Glacial Modification

Part II

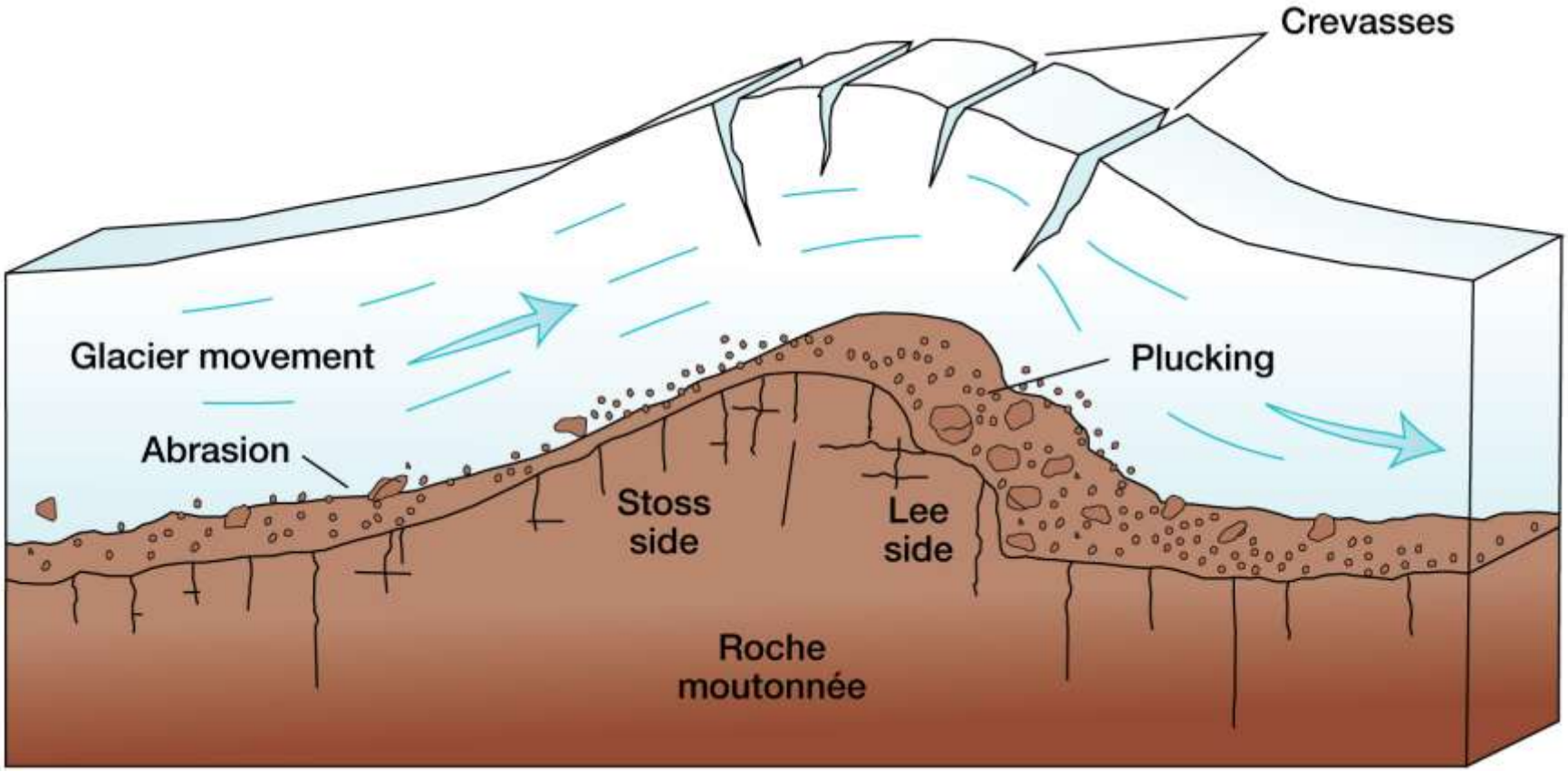
Stupendous glaciers and crystal snowflakes -- every form of animate or inanimate existence leaves its impress upon the soul of man.
-Orison Swett Marden

❖ Continental Ice Sheets

- Development and Flow
  - Origin of Pleistocene Ice Sheets
    - Northern Hemisphere: Subpolar and midlatitude locations
    - Antarctica
- Erosion by Ice Sheets
  - Ice Excavations (extensive plucking action)
    - Hudson Bay basin
    - Great Lakes basins
    - Finger Lakes

