Periglacial Geomorphology

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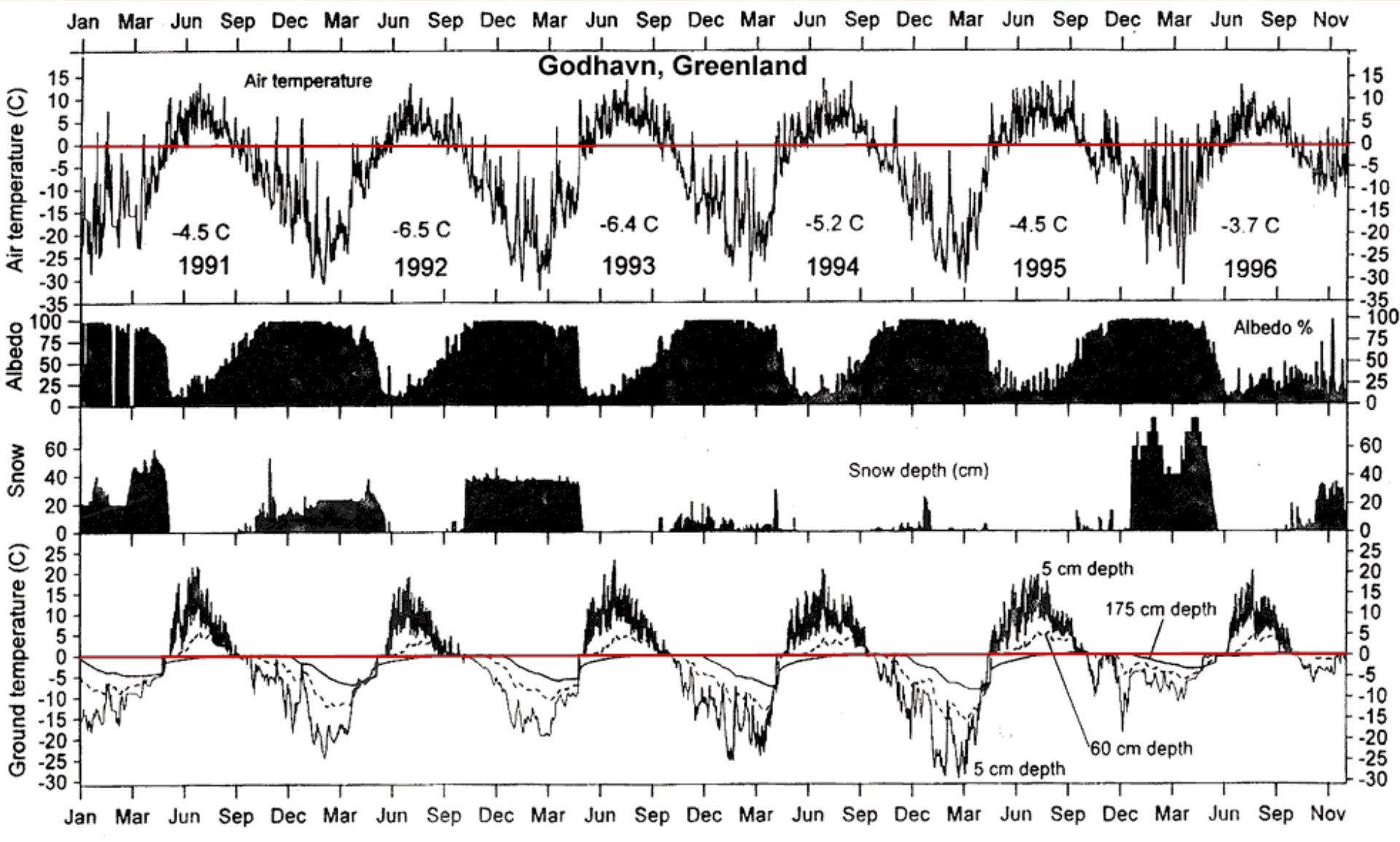
Periglacial: literally means “around glacial” - term introduced in 1909 to describe landforms and processes around glaciated areas.

Periglacial environments: very cold climates in areas not permanentley covered with snow or ice, but in which permanently frozen ground (permafrost) occurs.

Permafrost develops where the temperature profile at depth remains below 0° C throughout the year.

Active Layer: zone of near-surface material that seasonally thaws and freezes.

Periglacial Environments



Periglacial Environments: Permafrost

Permafrost: soil, regolith, and bedrock at a temperature below 0º C, found in cold climates.

- Permafrost reaches a depth of 300 to 450 m near 70º N
- ***Ground ice***: water frozen in pore spaces
- ***Active layer***: surface layer that freezes and thaws with the seasons

Periglacial Environments: Active Layer

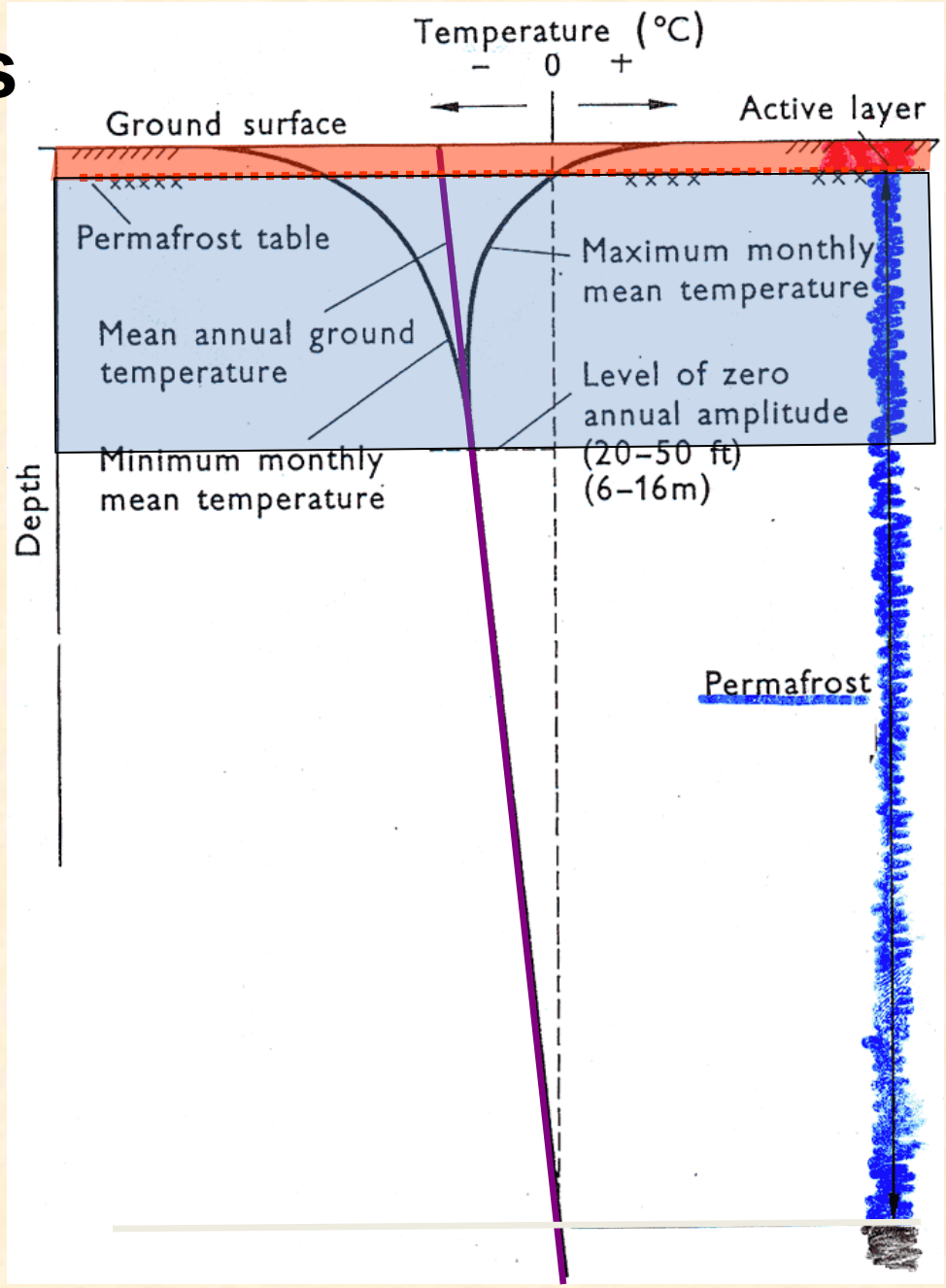
The thickness of the active layer is a function of how deep thawing penetrates frozen ground.

