The Climate Time Machine Activity

Using Fossils to Study Climate Change

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Background

In the springtime, pollen signifies the long-awaited arrival of warm weather. For some, Pollen means unpleasant allergies. For paleoclimatologists - scientists who study past climates - pollen is like a climate time machine!

Pollen that settles on the surface of a body of water eventually sinks to the bottom where it gets trapped in the sediment. As the sediment and pollen accumulate, the annual layers increase in thickness. Paleoclimatologists extract long tubes of sediment cores and use them to figure out how climate conditions might have changed over time. The fossilized pollen is extracted and identified to see what plant species were prevalent in the past. Because the scientists know the preferred climate conditions of each species, they can infer what the climate was like during those time periods.

In *The Climate Time Machine* activity, students will look for "pollen" in "lake sediment." Based on actual pollen data collected from Battleground Lake in southwest Washington state, students will track how the climate has changed in the past 20,000 years.

Time Considerations

- Two hours for prep
- One hour for activity

Materials

- 11 different colors of seed beads (see Table 1 for colors)
- White sand (~5 pounds)
- 5 colors of ground up chalk, preferably orange, green, purple, pink and blue.
- 5 gallon-sized freezer bags
- Vegetation info cards, on website
- 10 pie tins or small trays
- 10 small paper cups
- Handouts, one per group:
    - Student Handout, pg. 4
    - Blank graph, pg. 5
- Transparencies:
    - Blank graph, pg. 5
    - Ice core graph, pg. 6
- Wet erase markers
- Overhead projector
- PDF of pictures downloaded from MEEP website and saved to your computer
- Computer with LCD projector

Preparation

Note: Maine Energy Education Program has kits for loan.
Email Peter Zack at peter@meepnews.org for more information.

1. Make "sediment" by separating sand into five equal portions. Place each sample into a gallon-size plastic bag along with one color of the ground-up chalk. Shake the bags to mix well. Label each bag with the layer number and time period, again from table 1.
2. Add seed beads to each bag, as directed in table 1. Each bag should have some combination of 25 seed beads. You may choose to count out extra sets of beads for each sediment if you plan to do the activity more than once because beads tend to get lost. You can keep the extra sets of beads in tiny plastic zipper bags from the jewelry section of a craft store.
3. Print the vegetation info cards, available on the MEEP website, double-sided. Separate them into five sets, based on the layer of sediment they belong with. Each set will have 3-5 cards. Students will use these cards to identify the "pollen" in their sediment samples.

Introducing the Activity

1. Ask the students if they know what a climatologist does. How is a climatologist different from a meterologist? Do they know how climatologists learn about past climates?
2. Using an LCD projector, project the PDF of pictures downloaded from the MEEP website. As you move through the first five slides, explain that researchers are removing long cores of ice in Antarctica.

3. Ask the students what the scientists are looking for (carbon dioxide). Explain that as ice freezes, little air bubbles get trapped in the ice. The ice builds up over many years and the core tells a story like the rings of a tree trunk.
4. Move on to slides 6-12. What are the climatologists looking for in the lake sediment cores? Give the students a hint by asking them if they can identify the strange objects photographed by an electron scanning microscope (pollen).
5. Show slide 13. Explain that as sediment falls to the bottom of the lake, it builds up over time. Pollen gets trapped in the layers. We can identify different kinds of pollen. Because we know what kinds of habitats or climates the plants prefer, we can infer what the climate may have been like when that pollen was shed.

Table 1. Key to species in each sediment layer (for teacher).

Sediment Layer	Plant Species	Bead Color	# of Beads	Ratio
5 4,500 ybp to Present (Orange)	Western Red Cedar Western Hemlock Douglas Fir Alder	Blue Cream Gold Red	6 5 10 4	24% 20% 40% 16%
4 9,500 ybp to 4,500 ybp (Green)	Douglas Fir Oak Mixed Meadow Species	Gold Yellow Lt. Purp.	3 3 19	12% 12% 76%
3 11,200 ybp to 9,500 ybp (Purple)	Douglas Fir Grand Fir Alder	Gold Pink Red	7 5 13	28% 20% 52%
2 15,000 ybp to 11,200 ybp (Pink)	Lodgepole Pine Englemann Spruce Grasses & Sedges Alpine Sagebrush Grand Fir	Lt. Blue Lt. Green Green Clear Pink	7 3 3 9 3	28% 12% 12% 36% 12%
1 20,000 ybp to 15,000 ybp (Blue)	Grasses & Sedges Alpine Sagebrush Lodgepole Pine Englemann Spruce	Green Clear Lt. Blue Lt. Green	15 4 4 2	60% 16% 16% 8%