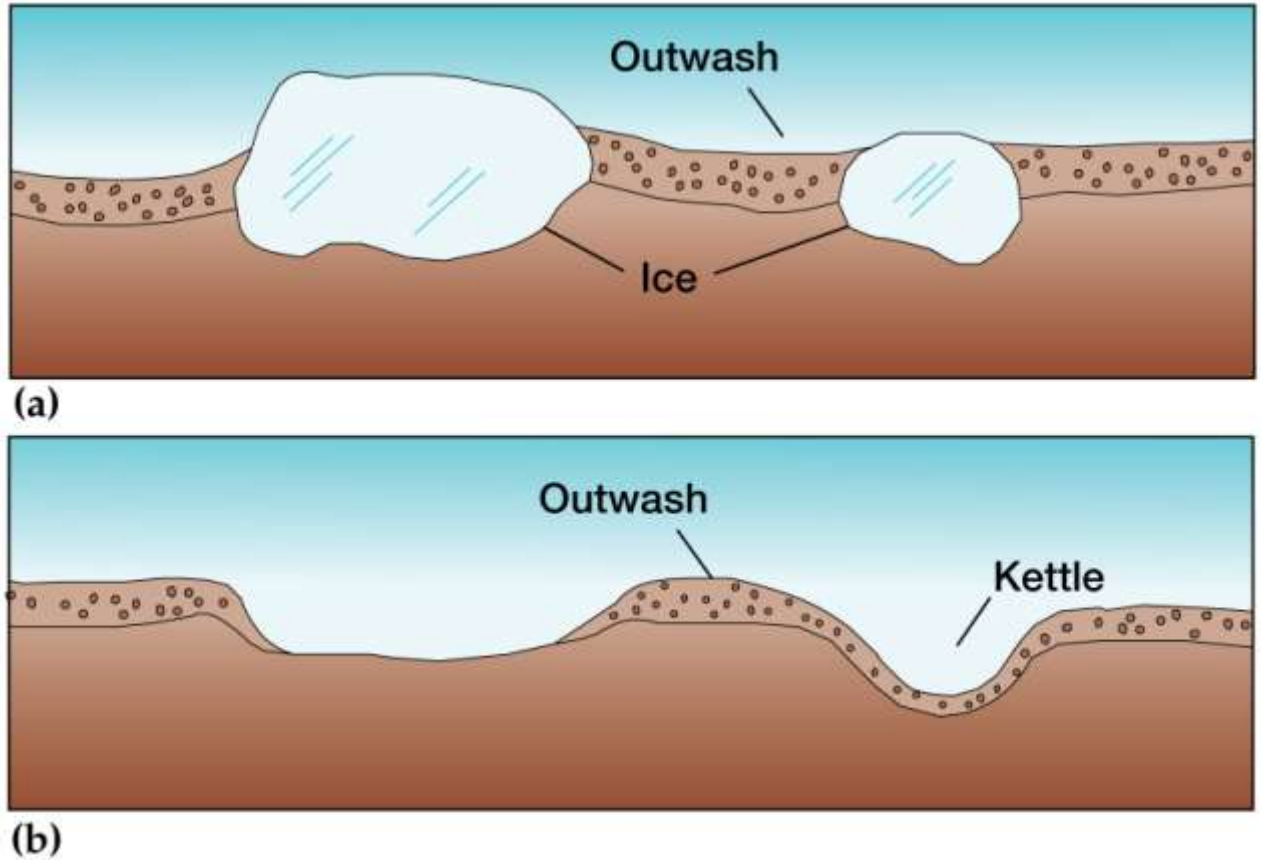
Finger Lakes of upstate New York

– Roche Moutonnée



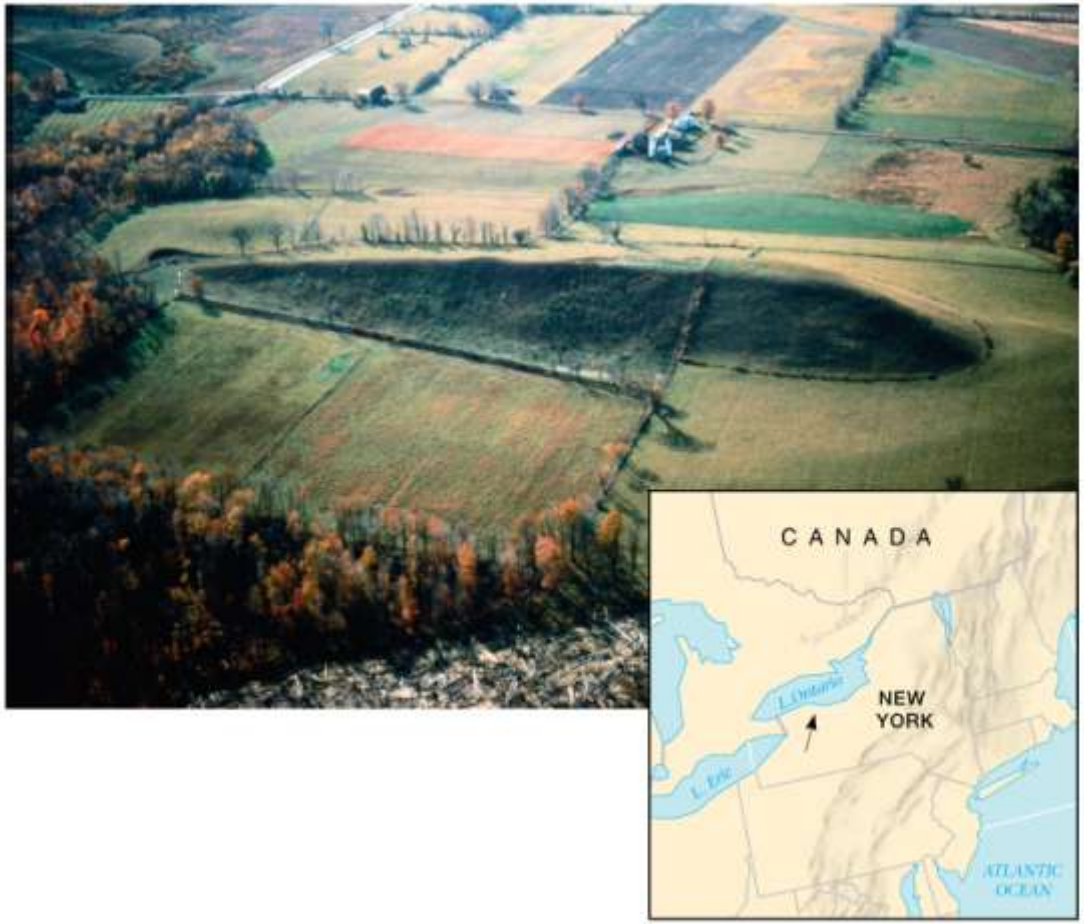
Lembert Dome, a roche moutonnée

- Deposition by Ice Sheets
  - Kettle



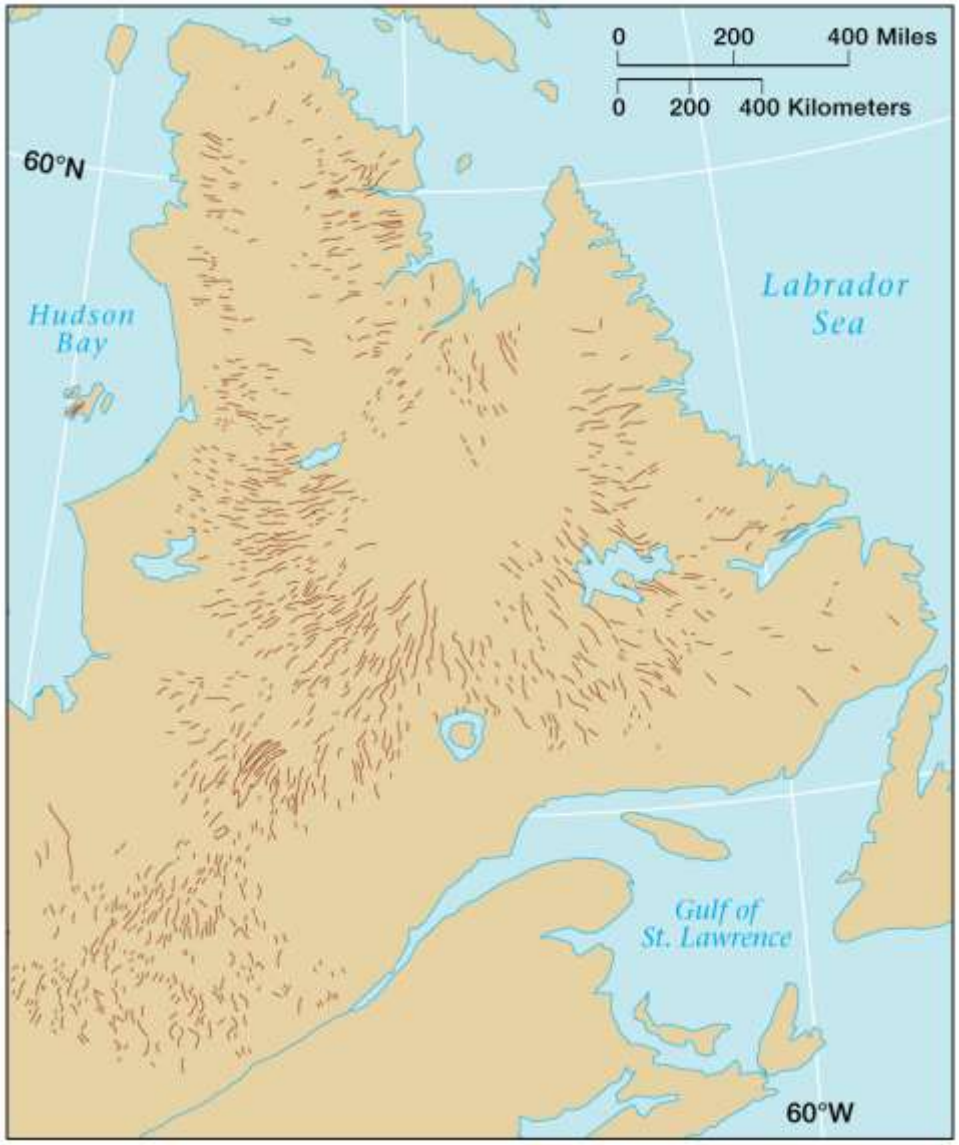
The formation of kettles

– Drumlin



Drumlin west of Rochester, NY

– Esker



Eskers in eastern Canada

– Lakes
  - Deranged drainage

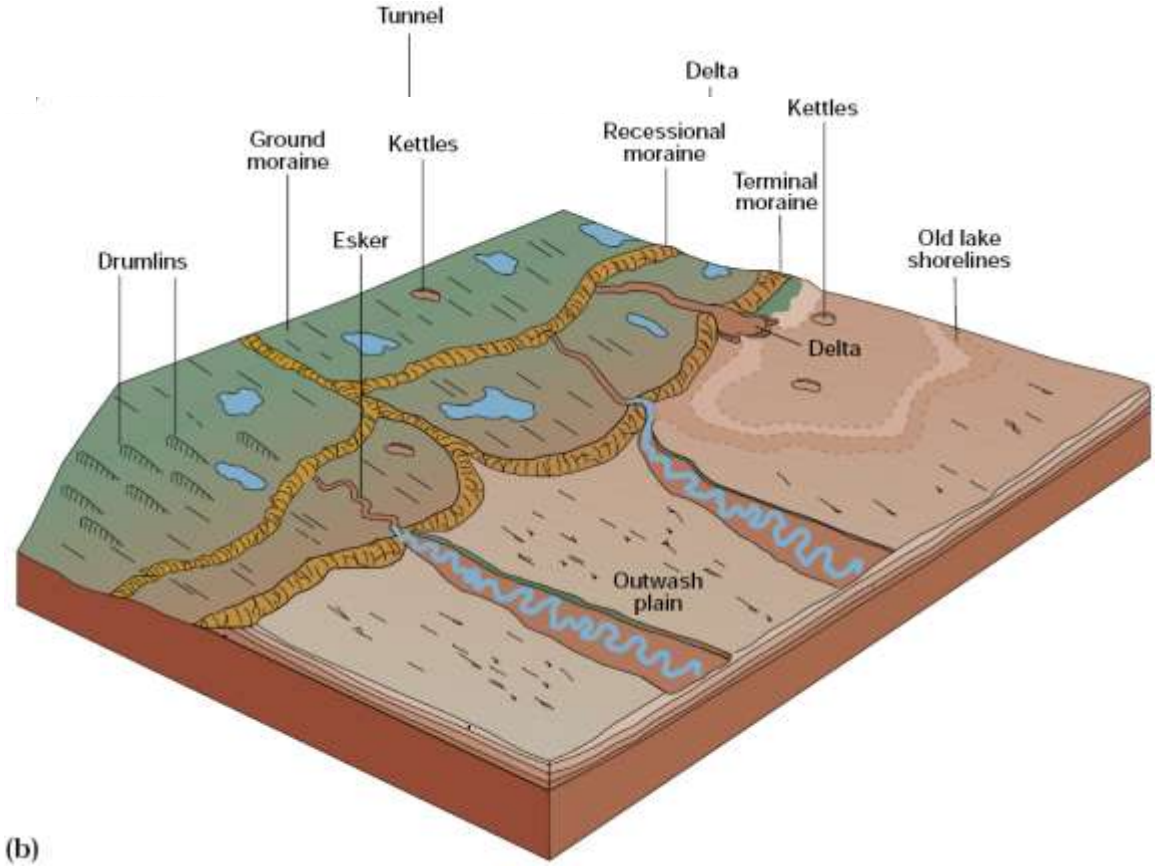
(a)

(b)

(c)

Lakes north of Ohio and Missouri rivers

– Summary diagram of deposits associated with icesheets



Glacier-deposited and glaciofluvially deposited features of a landscape

❖ Mountain Glaciers

- Development and Flow
  - Development
    - Long-term, high-elevation snowfall, above the equilibrium line
  - Flow
    - Highland icefields submerge uppermost peaks, tongues of ice flow down slope into adjacent valleys
    - Alpine glaciers form in sheltered heads of valleys and flow down the valleys.

