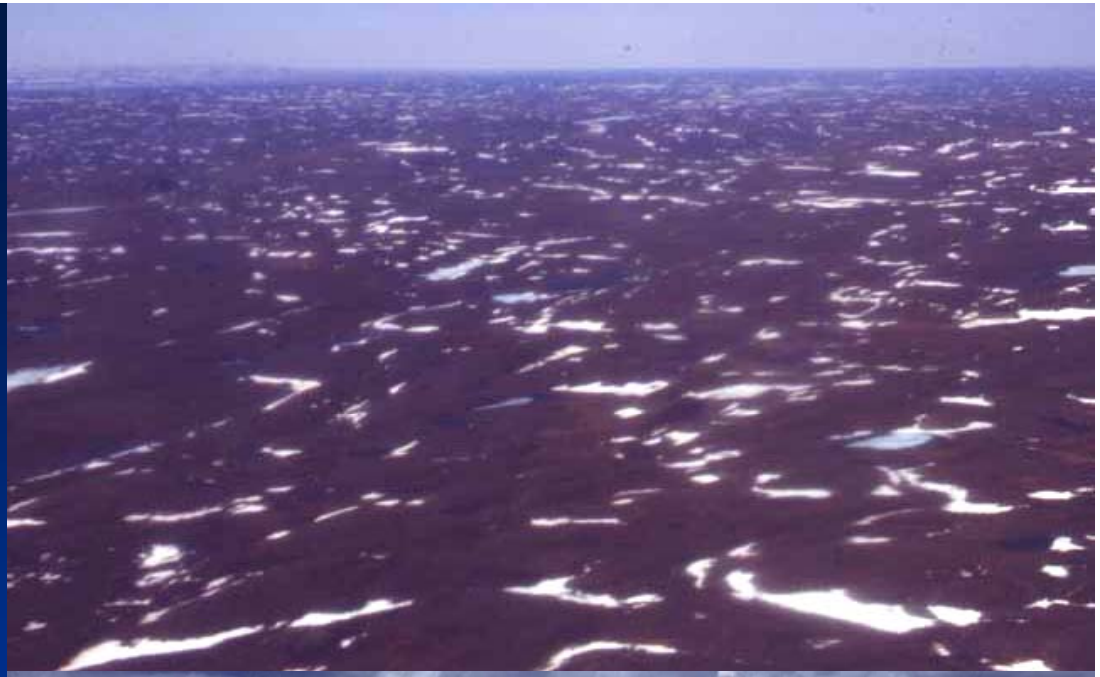
Erosional Forms and Landscapes

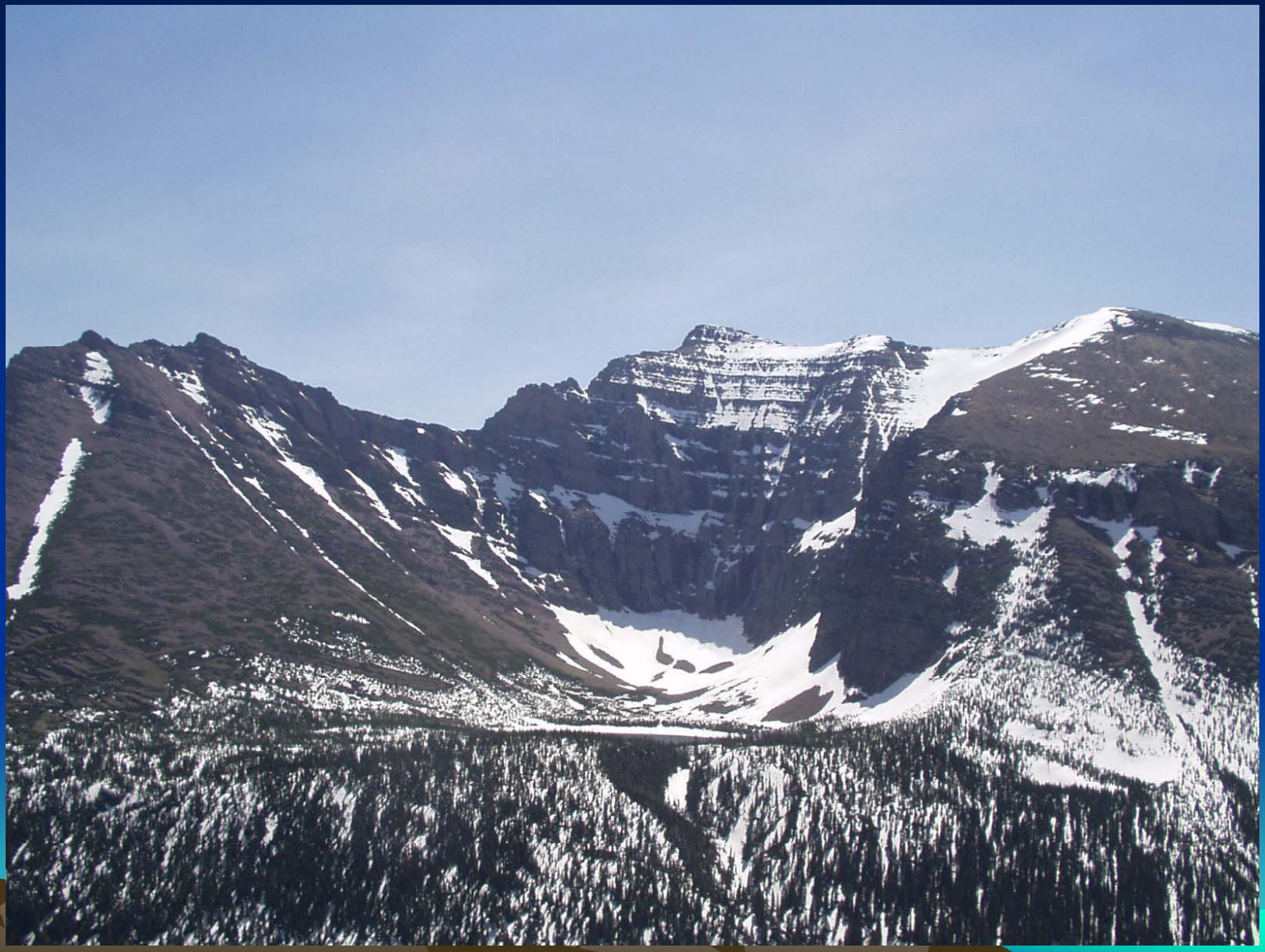
Erosional Landscapes

- Areal Scour vs.
- Selective Linear Erosion



Cirques

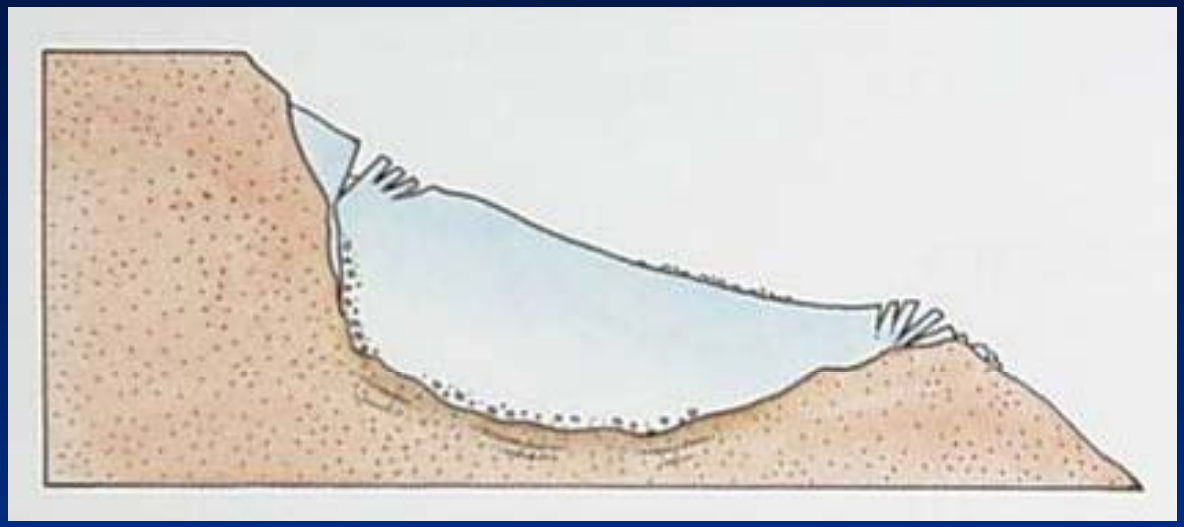
Form and Morphology

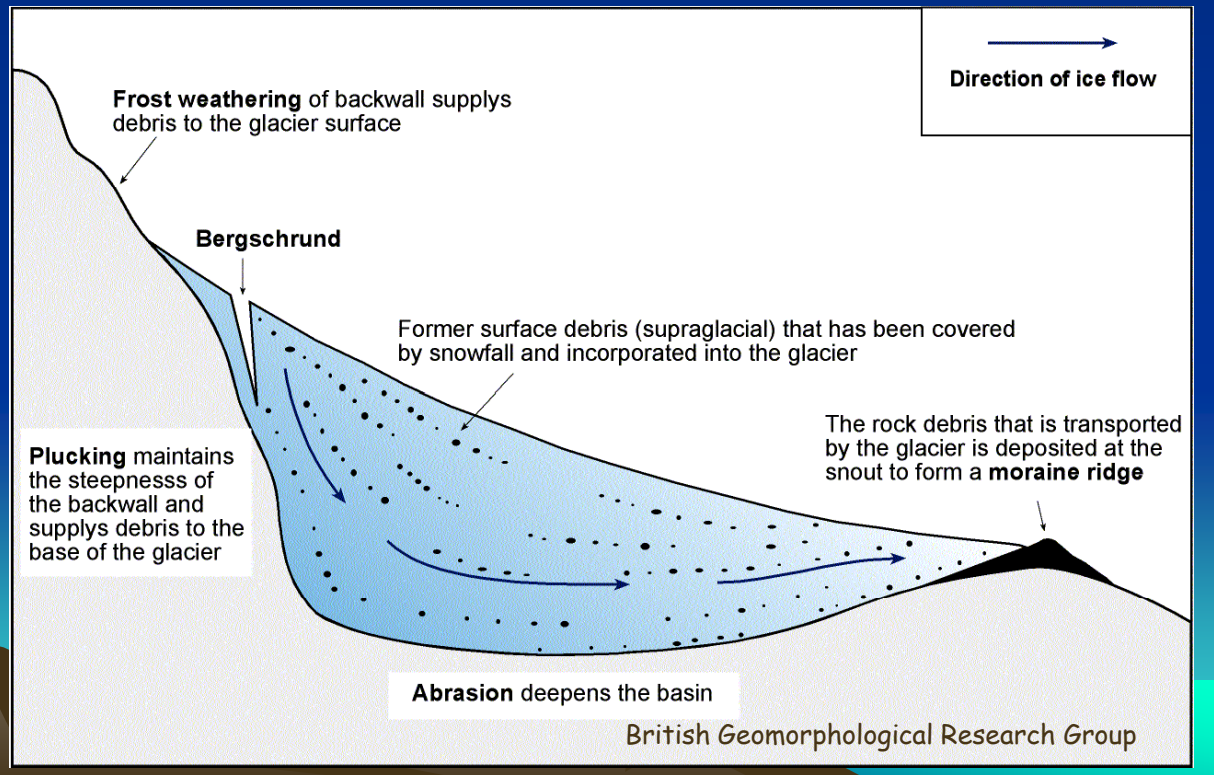


Many Forms

Process

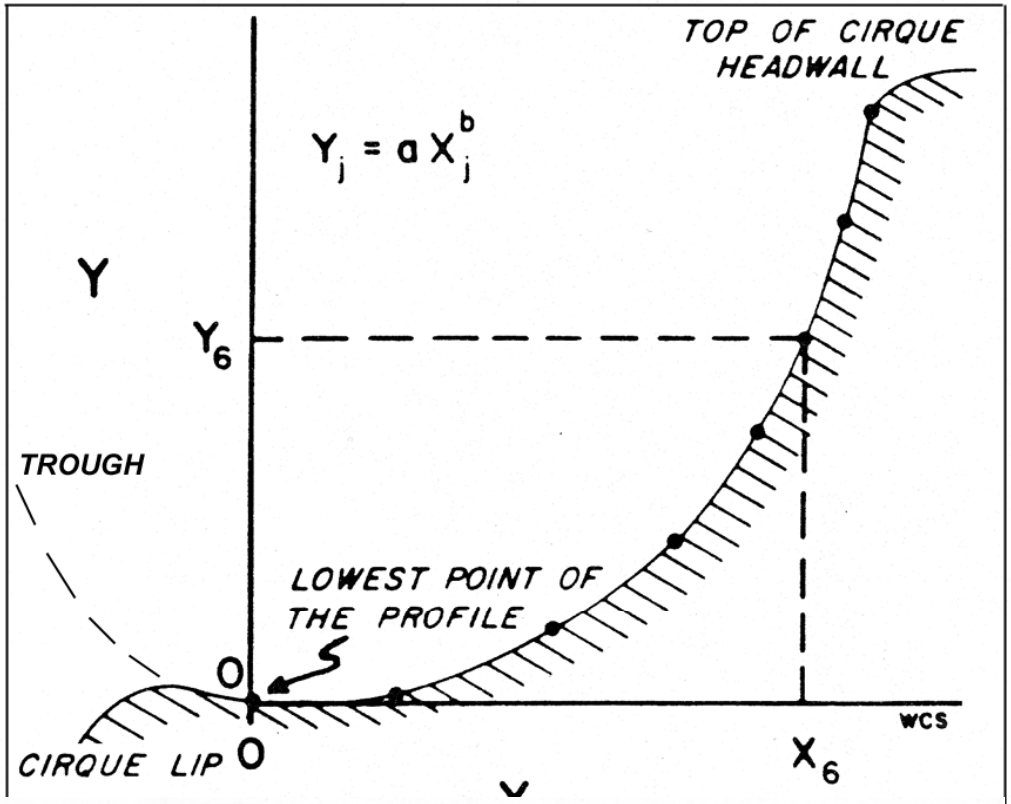
- Rotational Flow
- Headwall
  - Back movement
- Floor
  - Overdeepening
- ELA
  - Max. erosion

