Erosional Forms and Landscapes

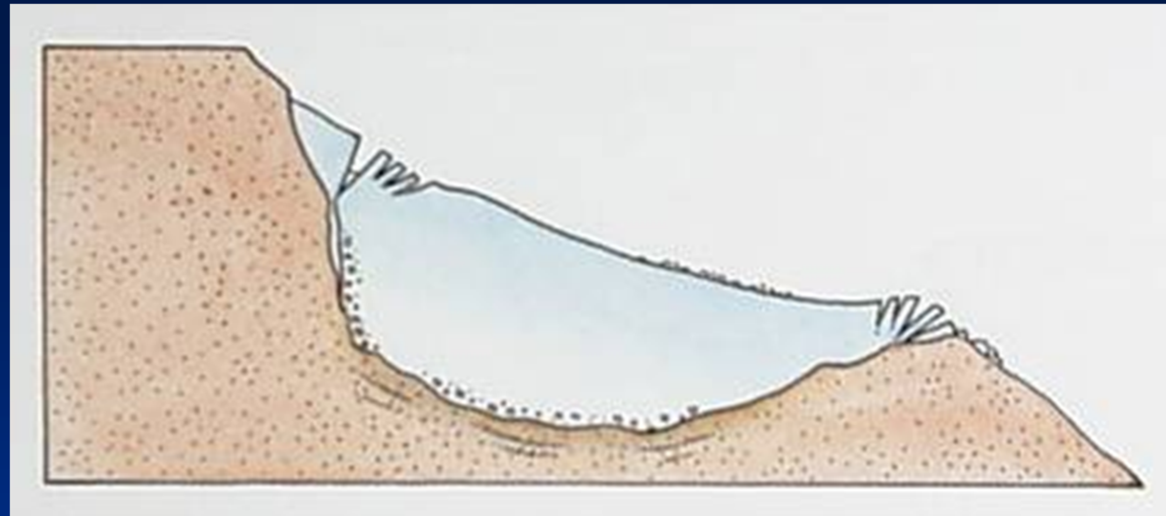
Cirques

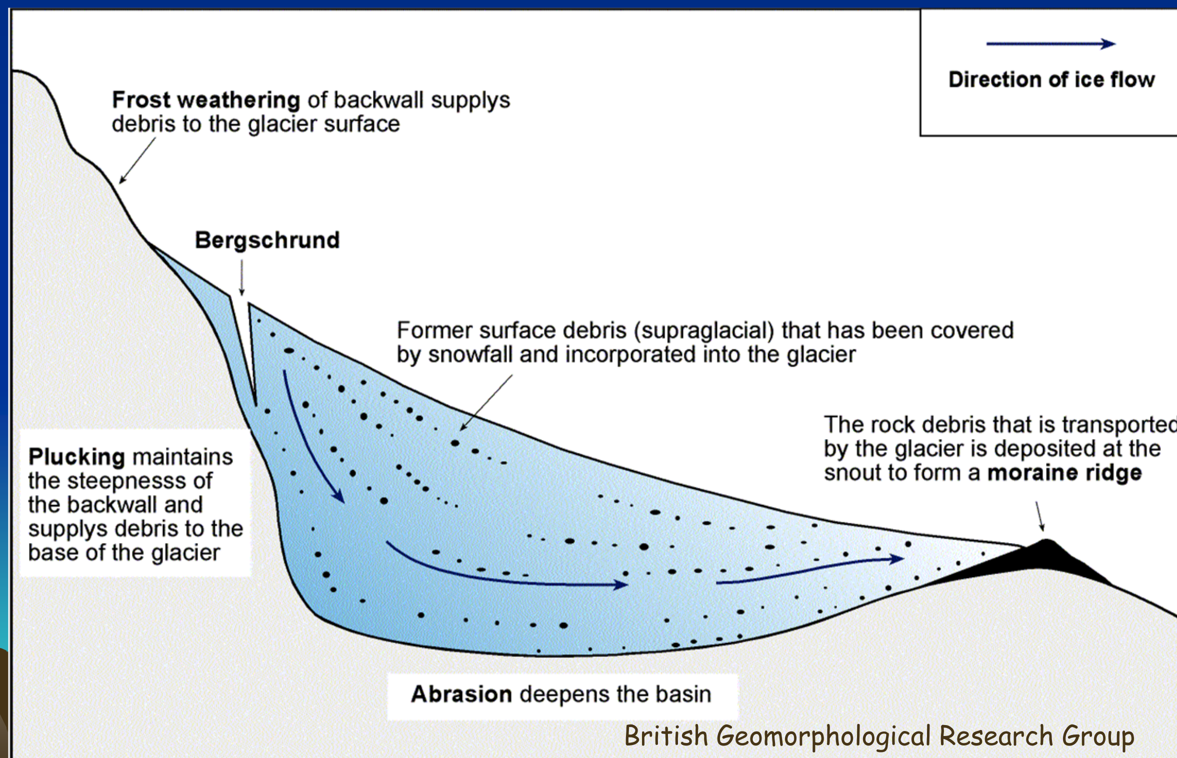
Many Forms

Red Tarn Cirque Basin, English Lake District
British Geomorphological Research Group

Process

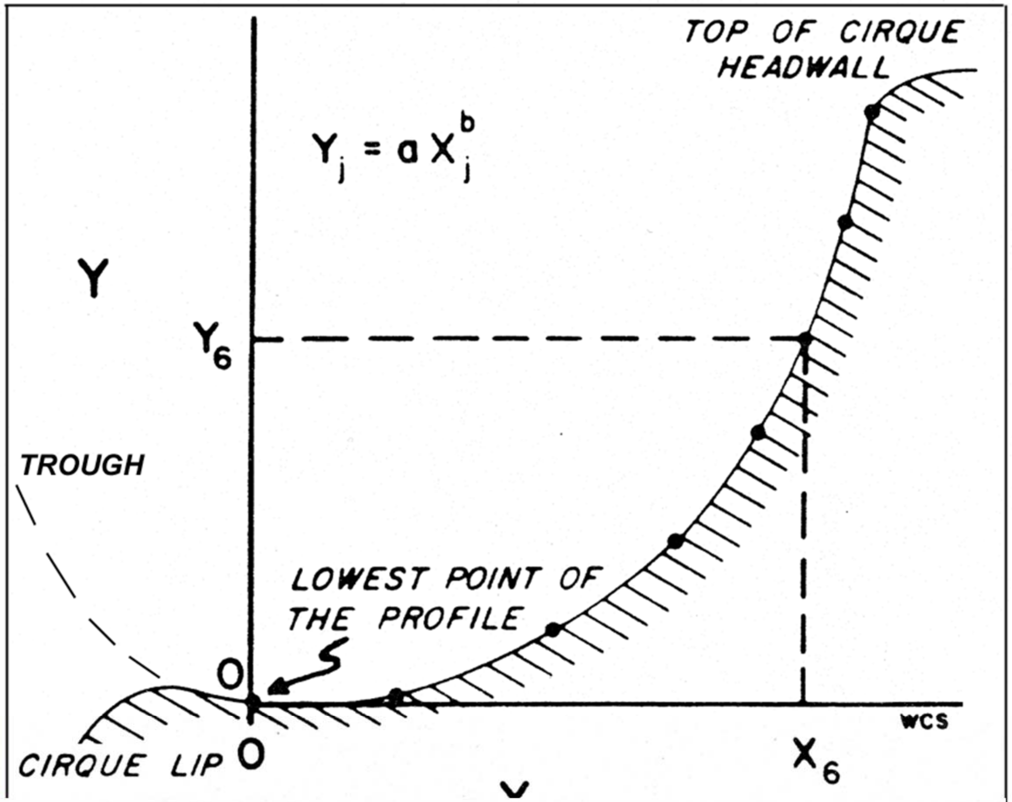
- Rotational Flow
- Headwall
  - Back movement
- Floor
  - Overdeepening
- ELA
  - Max. erosion

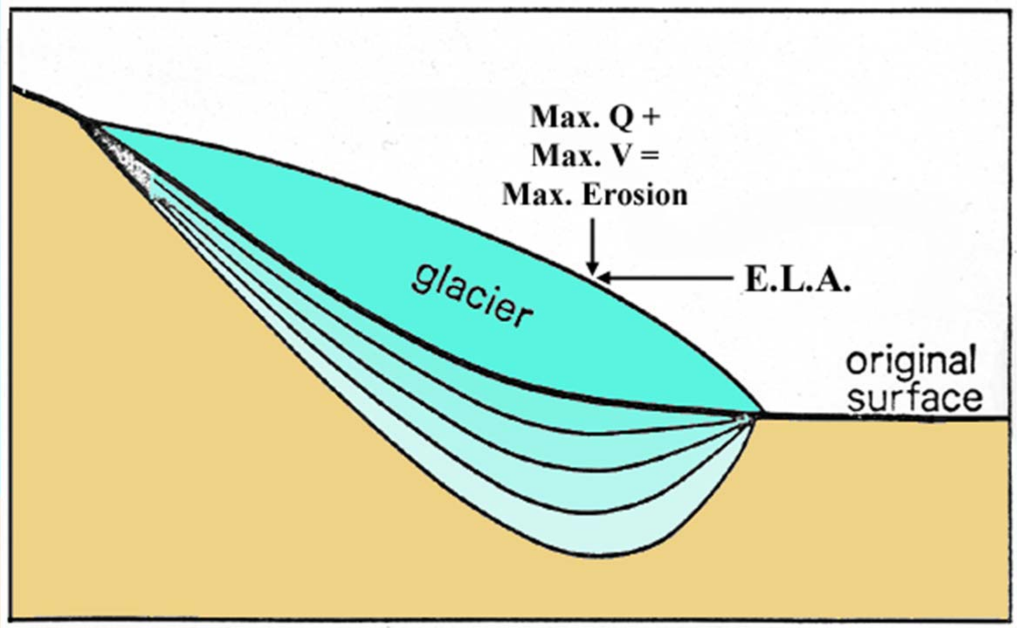




Cirque Form

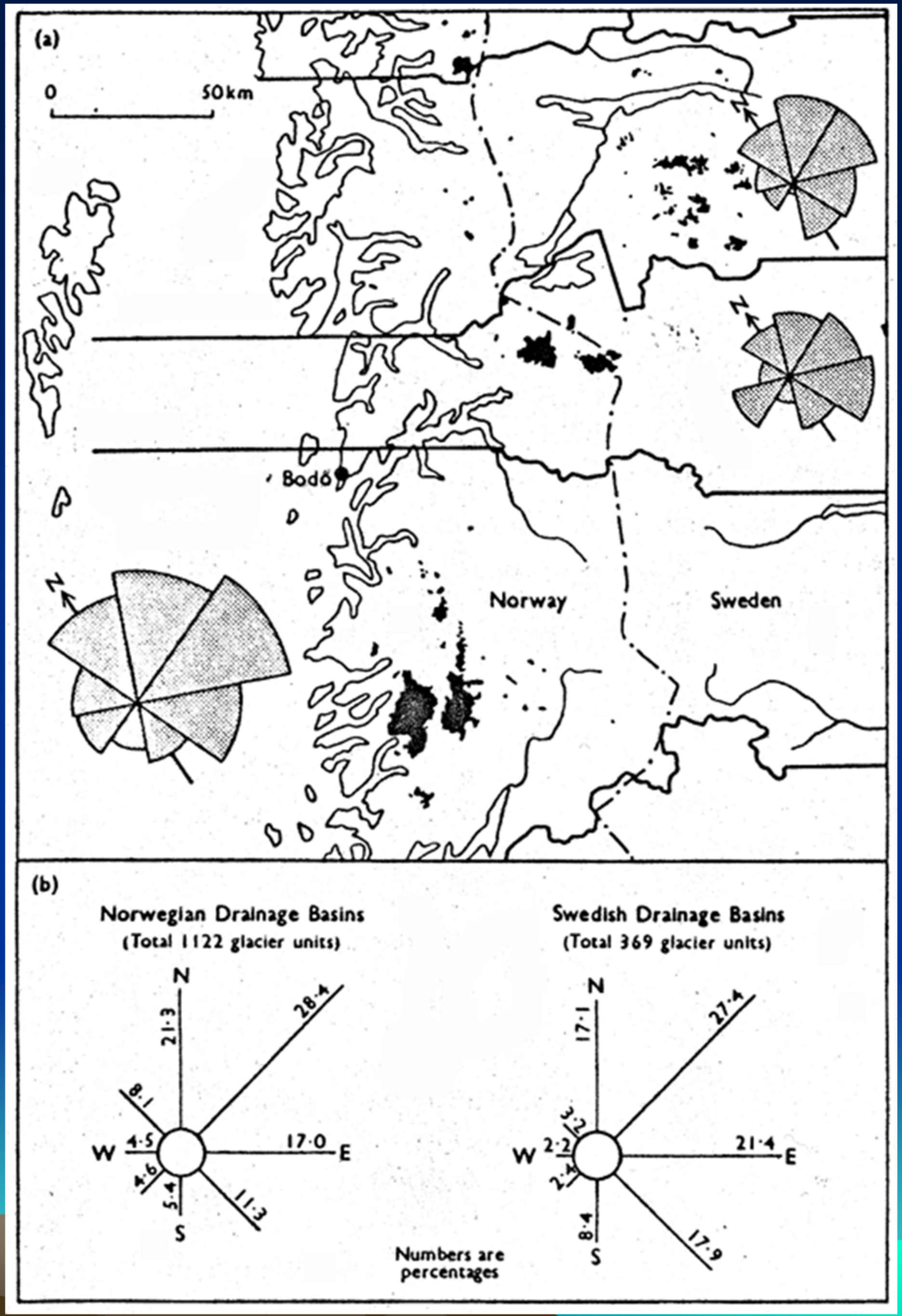
- Exponential
- Process
  - Overdeepened
  - Max work @ ELA
  - Tarns



