Glacial Processes And Landforms

July 28th, 2021

Glaciers

Glaciers

A glacier occurs when there is **a net year-to-year accumulation of snow** over a period of years.

An extended mass of ice formed from snow falling and accumulating over the years and moving very slowly, either descending from high mountains, as in valley glaciers, or moving outward from centers of accumulation, as in continental glaciers.

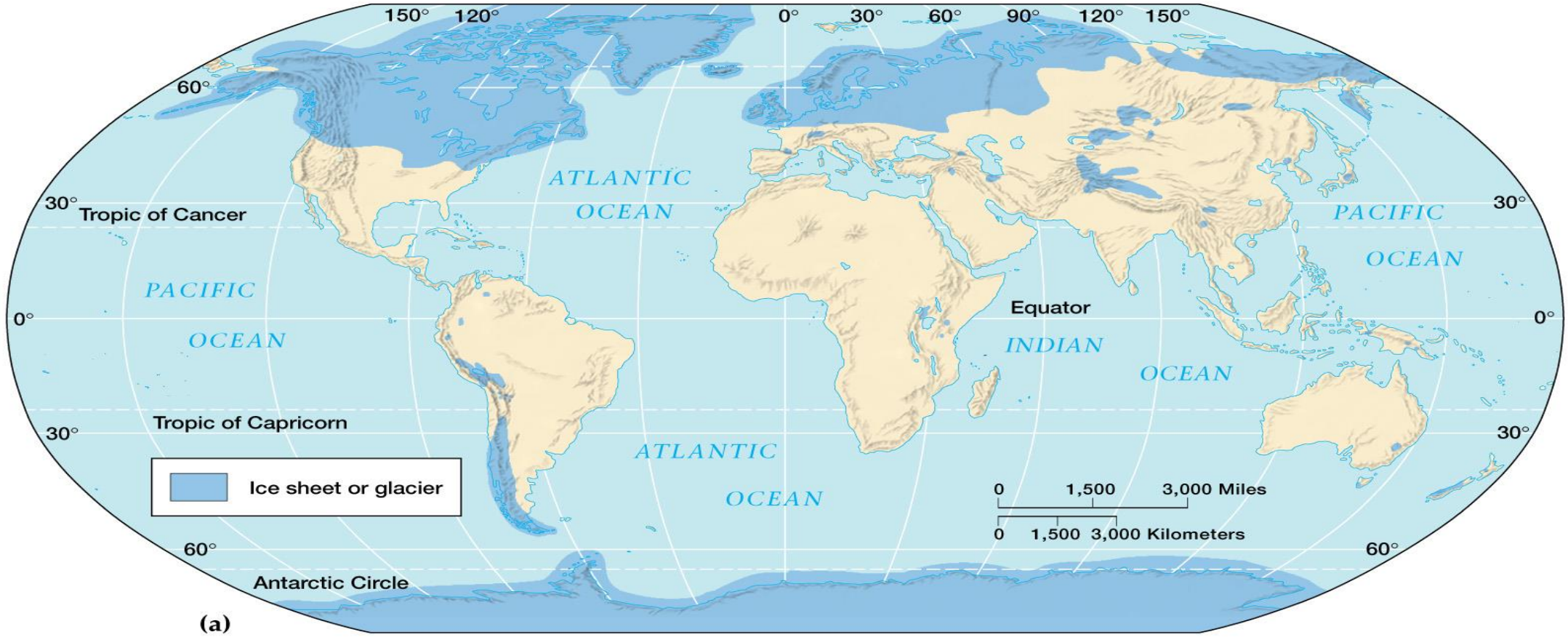
Glaciers are finely tuned environments with a delicately balanced nourishment budget.

Glaciers have had overwhelming impact on landscapes because moving ice grinds away almost anything in its path.

- Significantly reshaping the topography.

About 7% of all contemporary erosion is accomplished by glaciers.

The maximum extent of Pleistocene glaciations worldwide



Pleistocene ended between 10,000 – 11,500 years ago
Consisted of an alternation of glacial and interglacial periods.
Glacial—times of ice accumulation.
Interglacial—times of ice retreat.

(b)

The maximum extent of Pleistocene glaciations in North America.

Glaciations Past and Present

Contemporary glaciation

- Limited ice cover today **(about 10 percent of total land surface)**
- **96 percent of the total ice cover in Greenland and Antarctica**
- Antarctic ice cap
  - Consists of two unequal sections separated by Transantarctic Mountains (see figure)
  - West Antarctica has a few "dry valleys"
- Greenland ice cap
- North American glaciers

Transantarctic Mountains

Contemporary Glaciers

(a) Western U.S.