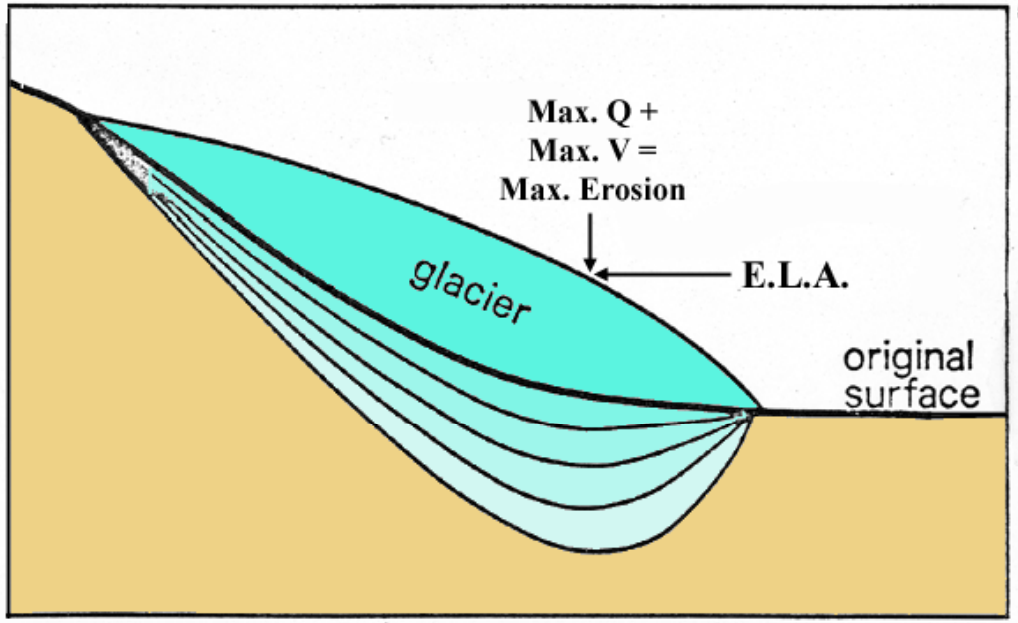




Cirque Form

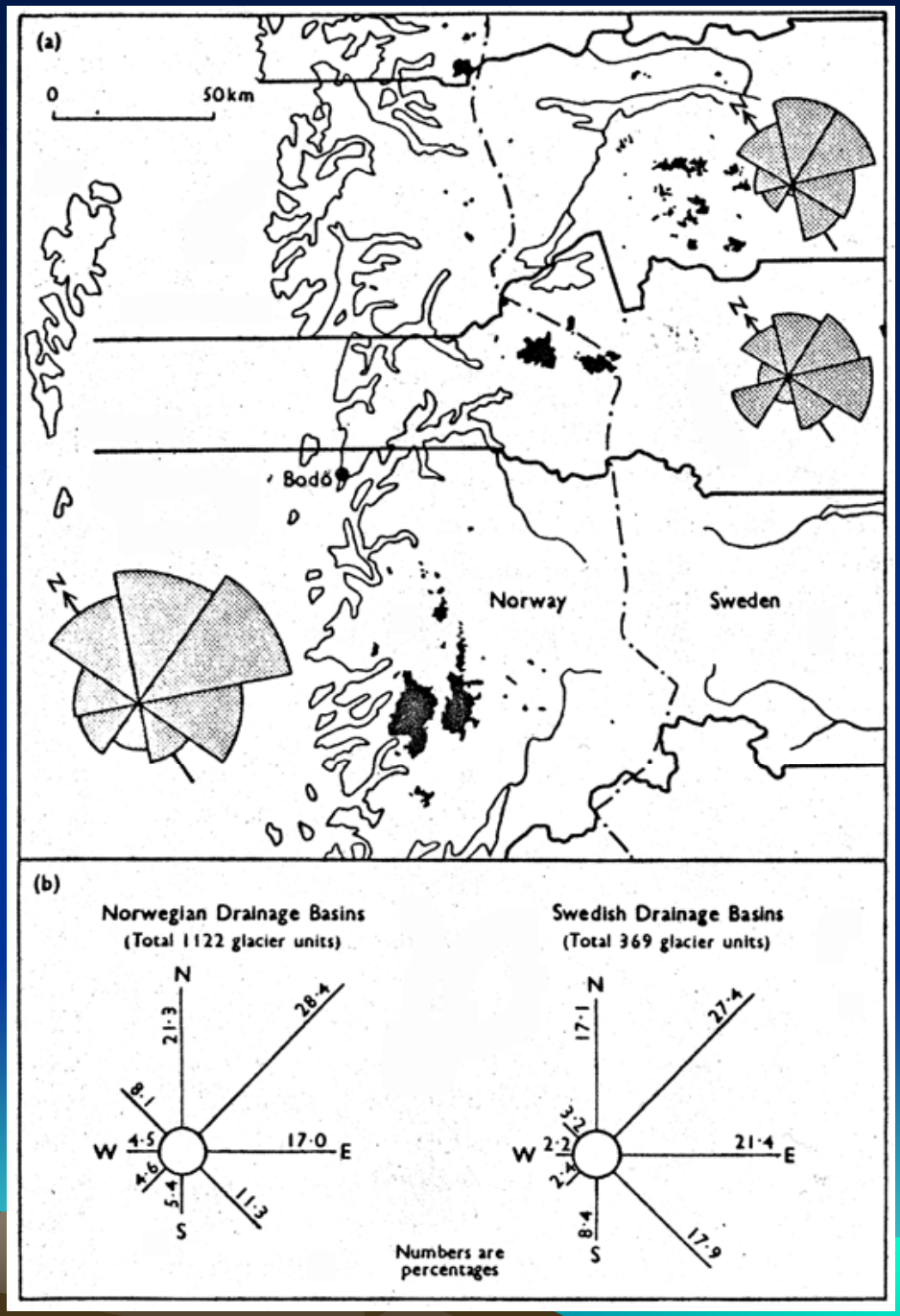
- Exponential
- Process
  - Overdeepened
  - Max work @ ELA
  - Tarns





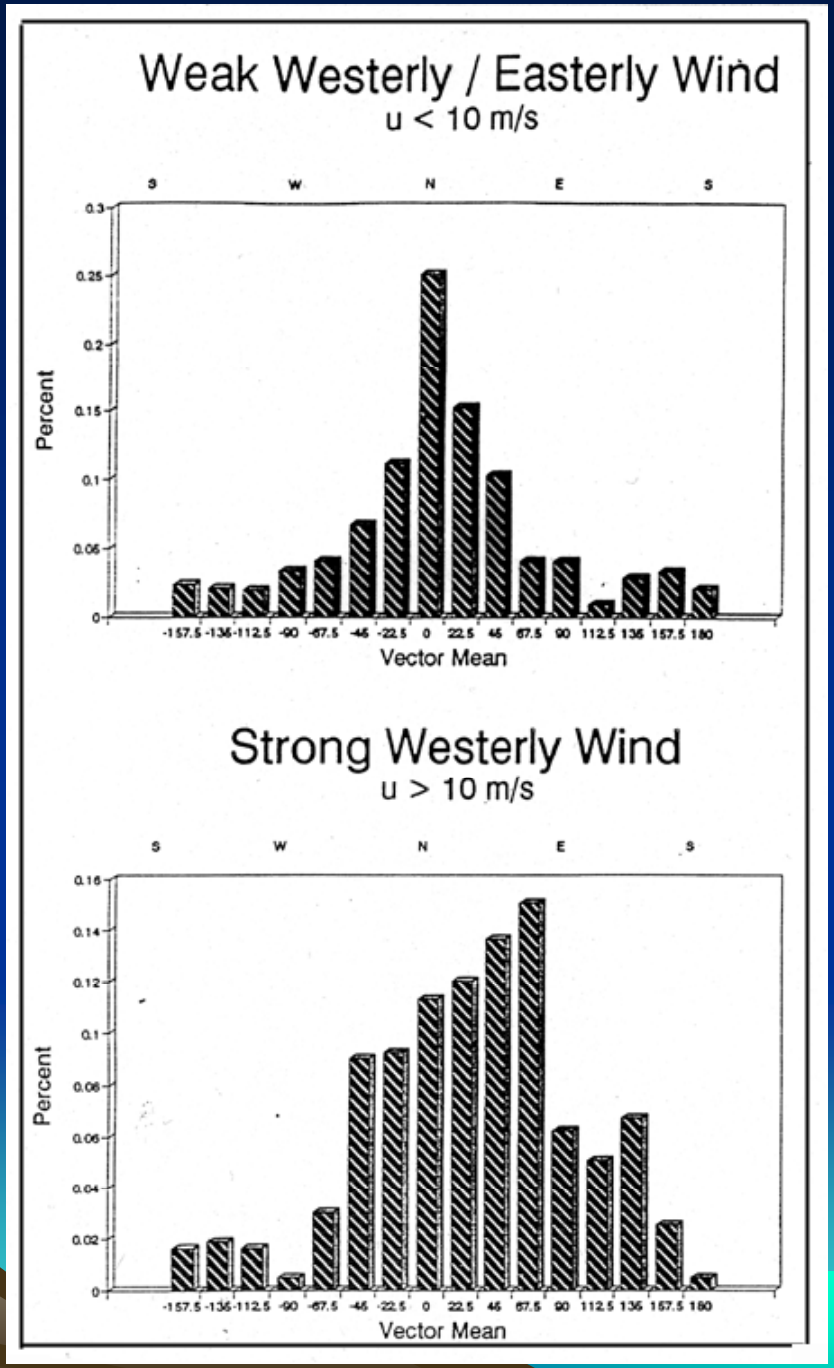
Cirque Orientation

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

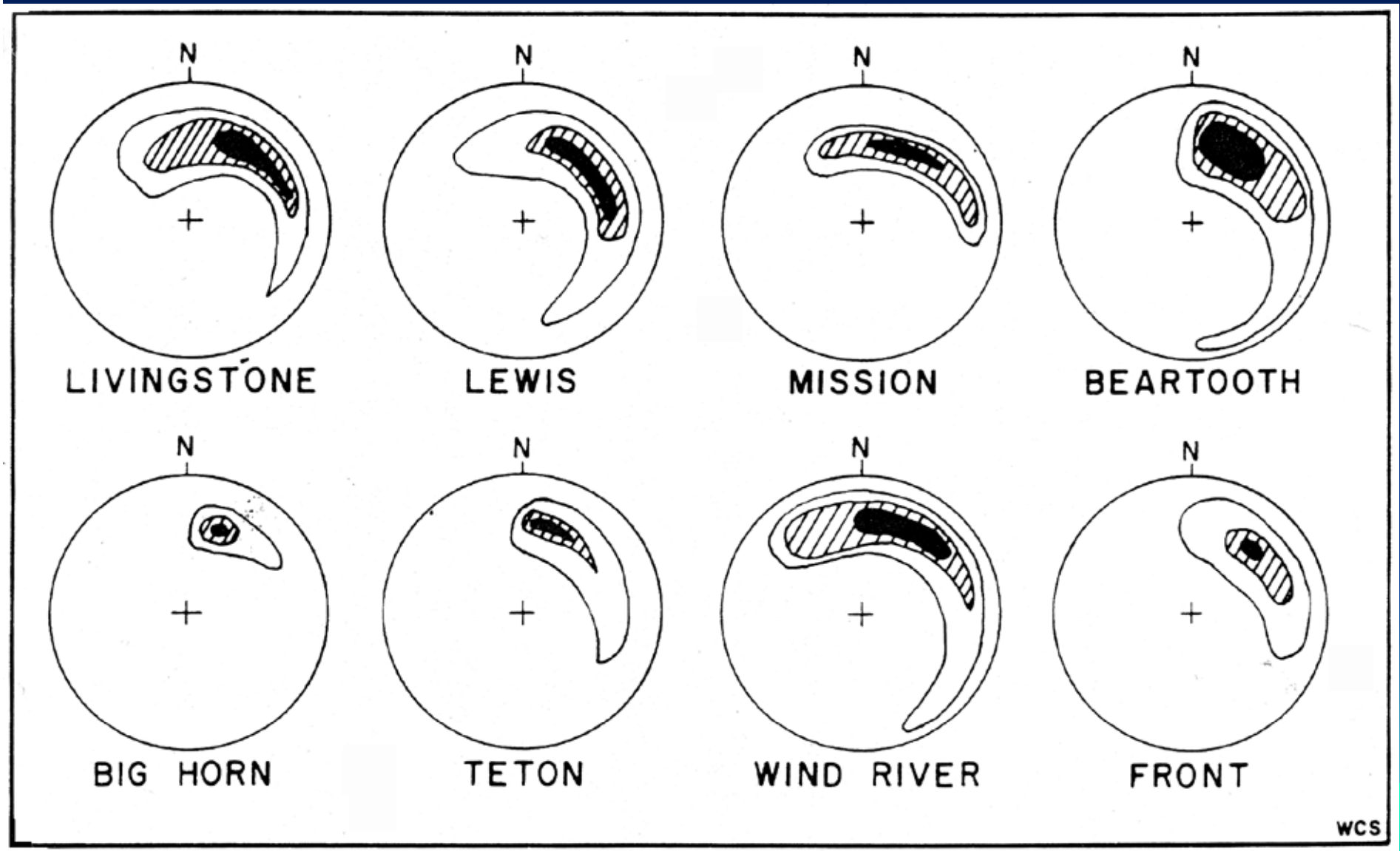


Why to NE?

- Insolation + sensible heat transfer?
- Effect of wind drifting?
- Where to test this hypothesis?

