Snow Pit Protocol & Guide to Snow Grain Types

Winter Ecology – CU Mountain Research Station

- On flat terrain dig snow pit so south wall of pit is undisturbed
- On steep terrain dig snow pit so uphill wall is undisturbed
- Use the provided *Snow Cover Profile Form*
- Record date, time, observer, shaded air temperature, cloudiness, precipitation, wind, & surface hardness

- **Measure Density**
    1. Work from snow surface to ground
    2. Tare the density scoop
    3. Make first density measurement so that the next density measurement starts at an even 10cm (ex. snow depth = 43 cm mark first density measurement from 43 to 30 cm, snow depth = 47 cm mark first density measurement from 47 to 40 cm)
    4. Each density measurement then is every ten cm on the tens (e.g., 40 to 30 cm).
    5. Stagger the density measurements laterally
    6. Near the ground there may be rocks or bushes that interfere with the density scoop, so move laterally if necessary
    7. If there is a void at the snow ground interface measure density from 15-5cm or simply use the same value you got for 20-10 cm for 10-0 cm.

- **Measure Snow Temperature**
    1. Calibrate thermometers in an ice bath.
    2. As you are measuring the density, place a thermometer in the shaded top 2 cm, the middle of the density measurement height, and the middle of the next density height
    3. Allow thermometers a few minutes to equilibrate
    4. Leapfrog the thermometers through the middle of the density measurement heights with the final measurement having the thermometer at the snow/ground interface.
    5. Avoid measurements near exposed or buried bushes
    6. Here's what you are doing: density measurements every 10 cm on multiples of tens, with temp measurements every 10 cm in the middle of the density measurement. Thus, the temp measurements are at 5's (e.g., 35, 25, 15, 05 cm). And with measurements at the top and bottom of the snowpit.

- **Identify Stratigraphy**
    1. Work from top down. Clean snow surface with shovel.
    2. Using knife or edge of card to first vertically identify layers and delineate. Then go back and sample each unique layer.
    3. Estimate **Hardness** (Fist, 4-Fingers, 1-Finger, Pencil, Knife, Ice) - use Symbols in *Observation Guidelines* §2.5.3
    4. Estimate **Grain Size** (in mm) using snow crystal card and magnifying loop - see *Observation Guidelines* §2.5.5
    5. Identify **Grain Shape**: New Snow, Fragments, Rounded, Faceted, Depth Hoar, Surface Hoar, Melt-Freeze Forms, Ice - use Symbols in *Observation Guidelines* §2.5.4. Subcategories (and corresponding symbols) are in Appendix F.

        → Relate these to succession of processes: Temperature Gradient (TG), Equitemperature (ET), Wet Snow Metamorphism (WM), Ice & Crust Formation – see Tables & Figure next page, and *Observation Guidelines* App. F.

    6. Estimate **Liquid Water** - use Classes in *Observation Guidelines* §2.5.6

- **Test Pack for Blocking**

Data entered into SnowPilot back at the Lodge (see last page)

6/09 K Chowanski; rev 1/11,1/14 T Kittel

Metamorphism:

From the instant snow hits the ground, it begins an endless process of metamorphism. No commonly-occurring substance in nature undergoes such dramatic and rapid changes because snow exists near its "triple point", meaning that solid, liquid and vapor phases all exist at the same time. In other words, small, subtle changes in temperature, pressure, humidity and temperature gradient can have a dramatic effect on the type of snow crystal that forms. This makes snow one of the most complex and changeable substances on Earth. Here is a condensed list of the most common types:

Type	Also called:	Looks like:	Where you find it	How it's formed
New snow	Powder, rime, graupel, etc.	No two are alike	On the snow surface	Falls from the sky
Rounded snow ET	Equilibrium snow Old Snow	Fine-grained, chalky	Old layers of snow	Low temperature gradient conditions (less than 1 deg C per 10 cm)
Faceted Snow TG	Sugar Snow Kinetic Snow Depth Hoar (when near the ground)	Sparkly, large-grained	Anywhere in the snowpack	Large temperature gradient conditions within the snowpack (more than 1 deg C per 10 cm)
Surface Hoar	Frost, Feathers	Sparkly, large-grained	On the snow surface or buried by more recent layers	Winter equivalent of dew on the snow surface
Melt-Freeze Snow WM	Corn snow Spring snow Wet snow	Corn snow Spring snow Wet snow	Snow surface or buried by more recent layers	Repeated melting and freezing of the snowpack

