

# The periglacial landforms of Svalbard

## Content

- ) ice-wedges
- ) rock glaciers
- ) pingos
- ) solifluction
- ) avalanches
- ) debris flows
- ) rock falls
- ) nivation
- ) aeolian landforms

## Glacial landforms

- ) surge glaciers



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# Polygons – ice-wedges

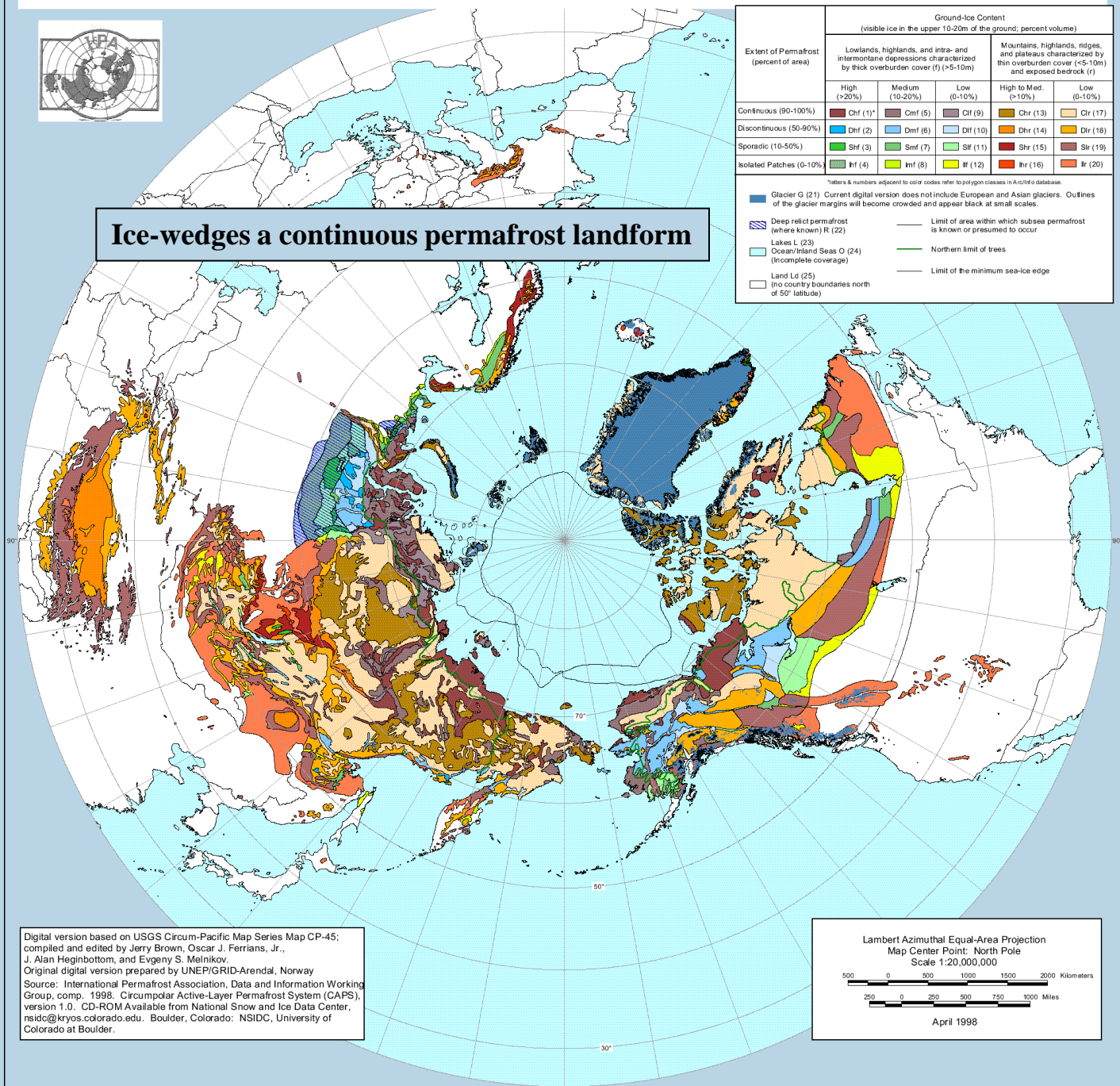


# CIRCUM-ARCTIC MAP OF PERMAFROST AND GROUND-ICE CONDITIONS



**Ice-wedges a continuous permafrost landform**

**MAAT:  
-6°C**



Extent of Permafrost (percent of area)	Ground-Ice Content (visible ice in the upper 10-20m of the ground; percent volume)			
	Lowlands, highlands, and intra- and intermontane depressions characterized by thick overburden cover (>5-10m)		Mountains, highlands, ridges, and plateaus characterized by thin overburden cover (<5-10m) and exposed bedrock (r)	
	High (>20%)	Medium (10-20%)	Low (0-10%)	High to Med. (>10%)
Continuous (90-100%)	Chf (1)*	Cmf (5)	Chf (9)	Chr (13)
Discontinuous (50-90%)	Dhf (2)	Dmf (6)	Dhf (10)	Dhr (14)
Sporadic (10-50%)	Shf (3)	Smf (7)	Shf (11)	Shr (15)
Isolated Patches (0-10%)	If (4)	mf (8)	If (12)	Ir (16)
				R (20)

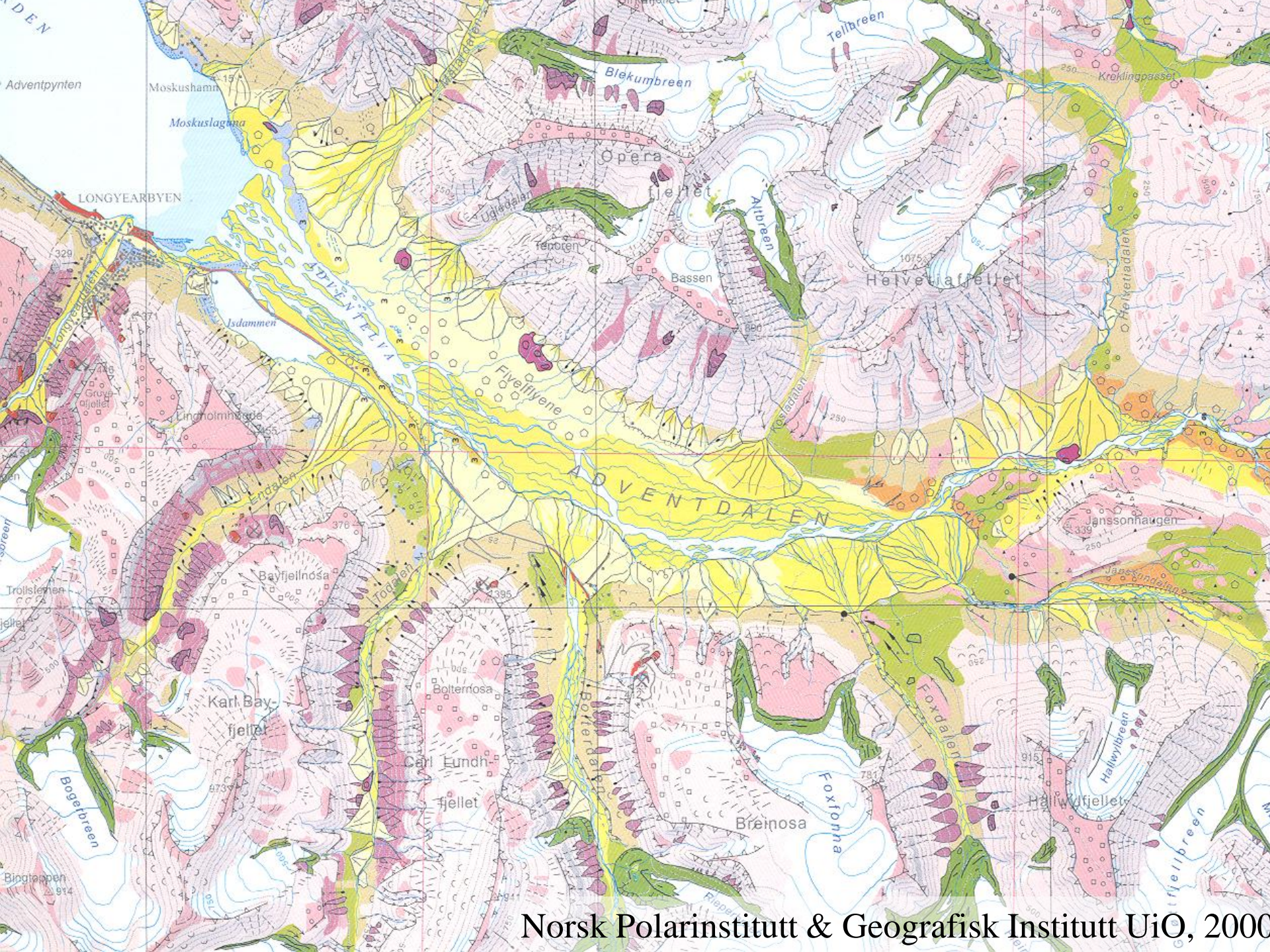
\*letters & numbers adjacent to color codes refer to polygon classes in Arctic/ro database.

- Glacier G (21) Current digital version does not include European and Asian glaciers. Outlines of the glacier margins will become crowded and appear black at small scales.
- Deep relict permafrost (where known) R (22)
- Lakes L (23)
- Ocean/Inland Seas O (24) (incomplete coverage)
- Land Ld (25) (no country boundaries north of 50° latitude)
- Limit of area within which subsea permafrost is known or presumed to occur
- Northern limit of trees
- Limit of the minimum sea-ice edge

Digital version based on USGS Circum-Pacific Map Series Map CP-45; compiled and edited by Jerry Brown, Oscar J. Ferrians, Jr., J. Alan Heginbottom, and Evgeny S. Melnikov. Original digital version prepared by UNEP/GRID-Arendal, Norway. Source: International Permafrost Association, Data and Information Working Group, comp. 1998. Circumpolar Active-Layer Permafrost System (CAPS), version 1.0. CD-ROM Available from National Snow and Ice Data Center, nsidc@kryos.colorado.edu. Boulder, Colorado: NSIDC, University of Colorado at Boulder.

