



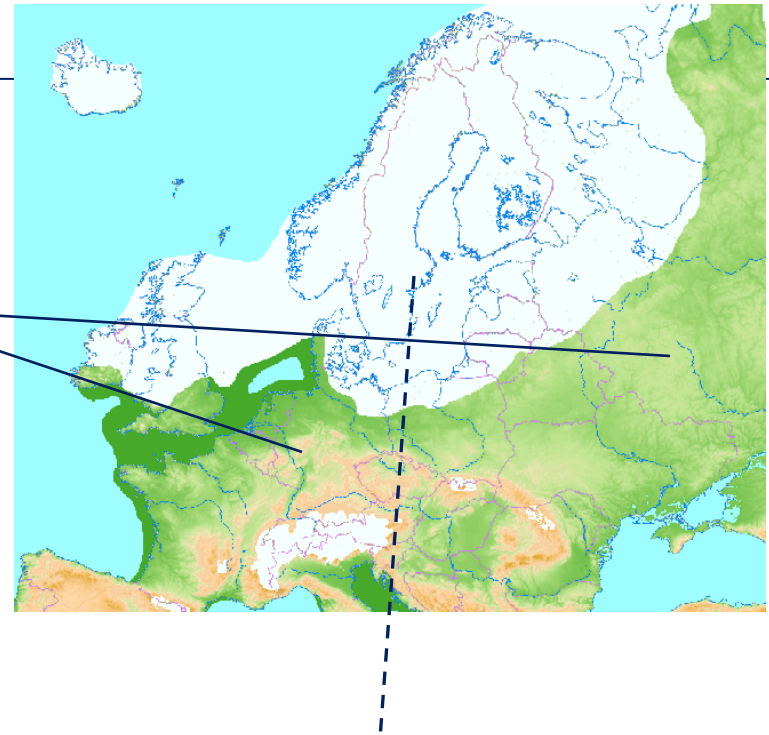
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ACNA4007 – Physical Landscape and the Geosphere
Dr Alissa Flatley

Freeze and Squeeze
Periglacial Dynamics
and Landscapes

Definition

- **Periglacial** was originally used to describe places near to or on the fringe of ice sheets or glaciers...
- Now it is defined more widely (no single definition), usually referring to areas:
 - with **permafrost** (frozen ground > 1 yr)
 - intense **frost action** and bare ground for some of the year
 - where **freeze-thaw cycles** dominate the landform creating processes;
 - which have a distinctive ecosystem adapted to the periglacial environment
- Such areas as these now make up approximately 25% of the world's total land area!

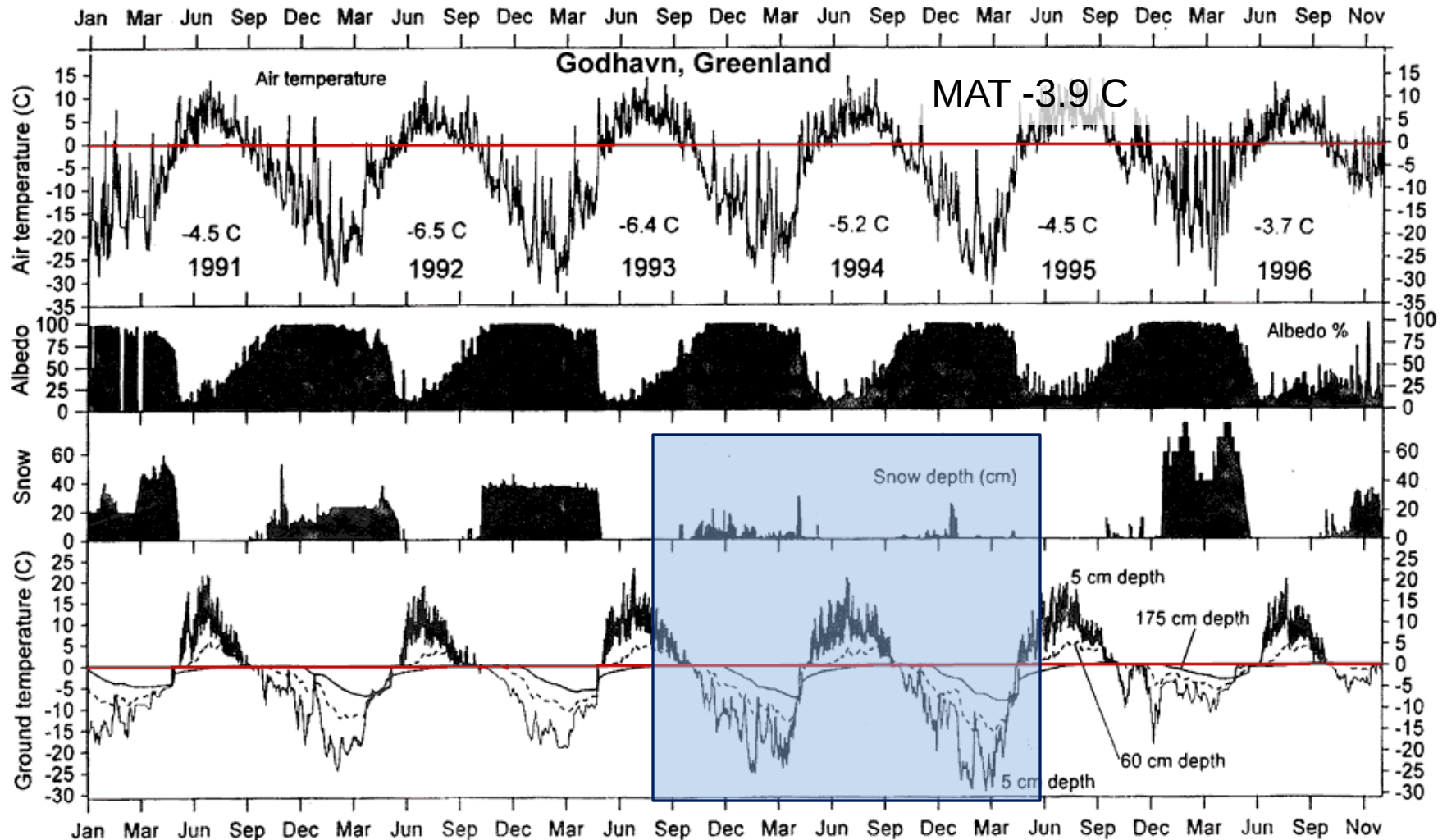


≠ **Paraglacial:**

Lasting geomorphic
impact of past
glaciation on post-
glacial landscape
(„glacial hangover“)

