

An aerial photograph of a vast, snow-covered mountain slope. A distinct path or ridge line runs diagonally across the frame, leading from the bottom left towards the top right. The snow is textured with subtle ridges and shadows, suggesting a rugged terrain. The sky is a pale, overcast blue.

Digging into the Avalanche Phenomenon

Presented at UNBC

Feb 8th 2017

By Laurent Janssen

Scope of this presentation

- Basic knowledge of the Avalanche Phenomenon
- Basic knowledge of Avalanche Terrain Morphology
- Basic knowledge of the life of a snowflake
- Better appreciate the complexity of the Avalanche Phenomena
- I will try not to get into backcountry avalanche safety.

Avalanche definition :

- Oxford dictionaries: A mass of snow, ice, and rocks falling rapidly down a mountainside. (en.oxforddictionaries.com)
- Dictionary.com: a large mass of snow, ice, etc., detached from a mountain slope and sliding or falling suddenly downward. (www.dictionary.com)
- Oxford dictionaries: A sudden arrival or occurrence of something in overwhelming quantities.
- Origin of the word Avalanche: Late 18th century: from French, alteration of the Alpine dialect word lavanche (of unknown origin), influenced by avaler descend; compare with Italian valanga. (en.oxforddictionaries.com)



The Avalanche on Television!

The common avalanche.



Canadian Snow Avalanche Size Classification

Size	Description	Typical Mass (tonnes)	Typical Path Length	Typical Impact Pressures
1	Relatively harmless to people	<10 t	10 m	1 kPa
2	Could bury, injure or kill a person	10^2 t	100 m	10 kPa
3	Could bury a car, destroy a small building, or break a few trees	10^3 t	1000 m	100 kPa
4	Could destroy a large truck, several buildings, or a forest with an area up to 4 hectares	10^4 t	2000 m	500 kPa
5	Largest snow avalanches known. Could destroy a village or a 40 ha forest	10^5 t	3000 m	1000 kPa

Table 3: Canadian Snow Avalanche Size Classification

Size 1

Relatively harmless
to people

Typically:

- Mass: 10 tonnes
- Run: 10 meters
- Force: 1 kilopascal



Size 2

Could bury, injure or kill a person

Typically:

- Mass: 100 tonnes
- Run: 100 meters
- Force: 10 kilopascals



Size 3

Could bury or destroy a car,
damage a truck, destroy a
wood frame house or
break a few trees

Typically:

- Mass: 1,000 tonnes
- Run: 1,000 meters
- Force: 100 kilopascals



Size 4

Could destroy a railway car,
large truck, several buildings
or up to 4 hectares of forest.

Typically:

- Mass: 10,000 tonnes
- Run: 2,000 meters
- Force: 500 kilopascals



Size 5

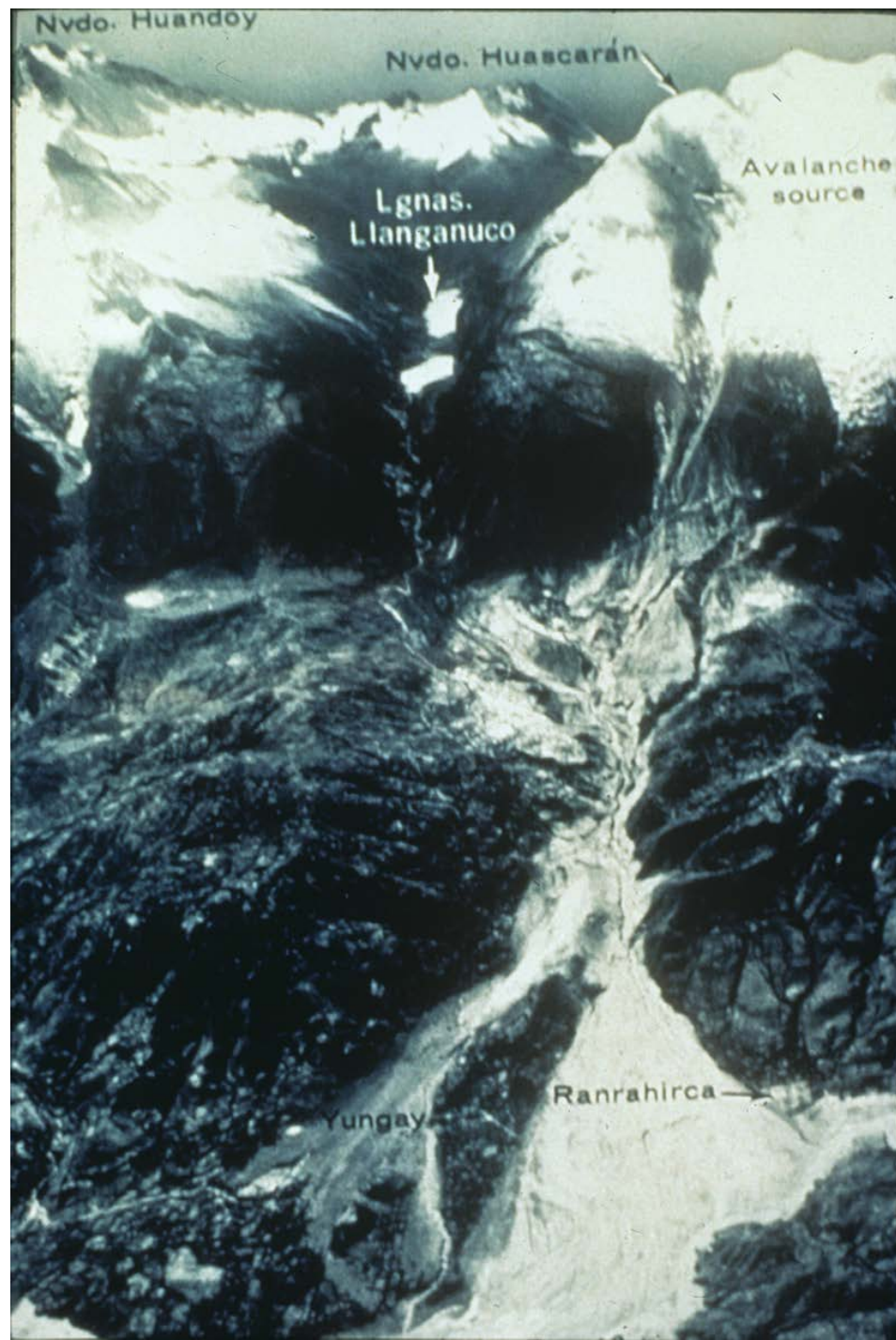
Catastrophic

Typically:

- Mass: 100,000 tonnes
- Run: 3,000 metres
- Force: 1,000 kilopascals

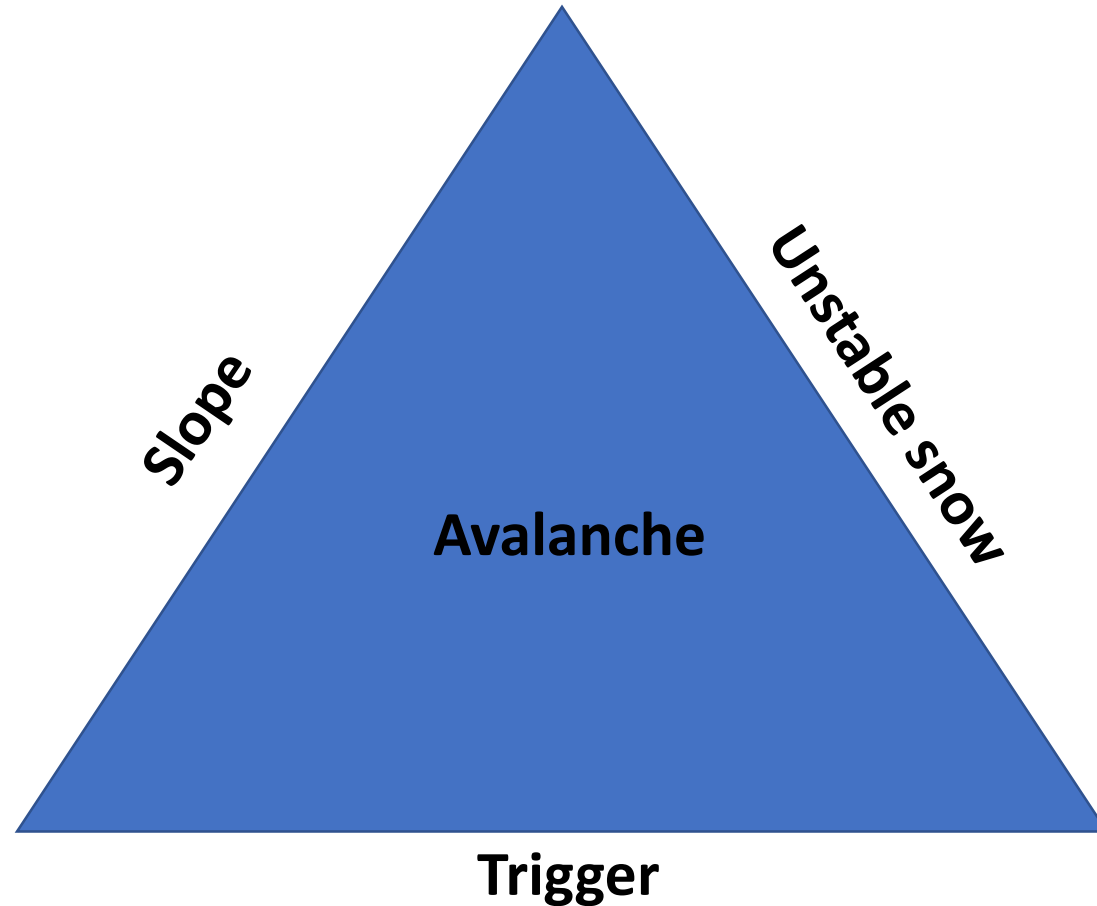
Huascaran avalanche in Peru, May
31, 1970