Lambert Azimuthal Equal-Area Projection  
Map Center Point: North Pole  
Scale 1:20,000,000

April 1998

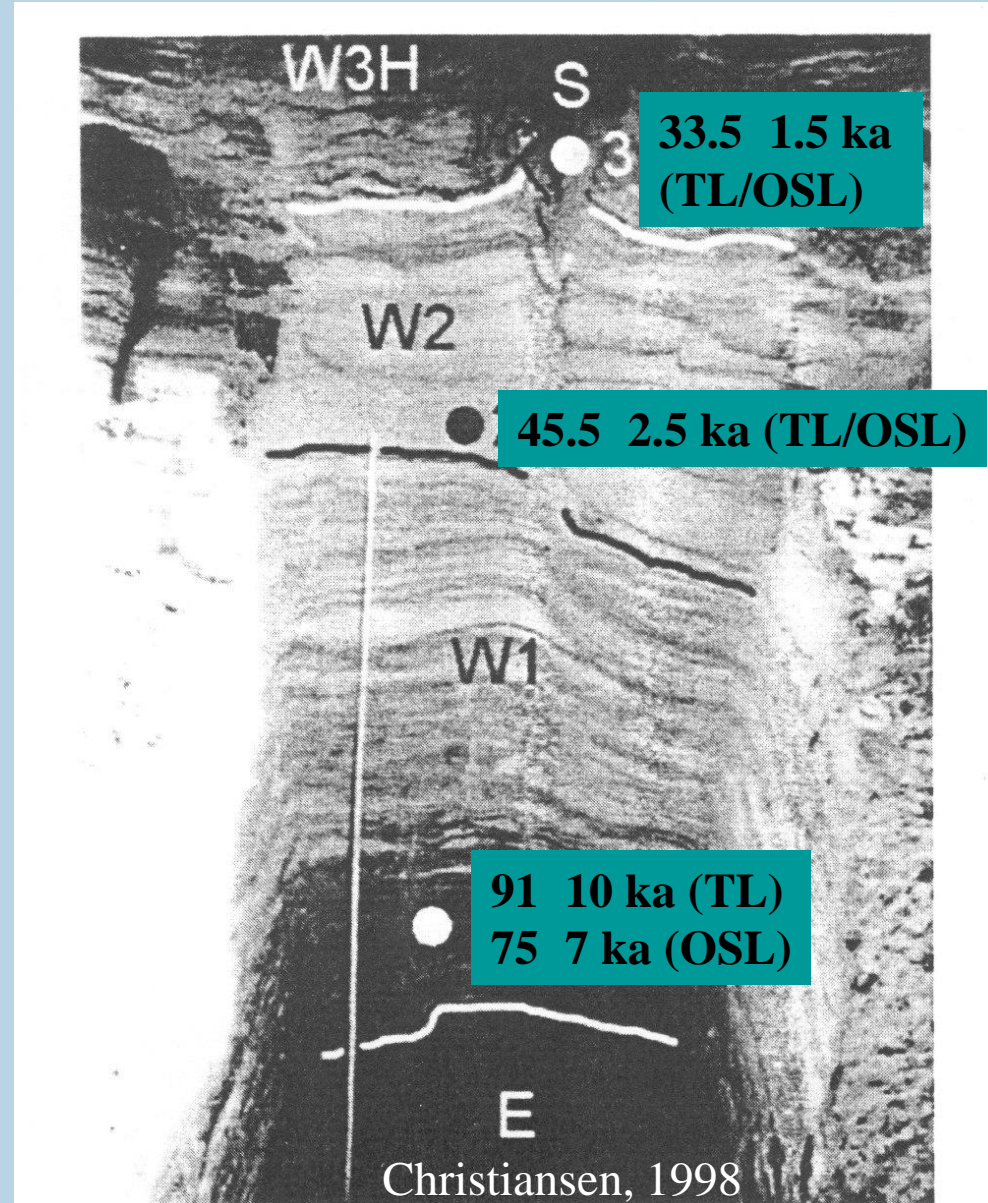




# Danish ice-wedge cast and sand-wedge



Christiansen, 1993



# Pingos



**Very active pingo in  
Adventdalen, Svalbard**





# Cyclic pingo formation



# Permafrost hydrology

taliks

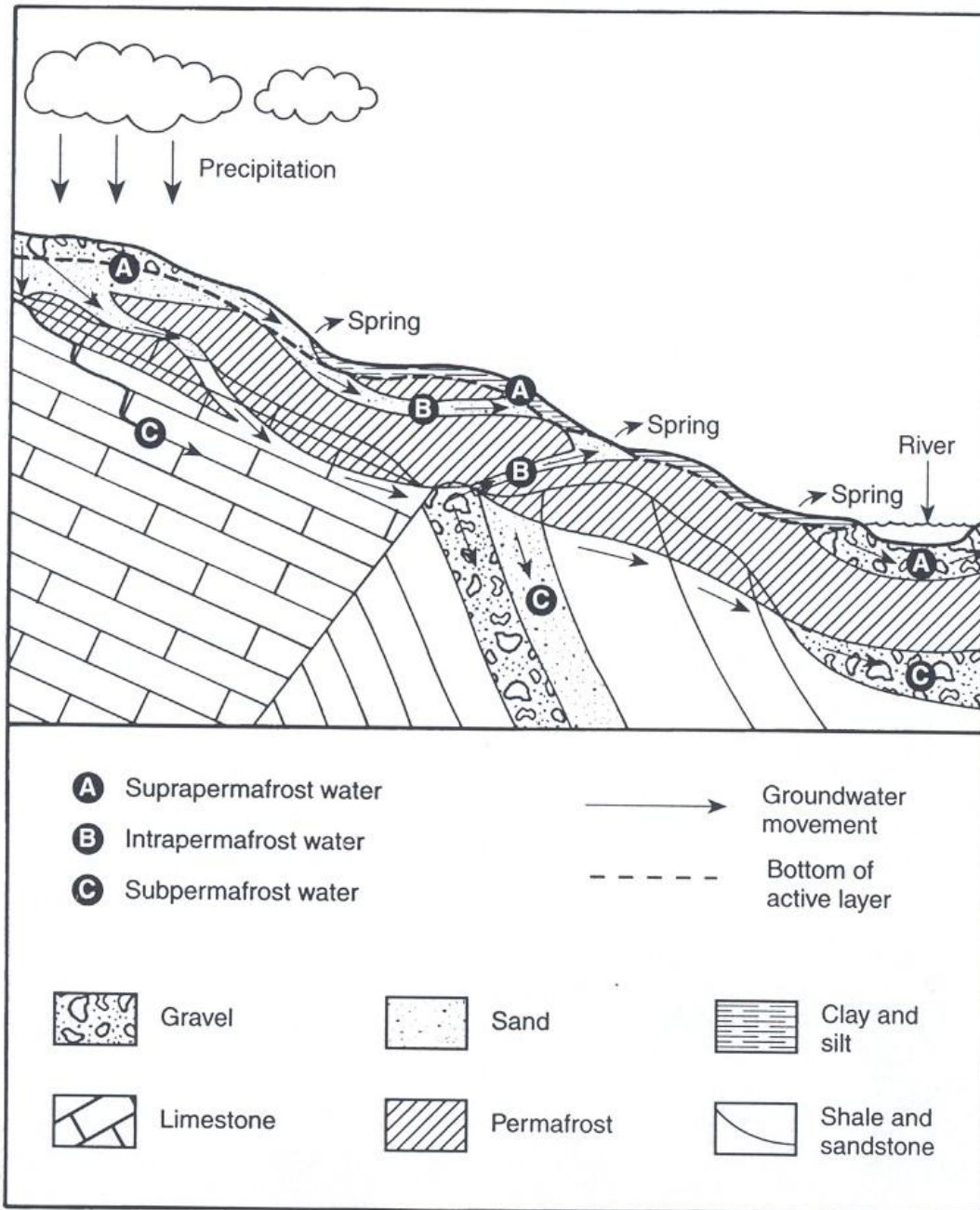


Figure 5.15 Occurrence of groundwater in permafrost areas

# Open system pingos

This pingo type is usually found in high relief permafrost areas

Growth rate never measured directly

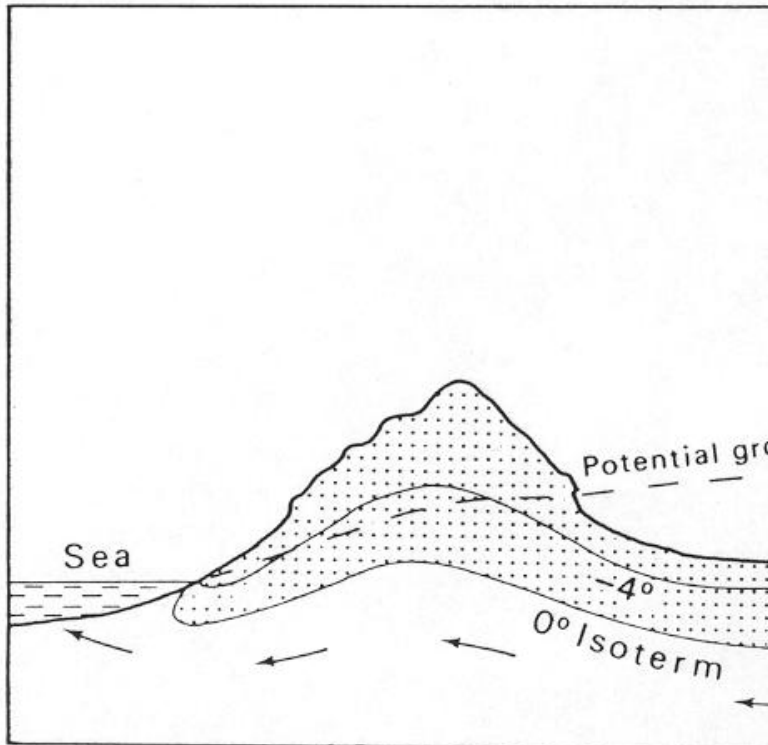
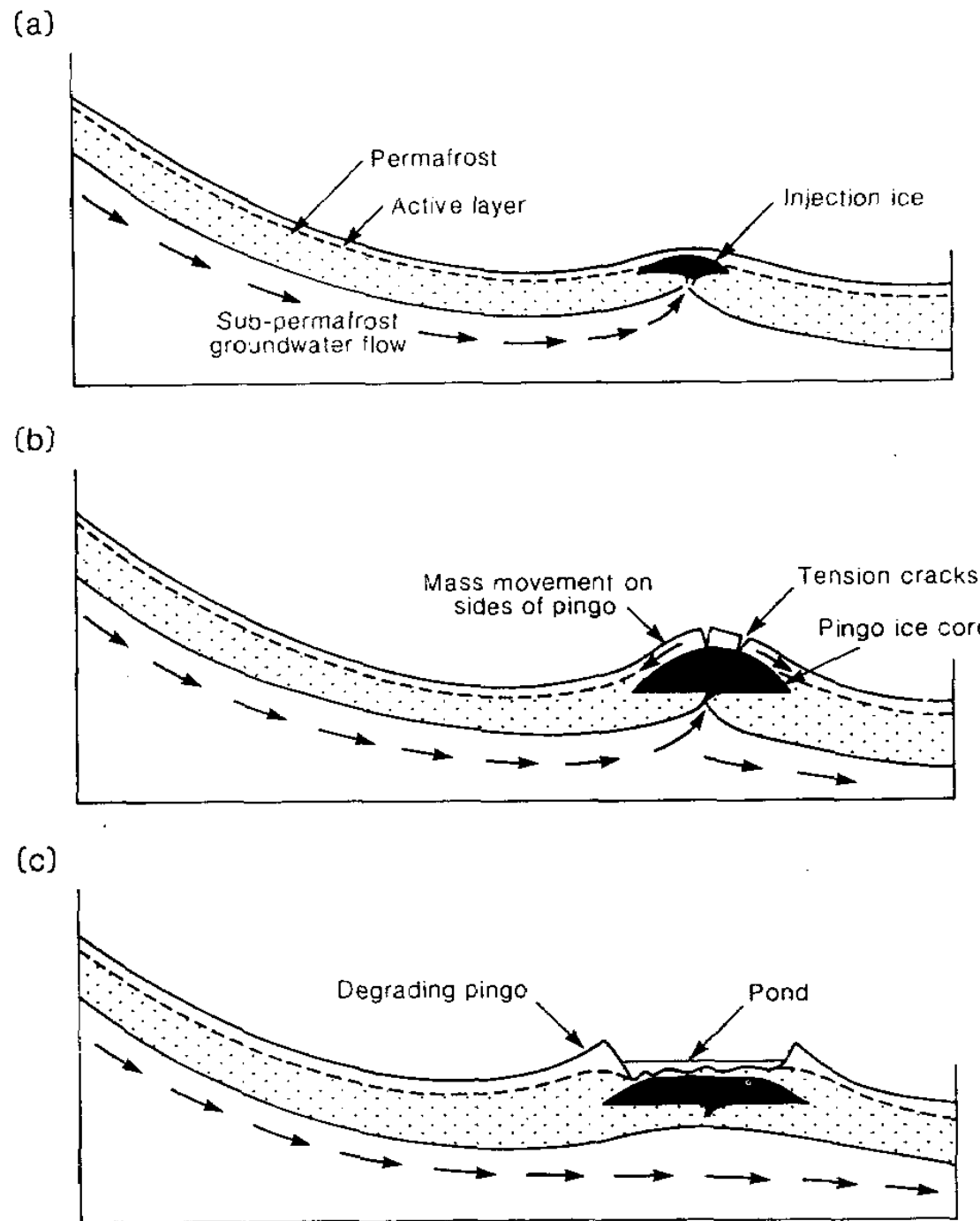