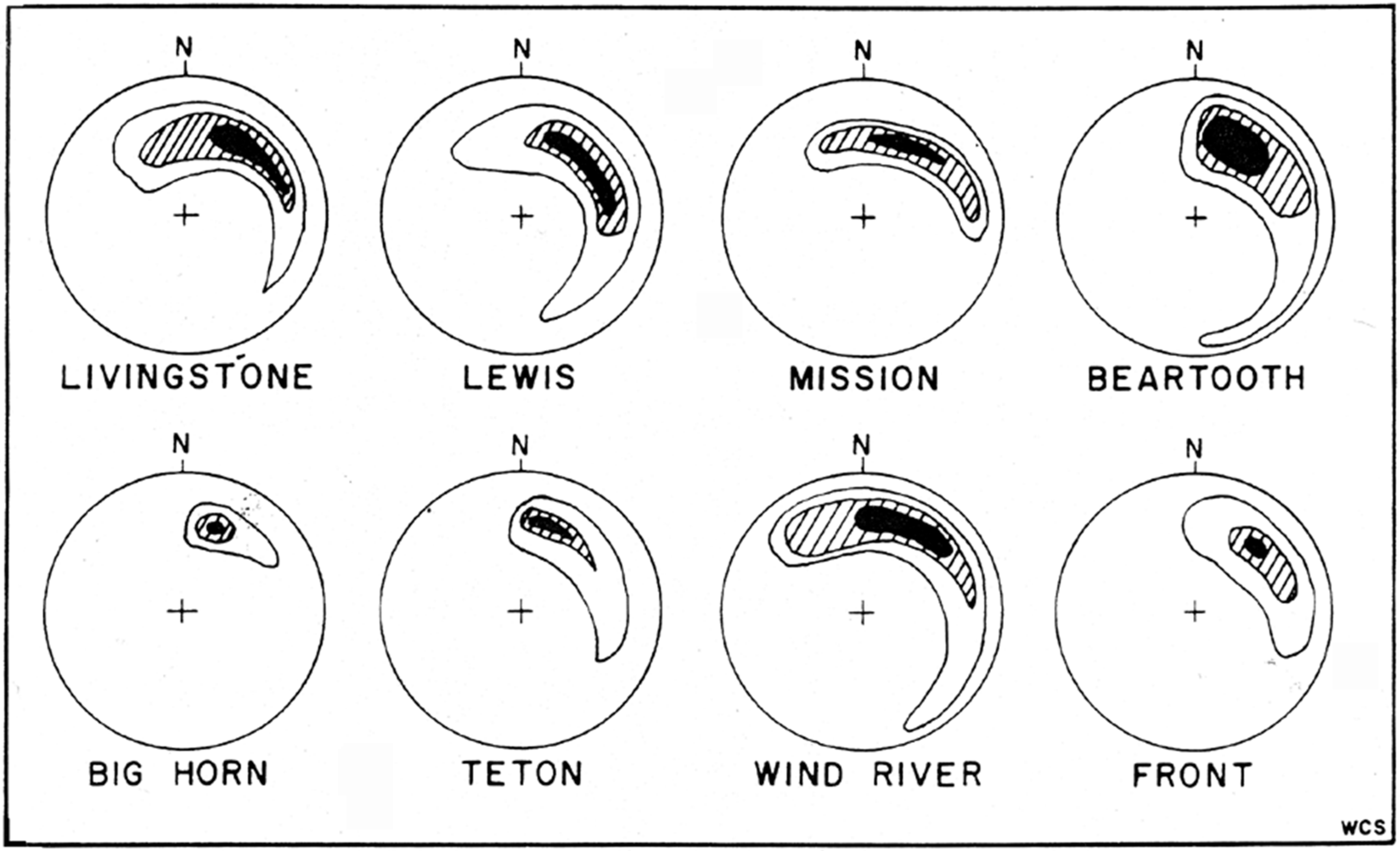


Cirque Orientation

- Any orientation is possible
  - Commonly to NE in Northern Hemisphere



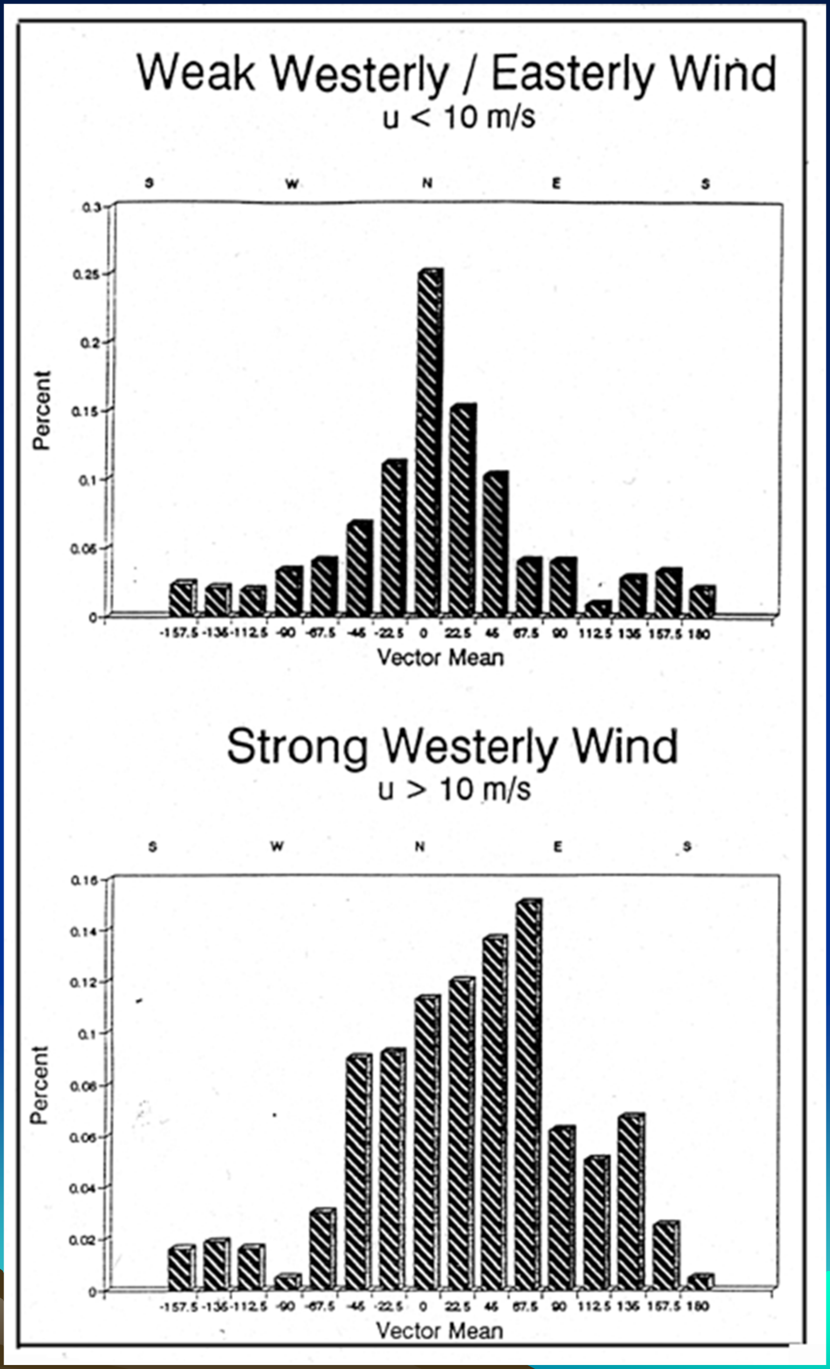
Cirque Orientation



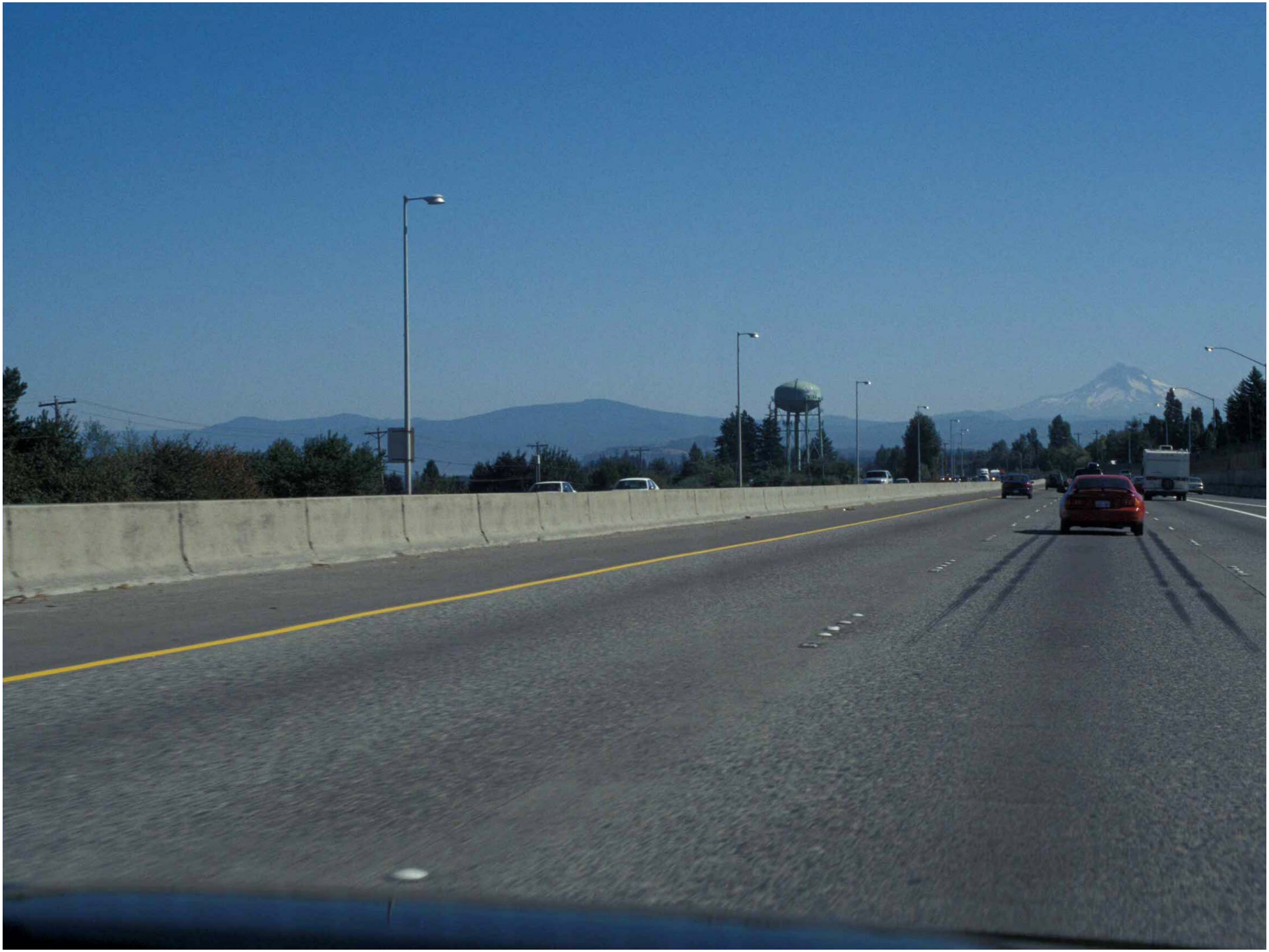
Why to NE in the North America?

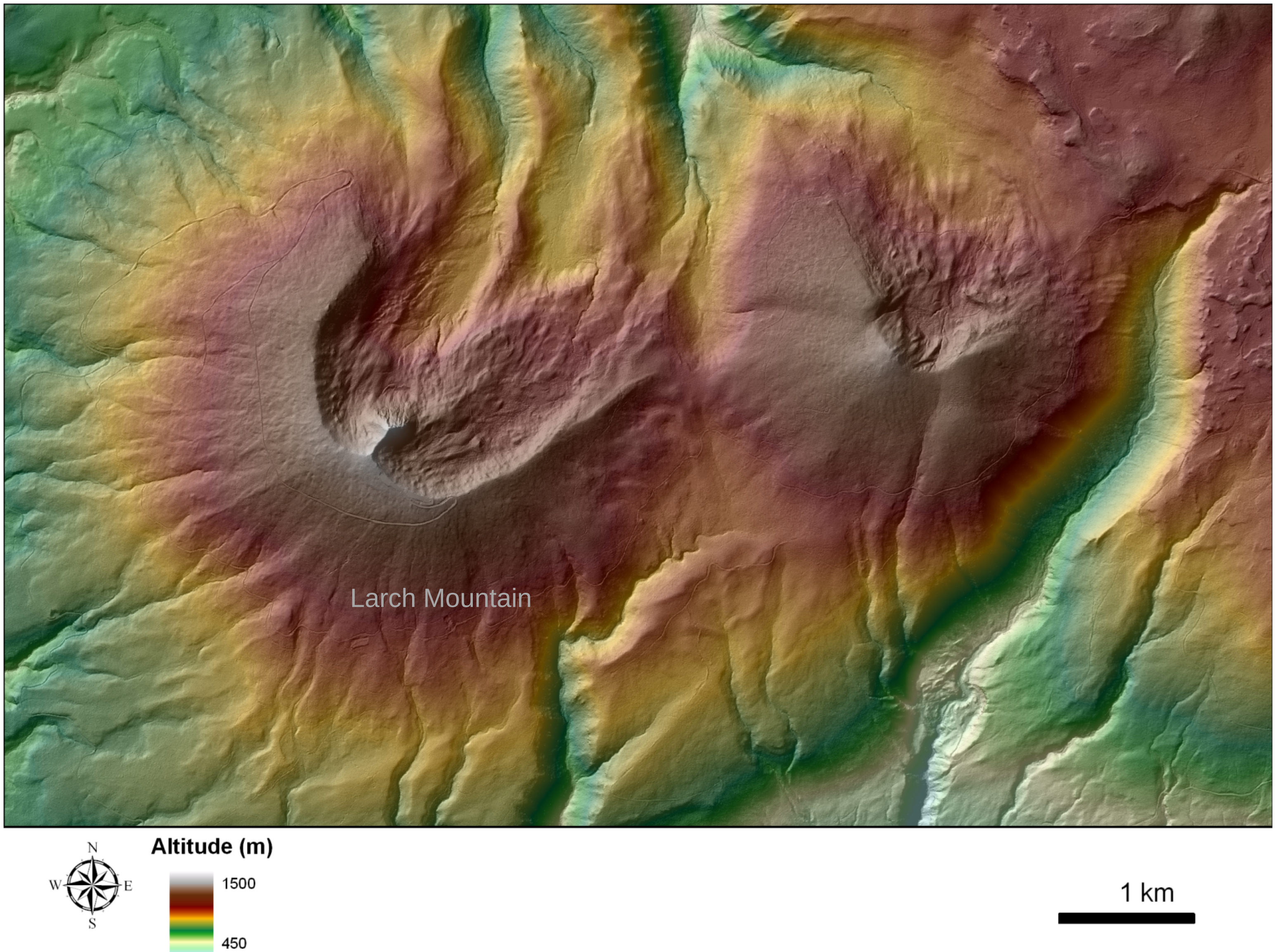
- Insolation + sensible heat transfer?

- Effect of wind drifting?



Where is the closest cirque to Portland?





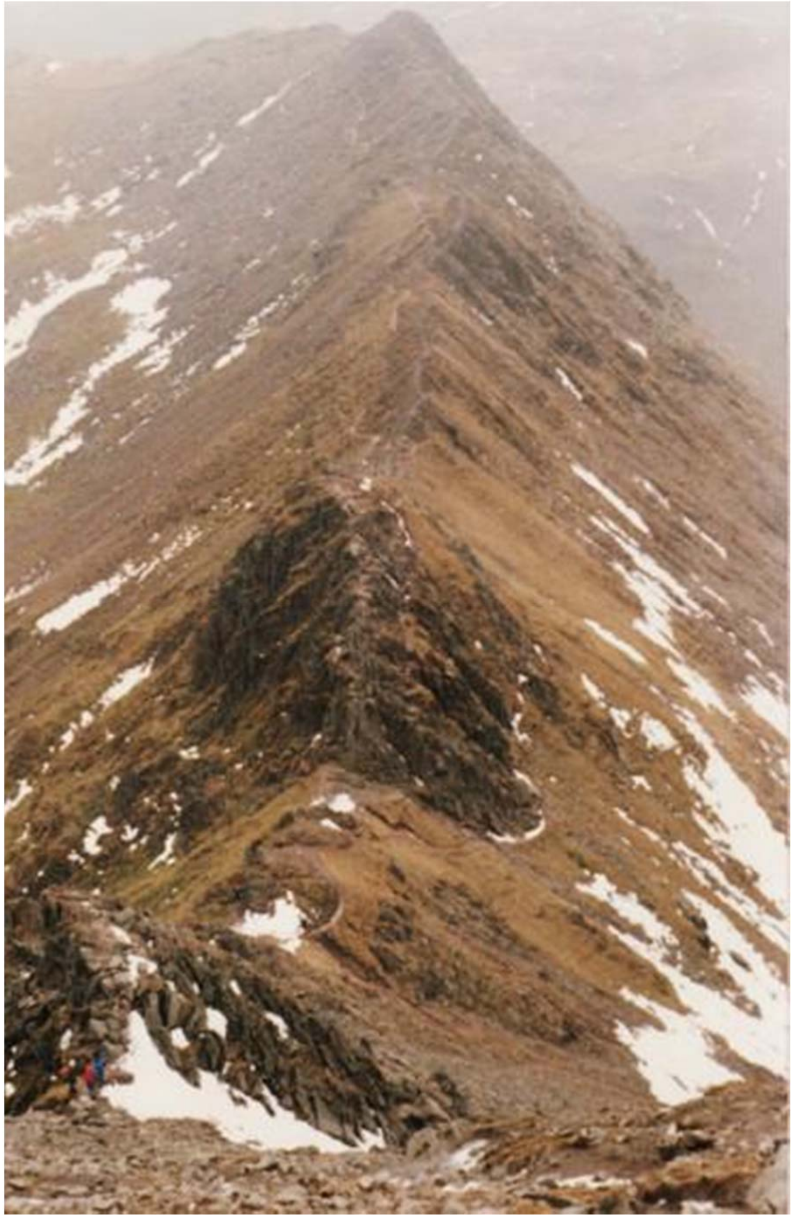
Portland LiDAR Consortium

Arêtes

- Jointing and mass wasting (two cirques)