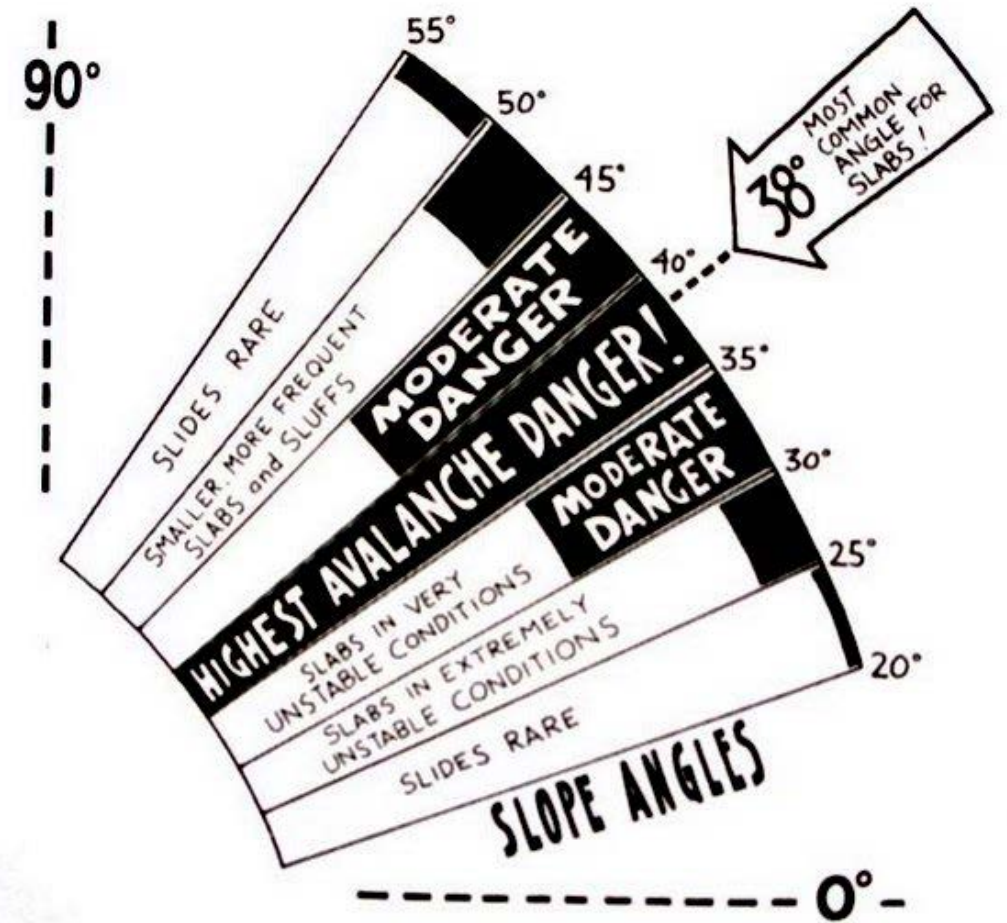
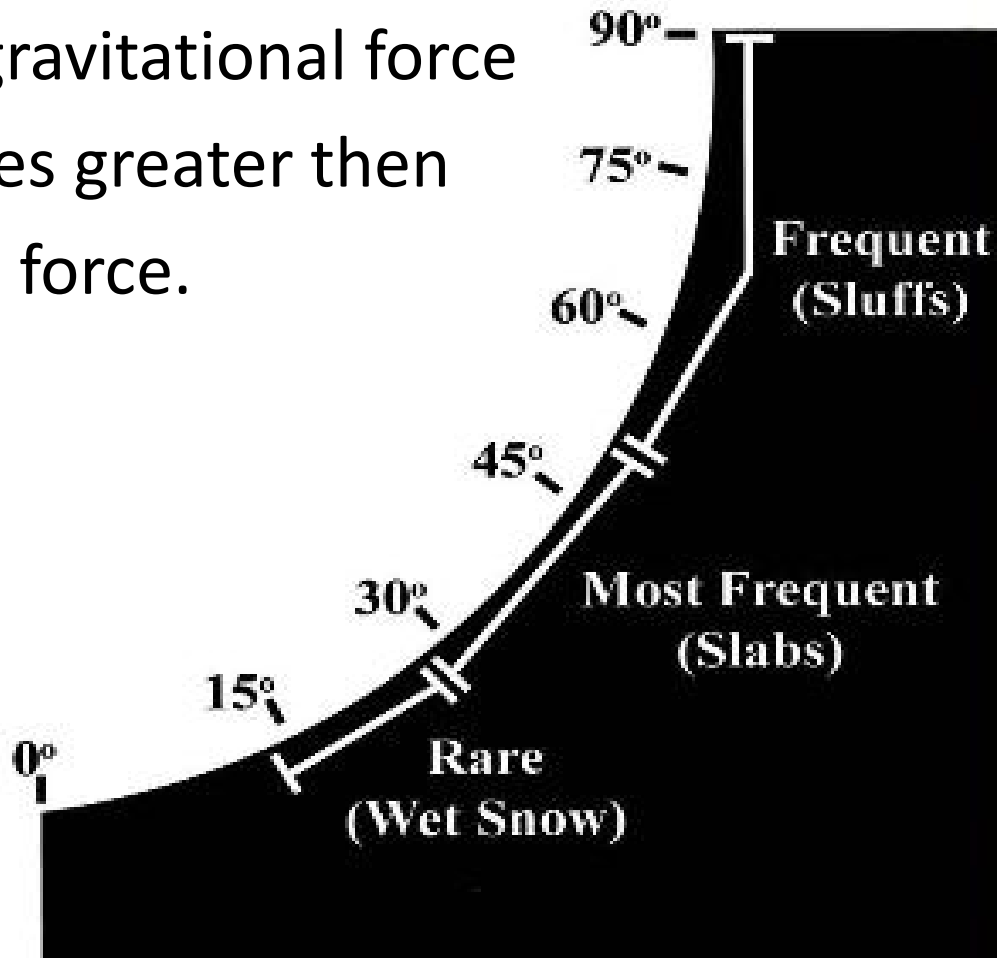
The Avalanche Triangle

The 3 ingredients necessary to produce an avalanche



Slope

- An avalanche happens when gravitational force becomes greater than friction force.



Trigger

Natural trigger such as:

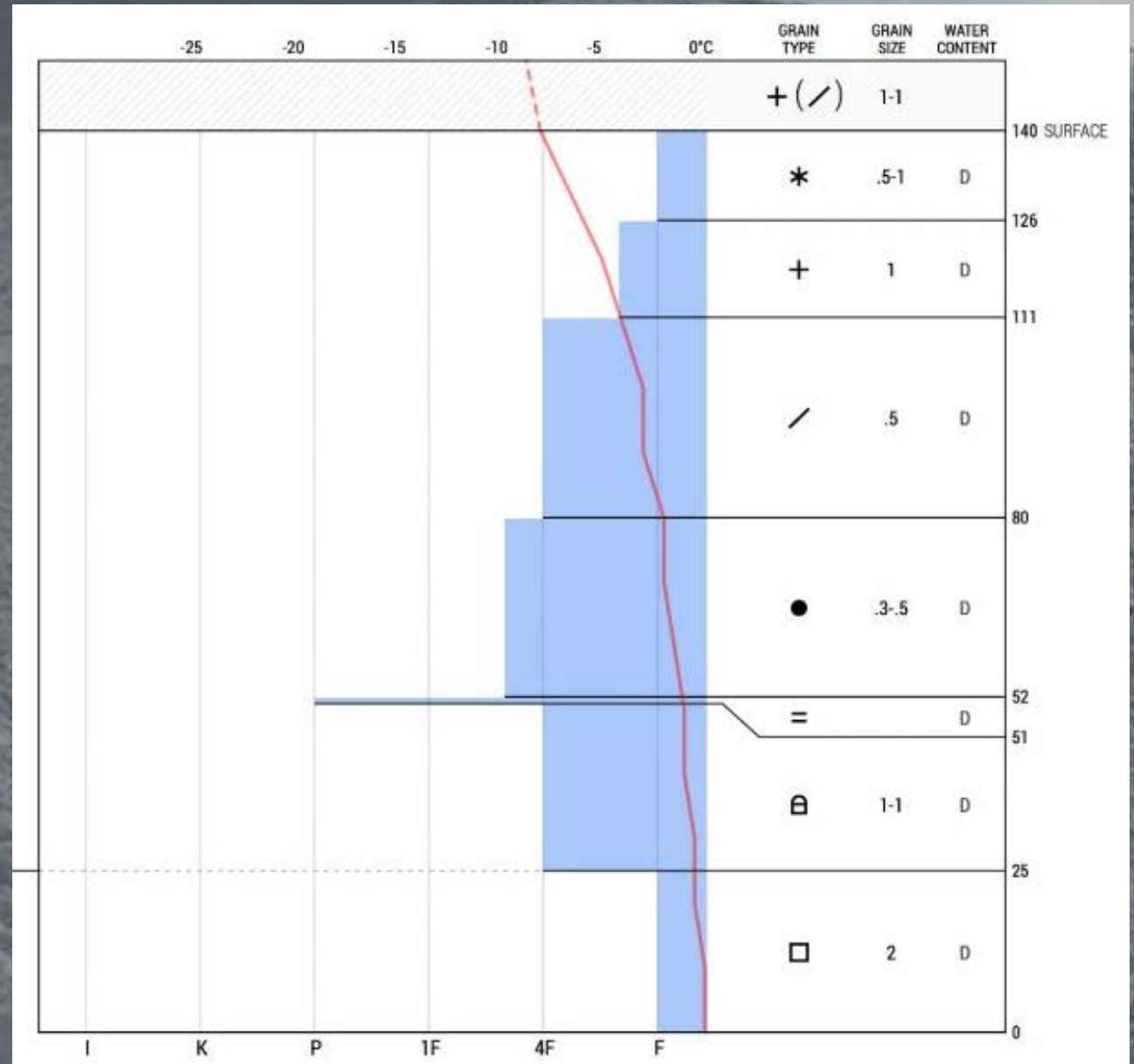
- Extra load : Precipitation (snow or rain)
- Wind : transporting snow, therefor creating extra load
- Rapid warming : radiation (sun), weather (frontal)
- Earthquake
- Cornice fall