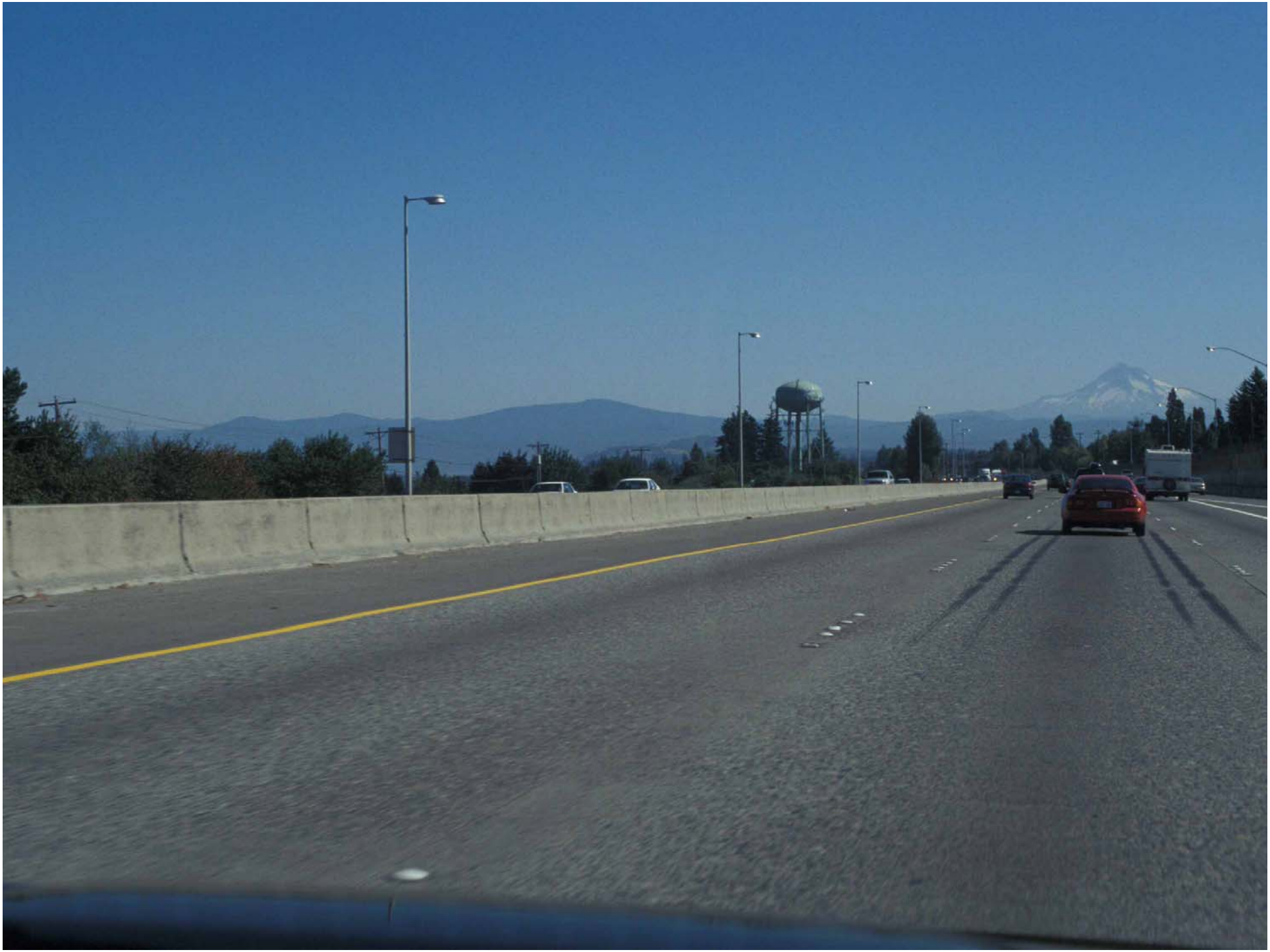


Cirque Orientation



Backwall – processes?

Where is the closest cirque to Portland?

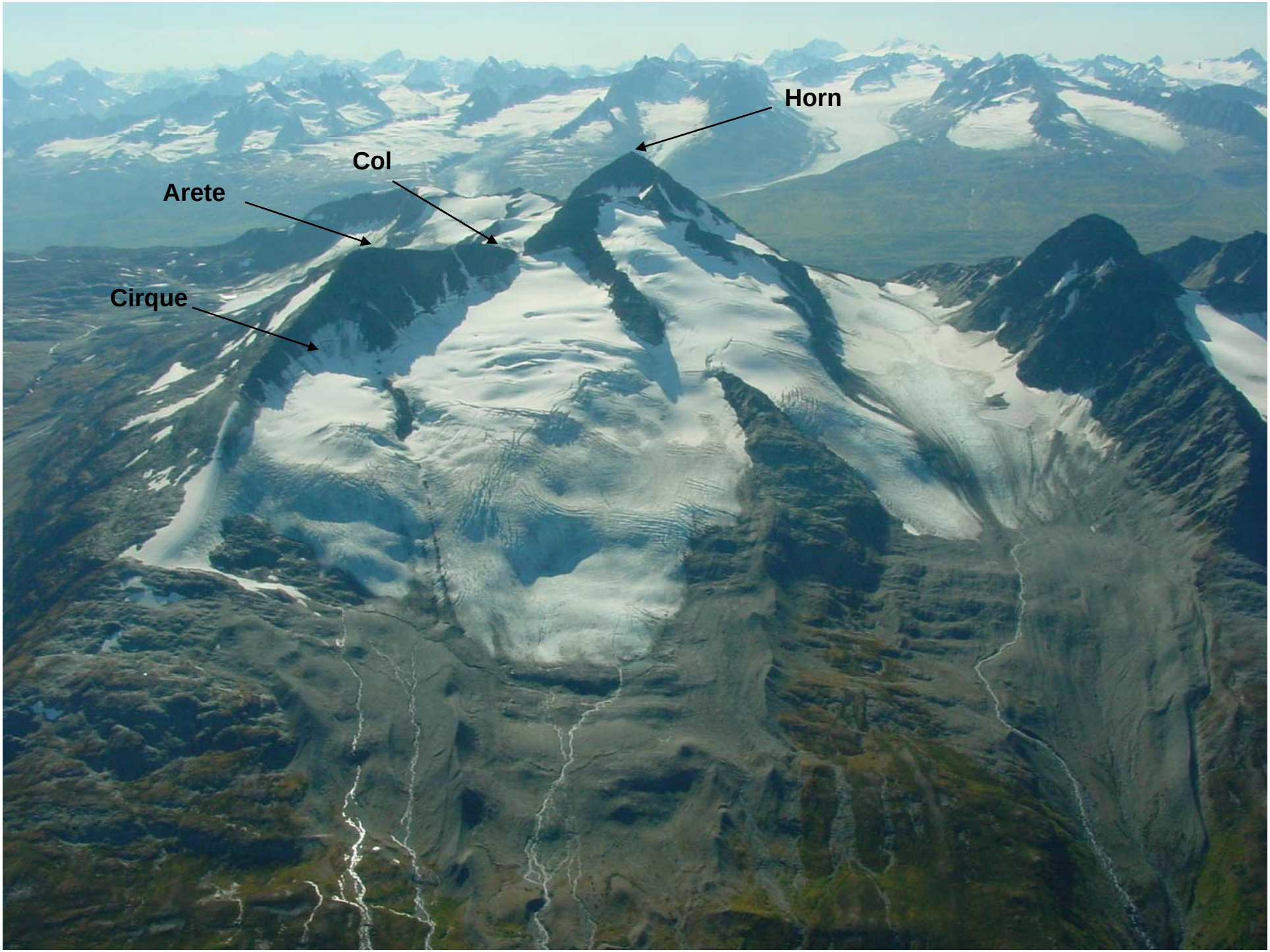


Arêtes

- Jointing and mass wasting (two cirques)

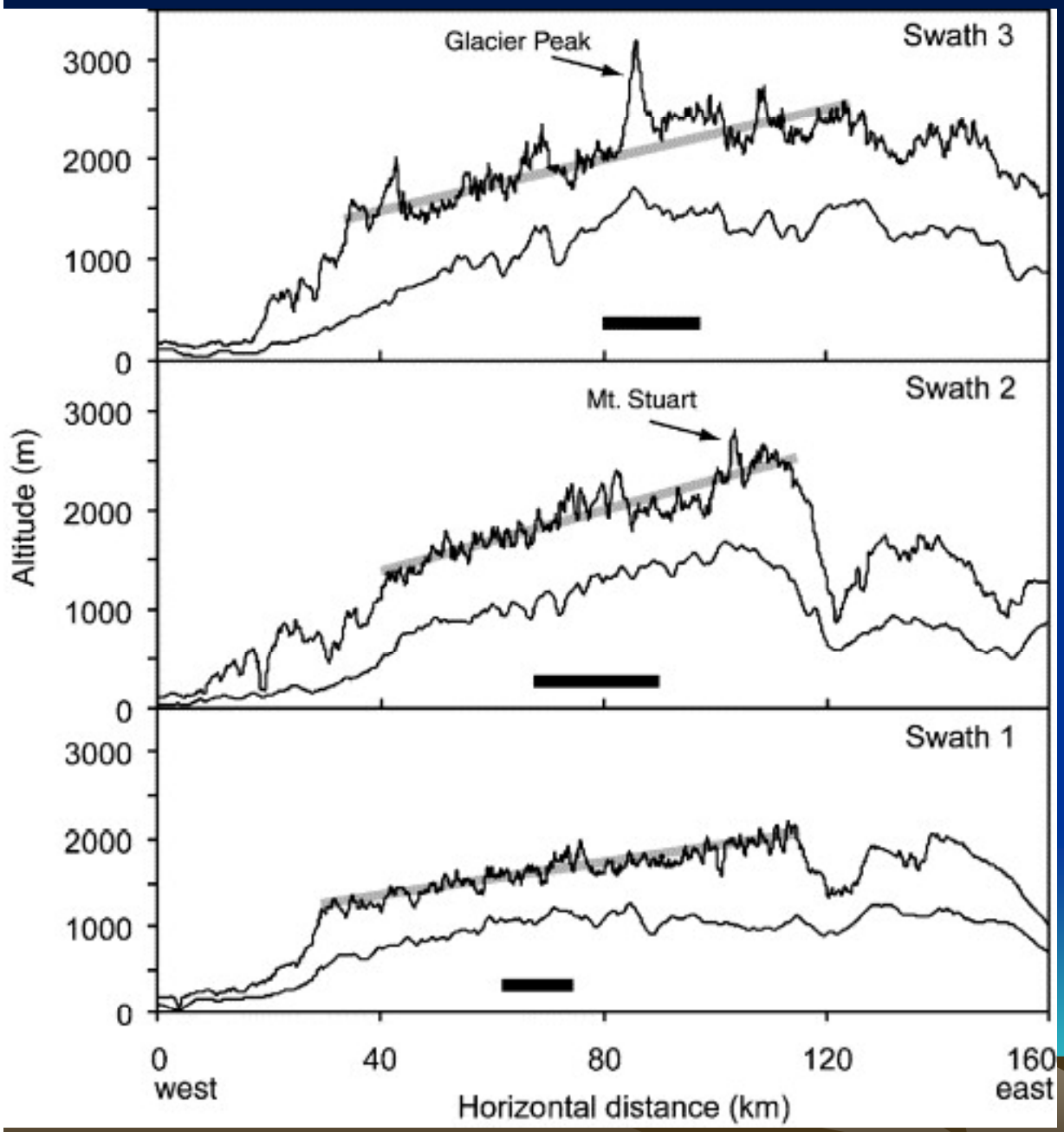
Arêtes and Horns

- 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?

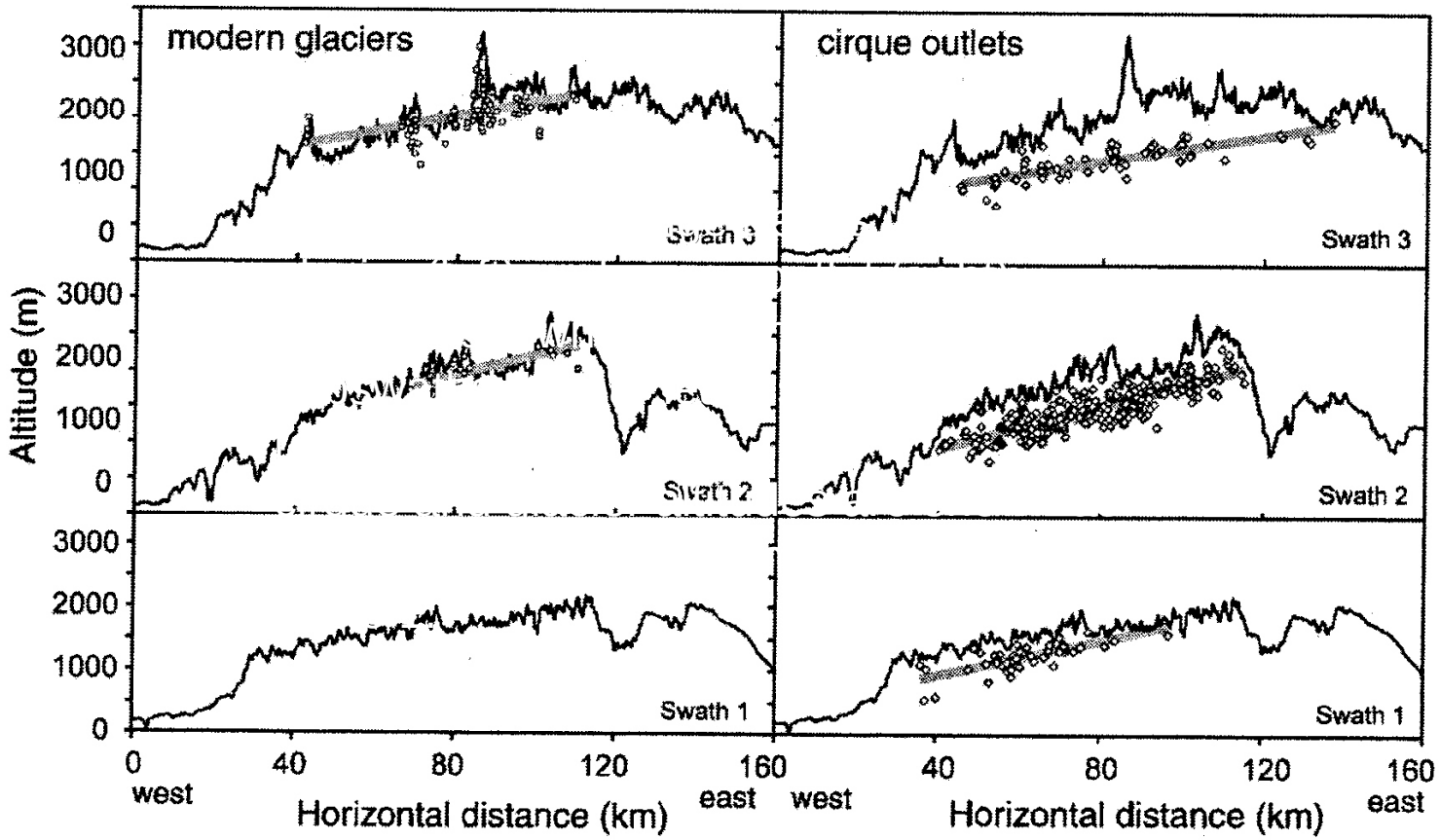


Figure 5. Cross-range trends in average glacier (left) and cirque outlet (right) altitudes shown on the three topographic subswaths. Linear least-square regressions of cirque and glacier altitudes are shown as thick gray lines; slope and R^2 values are in Table 1.

are there cirques on Cascade volcanoes?

why or why not?