Periglacial climate

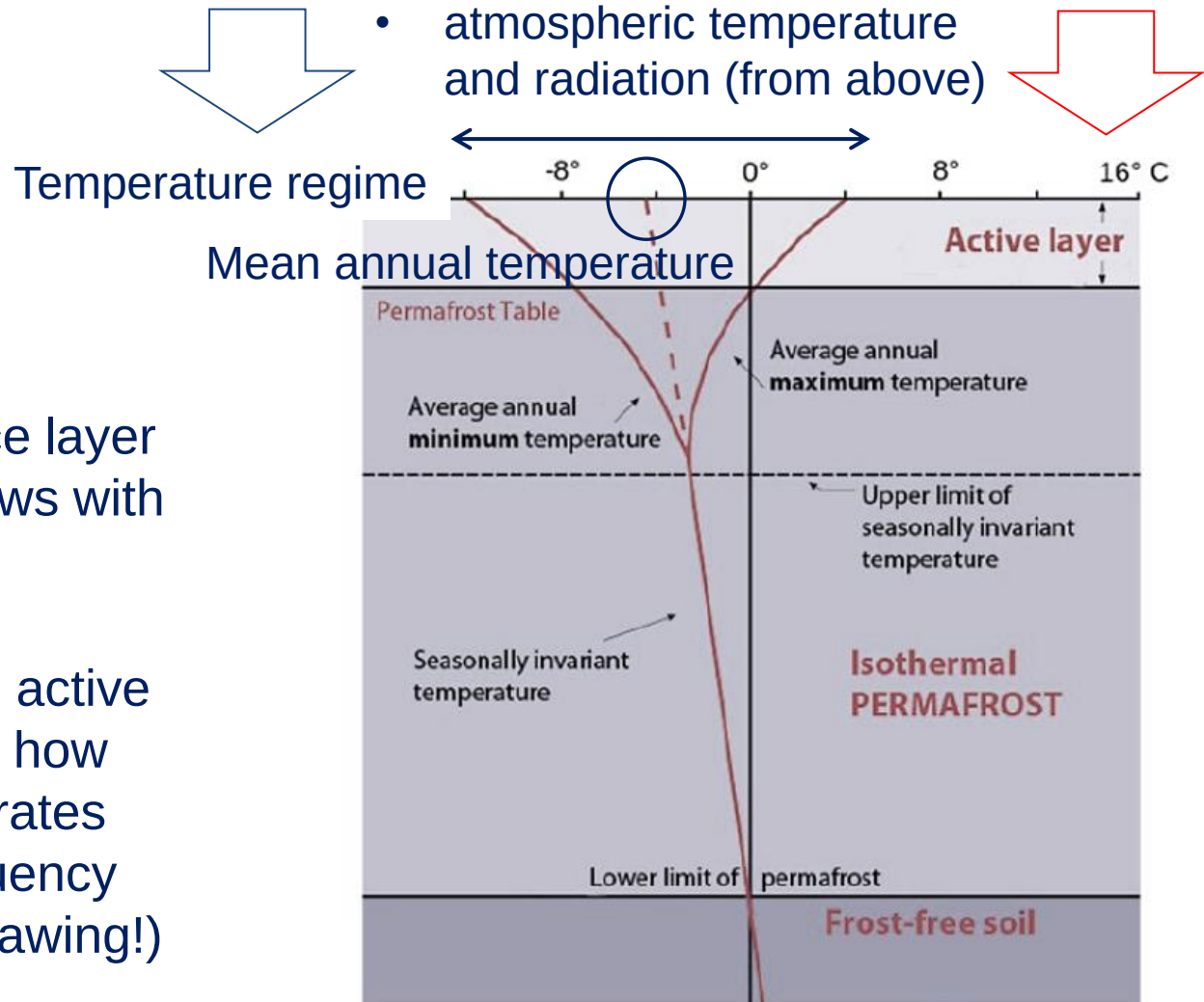
- Temperature (and seasonal variation)



- Snow cover** (and vegetation!!) can insulate the ground and form a buffer layer that can reduce the amplitude of seasonal temperature oscillations in the soil !!