Fig. 2. Vertical profile of the permafrost layer out



# Pingo distribution on Svalbard

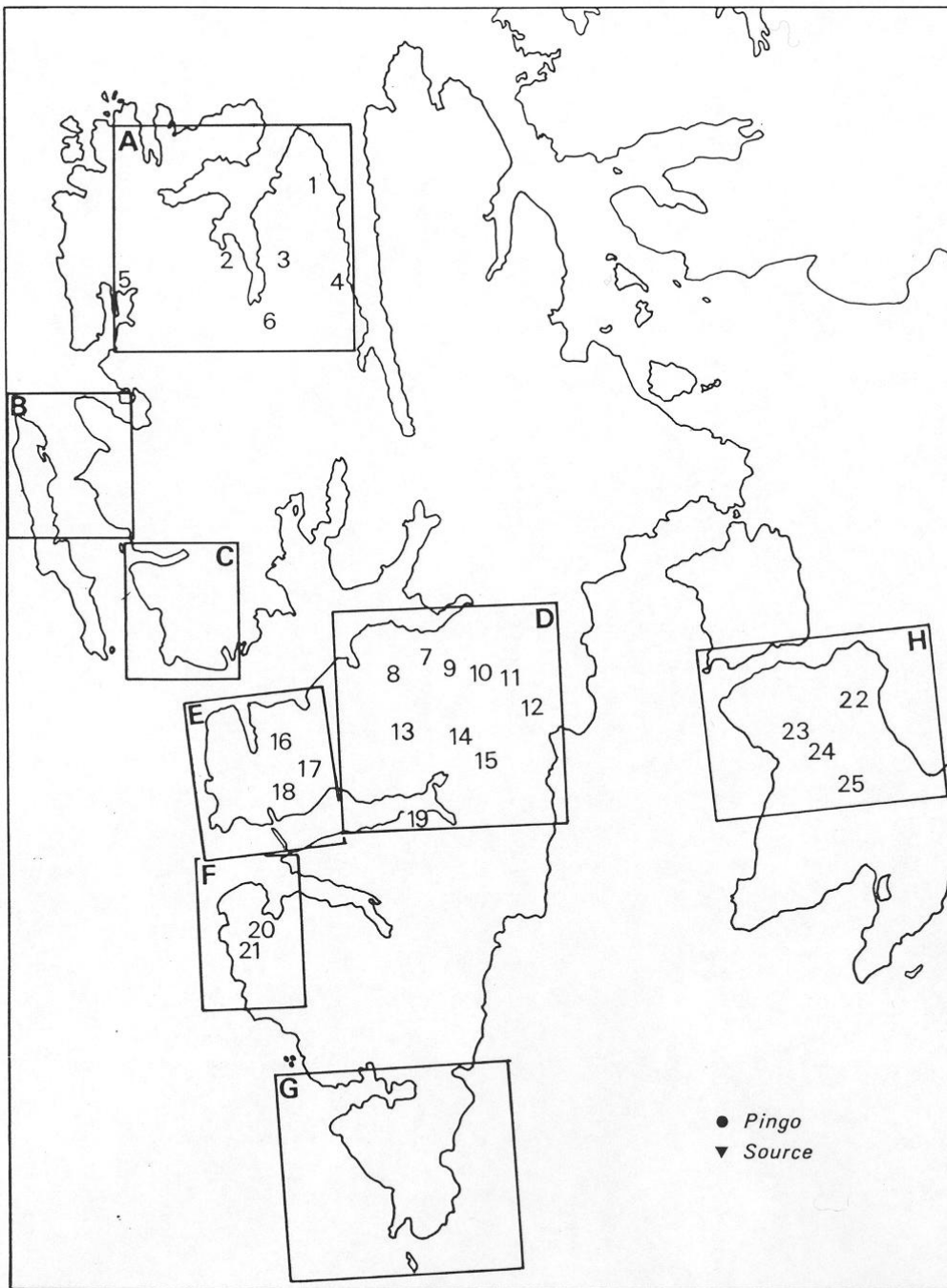


Fig. 4. Outline map of the more detailed maps showing the site of the different pingos and springs described.

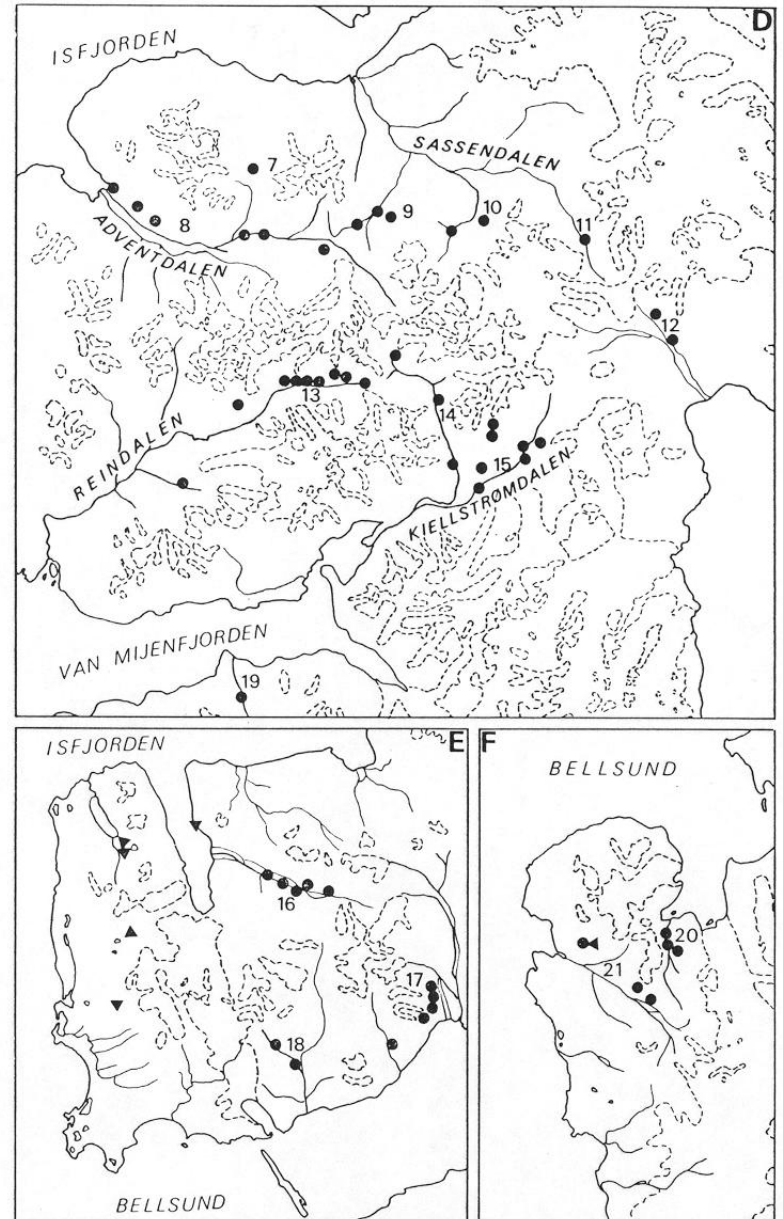


Fig. 8. Map of the area between Isfjorden, Agardhbukta and Van Mijenfjorden.

# Rock glaciers

**Rock glacier:** A thick lobate or tongue-shaped body of frozen debris that moves slowly downslope through deformation of internal ice or ice-rich sediment. Moves due to permafrost creep. PF temp. and the amount of ice regulates the speed.

## Two types:

Talus rock glaciers (talus-derived or protalus RGs)

Glacigenic rock glaciers /glacier derived rock glaciers (debris or morainic RGs)

## Activity status:

Active (mobile) 0.005-2 m/yr.

Inactive (immobile; contains internal ice)

Relict (immobile: no perennial internal ice)

# Rock glaciers



## Rock glacier characteristics

Steep margins 10-70 m high

Surface microrelief:

- closed depressions

- longitudinal ridges & furrows

- transverse ridges & depressions.

Surface layer of unfrozen coarse debris 1-5 m thick overlies ice-rich sediment and pure ice.

Internal ice: 50-90% of RG volume.