(b) Alaska

Direct Impacts of Glaciers

Glacial topography and meltwater are the bases for many of the world's lakes and river channels.

Glaciers sculpted the awesome alpine vistas; glacial deposits are parent material for soils

Types of Glaciers

Two different types of glaciers: ice sheets and mountain glaciers.

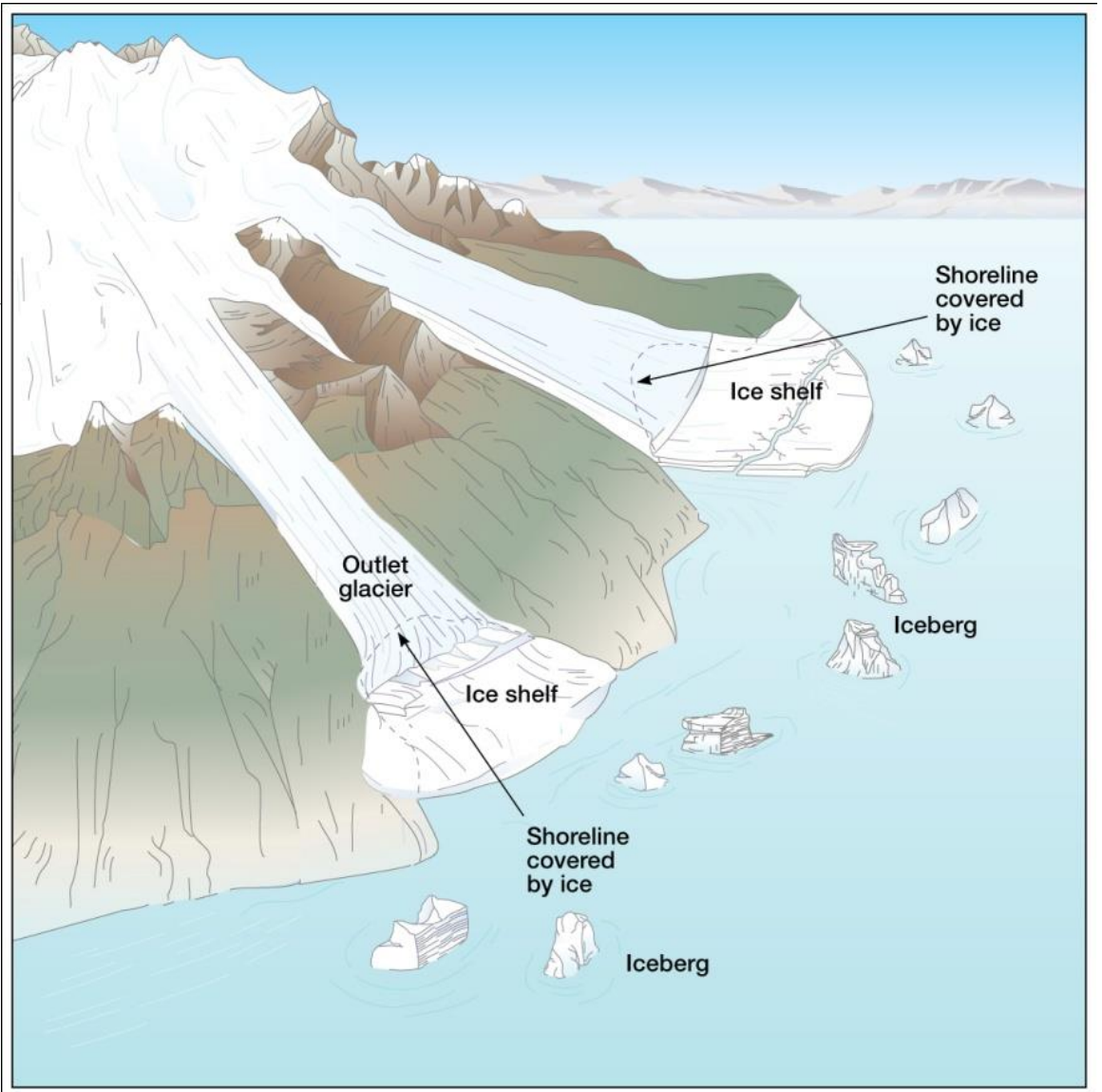
1. Continental Ice Sheets

- **Ice sheet**—an immense blanket of ice that completely inundates the underlying terrain to depths of hundreds or thousands of feet.
  - (Antarctica about 4000-13000 feet deep)
  - Formed in non-mountainous areas of continents.
- **Only two true ice sheets currently: Antarctica and Greenland**.