From: http://www.fsavalanche.org/Encyclopedia/metamorphism_snow.htm

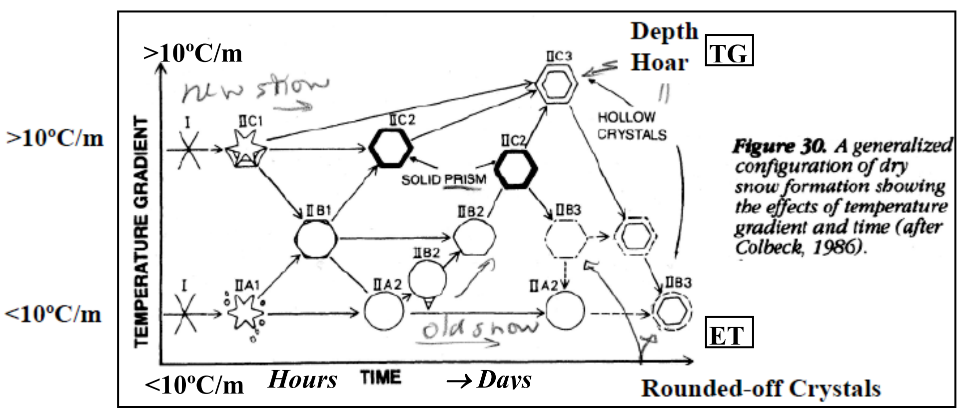


***Figure 30.** A generalized configuration of dry snow formation showing the effects of temperature gradient and time (after Colbeck, 1986).*

Table 5. Snow classification system (Colbeck 1986).

- I. Precipitation
- II. Dry Snow
  - A. Equilibrium (rounded) form ET
    1. Initial rounding of precipitate
    2. Fully rounded (may be faceted at low temperatures)
  - B. Mixed rounded and faceted
    1. Intermediate growth rate
    2. Transitional as temperature gradient increases
    3. Transitional as temperature gradient decreases
  - C. Kinetic growth (faceted) form = TG
    1. Faceted growth on precipitate
    2. Solid crystals, usually hexagonal prisms
    3. Hollow crystals called depth hoar
- III. Wet Snow
  - A. Pure grain clusters WM
  - B. Melt-freeze particles
  - C. Slush

From: Halfpenny & Ozanne 1989

Citation: Greene, E., D. Atkins, K. Birkeland, K. Elder, C. Landry, B. Lazar, I. McCammon, M. Moore, D. Sharaf, C. Sternenz, B. Tremper, and K. Williams, 2010. Snow, Weather and Avalanches: Observation Guidelines for Avalanche Programs in the United States. American Avalanche Association, Pagosa Springs, CO, Second Printing Fall 2010.

2.5.3 Snow Hardness (R)

Observe the hardness of each layer with the hand hardness test. Record under "R" (resistance) the object that can be pushed into the snow with moderate effort parallel to the layer boundaries.

Slight variations in hand hardness can be recorded using + and - qualifiers (i.e. P+, P, P-). A value of 4F+ is less hard than 1F-. Individual layers may contain a gradual change in hand hardness value. These variations can be recorded in a graphical format (Figures 2.8 and 2.9), or by using an arrow to point from the upper value to the lower value (i.e. a layer that is soft on top and gets harder as you move down would read 4F+ $\rightarrow$ 1F).

Table 2.1 Hand Hardness Index

Symbol	Hand Test	Term	Graphic Symbol
F	Fist in glove	Very low	
4F	Four fingers in glove	Low	/
1F	One finger in glove	Medium	X
P	Sharp end of pencil	High	//
K	Knife blade	Very high	⋇
I	Too hard to insert knife	Ice	■

2.5.5 Grain Size (E)

Determine the grain size in each layer with the aid of a crystal card. In doing so, disregard the small particles and determine the average **greatest extension** of the grains that make up the bulk of the snow. Record the size or the range of sizes in millimeters in column "E". Record size to the nearest 0.5 mm, except for fine and very fine grains which may be recorded as 0.1, 0.3 or 0.5mm.

Where two distinct grain forms exist in a layer, list the size of the primary crystal form first followed by the size of the secondary class in parentheses.