Procedure

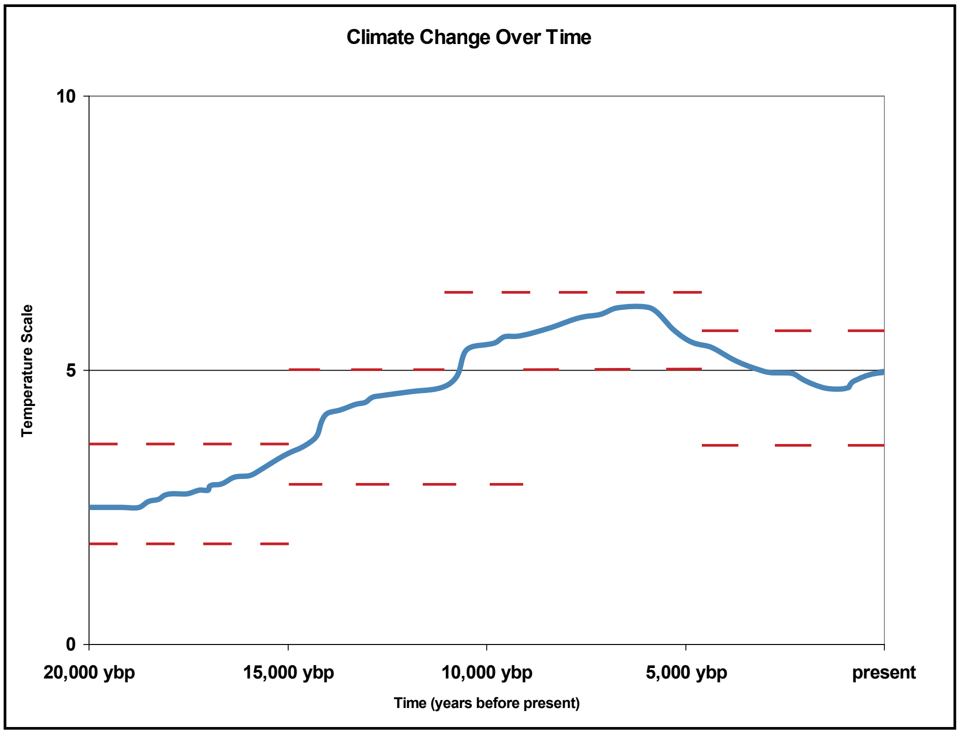
1. Divide the students into five groups. Distribute one sediment sample, the corresponding set of vegetation info cards, two small trays and one copy of each handout to each group.
2. Tell the students that they will search for "pollen" in this simulated lake sediment. Referring to the model sediment core on slide 13, explain that layer 1, at the bottom, is the oldest sediment - forming as long ago as 20,000 years before present.
3. Have the students search for the pollen. It works best to pour the sediment into the sample trays and keep the beads in the paper cups. If they you have tools that will aid in their search, such as spoons or funnels, feel free to make them available.
4. Once a group finds 25 beads, have them separate them by color and use thier vegetation cards to identify the types of pollen. The back of each card shows the plants' preferred climate range. This is a relative scale with "5" being today's climate in Washington state. Anything below 5 is a cooler climate. Anything above 5 is a warmer climate.
5. Students should record their findings on the blank data table. For each color of bead, have them list the color, quantity, species and preferred climate range. As a group, they should determine a climate range that would make it possible for all plants to live there during their time period.
6. Once a group has recorded all their data, they should put the beads and sand back into the plastic bag. You can collect their materials.
7. Have each group hypothesize how the average global temperature has changed over time by drawing a line to represent the temperature on their blank graph. Have them keep in mind the temperature range during their time period. Remind them that "5" represents today's climate.
8. Using the overhead projector, show the transparency of the blank graph. Ask each group to share the climate range they came up with for their time period. Using a wet erase marker, draw horizontal lines in each