Continental Ice Sheets

Outlet glacier—a tongue of ice around the margin of an ice sheet that extends between rimming hills to the sea.

Icebergs form from chunks of ice that break off ice shelves and outlet glaciers.



Types of Glaciers

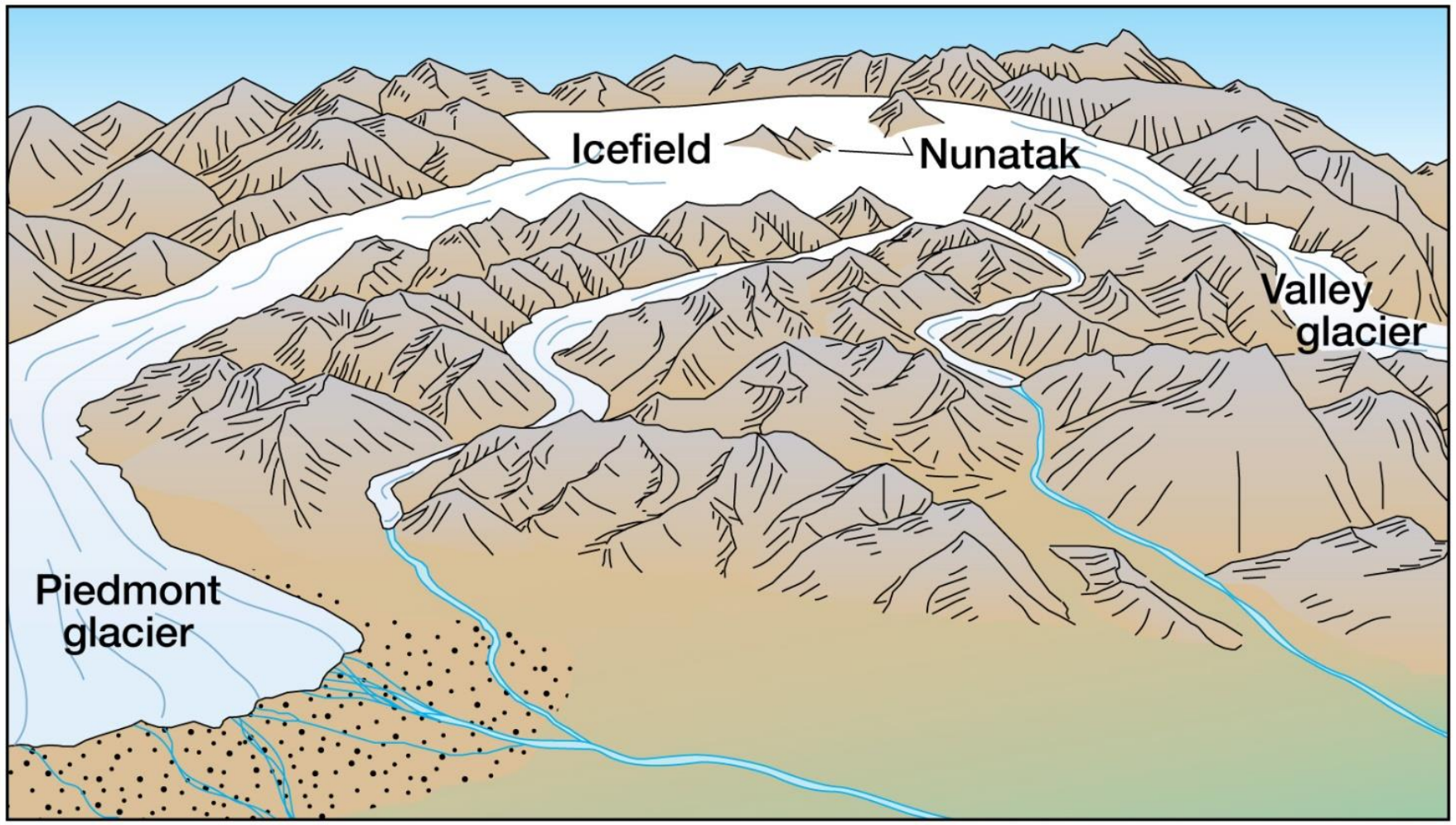
2. Mountain Glaciers

Two types of mountain glaciers: ***ice fields and alpine glaciers***.

Icefield—an unconfined sheet of ice in high-mountain areas, and which can develop into valley glaciers and piedmont glaciers.

