Ice Cores: A New Perspective on the Past

Primary Subject: Science

Grade Level: 8-11

Students Should Be Able to:
- define and describe the field of paleoclimatology
- understand that the chemical composition of the Earth's atmosphere is recorded in layers of ice
- graph and analyze trends of real data collected from Mt. Logan, Canada ice cores
- describe the impacts of anthropogenic activity, especially during periods of industrialization

Part 1: A Lesson in Paleoclimatology
Make sure each student gets a copy of the hand out entitled "A Lesson in Paleoclimatology." You may chose to have students work independently, in groups, or as a class, to read and answer the questions.

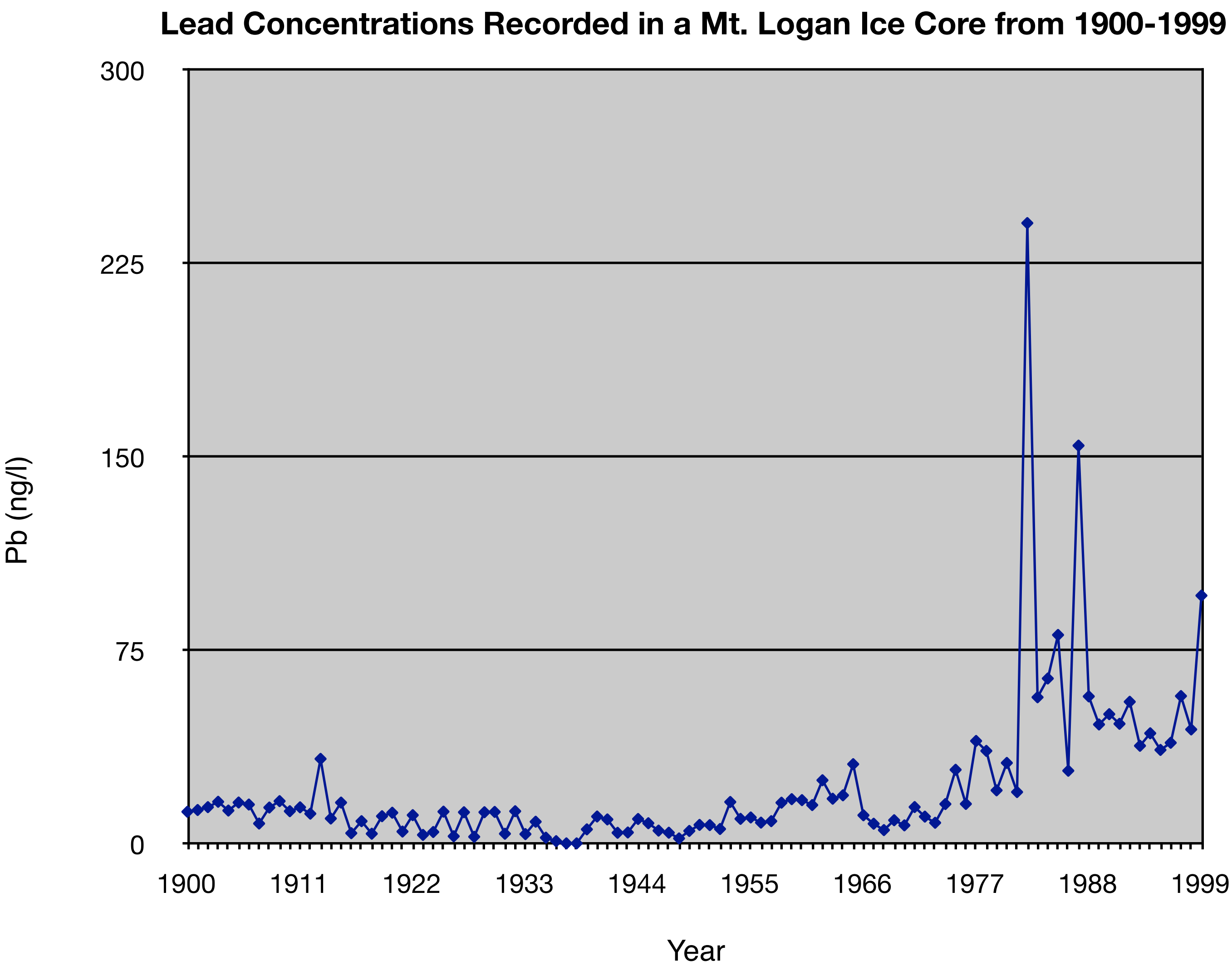
Suggestions for Further Discussion:

Keep in mind that paleoclimatologists are confined to computer models to conduct experiments and make predictions, because it would not be smart to conduct experiments on the Earth's climate system. What are some limitations/assumptions to this?