Artificial trigger such as:

- Skier, snowboarder, snowmobiler, snowshoer....
- Explosives

Unstable snow

- Snow with little or no cohesion, no strength
- [Snow pack layering](#)



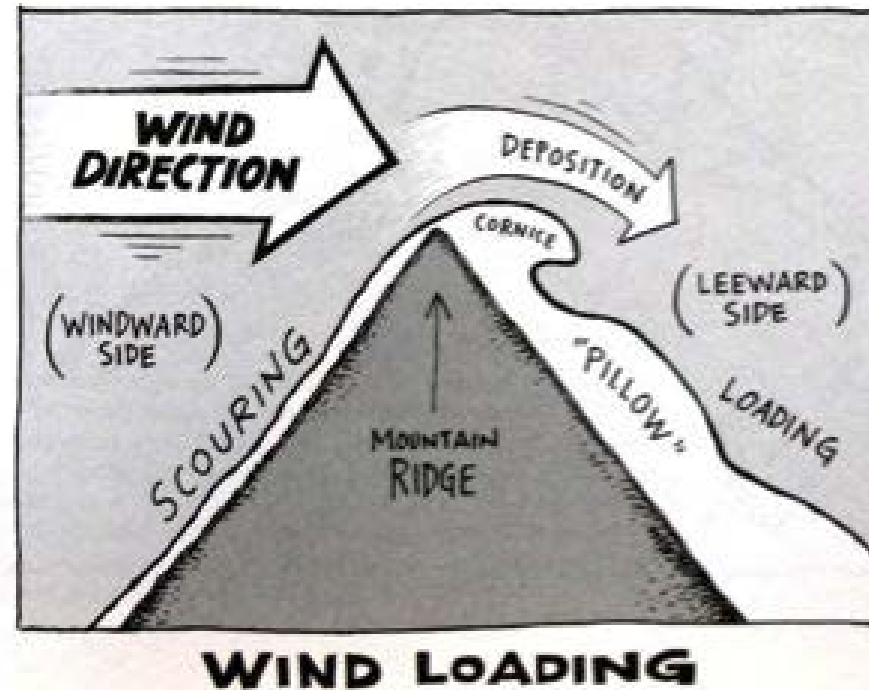
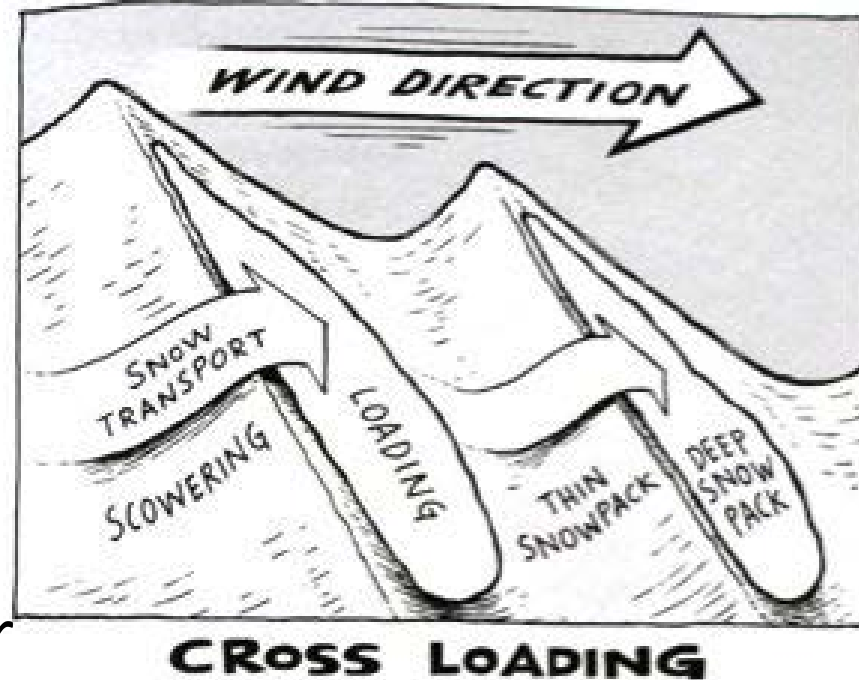
Avalanche Terrain Morphology



- The classic avalanche path

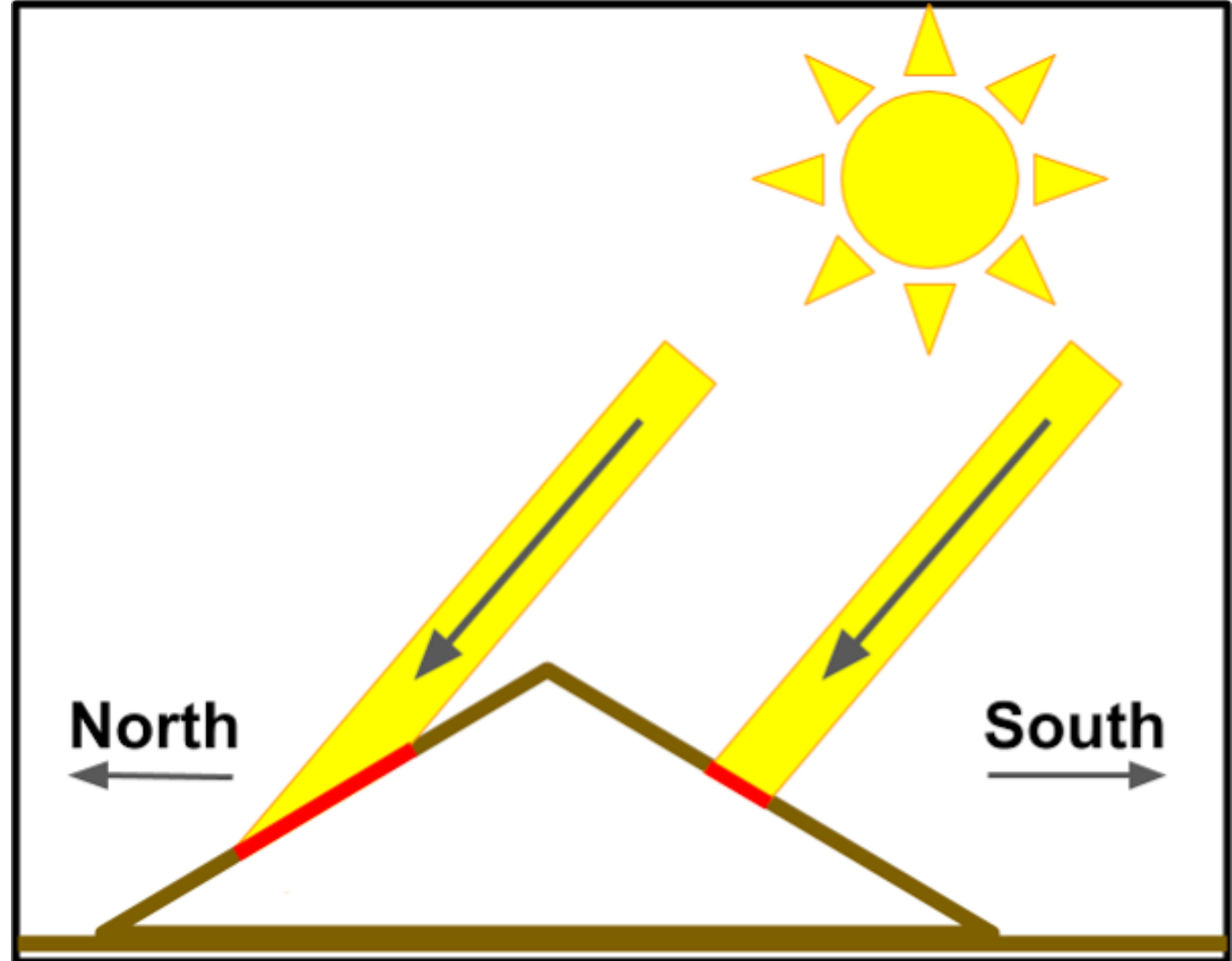
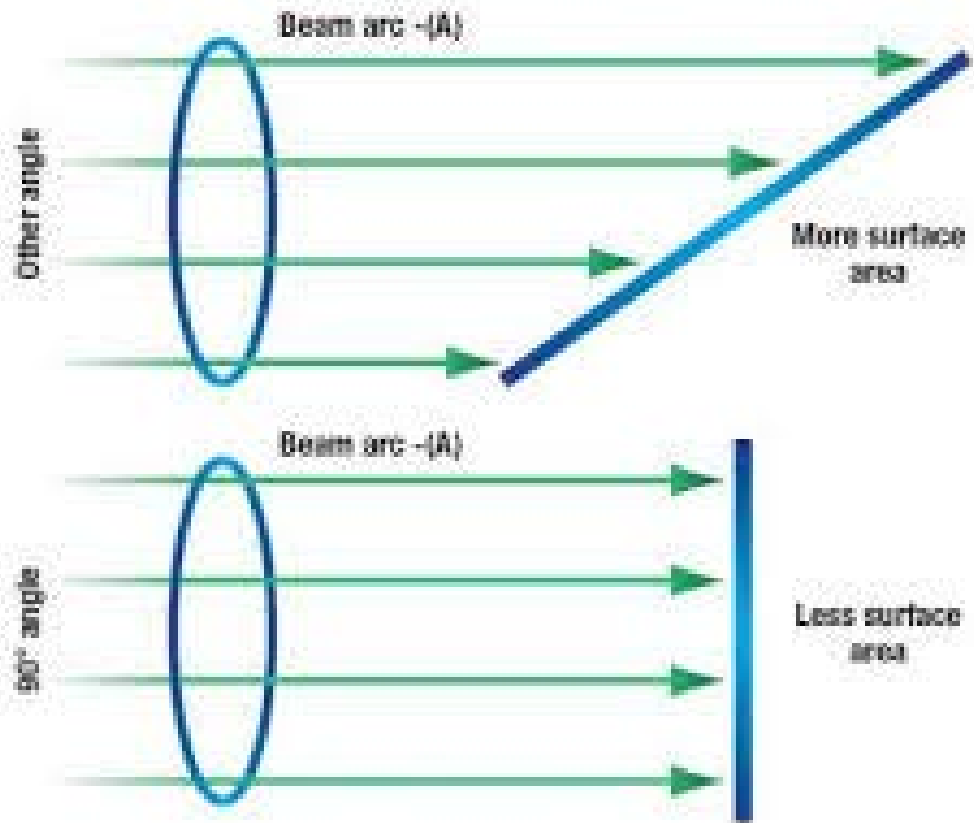
Wind Effect

