Snow Pit Procedures

Background: A snow pit is a trench exposing a flat, vertical snow face from the snow surface to the ground. It allows you to study the characteristics of the different layers of the snowpack that have developed as the snow has changed due to compaction and weather changes. Snow pits are routinely used in mountainous areas to determine if one layer might slip on another causing an avalanche. Snow pits also help researchers measure the water content of a snow pack. This is essential in flood prone areas, and it is essential in those dry areas where the snowpack provides water for the coming year.

As snow accumulates and changes over time, it develops layers marked by physical differences. These layers are used to determine the history of the snowpack. Layers are often broadly classified as *new snow*, *firn* or *depth hoar* (careful observers often distinguish other layers within these categories). The *new snow* layer consists of new sharp crystals lying loosely on the top of the snow bank that are slowly being compacted by additional falling snow. Just below the *new snow* layer is a layer called *firn*. The *firn* layer consists of crystals that have lost their sharp edges due to evaporation, freezing and compaction. They are rounded into more sphere-like shapes, in the process of becoming particles of ice. This snow is dense and the grains are more closely bonded together, which increases the mechanical strength of the *firn* layer. At the bottom of the snowpack is the depth hoar layer consisting of snow crystals that have transformed (metamorphosed) into lumps of ice through evaporation, condensation, and compaction. This layer is more weakly bonded than either the *firn* or *new snow* layers. The *depth hoar* layer is loose and grainy. The crystals sift through your fingers and it is often nicknamed sugar snow.

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

Overview: The study of your snow pit is separated into several steps. Each step will have its own procedure. Basic weather data will be recorded on a Weather Watch Field Data sheet. All snow pit data will be recorded on a Snow Pit Field Data sheet. The steps are:

1. Locate and prepare snow pit.
2. Make basic weather measurements.
3. Map study site.

4. Obtain basic site data.
5. Measure temperature profile of snowpack.
6. Mark snow layers.
7. Determine snow grain size and shape.
8. Measure snow density and snow water equivalent.

Materials:

- Snow shovels
- Metric tape measure (30 m) or meter stick
- Compass
- Clinometer
- Thermometers (3) – preferable a dial stem variety to insert into snow face
- Soft paintbrush – 4 inch
- Golf tees, popsicle sticks, etc. to mark transition horizons between layers
- Pencil with eraser
- Plastic knife
- Spatula
- Hand lens (5X or 10X)
- Snow crystal card or playing card to hold snow grains (Life-Link Snow Pit or Snow Crystal Card recommended)
- Small plastic centimeter/millimeter ruler
- Balance – an inexpensive, but accurate, gram/kilogram kitchen scale. (It should have the capacity to mass the snow in the sampling tube.)
- Snow sampling tube (This is a small, open-ended aluminum or plastic tube of known volume and mass. You can use an aluminum soup can and remove both ends. Cork borers are used for narrow layers of snow.)
- Weather Watch Field Data sheet
- Snow Pit Field Data sheet

Procedures:

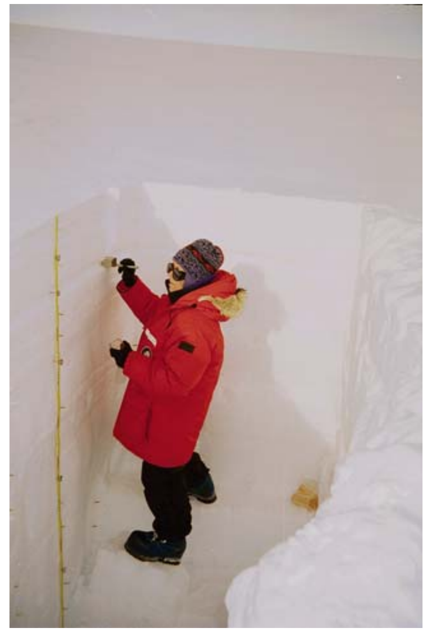
<u>Locate and Prepare Snow Pit</u>

1. Be careful not to walk on or alter an area you might use for the snow pit. Locate an area that is open and free from obstructions that might cause drifting. Open meadows and athletic fields make excellent locations. Choose a site representative of the snowfall in your area.