time period to represent the low and high end of each range. See red dashed lines at right for an example.
9. Ask a volunteer to approach the overhead projector and draw a temperature line that spans all time periods but stays within the temperature ranges determined by the class. See blue line at right for an example.
10. Next, show the students the transparency depicting ice core data from Vostok Station. Ask if they can tell what two lines represent (atmospheric CO_2 concentration and average global temperature over the past 20,000 years). What are the trends? Is there a correlation? Why does the CO_2 level spike upward in the post-industrial era?
11. Overlay the graph based on your pollen data. Be sure that the two axes line up - the "0" on the ice core graph and the "5" on the pollen graph. Explain that climatologists compare the various ways to study past climates to see if the data agree.

Extension: Keeling Curve

1. Explain to your students that humans have been tracking atmospheric carbon dioxide levels directly since 1958. The "Keeling Curve" is perhaps the most famous dataset, started by Charles David Keeling. Measurements are taken dozens of timea each day *upwind* of Mauna Loa in Hawaii.
2. Using the LCD projector, show the following website: scripps.ucsd.edu/programs/keelingcurve/.
3. Below the graph, hover your mouse over "full record" to see all of the data from 1958 to present. Ask the students for their observations. Does anyone know why the line zig-zags?
4. Hover over Two Years and One Year to give them a closer look. What are their theories about the annual fluctuation? This phenomenon is in line with the seasons; in summer the vegetation absorbs CO_2 during photosynthesis. in late fall, plant material dies and releases some of that CO_2 back into the air. Note that there is far more land, and therefore vegetation, in the northern hemisphere. That's why the graph follows the seasons in the northern hemisphere.
5. Ask your students to think about the overall trend of the Keeling Curve. Is the growing vegetation absorbing enough CO_2 to compensate for what is being released through the combustion of fossil fuels? Another thing to consider is the impact of deforestation in the rainforest, for example.

Figure 1. Sample graph with teacher/student input.



Extension: Diatoms

1. Pollen isn't the only thing paleoclimatologists seek when studying climates of the past. Diatoms are single-celled organisms that live suspended in water or in sediment on the bottom. Diatoms' cell walls are composed of silicon dioxide.
2. Scientists study the oxygen isotope ratios in diatom shells because different ratios form in different water temperatures.
3. In addition, the abundance of diatoms coupled with the variety of species is an indicator of environmental conditions. Warmer water typically results in more diatoms.
4. If your students have access to computers, they can find images of diatoms by searching for "diatom electron scan" on the web. Like pollen, they are all so very different!

Student Handouts

Pollen Key and Climatic Characteristics

Species	Climatic Characteristics
Western Hemlock	Principal dominant tree of lowland, temperate conditions. Requires very moist, temperate confitions for growth.
Douglas Fir	Broadly distributed throughout the Pacific Northwest from moderately cool to warm sites. Grows best under temperate, somewhat moist conditions.
Grasses & Sedges	This mix of pollen from grasses and sedges is typically found in alpine/subalpine meadows characterized by cool summers, harsh winters and short growing seasons.
Alder	Widespread throughout the northwest, it typically colonizes gravel and other poor soils. It prefers abundant water and can grow in cool climates.
Grand Fir	Found at mid-level elevations in the Cascade Mountains. Grows in cool climates, but not as cold-tolerant as trees found at higher altitudes.
Englemann Spruce	Found in cold, usually subalpine sites. It is an important timberline species in the Rocky Mountains.
Western Red Cedar	Found only in temperate, very moist climates.
Lodgepole Pine	Found in areas of very cool climates, typically growing in poor soils, often at high altitudes (above 3,500 feet) under present climate.
Mixed Meadow Species	This mix of pollen is typical of a mixture of herbceous plants common to warm/temperate meadowlands. Typically, these species grow in areas of warm summer temperatures and summer drought.
Oak	Found in warm-temperate sites characterized by dry, warm summers.
Alpine Sagebrush	Woody, low-growing shrub found only at high-altitude, cold sites.