- Lee aspect : opposite aspect of the wind direction
- Cross loaded aspect : perpendicular aspect to wind direction



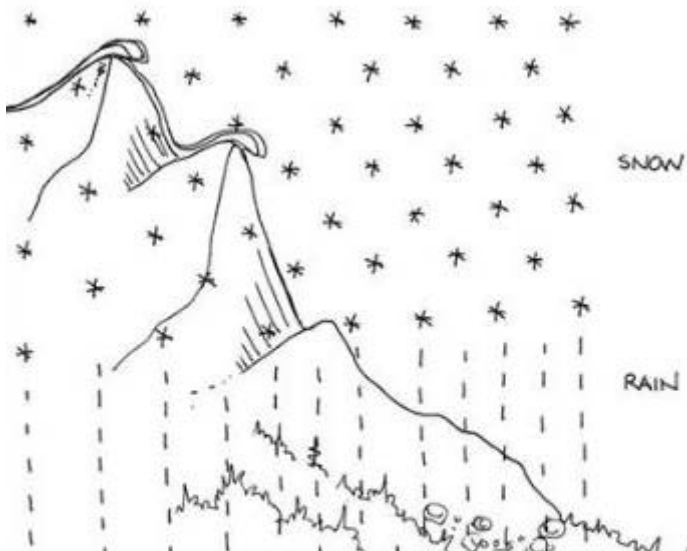
Solar aspect

- The angle is everything

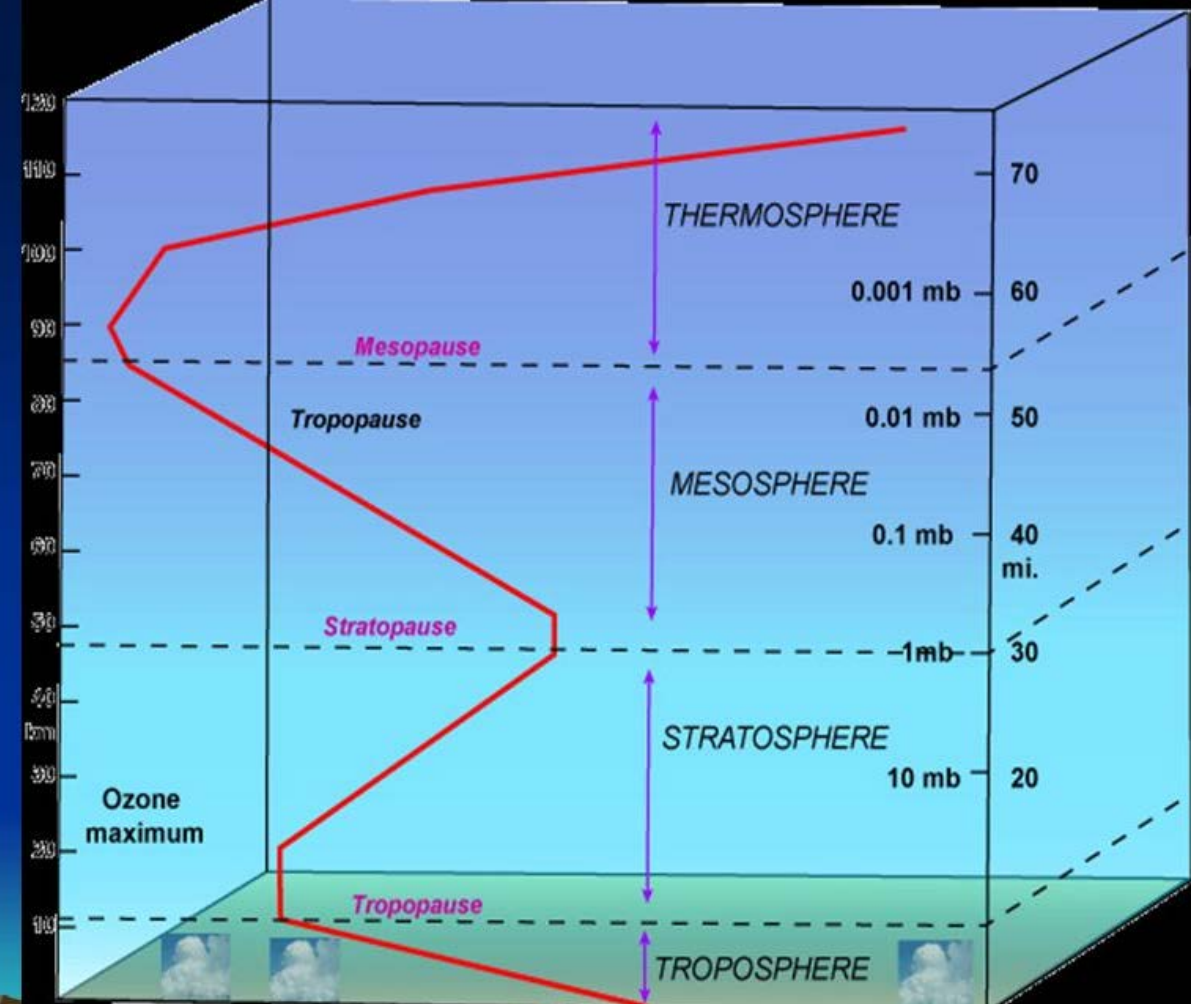


Elevation

- The air normally gets cooler as we get higher (in the Troposphere), which will have an influence on the snowpack and precipitation type...



Atmospheric Temperature Profile with Height.



Avalanche Terrain Exposure Scale

- Simple Terrain
- Challenging Terrain
- Complex Terrain

Simple terrain



Challenging terrain



Complex terrain

Avalanche Character or type

As define by Avalanche Canada

Slab avalanches

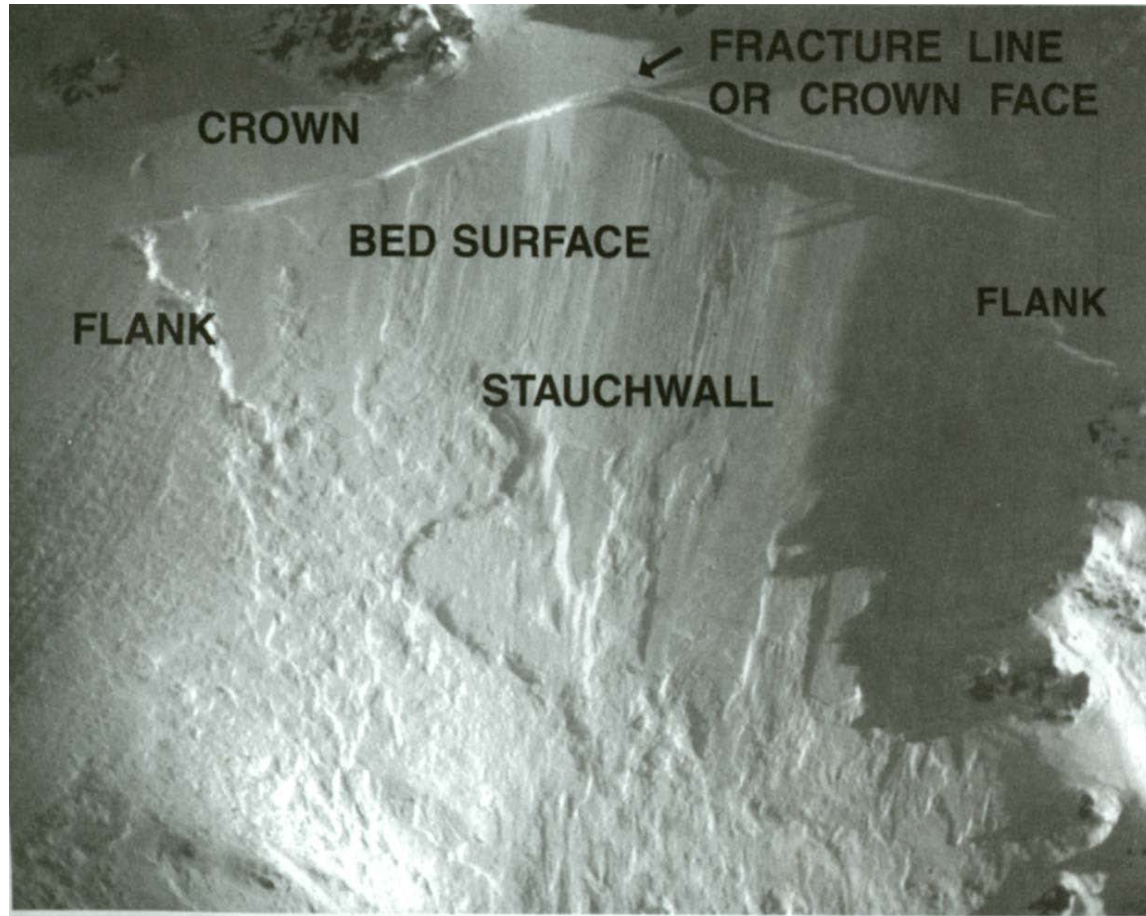
- Wind slab
- Wet slab
- Storm slab
- Persistent slab
- Deep persistent slab

Loose avalanches

- Loose wet
- Loose dry

Cornice fall

Slab Avalanches



Slab avalanche nomenclature.