This will be controlled by:

- geothermal gradient (from below)
- atmospheric temperature (from above)
- vegetation, snow cover and organic litter can insulate the ground and form a buffer layer that can reduce the amplitude of seasonal temperature oscillations in the soil.

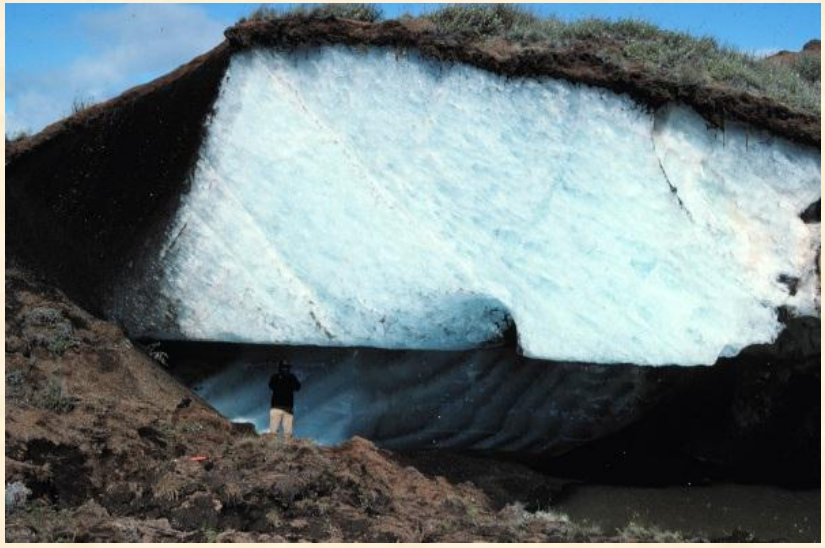
Ground Temperatures

- Mean T increases with depth
- Permafrost
  - Active layer to base of permafrost
- Seasonal
- Geomorphic work
  - Active layer



Types of Permafrost

Continuous: Pervasive permafrost beneath the active layer broken only by open **taliks** (thawed ground) under lakes.

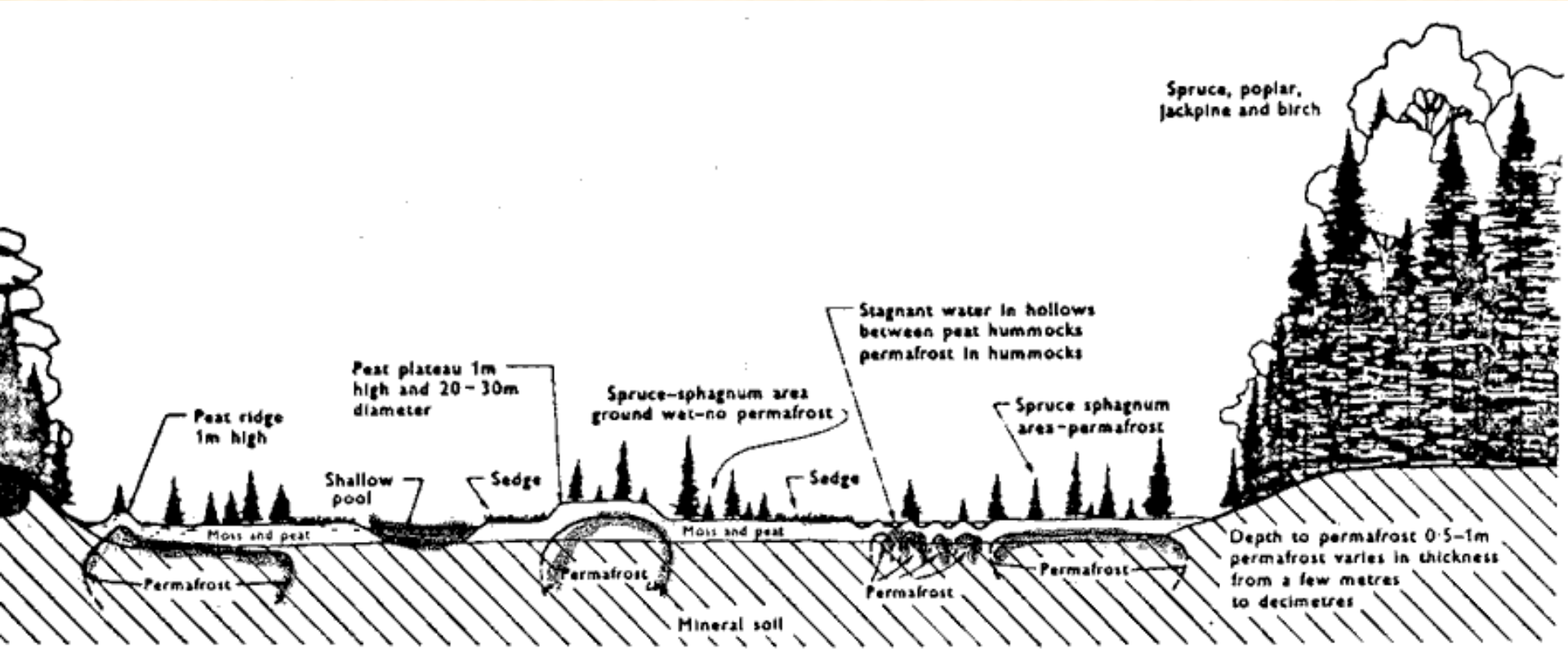


Discontinuous: Continuity of permafrost broken by through-going taliks even in the absence of lakes.

Sporadic: Isolated blocks of relatively thin permafrost - most common at margins of periglacial environments.

Discontinuous Permafrost: Local Distribution

- Absent beneath water
- Absent beneath forest
- Present beneath moss - hummocks



Extent of Permafrost

Continuous permafrost occurs in northern Russia, Canada, Alaska and Greenland.

