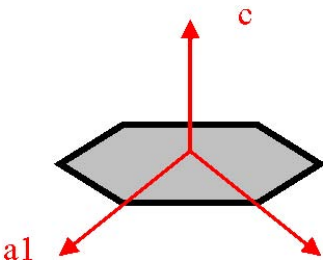
Ice Core Procedures

Background: As temperatures fall in the winter, water in ponds and lakes begin to freeze. The weather conditions during the freezing process control the structure of the ice. During the long and often slow process of creating a foot or more of ice, layers form in the ice. Each layer tells something about the weather conditions when that layer formed. A record of weather conditions is 'frozen' into the ice. This is similar to the layers present in the snow pack that you see when you prepare the snow pit.

When water freezes, hexagon-shaped crystals form because of the shape of water molecules. When the crystal grows, so that the hexagon becomes bigger, scientists say that the crystal grew along the "a" axis. The crystal can also grow so that the hexagon becomes thicker (like stacking plates). Scientists say that this kind of growth is growth along the "c" axis.



When snowflakes are forming, growth along the "a" axis makes sectored plates and stellar dendrites. When snowflakes grow along the "c" axis, needles form.

Three types of ice can form in a lake or pond. The kind of ice that forms depends on weather conditions.

1. On very cold, calm nights the surface water of the lake can drop below freezing. When ice crystals begin to form, they spread rapidly across the lake surface. The "c" axis of the crystals is vertical (up and down). Individual crystals can be a meter wide. This process is called Spontaneous Nucleation
2. When lake conditions are cold and winds blow dust, snow or frozen rain on the lake surface, Heterogeneous Nucleation occurs. This means that the dust, snow or frozen rain is a nucleus or center, and the lake ice crystals form around these centers. The lake ice grows with the "c" axis of the crystals horizontal.
3. Snow Ice forms when snow falls on ice and becomes wet and then freezes – becoming part of the lake ice. Snow Ice has very fine crystals and often looks white and isn't clear.

You can also tell how fast the ice formed. When you look at an ice core that has been cut in a slice from top to bottom, you may see clear ice and ice with air bubbles. The picture of an ice core shown below shows layers. When the ice freezes rapidly, bubbles are trapped in the ice. Slow freezing allows air bubbles to escape.

The thin top layer is white and probably is snow ice.

The next layer is clear and indicates slow freezing.

This is a moderately fast freezing layer.

These are fast-freezing layers.

A slow freeze layer.

And so on from the top of the ice core to the bottom.

While these differences are visible without any special equipment, the direction of the “c” axis can only be detected with special equipment. You will learn to use this equipment, and you will learn to read the story of weather in ice cores.

Purpose: To identify the layers of an ice core and compare the layers with past weather events. You should examine the data to see if there are any relationships between basic weather data and the layers in the ice core. Compare your ice core and weather data with data from other parts of the country to see how differences in weather affect ice.

Overview: The study of your ice core is separated into several steps. Record basic weather data on the Weather Watch Field Data sheet. Record all ice core data on the Ice Core Data sheet. The steps are:

1. Obtain an ice core. (Cutting an ice core is dangerous. Your teacher will provide an ice core for you.)
2. Make basic weather measurements and measure the temperature of the water
3. Measure the layers of the ice core.
4. Prepare thin sections of ice and identify the direction of the "c" axis.

Materials:

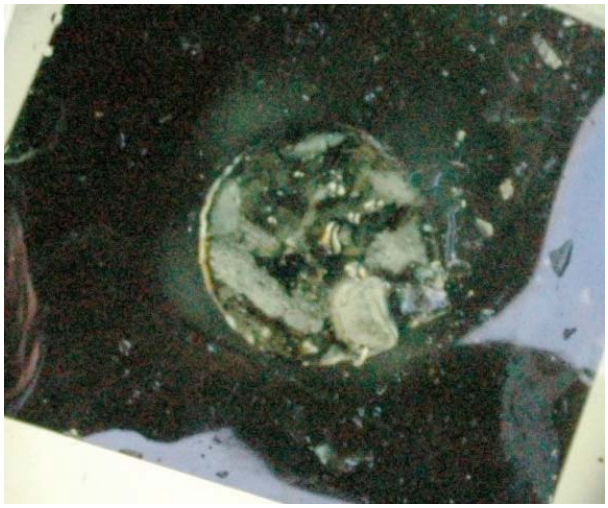
- Snow shovels
- Metric tape measure or meter stick
- Thermometers
- Weather Watch Field Data sheet
- Ice Core Data sheet
- Hot plate with low heat.
- Medium grit sandpaper
- Glass plates (10 cm x 10 cm)
- Light table (a box with fluorescent lights covered with opaque glass)
- Polarizer sheets (approx. 22 cm x 28 cm)