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)

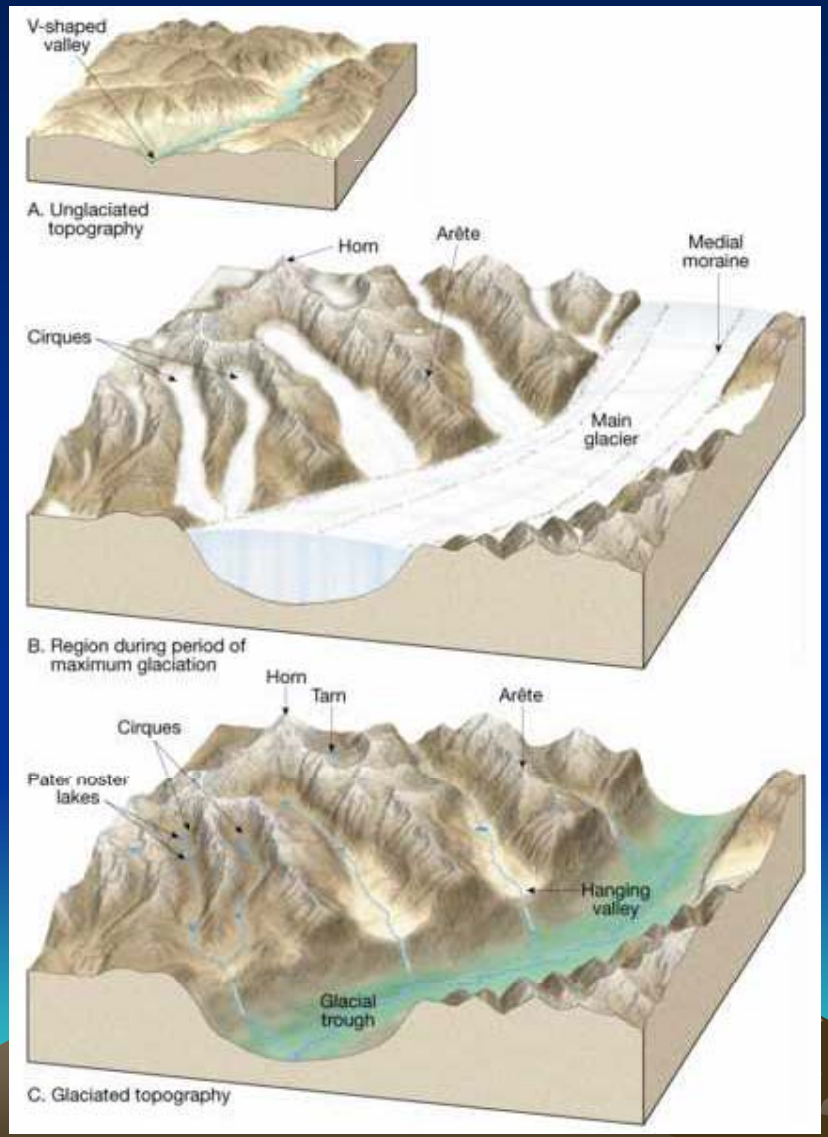
Troughs

- "U" shaped
  - Like a stream, but slower!
  - X-section area = f(Q)

Troughs

- "U" shaped
  - Like a stream, but slower!
  - X-section area = f(Q)
  - Elevation = f(Q) at common surface