(Photo by Chuck O'Leary)



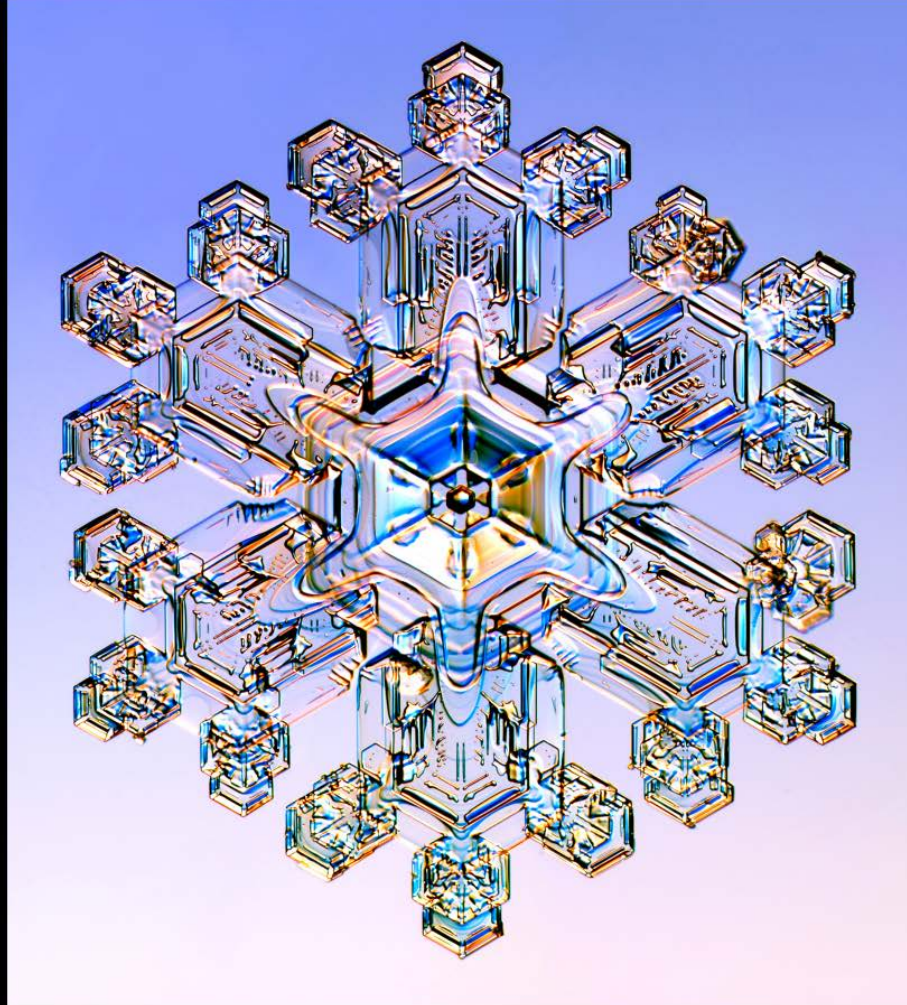
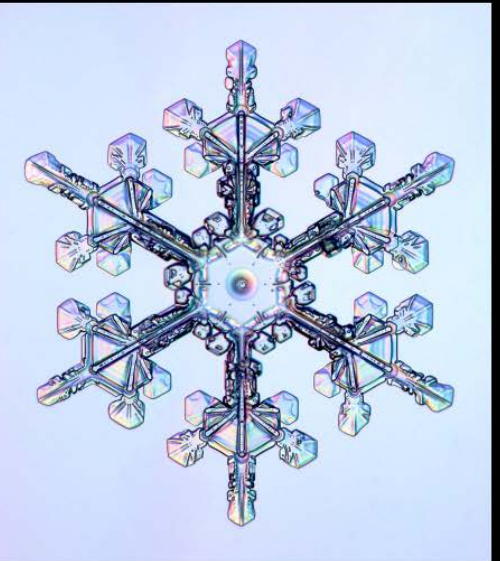
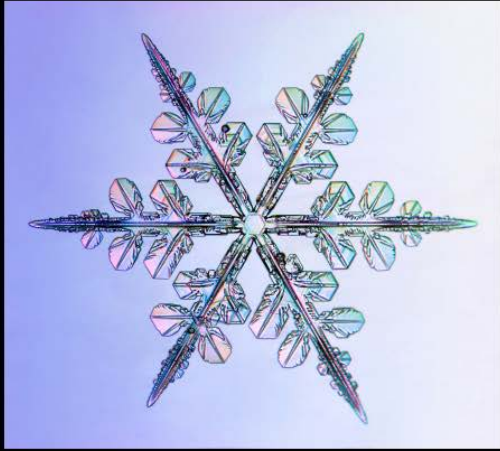
Loose Avalanches (sluff)

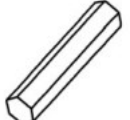

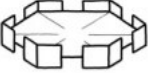
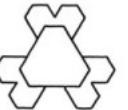
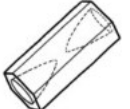







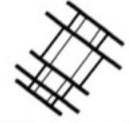


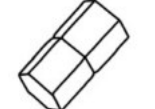








Cornice fall



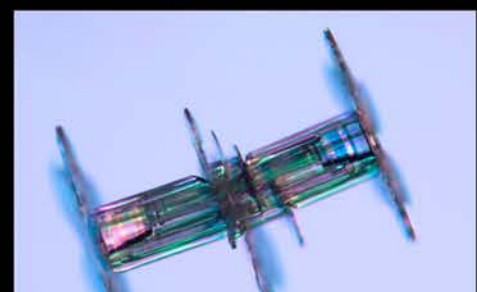
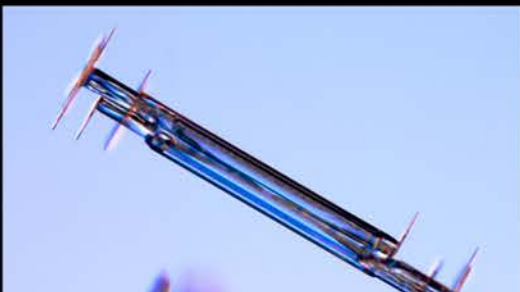
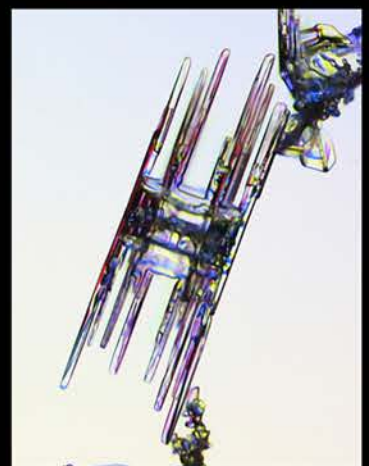
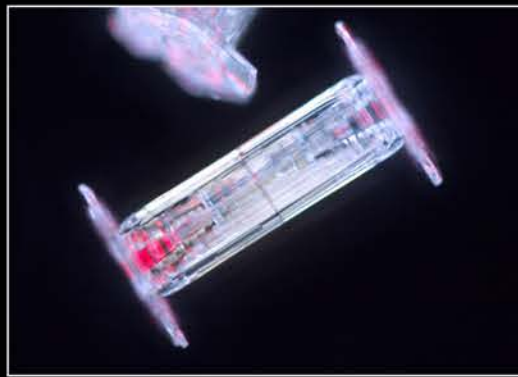
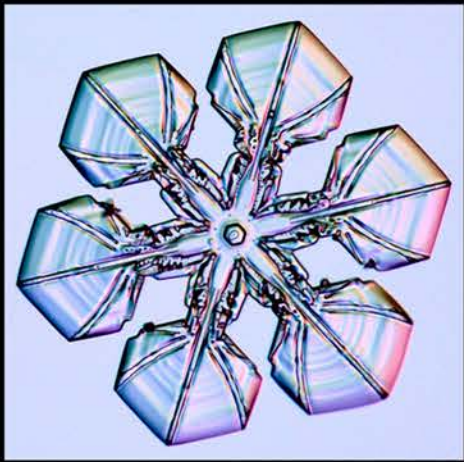
The life of a snowflake