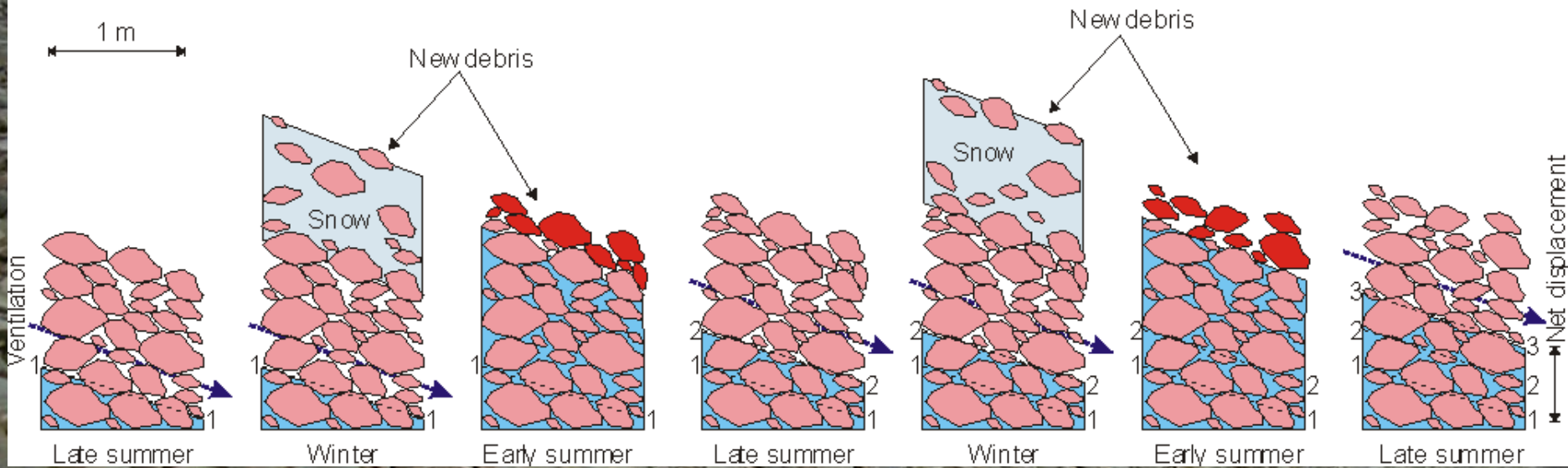
Glacigenic RGs: glacier ice. Talus RGs: ice segregation, burial of surface snow and ice.







# Displacement of active layer and permafrost caused by debris accumulation

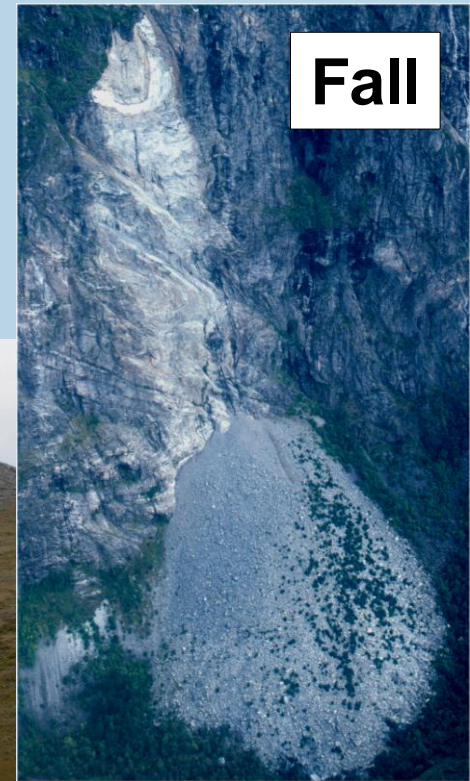
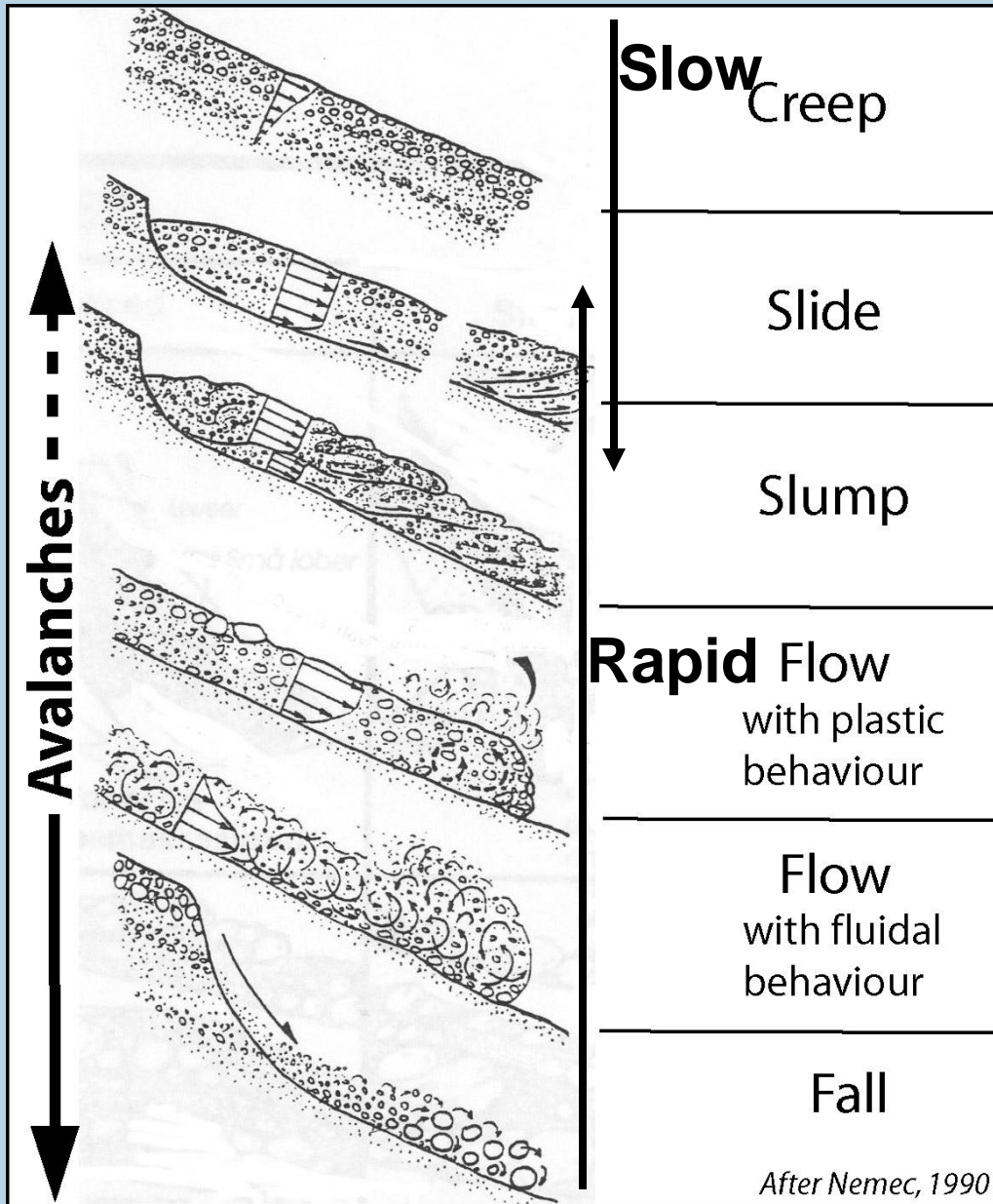


**Annual permafrost net growth rate: 0-5 cm**





# Slow and rapid mass movements



# Solifluction lobes

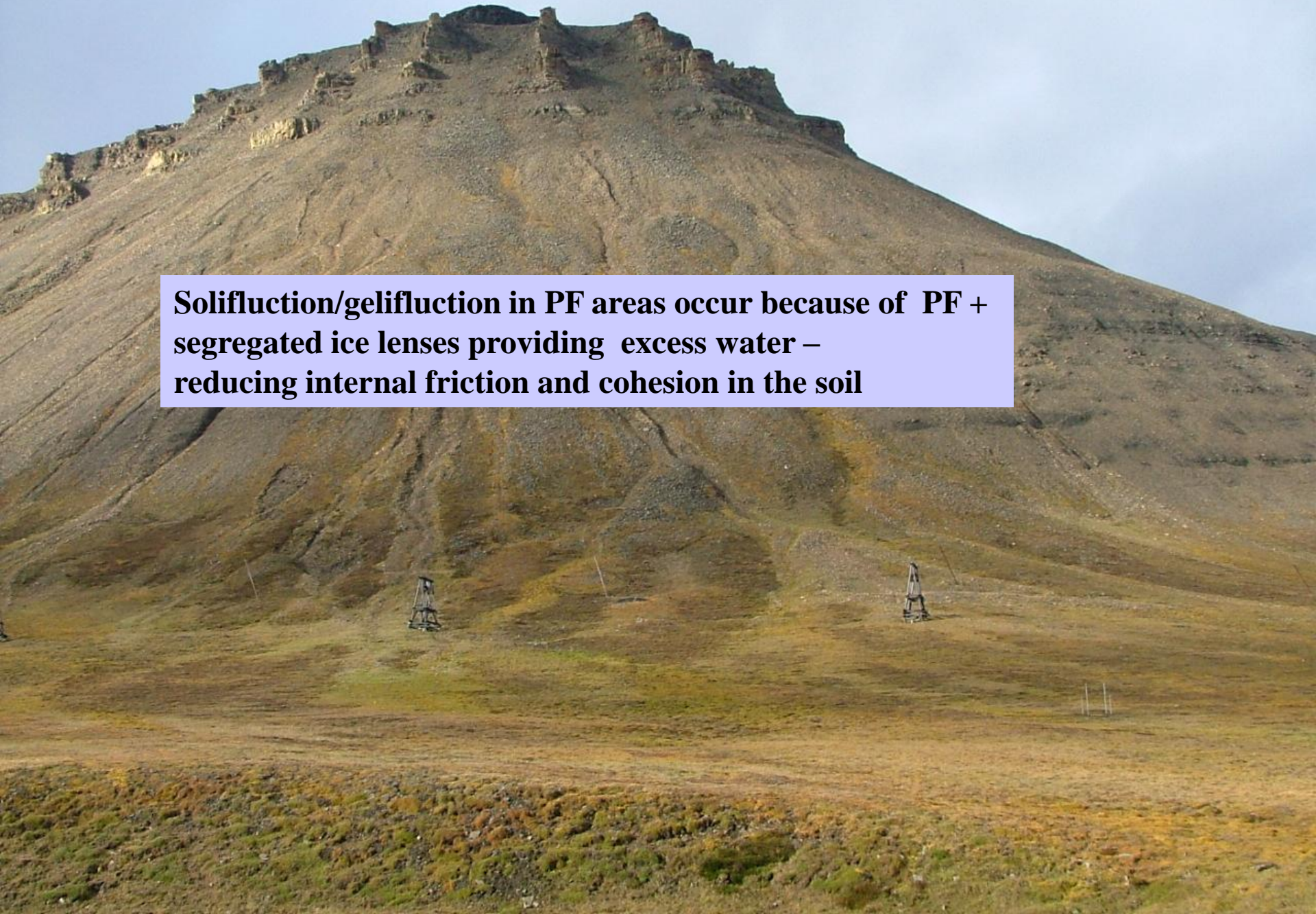


**Solifluction small lobes**



# Solifluction sheets

**Solifluction/gelifluction in PF areas occur because of PF + segregated ice lenses providing excess water – reducing internal friction and cohesion in the soil**