Frost and the ground

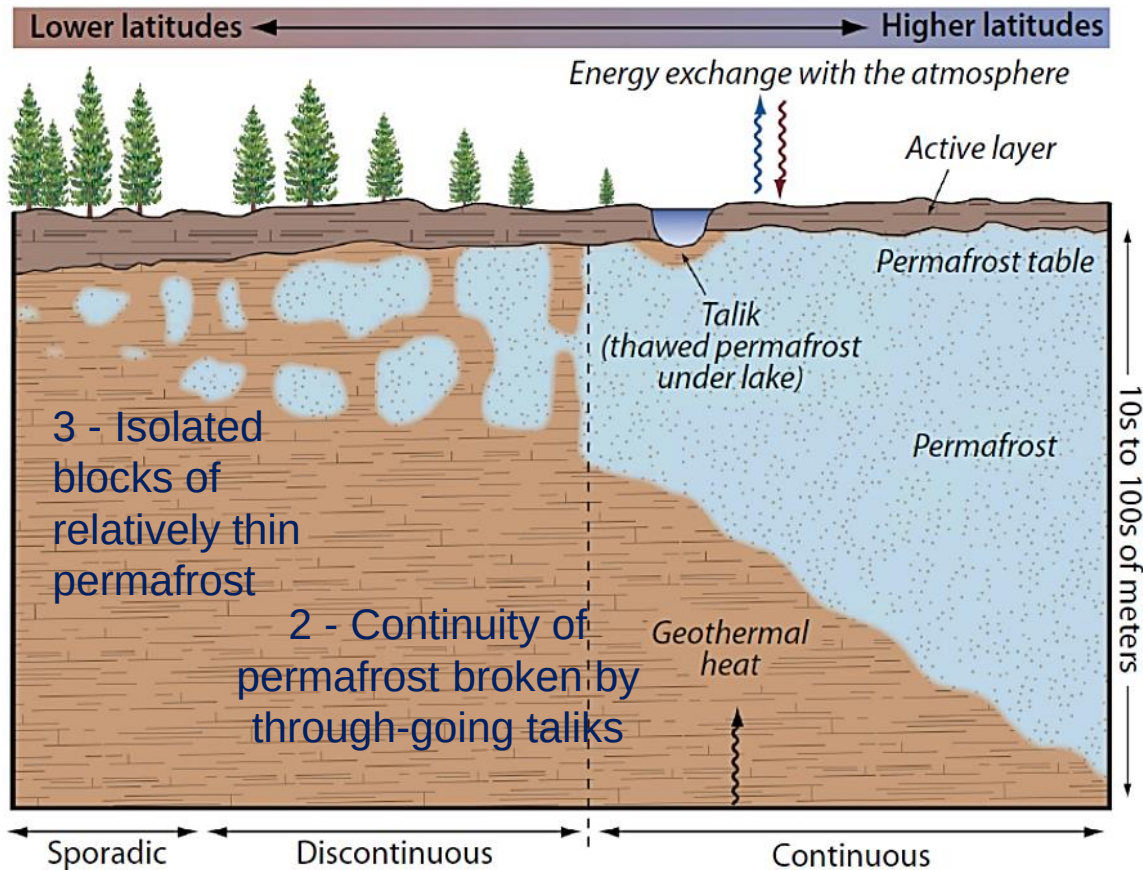
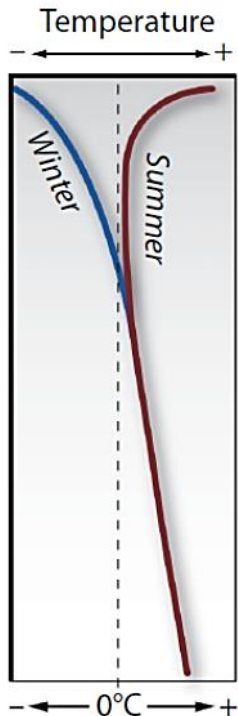
- Energy exchange with atmosphere...
- Depth, time and age
- **Active layer:** surface layer that freezes and thaws with the seasons
- The thickness of the active layer is a function of how deep thawing penetrates frozen ground (frequency and magnitude of thawing!)
- Dynamic seasonal system...



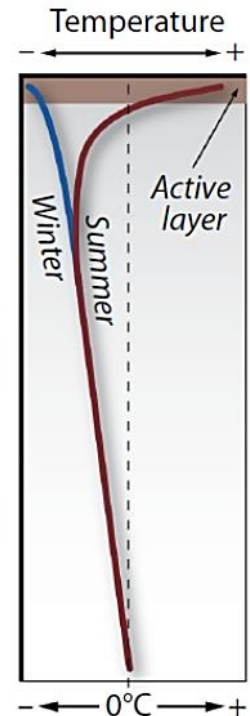
Permafrost...

- Absent beneath water
- Absent beneath forest

No permafrost



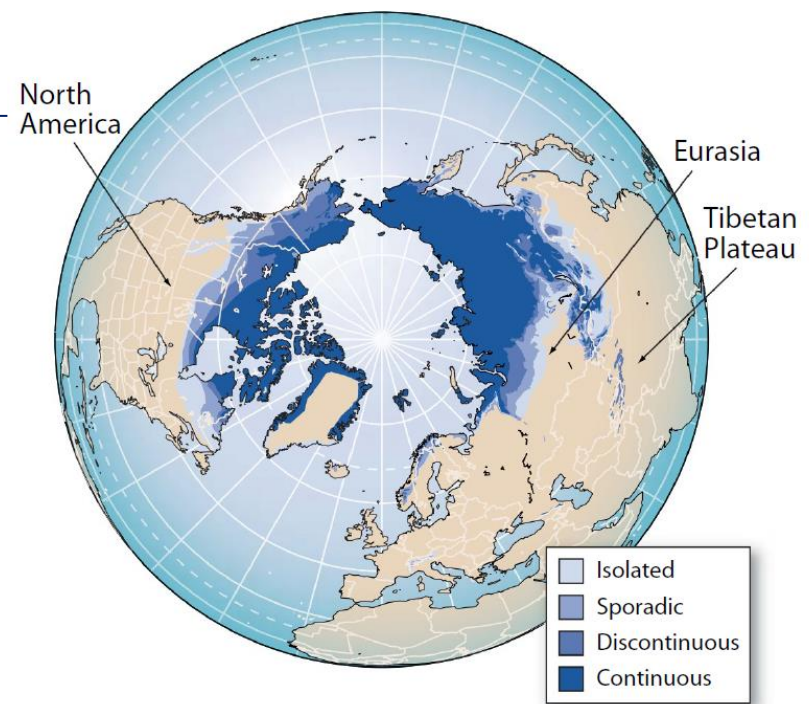
Permafrost



1 - Pervasive permafrost beneath the active layer broken only by open taliks (thawed ground) under lakes

