Describe the data (both oxygen isotopes and IRD percentages) that correlate with Heinrich Events.

TABLE 1. DATE RANGES OF HEINRICH EVENTS

Heinrich Event	Age (ka, x1000 years)
H0	9–13
H1	14–17
H_2	21–24
H3	29–32
H4	35–39

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a. Do all the Heinrich Events in Table 1 correlate neatly with the data on both graphs? Explain your answer, using the graphs as evidence.

b. Which data do you think is better for determining when Heinrich Events occurred- oxygen isotope or percentage of IRD within a core? Explain your answer.

Synthesis

1. Why do you think scientists who study IRD in cores make a graph of IRD along the core? What is the potential benefit of displaying the occurrence of IRD in a graph?

2. How would you determine if a Heinrich Event was caused by a localized, regional, or global oscillation in climate? What additional information might you need to come to this conclusion? Use the map of **ocean drilling sites** to determine which you would you consider as vital to your claim.

3. Where on the graph do you think a rapid change in climate is occurring? Speculate on what might cause a rapid oscillation in global climate.

Extensions

1. Most of the sediment deposited on the ocean floor does not come from melted ice. What types of sediment are commonly found on the ocean floor, what is their source, and how to they get to the ocean? How might these types of sediment also be used as evidence of environmental or climate change?

2. IRD are large stones deposited on the ocean floor after being dropped from melting icebergs or glaciers. What other processes on Earth result in the formation or deposition of large rocks?

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HANDOUTS

HANDOUT A

Label the map following the instructions in step 1:

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HANDOUT B
IRD within a core taken from drilling Site 609

		Core:
LF1	Size and Description	
	Section # and Depth	
LF2	Size and Description	
	Section # and Depth	
LF3	Size and Description	
	Section # and Depth	
LF4	Size and Description	
	Section # and Depth	
LF5	Size and Description	
	Section # and Depth	
LF6	Size and Description	
	Section # and Depth	
LF7	Size and Description	
	Section # and Depth	
LF8	Size and Description	
	Section # and Depth	
LF9	Size and Description	
	Section # and Depth	
LF10	Size and Description	
	Section # and Depth	

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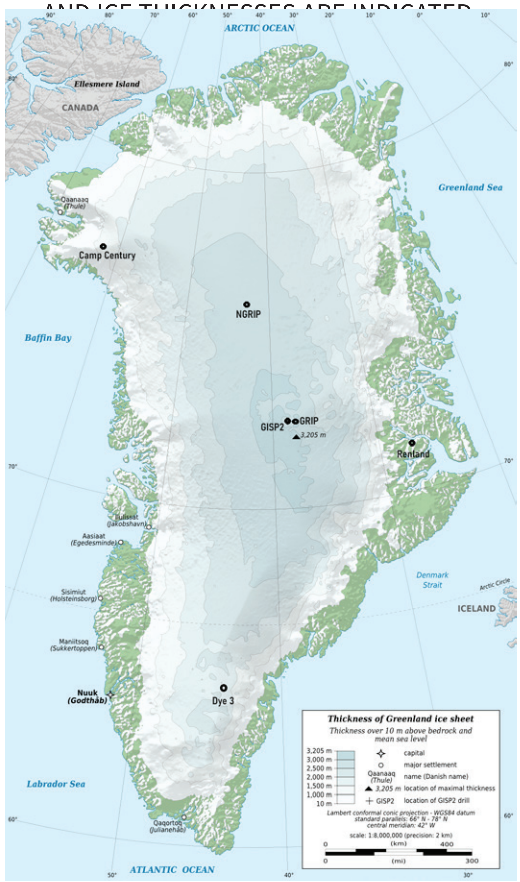
HANDOUT C
Greenland Ice Sheet Project 2 (GISP2)

FIGURE A. MAP OF GREENLAND SHOWING THE LOCATION OF DEEP ICE CORING SHEETS. PERIODS OF ACTIVE DRILLING AND ICE THICKNESSES ARE INDICATED



Credit: Ruth, 2003

The Greenland Ice Sheet Project was a major decades long project of the United States, Denmark, and Switzerland to drill ice cores in Greenland. The ice cores themselves provide a proxy record of temperature and atmospheric composition that helps to understand past climate variations. GISP2 was drilled at the summit of the ice sheet allowing for a deeper continuous record. Following 5 years of drilling, bedrock was struck on July 1, 1993—with a depth of 3053.44 meters it was the deepest ice core recovered in the world at the time. The majority of the GISP2 ice core is stored at the National Ice Core Laboratory in Denver, Colorado.

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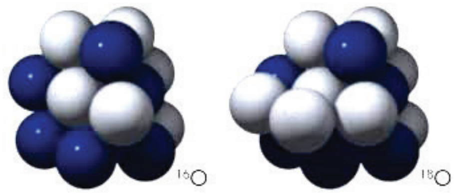
FIGURE B. OXYGEN ISOTOPES



Credit: **NASA Observatory**

One of the major items measured in nearly all ice and sediment cores is the ratio of two of the isotopes of oxygen — ^{16}O and ^{18}O.

All oxygen atoms have 8 protons, but the nucleus might contain 8, 9, or 10 neutrons. “Light” oxygen-16, with 8 protons and 8 neutrons, is the most common isotope found in nature, followed by much lesser amounts of “heavy” oxygen-18, with 8 protons and 10 neutrons. Both light and heavy oxygen can bond with hydrogen to form water, which can also be classified as light or heavy, depending on which isotope of oxygen is used to form it.