Lake District, England

Arête des Domes de Miage

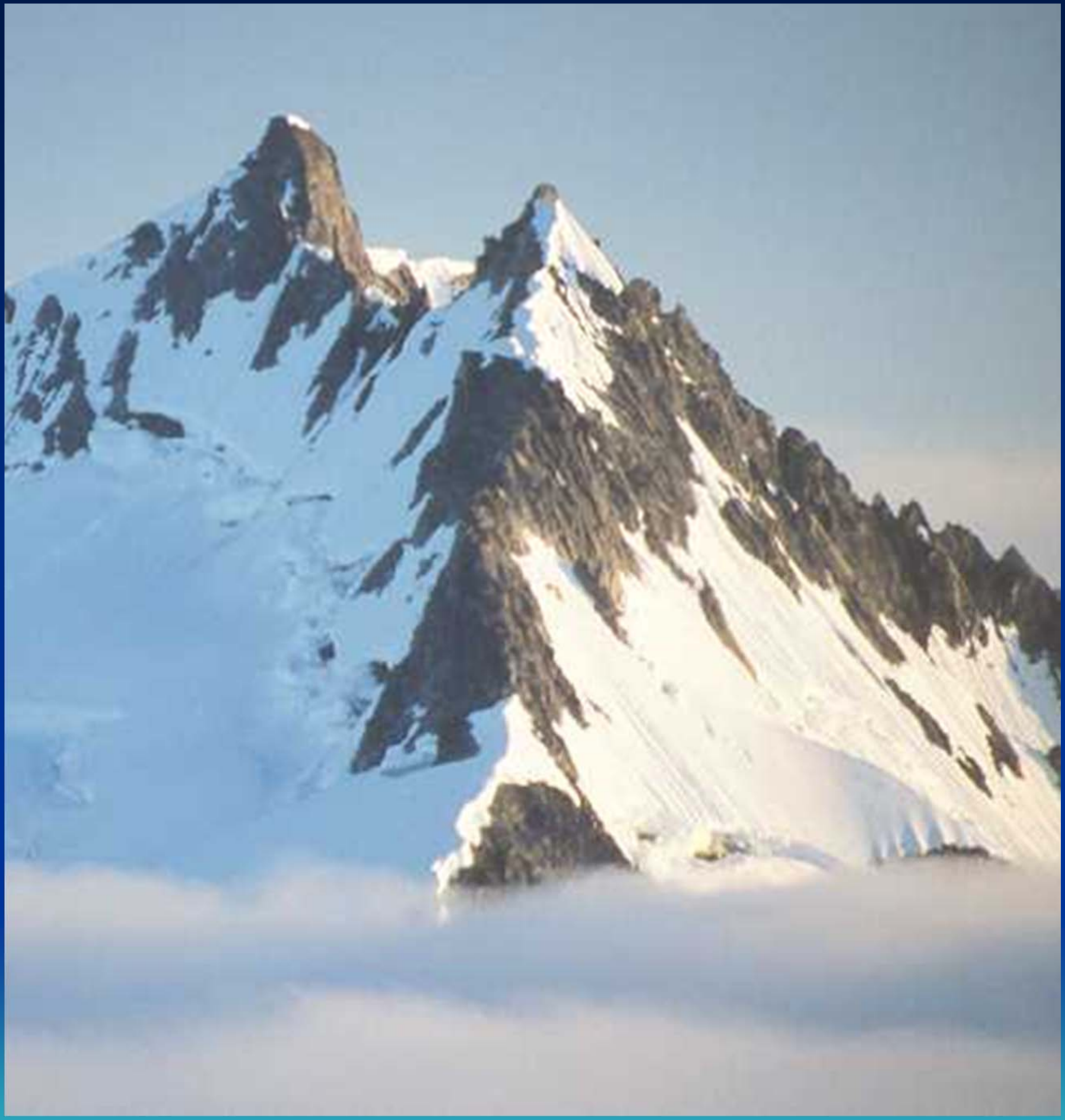


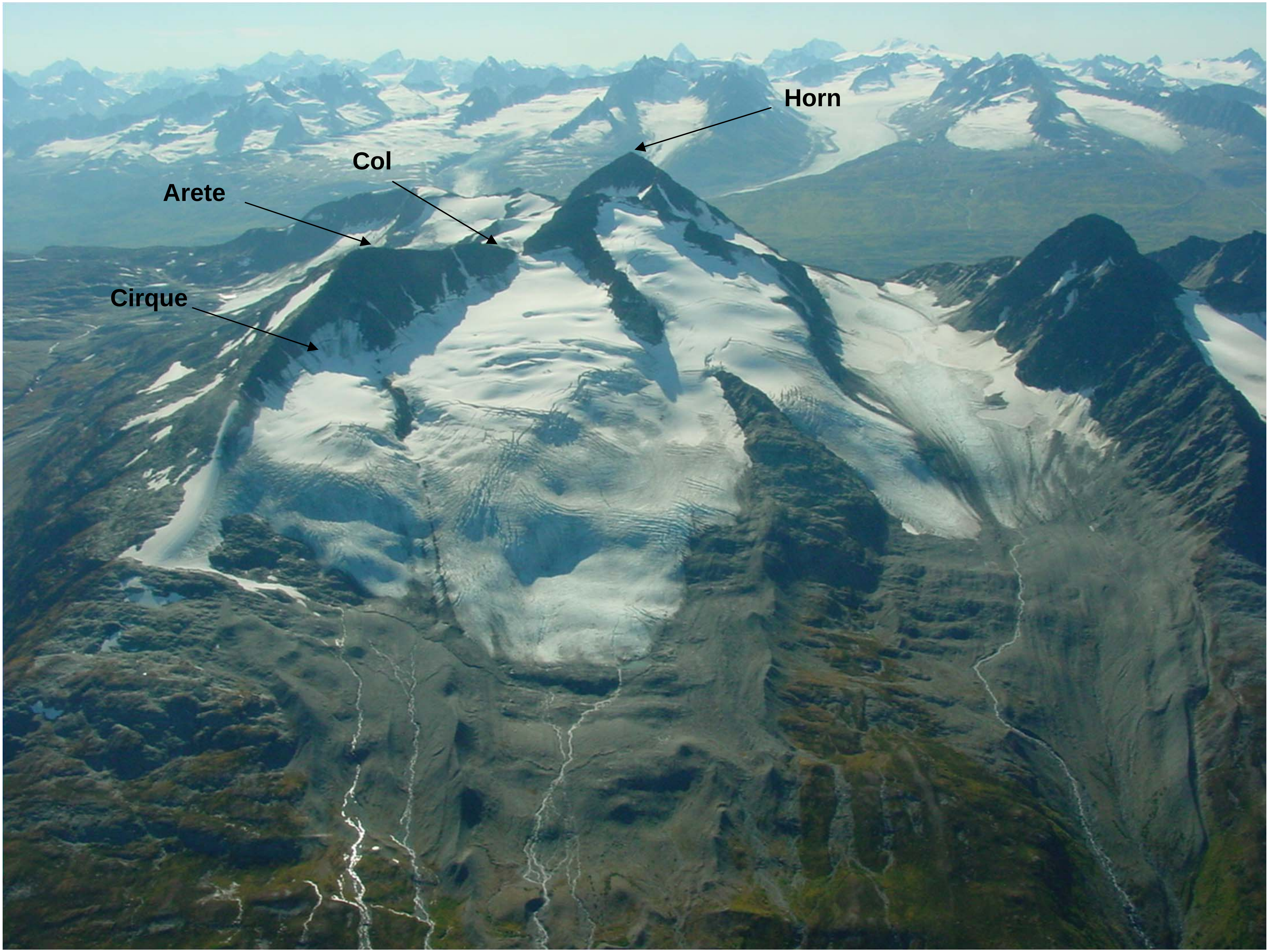
Internet Geography, UK
http://www.bennett.karoo.net/topics/glaciation.html#Hely

Mont Blanc Massif
http://fabriceb.verof.free.fr/randos/Dom_Miag/deroule.htm

Arêtes and Horns

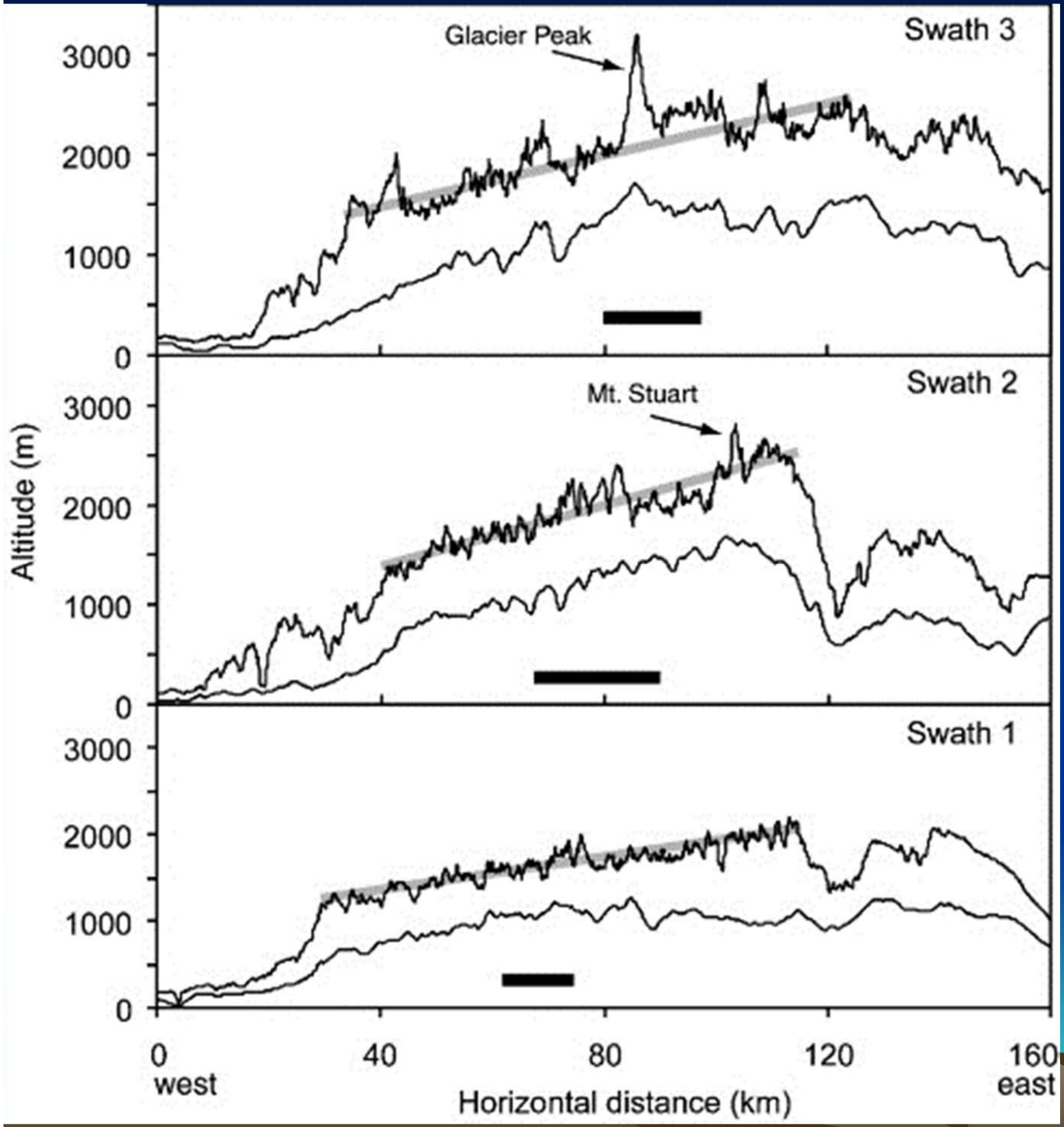
- Jointing and mass wasting (two cirques)
- Coalescence of three or more cirques




Horn
Col
Arete
Cirque

ELA

- Cirque vs. valley glacier
- Altitude



- Washington Cascades
  - ridge and average elevations

Glacial buzz-saw: do average cirque elevations → Cascade erosion?

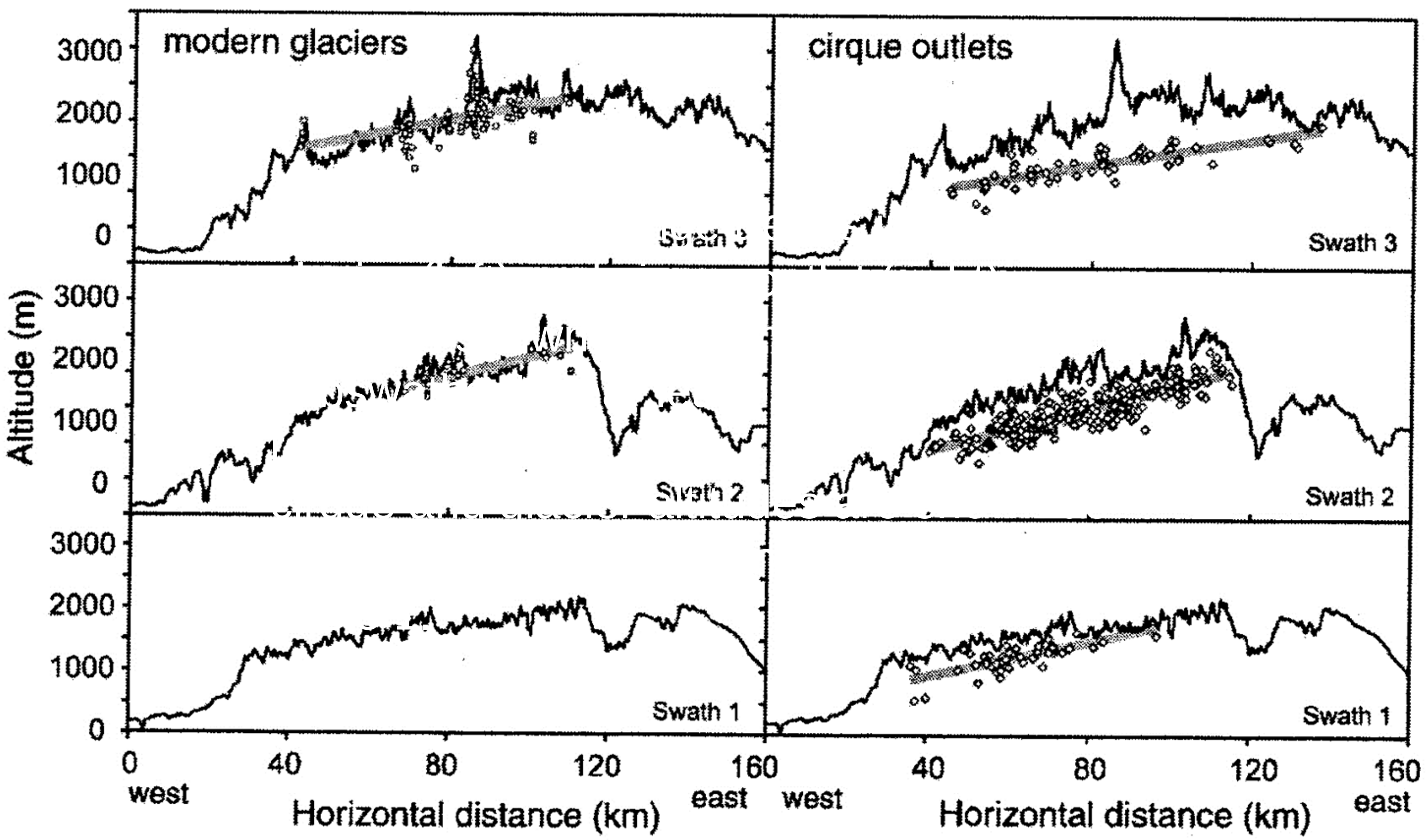
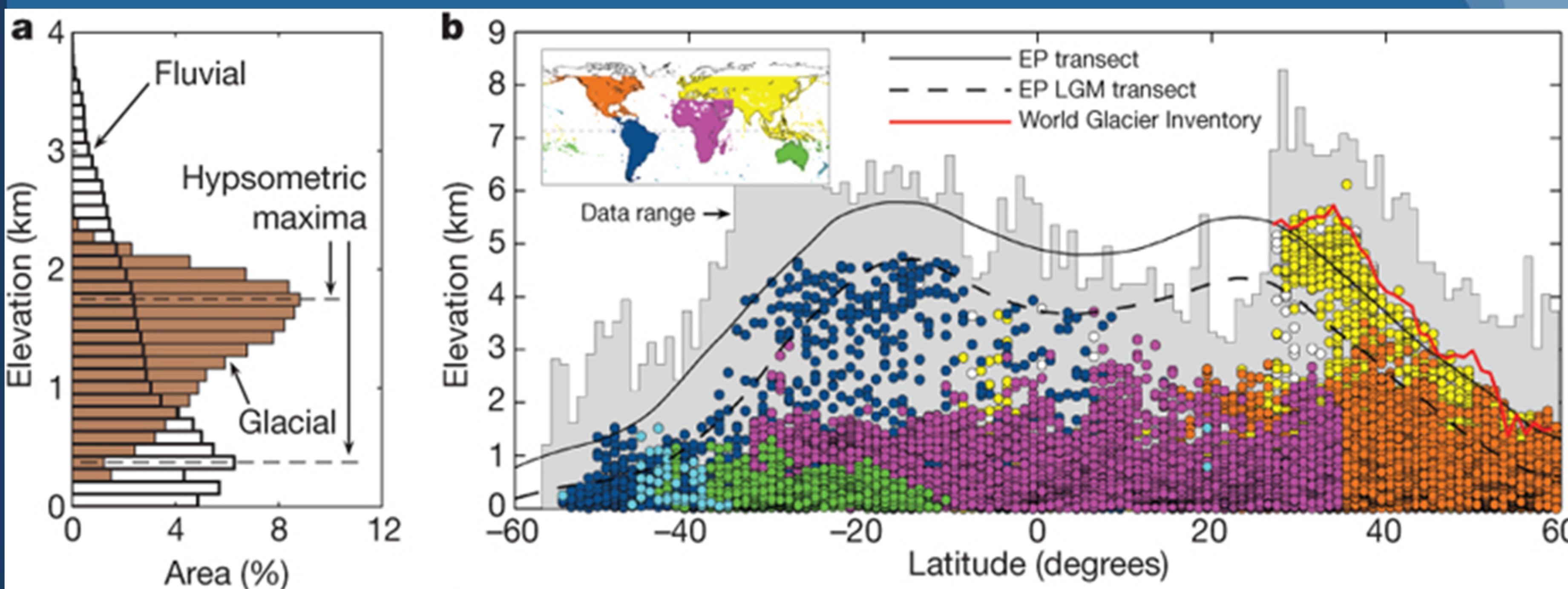


Figure 5. Cross-range trends in average glacier (left) and cirque outlet (right) altitudes shown on the three topographic subswaths. Linear least-square regressions of cirque and glacier altitudes are shown as thick gray lines; slope and R^2 values are in Table 1.