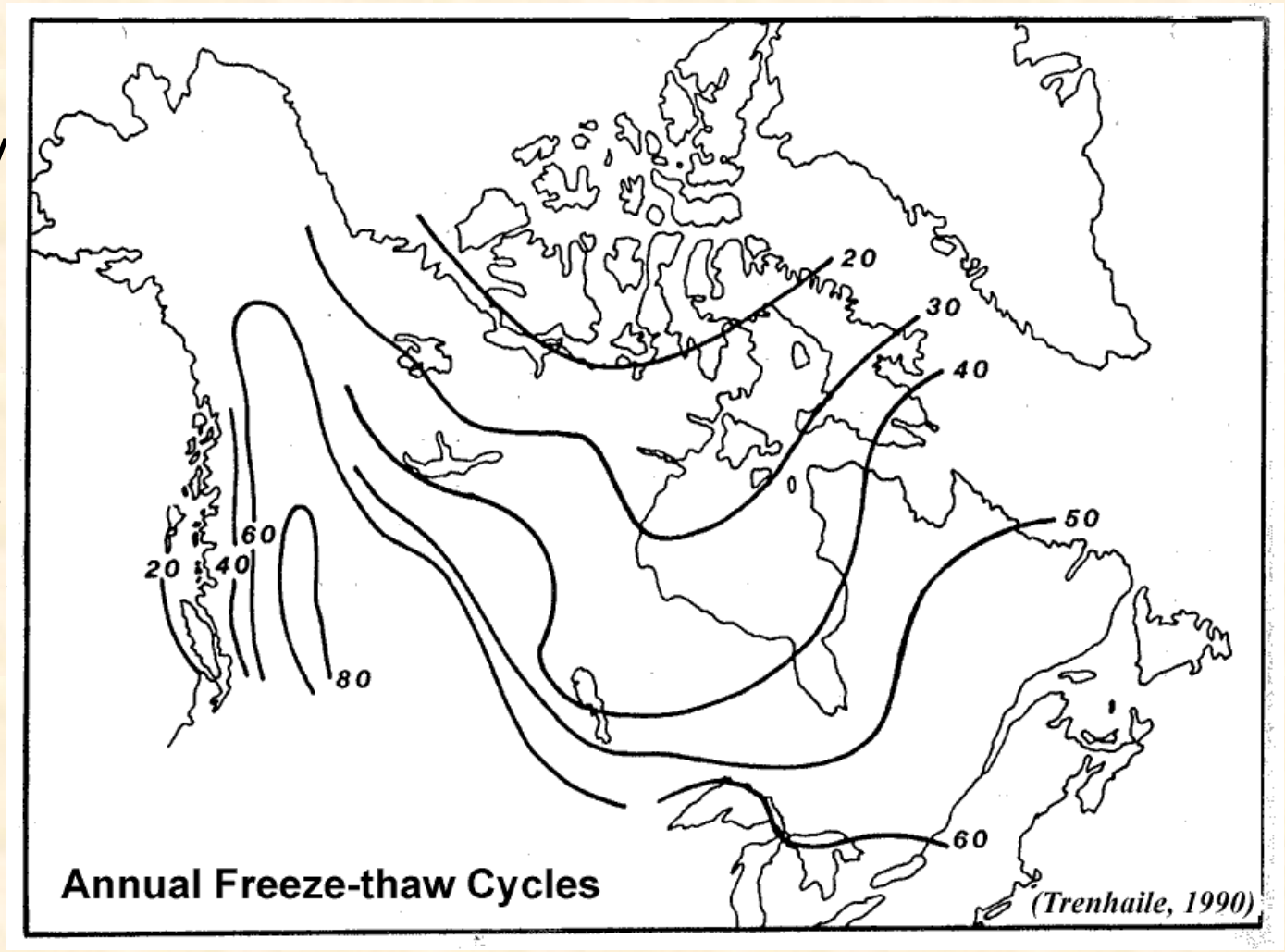
Discontinuous permafrost extends to 50° N in Siberia and E. Canada.

Alpine permafrost occurs at very high elevations as far south at 30° N.

Periglacial Processes Common Above Treeline

Freeze-thaw cycles

- Weathering
  - Frequency
  - Intensity
- Maximum
  - Mountains
  - South!
- Minimum
  - North
  - W. coast



Frost Shattering: Identification of Glacial Trimlines

Frost shattering of rocks is common in periglacial environments. Areas of extensive frost shattering can help identify nunataks (isolated ridgetops that extend above glaciers).

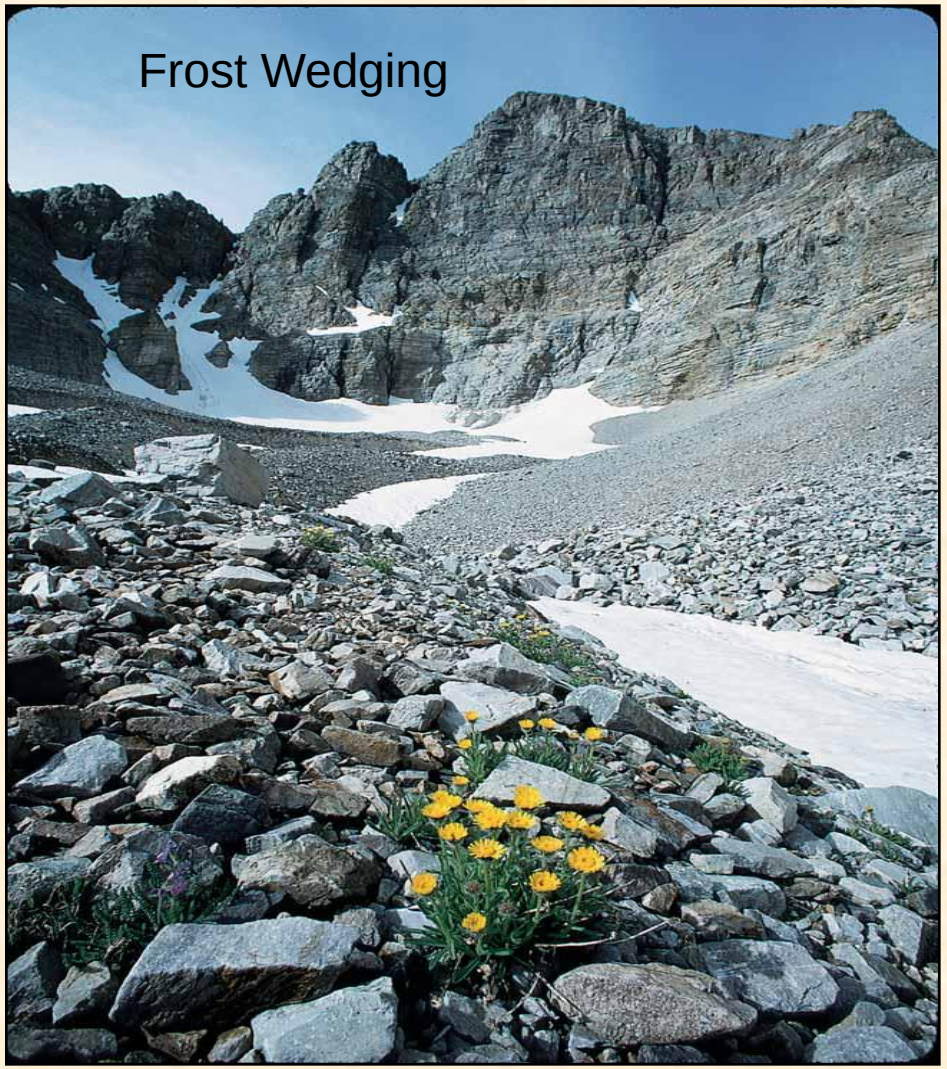
Extent of periglacial landforms helps to constrain position of glacial trimlines (below which substantial glacial erosion occurred).