Example: 0.3 (2.5)

2.5.6 Liquid Water Content (θ)

Classify liquid water content by volume of each snow layer that has a temperature of 0 °C. Gently squeeze a sample of snow with a gloved hand and observe the reaction; record in the column headed "θ" (theta).

Table 2.4 Liquid Water Content of Snow (adapted from Fierz and others, 2009)

Class	Definition	Water Content (by volume)	Symbol	Data Code
Dry	Usually the snow temperature (T) is below 0 °C but dry snow can occur at any temperature up to 0 °C. Disaggregated snow grains have little tendency to adhere to each other when pressed together. Difficult to make a snowball.	0 %		D
Moist	T = 0 °C. Water is not visible even at 10 x magnification. When lightly crushed, the snow has a distinct tendency to stick together. Snowballs are easily made.	<3 %	|	M
Wet	T = 0 °C. Water can be recognized at 10x magnification by its meniscus between adjacent snow grains, but water cannot be pressed out by moderately squeezing the snow in the hands (Pendular regime).	3 - 8 %	||	W
Very Wet	T = 0 °C. Water can be pressed out by moderately squeezing the snow by hand, but there is some air confined within the pores (Funicular regime)	8 – 15%	|||	V
Slush	T = 0 °C. The snow is flooded with water and contains a relatively small amount of air.	>15%	||||	S

2.5.4 Grain Form (F)

The International Classification for Seasonal Snow on the Ground (Fierz and others, 2009) presents a classification scheme composed of major and minor classes based on grain morphology and formation process. This scheme is used throughout this document. Primary classes are listed in the table below. Subclasses are listed in Appendix F.

Table 2.2 Basic Classification of Snow on the Ground

Symbol	Basic Classification	Data Code
+	Precipitation Particles (New Snow)	PP
◎	Machine Made snow	MM
⁄	Decomposing and Fragmented Particles	DF
●	Rounded Grains	RG
□	Faceted Crystals	FC
Λ	Depth Hoar	DH
V	Surface Hoar	SH
O	Melt Forms	MF
▬	Ice Formations	IF

In warm weather the crystals may melt and their shape may change rapidly on the crystal card. In this case, a quick decision must be made and repeated samples taken from various depths of the same layer.

Snow layers often contain crystals in different stages of metamorphism. The classification should refer to the predominant type, but may be mixed when different types are present in relatively equal numbers. A maximum of two grain forms may be displayed for any single layer. The sub-classification in Fierz, and others, 2009 has "mixed forms" classes that can be used by experienced observers who recognize grains that are in a transition stage between classes.