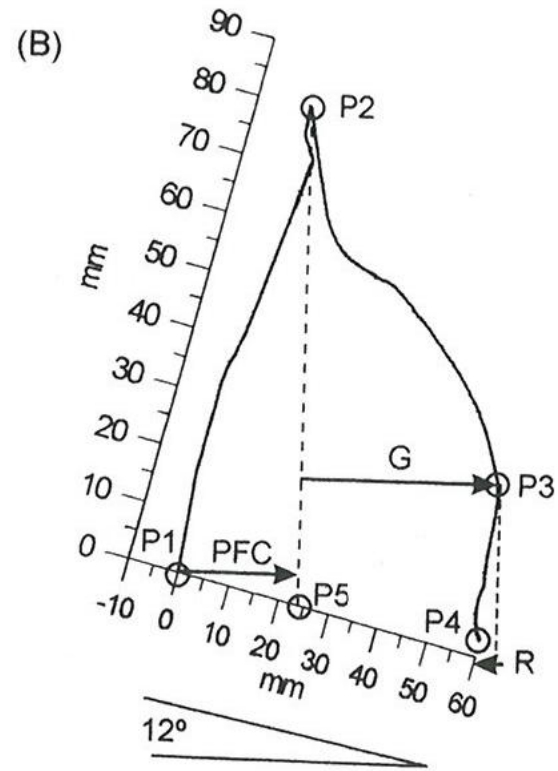
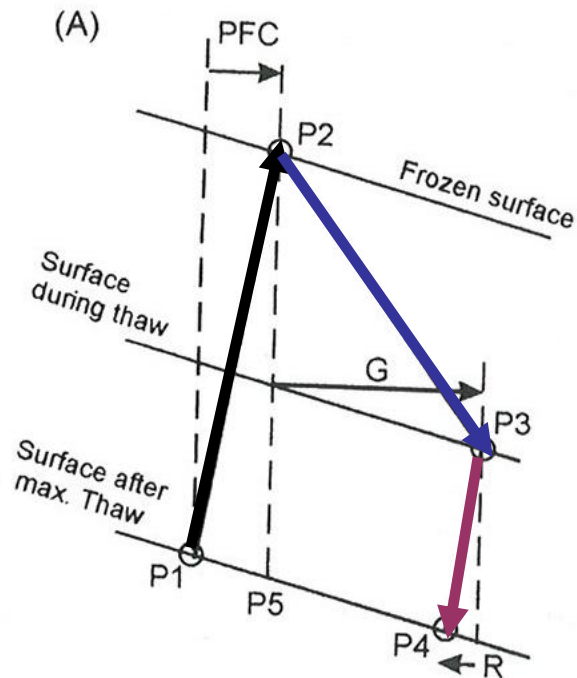
## Taubane towers as solifluction monitoring instruments



**Old Longyearbyen house piles (tree trunks) registering solifluction**



# Creep and gelifluction = solifluction

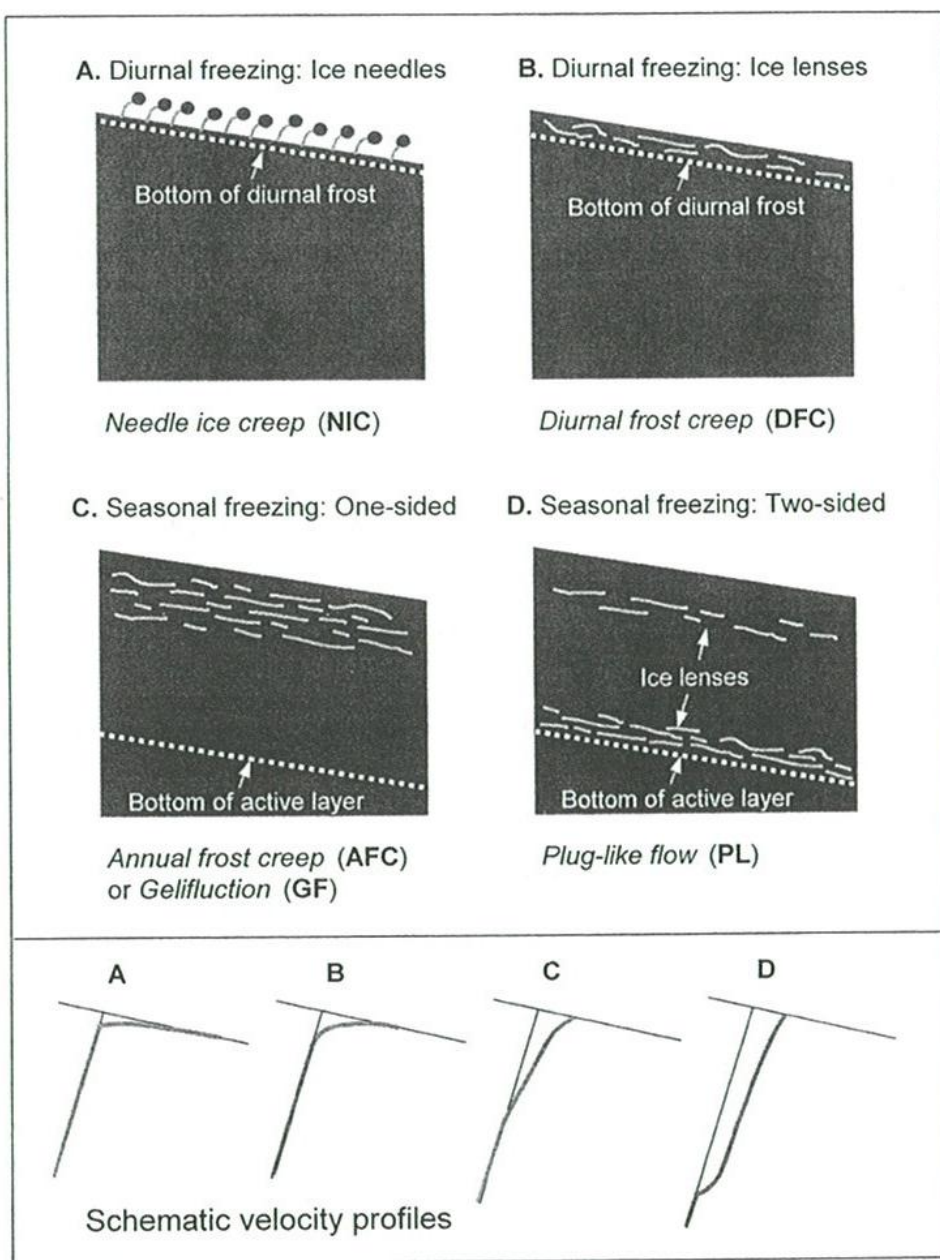


- P1 → P2      Path of target during frost heaving of ground
- P1 → P2 → P5      Theoretical path of target assuming maximum possible frost creep (vertical settlement)
- P2 → P3      Path of target during gelifluction
- P3 → P4      Path of target during settling of ground

$$\text{Creep} = \text{Heave} * \tan(\text{slope}^\circ)$$

$$\Delta l = h \tan(\sigma)$$

**Figure 9.7.** The components of solifluction. (A) Theoretical displacements of a soil particle due to potential frost creep (PFC), gelifluction (G), and retrograde movement (R). (B) Interpretation of observed surface movement vector in a controlled large-scale laboratory simulation of gelifluction movement at CNRS, Caen, France. Data from Harris and Davies (2000).



**Figure 9.8.** Summary of frost heave types and associated velocity-depth profiles of solifluction movement. From Matsuoka (2001c). Reprinted from Earth Science Reviews, with permission from Elsevier.