Colorado Front Range

Strong Mechanical / Weak Chemical Weathering

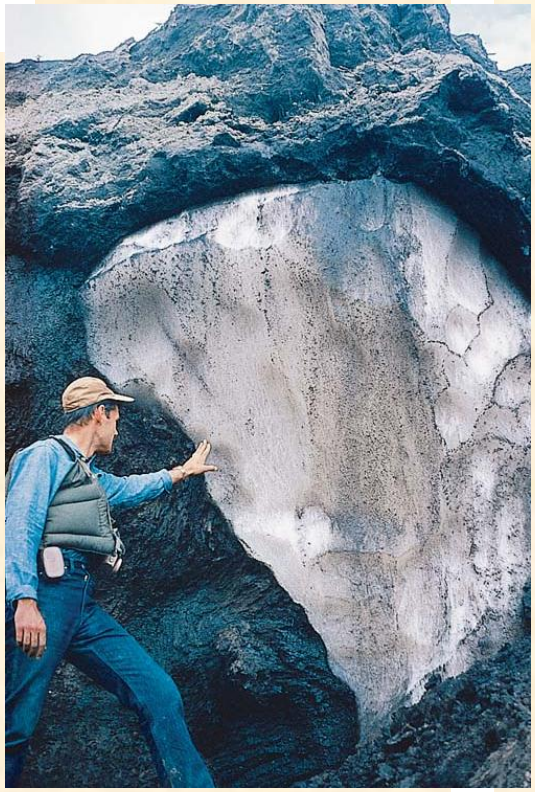
Thermal Expansion & contraction

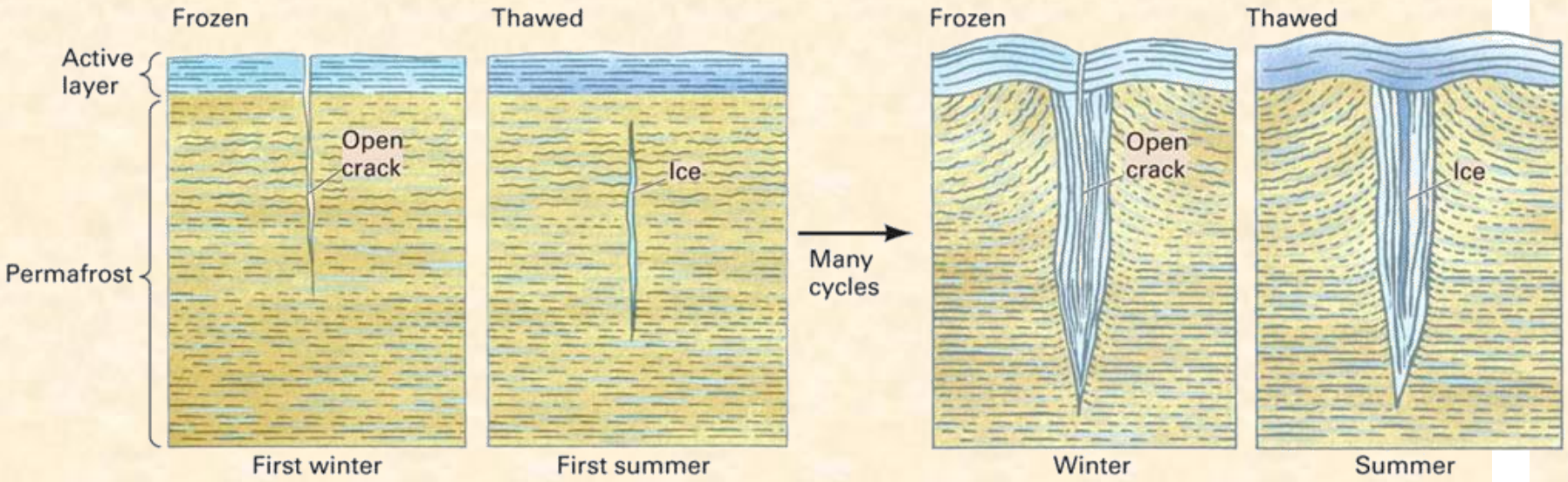
Frost Wedging



Frost (Ice) Wedges

- Frost wedging
  - Expand/contract
  - Add water
  - Repeat
- Upon warming, fill in with noncohesive sediment





Patterned Ground

The dynamics of seasonal freeze/thaw action in the active layer leads to a wild variety of patterned ground in periglacial environments.

Polygons:
Range from small features < 1m across to polygons over 100 m across. Ice-wedge polygons only form in presence of permafrost, but other types of polygonal ground can form in other environments.

Circles:
Characteristically rimmed by vegetation sorted - bordered by stones that tend to increase with size of the circle; typical dimensions are 0.5 to 3 m across.

Stripes:
Tend to form on steeper slopes with alternating stripes of coarse and fine material elongated downslope.

Ice Wedge Polygons

Begin with cracking due to intense cold and thermal contraction.

Networks of vertical ice wedges shape the polygons which occur below the active seasonal freeze-thaw layer.

The visible surface formation is a result of the soil slumping above the ice wedges.

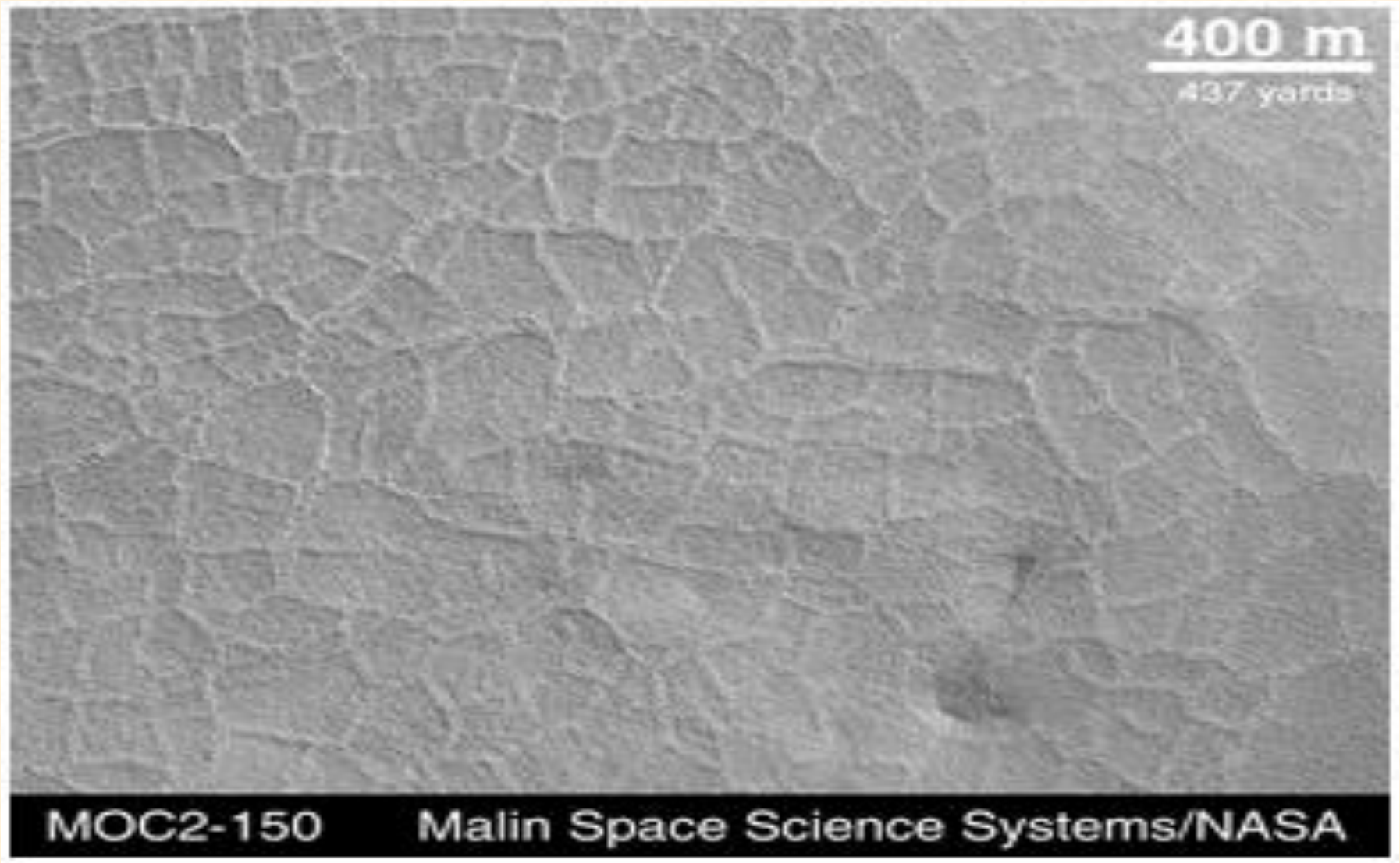
May be a few meters to over 100 meters in diameter.

Low centered if ice wedge is growing

High centered if thawing is more prevalent causing stream channels along ice-wedges