The ratio (relative amount) of these two types of oxygen in water changes with the climate. By determining how the ratio of heavy and light oxygen in marine sediments, ice cores, or fossil, information regarding climate changes that have occurred in the past can be understood. Because water molecules that have light oxygen isotopes can evaporate more readily when the climate is warmer, sediment and other deposits that form during these periods will contain a greater percentage of heavy oxygen. Lower values of heavy oxygen will occur in deposits formed during cooler climate events.

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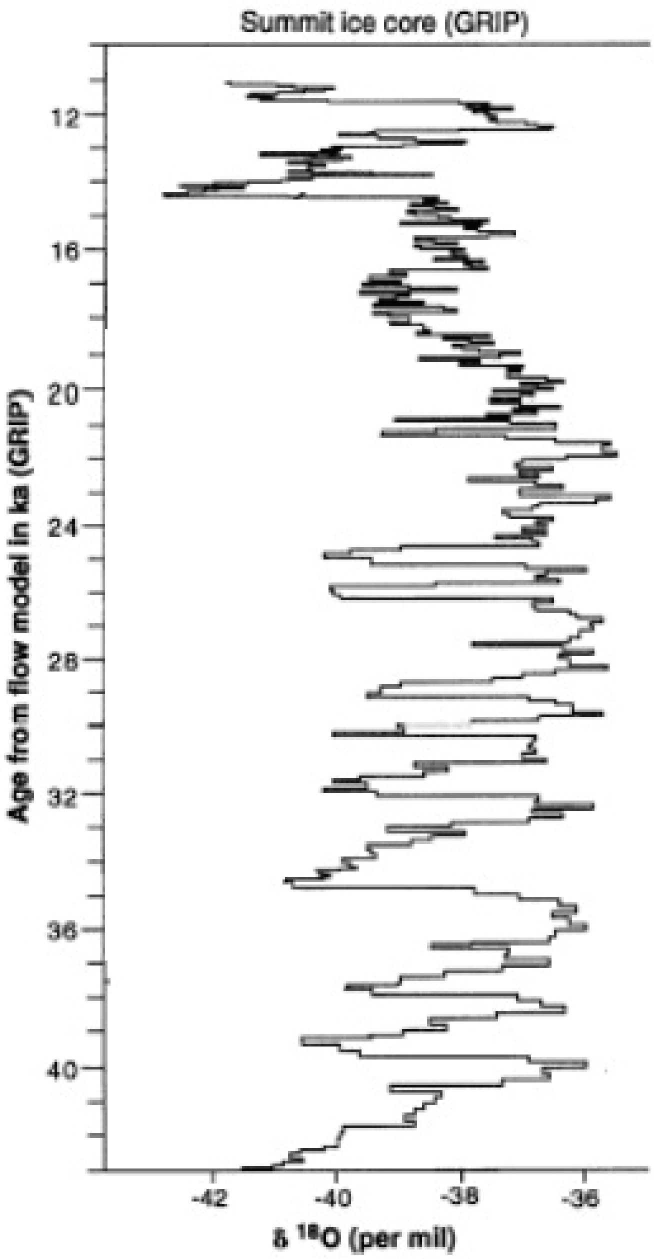
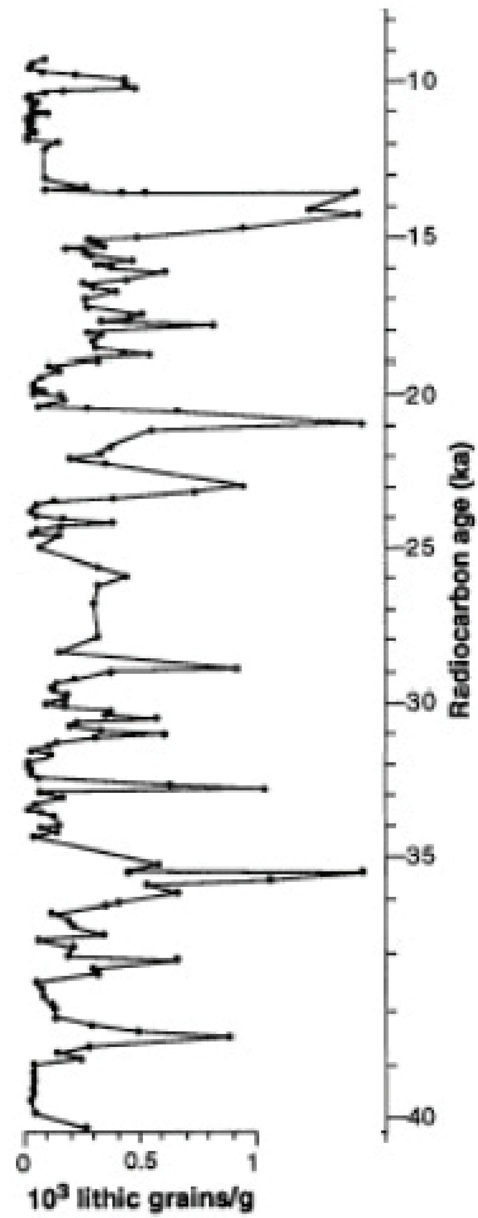
HANDOUT D-1



HANDOUT D-2



Credit: Modified from Bond and Lotti (1995).