Procedure:

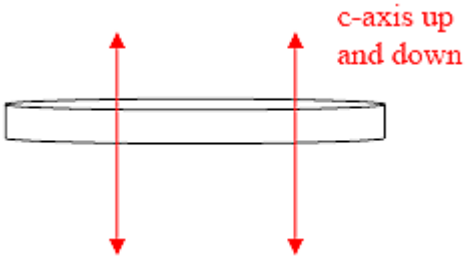
1. Once the temperatures are below freezing, record basic weather measurements on the Weather Watch Field Data sheet.
2. Record the water temperature that your teacher gives you.
3. Measure the distance of each layer from the bottom of the ice core and measure the thickness of each layer.
    a. Lay the ice core on a cold, flat surface.
    b. Lay the metric tape or meter stick next to the ice core with the 0.0 cm mark at the bottom of the core.
    c. Identify layers by differences in visual appearance. Features like clear ice, closeness of bubbles, and white (opaque) ice help to define layers. Use the picture of the ice core above to help you identify the layers.
    d. Measure the distance from the bottom end of the core to the bottom of the second layer. Record this measurement as the thickness of the first layer. Also, record this measurement as the 'Distance from Bottom of Core' for the second layer.
    e. Measure the thickness of the second layer and record it on your data sheet.
    f. Continue recording data for all ice layers. Remember to record layers from the bottom of the data sheet to the top.

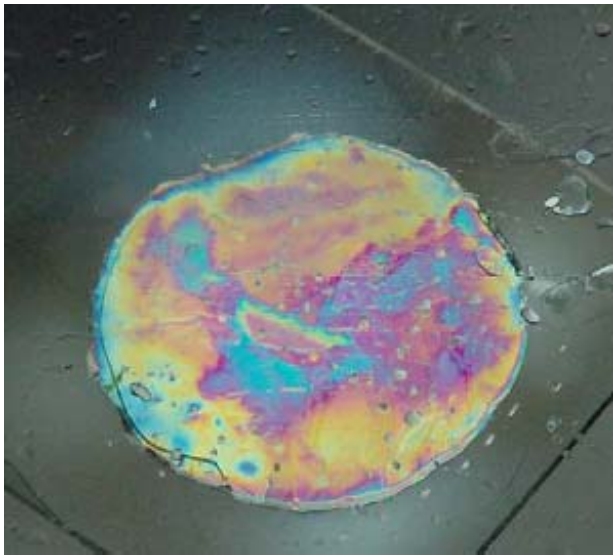
4. In an area where the temperature is below freezing, prepare thin sections from each layer of the ice core.
    a. Your teacher will cut a disk about 0.5 cm thick from each layer of the ice core with a band saw. You may need to lightly sand the surface of the ice disk with sand paper. Don't mix up the disks.
    b. Place one polarizer sheet on the light table and put the 10 cm x 10 cm glass sheet on top of the polarizer disk.
    c. Warm up the hot plate to a low heat. The hot plate must not be hot enough to burn your fingers.
    d. Place the 0.5 cm ice disk on the hot plate and move it in circles to melt the ice. Melt until the ice is about 1mm thick.
    e. Place the thin section of the ice disk on the glass sheet on the light table
    f. Place the second polarizer sheet on the disk of ice. Rotate the top polarizer sheet until it appears black. (This is like putting one pair of polarizer sunglasses in front of another pair of polarizer sunglasses while you look through them. When you rotate them until they make a cross, no light comes through and you see black.)
    g. Look directly down at the thin section of the ice core through the polarizer. Make sure you are directly over the light box and looking down, not at an angle from the side.
    h. The following guide will help you to interpret what you see when you look at thin sections through the polarizer sheets on the light box.