Ice Wedge Polygons

Ice Wedge Polygons (?) on Mars



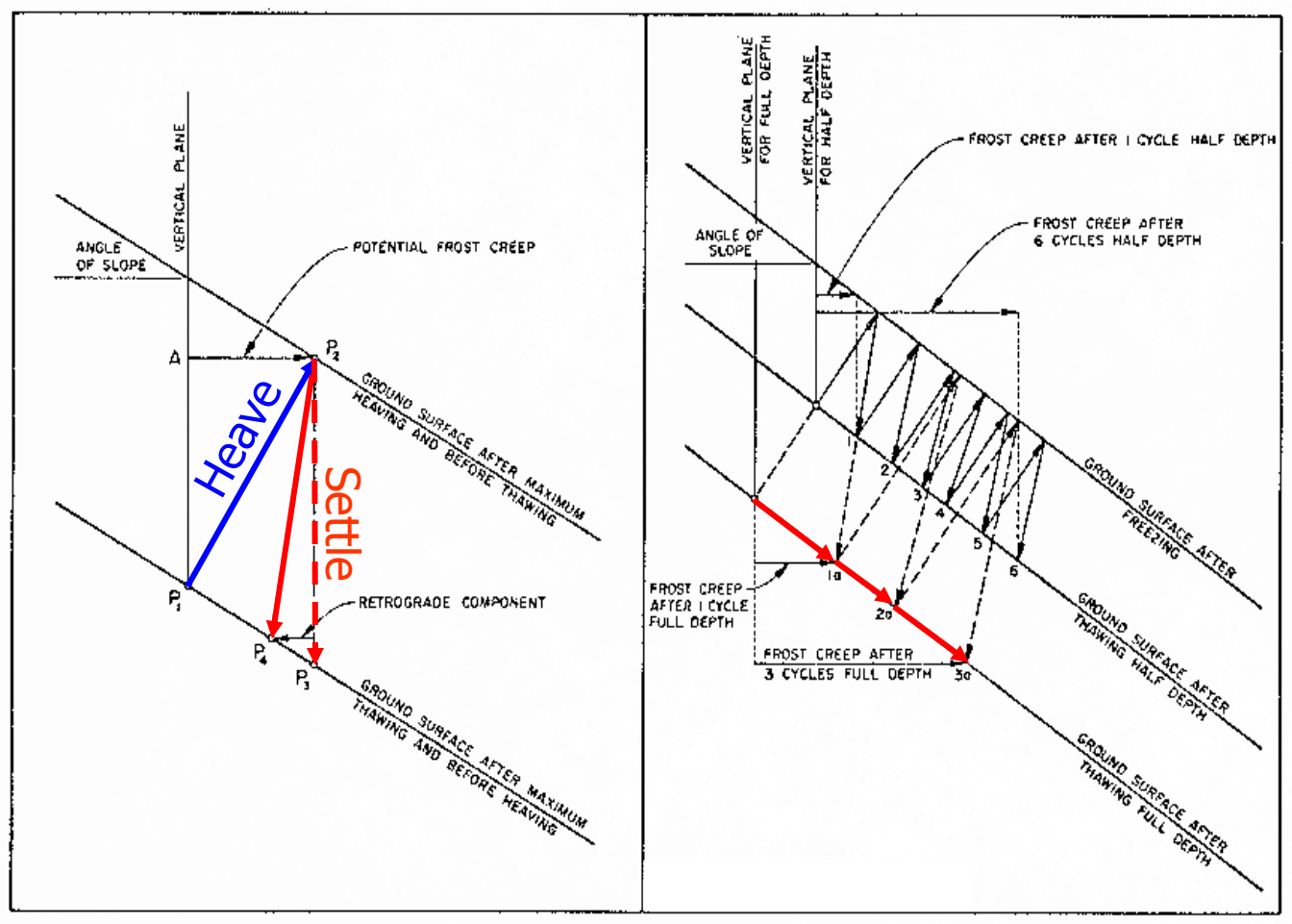
Periglacial Slopes

Periglacial landforms reflect:

- Freeze-thaw cycles
- Slope angle
- Water saturation
- Sediment size
- Sediment supply
- Snow/water/ice supply

Frost Heave

- Heave
  - Moisture
  - Grain size
- Creep
  - Saturation
  - Grain size
  - Slope