- **Valley glacier**—a long, narrow feature resembling a river of ice, which spills out of its originating basin and flows down-valley.
- **Piedmont glacier**—a valley glacier that extends to the mouth of the valley and spreads out broadly over the flat land beyond.
- **Nunatak**- sometime ice does not cover all topography, these are protruding pinnacles

Mountain Glaciers



Types of Glaciers

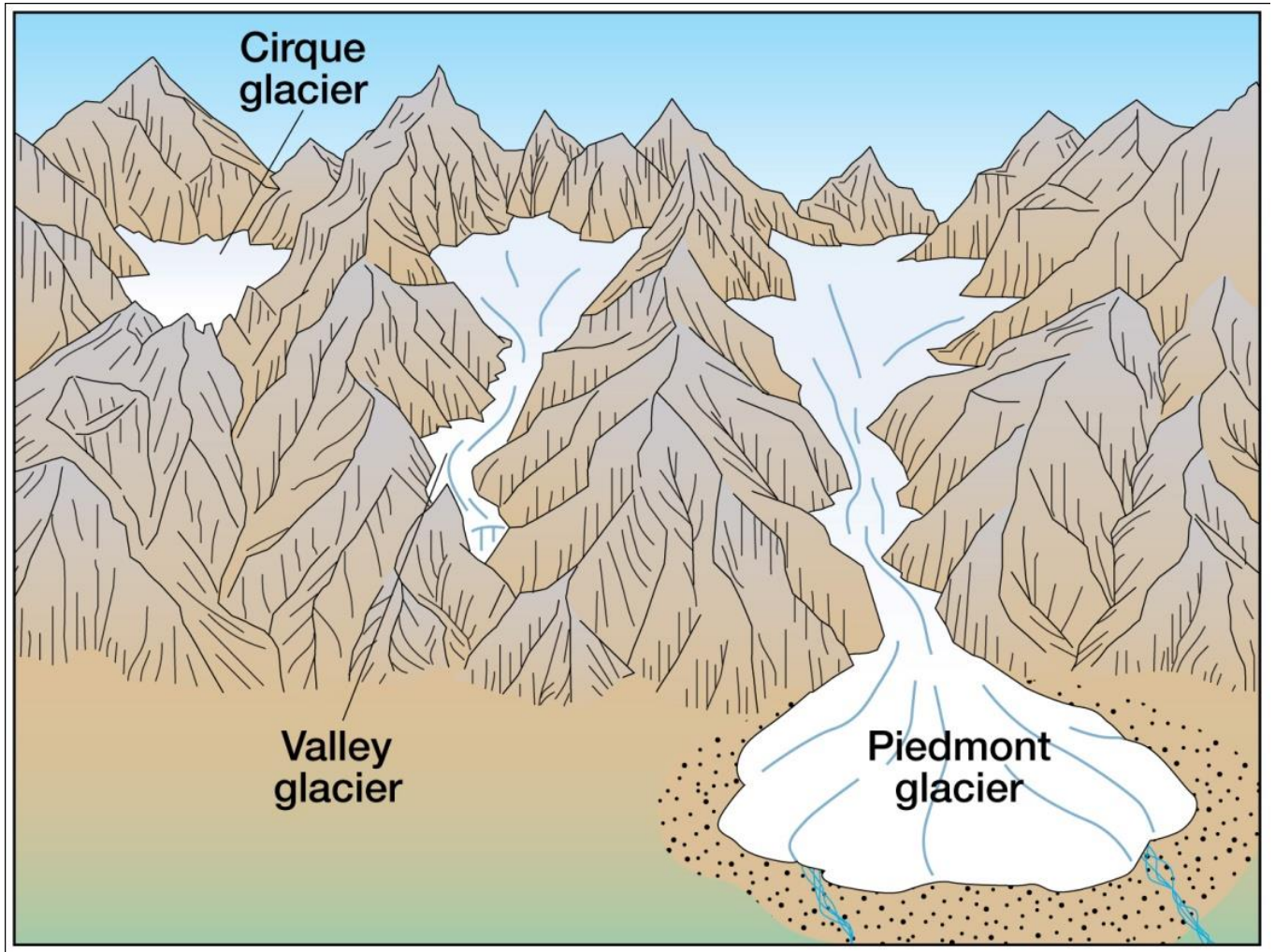
2. Mountain Glaciers

Two types of mountain glaciers: ***ice fields and alpine glaciers***.

Alpine glacier—individual glacier that **develops near a mountain crest line** and **normally moves down-valley** for some distance.