**Small-scale slope failures in the active layer, >1 m deep.**

**Occur when shear strength is reduced,  
because of increased ice/water content.**

**Triggers: rapid spring thaw or summer rain**



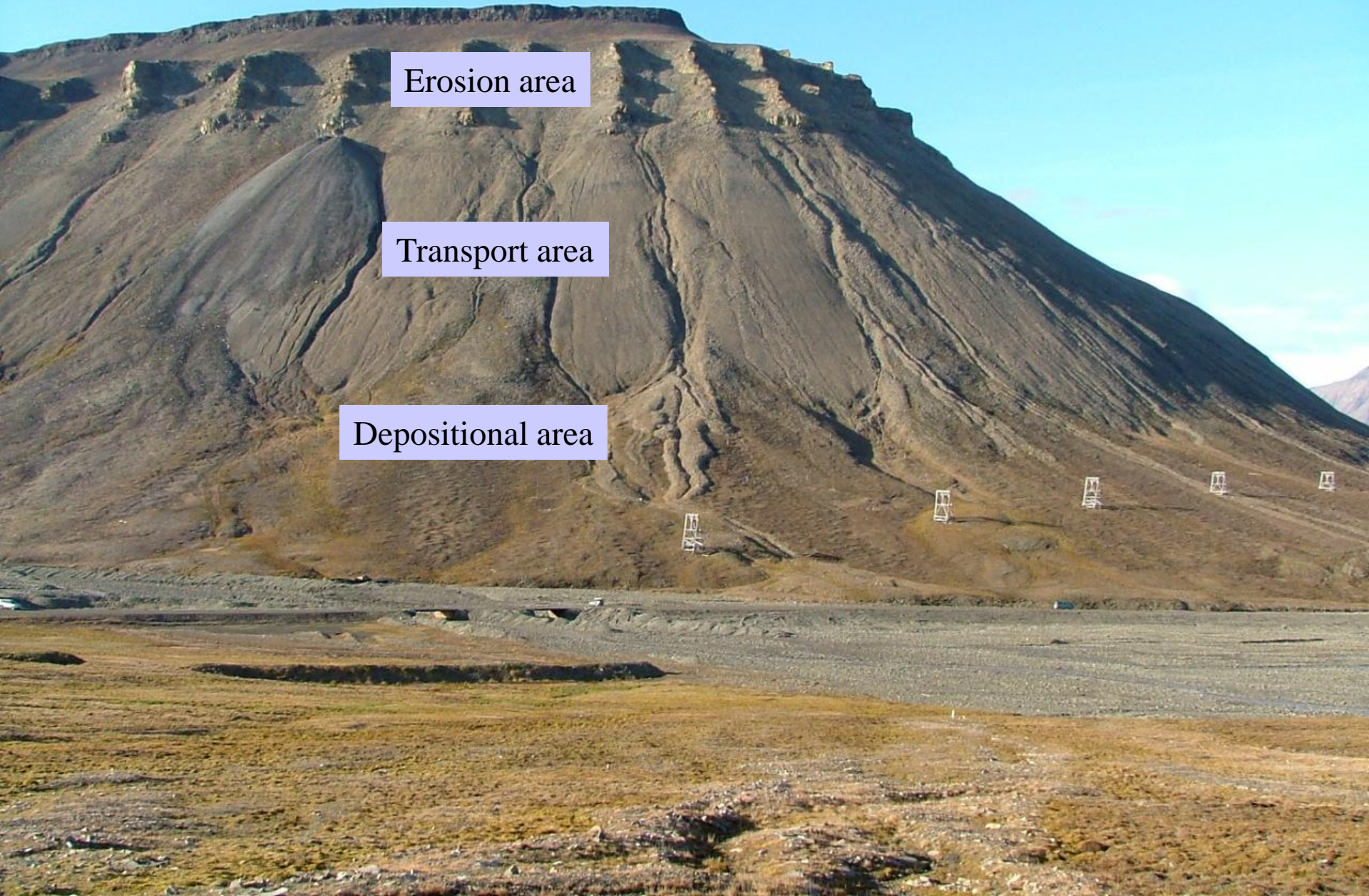
**Active layer detachment  
slides**

# Debris flows

Erosion area

Transport area

Depositional area



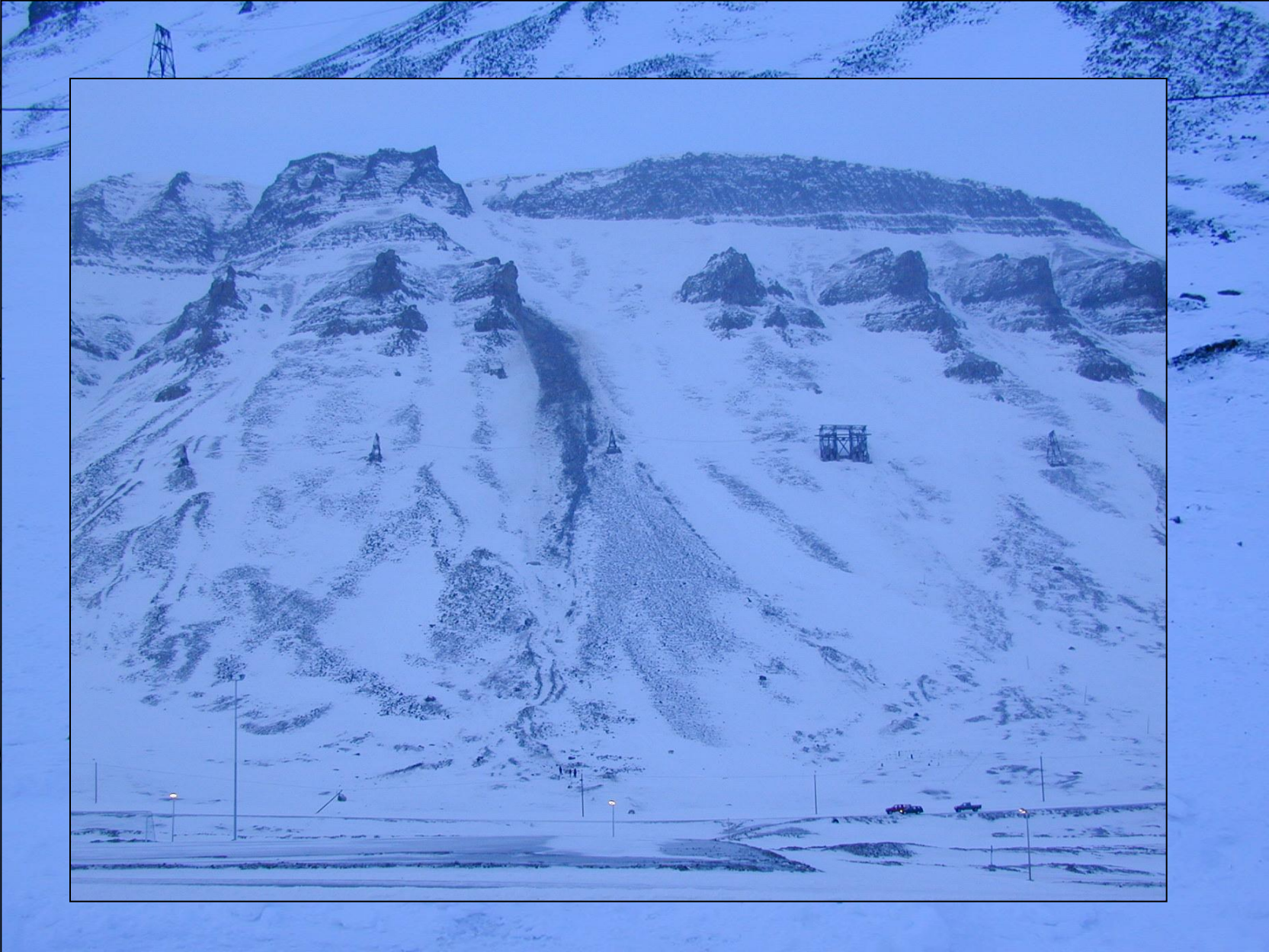
# Debris flow June 2003 Longyearbyen

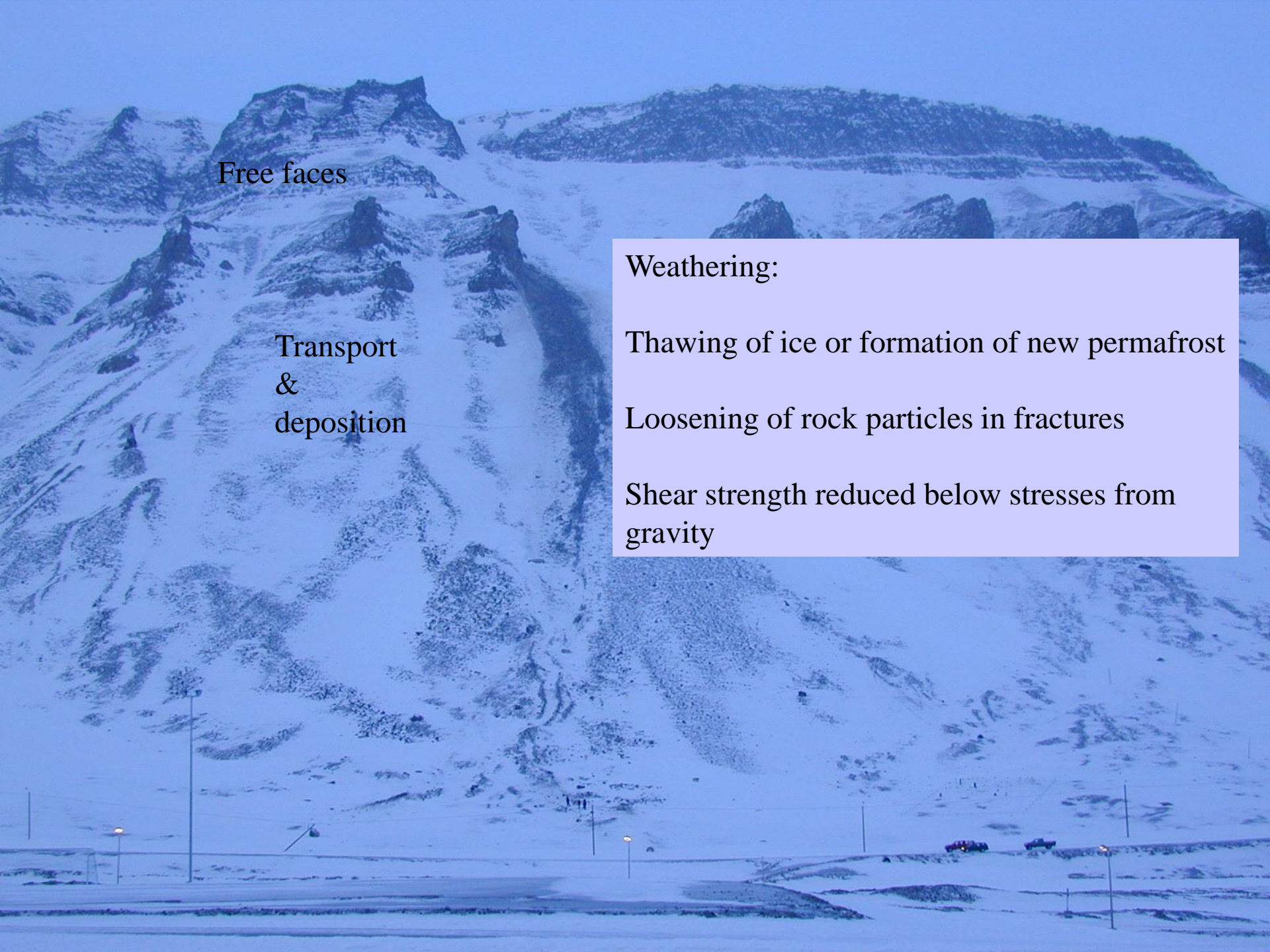






# Rockfalls





Free faces

Transport  
&  
deposition

Weathering:

Thawing of ice or formation of new permafrost

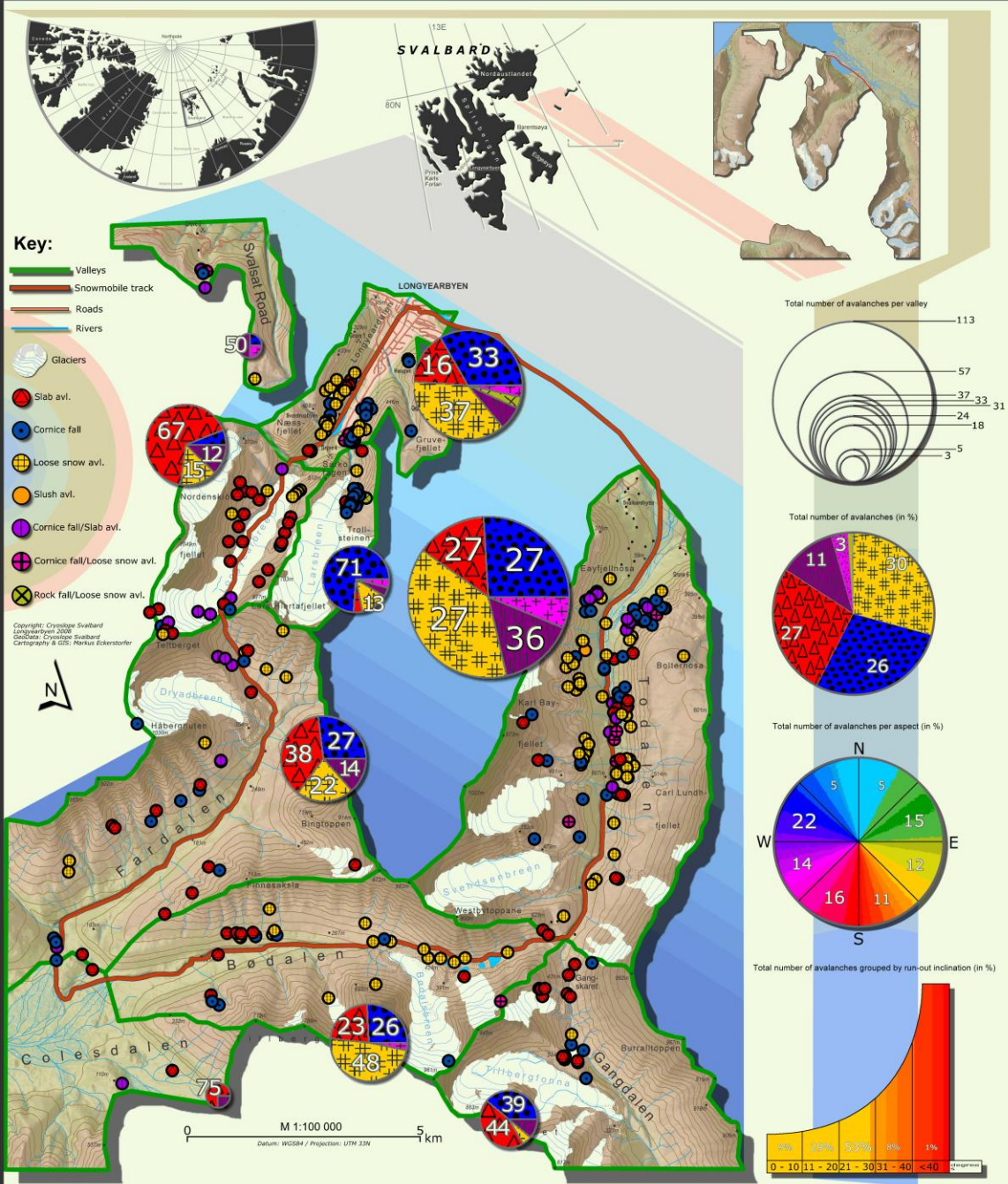
Loosening of rock particles in fractures