Permafrost

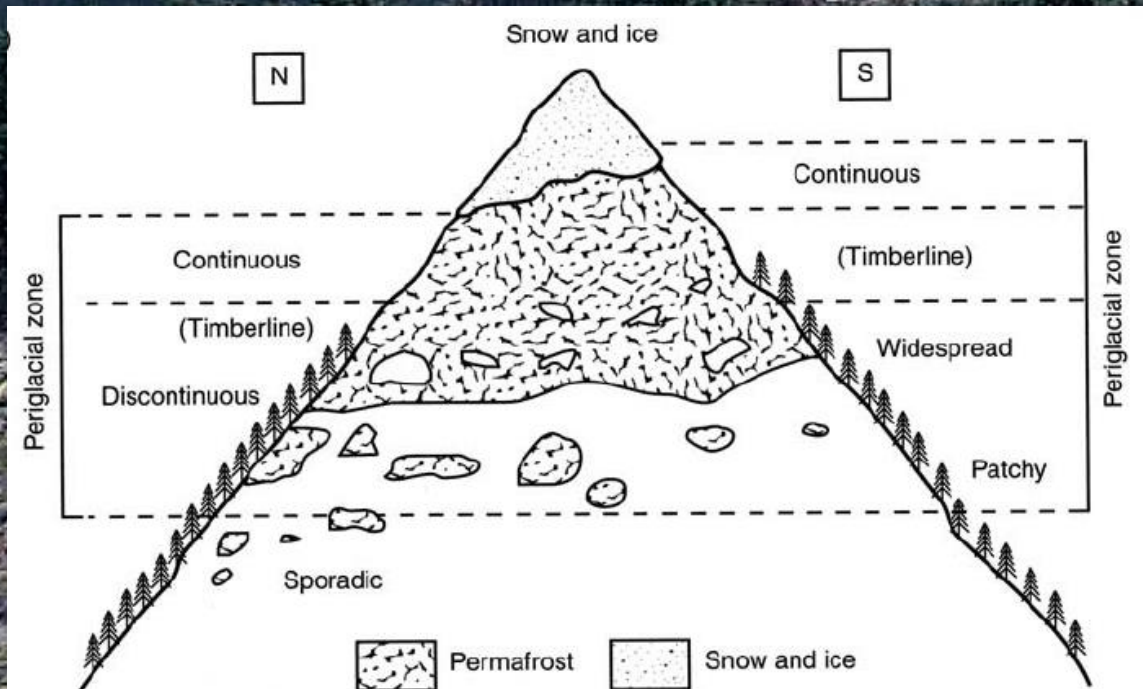
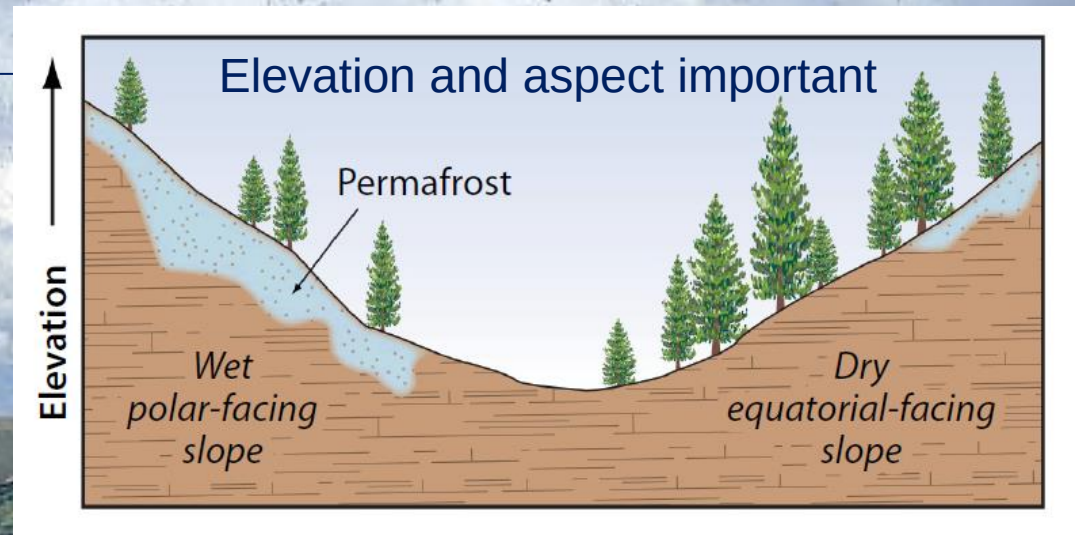
- **Permafrost:** soil, regolith, and bedrock at a temperature below 0°C (or -2°C), found in cold climates.
- reaches a max depth of $>1500\text{ m}$, but averages of 300 to 450 m near 70° N



- **Ground ice:** water frozen in pore spaces
- Ice lenses (aggregates of “clean” ice)

Permafrost...

- Mountain Permafrost
- Periglacial processes / environments common above tree-line (timberline)



2 minutes...