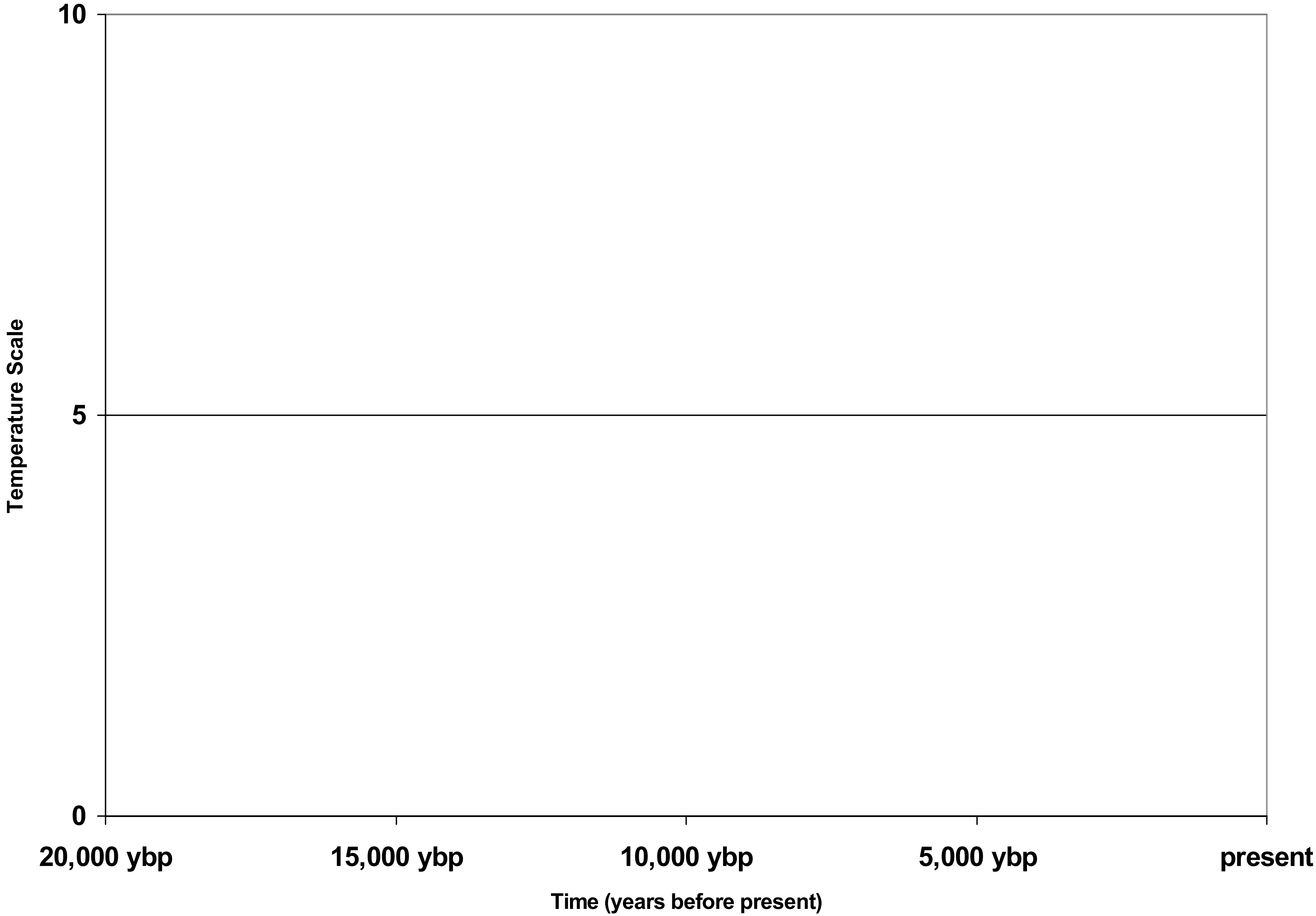
Data Sheet

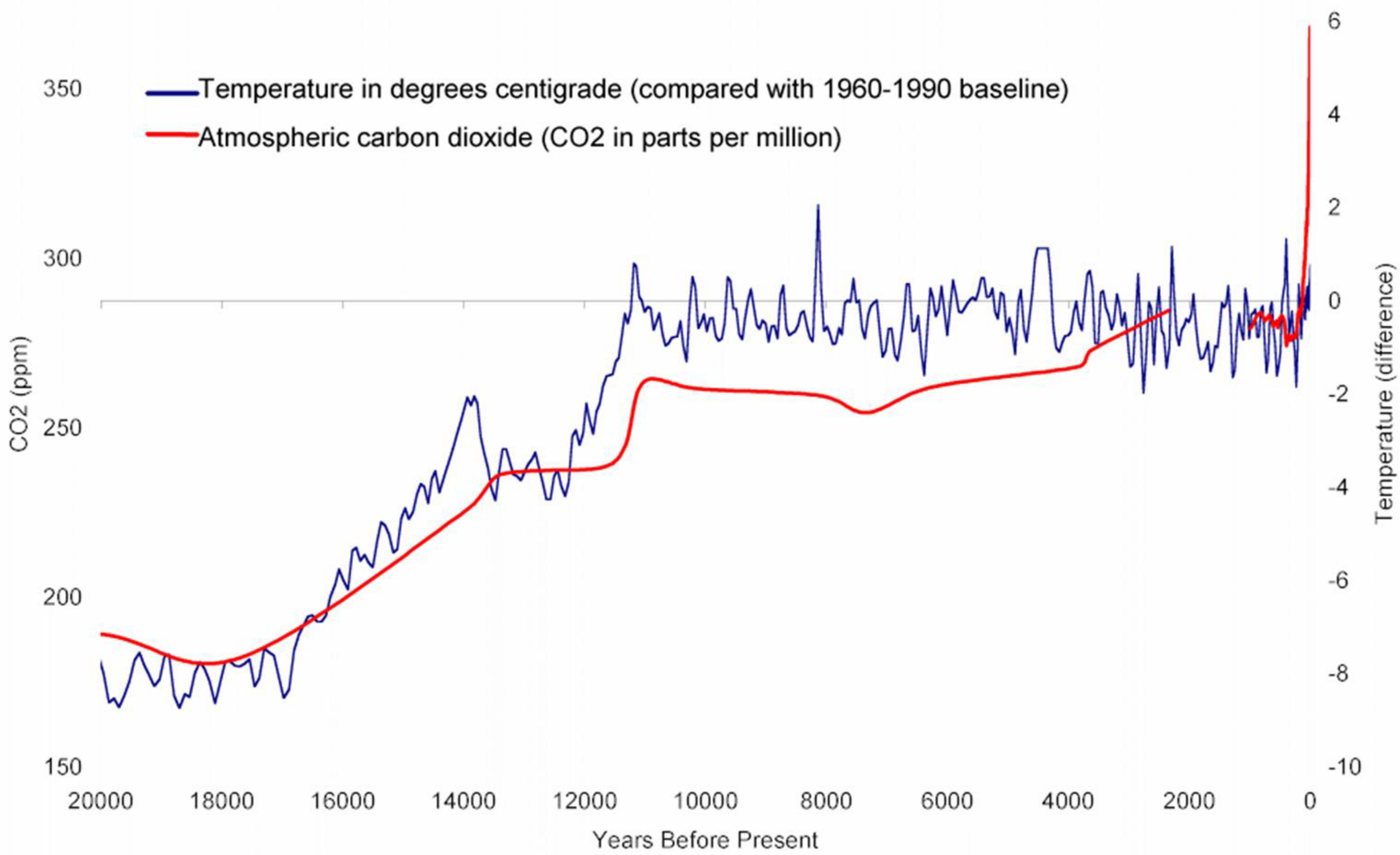
Layer #: ______________ Time Period: ____

Bead Color	Quantity	Species Represented	Preferred Climate Range

Average Climate Range for this Sediment Layer: ____

Climate Change Over Time





This figure shows the temperature record from the Vostock ice core (dark blue), together with CO_2 (red) from the Vostock ice core, the Law Dome ice core, and from the Mauna Loa monitoring station in Hawaii.

Vostock data are available from http://www.ngdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok.html, Law Dome ice data are available from http://www.ngdc.noaa.gov/paleo/icecore/antarctica/law/law.html, and Mauna Loa data are available from http://cdiac.esd.ornl.gov/trends/co2/sio-mlo.htm.

Source: http://www.brighton73.freeserve.co.uk/gw/globalwarmingfaq.htm