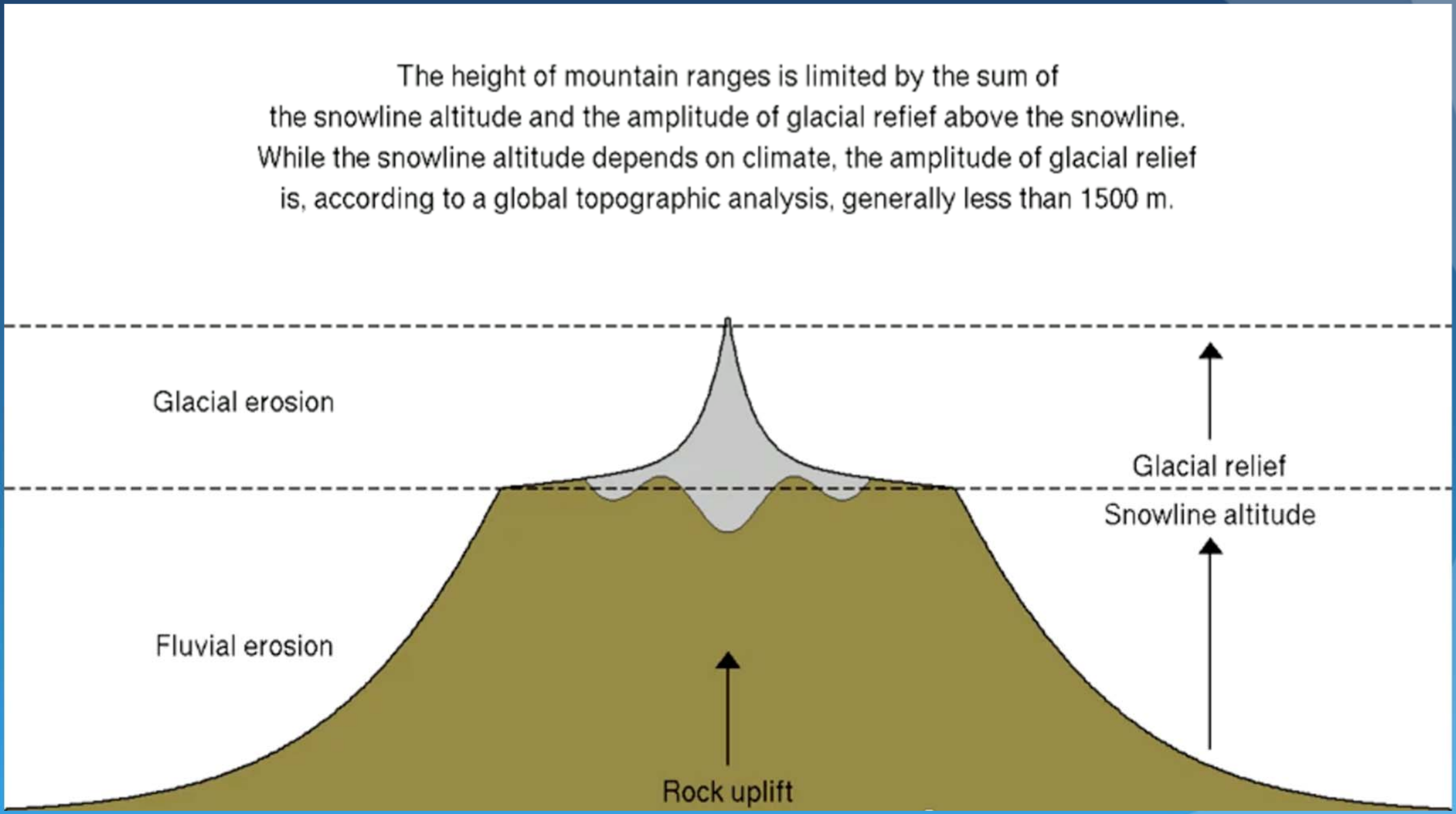
Cirques ⟶ the "glacial buzzsaw"

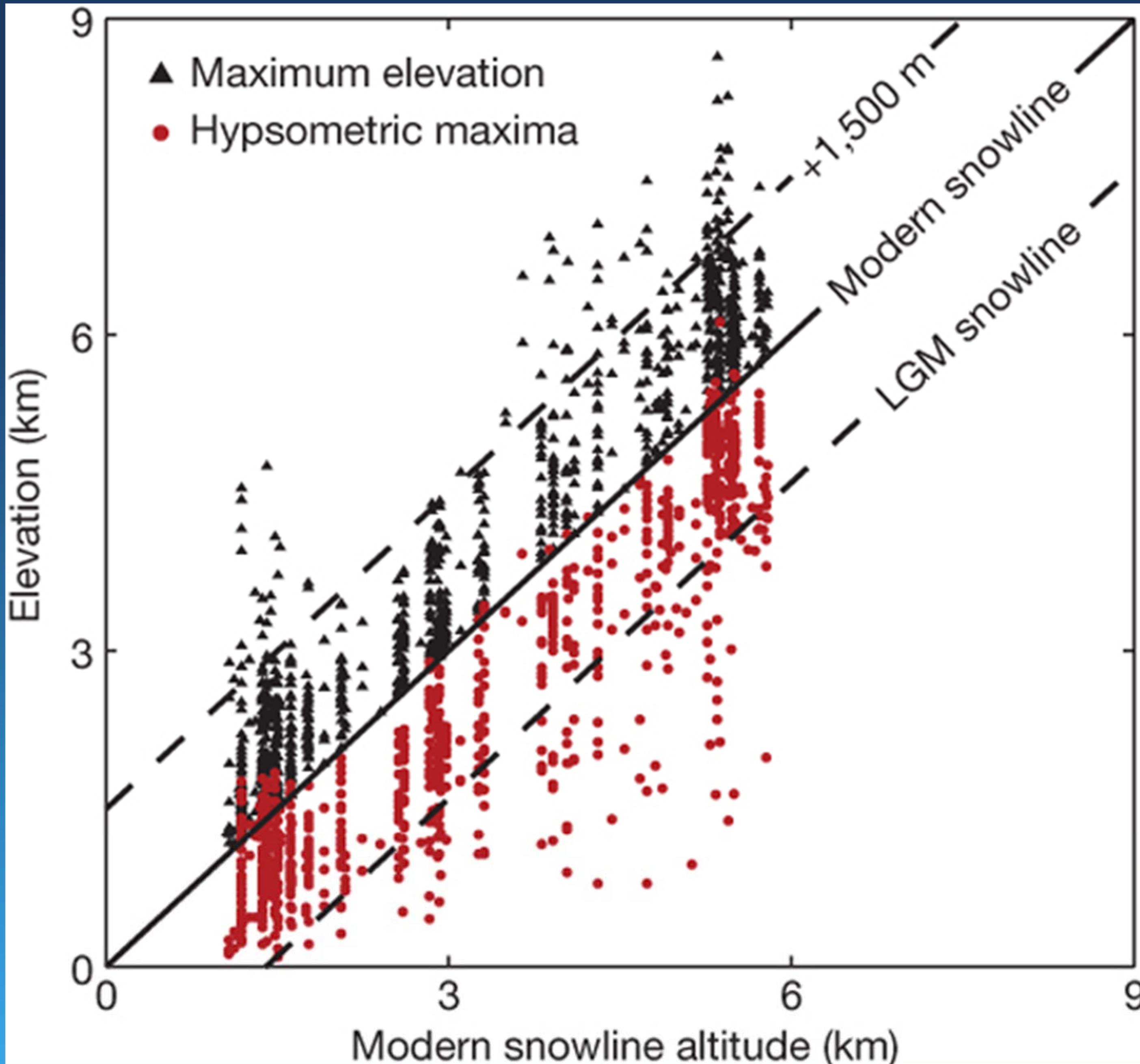
- Tectonic uplift, crustal strength vs. glaciation
- Hypothesis: hypsometric maxima correspond with snowlines and glaciers (≈1500m above snow line)



Egholm, 2009

The glacial buzzsaw – how does it work?





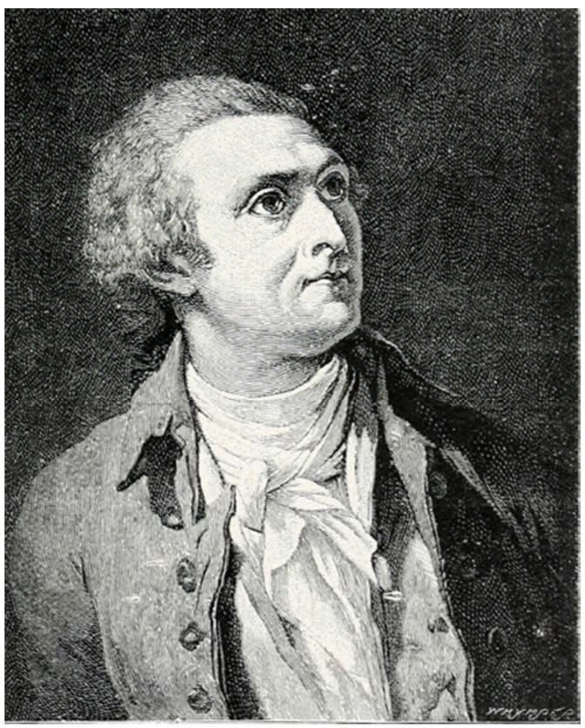
Maximum elevation
Hypsometric maxima
+1,500 m
Modern snowline
LGM snowline
Elevation (km)
Modern snowline altitude (km)
0
3
6
9

Egholm, 2009

Roche Moutonee

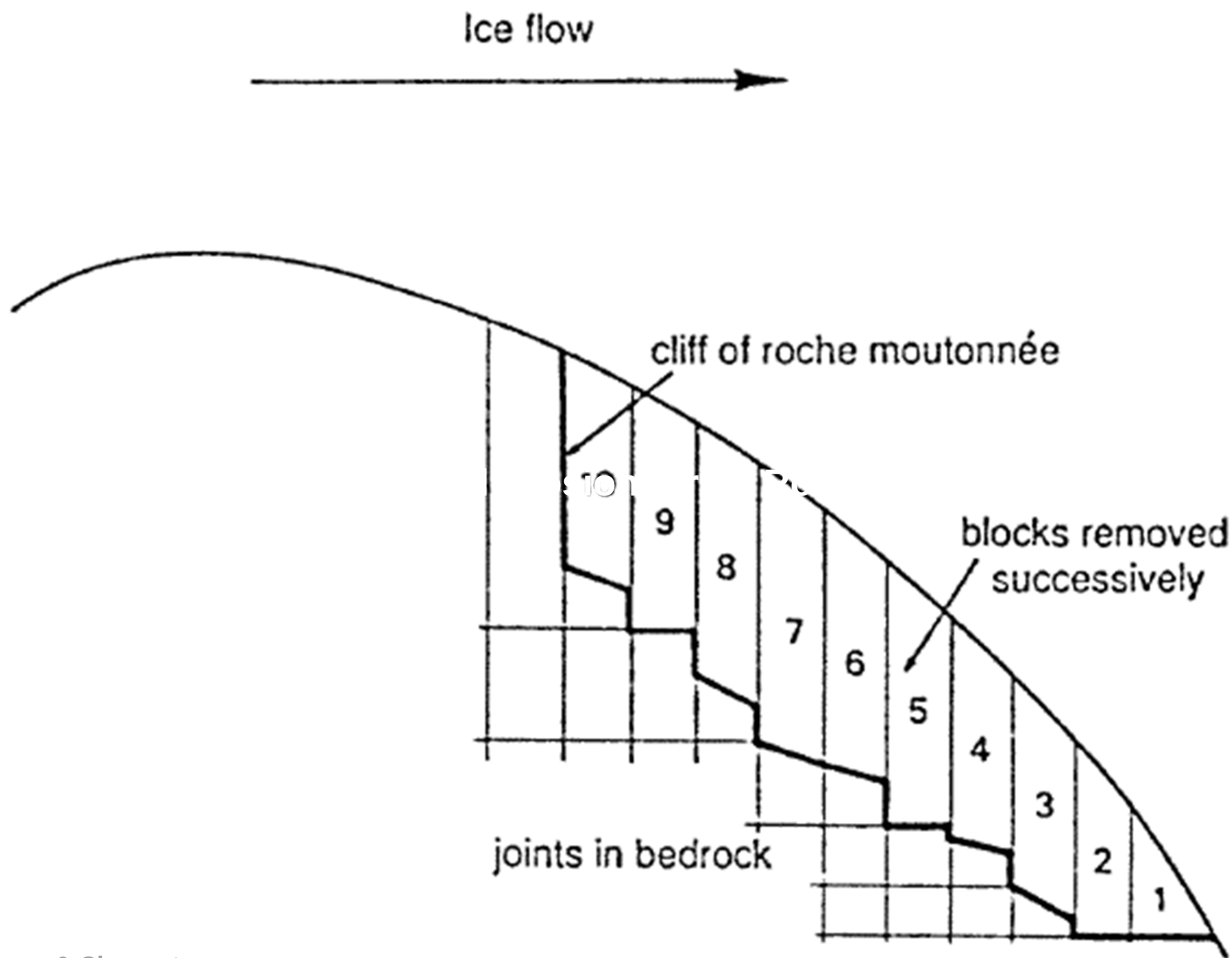
A rock which has been shaped by ice flowing over it.

The side from which the ice came is smooth which the side in the direction in which the ice departed is steep and has been plucked by the ice.



This asymmetrical erosion indicates the direction of ice movement. It often has striations (scratches)

The 18th-century Alpine explorer Horace-Bénédict de Saussure coined the term 'roches moutonnées' in 1786. He saw in these rocks a resemblance to the wigs that were fashionable amongst French gentry in his era and which were smoothed over with mutton fat (hence 'moutonnée') so as to keep the hair in place. The French term is often incorrectly interpreted as meaning "sheep rock"Wikipedia



(Sugden, Glasser, & Clapperton, 1992)

Competing Hypothesis

A. Glacial Erosion

B. Preglacial weathering remnants

Topography of Roches Moutonnées depends on:

- horizontal and vertical joints
- lithology
- modified by:
  - glacial erosion
  - weathering

Support for the Weathering Hypothesis

Non-Glacial Areas

Forms that look like Roches Moutonnées are found in non-glaciated areas such as East Africa and Australia

Glacial Areas

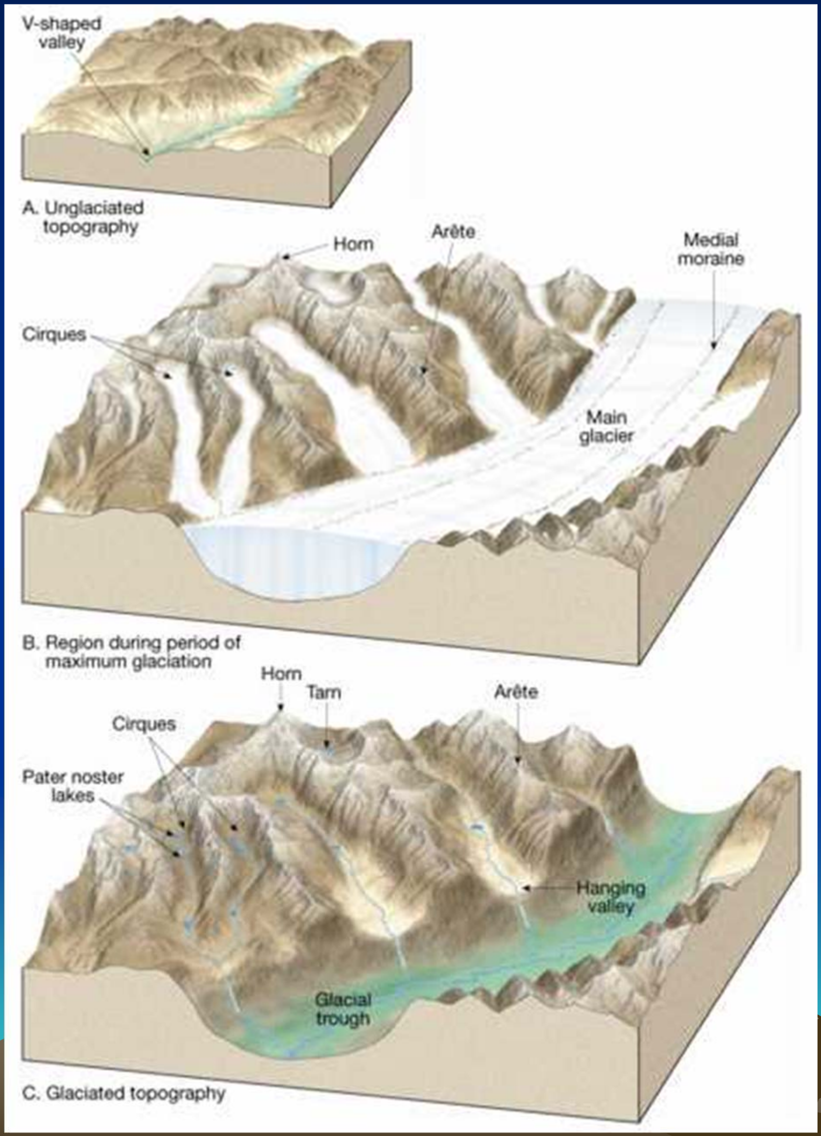
Roches Moutonnées with little or no signs of glacial erosion