Frost & Snow Processes

- Strong physical, weak chemical weathering
- Frost cracking, splitting, wedging

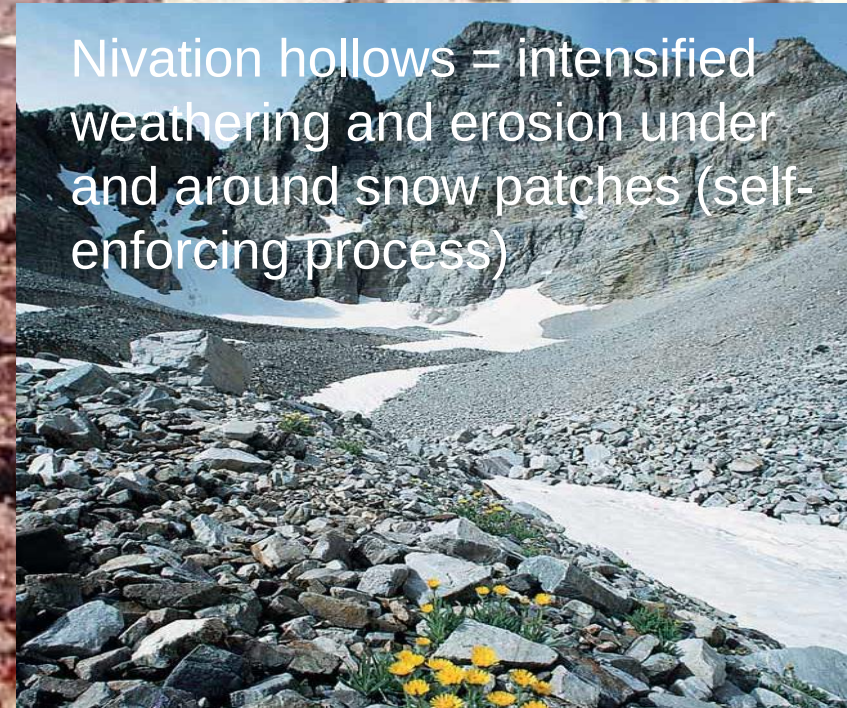


- Felsenmeer

Thermal expansion & contraction

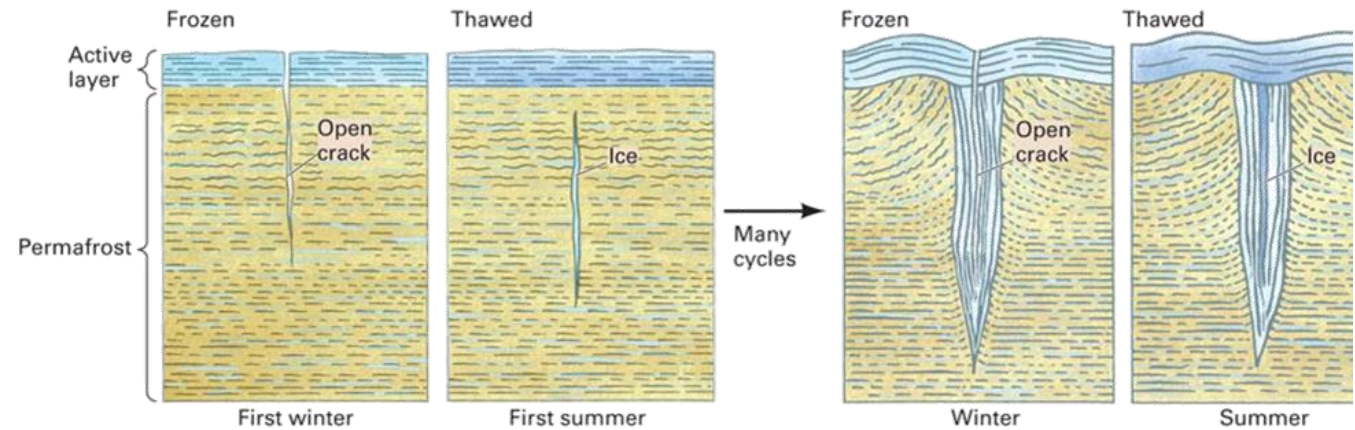


Nivation hollows = intensified weathering and erosion under and around snow patches (self-enforcing process)

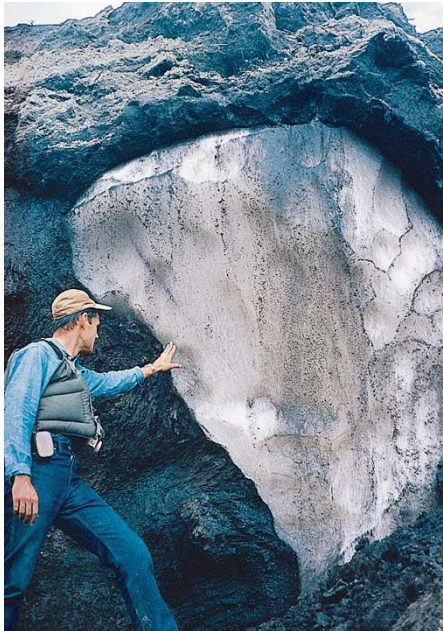


Frost Processes

- Frost wedging
 - Thermal contraction & expansion
 - Add water
 - Repeat



- Vertical ice wedge network - polygons below the active layer



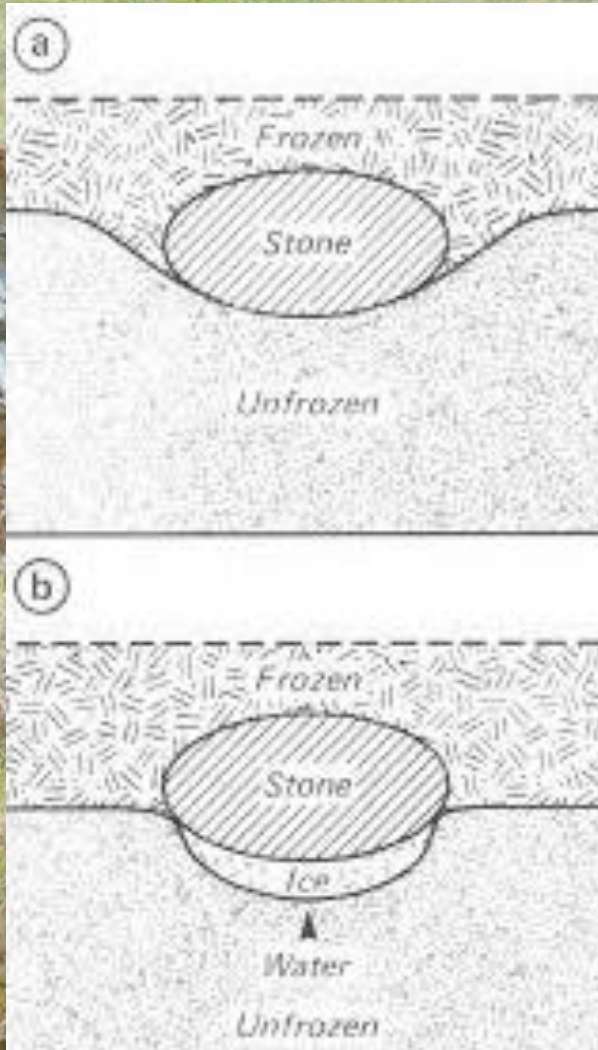
Frost & Snow Processes

- Evidence of past MAAT $< -6^{\circ}\text{C}$
- Ice wedges can fill with sediment or dust after they melt



Frost Processes

- A**
- Frost heave - soils containing water expand when frozen, moving soil upward