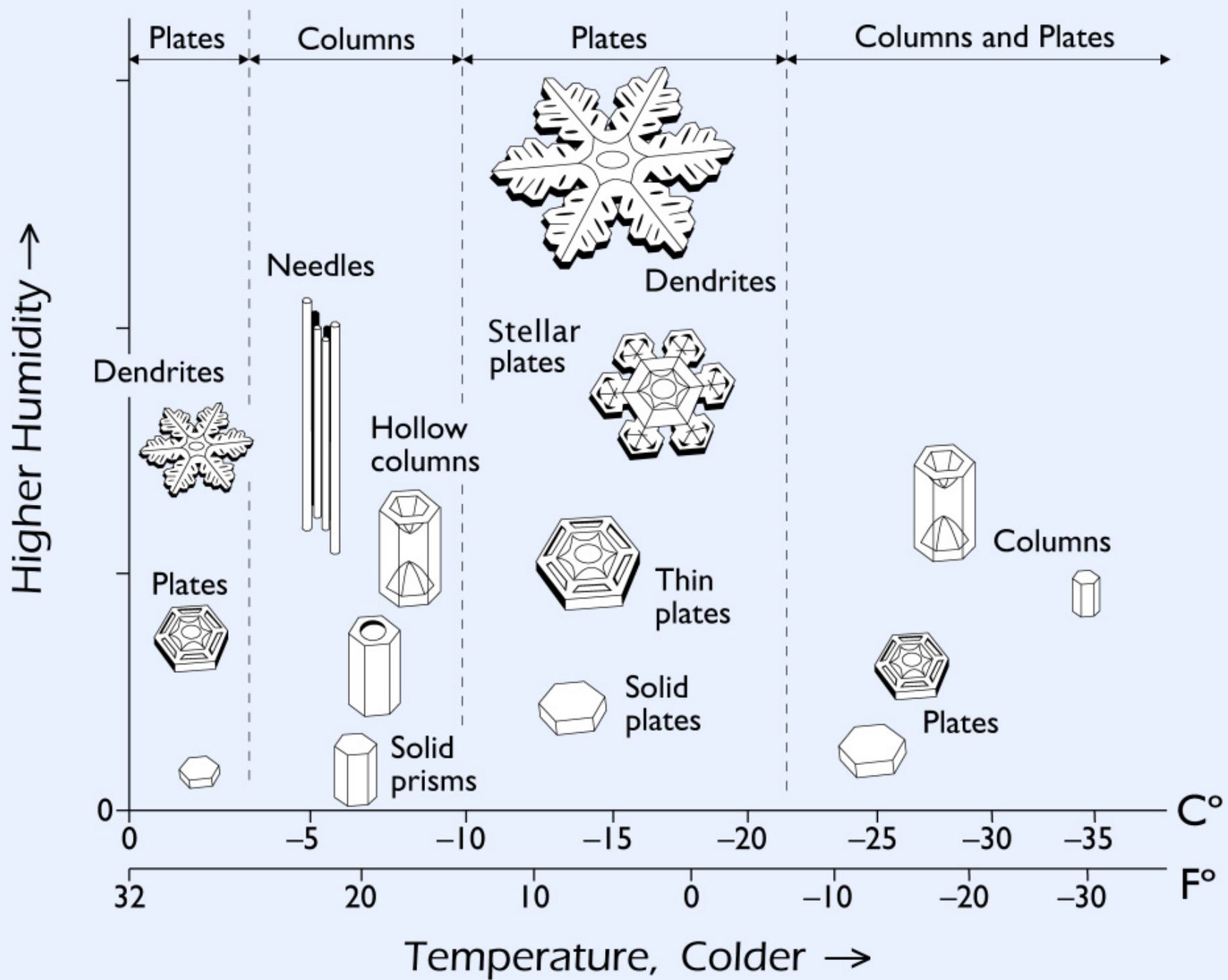


				
Simple Prisms	Solid Columns	Sheaths	Scrolls on Plates	Triangular Forms
				
Hexagonal Plates	Hollow Columns	Cups	Columns on Plates	12-branched Stars
				
Stellar Plates	Bullet Rosettes	Capped Columns	Split Plates & Stars	Radiating Plates
				
Sectorial Plates	Isolated Bullets	Multiply Capped Columns	Skeletal Forms	Radiating Dendrites
				
Simple Stars	Simple Needles	Capped Bullets	Twin Columns	Irregulars
				
Stellar Dendrites	Needle Clusters	Double Plates	Arrowhead Twins	Rimed
				
Fernlike Stellar Dendrites	Crossed Needles	Hollow Plates	Crossed Plates	Graupel

They form in the atmosphere

- No snowflakes are the same : The exact shape of the final snow crystal is determined by the precise path it took through the clouds. But the six arms all took the same path, and so each experienced the same changes at the same times





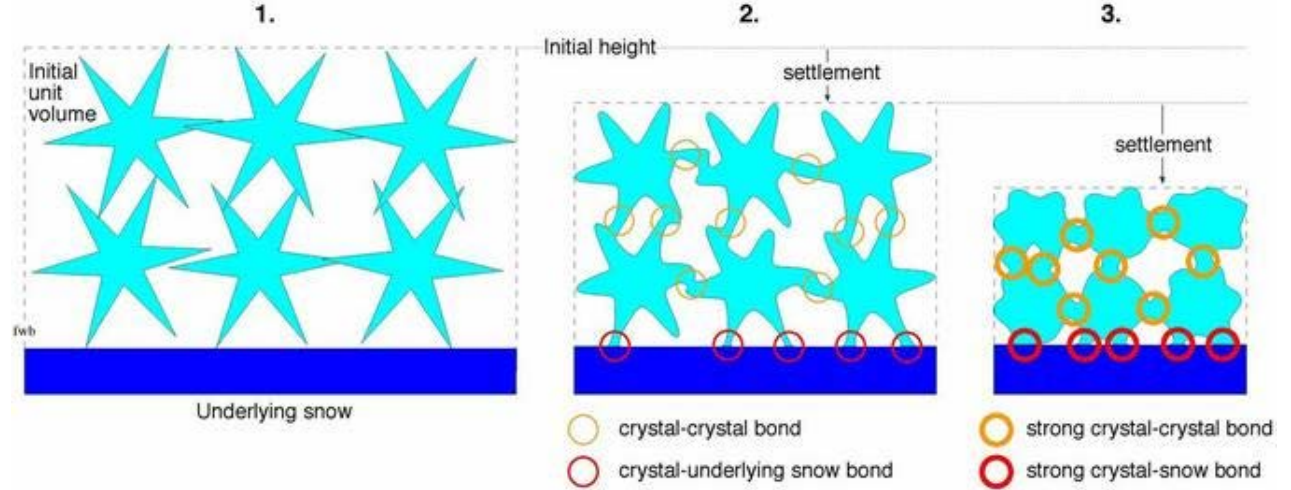
The most stable form of ice crystal



Metamorphic processes once on the ground

- Settlement
- Rounding
- Faceting
- Melting and freezing (crust formation)

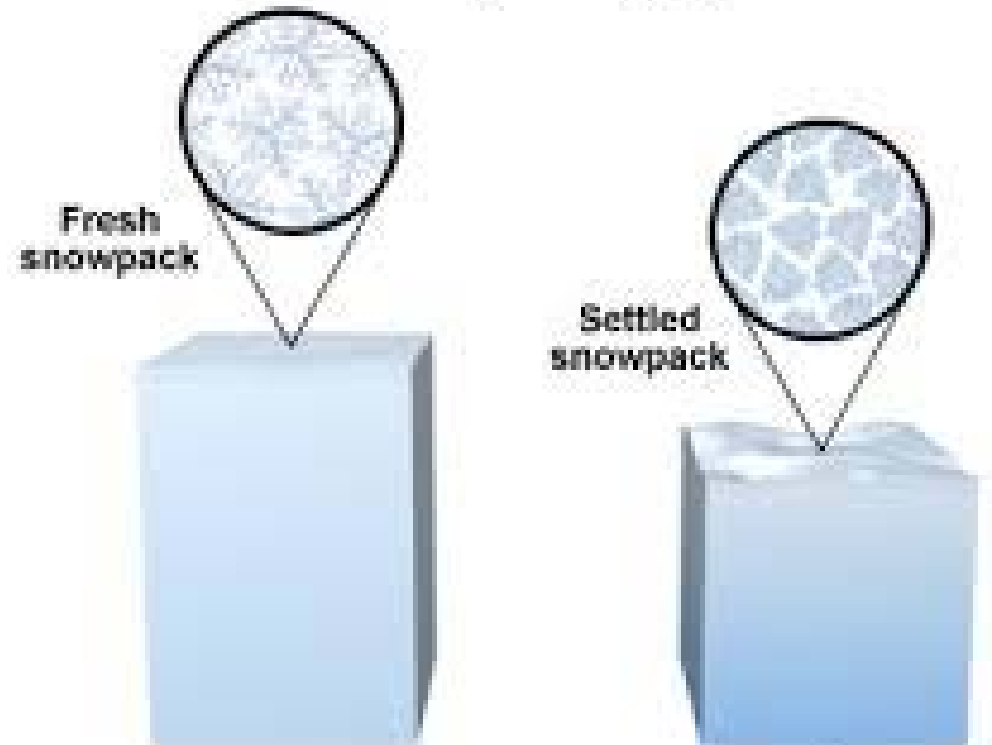
Settlement



Density of Snow Cover

Snow Type	Density (kg/m ³)	Snow Depth for One Inch Water
Wild Snow	10 to 30	98" to 33"
Ordinary new snow immediately after falling in still air	50 to 65	20" to 15"
Settling Snow	70 to 90	14" to 11"
Average wind-toughened snow	280	3.5"
Hard wind slab	350	2.8"
New firn snow	400 to 550	2.5" to 1.8"
Advanced firn snow	550 to 650	1.8" to 1.5"
Thawing firn snow	600 to 700	1.6" to 1.4"

Snowpack Aging



**SNOW
TEMPERATURE**

LOW
(Approximately -10°C
to -20°C , but may vary
depending on other factors,
i.e. wind chill temperature)



HIGH
(Approximately 0°C
to -2°C)