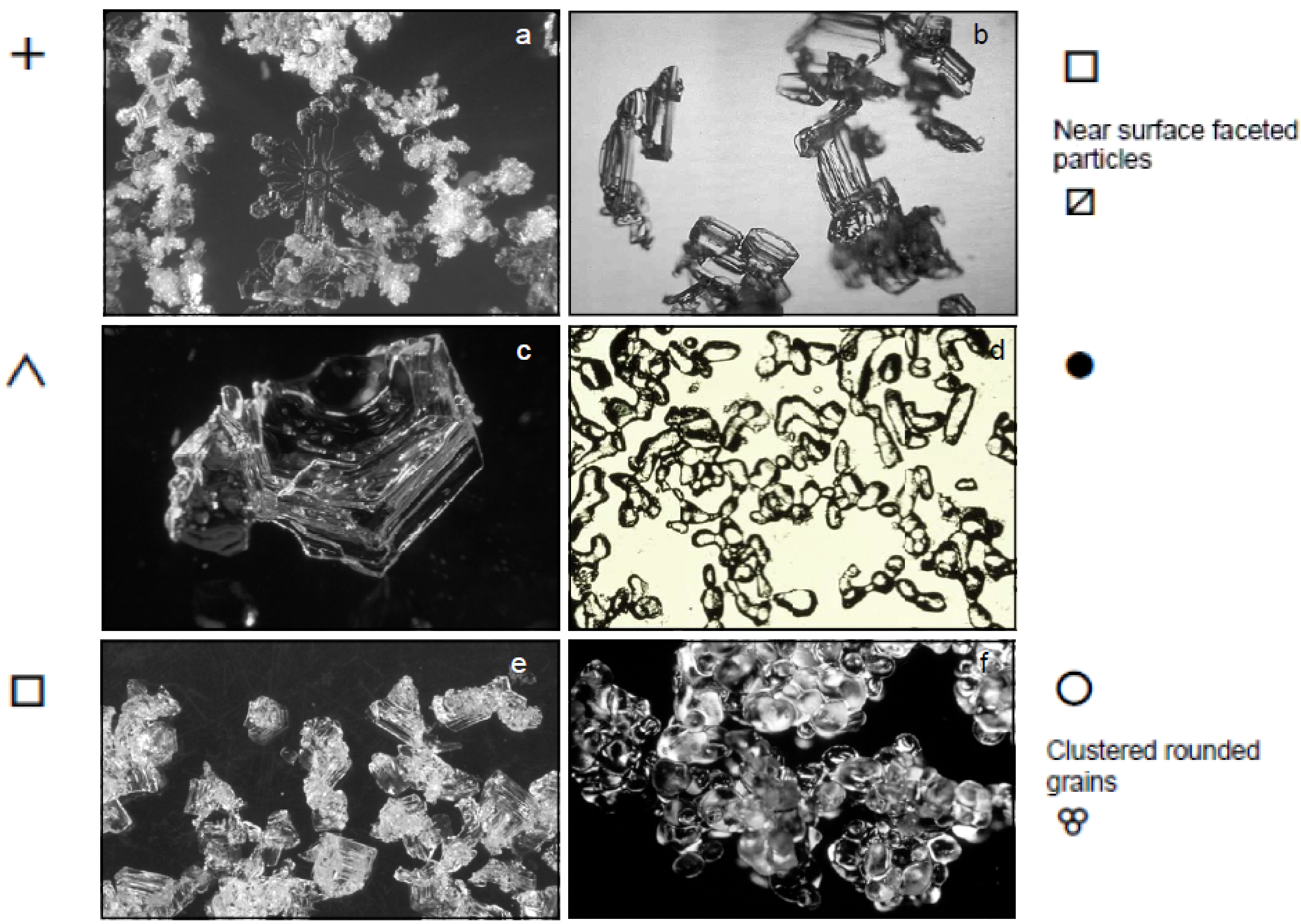
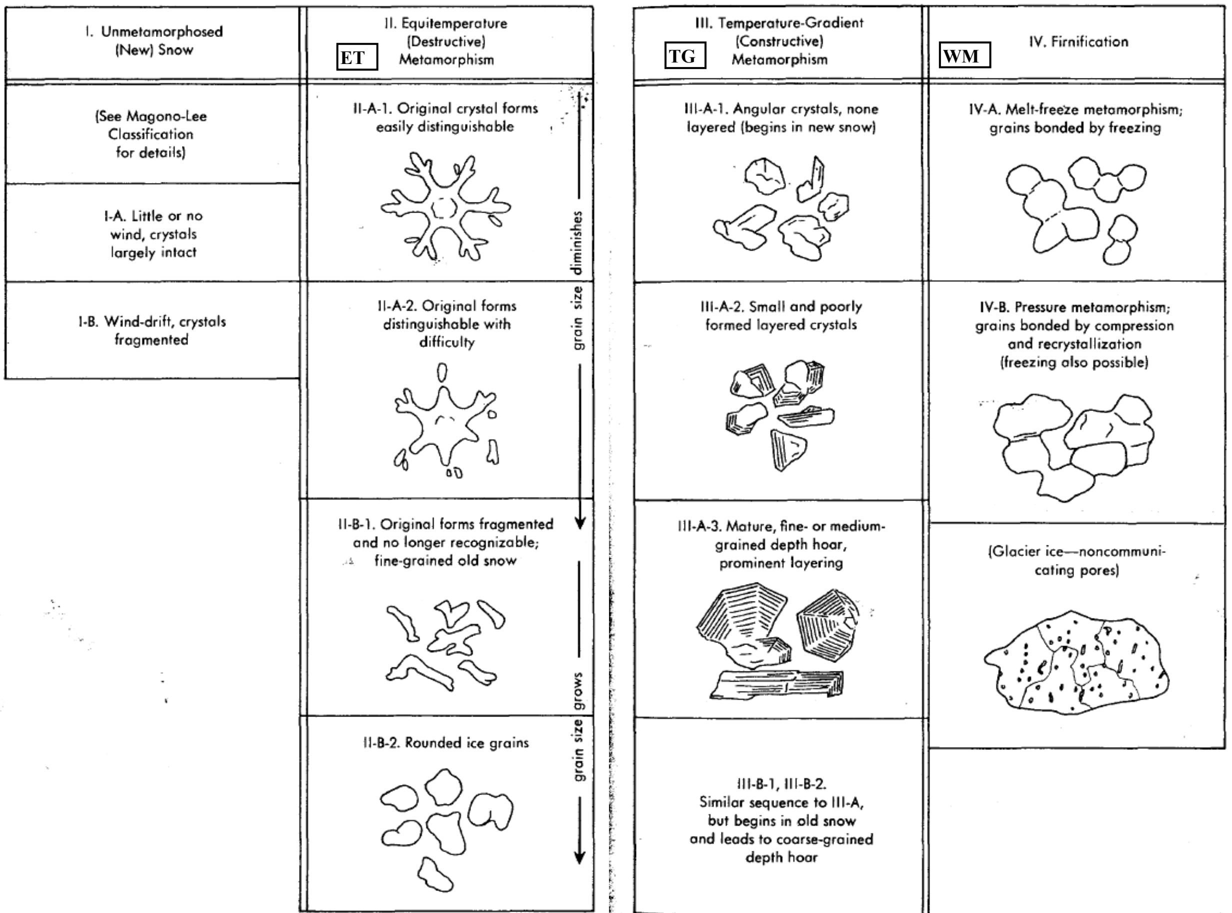