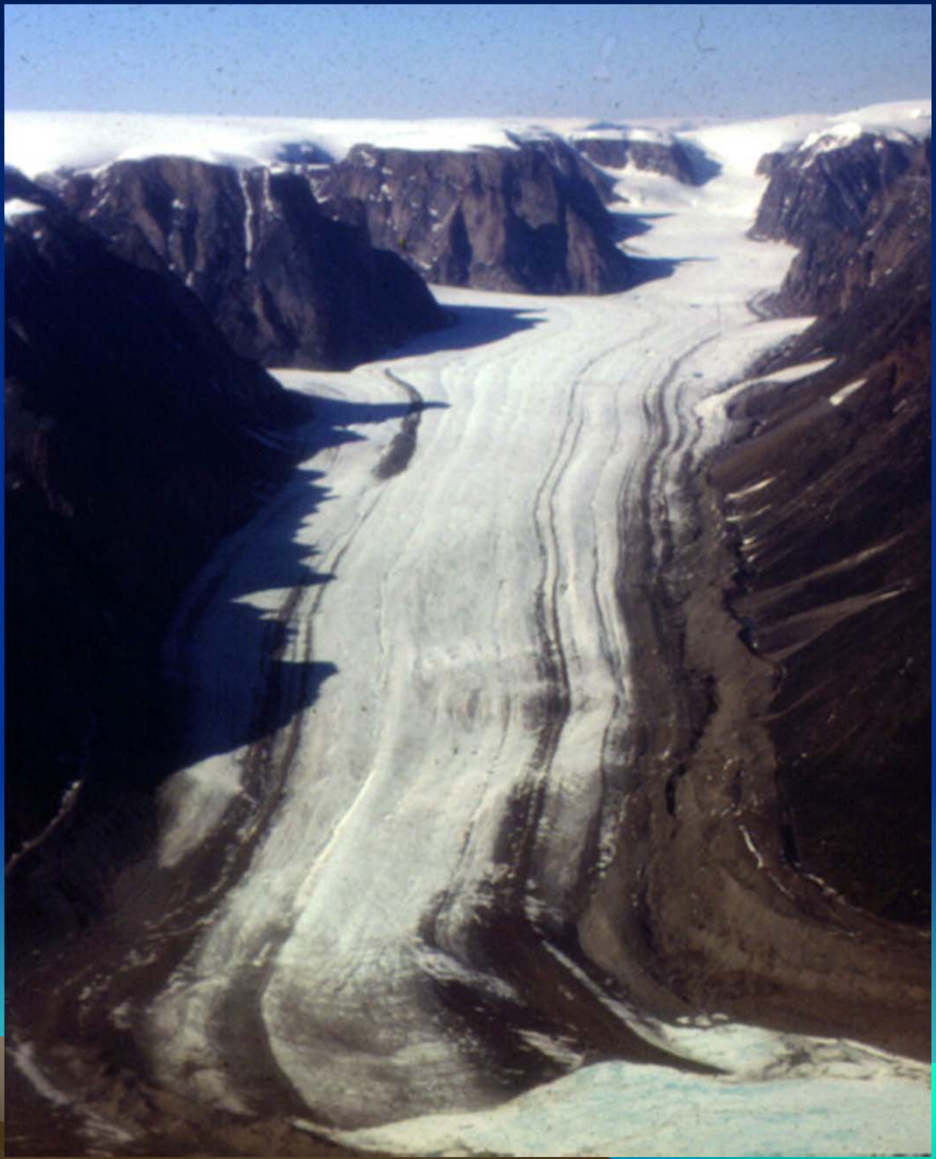
(Lindstroem, 1988)

Troughs

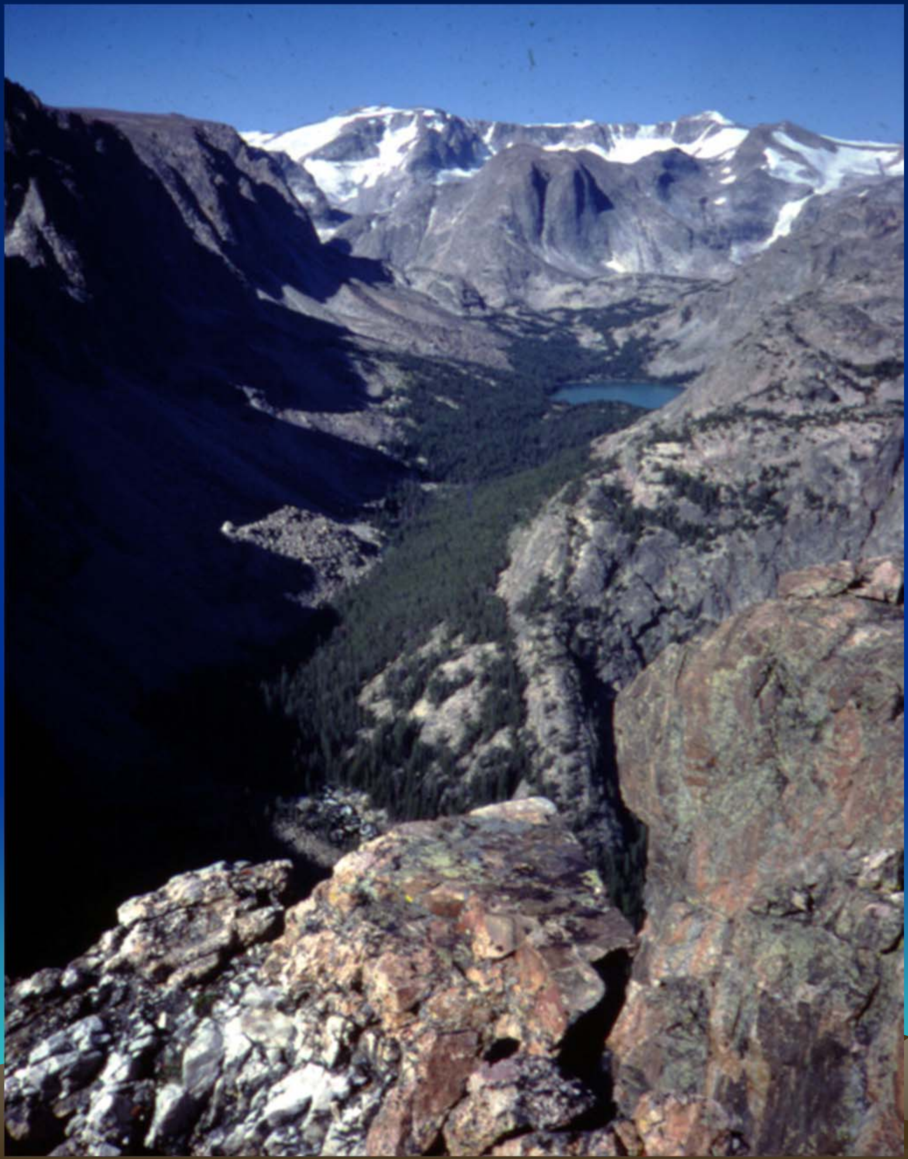
- "U" shaped
  - X-section area = f(Q)

