
Effect of supraglacial debris
in permafrost regions
glaciers

Effect of supraglacial debris in permafrost regions

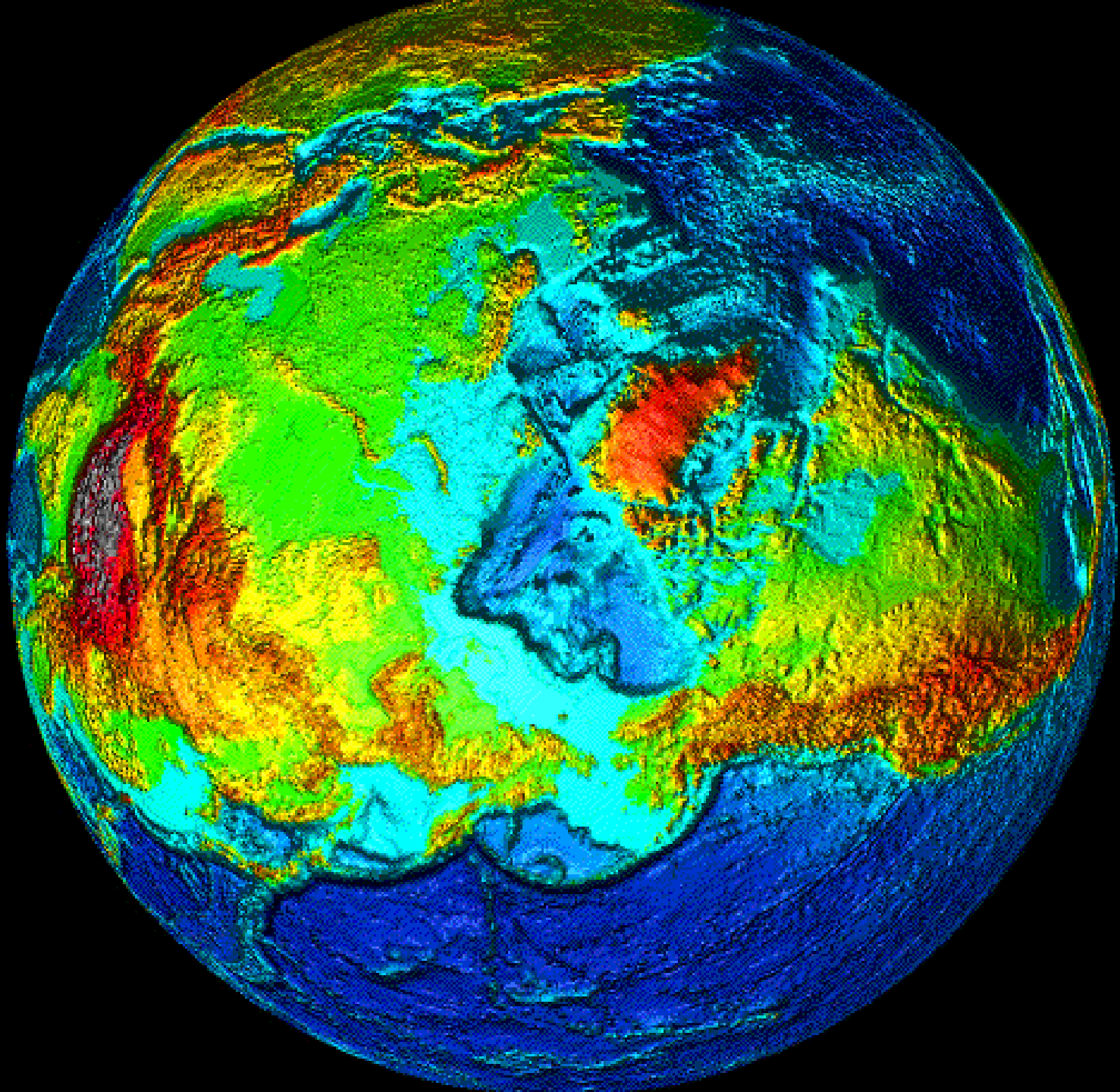
1: Environmental considerations

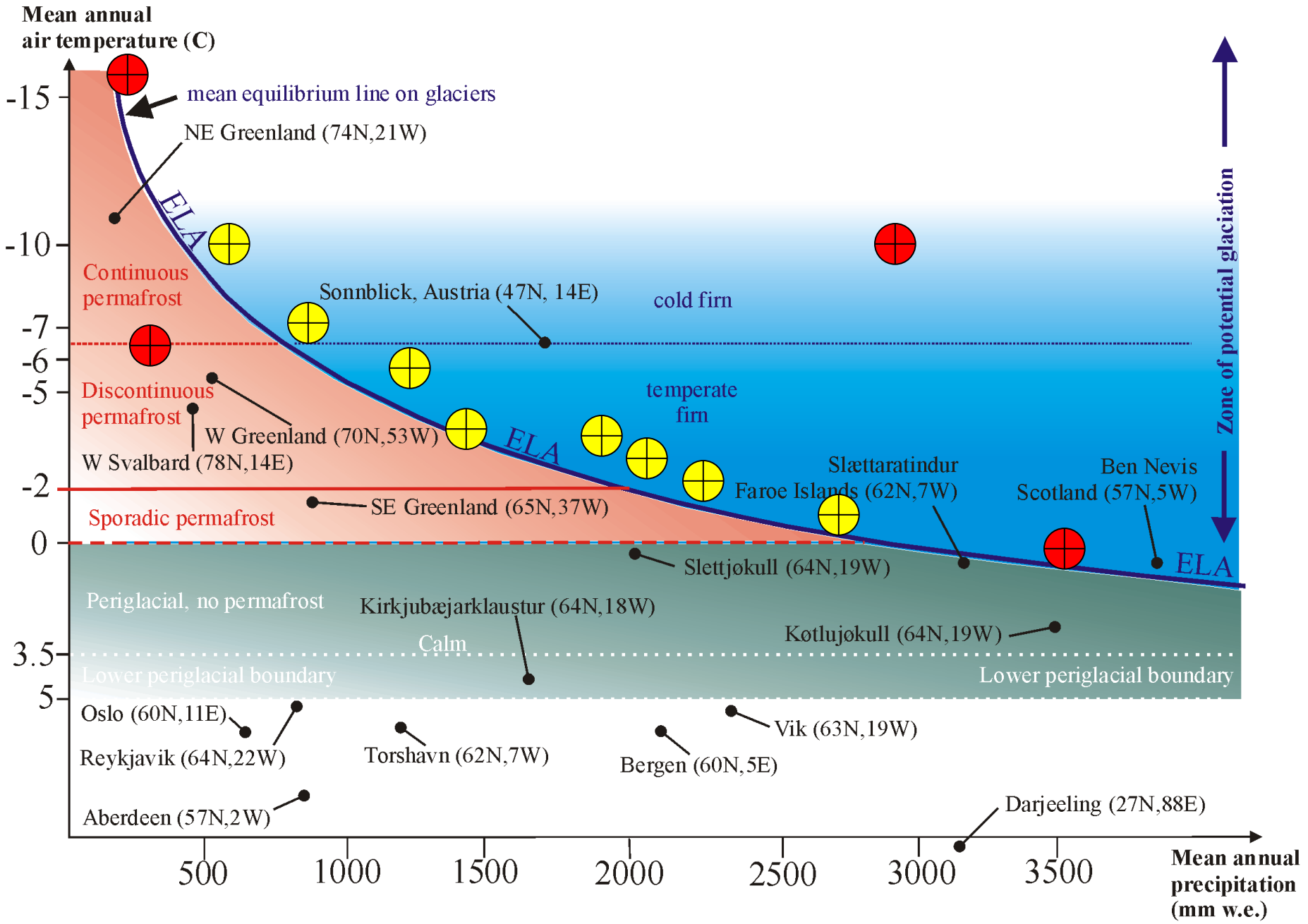
2: Thermal glacier types in permafrost regions