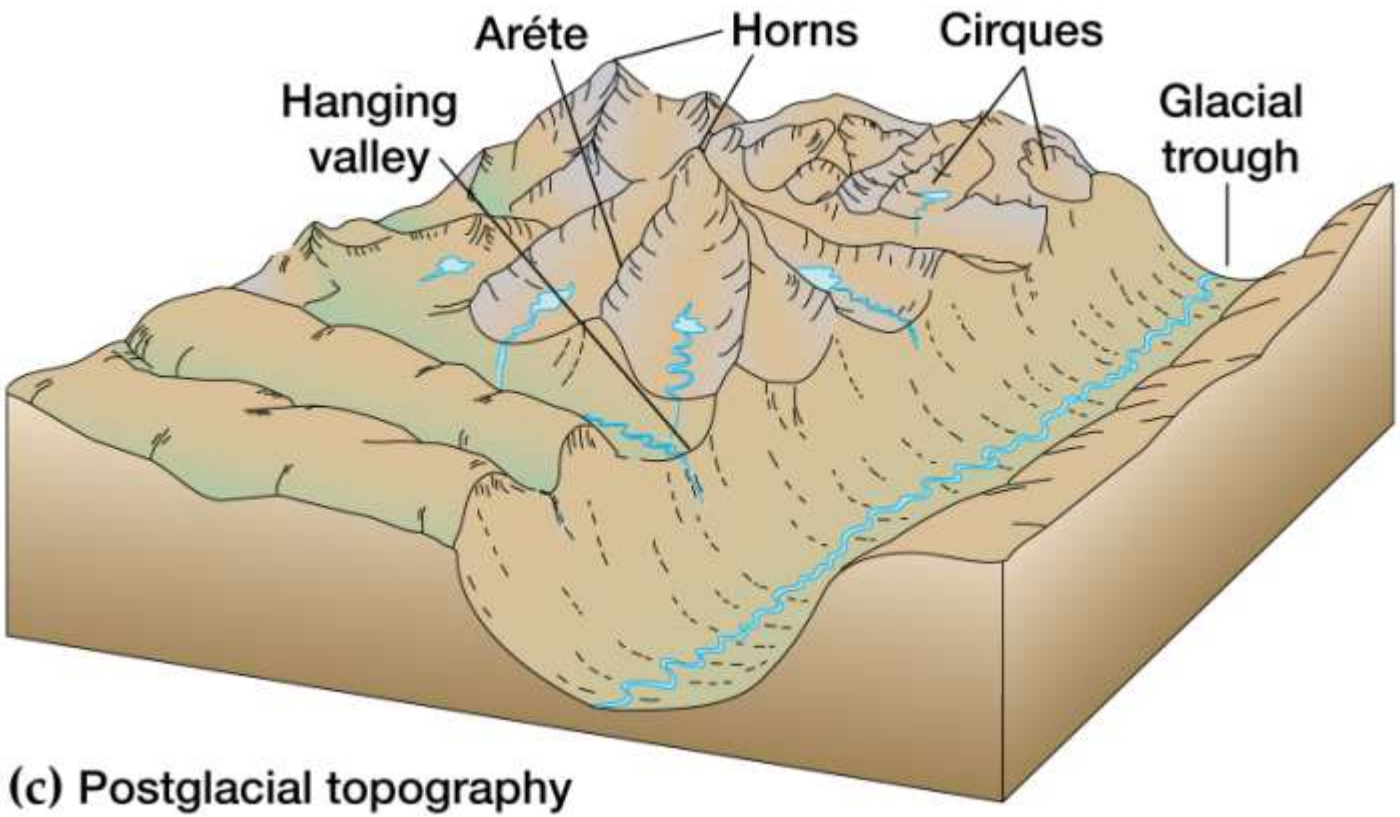
- Highland Icefield and valley (outlet) glaciers

(a)

(b)

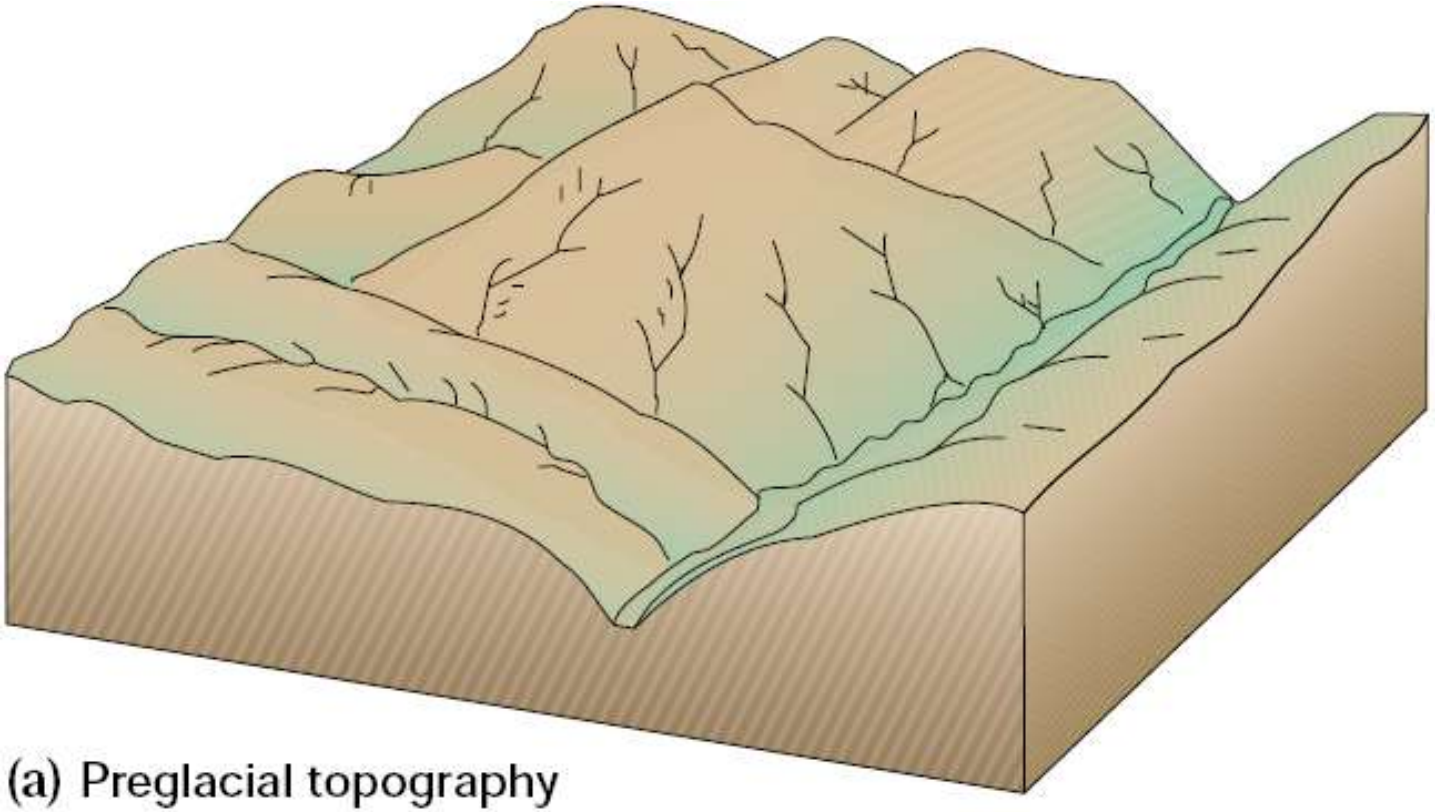
Mt. Rainier, WA. Highland icefields with tongues of valley glaciers radiating from the central field.

