CLIMATE CHANGE: PAST AND PRESENT

Overview:

In this lesson, students observe and analyze models of ice cores as a way to learn about Earth's past climate, then explore multimedia to learn about an ice coring project on a glacier in the Arctic National Wildlife Refuge.

Objectives:

The student will:

- create a scale drawing of an ice core sample;
- explain what climatic information can be measured in ice cores; and
- describe how ice cores can help us learn about past and future climatic conditions.

Targeted Alaska Grade Level Expectations:

Science

[9] SA2.1 The student demonstrates an understanding of the attitudes and approaches to scientific inquiry by formulating conclusions that are logical and supported by evidence.

[10] SD3.1 The student demonstrates an understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by describing causes, effects, preventions, and mitigations of human impact on climate.

Whole Picture:

Paleoclimatology is the study of past climates. The prefix paleo refers to things that are ancient or prehistoric and climatology is of course, the study of climate. Scientists learn about past climatic conditions by looking for clues. Tree rings, sediment layers (from the bottom of lakes or oceans), fossils and ice cores all contain clues about Earth's past climate. Although all of these natural climate recorders can provide valuable information, ice cores contain a great breadth of information. Analyzing ice cores can provide detailed information about: precipitation, temperature, abundance of atmospheric gases, solar variability, volcanic eruptions and more.

How is this information recorded in ice? When snow falls it carries what is in the air with it. In cold places (such as the polar regions and mountain tops) the snow rarely melts. Instead it continues to pile up year after year, compacting and forming layers of ice. Gases are trapped as small bubbles of air, recording samples of atmospheric conditions at different times. Compounds in the air (such as sulfate and nitrate released from burning fossil fuels and salt from ocean storms) are trapped in these layers as well.

Catastrophic events such as volcanic eruptions and nuclear bomb tests can be recorded in ice layers as well. A nuclear bomb explosion results in the distribution and fallout of radioactive material around the globe. Similarly, ash from a volcanic eruption is carried by wind and distributed around the globe. The discovery of thin radioactive layers (containing strontium-90 and cesium-137) or volcanic ash, chloride and sulfate, allows scientists to assign a year to a layer of ice within a core with a great degree of accuracy. Correlating the layer with known dates for these catastrophic events does this.

Ice cores can teach us even more about past climatic conditions. Scientists can analyze pollen recovered from ice core samples to determine the character of plant communities in the past. It is even possible to determine temperatures long ago by examining the ratio of hydrogen and oxygen isotopes trapped in the ice. (Isotopes are different forms of the same element. Isotopes contain the same number of protons and thus have the same chemical properties, but they have different numbers of neutrons and so differ in atomic mass.) Scientists can learn a lot about Earth's past climate by putting all of these clues together.

Ice cores are collected by driving a hollow tube deep into an ice sheet or glacier. Once extracted a core can be used to study the climate history of the core's location. Care must be taken not to damage the core as it is transported and it must be carefully stored to preserve it for future analysis. Some ice cores have provided an uninterrupted, detailed climate record extending back hundreds of thousands of years.

represent? (The ash in summer layers is most likely from forest fires. Ash in winter layers is more likely from a volcanic eruption. Discuss what can be learned from all of these observations and measurements. Note: The carbonated water may separate into two layers of its own. If students observe this phenomenon, explore the causes. Remember that ice is less dense than cold water, so it will begin to freeze on top and any impurities (including the carbon dioxide bubbles) are essentially pushed out as it freezes. This may create a layer of air space that is clearly visible as the ice core melts.

9. When the class has finished exploring the complete ice core, instruct students to finish STUDENT WORKSHEET: "Ice Cores." They will need to access MULTIMEDIA: "Extracting Ice Cores from McCall Glacier."

Extension Idea:

1. Allow time for students to explore the following interactive ice core sample. Students can click on the specific dates to learn more about the information scientists are able to obtain from ice cores. http://www.pbs.org/wgbh/nova/warnings/stories/icecore.html.