3: Source of supraglacial debris

4: Supraglacial debris: effects on ablation

5: Deglaciation in permafrost regions

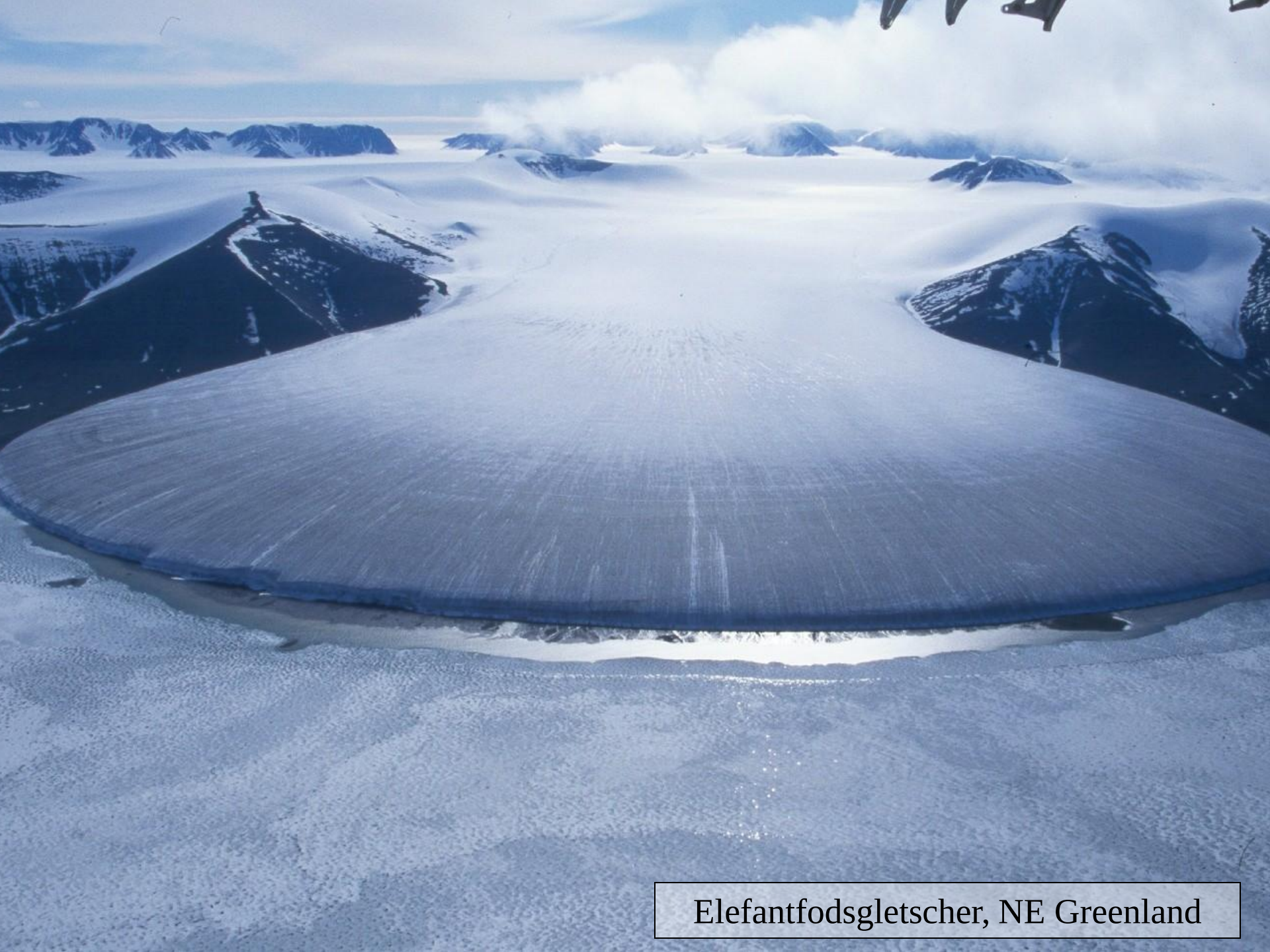



Mean annual
air temperature (C)
-15
-10
-7
-6
-5
-2
0
3.5
5
mean equilibrium line on glaciers
NE Greenland (74N,21W)
ELA
Continuous
permafrost
Discontinuous
permafrost
W Svalbard (78N,14E)
W Greenland (70N,53W)
Sonnblick, Austria (47N, 14E)
cold firn
temperate
firn
ELA
Sporadic permafrost
SE Greenland (65N,37W)
Slettjøkull (64N,19W)
Slættaratindur
Faroe Islands (62N,7W)
Ben Nevis
Scotland (57N,5W)
ELA
Zone of potential glaciation
Periglacial, no permafrost
Kirkjubæjarklaustur (64N,18W)
Calm
Køtlujøkull (64N,19W)
Lower periglacial boundary
Lower periglacial boundary
Oslo (60N,11E)
Reykjavik (64N,22W)
Torshavn (62N,7W)
Bergen (60N,5E)
Vik (63N,19W)
Aberdeen (57N,2W)
Darjeeling (27N,88E)
500
1000
1500
2000
2500
3000
3500
Mean annual
precipitation
(mm w.e.)

Ole Humlum

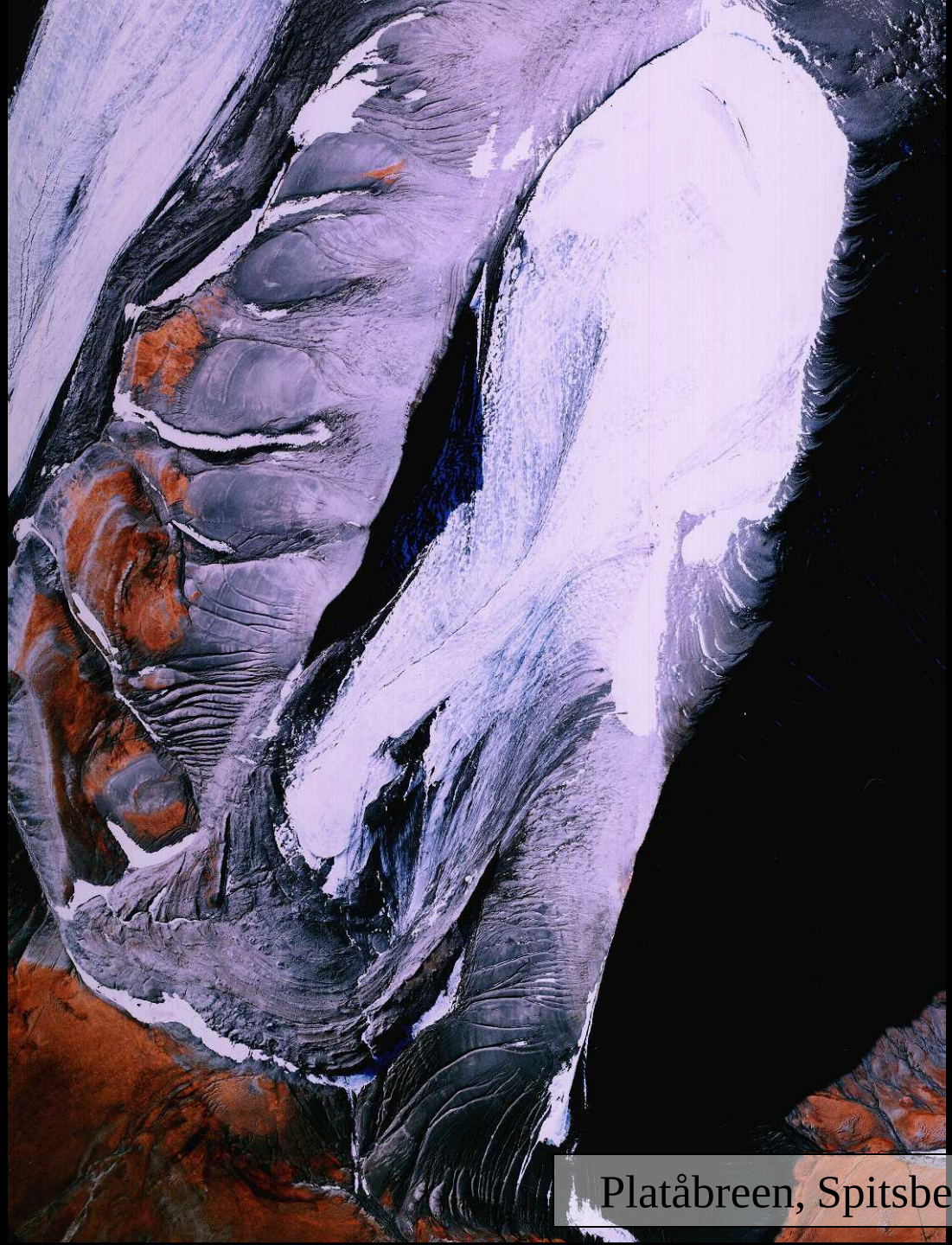
Thermal glacier types in permafrost regions:

Dry valley, Antarctic



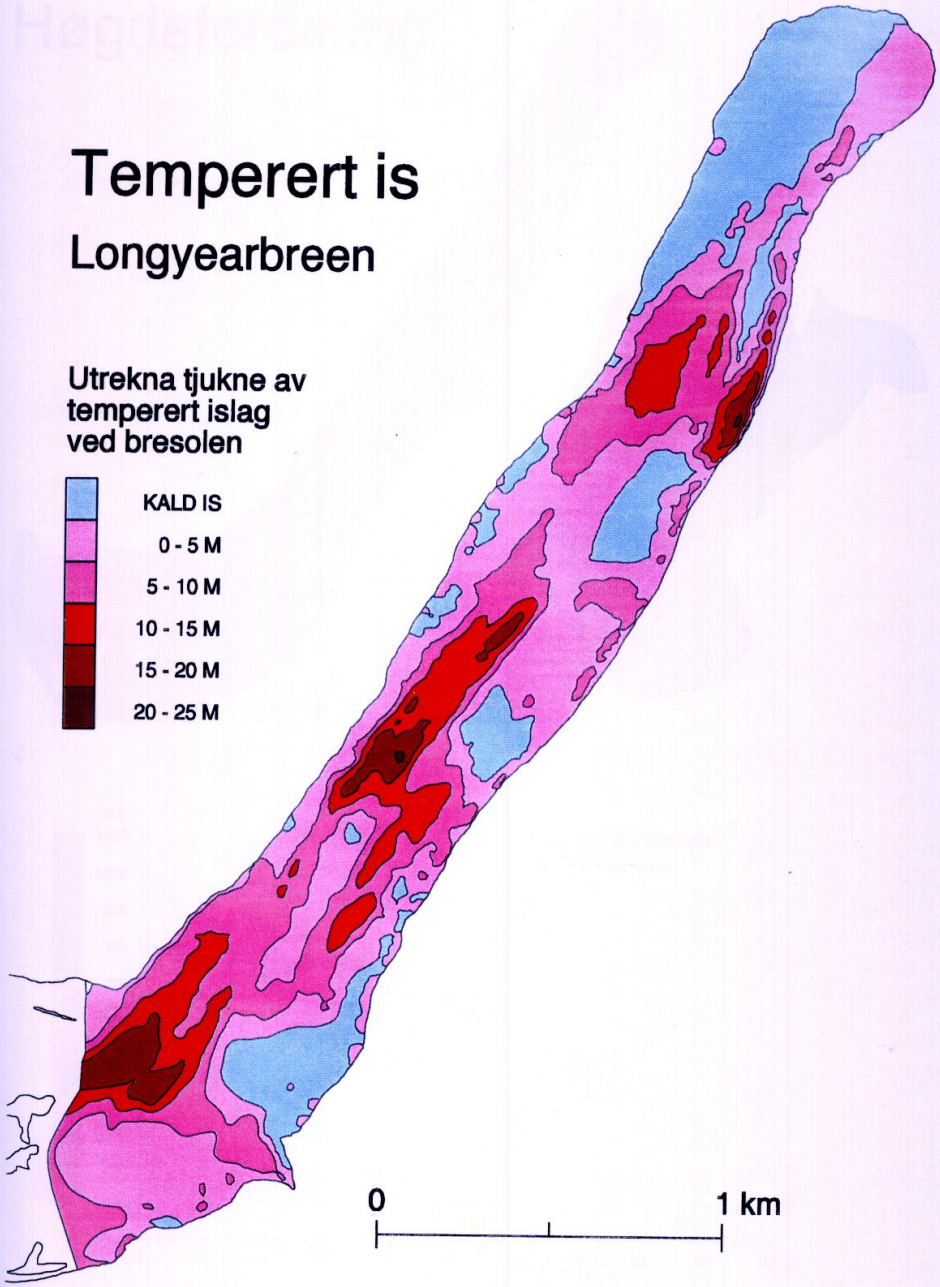
Elefantfodsgletscher, NE Greenland

Hofmannskees, Gross Glockner, Austria

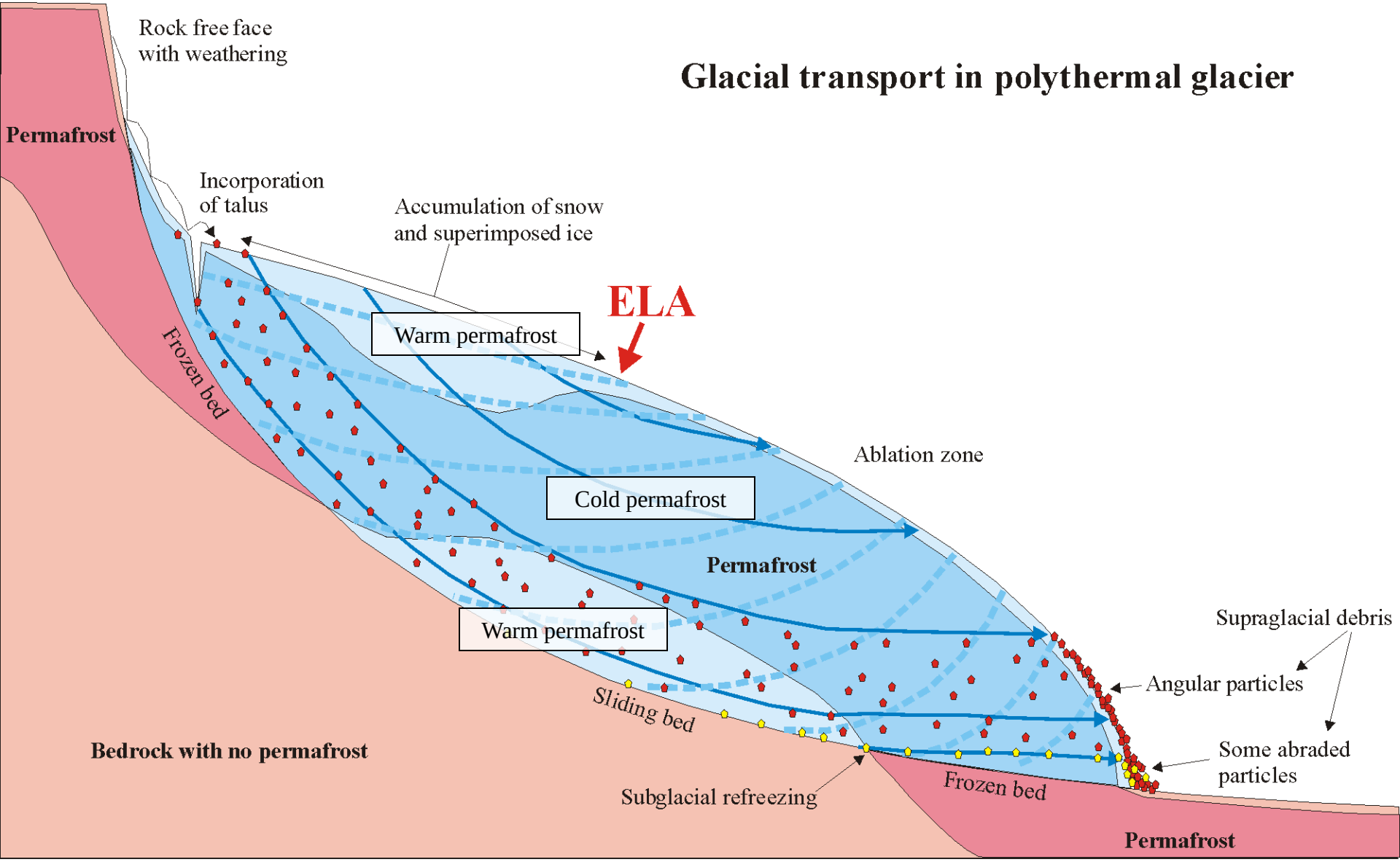


Platåbreen, Spitsbergen, Svalbard

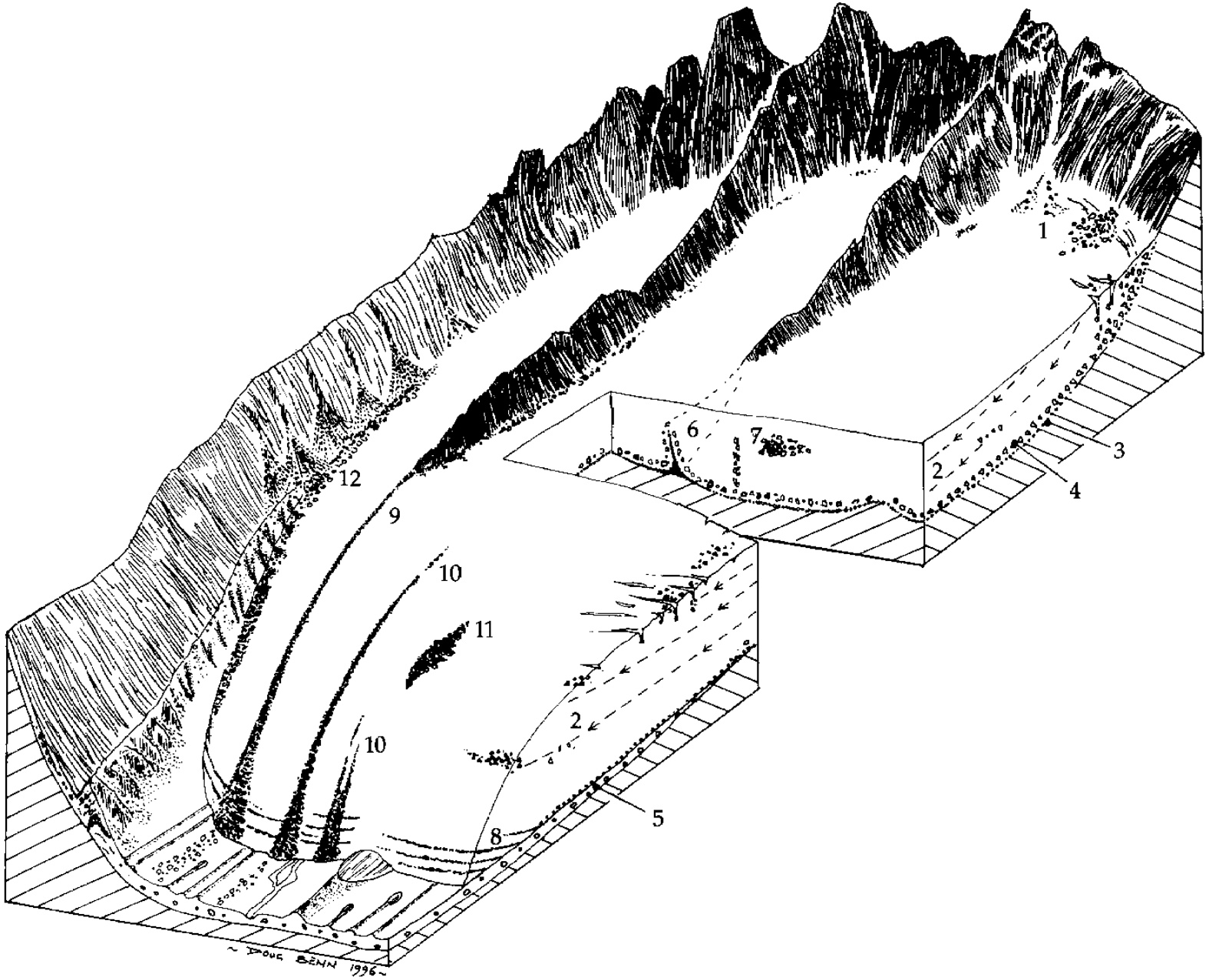

Longyearbreen, Spitsbergen, Svalbard



Figur 3.8: *I følgje radarmålingane har eit temperert islag under Longyearbreen ei utbreiing som synt over.*


Glacial transport in polythermal glacier
Rock free face
with weathering
Permafrost
Incorporation
of talus
Accumulation of snow
and superimposed ice
ELA
Warm permafrost
Frozen bed
Ablation zone
Cold permafrost
Permafrost
Warm permafrost
Supraglacial debris
Angular particles
Some abraded
particles
Sliding bed
Bedrock with no permafrost
Subglacial refreezing
Frozen bed
Permafrost

Source of supraglacial debris:


1
2
3
4
5
6
7
8
9
10
10
11
12
2
~ DOUG BENN 1996 ~

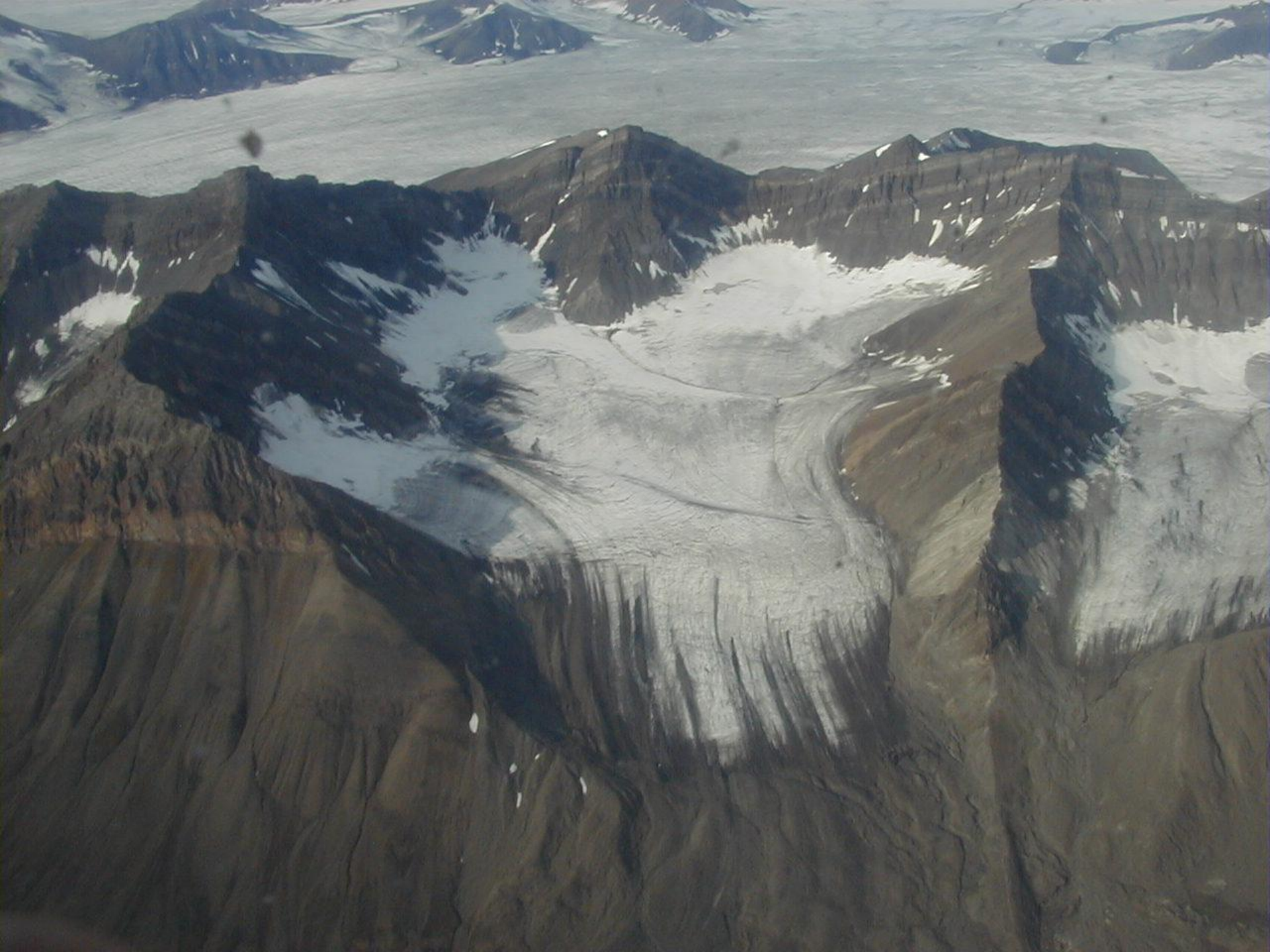
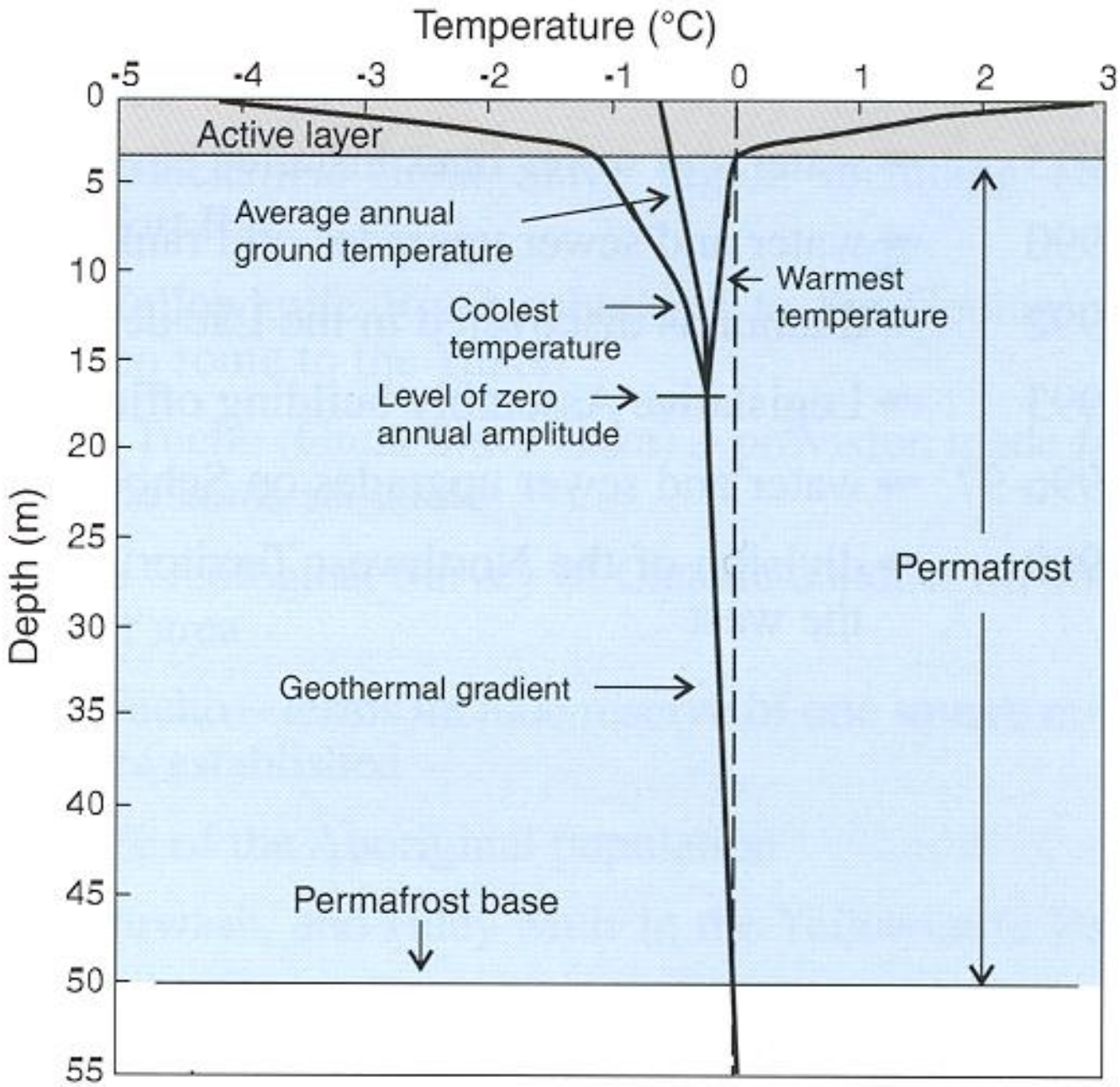
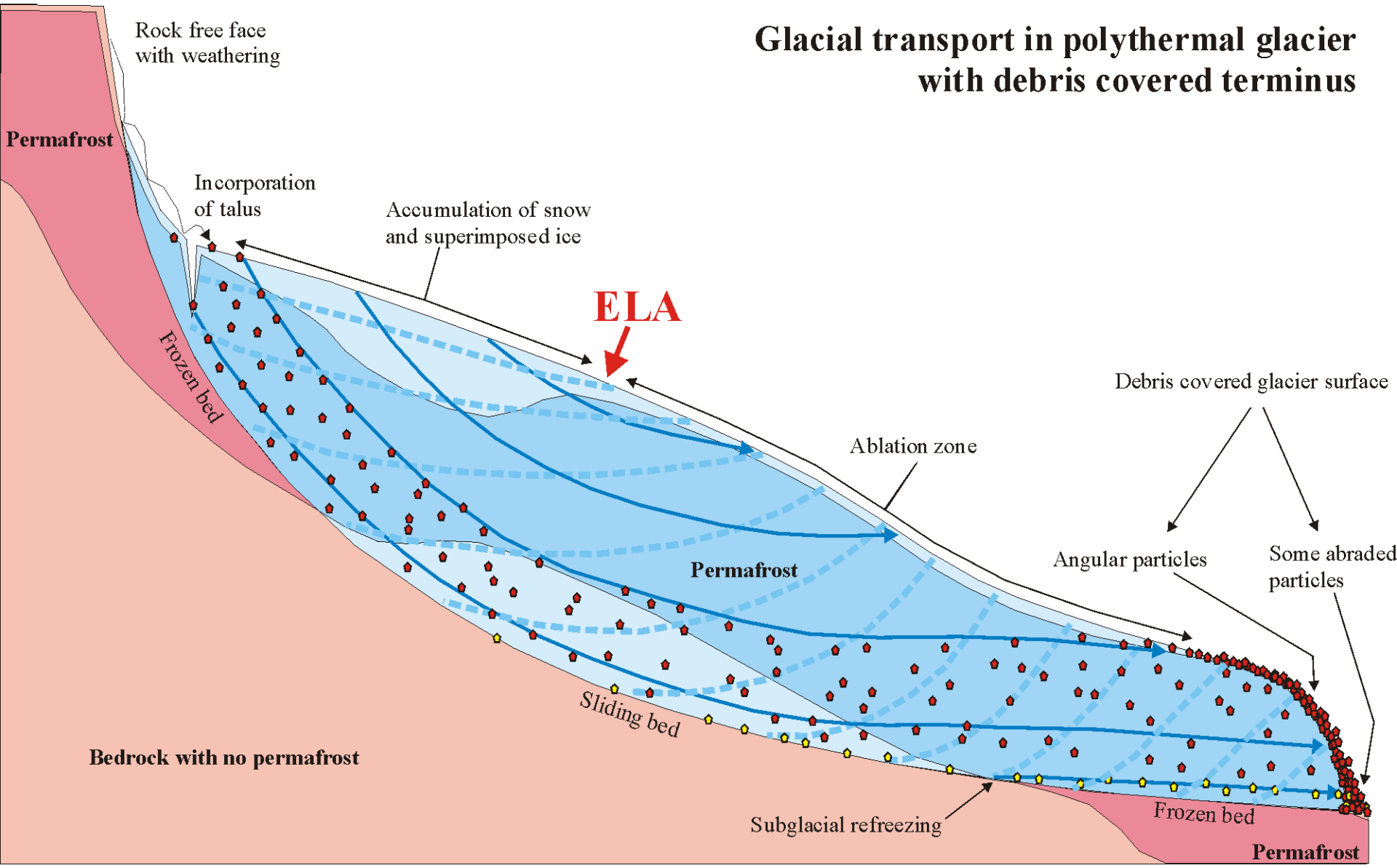
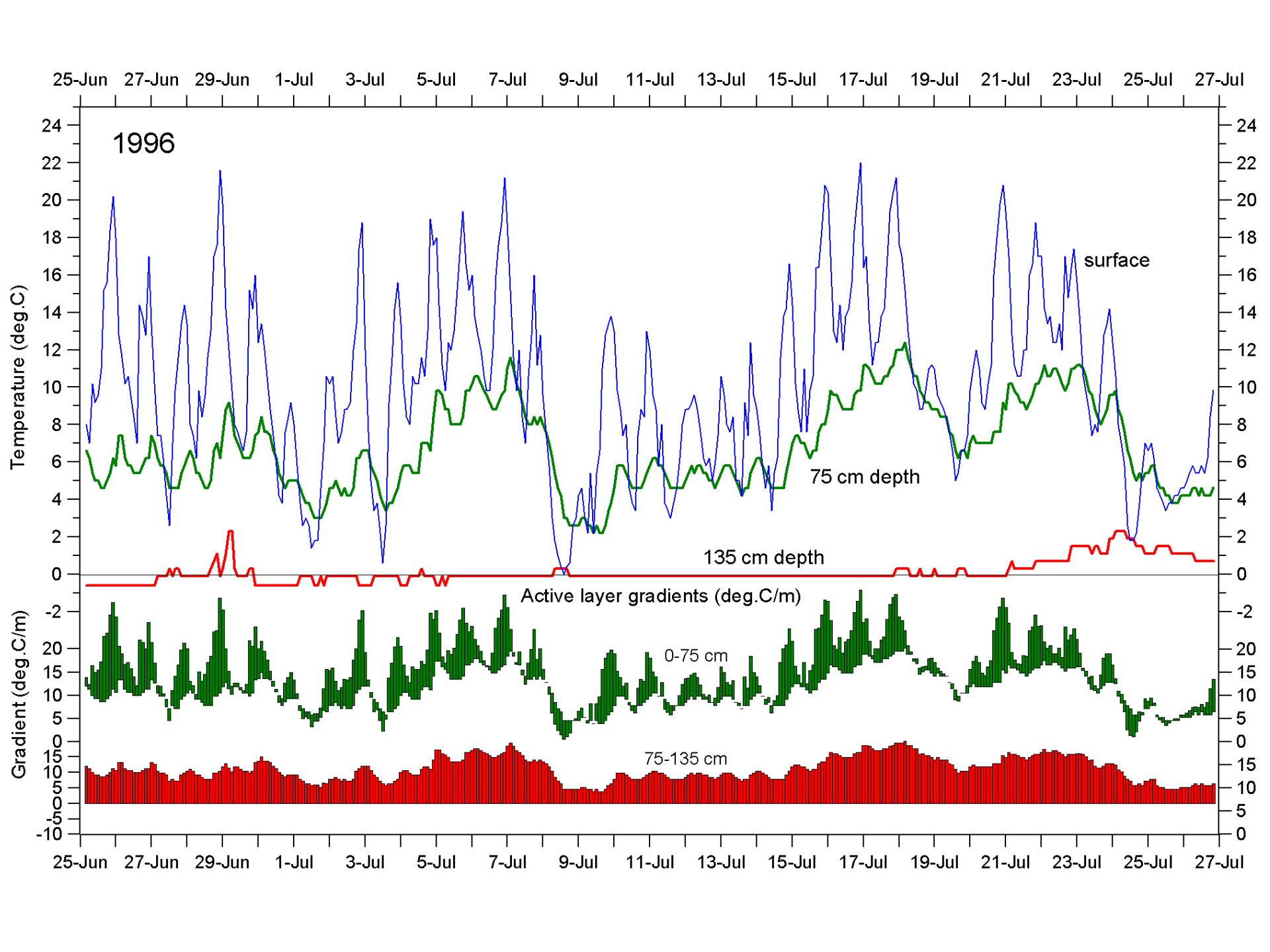