- Erosion by Mountain Glaciers
  - Erosion dominates upper portion of the valley



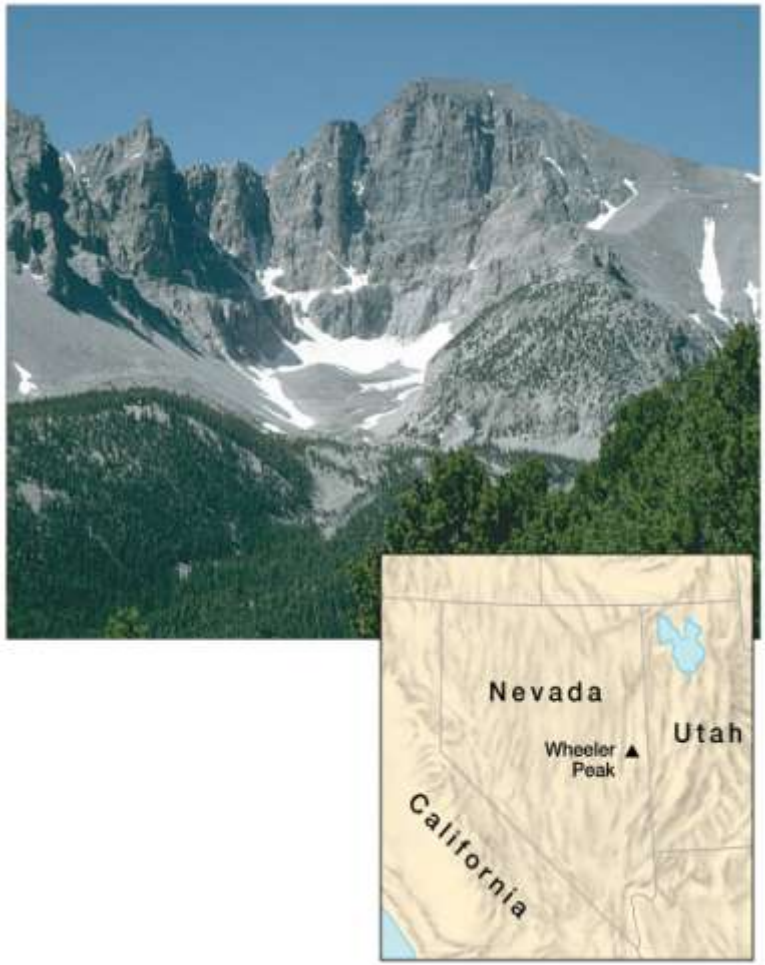
(c) Postglacial topography

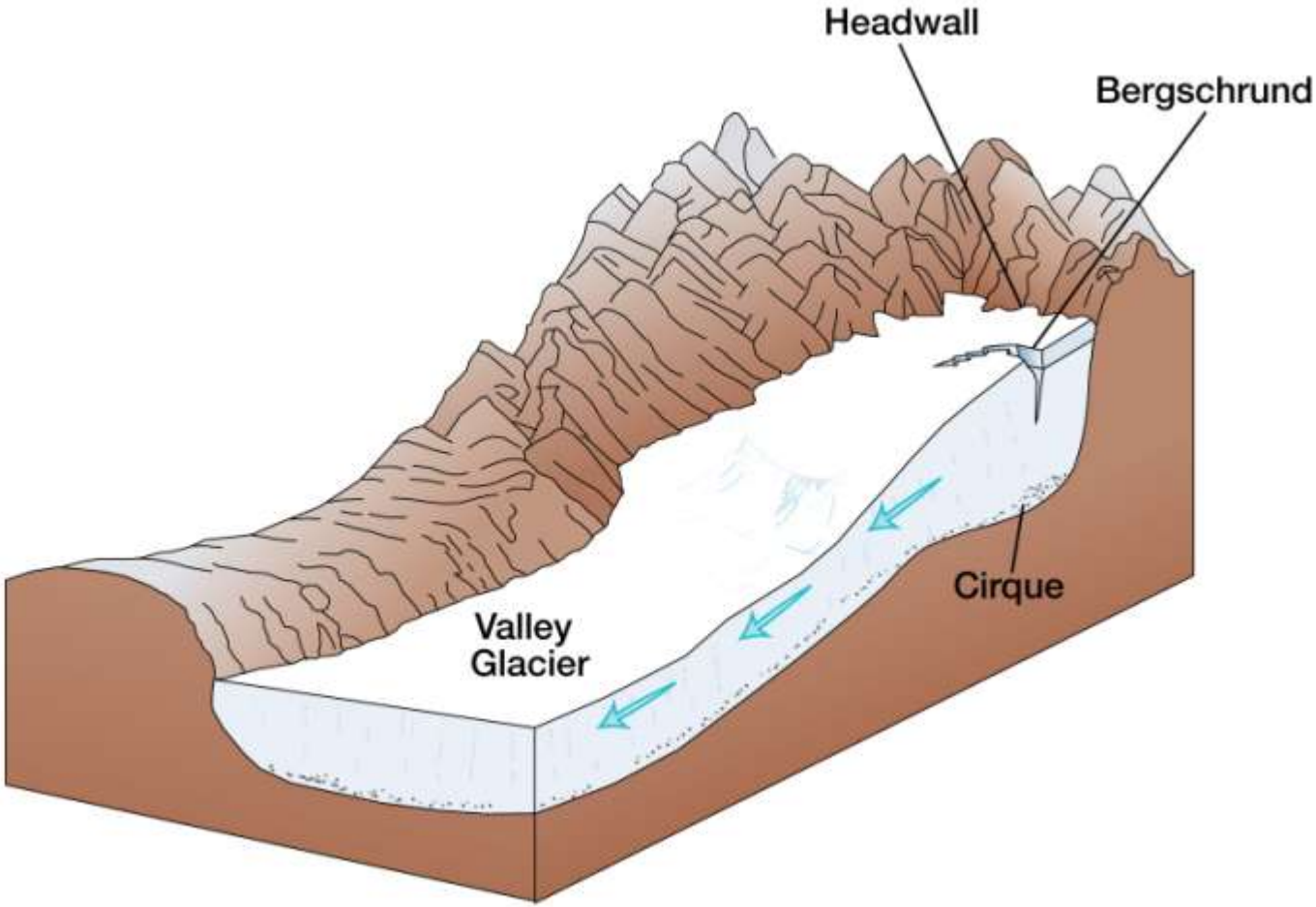
- Development of the erosional landscape