Answers:

1. An ice core is a sample taken from an ice sheet or glacier.
2. Paleoclimatology is the study of past climates.
3. Each group's ice core contains 5 layers (seasons) or 2½ years.
4. Answers will vary depending on how many groups you are working with. Each group's sample represents 2½ years, so if you are working with four groups, the total sample represents 10 years (20 layers or seasons). If you are working with six groups, the total sample represents 15 years (30 layers or seasons).
5. Answers will vary depending on which core groups they are working with. Answers should include at least one of the following: a high pollen year (evidenced by yellow layer w/cornmeal), a summer forest fire (evidenced by ashes), a low snow year (evidenced by a small winter layer), a volcanic eruption (evidenced by ashes in the winter layer).
6. Bubbles in the sample are trapped carbon dioxide bubbles from the carbonated water. They represent atmospheric gases that can be trapped in real ice cores. These bubbles record samples of atmospheric conditions at different times.
7. Each couplet (large and small layer together) represents a year of snow accumulation. Summer layers are darker and smaller because melting and refreezing makes the layer denser. All the winter layers are not the same depth, nor are all the summer layers because snowfall varies from season to season.
8. Student descriptions may vary, but should include that the cores are drilled with a large drill and then pulled in segments from the pipe.
9. Student descriptions may vary, but should include the that the ice core samples are stored in a plywood freezer that is partially buried in the snow.
10. Student answers will vary but may include: drilling for ice cores, storing ice cores, sledding, keeping weather data, studying the ice with radar and camping.
11. Answers will vary but should reflect an understanding that analyzing ice cores can provide detailed information about the past climate including: composition of atmospheric gases, impact of catastrophic events like volcanic eruptions, temperatures, ocean conditions, and what types of plants were abundant. Scientists can learn a lot about Earth's past climate by putting all of these clues together. Understanding how things changed in the past can help us predict future conditions.
12. Answers will vary but should reflect an understanding of the following. Alaska Native Elders have passed down weather and climate records for many generations through stories. They provide clues and information about the climate of the past that scientists don't have the tools to measure (such as when rivers froze). Science uses tools such as ice cores to study climatic conditions hundreds of thousands and even millions of years ago. It is only by integrating all of this information that we will gain the most accurate and thorough understanding of Earth's past, present and future climate.

Research team draws 150-meter ice core from McCall Glacier by Marmian Grimes

July 10, 2008

A 150-meter ice core pulled from the McCall Glacier in the Arctic National Wildlife Refuge this summer may offer researchers their first quantitative look at up to two centuries of climate change in the region.

The core, which is longer than 1½ football fields, is the longest extracted from an arctic glacier in the United States, according to Matt Nolan, an associate professor at the University of Alaska Fairbanks Institute of Northern Engineering who has led research at McCall Glacier for the past six years. The sample spans the entire depth of the glacier and may cover 200 years of history, he said. "What we hope is that the climate record will extend back into the Little Ice Age," said Nolan. "Up until the late 1800s these glaciers were actually growing."

Since then, arctic glaciers have been shrinking at an increasing rate, he said. "There is no doubt that this is due to a change in climate, but until now we can only guess at the magnitude of that change. Within these cores, we will hopefully capture this shift in climate quantitatively, and we're glad to have recovered them now before more of this valuable record melts and flows into the Arctic Ocean."

Ice core samples offer a window into past climate using clues, such as gas bubbles or isotopes of oxygen and hydrogen, locked in the ice when it formed. In addition, debris in the ice, such as layers of volcanic ash and pieces of organic material such as insects, can help scientists draw a timeline through the depth of the glacier.

Because McCall Glacier has been studied extensively since the International Geophysical Year in1957-58, the research history there offers a unique opportunity to compare ice core data with a wealth of related information, such as ice temperature and speed, air temperature and snowfall, and models of how the glacier changes within those parameters. Those comparisons with the modern parts of the ice core can help scientists better understand changes in the older sections, Nolan said.

"Due to its remote location, long-term instrumental climate data here are sparse to nonexistent, so ice cores from this glacier are one of our few means to determine climate variations in this huge region over the past few hundred years," Nolan said. "We are also quite fortunate and privileged to be granted permission for this work. Research at McCall Glacier predates the formation of the refuge and meshes well with scientific aspects of the refuge's mission to conduct long-term ecological research."