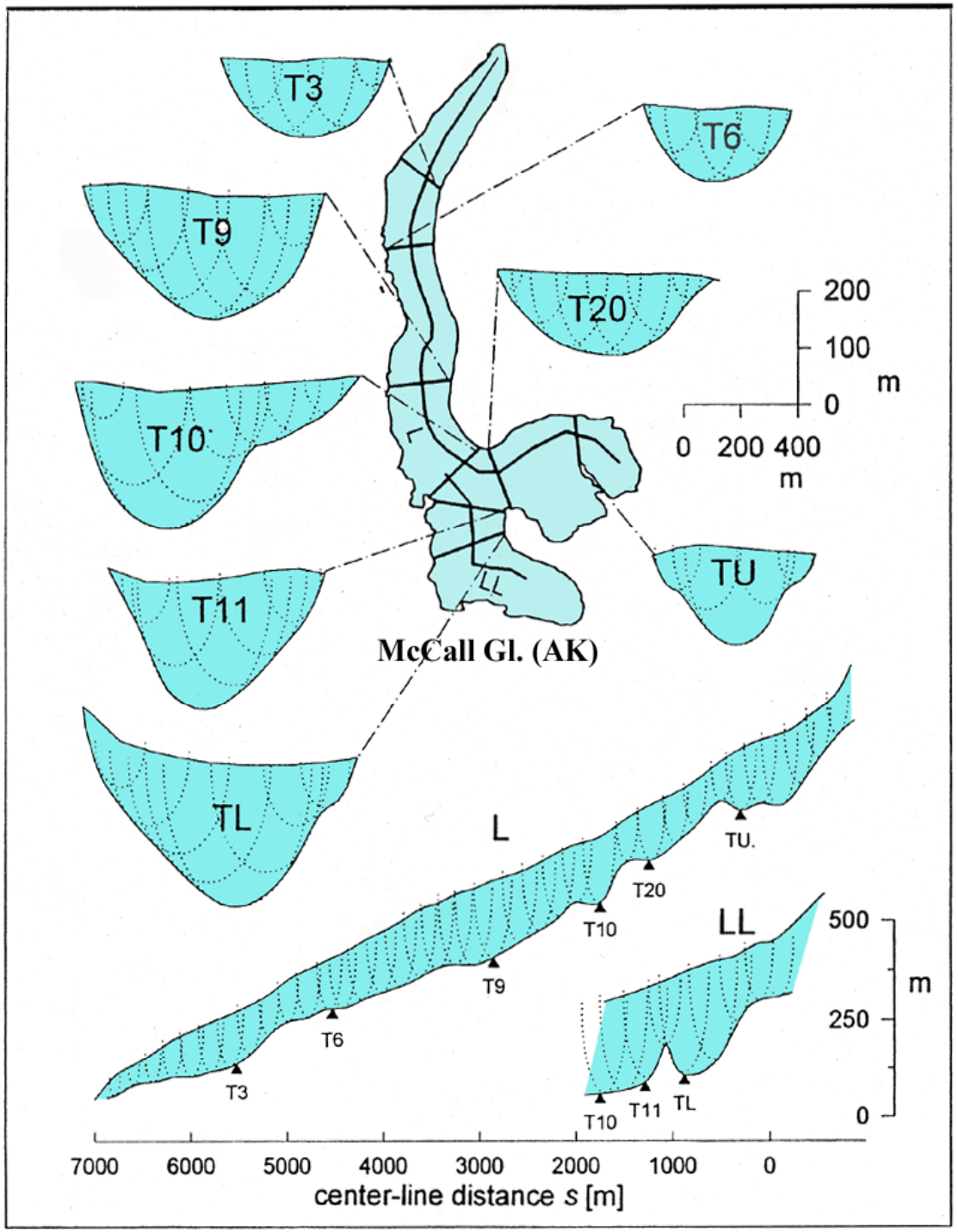
Trough Erosion



Trough Erosion

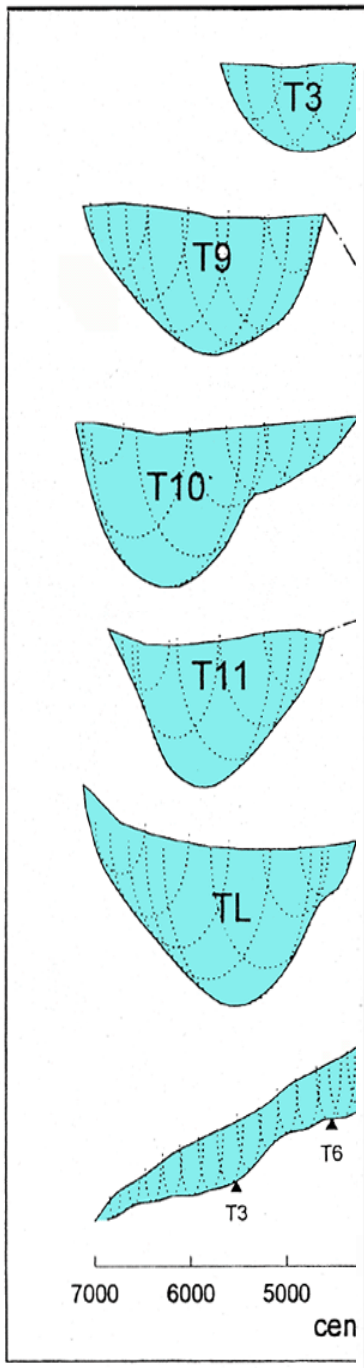
Trough Evolution

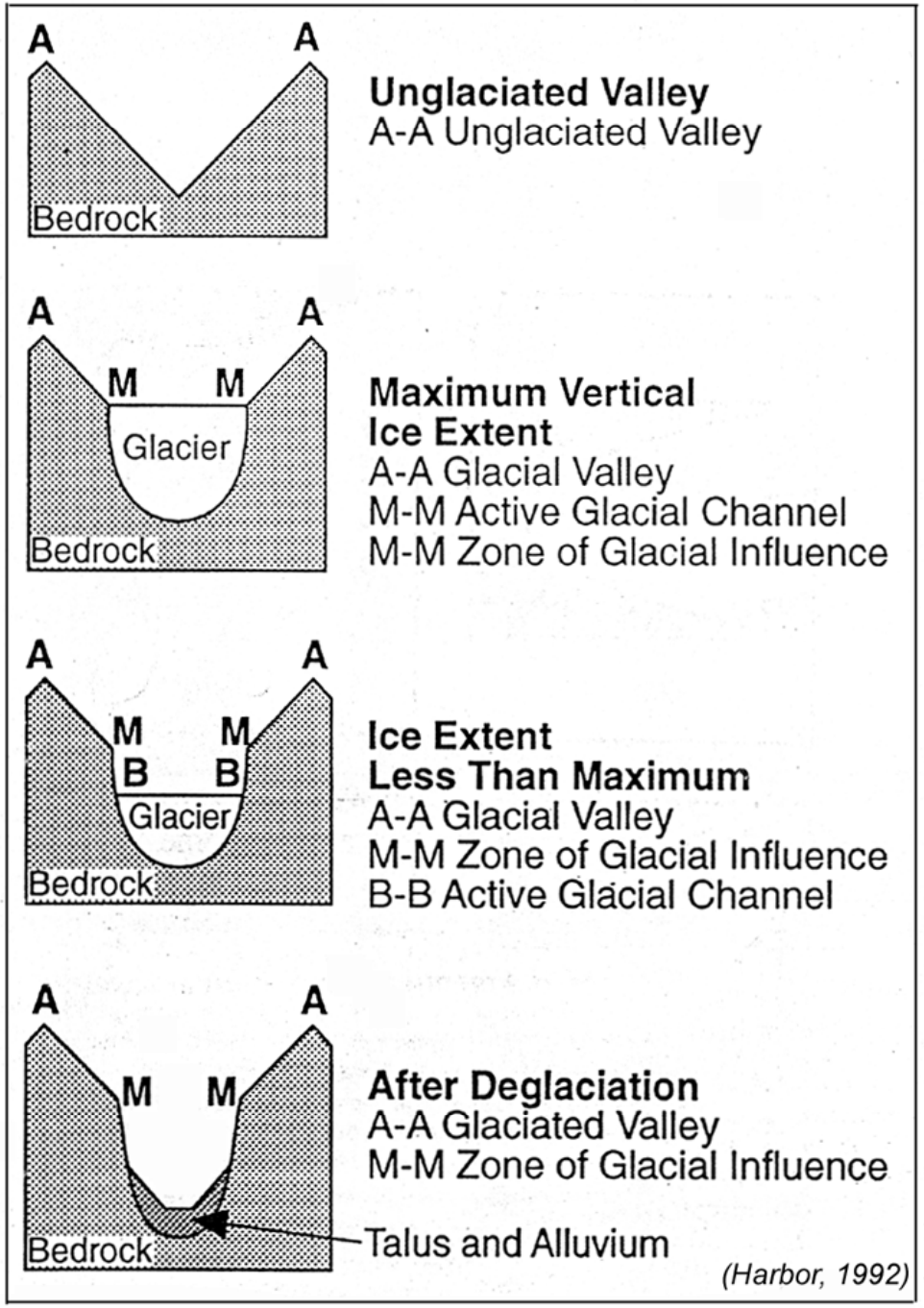
- Real form



Trough Evolution

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





Erosion

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

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

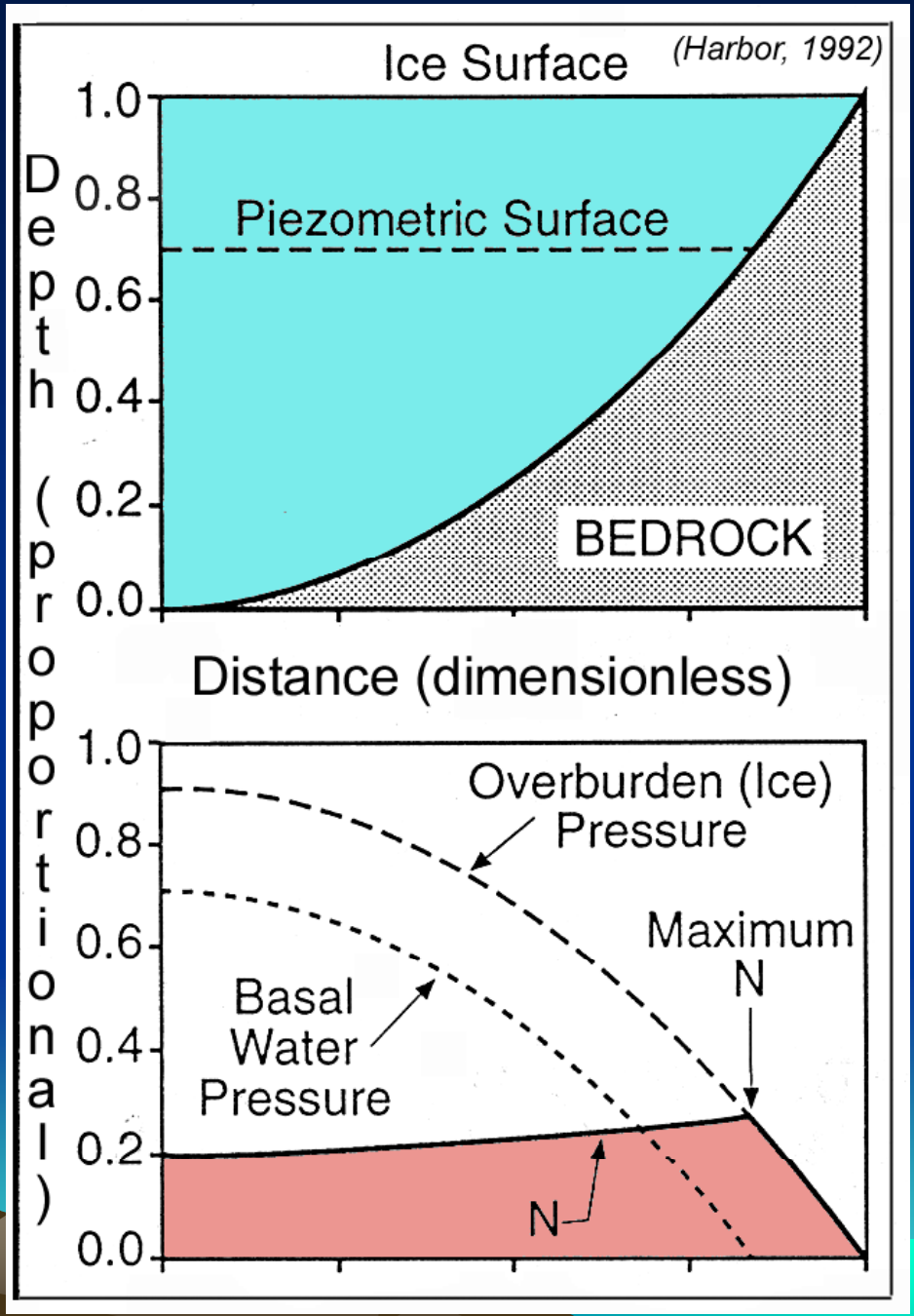
Sliding

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

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

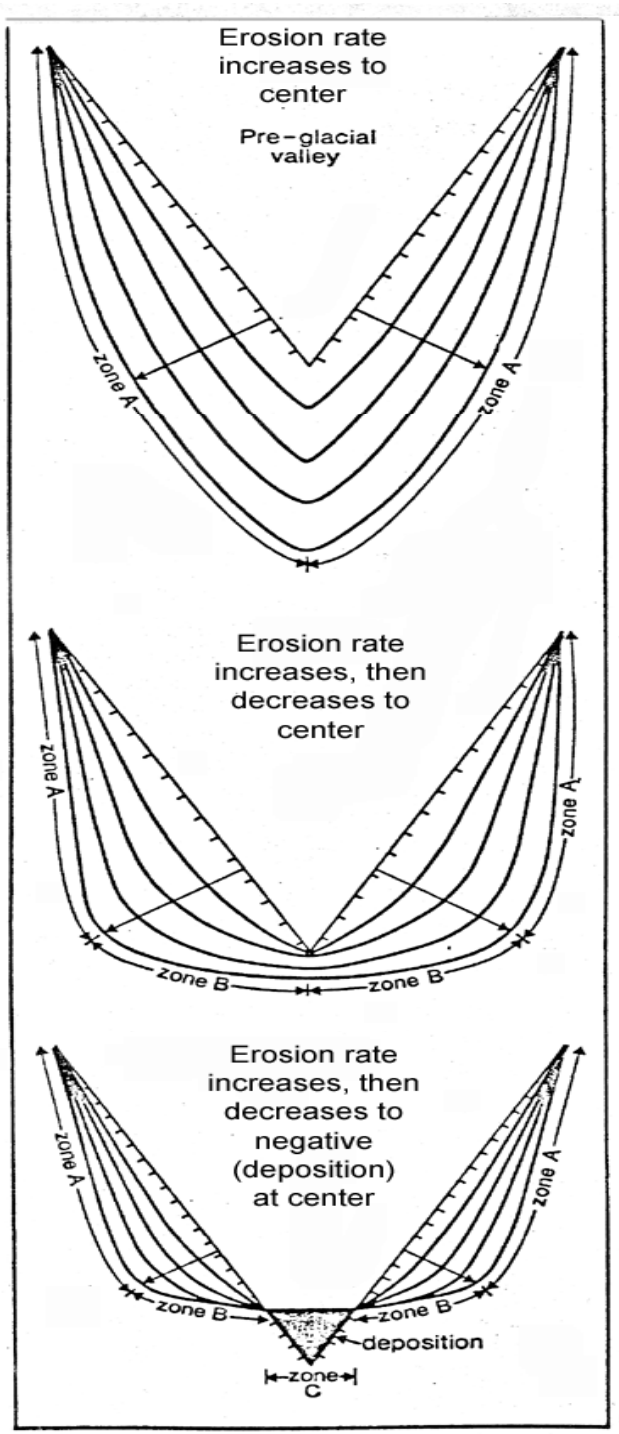
Trough Erosion

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



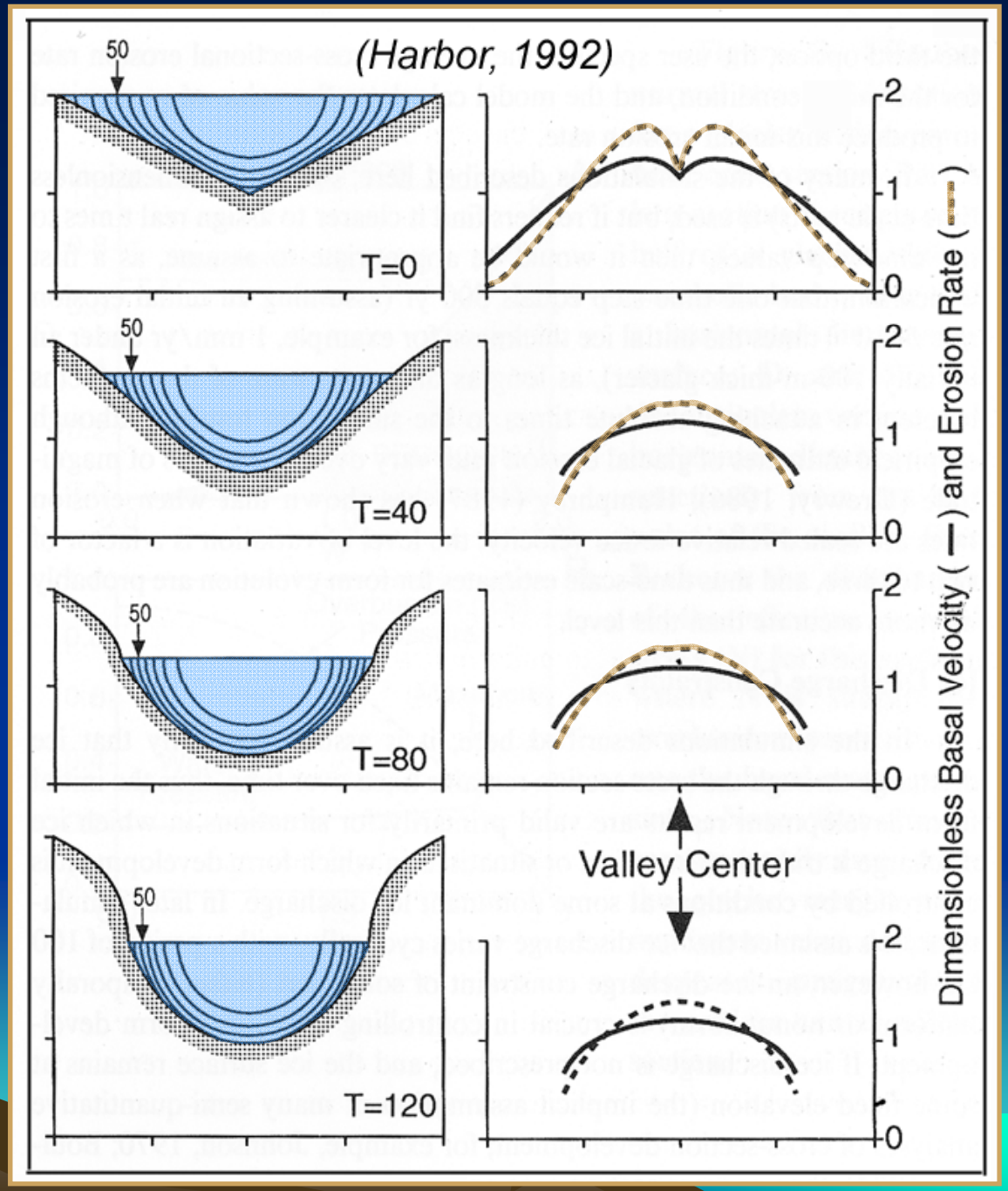
Trough Erosion

- Erosion = f (effective pressure)
  - N = f (water pressure)
- Erosion = f (velocity)
- Morphology = complex function!

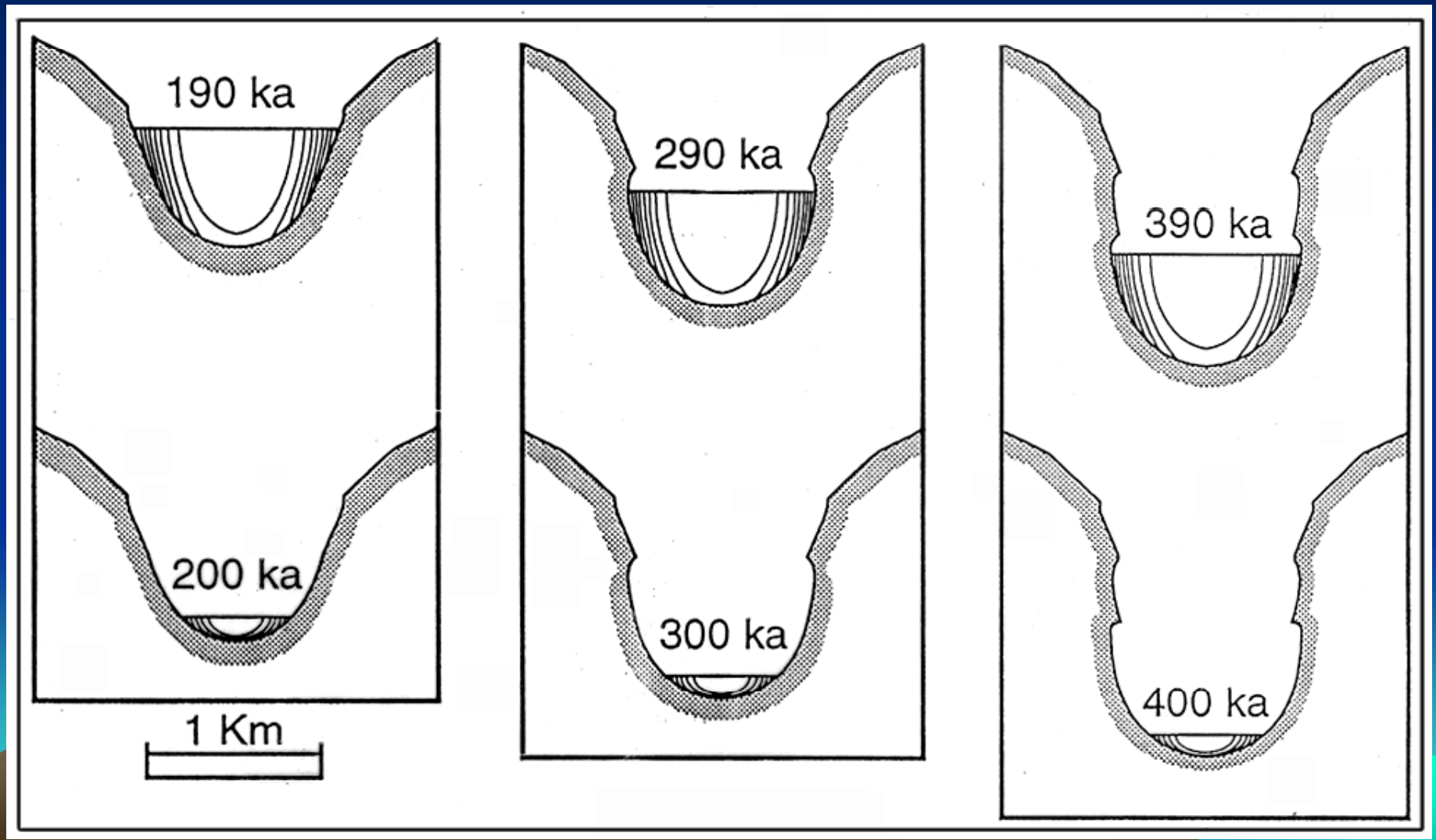


Trough Evolution

- Modeled by Harbor (1992)
- Results in “realistic” erosion
- Sequence = less realistic!