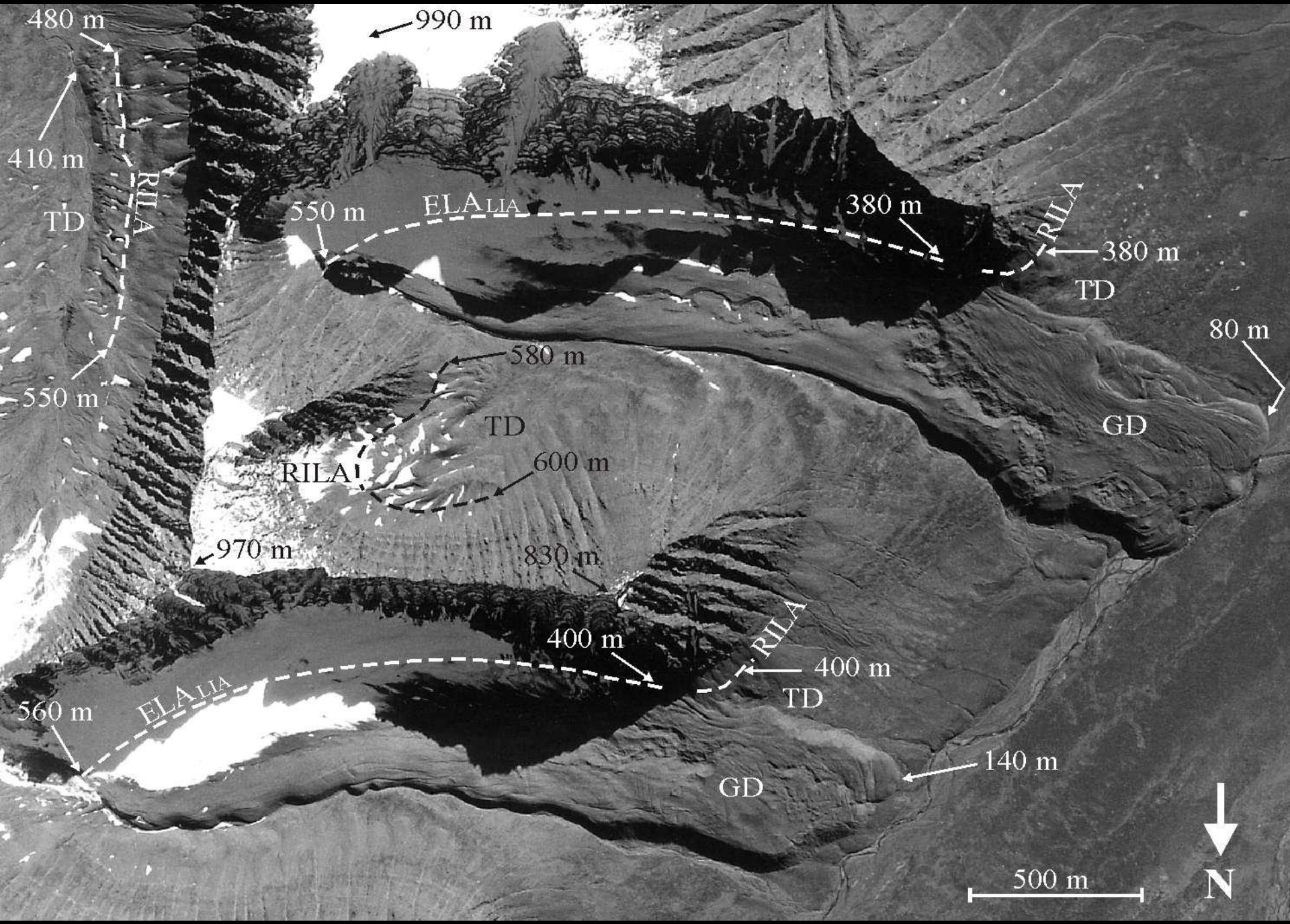
Photo: Doug Benn

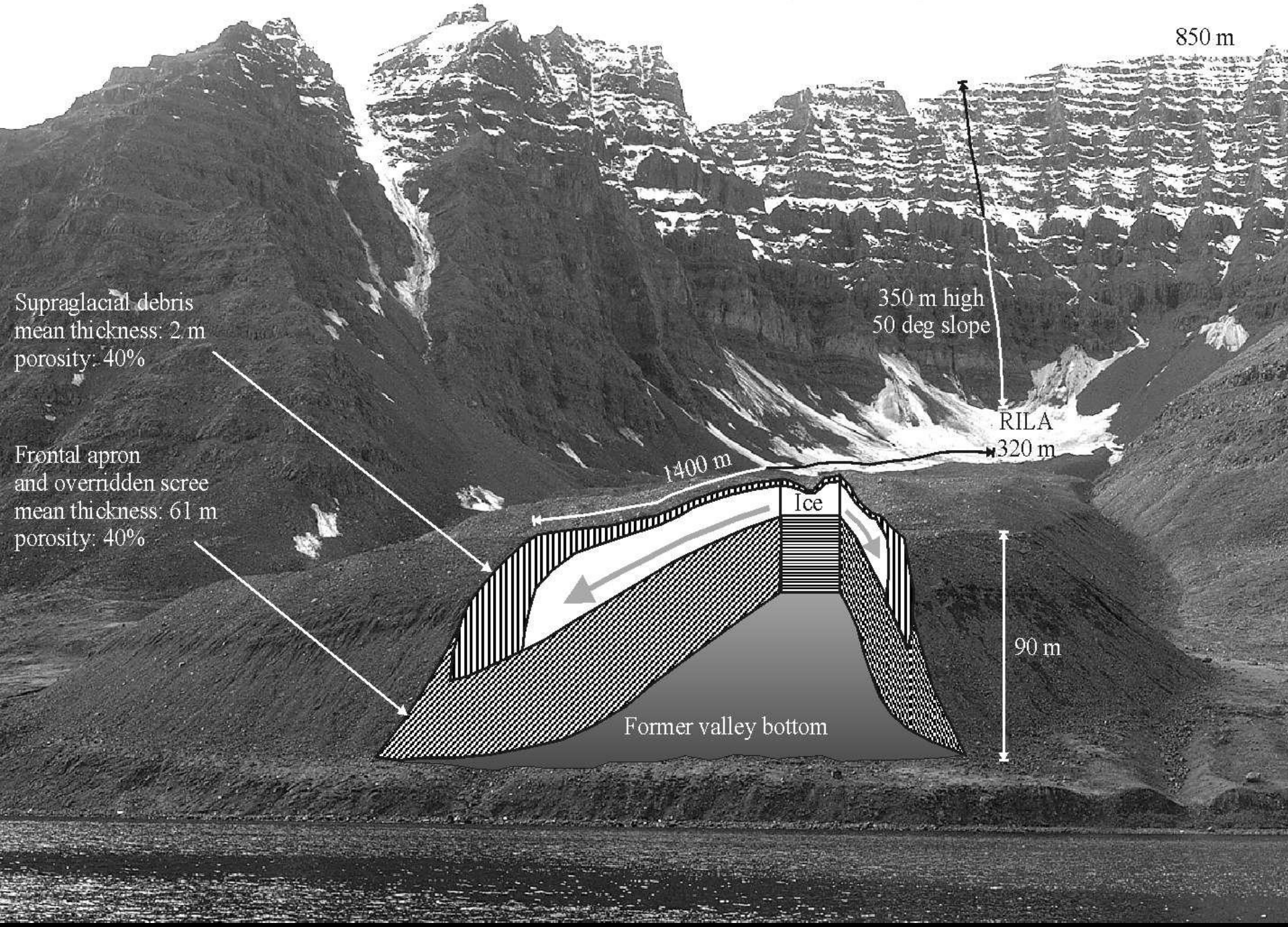
Effect of supraglacial debris on ablation in permafrost regions:

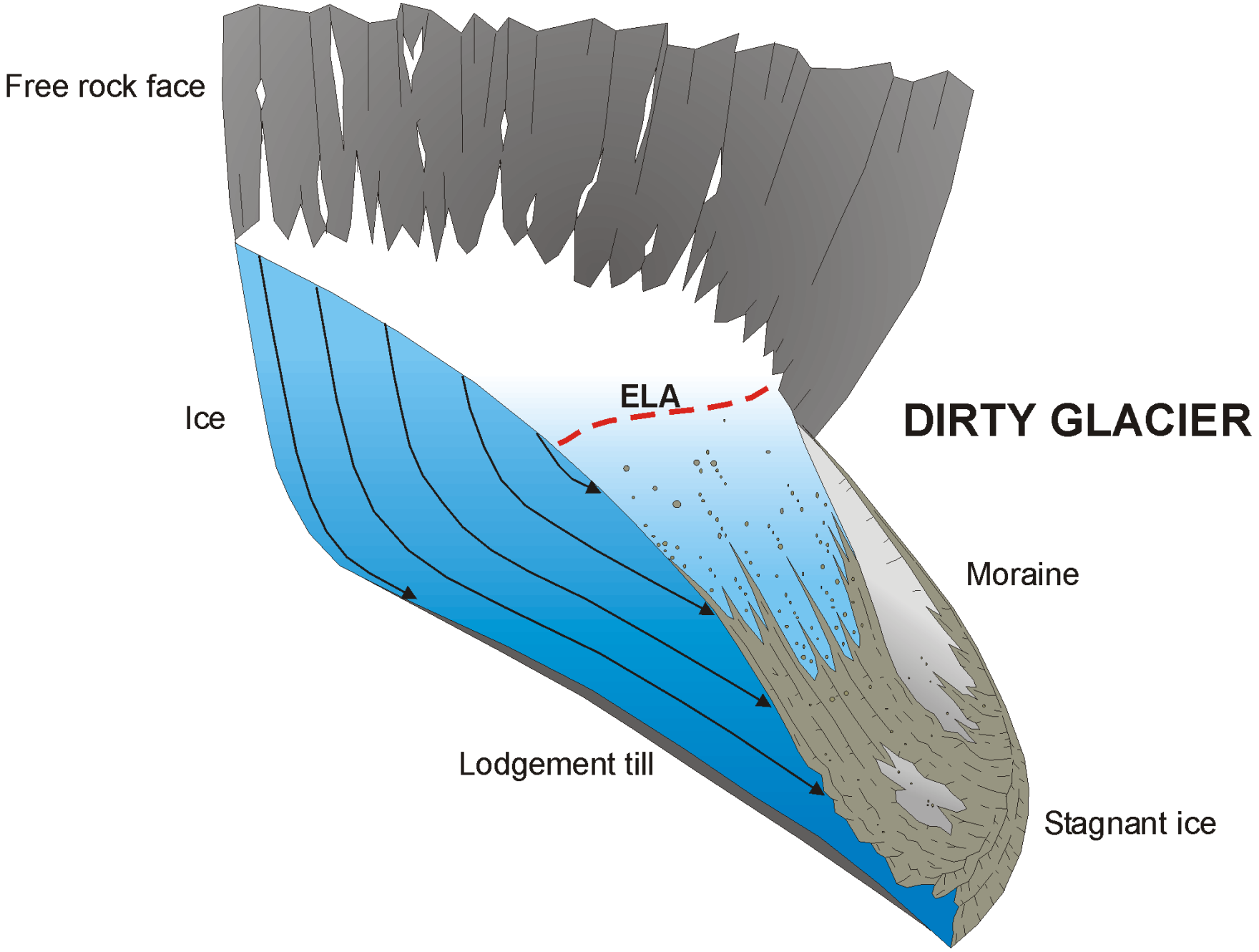

Temperature (°C)
-5
-4
-3
-2
-1
0
1
2
3
0
5
10
15
20
25
30
35
40
45
50
55
Depth (m)
Active layer
Average annual ground temperature
Coolest temperature
Warmest temperature
Level of zero annual amplitude
Permafrost
Geothermal gradient
Permafrost base

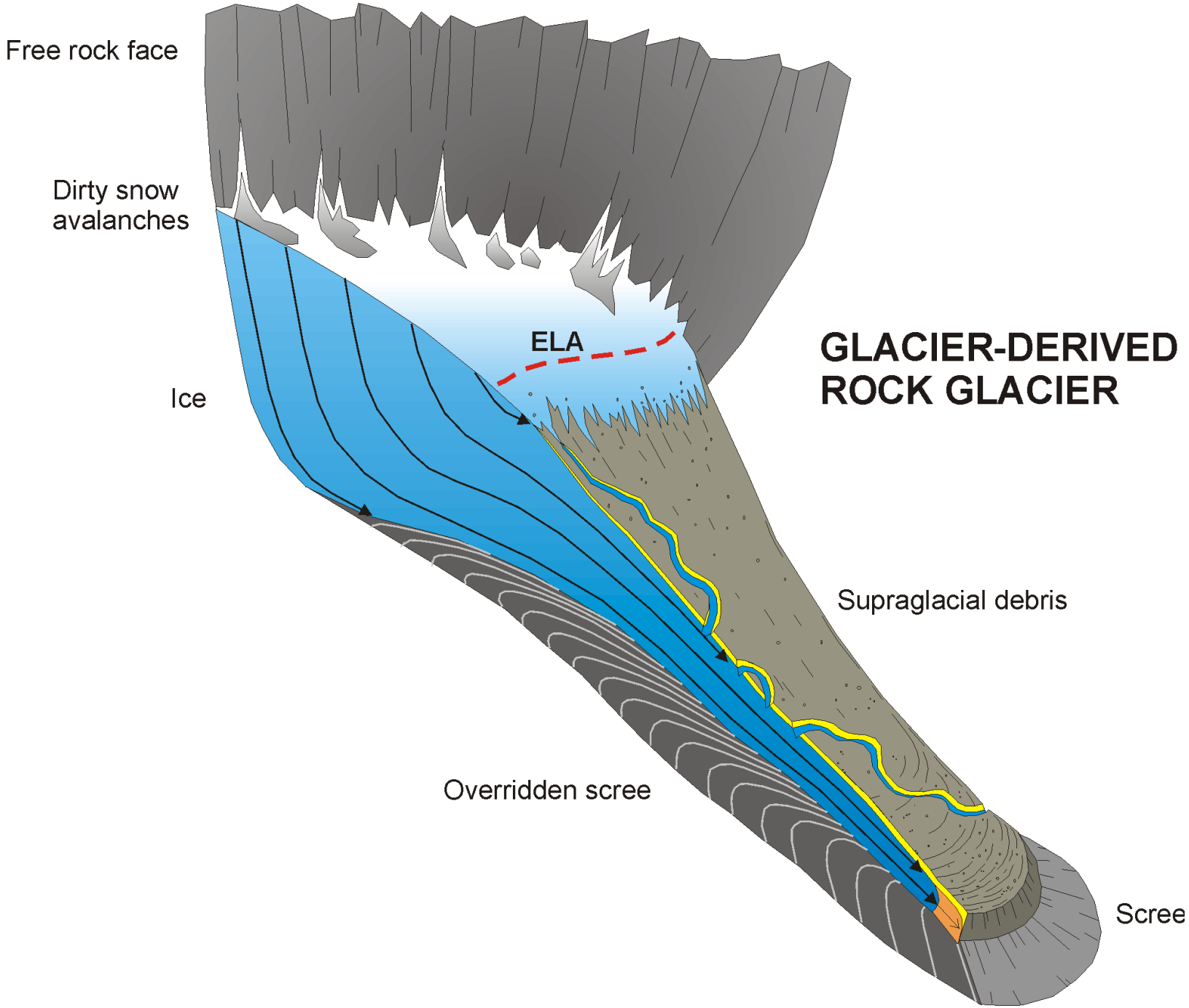

Glacial transport in polythermal glacier with debris covered terminus
Rock free face with weathering
Permafrost
Incorporation of talus
Accumulation of snow and superimposed ice
ELA
Frozen bed
Debris covered glacier surface
Ablation zone
Angular particles
Some abraded particles
Permafrost
Sliding bed
Bedrock with no permafrost
Subglacial refreezing
Frozen bed
Permafrost


1996
Temperature (deg.C)
surface
75 cm depth
135 cm depth
Active layer gradients (deg.C/m)
Gradient (deg.C/m)
0-75 cm
75-135 cm
25-Jun
27-Jun
29-Jun
1-Jul
3-Jul
5-Jul
7-Jul
9-Jul
11-Jul
13-Jul
15-Jul
17-Jul
19-Jul
21-Jul
23-Jul
25-Jul
27-Jul


480 m
990 m
410 m
RILA
TD
550 m
ELALIA
380 m
RILA
380 m
TD
80 m
580 m
550 m
TD
GD
RILA
600 m
970 m
830 m
RILA
400 m
400 m
TD
560 m
ELALIA
140 m
GD
500 m
N

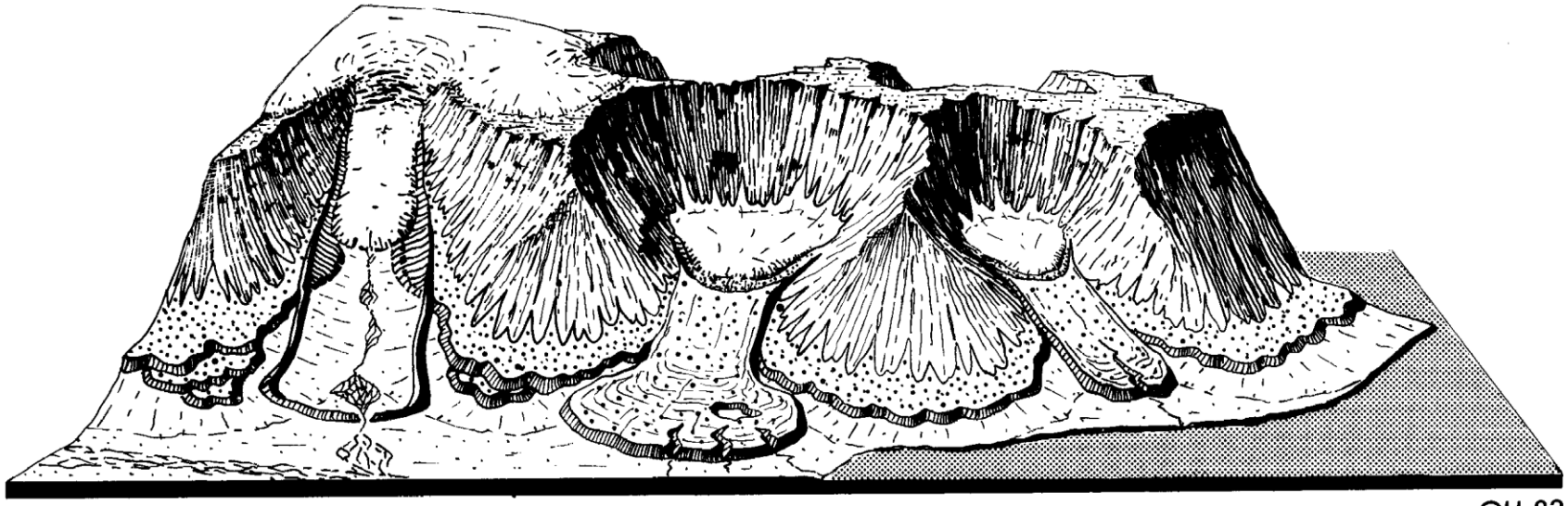

850 m
Supraglacial debris
mean thickness: 2 m
porosity: 40%
350 m high
50 deg slope
RILA
320 m
Frontal apron
and overridden scree
mean thickness: 61 m
porosity: 40%
1400 m
Ice
90 m
Former valley bottom