A team using a drill from the Ice Core Drilling Service at the University of Wisconsin-Madison pulled the cores from the glacier, one meter at a time, for nearly two weeks straight, despite storms strong enough to break and blow away some of their tents. About midway down, drillers hit an aquifer in the ice, which filled the borehole with water and complicated the drilling effort.

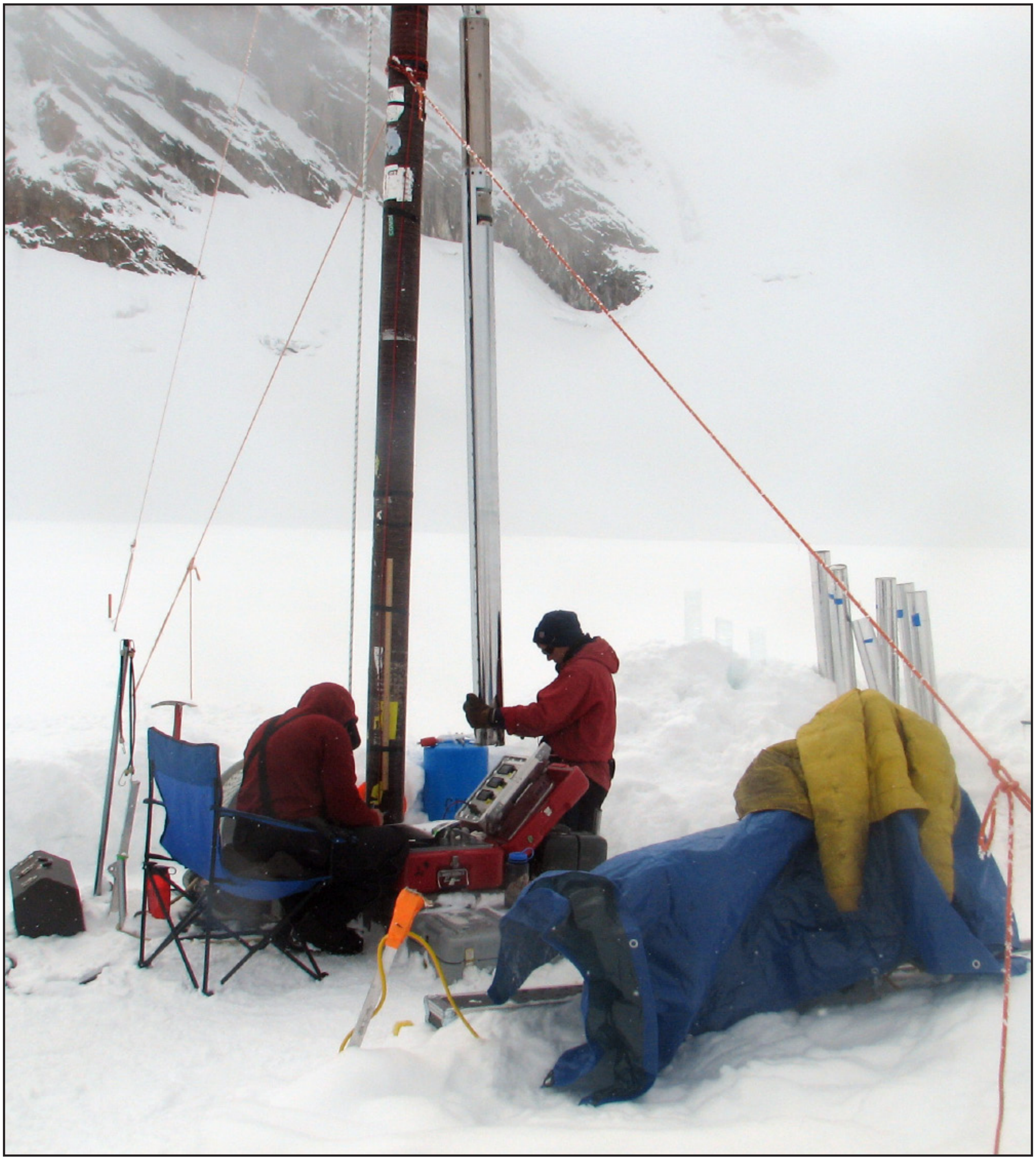
"The drill team did an excellent job of making their tools work in challenging conditions, in particular drilling the last 80 meters of core under water," Nolan said. "This is a very unusual situation for ice coring, as most cores are taken from summits of cold, dry polar ice sheets not warm, flowing valley glaciers."