Shear strength reduced below stresses from gravity

# Traffic and snow avalanches



# Avalanches from 01.01.08 to 05.06.08 observed by the CRYOSLOPE SVALBARD PROJECT



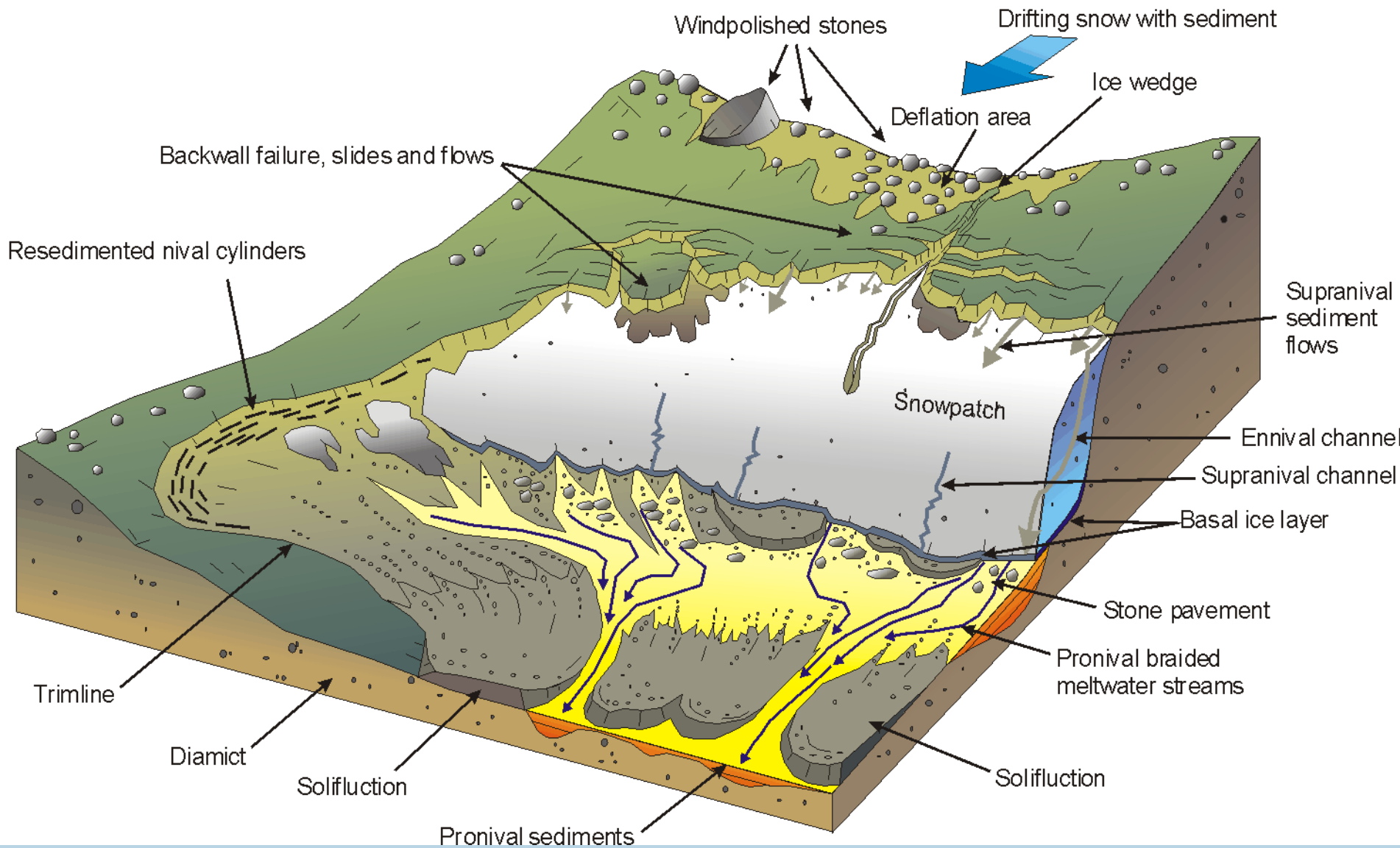
Building the first systematic database with all slope activity to access meteorological control on snow avalanches

Now more than 600 avalanches since 1 January 2007

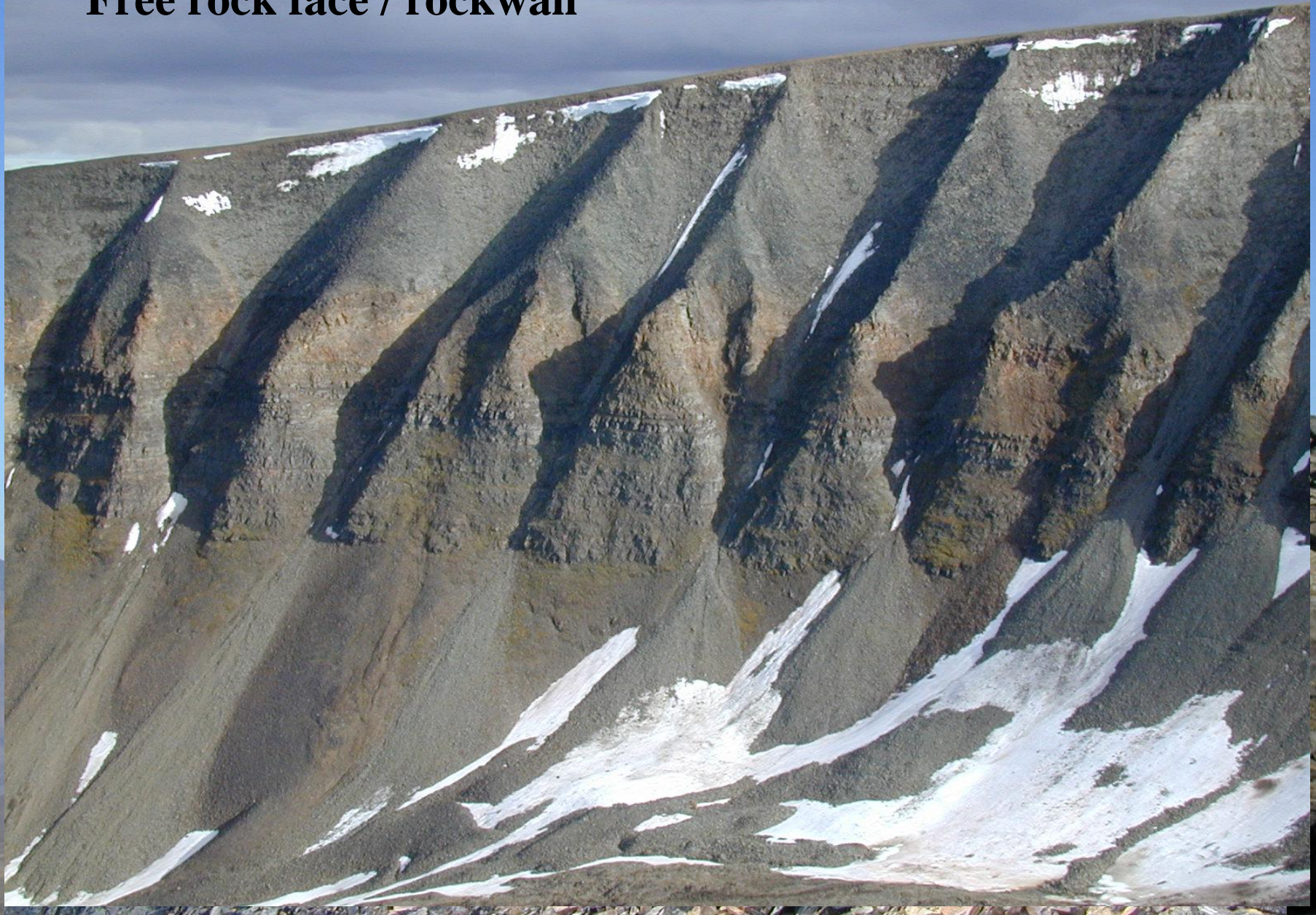




# High Arctic Nivation Process-Form-Sediment Model



**Free rock face / rockwall**



**Weathering landforms**



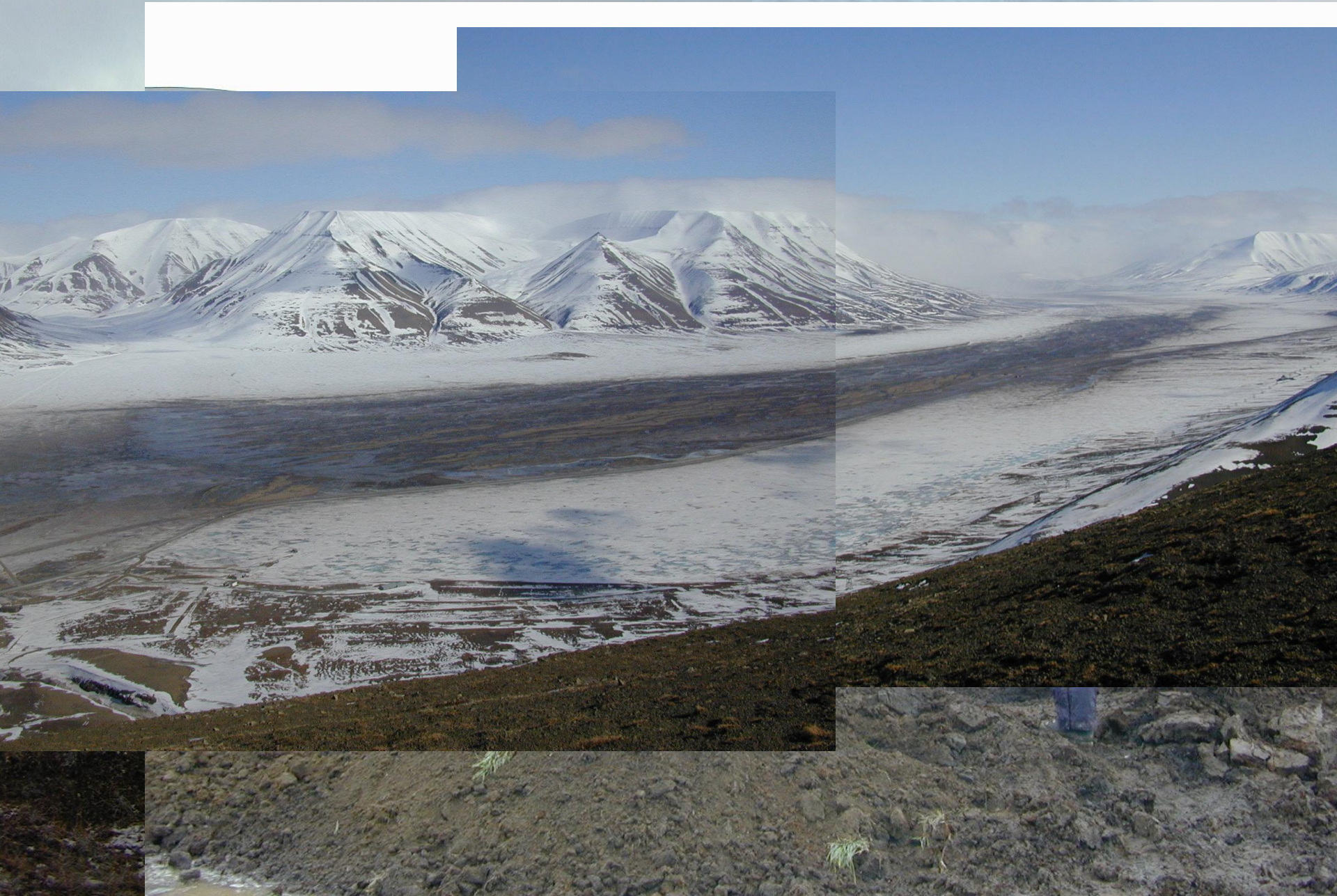
**Wind – a very important geomorphological factor in Svalbard !**