(a) Preglacial topography

- Cirque
  - Upper end (head) of a glaciated valley.
  - The signature feature of alpine glacial topography
    - Small remnant glacier on the north side of Wheeler Peak in Nevada's Great Basin National Park

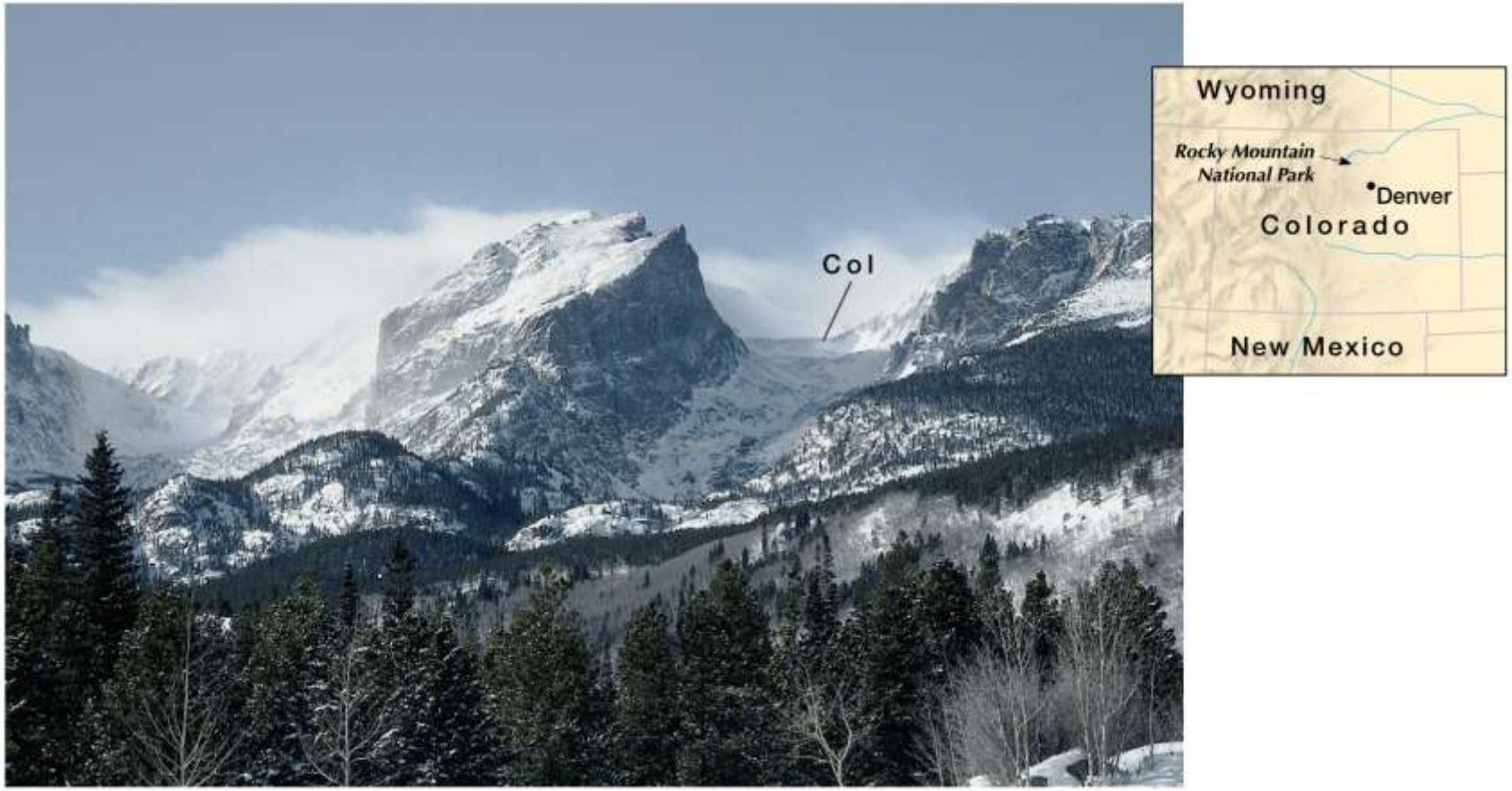




Development of a cirque at the head of a valley glacier.

Three small cirques on Mount Nebo in central Utah.
The cirques glaciers never grew out of their basins.

– Col



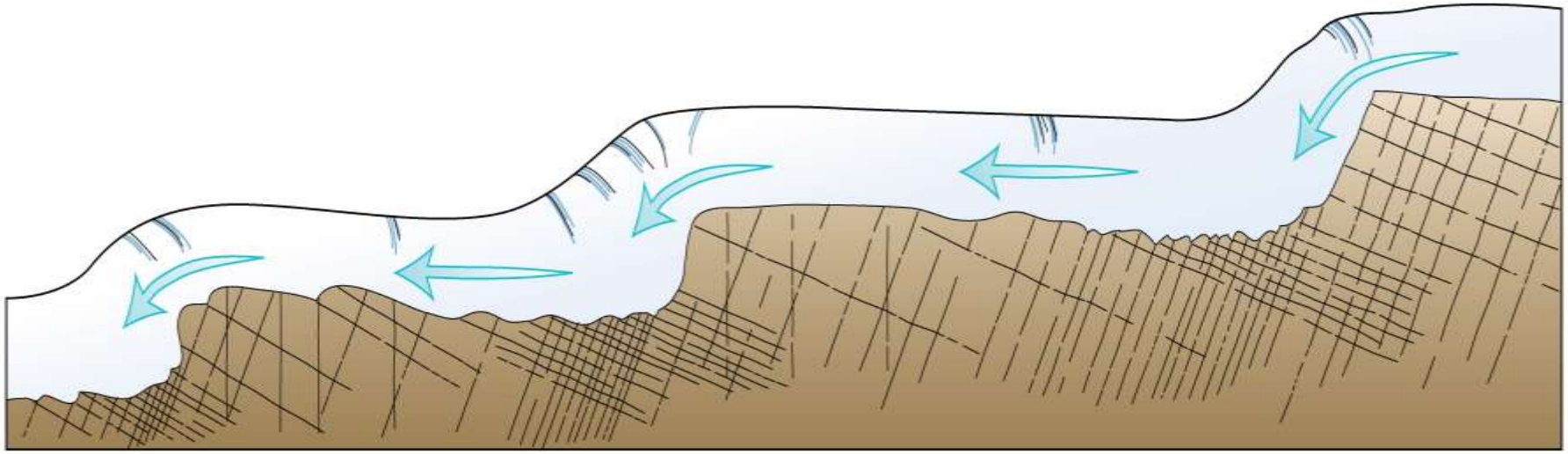
Col in a glaciated section of the Front Range in north-central Colorado