Part 2: Graphing Ice Core Data
Organize students into teams of 2-4, or have them work independently and provide each team with copies of the "Graphing Ice Core Data" and "Mt. Logan Ice Core Data" student handouts.

Again, depending on your preferences you may chose to have students work independently, in groups, or as a class, to read and answer the initial questions.

Tell students they will be analyzing lead concentrations measured in ice core data from Mt. Logan, Canada in this activity. Have students graph the data, making sure that each team starts with the oldest data, year 1900, and that all teams graph the appropriate variable on each axis (time on the x-axis, and lead concentration on the y-axis). Graphs should look similar to that pictured on the next page.



After graphing is completed, reconvene as a class and discuss each team's interpretations of the data. Do all interpretations agree? Why or why not? What additional questions do students have about the data?

Have students read the rest of the handout. This is meant to get students thinking about anthropogenic effects on the environment. You may wish to conclude with a class discussion of students' perceptions of pollution and climate change, or use this as a jumping off point to introduce such curriculum.

Name:________________________ **Date:________________**

A Lesson in Paleoclimatology

Global climate change is something you probably hear about a lot. But how do scientists know that such change is *actually* occurring? Have scientists discovered a time machine transporting them back to the days of the dinosaurs to find out what the climate was like back then? The answer, in a way, is YES!

Scientists who work in climatology, the study of how the Earth's climate system works, have to look further than most when it comes to studying the climate. Sure, technology has advanced enough that everyday a weather man seems to "see" into the future and forecasts temperatures, wind speeds, and precipitation levels for the upcoming week, but this has largely to do with weather instruments that can track high and low pressure air systems that travel around the Earth and cause weather conditions. It is true, also, that almanacs record a history of temperature weather conditions, but this record only extends back as far as the instruments used to record them do, or about 100-200 years. Considering the Earth is over 6 billion years old, is information based on 150 years worth of evidence *really* enough to claim that something unnatural is actually occurring? Those who study climate will argue, as I'm sure you will agree, that this is not enough evidence. Then how can scientists still claim that global climate change is occurring with so much confidence?

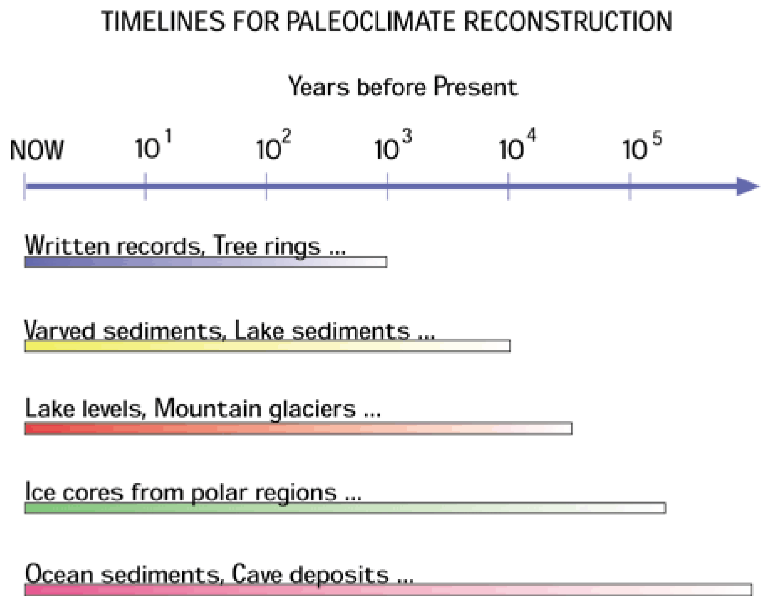
Paleoclimatology, the study of past climates uses information stored in tree rings, corals, fossils, and glaciers to recreate the history of Earth's climate system. As the climate changes, the chemical and physical structure of its oceans, life, and land changes. By studying these how these structures, known as climate proxies, change over time we can understand seasonal changes in specific regions, as well as general climate patterns over the entire Earth.