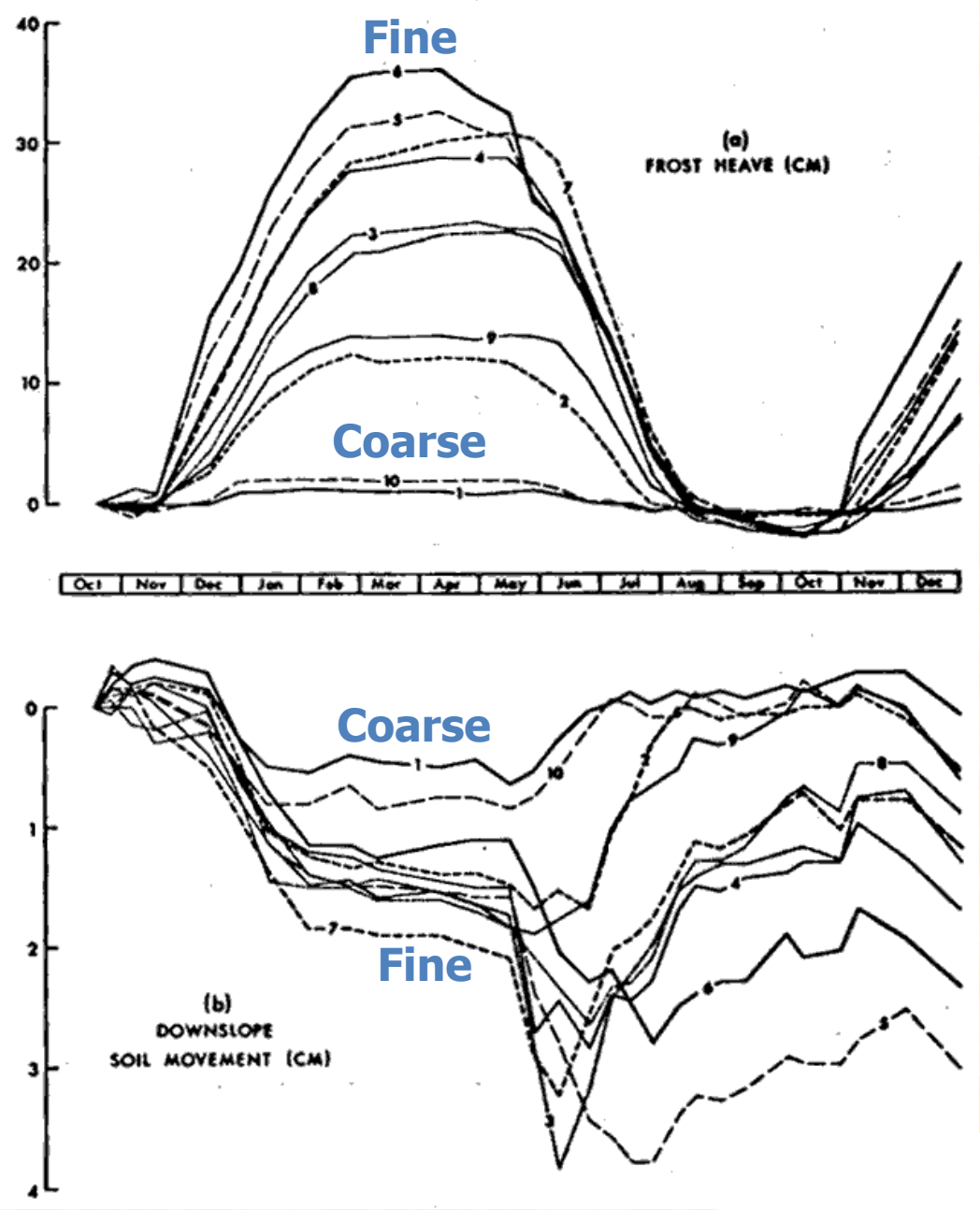


Frost Heave

Movement is a function of time and slope

Fine material moves farther than coarser material

Transect across a flow **lobe**

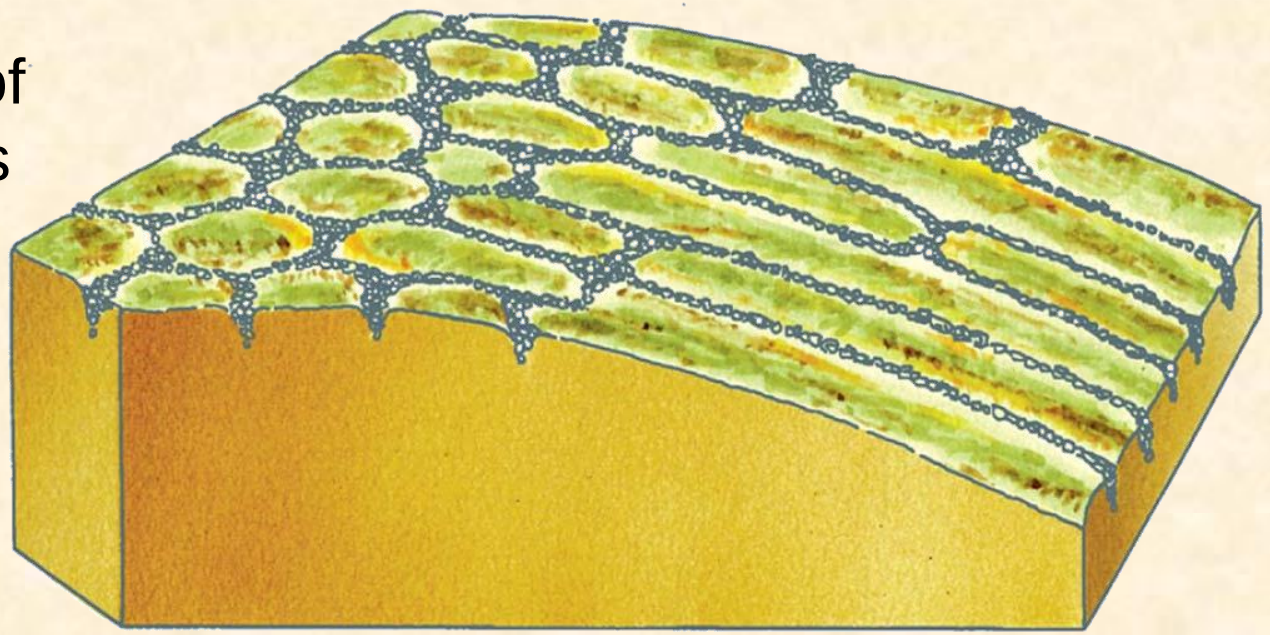


Frost Heave

Soils containing water expand when frozen, moving soil upward.

Patterned Ground: Sorted Circles

Annual freezing and thawing sorts particles by size, producing rings of coarse fragments



Produces polygons and rings, or sorted circles on low-gradient slopes and sorted stripes on steeper slopes.

Patterned Ground: Sorted Circles

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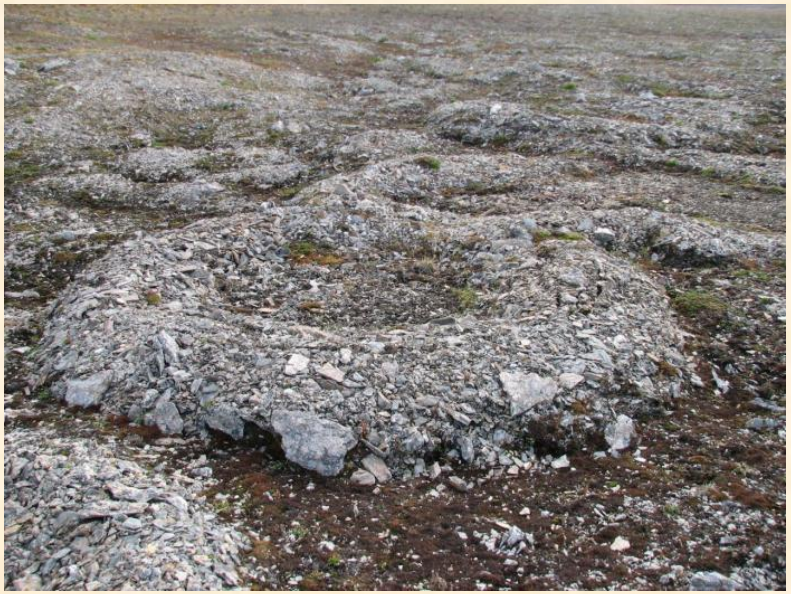
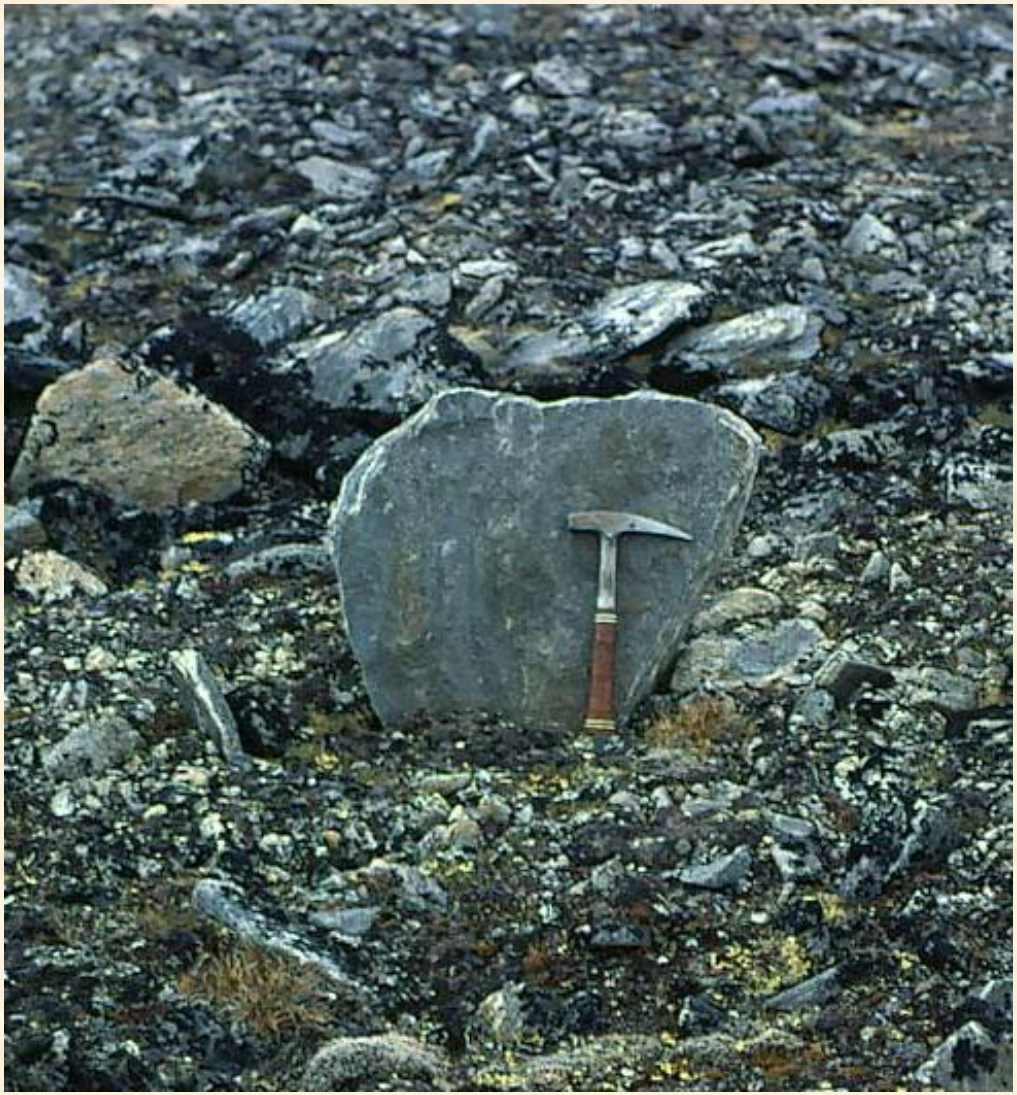
Thermal gradients across the active layer can drive pore water circulation that develops into discrete cells defined by zones of upwelling and downwelling.

This process results in an actively convecting core of fine sediment and accumulation of coarse particles that are difficult to “subduct” at the downwelling zones.