– Horn

Mount Aspiring, a prominent horn in the Southern Alps of New Zealand

– Glacial trough

Glacial Trough and Half Dome in Yosemite National Park, CA



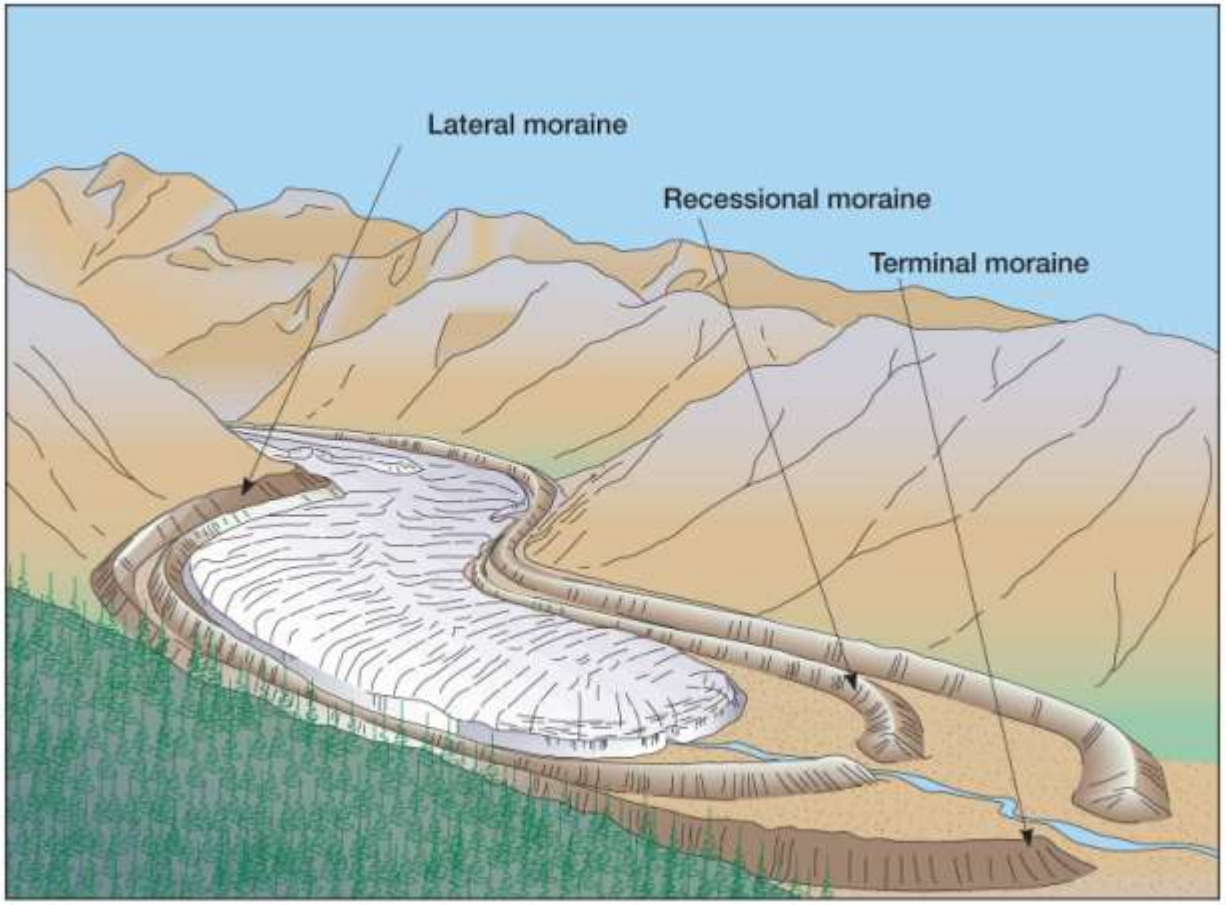
Longitudinal cross section of a glacial trough
showing sequence of glacial steps (glacial stairway)