Tree rings can be counted to determine age, and the thickness of each tree ring itself can tell scientists about patterns of temperature and precipitation over the course of that year. Trees grow more when they have optimal nutrients and water. During optimal conditions, the tree will grow more than in periods of drought or cold temperatures.

Coral, made up of thousands of tiny organisms, also consists of "rings" that give scientists information. The rate of coral growth changes as the water temperature and other factors change. By studying the coral, scientists can recreate sea surface temperatures and salinity from the past few centuries.

When microorganisms, plants, and animals die, sometimes their remains sink to the bottom of a lake or ocean where they become buried over time. Since different organisms are suited for living in different environmental conditions, scientists can recreate climatic conditions by taking sediment cores and looking at which organisms are found at different depths in the sediment.

There are limitations to these proxies, however. One of the most important is the fact that such records only stretch as long as the organisms are alive.



The diagram above shows the limitations of various climate proxies. The colored areas represent the confidence of the record.

1.) Estimate the length of records written, tree, and lake sediments scientists can *confidently* obtain information from.

2.) What characteristics about the environments ice cores, ocean sediments, and cave deposits are obtained from that extends the life of the proxy data? (Hint: Think about where these things are located. What do they have in common?)

By reading the signs of past climate, scientists can reconstruct the history of Earth's climate over hundreds of thousands—in some cases millions—of years. When combined with observations of Earth's modern climate in computer models, paleoclimate data help scientists to predict future climate change.

Name:________________________ **Date:________________**

Graphing Ice Core Data

If scientists understand Earth's climate system and have constructed a model correctly, the behavior of the model should mimic the behavior of the Earth's climate system. By acquiring detailed climate records extending back hundreds of thousands of years, scientists can test and improve upon the accuracy of the models.

The study of ice cores is an important part of this process. Glacial ice in Antarctica and other regions holds a special key to the mysteries of Earth's past climate. As snow falls, it traps air and water from the clouds, gases, and dust from our atmosphere. As more snow falls, and the older snow gets buried, it is compacted and eventually turns to ice. As it gets compacted, the air between snowflakes get trapped and squeezed. This record, although still short (in geologic terms), it can be highly detailed, including information on temperature, precipitation, chemistry and gas composition of the lower atmosphere, volcanic eruptions, solar variability, sea-surface productivity and a variety of other climate indicators. The ice in Allan Hills, Antarctica is believed to hold information about Earth's climate history extending as far back as 2.5 million years!

Over the past decade, research on the climate record frozen in ice cores has completely changed our understanding of how the climate system works. Changes in temperature and precipitation which, according to our models would require many thousands of years to happen, happened at a much faster rate! These discoveries have forced scientists to look toward other mechanisms that may be changing the climate. One such mechanism is the interaction between humans and their environment.

In the following activity you will graph and analyze data from an ice core obtained from Mt. Logan, Canada.

Using Excel and the data your teacher has provided to you in spreadsheet format, graph the concentration of lead (Pb) versus time.

1.) What do you notice?