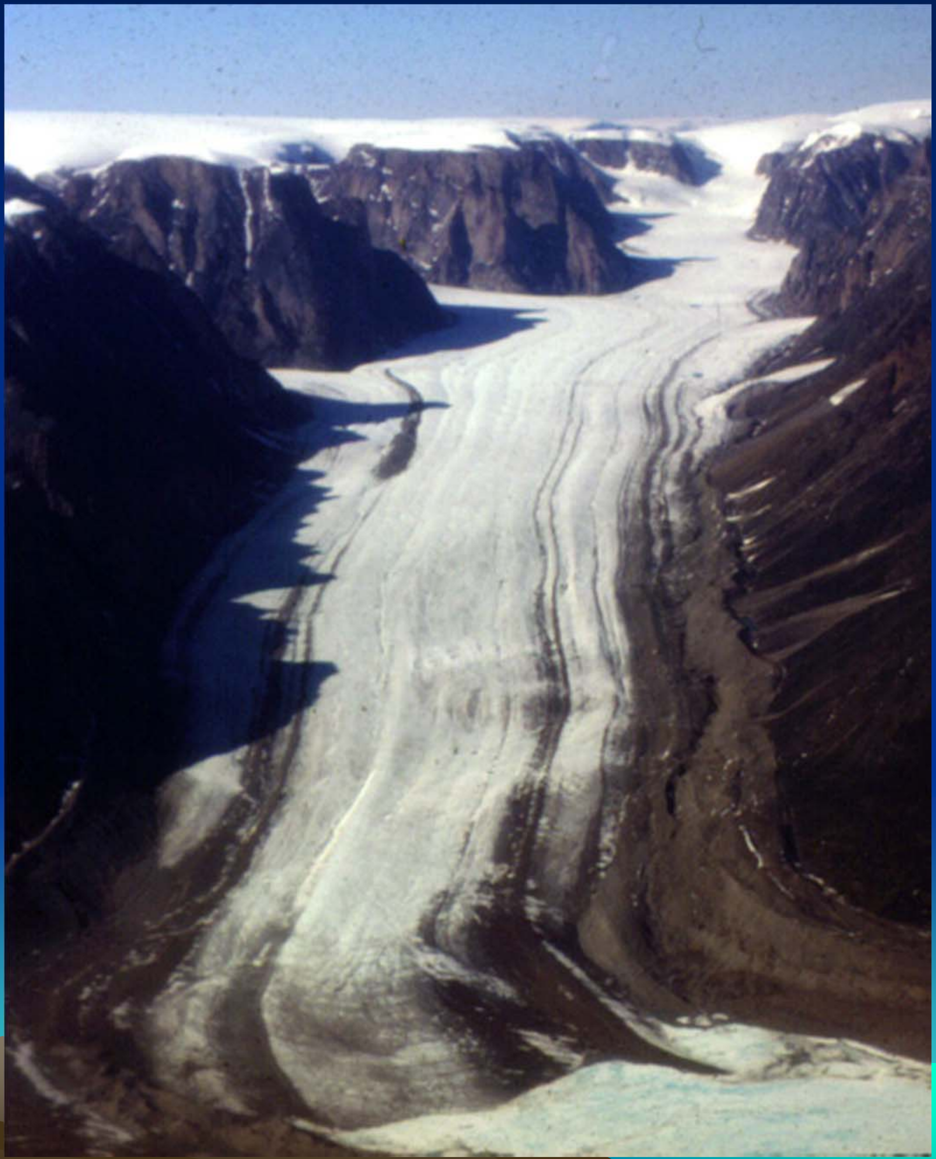
Trough Erosion





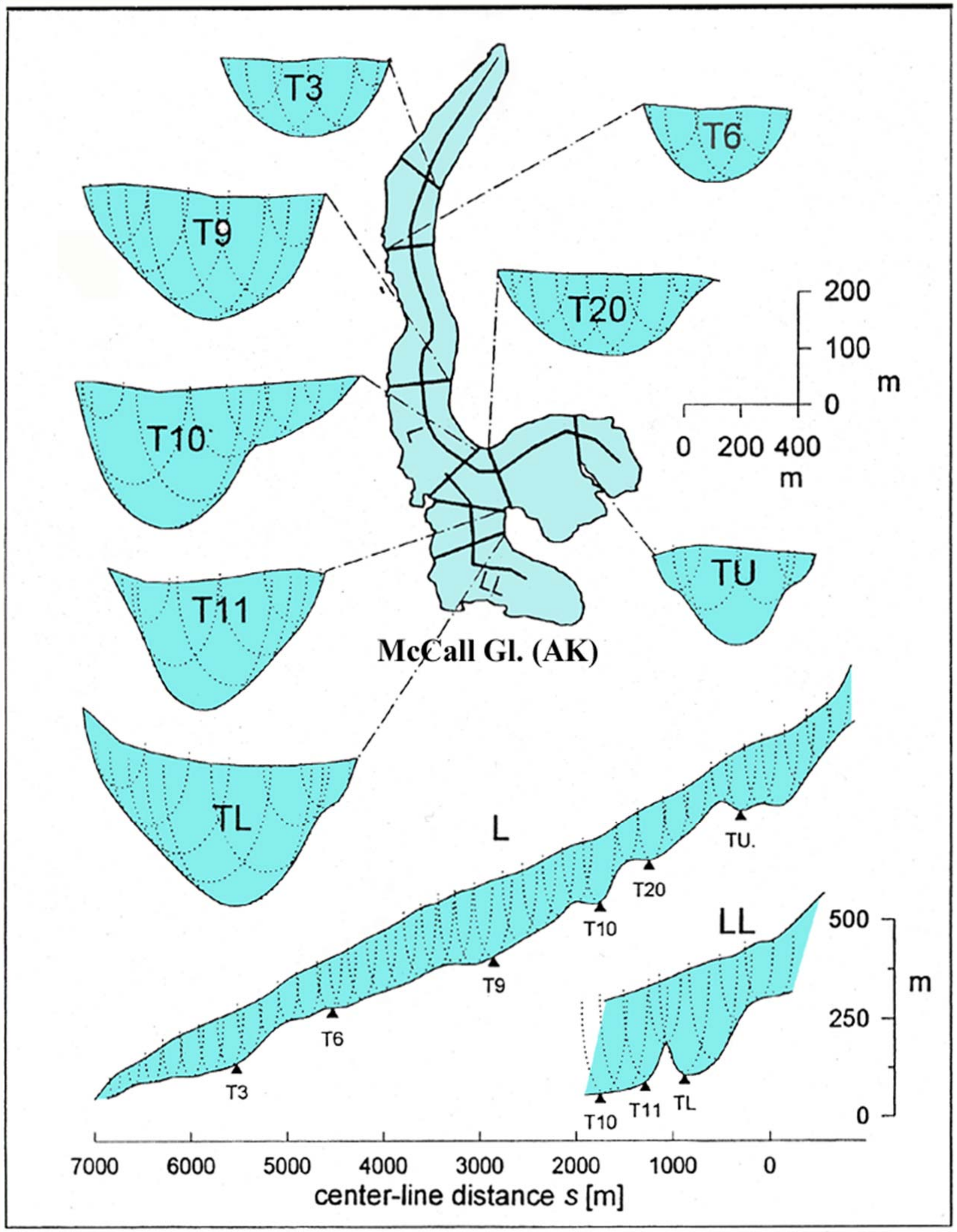
Trough Erosion





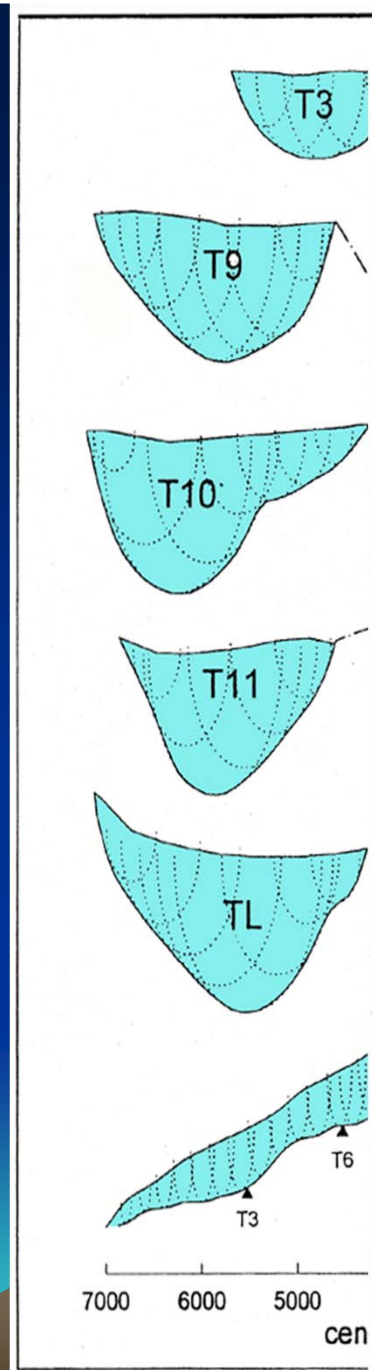
Trough Evolution

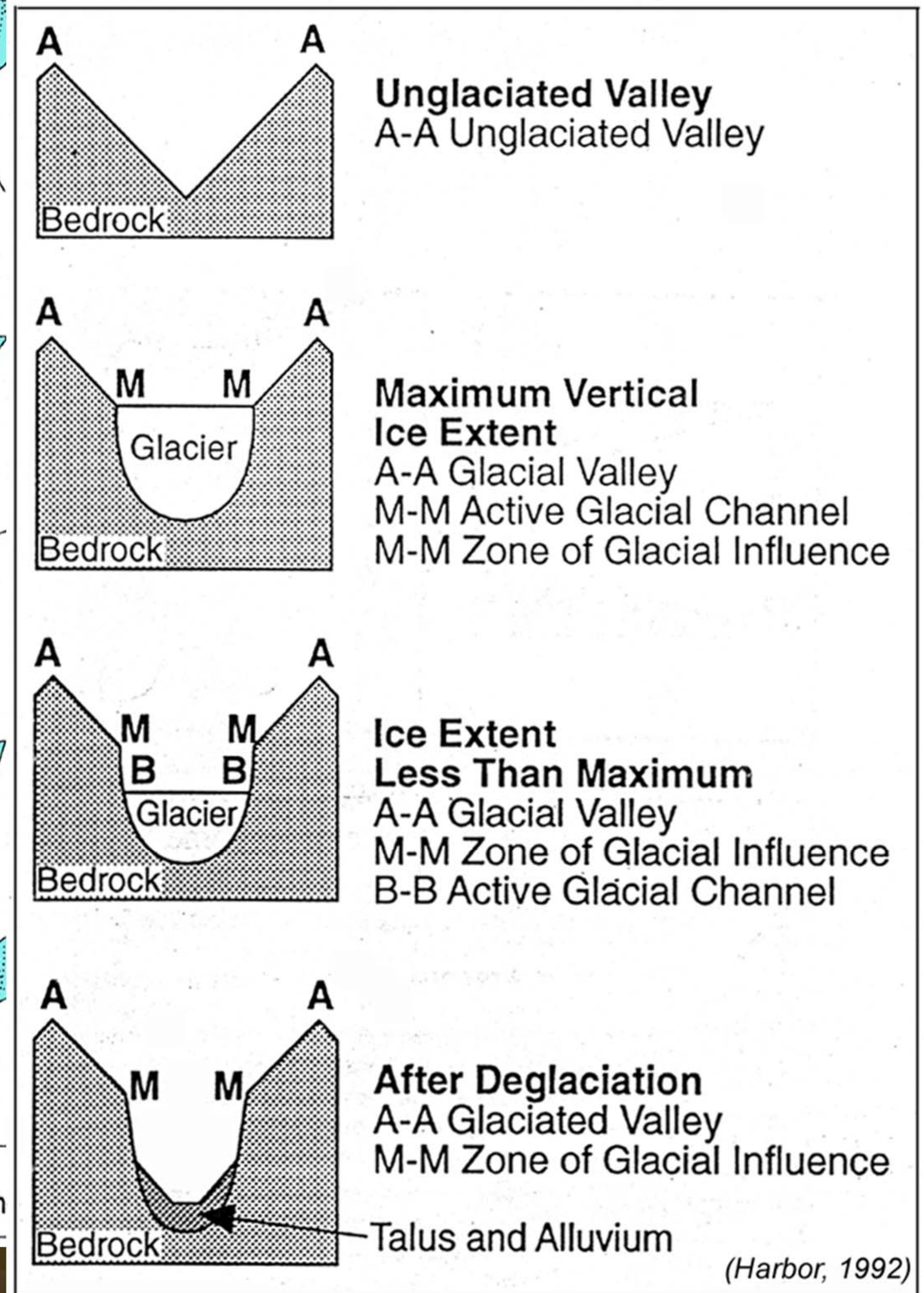
- Real form
- Overdeepen at confluences

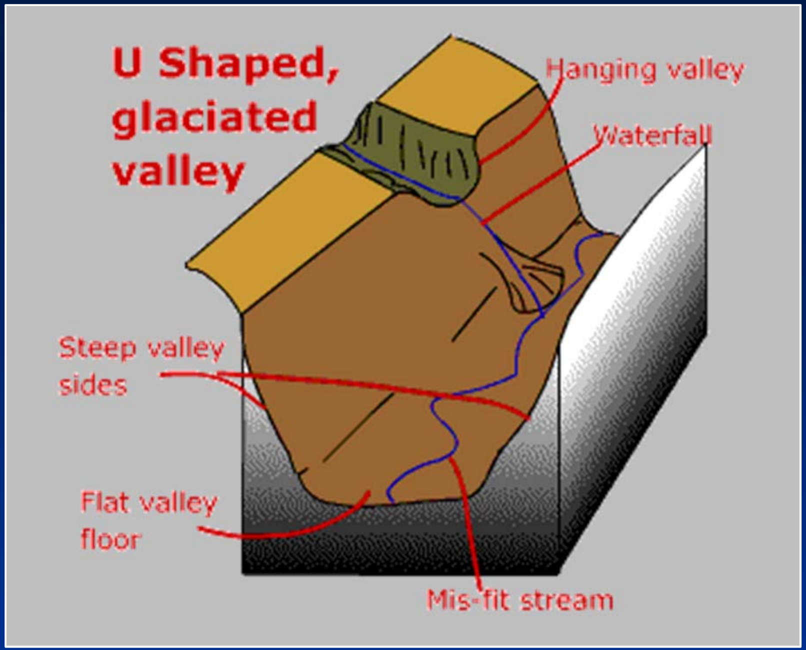


Trough Evolution

- Real form
- Modeled form (Harbor, 1992, *GSAB*)







Cornell Geology

REVIEW

Erosion

$$\dot{A} = k\, F_n\, C\, U_b$$

k - constant
F - contact force
C - concentration
U_b – basal ice velocity (sliding)

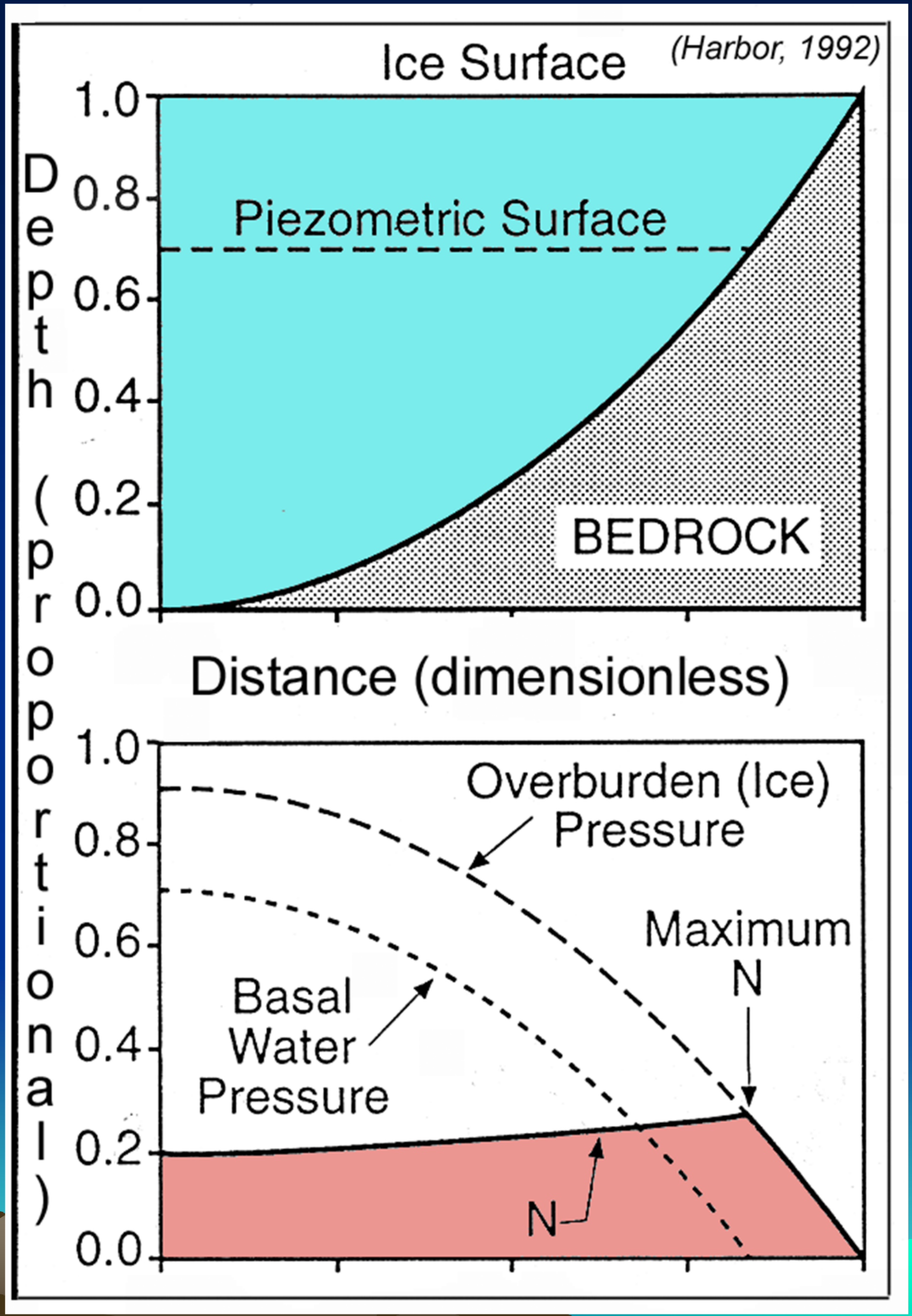
Sliding

$$u_b = \frac{j\tau_b}{(\rho g h - P_w)^q}$$

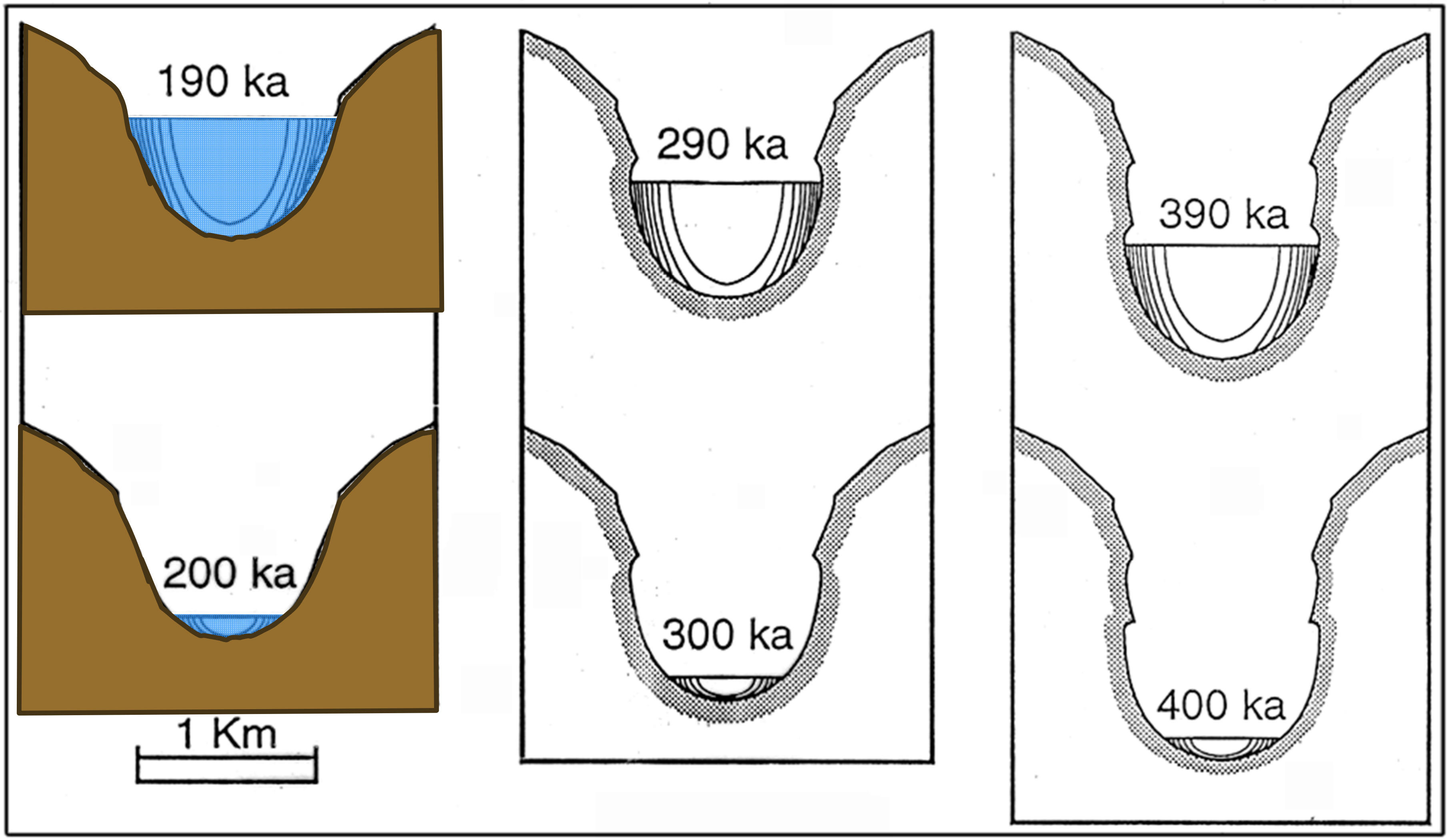
P_w is the subglacial water pressure
where j and q are empically determined constants

Trough Erosion

- Erosion = f (effective pressure)
  - "Effective" N = f (water pressure)



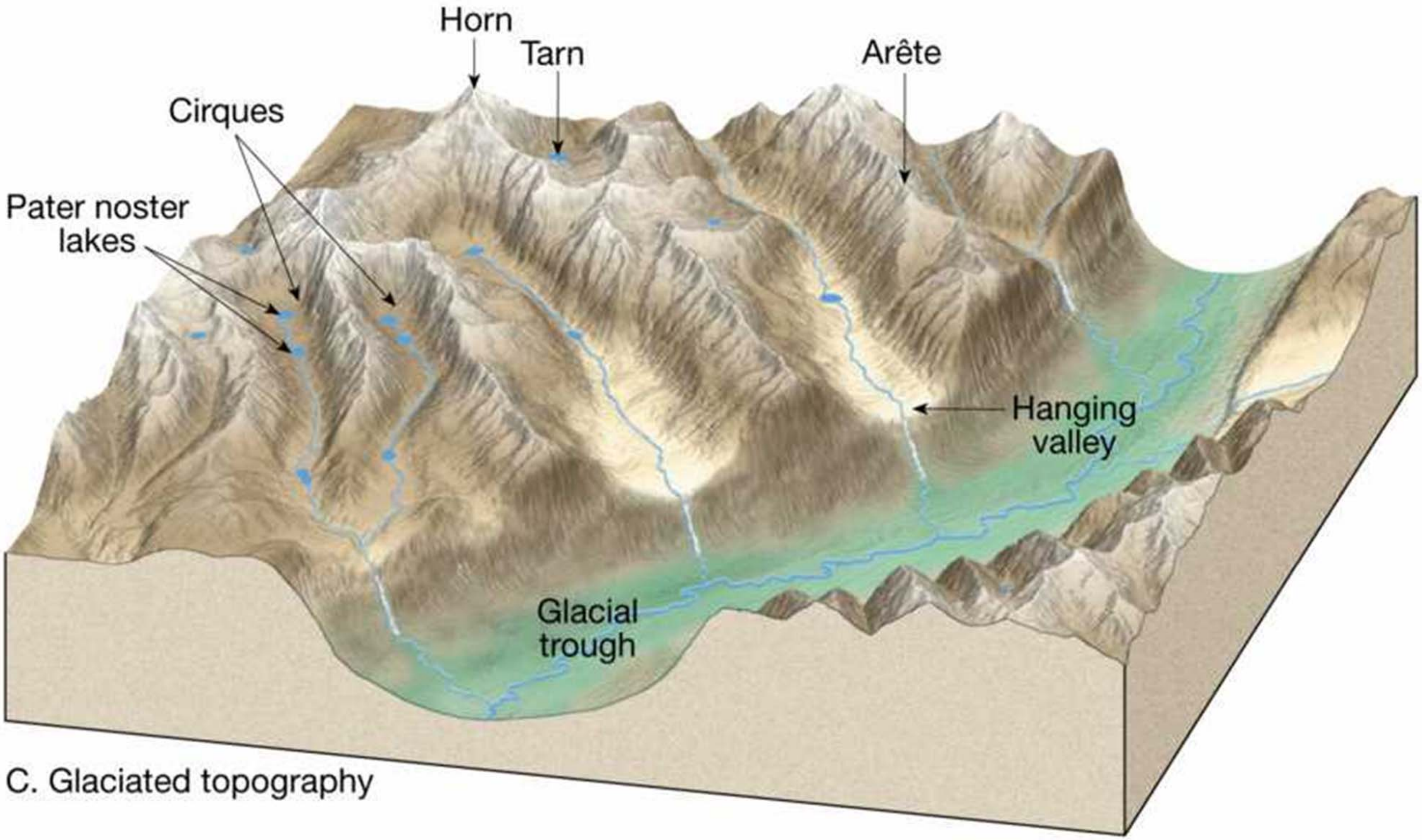
Trough Evolution



Paternoster Lakes

- Local overdeepenings
  - Relative erodibility?
  - Ice thickness variation
    - Some evidence of cyclicity


Swiftcurrent
Redrock Lake
Redrock Falls
Fishercap Lake
Campground
SHERBURNE
Bullhead Lake
Grinnell Point
Mount Grinnell
Grinnell Lake
Grinnell Creek
Grinnell Falls
Upper Grinnell Lake
Salamander Falls
Grinnell Glacier
Lake Josephine
Swiftcurrent Lake
Falling Leaf Lake
Allen Mountain