Analysis of Thin Sections of Ice Using Light Table and Polarizers

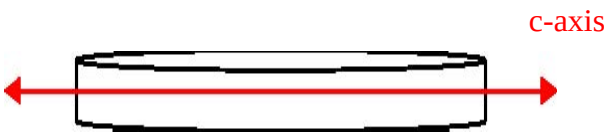


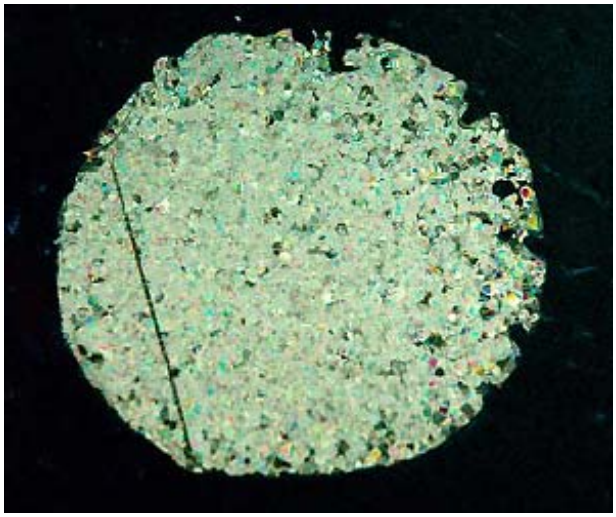
The thin section of ice disk is the circular feature in the middle. The thin section is shades of gray. No reds, blues, or green are visible. This means that the c-axis of the ice crystal making up this section of the ice core is up and down if you looked at the disk from the side.





This thin section shows colors when viewed through the polarizer sheets. This means that the c-axis of the ice crystals is horizontal through the ice core.





This section looks very grainy with small points of red, blue, green and dark. This is a characteristic of snow ice. There are many small crystals. The c-axis points in a different direction for each crystal.

Appendix: Teacher's Instructions for Cutting Ice Core

1. Local fishermen, university or Park Service staff are familiar with lake ice and equipment. A few well-placed calls should connect you to individuals who have the equipment and expertise to help you get ice cores.
2. Make certain that the ice on a pond or lake near you is thick enough to support your weight safely.
3. Use an ice auger to cut an ice core. Because an ice auger is hollow, the ice core will be inside the auger.
4. Carefully lay the auger on the ice and slowly remove the core. Some ice layers in the core may separate as you remove it from the auger. Use care to keep the layers in the right order.
5. Pack the core for transportation so that it remains frozen with the layers in the correct order.
6. If an ice auger is unavailable, a chain saw can be used to cut a rectangular piece of ice. After cutting the block, chip away the ice surrounding the block to enlarge the hole so that you can extract the ice block using ice tongs.

Simulated Ice Core

If you cannot get an ice core from a lake or pond, you can simulate one.

1. Obtain a 3-4' section of 4" PVC pipe and one end cap (socket fitting).
2. Dig a hole in the ground about 8" wide and 3.5' deep in a convenient and safe location. Dig the hole before the ground freezes. Cover the hole to protect it if you aren't going to use it immediately.
3. When freezing temperatures become common, cap the PVC pipe, set in the hole and loosely fill around the pipe with sand. Remember, you will want to retrieve the pipe when the ground is still frozen.
4. Fill the pipe with water to ground level. Leave it open to the elements and mark the spot so you can find it.
5. After two to six weeks of freezing temperatures, retrieve the pipe.
6. Warm the outside of the pipe to free the ice core.
7. Store the ice core in a location that is below freezing until you use it with your students.

Note: You can cut the pipe vertically to split it in half to make removal of the ice core easier. Duct tape the pipe halves together and put on the end cap. While this makes it easier to remove the ice core, the pipe may leak and you could lose some water.