2. Use your compass to determine South and make note of the position of the sun. The wall of your snow pit must not receive direct sunlight while measurements are taken. Direct sunlight will cause increased temperature readings.

3. Dig a pit several meters wide that goes all the way to the ground. The wall facing away from the Sun must be vertical and smooth. The pit should be large enough for several people to take measurements at the same time.

4. Anchor the measuring tape to the flat, smooth wall of the pit with golf tees or popsicle sticks. The zero point of the tape must be at ground level. Extend the tape straight up to the top snow level. Record the total depth of the snow.



Make Basic Weather Measurements

Measure basic weather conditions and record these data on the Weather Watch Field Data sheet.

Map Study Site

Draw a map of the study area. The map should represent an area at least 10 m x 10 m centered on the snow pit. Include on your map:

- Surface features of the snow (ripples, crust, drifts, etc.)
- Any vegetative cover (trees, small bushes, etc.)
- Direction of slope
- North and South
- Any unusual features

Obtain Basic Site Data

Complete Site Data Table on the Snow Pit Field Data sheet. This includes:

- Site description (where the site is)
- The Slope Aspect (use compass to determine the direction of down slope)
- Percent of Slope (use clinometer)
- Vegetative Cover (use Modified UNESCO Classification).

Measure Temperature Profile of Snowpack

1. The metric tape must be in place and anchored with zero at ground level and tape extended straight up to surface of snow.
2. Measure ground temperature to nearest 0.1°C and then the temperature immediately above the ground. This becomes the temperature at the zero height measurement. Record this temperature measurement in the *bottom* box of the Snowpit Field Data Table. Record your next measure in the box above the bottom box, and so on. This emphasizes that you are measuring from the bottom of the snowpack to the top.
3. Measure and record the temperature of the snow every 10 cm (every 5 cm if total depth of snow is less than 0.5 m) to the nearest 0.1° C and record in Snowpit Field Data Table. (Be careful that data entries start at the bottom of the table.)

Mark Snow Layers

The snowpack will consist of layers representing snowfalls and other weather events. Different layers may be of soft or granular snow. Daytime thaw followed by nighttime freezing and/or freezing rain may create ice layers. Some layers may be wetter than others. Your task is to identify the layers and determine their height above the ground and their thickness.

1. *Visual Inspection:* Stand in front of the smooth, vertical wall of the snow pit, and make your first inspection by eye. Ice layers appear shiny. Large grains glisten and appear pebbly. Soft snow may appear less reflective.

2. Insert markers (golf tees, toothpicks, popsicle sticks) into the wall close to the metric tape at the top and bottom of each layer.
3. *Naked Finger Test:* To refine your visual inspection use the tip of your bare index finger and move it gently through the snow from the surface to the ground level. You may feel differences in hardness or graininess that you were unable to see. Insert additional markers at the top and bottom of any new layers you detect.
4. *Knife Test:* Refine the mapping of layers by gently slicing a knife down through the profile and noticing any changes in resistance to the knife. Revise your marker positions as needed.
5. With all of the layer markers in place near the metric tape, record the height of each layer above the ground and the thickness of each layer in the Layer Profile Table. The ground will be the bottom of the first layer and is at zero height. Marker #1 (the first marker above the ground) will be the top of the first (bottom) layer. The distance from the ground (0.0 cm) to Marker #1 is the thickness of the first layer. Marker #1 also marks the bottom of the second layer. The distance from the ground to Marker #1 is the height of the second layer. The distance from Marker #1 to Marker #2 is the thickness of the second layer. Continue making and recoding layer measurements all the way to the surface.

Determine Layer Hardness

Take snow hardness readings in the center of each distinct snow layer. Ice layers are identified as Ice in the Layer Profile Table. Professionals use a Hardness Gauge that consists of disks of varying surface area. The technique is to slowly press each disc squarely against the snow and use a scale that records a value indicating pressure (g/cm) at which the disc begins to enter the snow. Instead of a hardness gauge, you will use your hand, a pencil, and a knife to estimate hardness. This technique is called the Hand Test. It is detailed on snow cards and is commonly used by professionals when they don't have a Hardness Gauge.