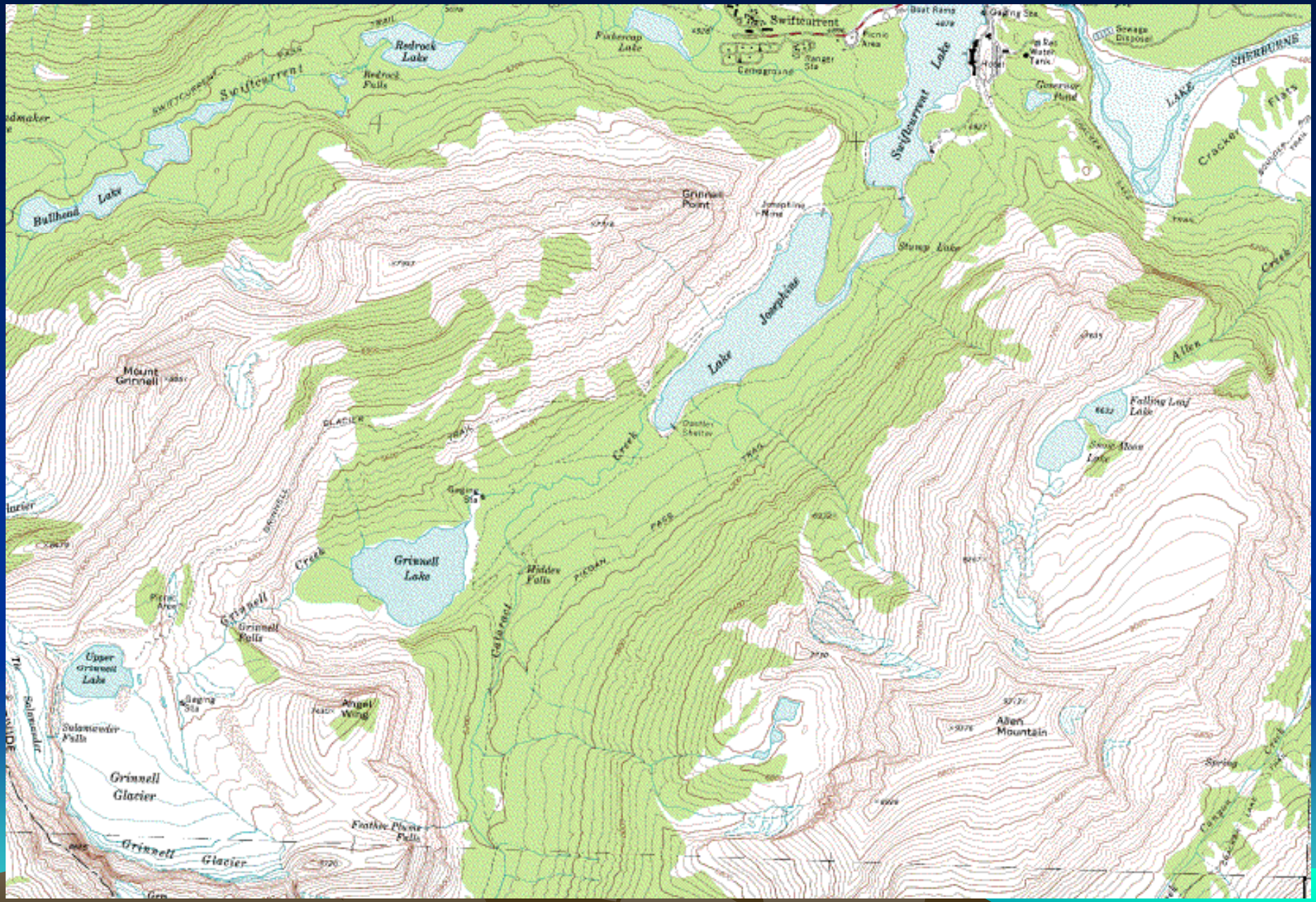


Trough Evolution



Paternoster Lakes

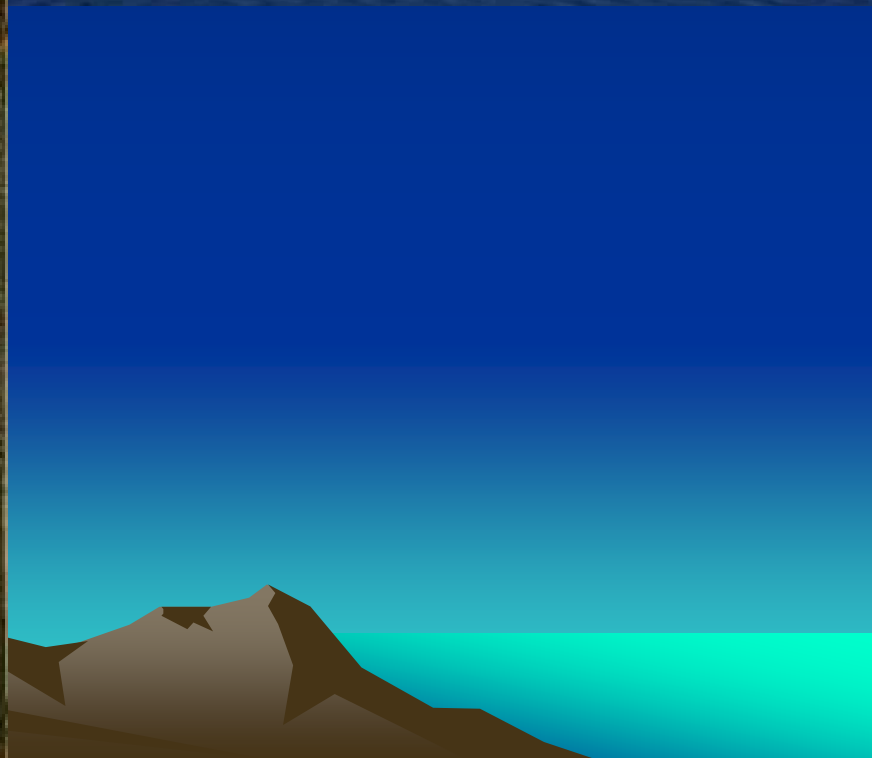
- Local overdeepenings
  - Rel. erodibility?
  - Extension/ compression?
    - Some evidence of cyclicity


Swiftcurrent
Redrock Lake
Redrock Falls
Fishercap Lake
Swiftcurrent Lake
Boat Ramp
Picnic Area
Campground
Ranger Sta
Gaging Sta
Sewage Disposal
Lake Sherburne
Cracker Flats
Cracker Creek
Bullhead Lake
Grinnell Point
Josephine Lake
Stump Lake
Allen Creek
Mount Grinnell
Glacier
Trail
Dancing Creek
Falling Leaf Lake
Snow Moon Lake
Grinnell Lake
Grinnell Creek
Pass
Hidden Falls
Cataract Creek
Picnic Area
Grinnell Falls
Upper Grinnell Lake
Angel Wing
Salamander Falls
Grinnell Glacier
Feather Plume Falls
Allen Mountain
Spring Creek

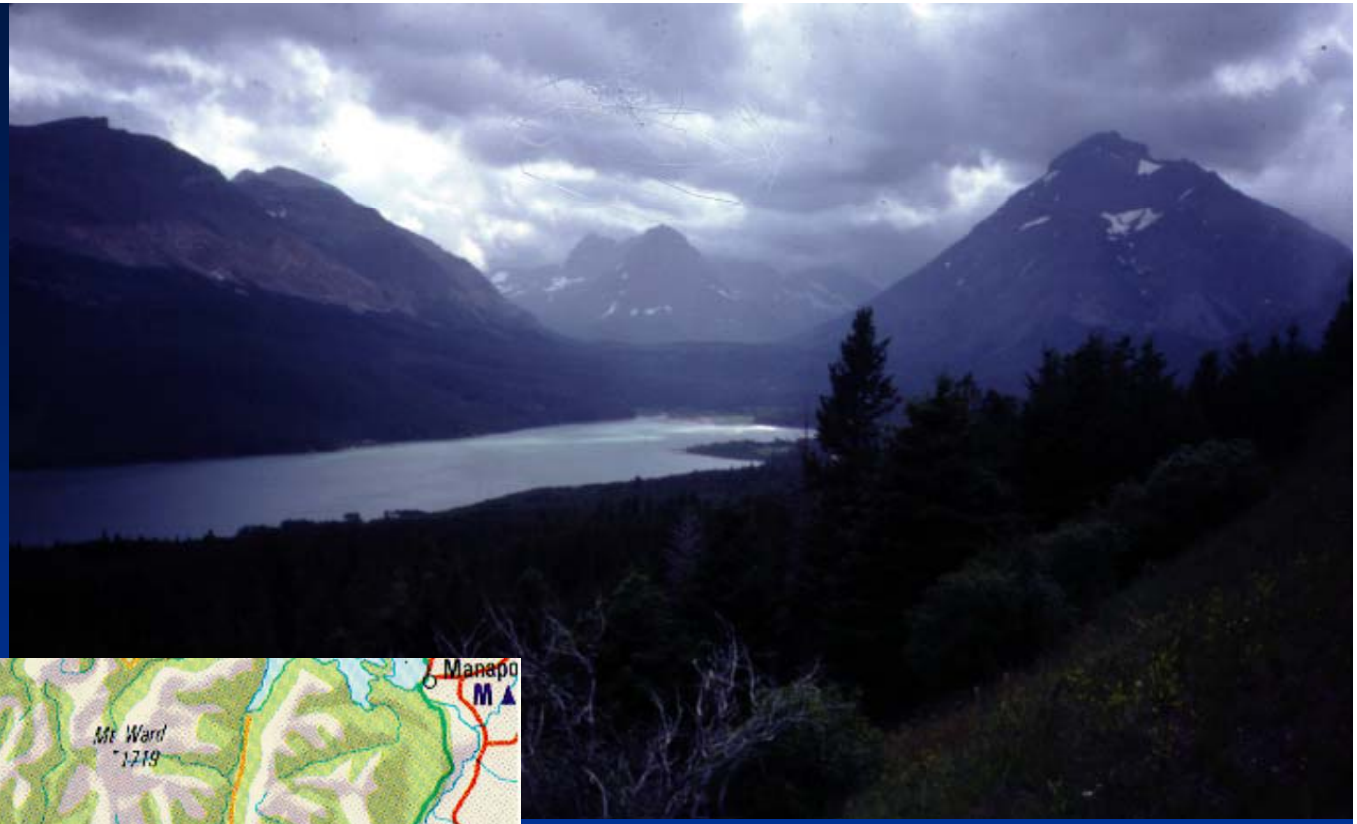
Fiords

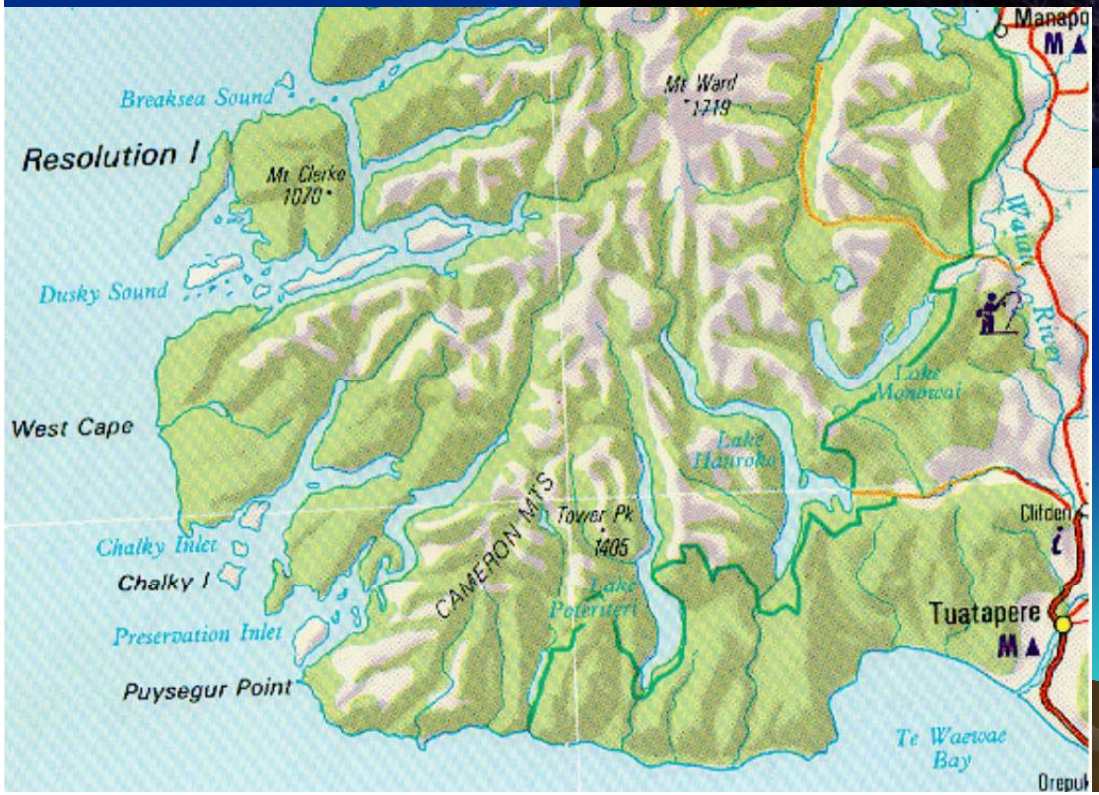
- Definition:
  - Drowned glacial troughs
- Appearance:
  - Steep walls rising from the sea

Fiords

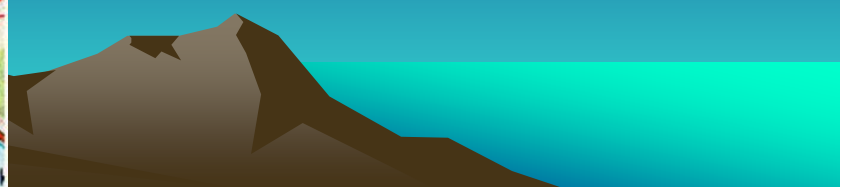


Trough Lake = Fiord?

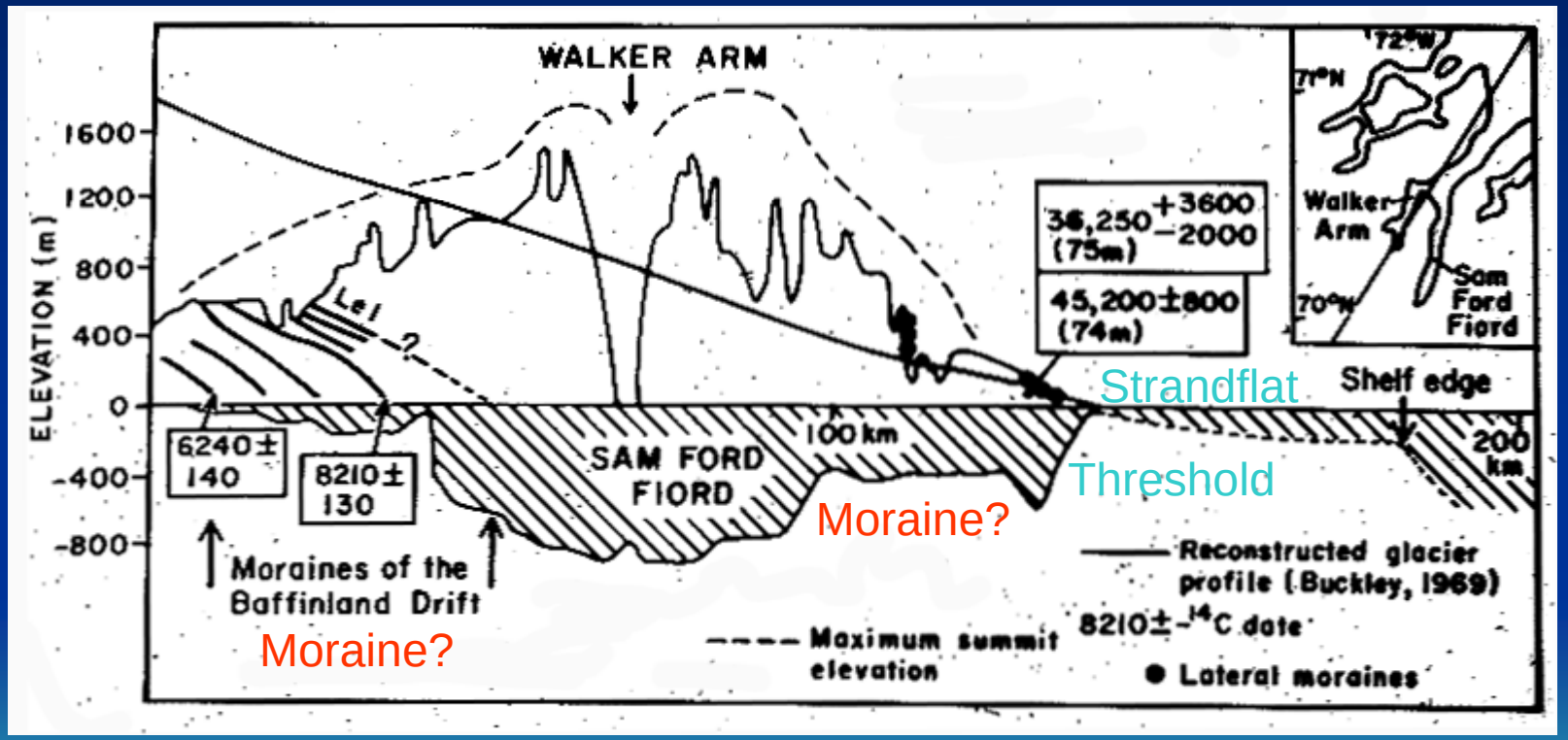




- Two Medicine Lk
- Fiordland (NZ)