Free rock face
Ice
ELA
DIRTY GLACIER
Moraine
Lodgement till
Stagnant ice

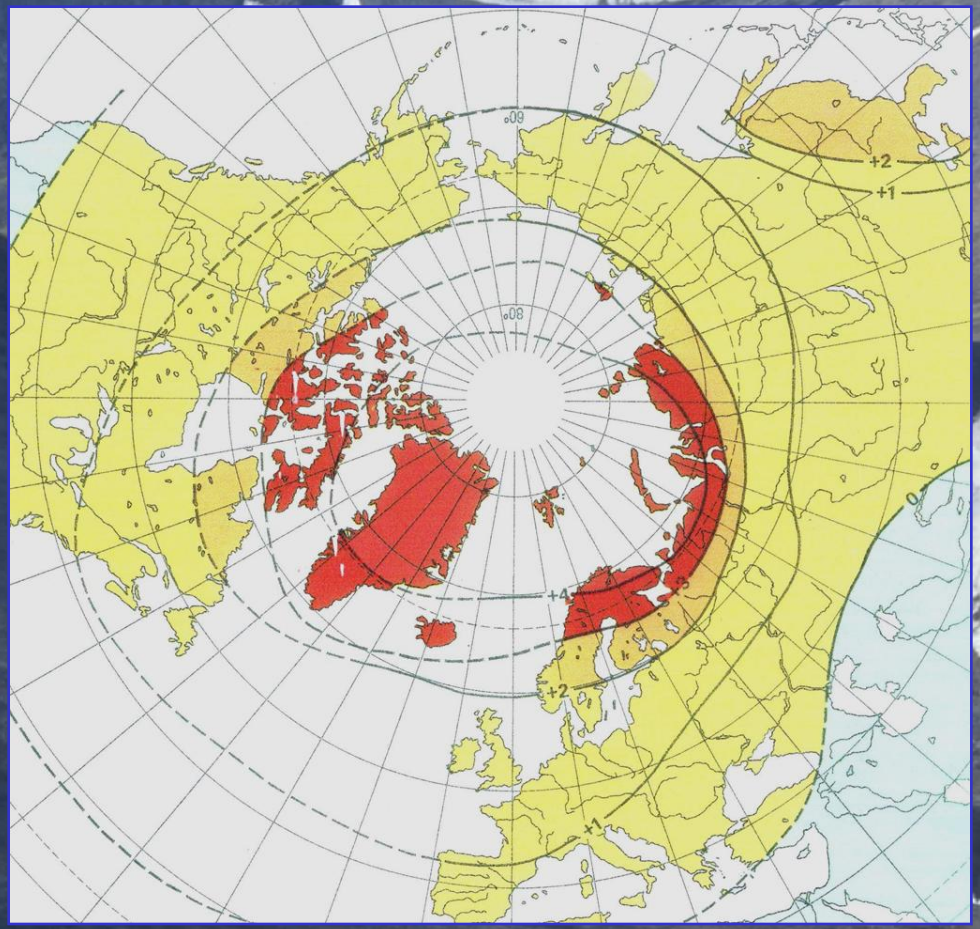

Free rock face
Dirty snow avalanches
ELA
Ice
GLACIER-DERIVED ROCK GLACIER
Supraglacial debris
Overridden scree
Scree