1. Start at Layer 1 (the layer nearest the ground).
   - If the layer is ice, record this layer as Ice.
   - If the first layer is not ice, gently push your fist into the middle of the layer. If your fist penetrates the layer easily, record this layer as Very Soft.
   - If your fist *doesn't* penetrate easily, hold your hand flat and horizontal so that the tips your four fingers are just touching the snow and push gently. If your four fingers penetrate the snow easily, record the layer as Soft.
   - If your four fingers *don't* penetrate easily, push gently into the snow with the tip of one finger. If one finger penetrates the snow easily, record the layer as Medium.
   - If one finger *doesn't* penetrate easily, gently push the sharpened end of a pencil into the snow. If the pencil penetrates easily, record this layer as Hard.
   - If the pencil *doesn't* penetrate easily, gently push the tip of a knife into the snow. If the knife penetrates easily, record this layer as Very Hard.

2. Repeat this procedure on all layers.

Test	Estimated Hardness
Fist	Very Soft
Four Fingers (Tips)	Soft
One Finger (Tip)	Medium
Pencil Point	Hard
Knife	Very Hard
	Ice

Determine Snow Grain Size and Shape

Collect a sample of snow from the bottom layer of the snow pit by gently scraping the snow with the plastic card so that the snow is retained on the card.

1. Examine the snow with a hand lens. Select five grains at random.
2. Use the grid on the card (or small metric ruler) to measure the size of each crystal and record on Layer Profile Table.
3. Identify the shape of the grain. For Comparative Images of Snow Crystals visit http://emu.arsusda.gov/snowsite/comparison/comp5.html , pages 5 and 6. The large images are from electron microscopes and the inset image is with a regular microscope.
   a. If whole crystal or parts of broken crystal, record as Fresh Snow.
   b. If grains are irregular and rounded, record as Granular.
   c. If grains are irregular with flat surfaces, record as Faceted.
   d. If grains are hollow, cup-shaped crystals, record as Depth Hoar.
4. Repeat with all other layers until you have identified the dominant grains in each layer.

Measure Snow Density and Snow Water Equivalent

To measure the density of the snow and to determine the percent of water in the snow, it is necessary to obtain a known volume of snow and find the mass of the snow. Density is defined as mass divided by volume. You will use a snow sampling tube. This may be a plastic or aluminum tube (an aluminum soup can with both ends removed may be used). You can only measure the density of a layer that is as thick as or thicker than the snow sampling tube.

In the classroom, measure the diameter and length of snow sampling tube and calculate the volume of the tube and record this volume. Also, find the mass of the snow sampling tube when it is clean and dry, and both ends are removed.

1. Begin at the top layer that is thick enough to sample. Clearly identify which layer you are sampling. Firmly push the snow sampling tube into the snow face of the layer, using the edges of the tube as push points. The greatest error source is an incomplete fill of the cylinder. The best way to accomplish the “fill” is to push the cylinder in beyond the face surface and then cut a channel over the tube that will enable a metal shave plate to be used to dress off the back and front faces of the cylinder. This is why you start at the top.

2. Record the mass, in grams, of the snow sampling tube filled with snow. Calculate the density and percentage water content of the snow in the classroom.
3. Empty the snow collection tube and repeat until you have sampled all layers.

*Be careful when you record density and percentage water in the Layer Profile Table. Every other measurement has started with the bottom layer of the snow pit as the first layer. Because you are digging into the snow face, you are starting with the top layer first. Be careful to record the density with the proper layer. In addition, you may not be able to sample a layer because it is too narrow for the sampling tube. Be certain that you skip a layer in the Layer Profile Table if you did not sample it.

<u>Equations and Calculations for Density and Percentage Water Content</u>

Volume of cylinder (sampling tube) = $\pi r^2 L$ (this is also the volume of snow if the tube is full of snow)

$\pi = 3.14$
r = radius of tube or diameter divided by 2
L = length of tube

Mass of snow in sampling tube = (mass of tube and snow – mass of empty tube)

Density of snow = (mass of snow) ÷ (Volume of snow)

% Water Content = Density of snow x 100