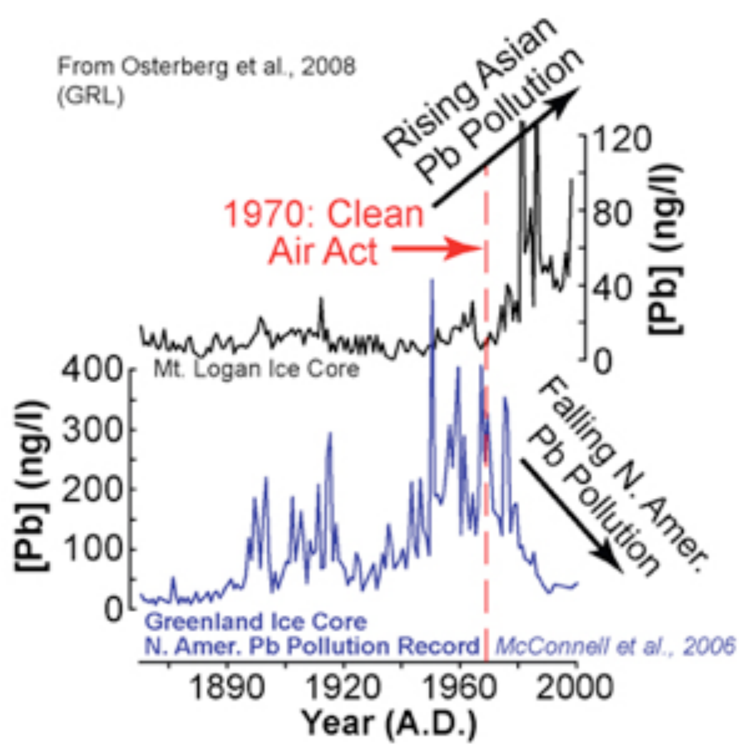
2.) Looking at the period from 1970 to the present, what is happening to the concentration of lead?

Scientists studying ice core records from Greenland, the Canadian Arctic, and the European Alps have created the same graph of atmospheric lead pollution that you just created.

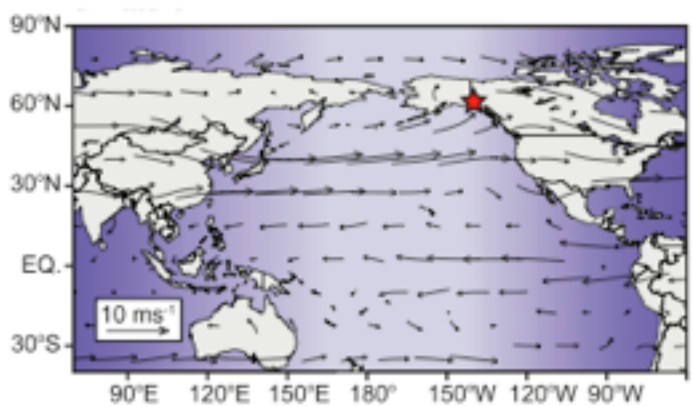
Leaded gasoline combustion is the largest Pb pollution source, followed by fossil fuel burning and metal smelting. Unfortunately, scientists have also discovered that lead is a very toxic substance to both humans and the environment. In the early 1970s, during what many have dubbed the environmental era, Western European Nations, Canada, and the United States (with the Clean Air Act of 1970), created strict regulations to limit the amount of lead pollution. Lead was phased out of gasoline and paint, and cleaner industrial practices were enforced.

You may have noticed, however, the ice core record obtained from Mt. Logan shows that lead concentration has continued to increase despite these environmental regulations. Studies have shown that rapidly developing nations in Asia have not been as aggressive than Western nations in limiting pollution emissions.

You may recognize part of the "Mt. Logan Ice Core" plot on the graph below, as it probably looks a lot like the one you created. This is the some of the same data that you had access to, the difference is that data collected over a longer time period.



Developing Asian countries currently represent the largest emitters of most pollutants in the world today (Pacyna and Pacyna, 2001), and due to the Earth's winds, their industrial practices are being recorded in the ice. Wind currents in the Earth's atmosphere behave much like ocean currents. These currents are predictable and follow a distinct path (see the diagram below). Prevailing westerly winds in the mid-latitudes carries pollutants from Asia across the Pacific to North America (the red star indicates the location of Mt. Logan).



As large as the Earth is, it represents a complex series of systems that are delicately balanced and combine to control climate. Scientists are seeing that human activity is changing the Earth system, and some of these effects are clearly visible with the help of ice cores and other climate proxies. In addition to increases atmospheric lead, green house gases, like carbon dioxide, have also increased at rates not previously found in the computer models that scientists are creating. With this information, we can gauge just how much of an impact humans are having on the Earth, and get a better understanding about what may be in store for its future.