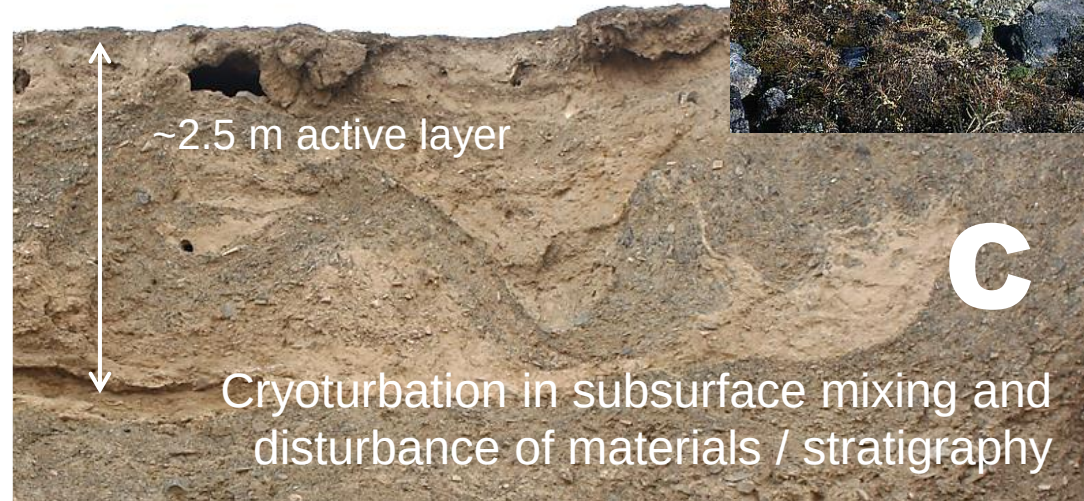
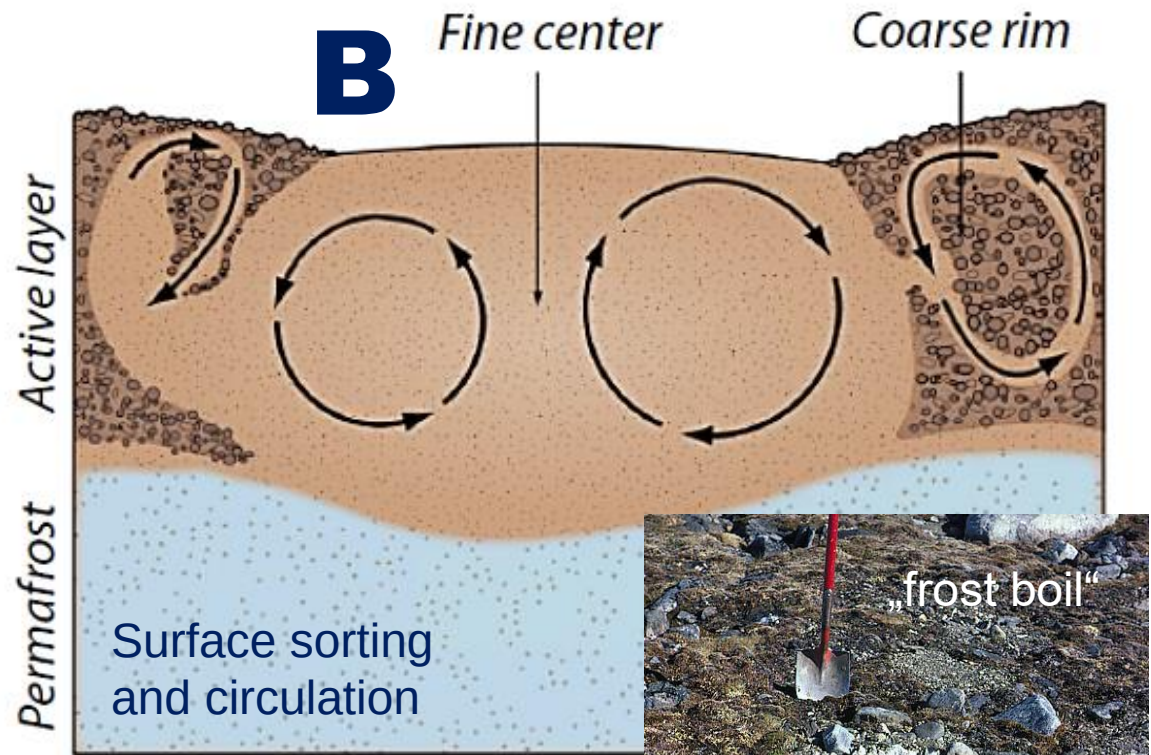
- Preferential freezing (coarse) and replacement (fines!), upheaving of coarser particles and sorting...



Tombstones: Frost heave can lever tabular rock up into disconcerting positions...

Frost Processes

- Thermal gradients across the active layer: (i) preferential flow of pore water (with preferential effects on fines), and (ii) hydrostatic pressures (with preferential effects on fines)
- ... results in an actively convecting core of fines with accumulation of coarse particles that are difficult to “subduct” at the downwelling zones



Patterned Ground



- Dynamics of seasonal freeze/thaw action in the active layer leads to a wild variety of patterned ground (polygons, circles, stripes...)

<https://www.amusingplanet.com/2015/11/patterned-grounds.html>

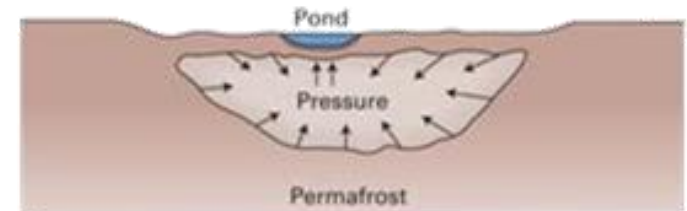
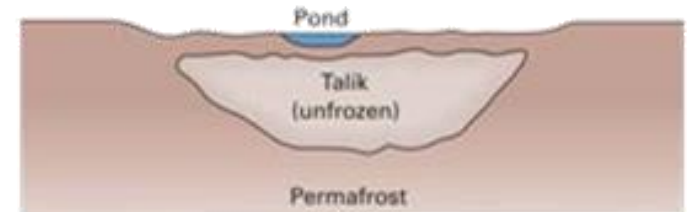
Patterned Ground

- Steeper slopes = frost heave and vertical collapse



Frost and Water...

- Pingo: Conical mound or circular hill – from hydrostatic pressure, or hydraulic (artesian)

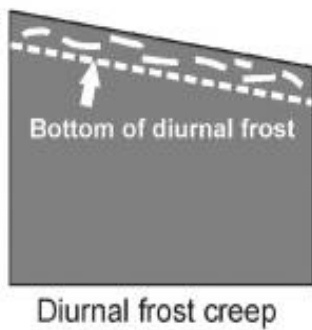


2 minutes...