# Wind erosion and transport in periglacial landscapes - Svalbard



# Wind transport and deposition in periglacial landscapes - Svalbard



# Wind erosion in periglacial landscapes - Svalbard

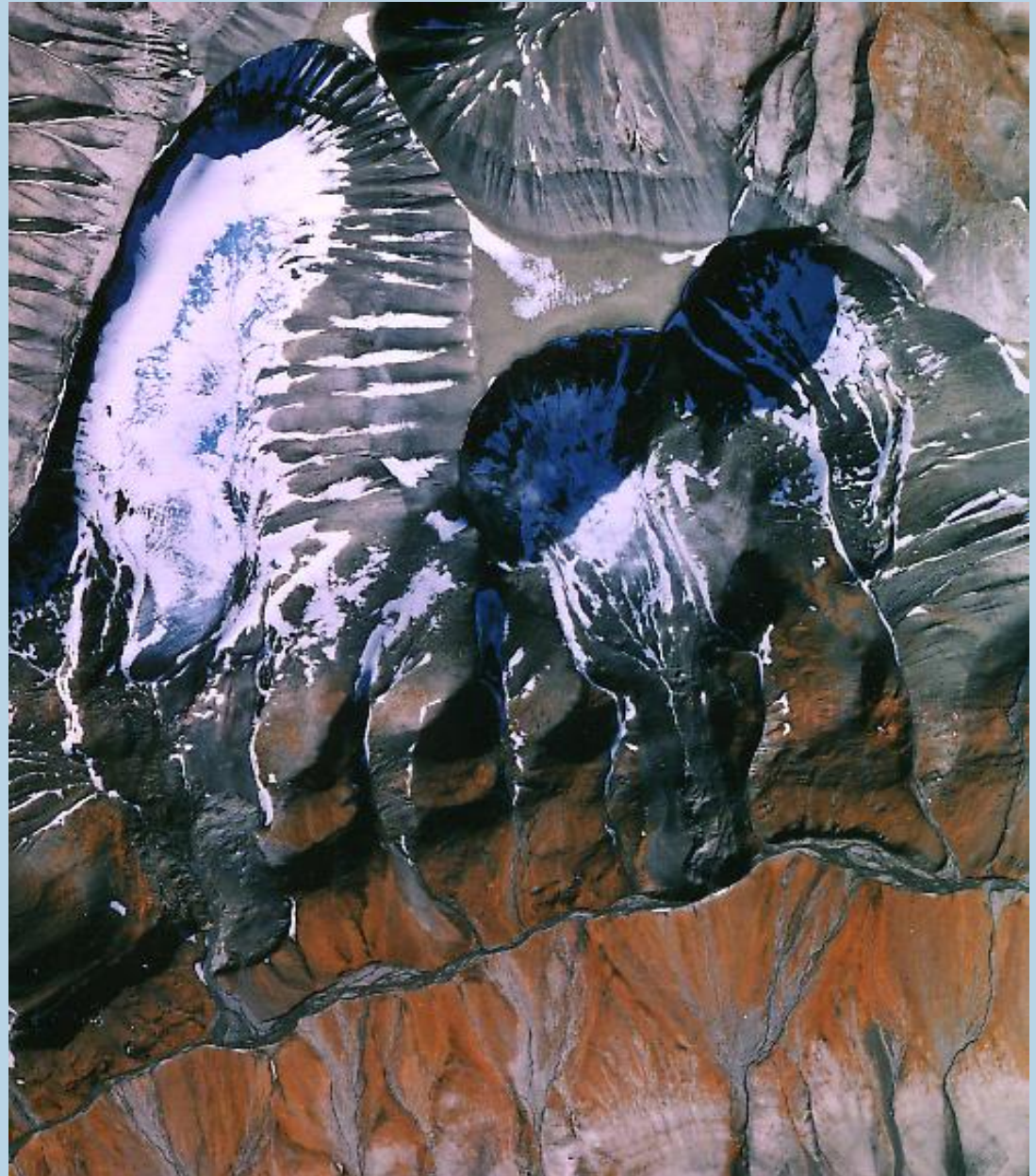


High geomorphic activity in permafrost regions at altitudes near the ELA

**rock falls,  
avalanches,  
glaciers,  
rock glaciers,  
snowpatches,  
streams,  
solifluction,  
etc.**

Site:  
Northern side of Hiorthfjellet,  
near Longyearbyen,  
Svalbard. North is towards  
bottom of figure

Figure measures 3000 x 2400 m



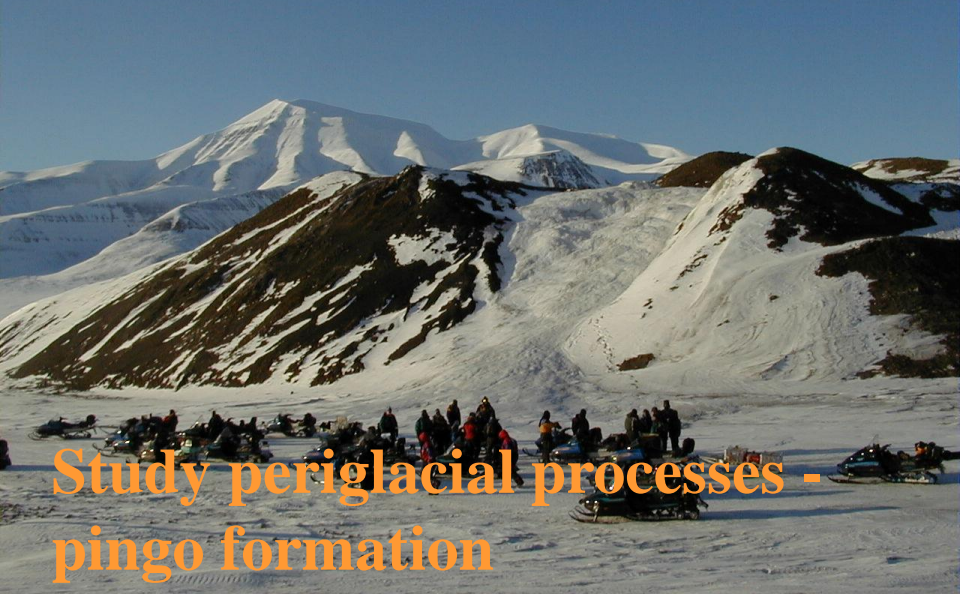




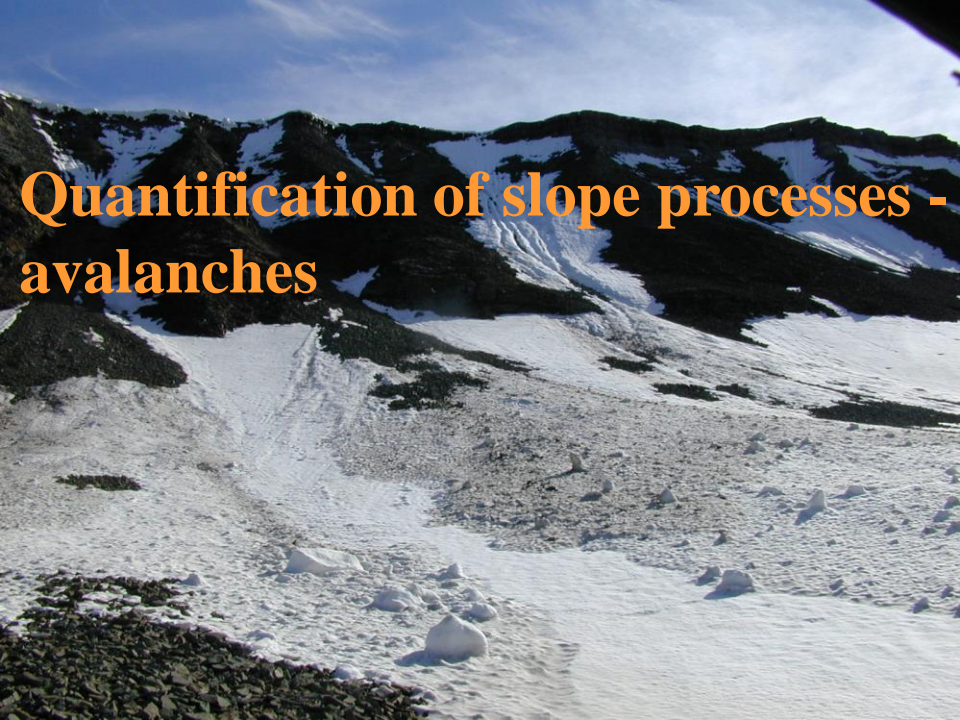
# Physical Geography at Department of Geology



Investigating modern meteorology at selected landforms



Study periglacial processes - pingo formation



Quantification of slope processes - avalanches



Study ice wedges and their palaeoclimatic history



## Readings

- ) H.M. French *The Periglacial Environment*, Third edition, 2007. Wiley, 458 p.
- ) Humlum, O, Christiansen, H.H. & Juliussen, H. 2008. (2007) Avalanche Derived Rock Glaciers in Svalbard. *Permafrost and Periglacial Processes*, 18, 75-88.
- ) Christiansen, H.H. (1998) Periglacial sediments in an Eemian - Weichselian succession at Emmerlev Klev, southwestern Jutland, Denmark. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 138, 245-258.
- ) Liestøl, O., 1976: Pingos, springs, and permafrost in Spitsbergen. Norsk Polarinstitut Årbok 1975, pp. 7-29.