Tombstones

Frost heave can lever tabular rock up into disconcerting positions…



Pingos

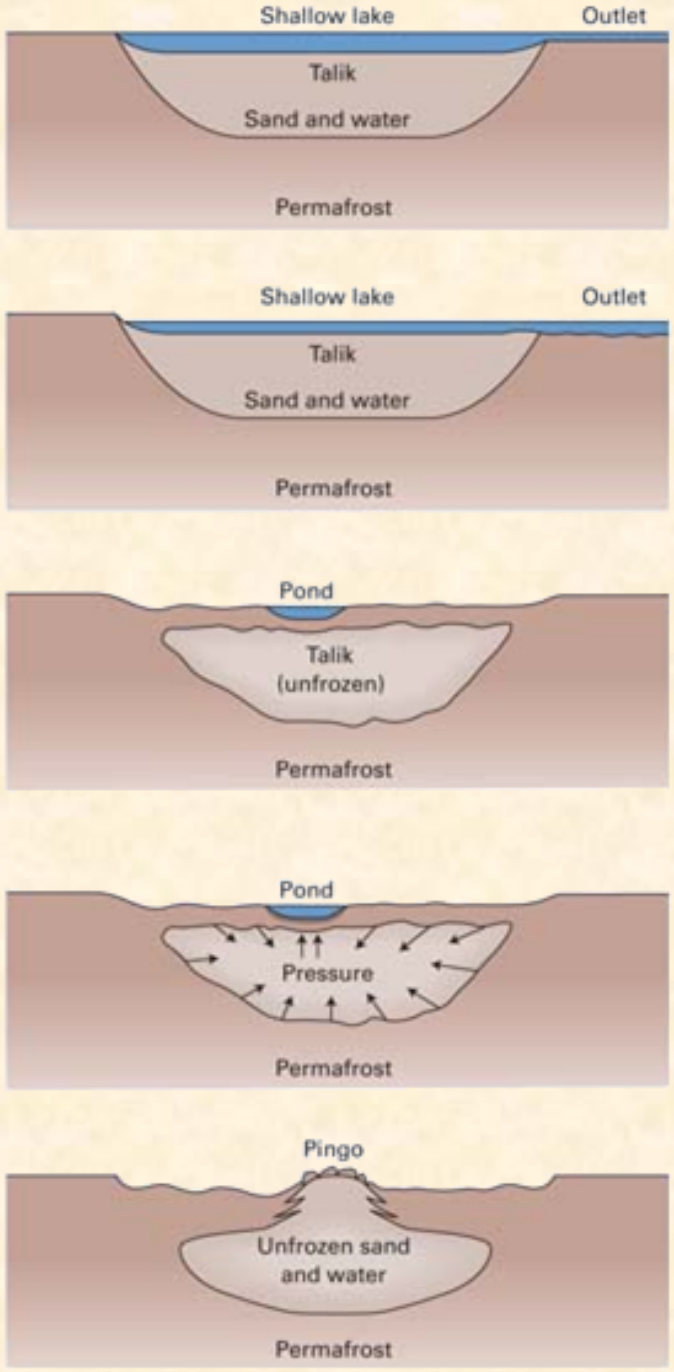
Conspicuous conical mound or circular hill, with a core of ice, found on tundra where permafrost is present.

Form under initially unfrozen lakes (taliks).

Pingos

If the lake is infilled with sediment and vegetation, or drained by drainage capture the insulation of the ground surface will increase and permafrost will advance from the sides and bottom of the talik - forcing water up into a zone of refreezing.

Growth of this “pingo ice” pops the overlying sediment up and results in an ice-cored hill.



Thermokarst

Characteristic landforms from thawing of ice-rich permafrost or the melting of massive ice blocks.

It is characterized by an irregular topography, with irregular pits and depressions develop by thaw settlement.

Solilifluction: Gelifluction

Solifluction

Slow downslope movement of soil due in cold regions due to freezing and thawing.

Frost heave:

Vertical rise in position of material in a soil due to volume expansion that accompanies freezing of pore water. Results in net downslope movement because lifting by heave occurs perpendicular to the slope while back-dropping after thawing occurs vertically.

Gelifluction

Seasonal thaw of the active layer saturates surficial soil as the water cannot percolate into frozen soil below. Can result in flow of active layer on slopes as gentle as 2˚ , and results in terrace-like lobes.

Solifluction Lobes

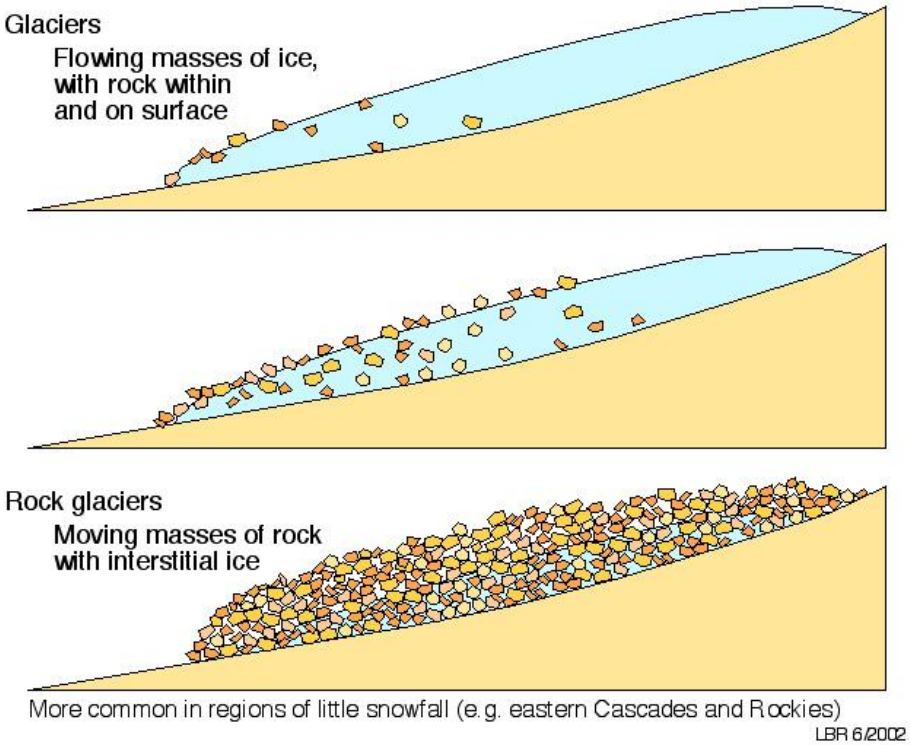
Solifluction Lobe

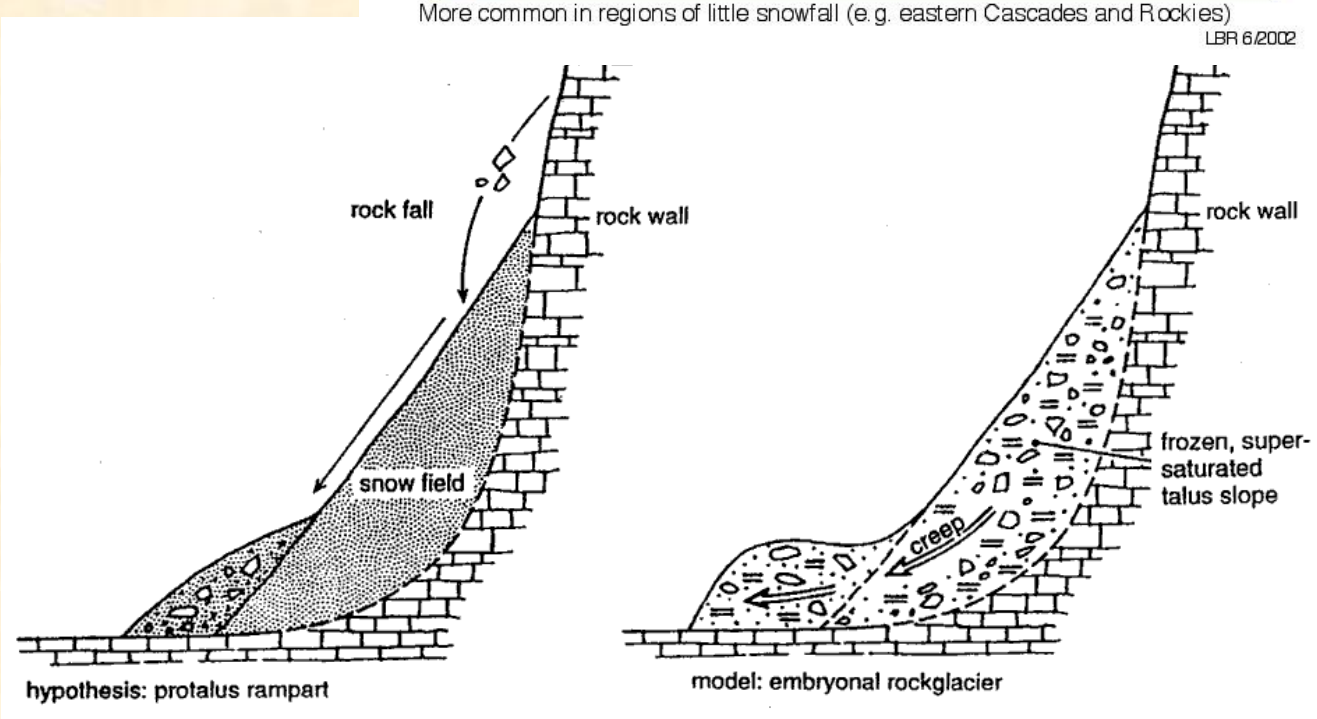
Stone Lobes

Block Streams & Block Fields (felsenmeer)