Solifluction

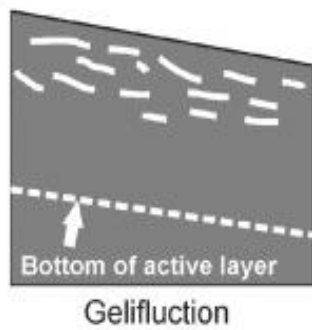
(A) Diurnal freezing: Ice lenses



a



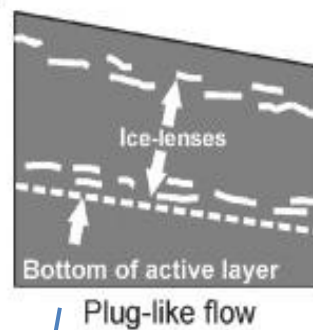
(B) Seasonal freezing: One-sided



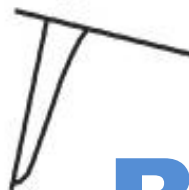
b



(C) Seasonal freezing: Two-sided



c

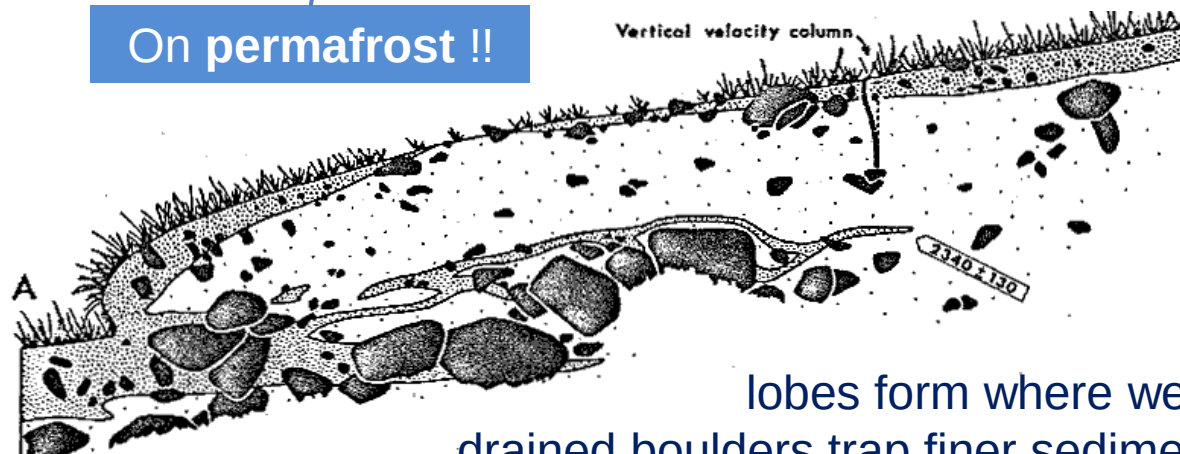


Schematic velocity profiles

Solifluction - Slow downslope movement of soil due in cold regions/conditions due to freezing and thawing (possible on 2° slopes)

Seasonal thaw of the active layer saturates surficial soil

On permafrost !!



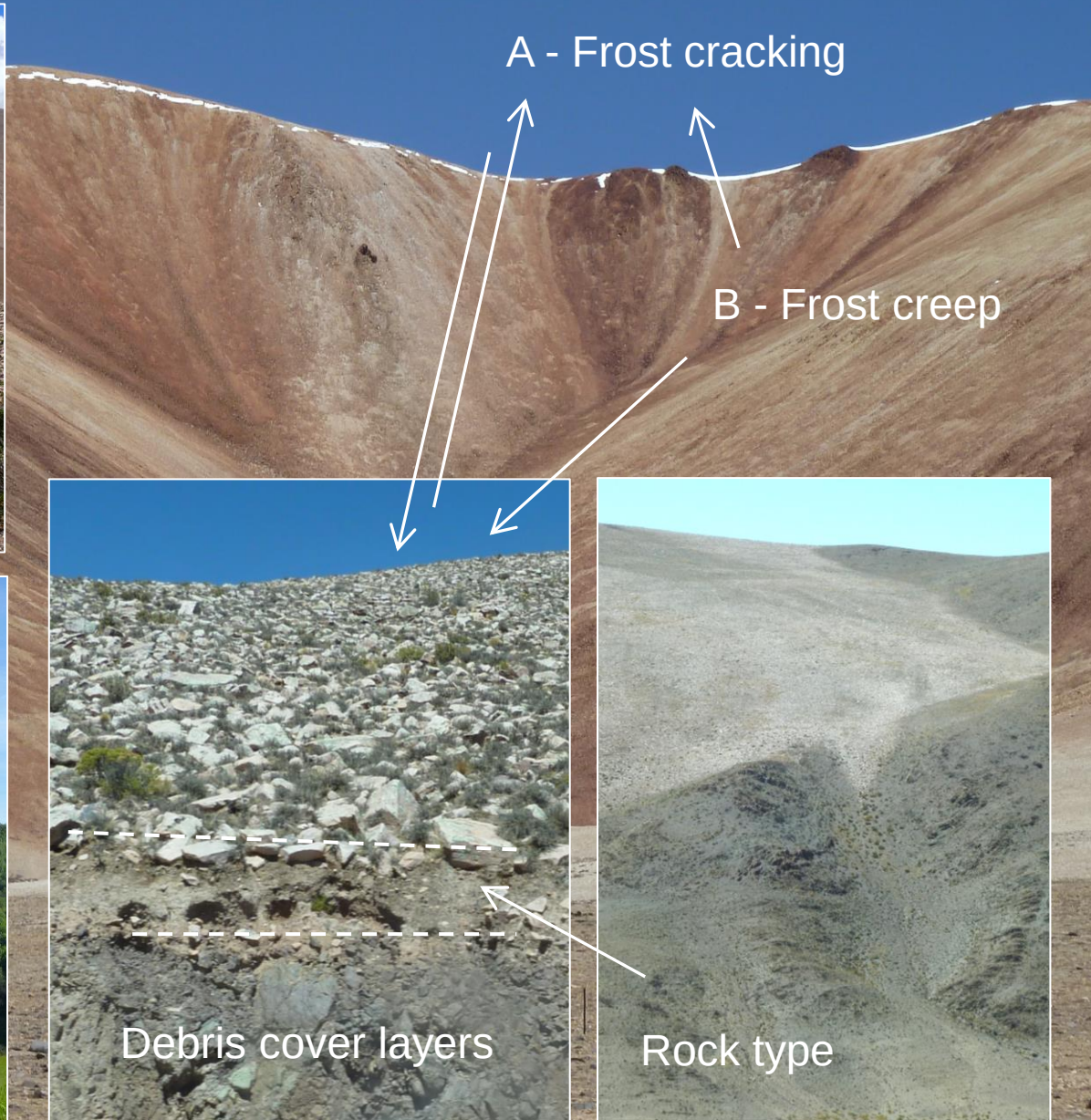
lobes form where well-drained boulders trap finer sediment

Frost heave and creep: vertical rise due to volume expansion from freezing of pore water, net downslope movement