Hollyford Valley, a glacial trough and stairway in South Island, New Zealand

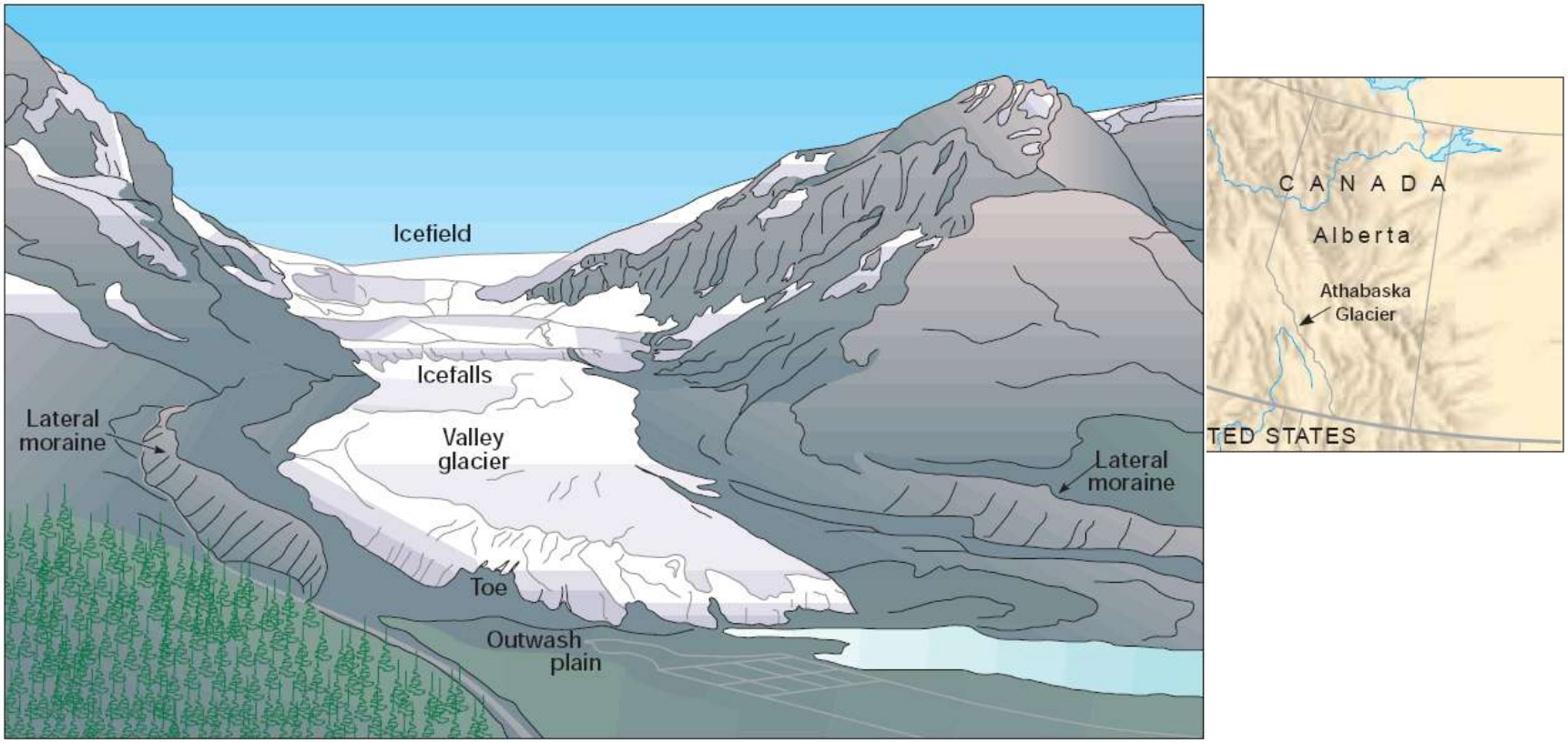
– Hanging Valley and Waterfall

Bridalveil Creek, occupies a hanging valley

- Deposition by Mountain Glaciers
  - Moraines (principal features)



– Lateral moraine and nearby features



Emerald Bay, on Lake Tahoe. Two lateral moraines almost close off the bay from the rest of the lake.

– Medial moraine

Dark strip of debris running down the middle of the glacier is a medial moraine.

– End moraine

Nellie Juan Glacier and terminal moraine, Prince William Sound, Alaska
(Source: U.S.G.S.: http://pubs.usgs.gov/of/2004/1216/m/m.html)

❖ The Periglacial Environment

- Periglacial – ‘perimeter of glaciation’
  - 20% of world’s land area
    - High latitudes and high elevations
  - Usually areas covered by ice during Pleistocene epoch
  - Non-glacial landscape features
    - Permafrost
    - Patterned ground

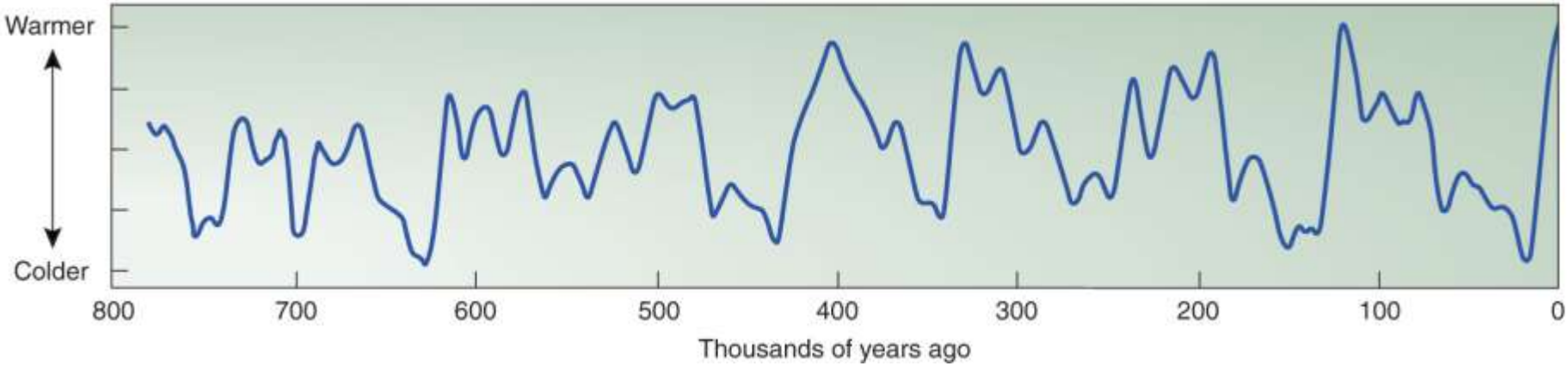
Polygonal ground patterns, near Prudhoe Bay, Alaska

- Proglacial lakes
  - Channeled scablands of Washington formed by periodic discharges from an ice sheet-dammed Lake Missoula, pro-glacial lake during the Pleistocene epoch.

❖ Causes of the Pleistocene

- Any explanation must explain 4 things:
  - Accumulation of ice masses in both hemispheres
  - Concurrent development of pluvial conditions in dryland areas
  - Multiple cycles of ice advance and retreat
  - Eventual total degradation of glaciers

- Explanations
  - Cyclical variation in Earth-Sun relations
    - Seem to explain cycles of glaciations and deglaciations involving tens of thousands to hundreds of thousands of years.
    - Shorter cycles are more difficult to explain.



Global temperature fluctuations. Many climate scientists theorize that very long-term climate cycles are controlled by cyclical changes in Earth-Sun relations.

- Other possible factors
  - Variability of solar output
  - Variations in amount of atmospheric CO_2
  - Changes in position of continents, configuration of ocean basins and ocean circulation patterns
  - Changes in atmospheric circulation due to increased elevation of continental mass after a period of tectonic upheaval
  - Reductions in insolation due to volcanic eruptions

- Are We Still in an Ice Age?
  - Is our climate merely an interglacial warming period?
  - If we are in an interglacial period, will human-induced global warming slow down the return of another glacial period?

❖ Summary

- Earth has experienced an unknown number of ice ages, but only the most recent — the Pleistocene epoch — is significant to our understanding of today's landscape.
- About one-third of Earth's land area was ice-covered during the Pleistocene; glaciers today occupy about one-tenth of the surface.
- Most of today's glacial ice is in Antarctica and Greenland.

- The two basic kinds of glaciers — ice sheets and mountain glaciers — are both prominent forces of erosion and agents of deposition.
- Glaciers form wherever more snow falls in winter than melts in summer over a period of time.
- Glacial ice forms beneath deep accumulations of snow due to compression caused by the pull of gravity.

- When the ice mass has great enough gravity, it causes the ice to flow outward or downslope from the zone of net accumulation.
- The force of moving ice severely erodes the preglacial terrain by plucking and abrasion.
- Fragmented rock debris is subsequently deposited in various forms by the ice and its meltwater.

- Climate scientists do not fully understand what causes glaciations in general.
- The Pleistocene epoch poses some intriguing questions about the future of the planet Earth.