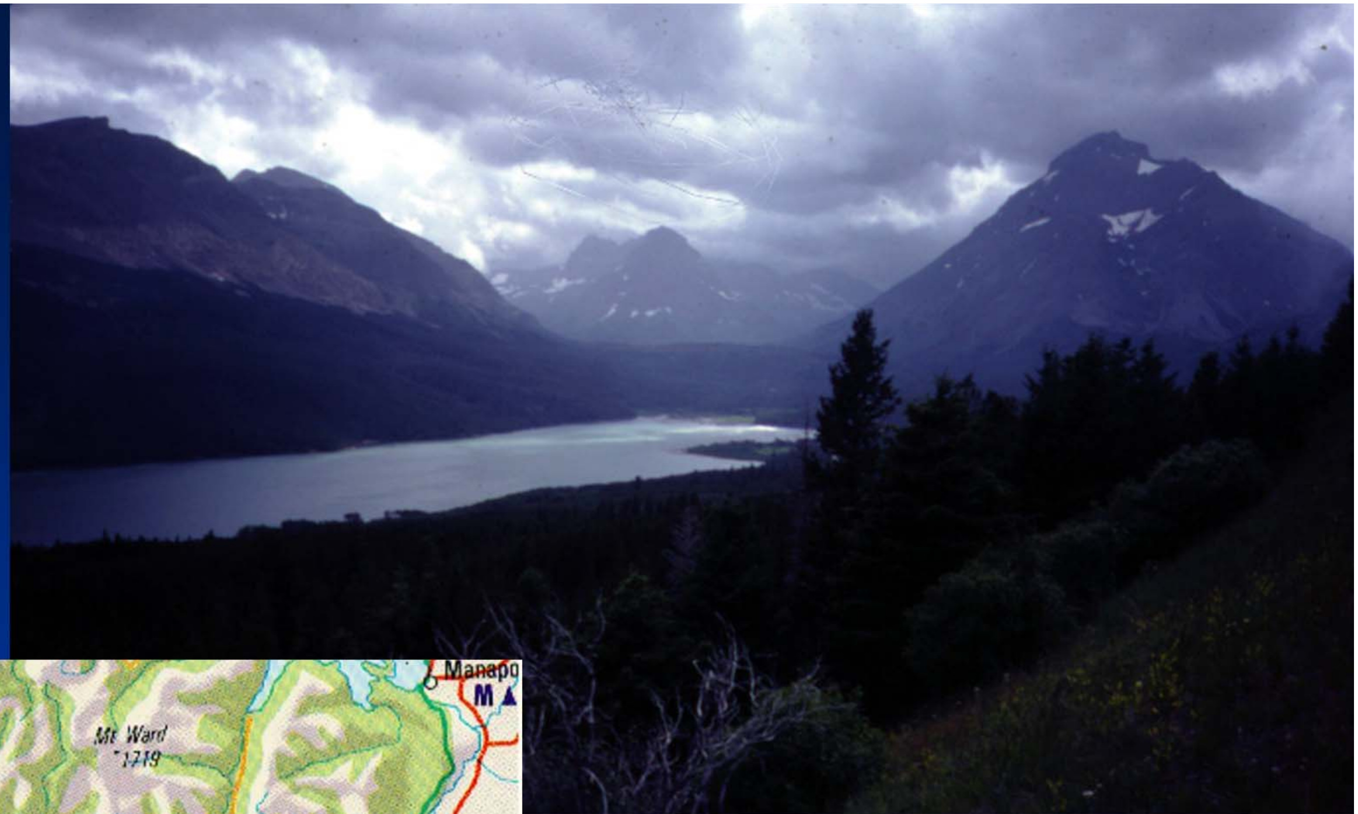
C. Glaciated topography

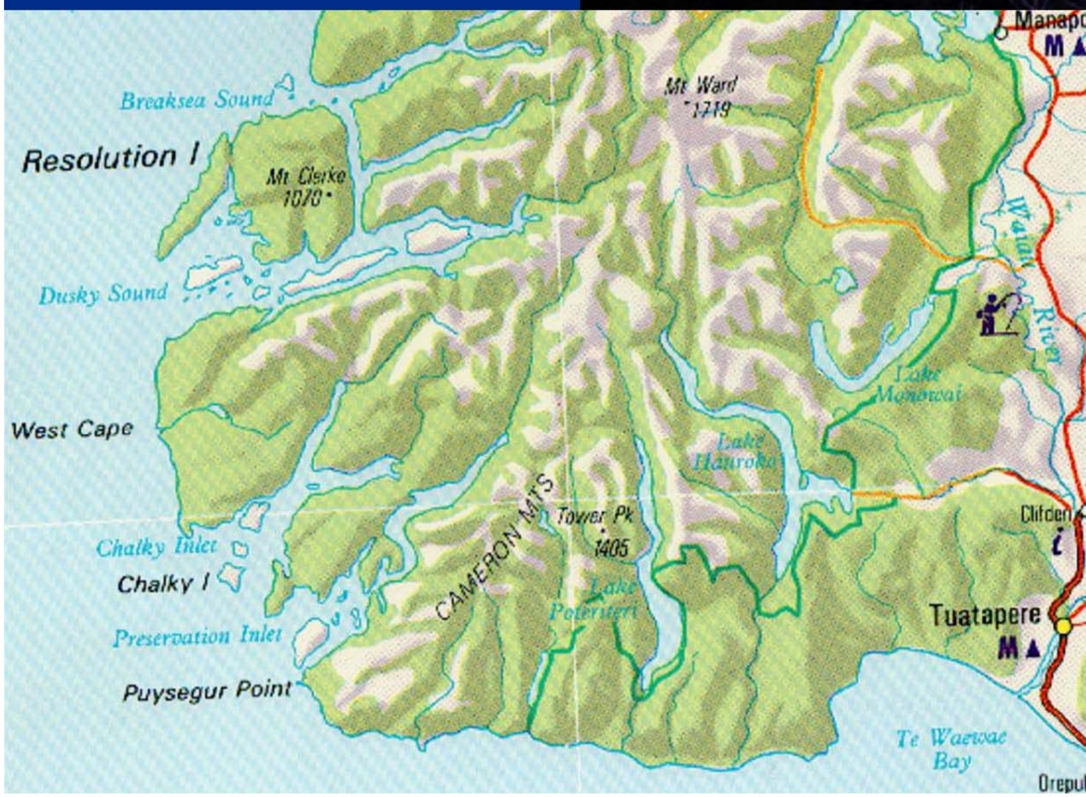
Fiords

- Definition:
  - Drowned glacial troughs
- Appearance:
  - Steep walls rising from the sea

Fiords

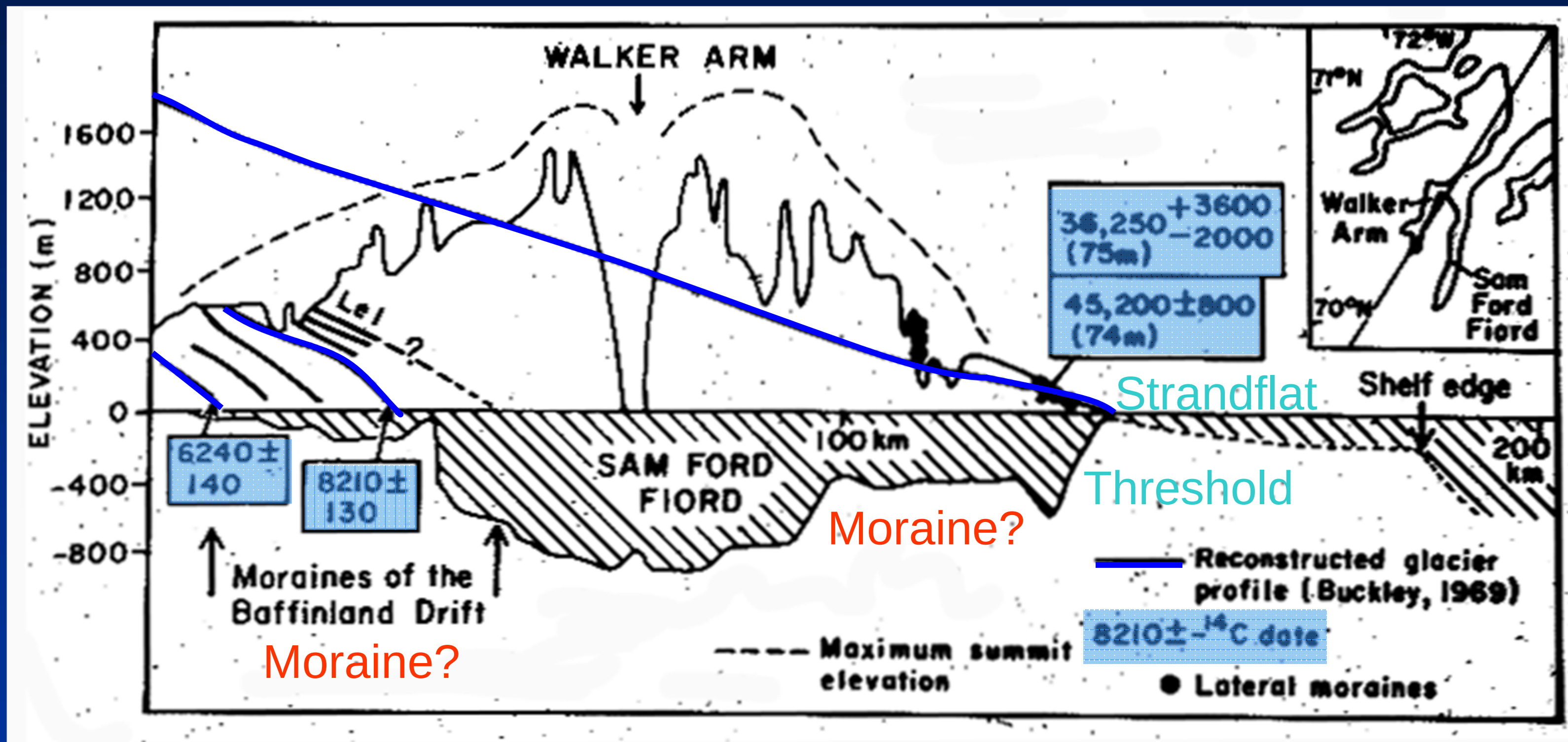
Trough Lake = Fiord?

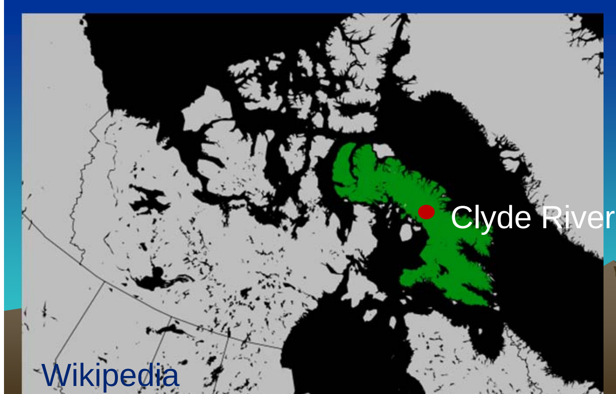




- Two Medicine Lk
- Fiordland (NZ)

Thresholds and Strandflats

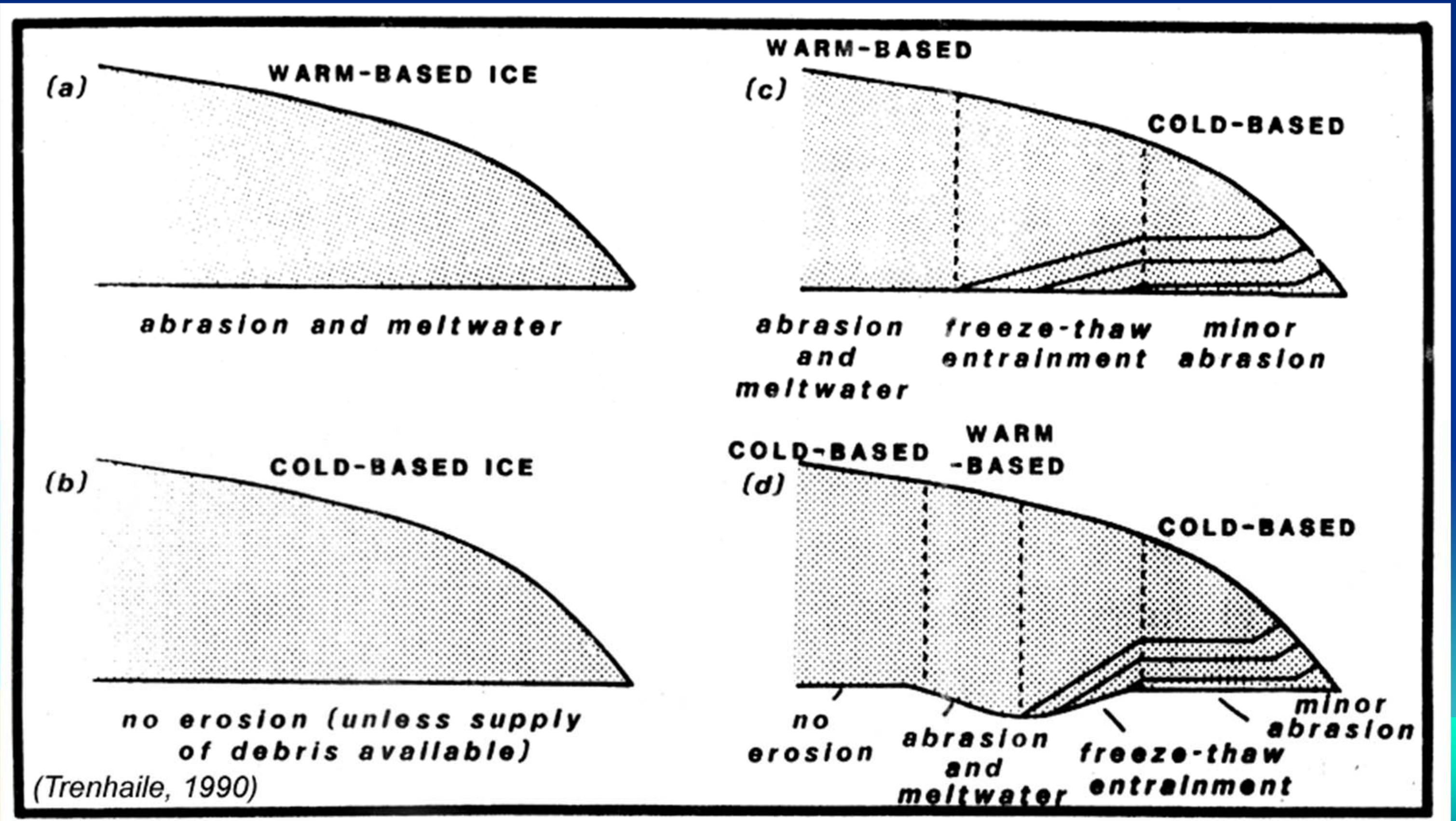




Adventure Travel
Sam Ford Fiord

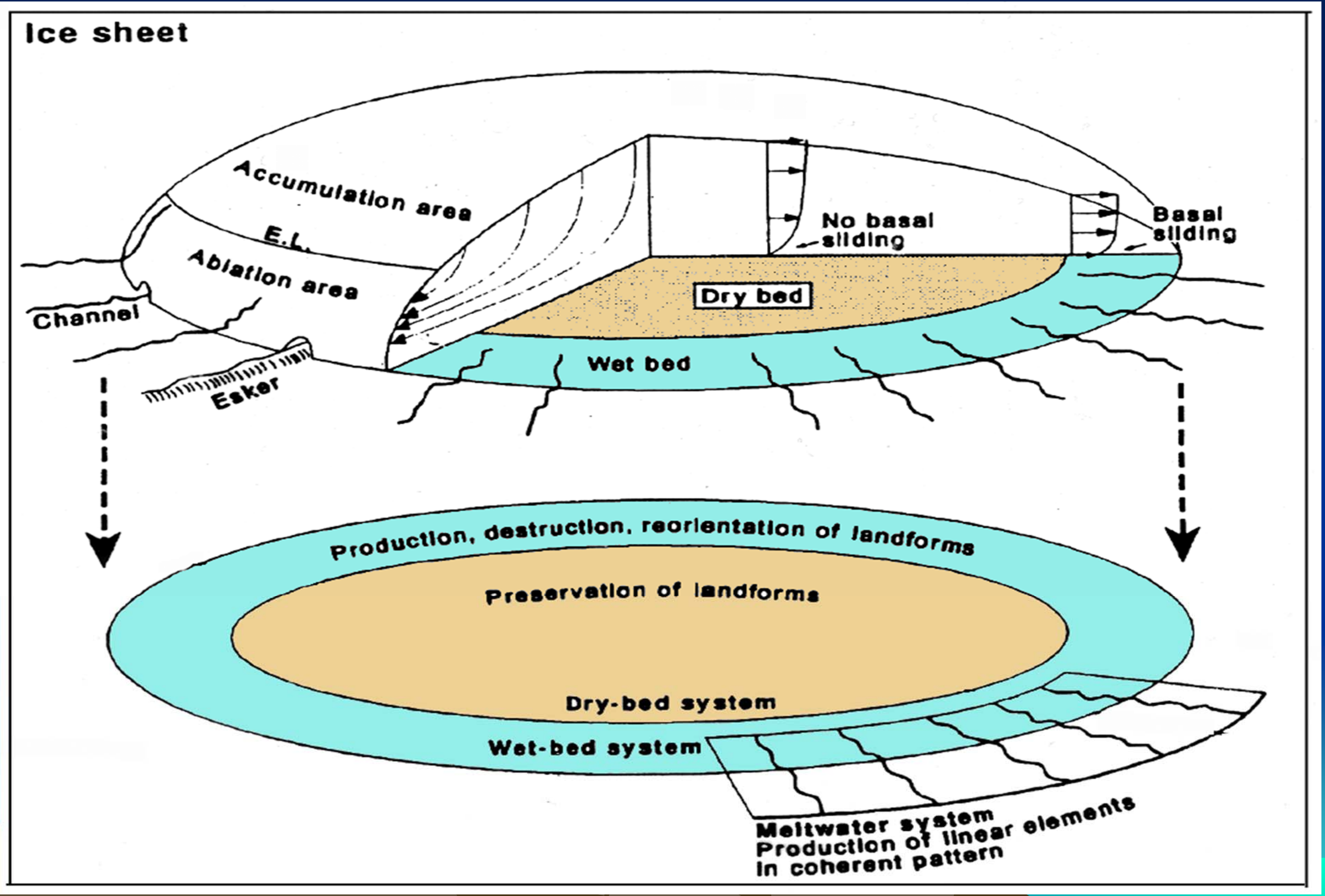
Areal Scour (ice sheet)