Rock Glaciers

- Transition between ice-glaciers and talus cones
- Lobate rock masses downhill from talus
- Often to treeline





Rock Glacier Head

Transitional to talus; coarse surface

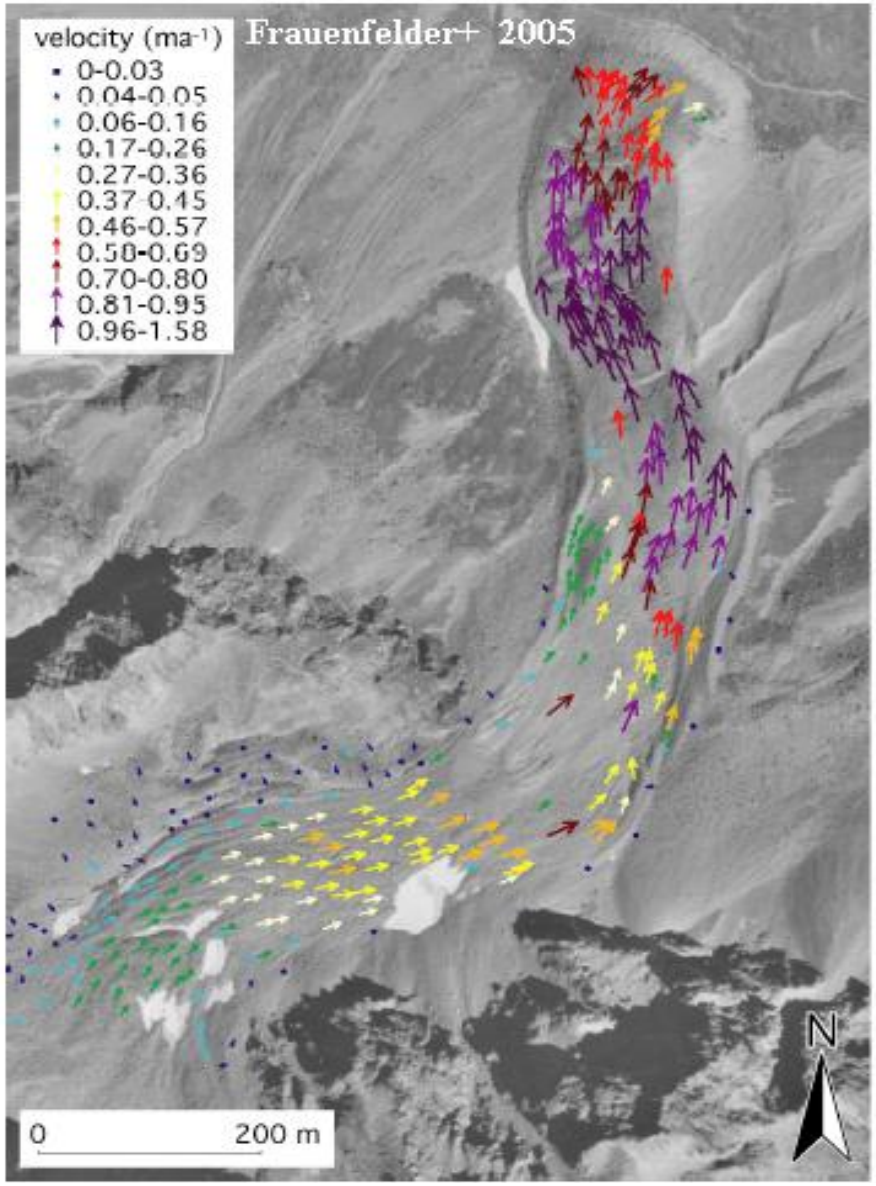
Rock Glacier: Lobate Ridges

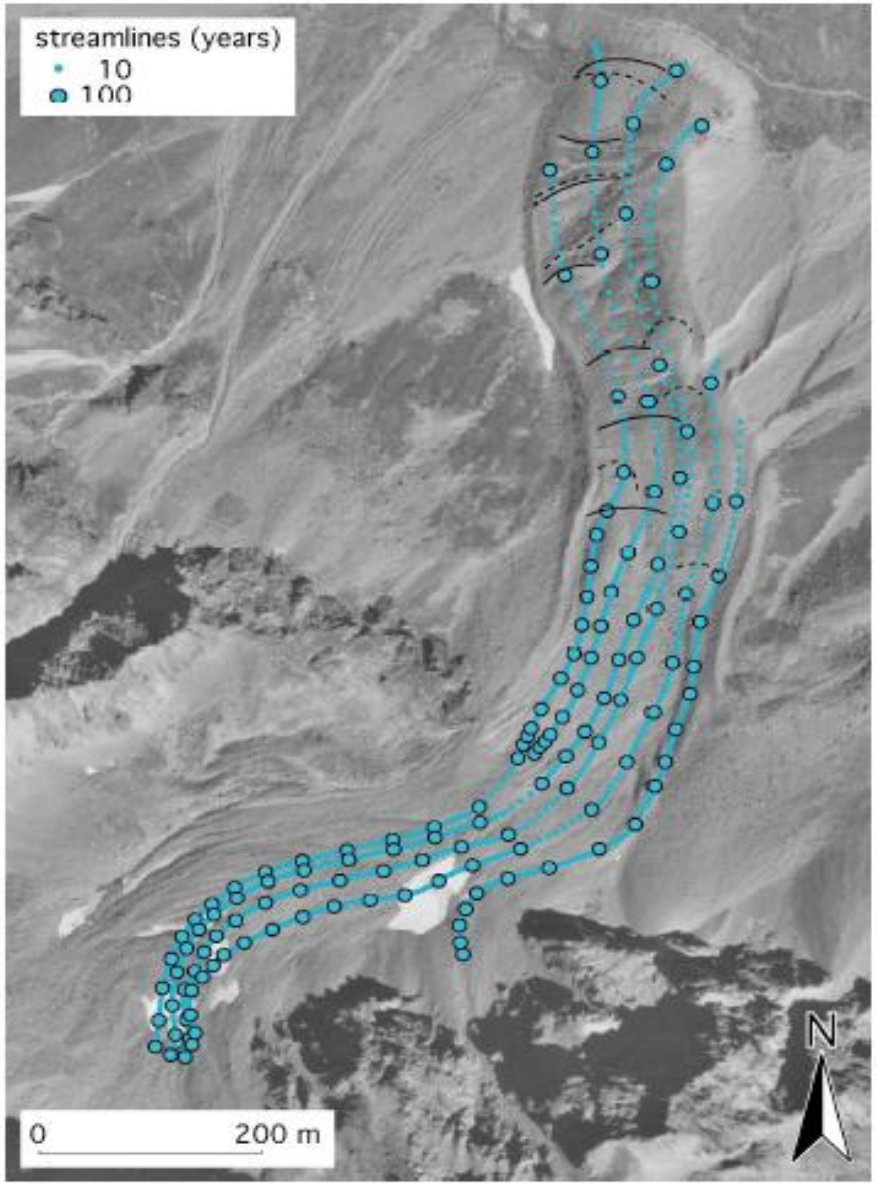
Evidence of flow, arcuate ridges

Rock Glacier Toe

Angle of repose; fine/frozen core

Rock Glacier





Rock Glacier