2 When the layers in the snowpack weaken and the upper layer loses support, the snow may collapse and begin to slide.



FRESH SNOWFALL

SUN CRUST

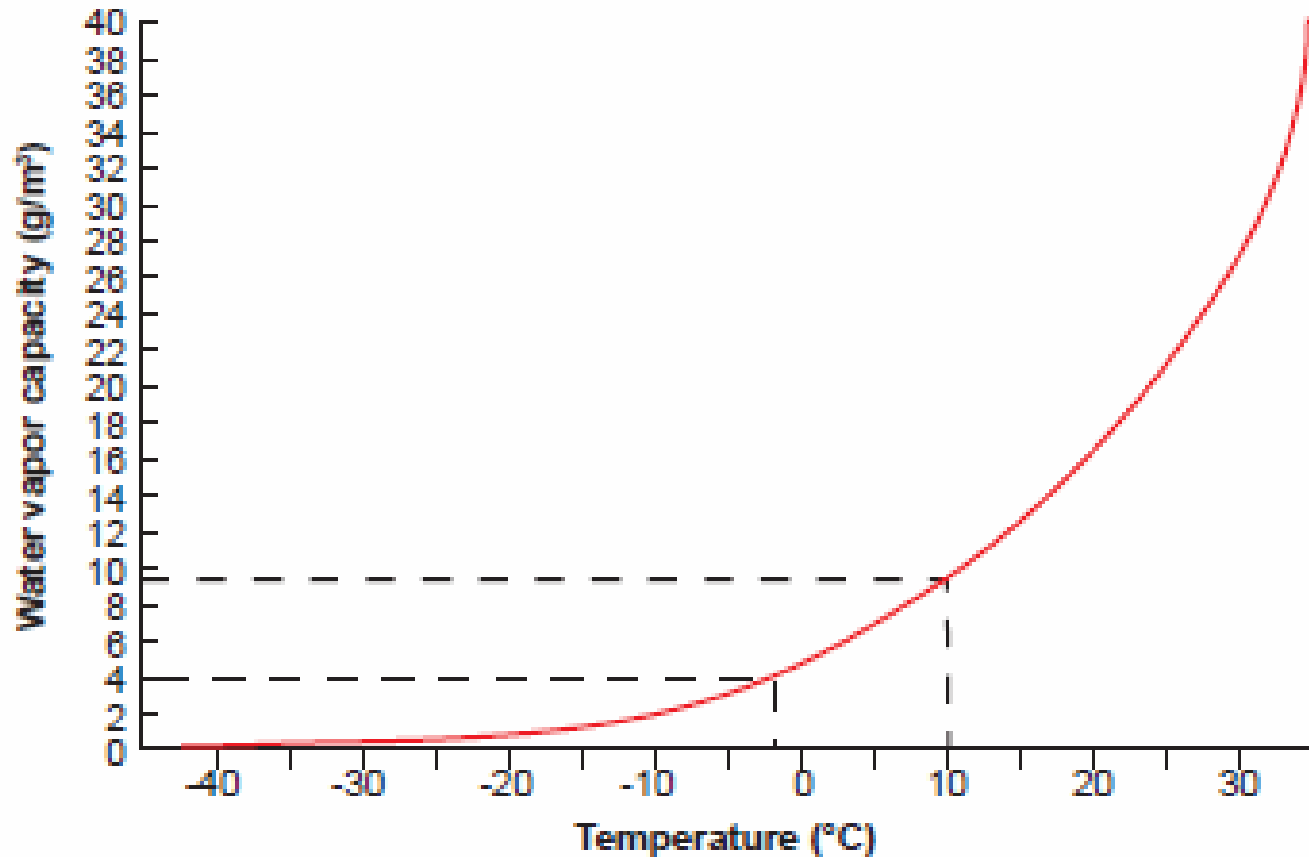
DEPTH HOAR CRYSTALS

WATER VAPOUR

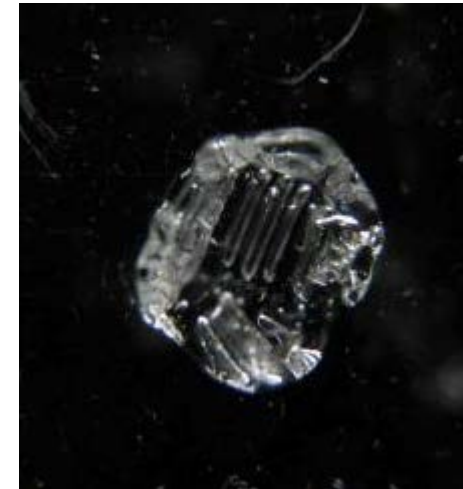
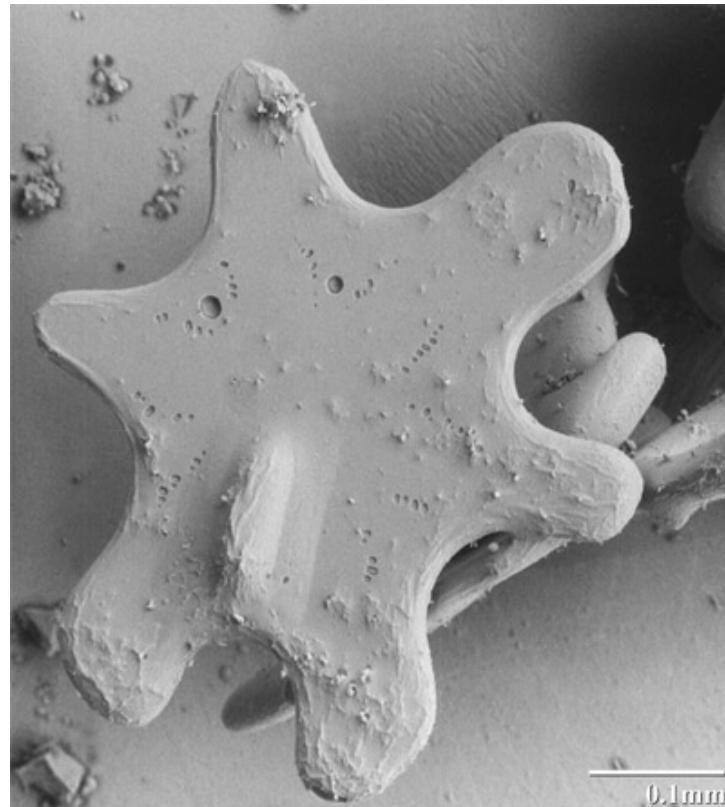
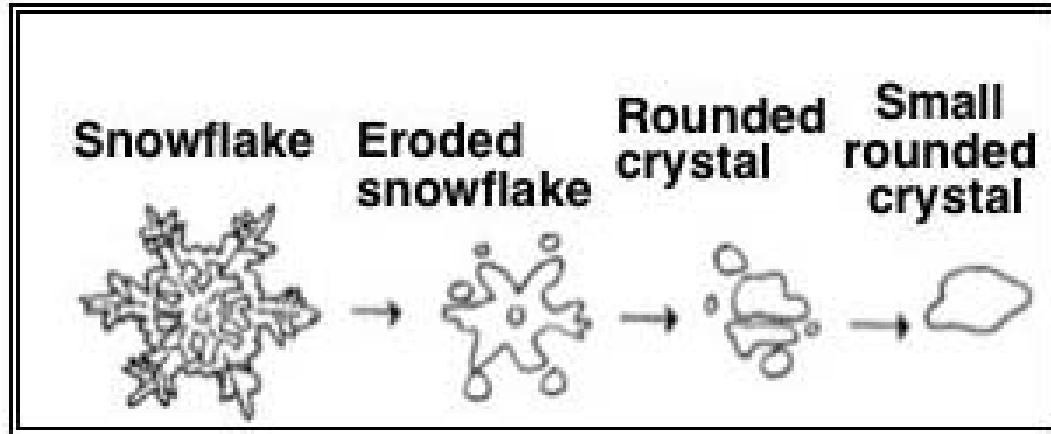
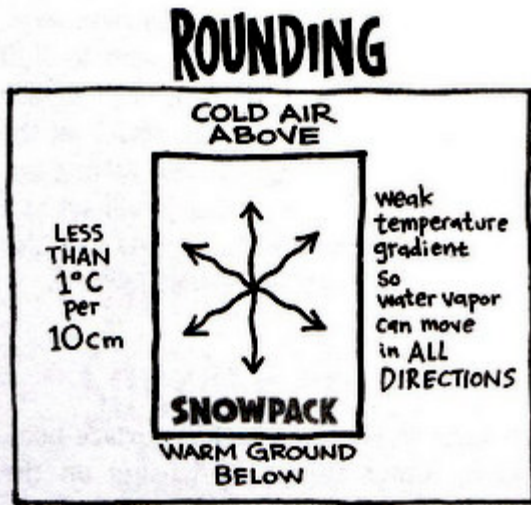
GROUND