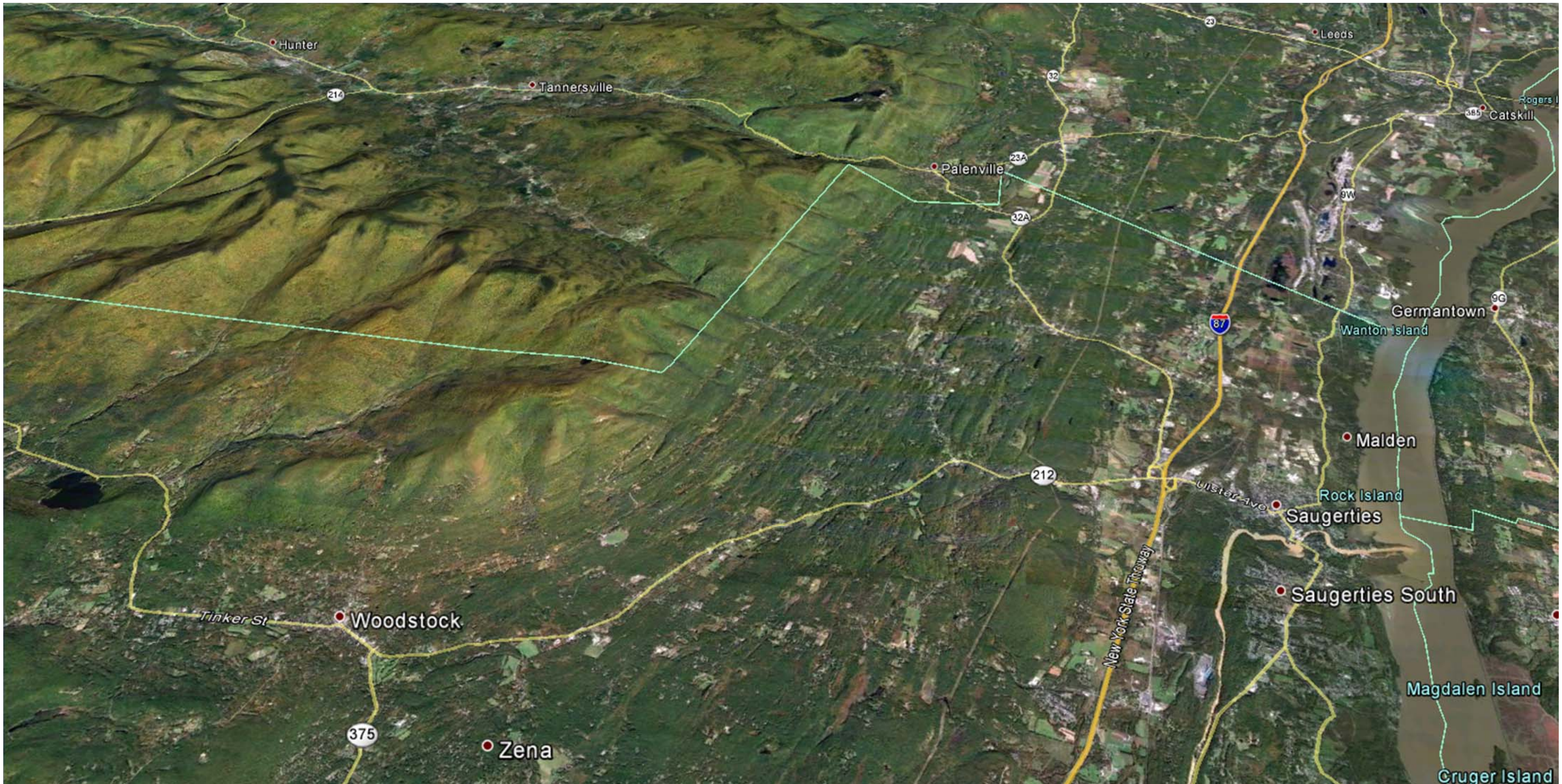
- Depends heavily upon basal processes = f(T)
- Results in a suite of landforms
- May show superimposed patterns

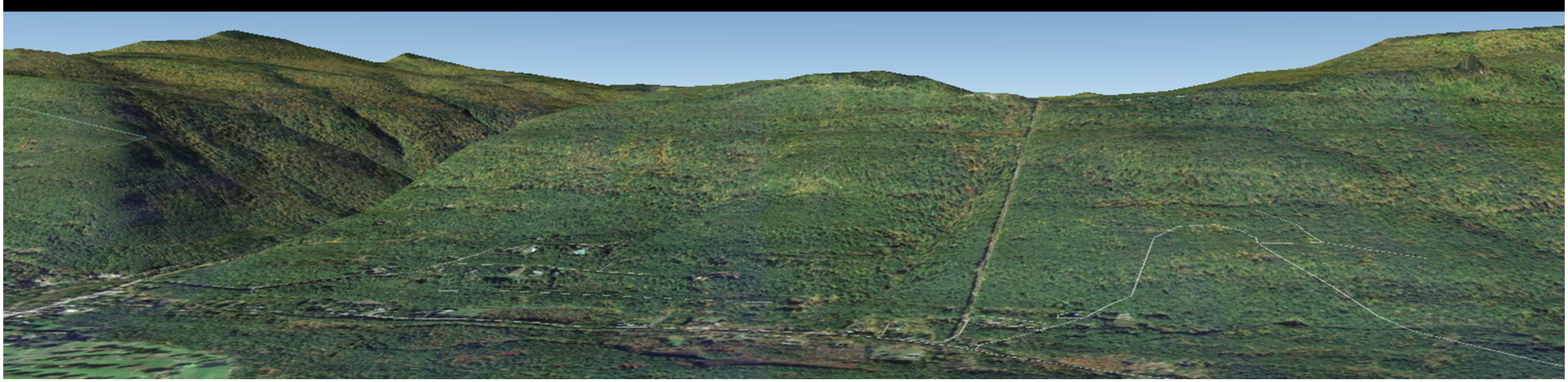


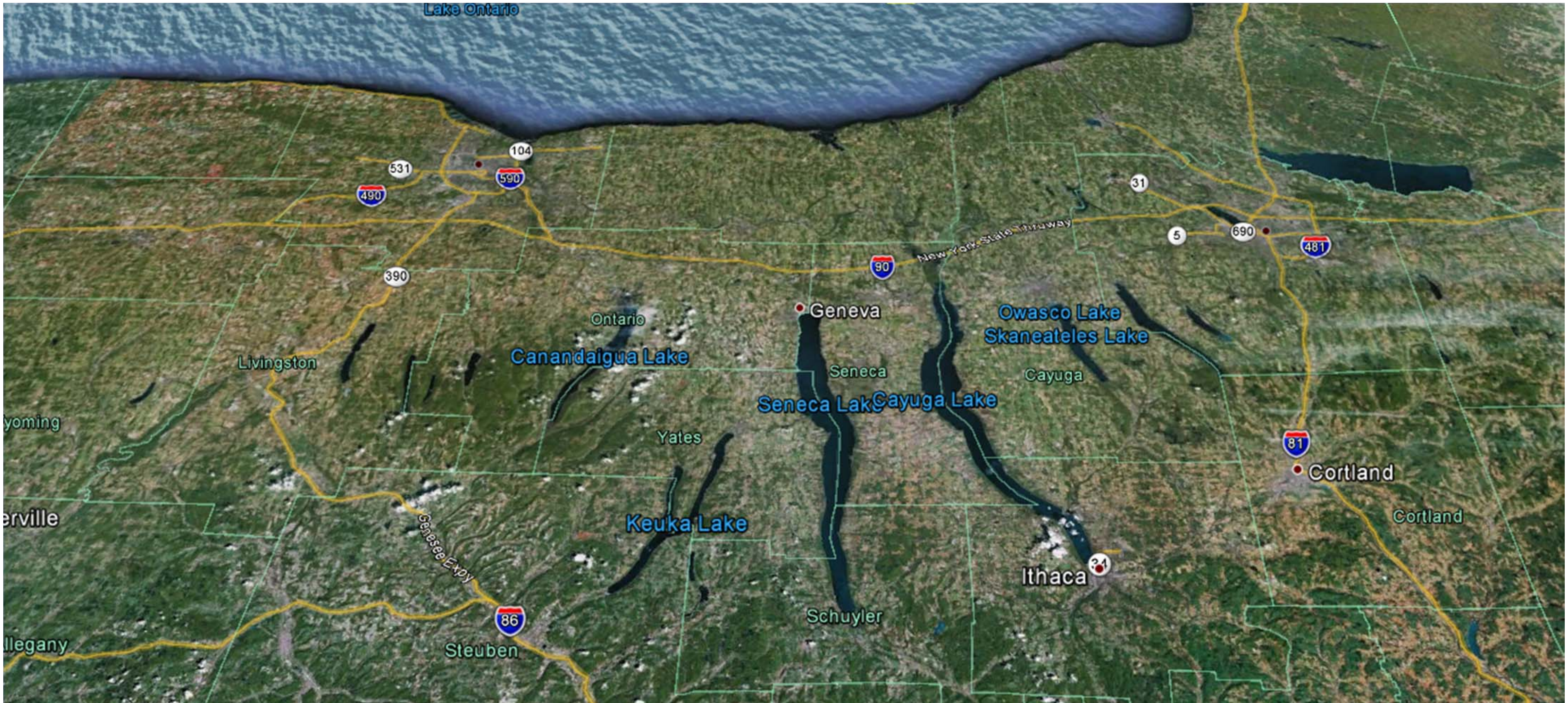
(Trenhaile, 1990)

Areal Scour (ice sheet)




Hunter
Tannersville
214
Leeds
23
32
Catskill
385
Palenville
23A
32A
9W
Germantown
9G
Wanton Island
87
Malden
212
Ulster Ave
Rock Island
Saugerties
Saugerties South
New York State Thruway
Tinker St
Woodstock
Magdalen Island
375
Zena
Cruger Island



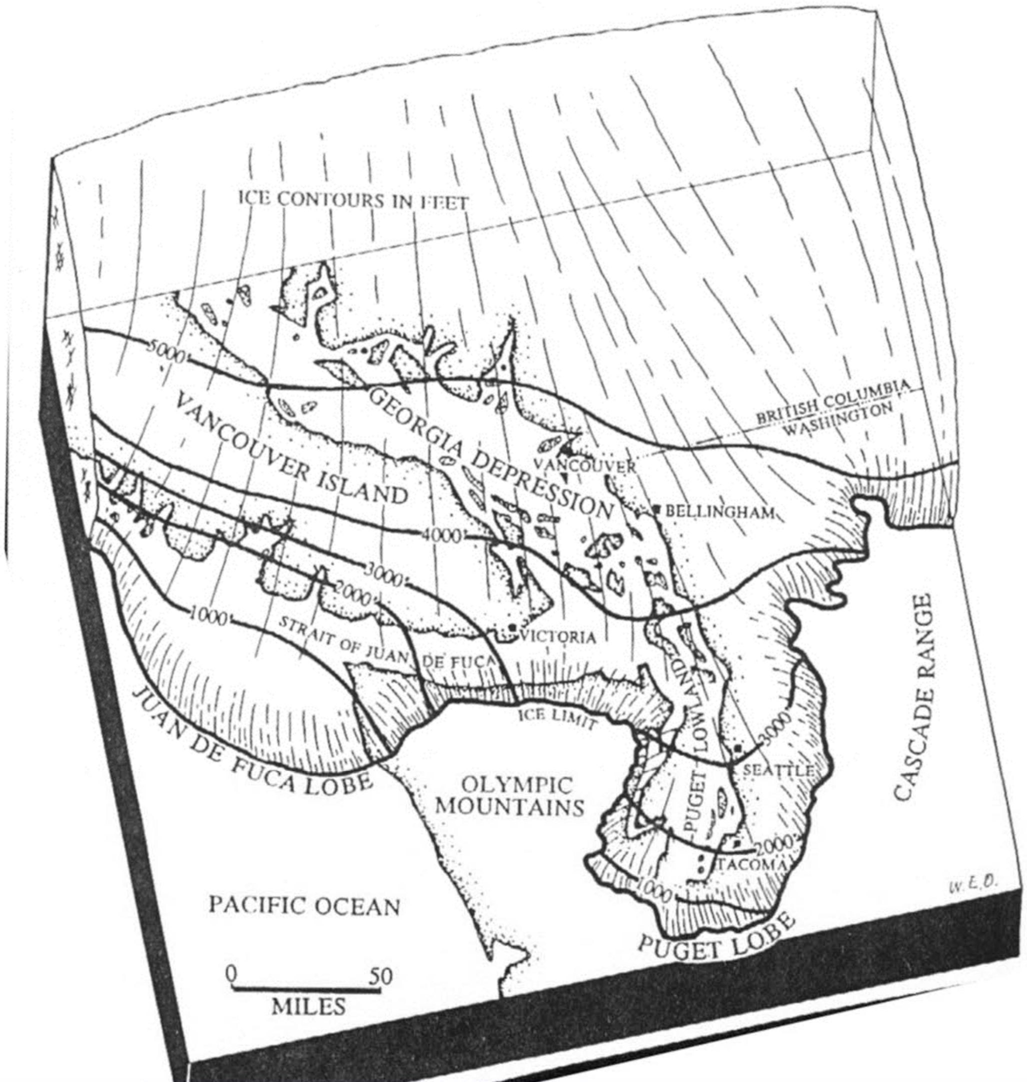

Lake Ontario
104
531
490
590
31
690
5
481
New York State Thruway
90
390
Geneva
Ontario
Canandaigua Lake
Livingston
Owasco Lake
Skaneateles Lake
Seneca
Cayuga
Seneca Lake
Cayuga Lake
Yates
81
Cortland
Keuka Lake
Cortland
Ithaca
Genesee Expy
86
Steuben
Schuyler


21
245

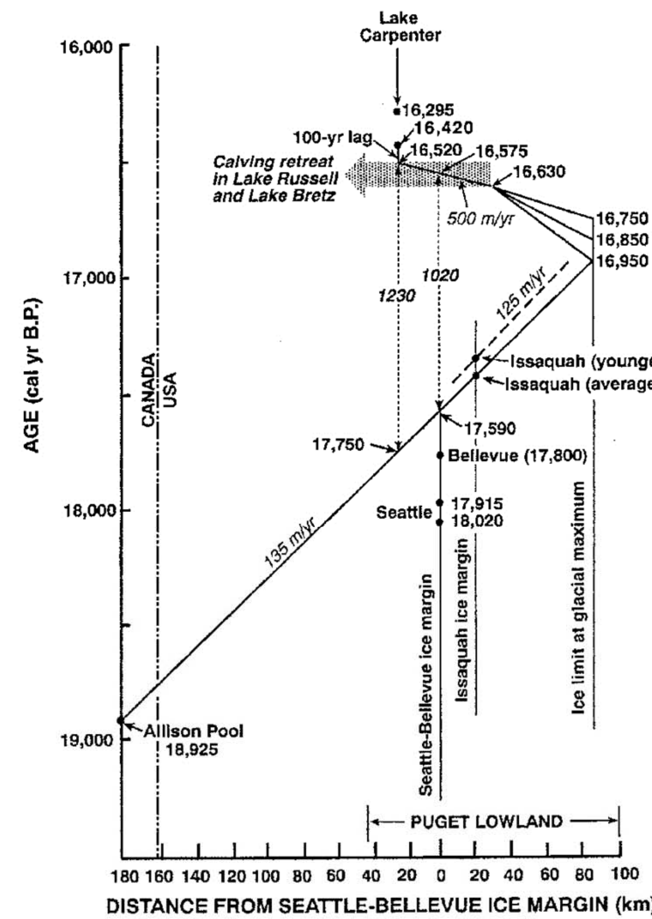
Breached Divides

- New England "notches"
  - Ice advances through notch
  - Subglacial drainage?

Puget Lobe



ICE CONTOURS IN FEET
5000
4000
3000
2000
1000
VANCOUVER ISLAND
GEORGIA DEPRESSION
BRITISH COLUMBIA
WASHINGTON
VANCOUVER
BELLINGHAM
VICTORIA
STRAIT OF JUAN DE FUCA
ICE LIMIT
JUAN DE FUCA LOBE
OLYMPIC MOUNTAINS
PUGET LOWLAND
SEATTLE
TACOMA
CASCADE RANGE
PACIFIC OCEAN
PUGET LOBE
0
50
MILES
W. E. D.



Lake Carpenter
16,295
16,420
100-yr lag
16,520
16,575
16,630
Calving retreat in Lake Russell and Lake Bretz
500 m/yr
16,750
16,850
16,950
Alternative times for beginning of ice retreat
1020
1230
125 m/yr
Issaquah (youngest: 17,315)
Issaquah (average: 17,420)
17,590
17,750
Bellevue (17,800)
Seattle
17,915
18,020
135 m/yr
Allison Pool
18,925
CANADA
USA
Seattle-Bellevue ice margin
Issaquah ice margin
Ice limit at glacial maximum
PUGET LOWLAND
AGE (cal yr B.P.)
16,000
17,000
18,000
19,000
180 160 140 120 100 80 60 40 20 0 20 40 60 80 100
DISTANCE FROM SEATTLE-BELLEVUE ICE MARGIN (km)


END
http://en.wikipedia.org/wiki/File:1_yosemite_valley_tunnel_view_2010.JPG/