At 150 meters, drillers hit a rock at what the team believes was the bottom of the glacier, based on radar measurements of ice depth.

The ice cores were flown to Fairbanks and are being housed at the Alaska Ice Art Museum until the fall, when glaciologists will return from the field to begin analysis.

The McCall Glacier project is part of UAF's contribution to research efforts during the fourth International Polar Year. Nolan's research at McCall Glacier is funded by the National Science Foundation and is part of a cooperative effort, involving 15 other nations, to gain a better understanding of the dynamic response of arctic glaciers to recent climate change. IPY is an international endeavor that is focusing research efforts and public attention on the Earth's polar regions. Other partners on the field team included the University of Silesia in Poland and the Kitami Institute of Technology in Japan. Additional core analysis will be performed at Ohio State University and the Free University of Brussels in Belgium.

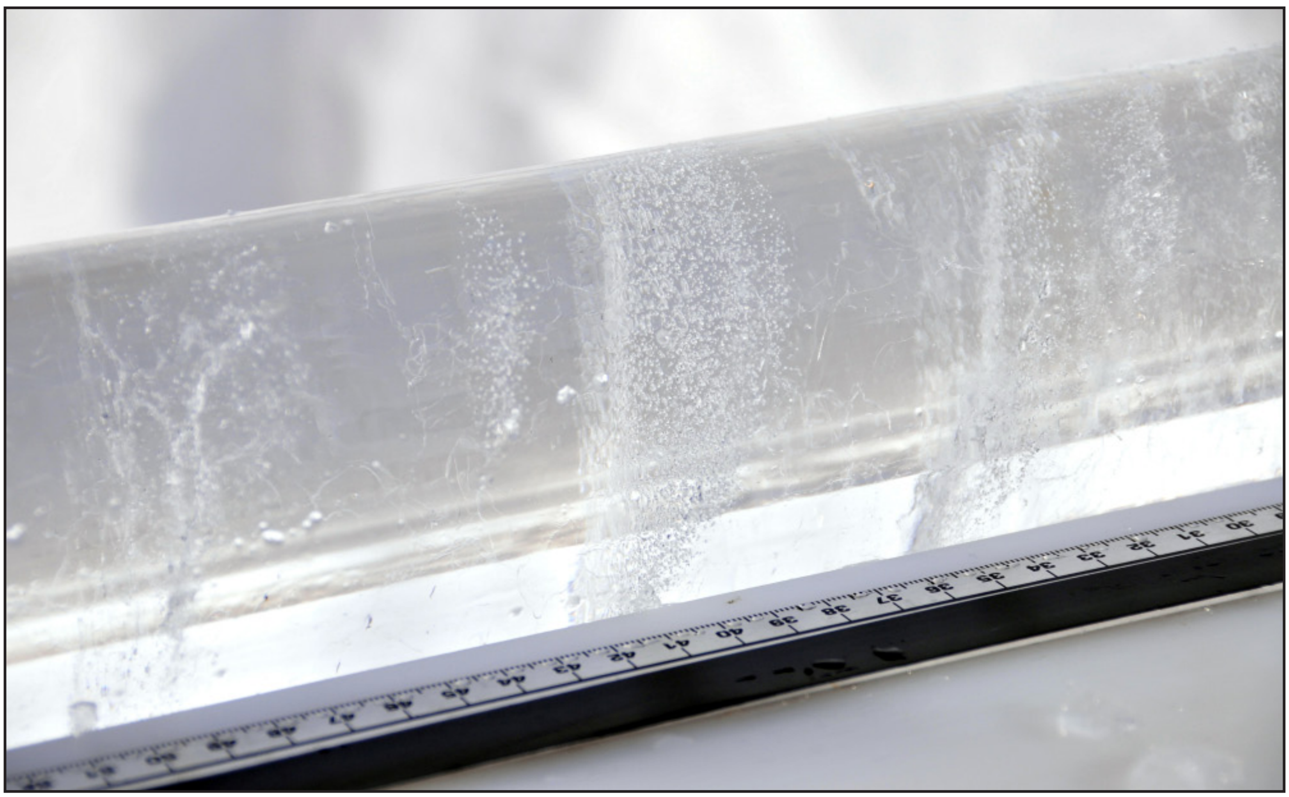
ICE CORES



Drillers Bella Bergeron and Terry Gacke run the drill during ice coring operations at McCall Glacier during the 2008 field season. Photo by M. Nolan.

ICE CORES

Ice cores rest inside a plywood freezer partially buried in the snow on McCall Glacier. The 4-foot by 4-foot by 8-foot box housed ice cores as the team pulled them from the glacier during the summer 2008 field season. By the time drillers were done, the box was nearly full. Photo by M. Nolan.



A section of ice core shows bands of bubbles frozen within the ice of McCall Glacier. Photo by M. Nolan.

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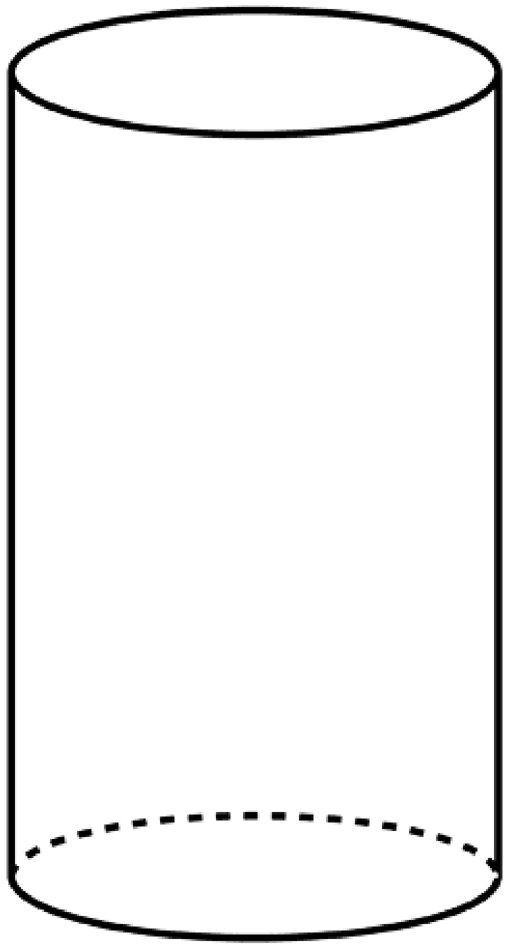
ICE CORES