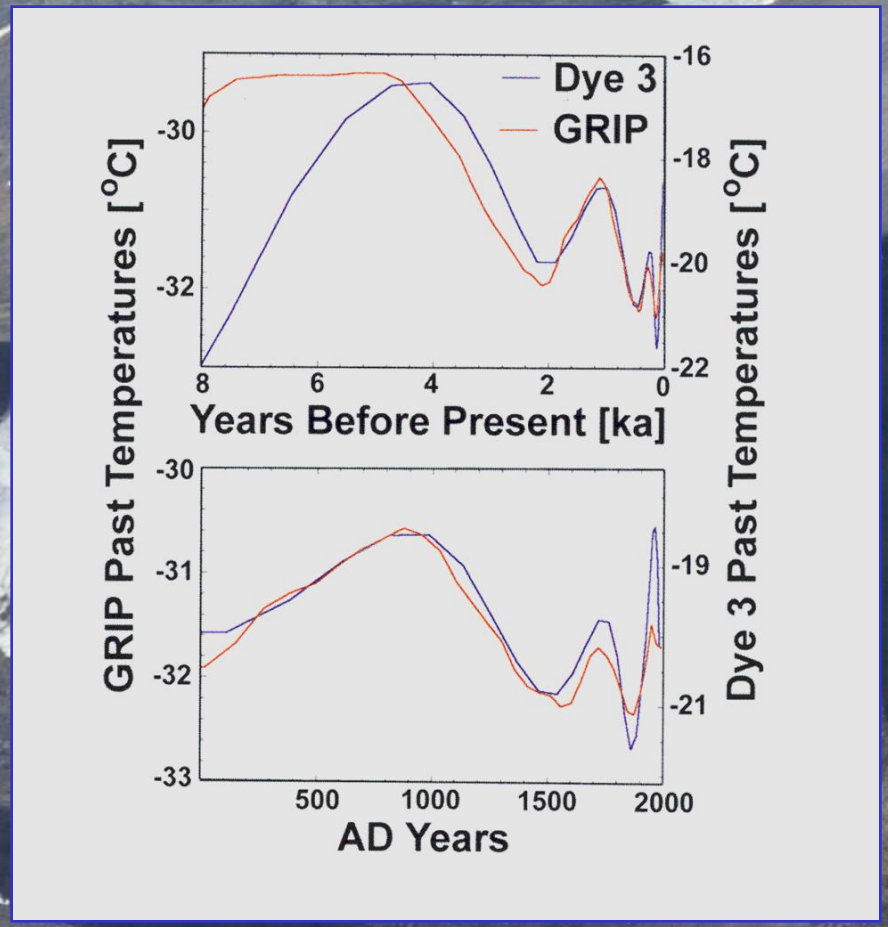
GREENLAND

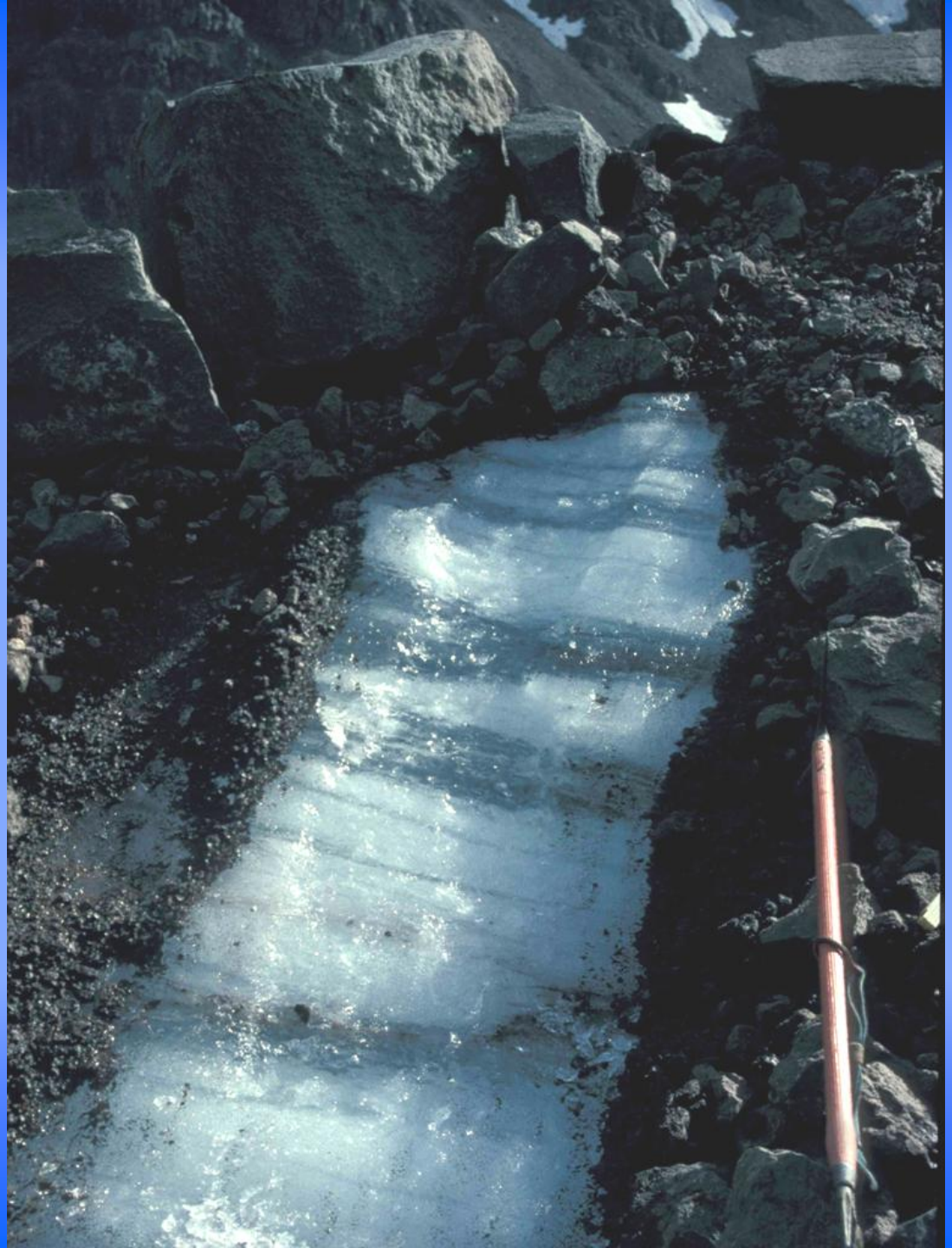
ROCK GLACIER TYPES, DISKO



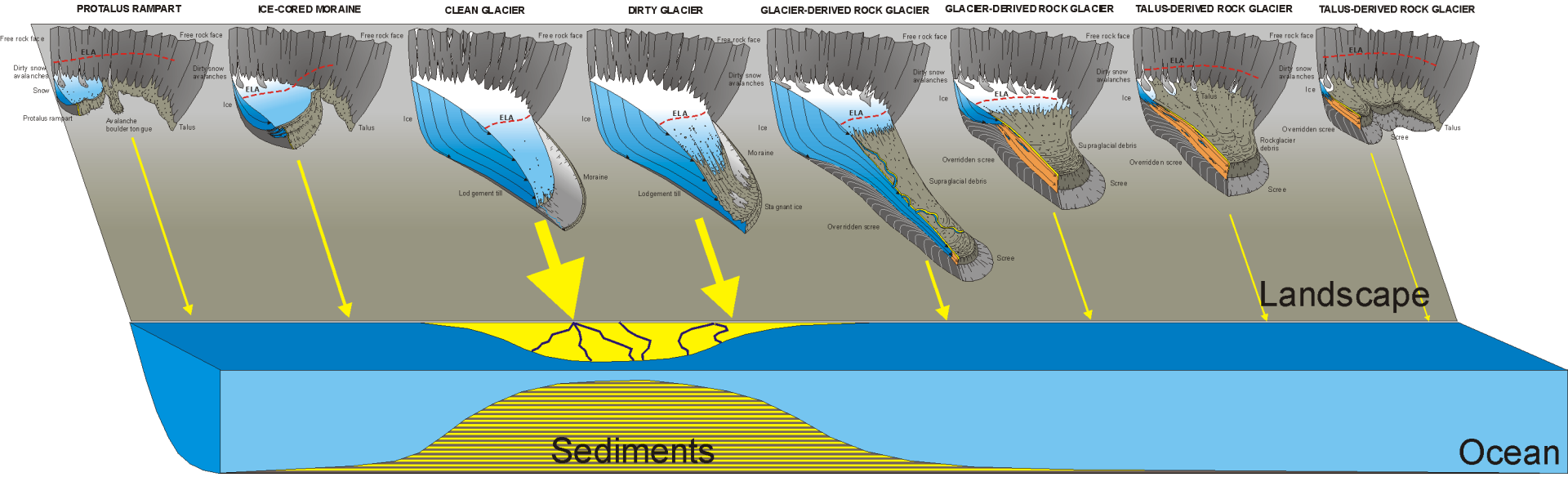
OH 82


+2
+1
+4
+2
+1

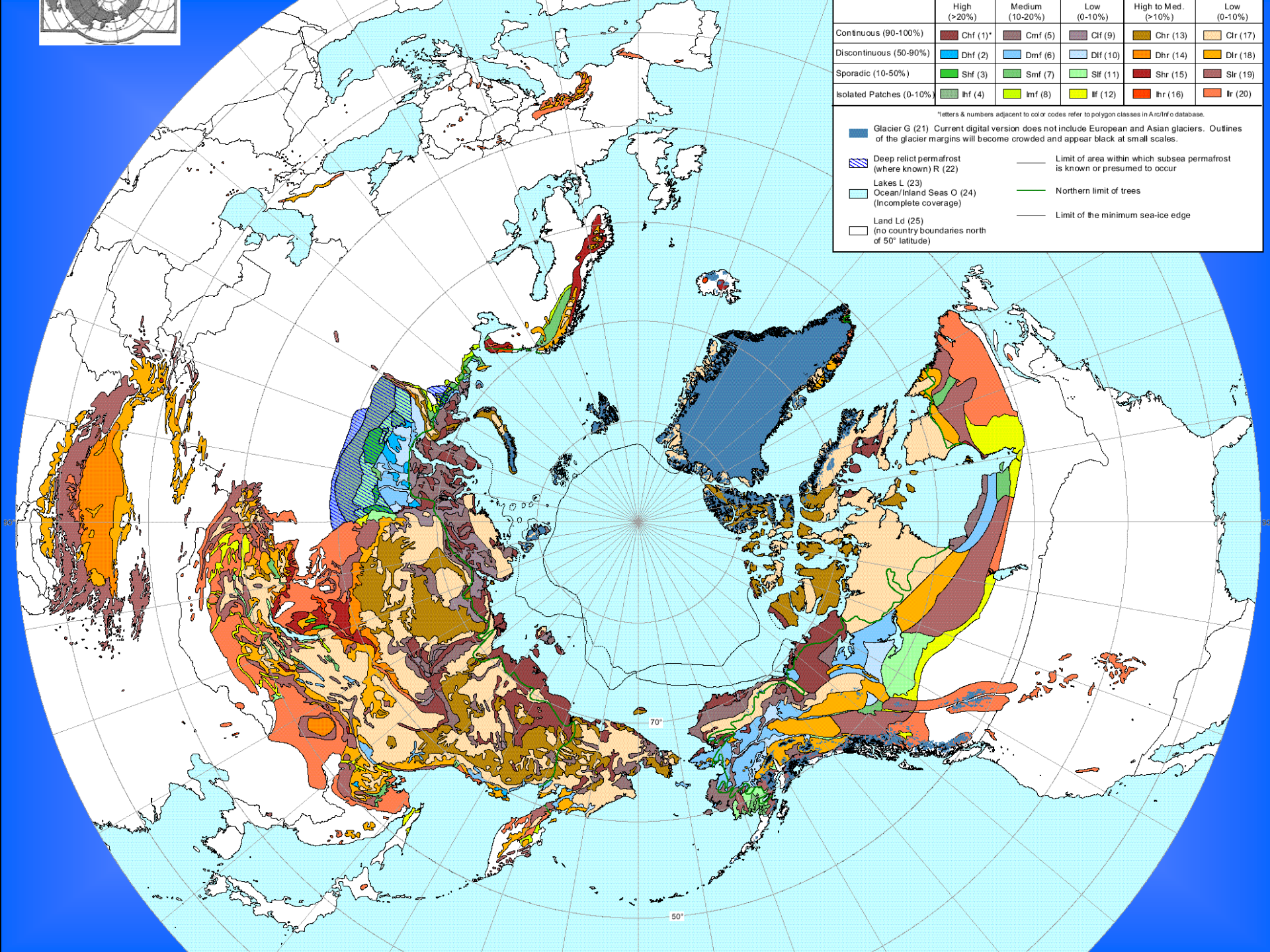

Dye 3
GRIP
-16
-18
-20
-22
-30
-32
8
6
4
2
0
Years Before Present [ka]
GRIP Past Temperatures [°C]
Dye 3 Past Temperatures [°C]
-30
-31
-32
-33
-19
-21
500
1000
1500
2000
AD Years



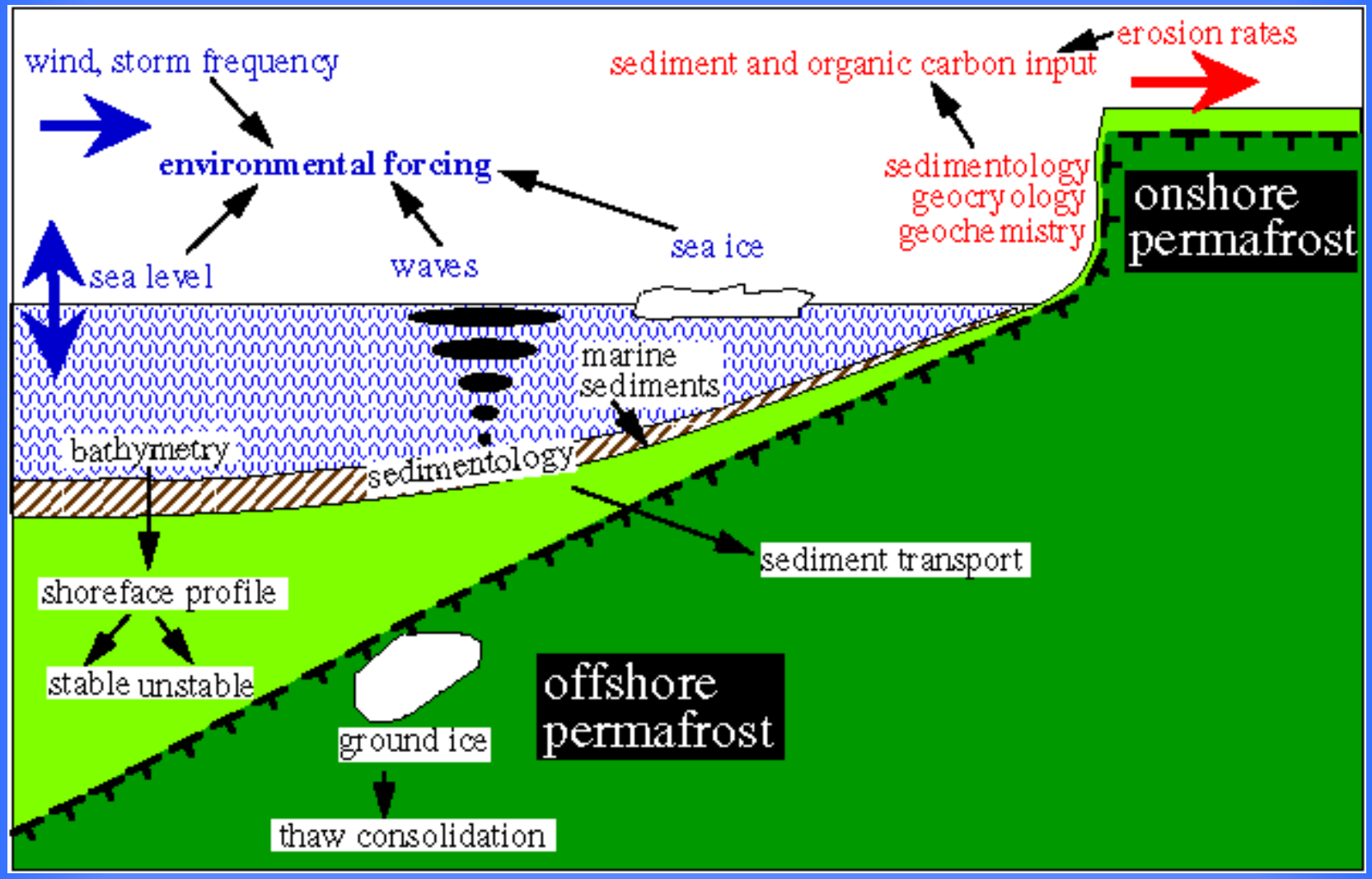
Efficient transport agents:


PROTALUS RAMPART
ICE-CORED MORAINE
CLEAN GLACIER
DIRTY GLACIER
GLACIER-DERIVED ROCK GLACIER
GLACIER-DERIVED ROCK GLACIER
TALUS-DERIVED ROCK GLACIER
TALUS-DERIVED ROCK GLACIER
Free rock face
Dirty snow avalanches
Snow
ELA
Protalus rampart
Avalanche boulder tongue
Talus
Ice
Moraine
Lodgement till
Stagnant ice
Overridden scree
Supraglacial debris
Scree
Rockglacier debris
Landscape
Sediments
Ocean

Deglaciation in permafrost regions:


High (>20%)
Medium (10-20%)
Low (0-10%)
High to Med. (>10%)
Low (0-10%)
Continuous (90-100%)
Chf (1)*
Cmf (5)
Clf (9)
Chr (13)
Clr (17)
Discontinuous (50-90%)
Dhf (2)
Dmf (6)
Dlf (10)
Dhr (14)
Dlr (18)
Sporadic (10-50%)
Shf (3)
Smf (7)
Slf (11)
Shr (15)
Slr (19)
Isolated Patches (0-10%)
Ihf (4)
Imf (8)
Ilf (12)
Ihr (16)
Ilr (20)
*letters & numbers adjacent to color codes refer to polygon classes in Arc/Info 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
70°
50°

Ice complex, Lena Delta (Foto A. Sher)


wind, storm frequency
environmental forcing
sea level
waves
sea ice
sediment and organic carbon input
erosion rates
sedimentology
geocryology
geochemistry
onshore permafrost
marine sediments
bathymetry
sedimentology
sediment transport
shoreface profile
stable unstable
ground ice
offshore permafrost
thaw consolidation

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Basal processes beneath an Arctic glacier and their geomorphic imprint after a surge, Elisebreen, Svalbard

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Received 24 March 2004
Available online 15 July 2005

PERMAFROST AND PERIGLACIAL PROCESSES
Permafrost Periglac. Process. **9**: 107–120 (1998)

Thermal Regimes Beneath Coarse Blocky Materials

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