These metamorphic processes are more efficient at warmer temperatures

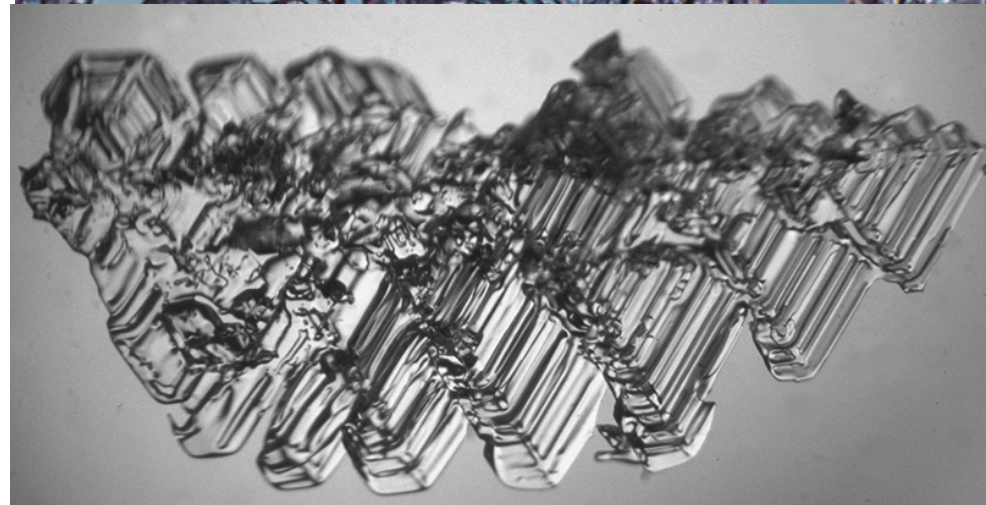
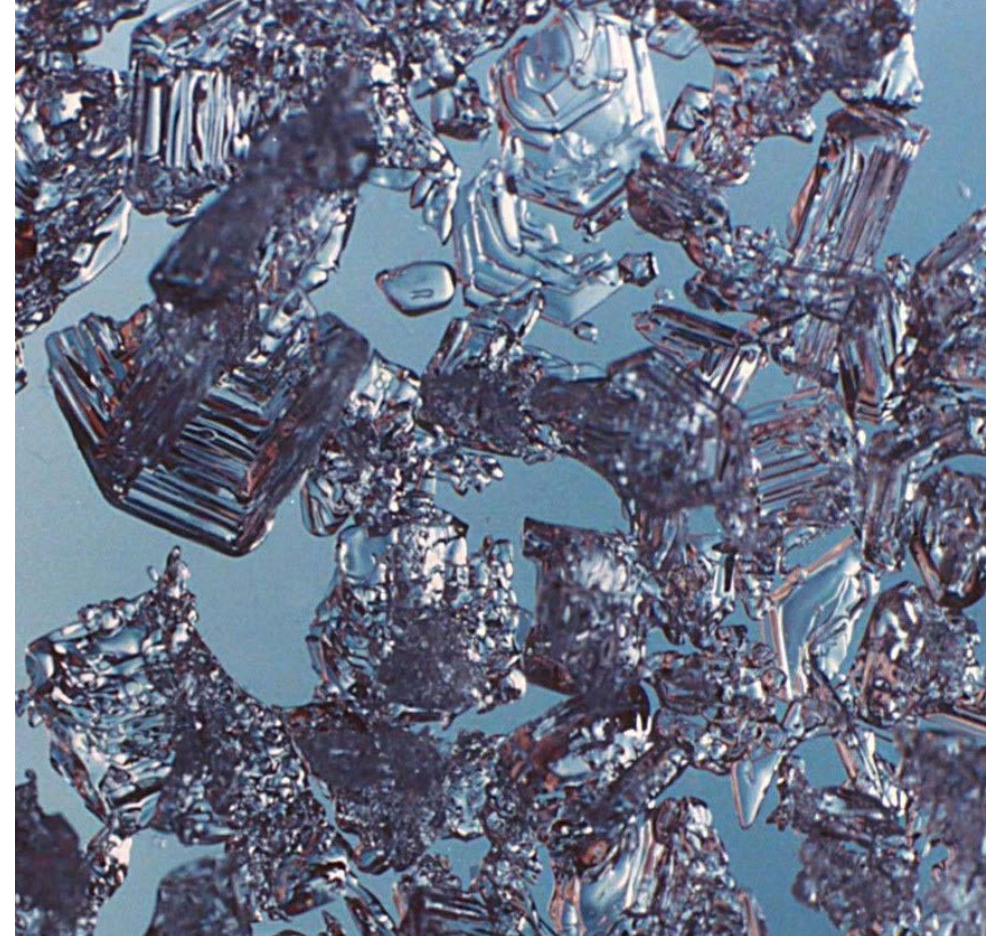
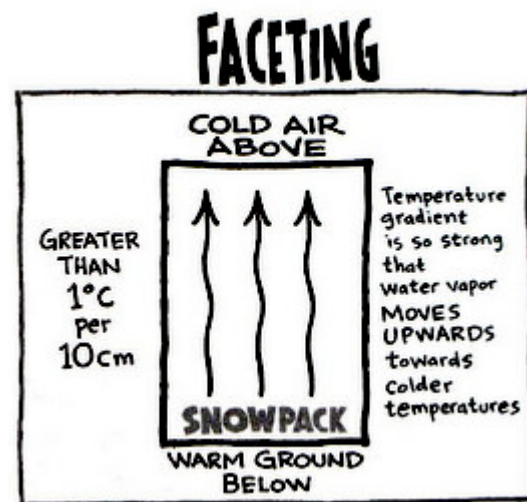
Clausius Clapayron Equation



Rounding



Faceting



Melting and freezing (crust formation)



CORN SNOW GRAIN CLUSTER:



Surface hoar formation



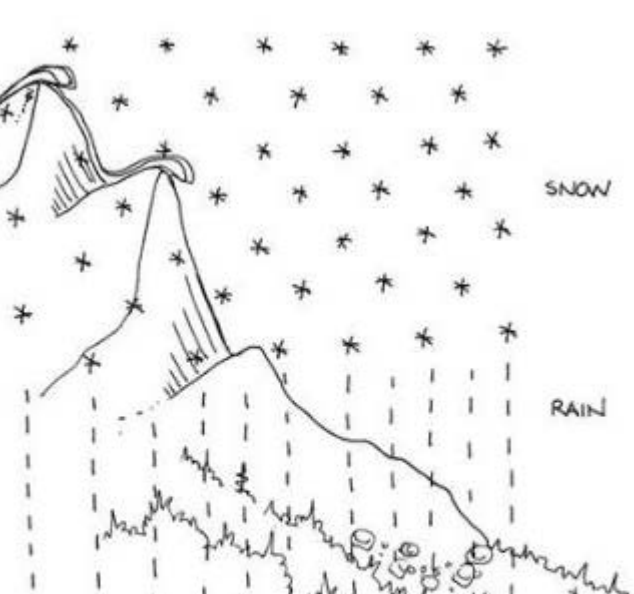
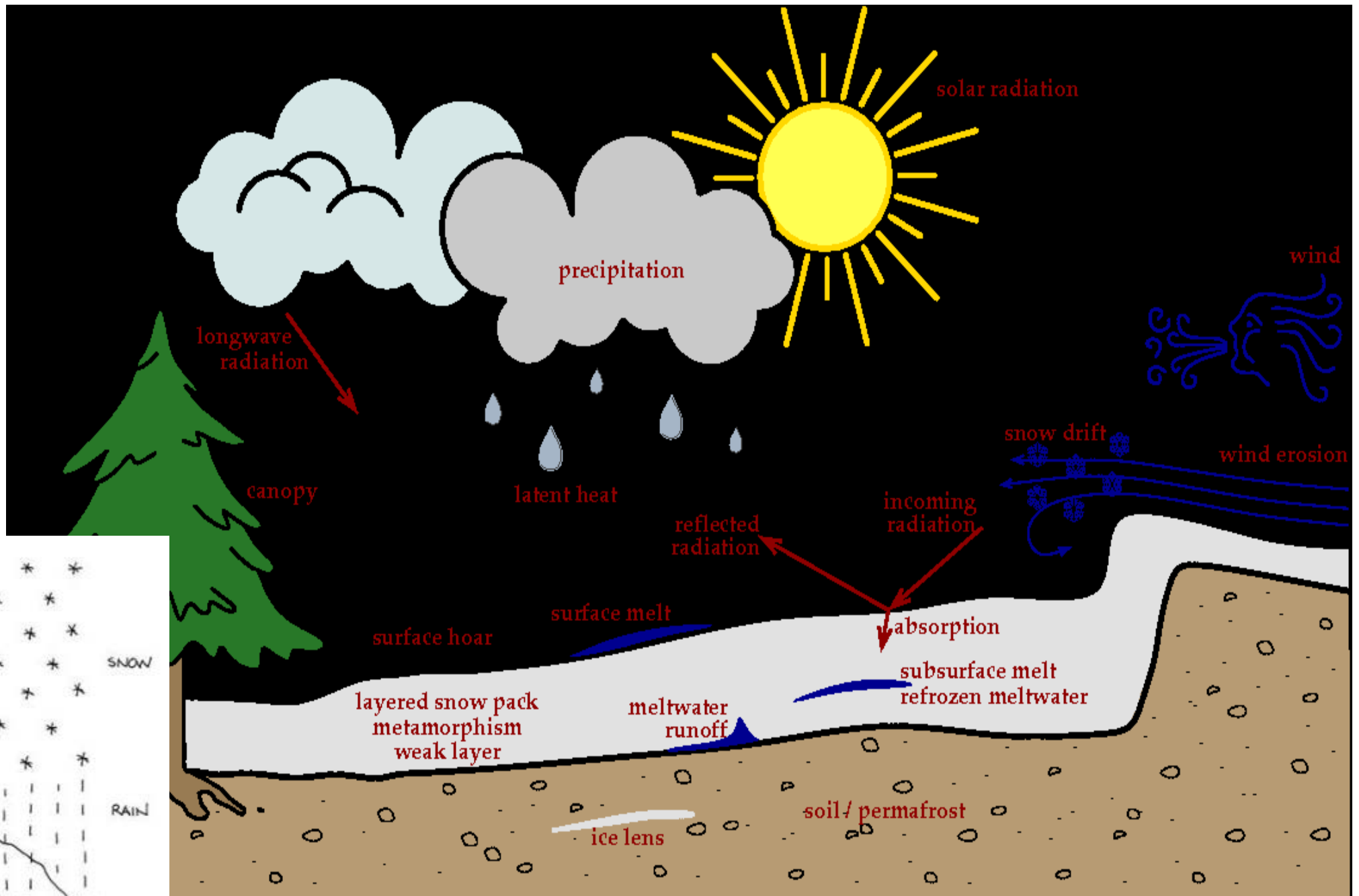


SURFACE HOAR FORMATION

- Clear sky
- Calm or light winds (about 3 mph is best)
- Open slope exposed to a clear sky (trees or clouds can radiate their own heat and disrupt the process)



- Humid air







Thank you!

References

- Avalanche Canada: www.avalanche.ca
- Oxford dictionary: en.oxforddictionaries.com
- Dictionary.com: www.dictionary.com
- McClung and Schaerer, D.McC. and P.S., 2006, The Avalanche Handbook 3rd ed, Seattle, The Mountaineers Books.
- Avy Snacks, Sherpa Cinema
- www.avalanches.org
- www.snowcrystals.com
- www.ngdc.noaa.gov/hazardimages