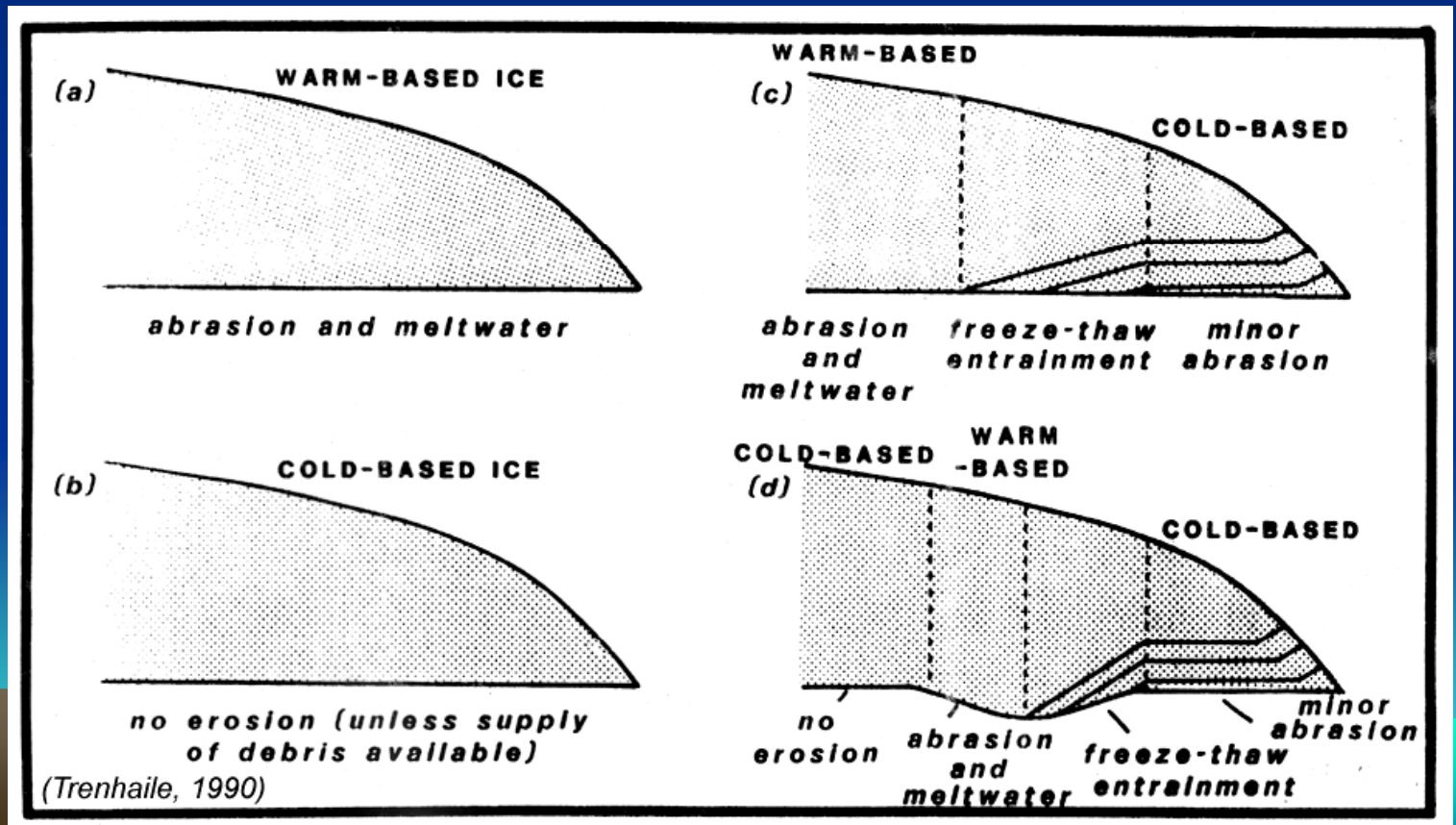
Thresholds and Strandflats



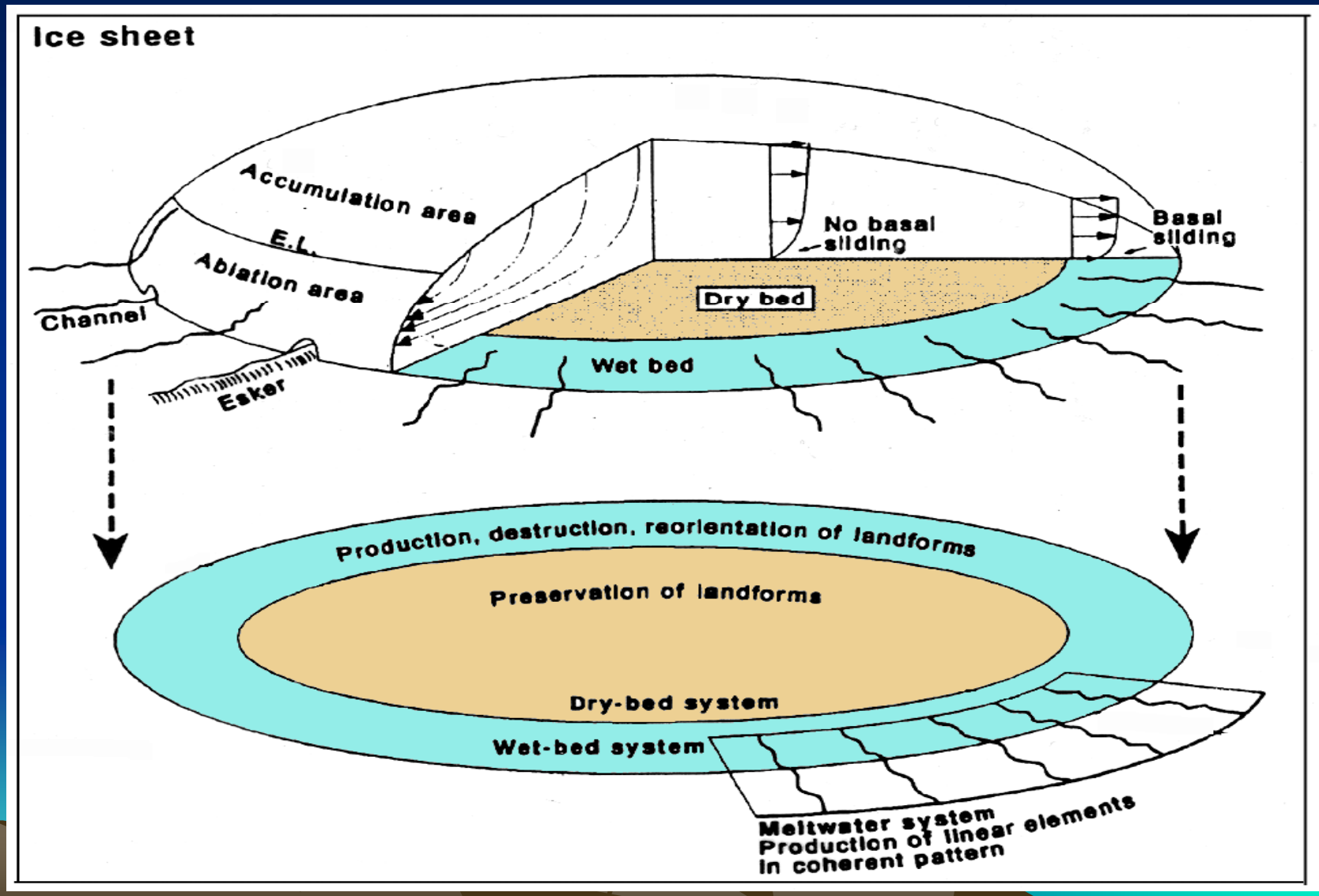
- Overdeepen at confluences
- Rise to threshold

Areal Scour (ice sheet)

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

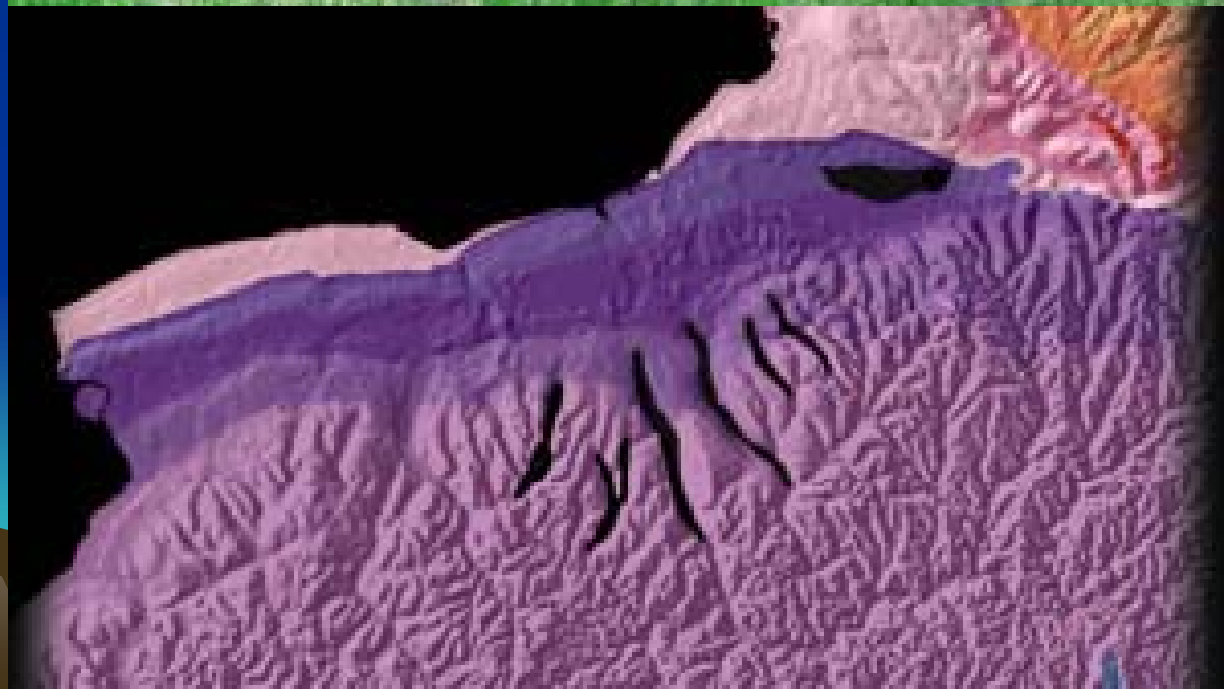


Areal Scour (ice sheet)



SLE (ice sheet)

- Examples: Finger Lakes
  - Selective linear erosion
  - Edge of Allegheny Plateau
  - Possibly locally wet-based; **feedback?**
  - **Fluvial?**



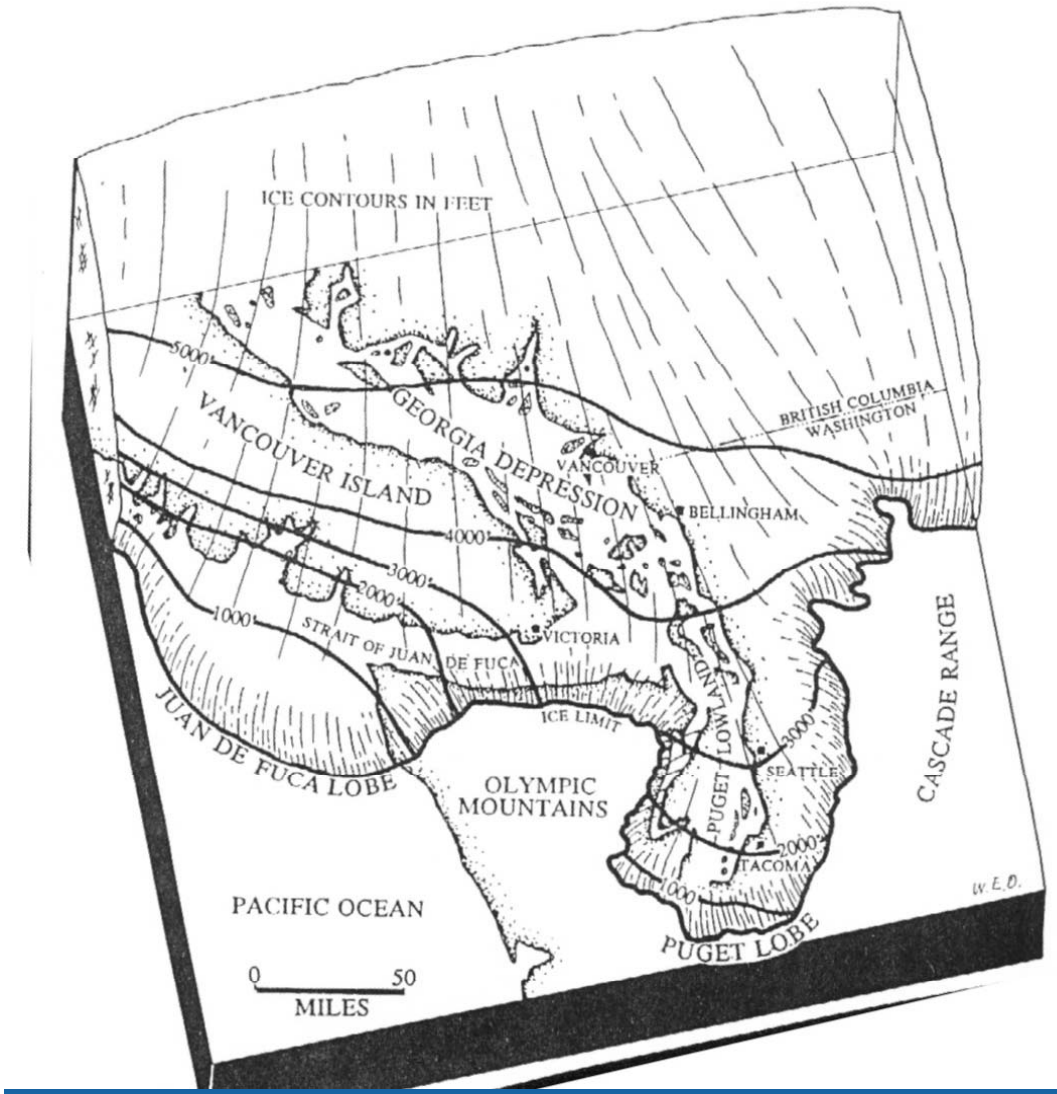
SLE (ice sheet)