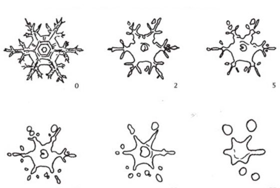
Figure 2.6 Snow crystal formations found in seasonal snow covers. a) Partially rimed new snow (+), b) Faceted grains formed near the snow surface (⧄), c) Depth hoar (Λ), d) Rounded snow grains (●), e) Faceted snow grains (□), f) Clustered melt forms (ꙮ) (photographs by Kelly Elder (a,c), Joe Stock (b), courtesy of John Montagne (d), Ethan Greene (e), and Sam Colbeck (f)).



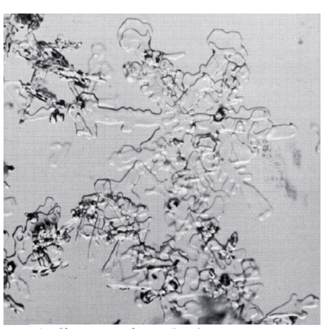
7. The classification of metamorphosed snow according to the scheme proposed Sommerfeld and LaChapelle (1969). This scheme applies to deposited snow on the ground

From: Halfpenny & Ozanne 1989

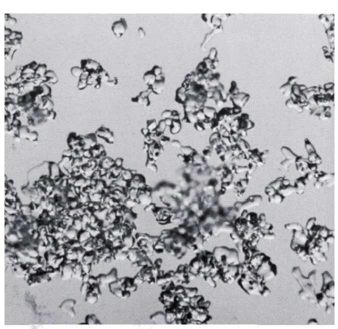
ET Equitemperature Metamorphism



The destructive metamorphism of a stellar snow crystal age in days

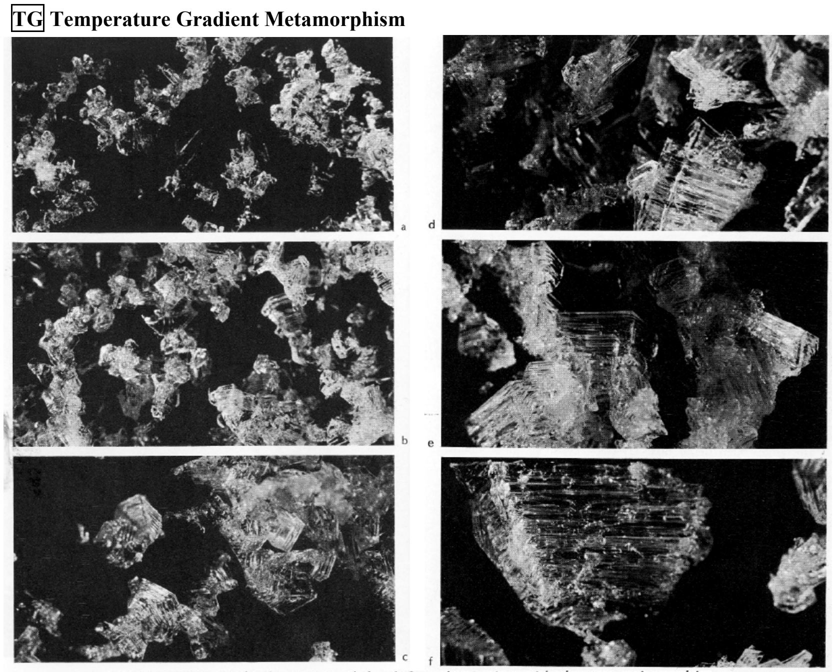


Stellar crystals in the first stages of equitemperature metamorphism. 26X



Stellar crystals which have lost almost all their identity through equitemperature metamorphism. 26X