Solifluction



Periglacial mountain erosion



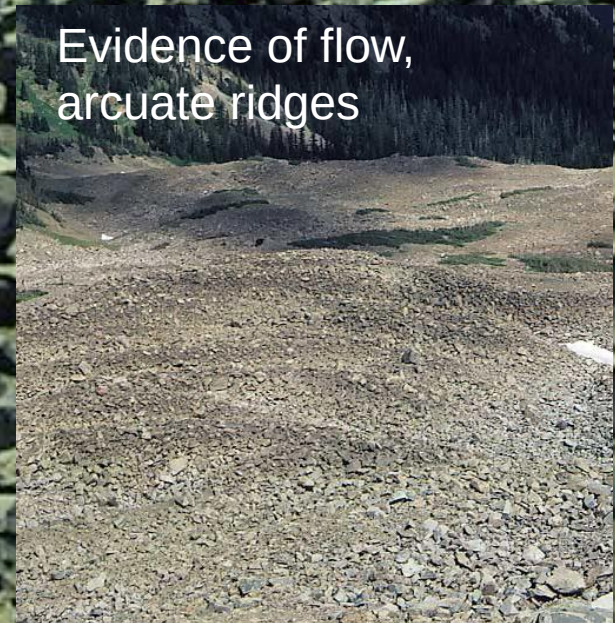
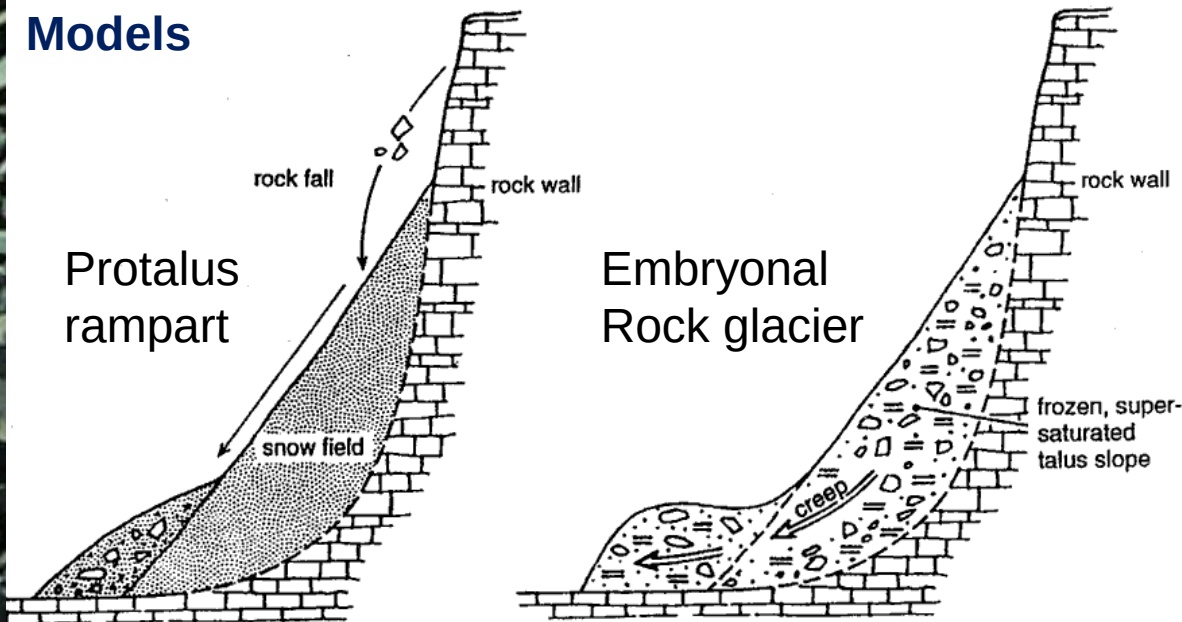
Rock glaciers

Rock
Glacier
Head

- Transition between ice-glaciers and talus cones - lobate rock masses downhill from talus: rock glacier

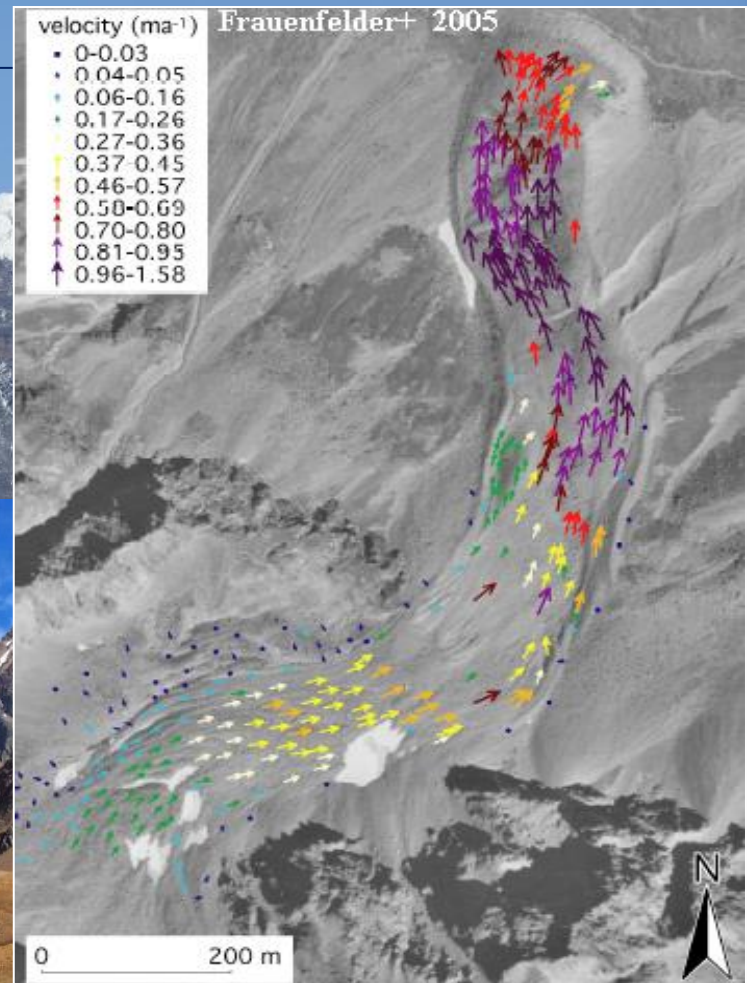


Models



Rock glaciers

- Need steep terrain (often in previously glaciated valleys)
- Contain ice in core (water resources!)
- Flow rates vary



Permafrost thaw

- Increased risk for slumping



Permafrost thaw

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

Permafrost thaw

An archive for the past !!



Summary

Periglacial processes important in large parts of the world

Frost (often permafrost) plays key role

Wide range of landforms

Erosional agent in mountains

Fossil periglacial landscapes inform on past climate