Directions: Write the number of your ice core in the box. Carefully observe the ice core. Use a ruler to measure the layers. Use the colored pencils to accurately represent the layers and create a scale drawing. Be sure to include things like gas bubbles and other substances you see in the ice. Label the oldest and youngest layers. Note your observations on the lines below.



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ICE CORES

Directions: Answer questions 1-7 based on your ice core samples. Access MULTIMEDIA: "Extracting Ice Cores from McCall Glacier" at www.uniteusforclimate.org/climate_resources_mm.html to answer question 8-10. Answer questions 11-12 based on what you have learned in class.

1. What is an ice core? ______________________________

2. What is paleoclimatology? ______________________________

3. How many years does your ice core sample represent? ______________________________

4. How many years does the total ice core sample represent? ______________________________

5. Describe any significant ecological events recorded in your sample. What evidence led you to this conclusion?

6. What created the bubbles in your sample? What creates the bubbles in a real ice core?

7. Describe the differences between winter and summer layers in your sample.

8. Describe how an ice core is extracted on McCall Glacier.

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ICE CORES

9. Describe how an ice core is stored on McCall Glacier.

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10. Name at least three different activities taking place at the drilling site on McCall Glacier.

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11. Describe what we can learn by studying past climatic conditions in ice cores.

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12. Describe how Alaska Native Elders have passed down climate information and how this can add to information gathered by studying ice cores.

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