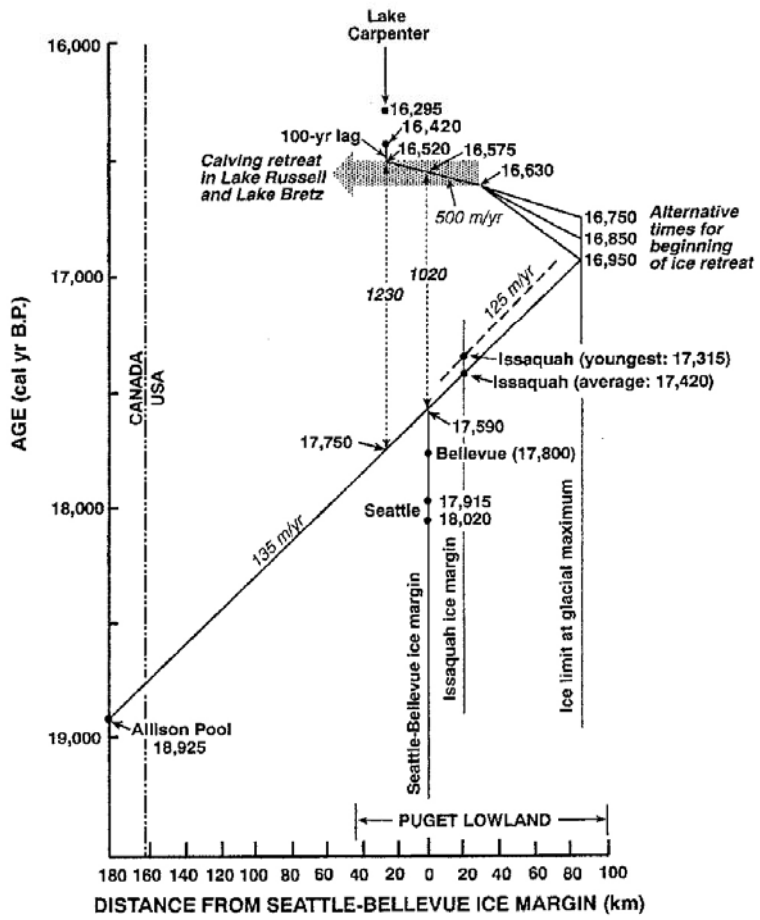
- Examples: Finger Lakes
  - Selective linear erosion
  - Edge of Allegheny Plateau
  - Possibly locally wet-based; feedback
- Not the only such example!

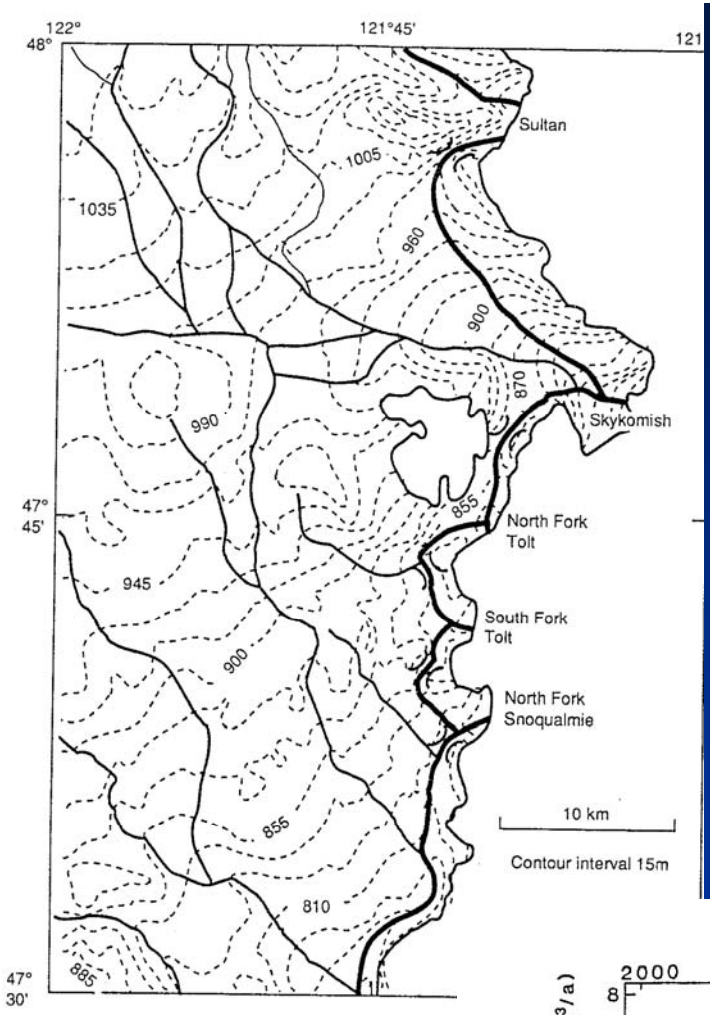
Breached Divides

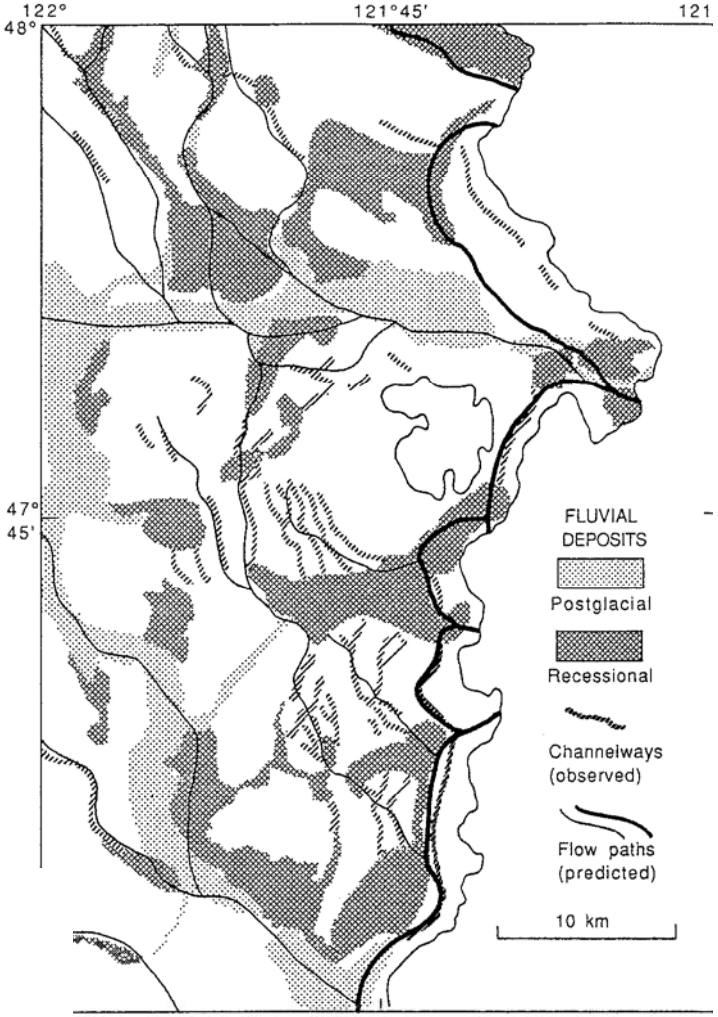
- New England "notches"
  - Ice advances through notch
  - Subglacial drainage?

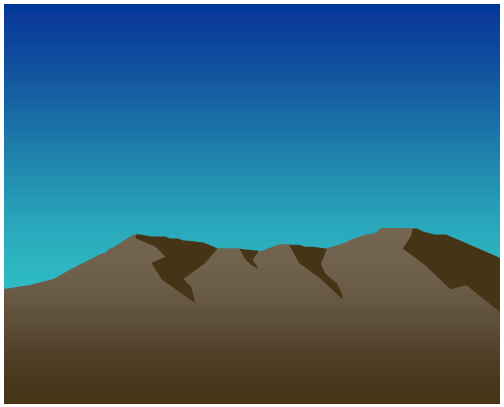
Puget Lobe

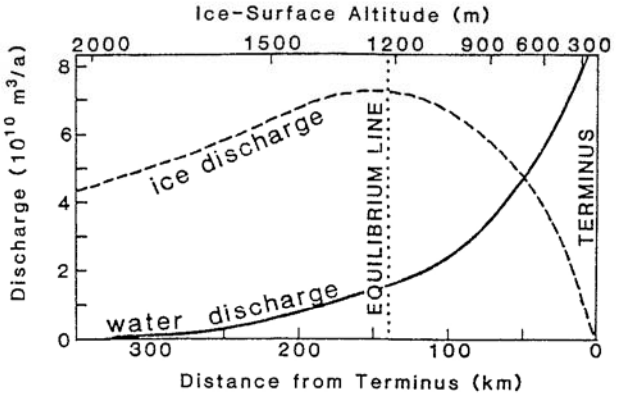

ICE CONTOURS IN FEET
5000
VANCOUVER ISLAND
GEORGIA DEPRESSION
VANCOUVER
BELLINGHAM
BRITISH COLUMBIA
WASHINGTON
4000
3000
2000
1000
STRAIT OF JUAN DE FUCA
VICTORIA
JUAN DE FUCA LOBE
ICE LIMIT
OLYMPIC MOUNTAINS
PUGET LOWLAND
SEATTLE
CASCADE RANGE
TACOMA
PACIFIC OCEAN
PUGET LOBE
0
50
MILES


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









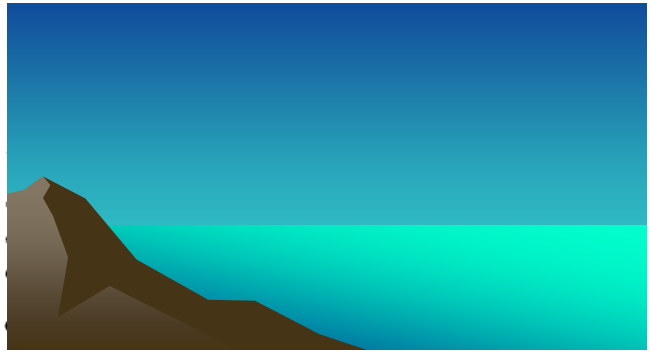


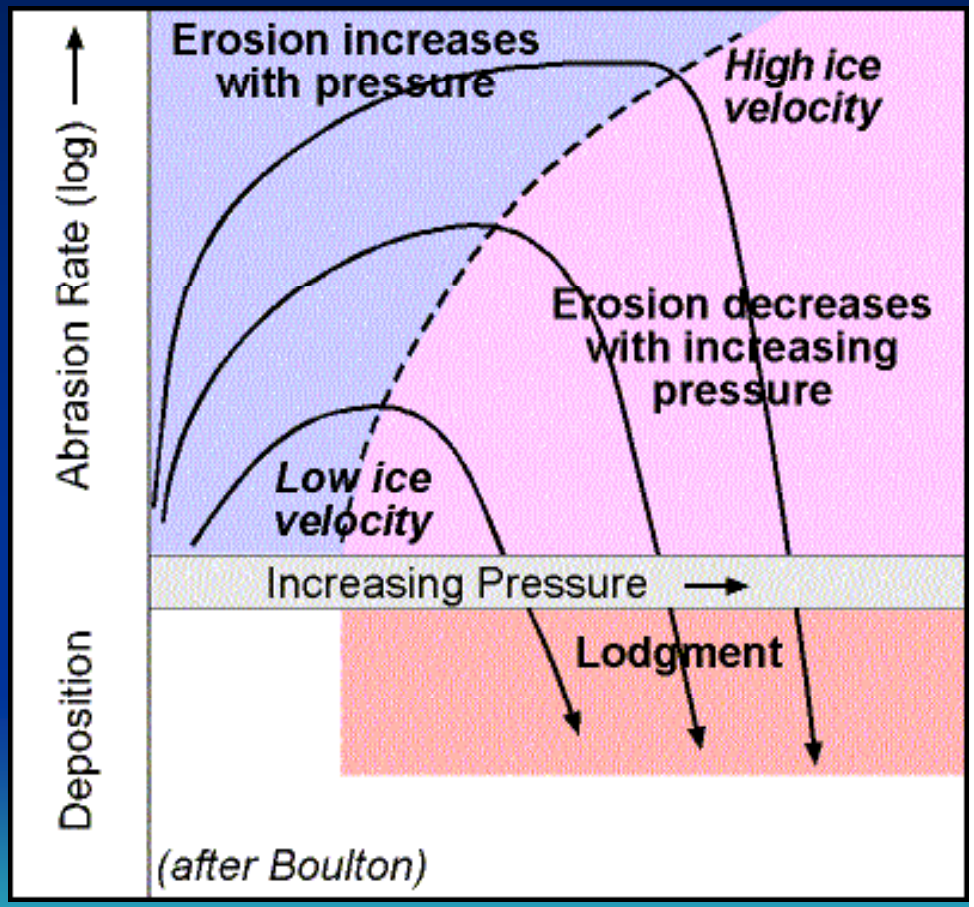
Figure 12. Total flux of ice and water across the entire Puget lobe as functions of longitudinal position. All values spatially averaged (that is, no channelization of water assumed). Equilibrium-line position and mass flux data are from Booth (1986a).

References

- Andrews, J.T., 1975, Glacial Systems, Duxbury Press, North Scituate, Mass.
- Battle, W.R.B., 1960, Temperature observations in bergschrunds and their relationship to frost shattering, in Lewis, W.V. (ed.), Norwegian Cirque Glaciers, Royal Geographic Society Research Series 4, p. 5-10.
- Benn, D.I., and Evans, D.J.A., 1998, Glaciers and Glaciation, Arnold Press, New York
- Evans, I.S., 1969, The geomorphology and morphometry of glacial and nival areas, in Chorley, R.J. (ed.), Water, Earth, and Man, Methuen, London, p. 369-380.
- Gardner, J.S., 1987, Evidence for headwall weathering zones, Boundary Glacier, Canadian Rocky Mountains, v. 33, p. 60-67.
- Haynes, V.M., 1968, The influence of glacial erosion and rock structure on corries in Scotland, Geografiska Annaler. Series A, Physical Geography, v. 50, p. 221-234.
- Hooke, R.L., 1991, Positive feedbacks associated with erosion of glacial cirques and overdeepenings, Geological Society of America Bulletin, v. 103, p. 1104-1108.
- Sugden, D.E., and John, B.S., 1976, Glaciers and Landscape, Wiley, New York.

Trough Erosion

- Erosion = f (effective pressure)
  - N = f (water pressure)
- Erosion = f (velocity)



Model Evolution

- "Equilibrium glacial trough"
  - "b" value between 2 and 2.5
  - Form ratio unstable (mass wasting?)