TG Temperature Gradient Metamorphism



51. The stages in the formation of depth hoar beginning with the snow pictured in Figure 50. Temperature gradient is 2°C/cm. (a) 23 hours; (b) 48 hours; (c) 71 hours; (d) 95 hours; (e) 120 hours; (f) 142 hours. All 14X

From: Field Guide to Snow Crystals by E.R. LaChapelle

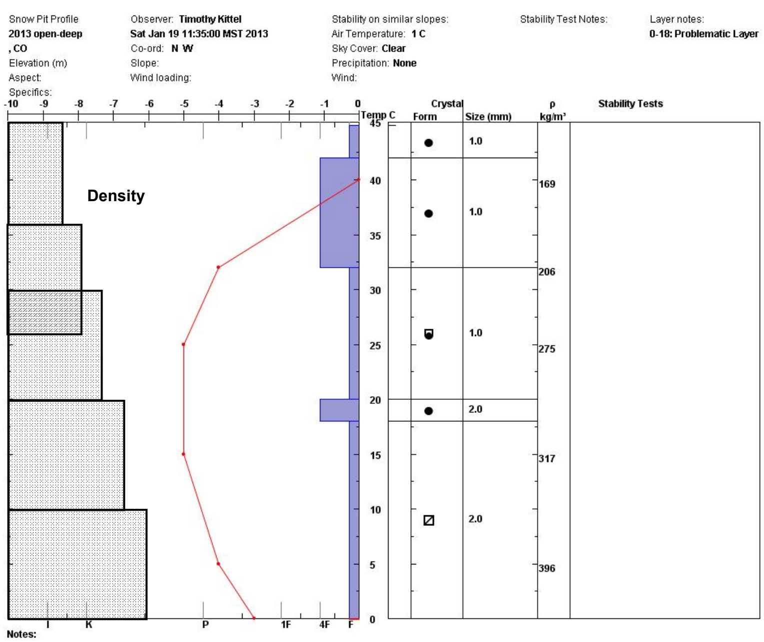
Snow Pit Analysis

- **Download** *SnowPilot* and QuickStart guide
  - http://snowpilot.org/
  - http://snowpilot.org/downloads.html – follow SETUP
  - watch the YouTube tutorial: http://www.youtube.com/watch?v=Qrkl7gtH86Y
  - http://snowpilot.org/Download-QuickStart.pdf

- Set up your **User** Info per tutorial and QuickStart guide
  - Set Preferences for
    - Hardness scale: Exponential
    - Units: all metric

- **Establish pit** —
  - Use naming convention: “NiwotC1 yyExposureCategory-DepthCategory”, where yy=year: such as “NiwotC1 14open-deep” or “NiwotC1 14forest-shallow” (display limit is 24 characters with spaces)
- Enter **Layer** info: Stratigraphy, Density, Temperature
  - Set a <u>dummy first layer</u> so all pits are graphed with same vertical scale, starting with height>height of deepest pit for the day and ending with height of your pit. Leave other info blank.
- Save pit
- Generate pit graph and save as .jpg

- Add **Density** graphics
  - Import .jpg into PowerPoint
  - Add “Rectangles” to left side of pit graph to represent density for each layer, as in graph below
  - Use for scaling Density rectangles, use Temperature scale ×100
  - Set transparency of rectangles to 90% (with “Fill Color” options)



- Save and share results:
  - Save .ppt – Name using *pit name* (per convention above), email to instructors, put on Google docs
  - Email Data file (PCPILOTV5.DAT) to instructors – Subject line = *pit name*

- Interpret results within and among pits, and record your conclusions
  - Refer to the day’s Lesson Points: http://culter.colorado.edu/~kittel/WinterEcology_Snow.html#field