- **Cirque glacier**—a small glacier confined to its cirque and not moving down-valley.
- An alpine glacier typically breaks out of its basin and forms a valley glacier, and can extend to mouth of valley to create a piedmont glacier.

Alpine Glacier



Glacier Formation and Movement

Glacier occurs when there is a net year-to-year accumulation of snow over a period of years.

Balance of accumulation and ablation is critical for persistence of glacier.

Every glacier can be divided into two portions on the basis of the balance between accumulation and ablation.

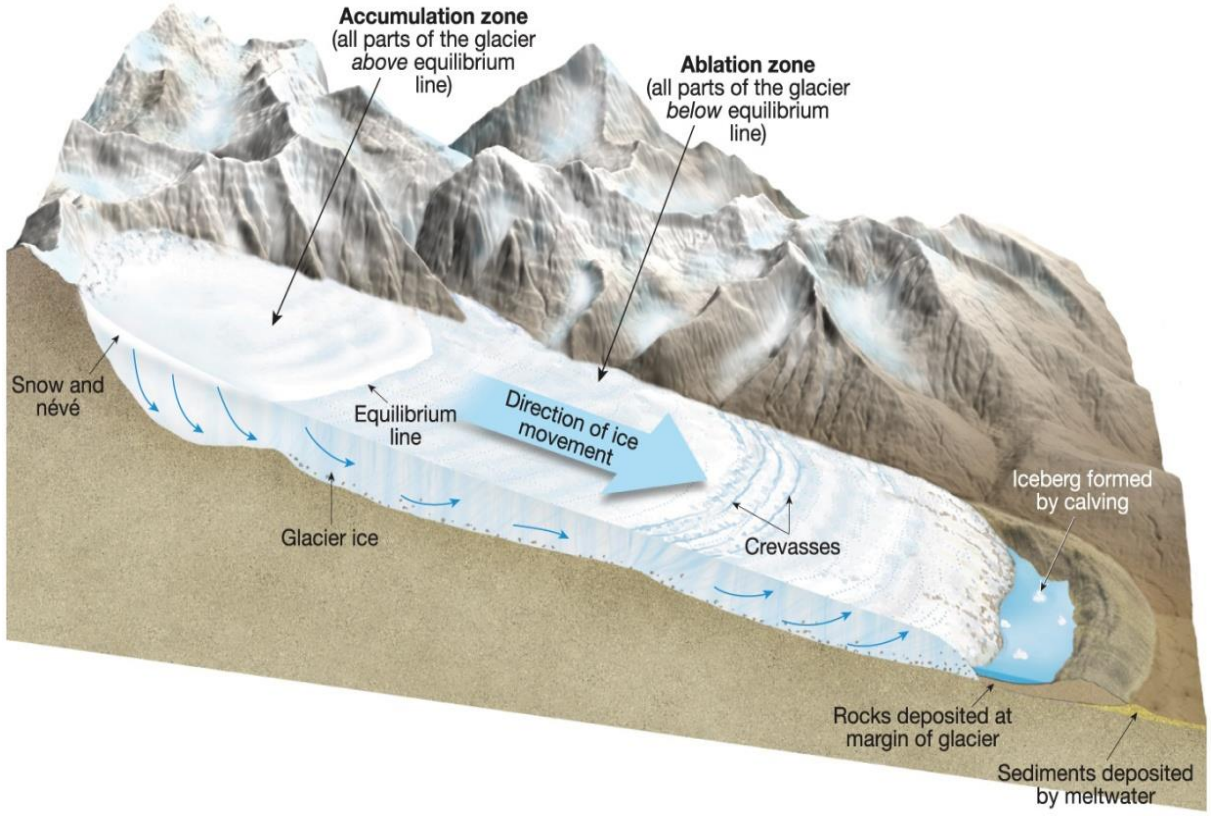
- The upper portion is called the accumulation zone.
  - **Accumulation**—addition of ice into a glacier by incorporation of snow.
  - The new ice added each year exceeds the amount lost by melting and sublimation.
- The lower portion is called the ablation zone
  - **Ablation** — wastage of glacial ice through melting and sublimation.
  - more ice is lost than is added each year.
- Separating the two is **a theoretical equilibrium line:** line separating the ablation zone and accumulation zone of a glacier along which accumulation exactly balances ablation.

Glacier Formation and Movement

Very little similarity between glacial movement, which is orderly, and liquid flow, which is disordered.

Glacier “flow” is sliding of ice molecules

Because ice under glacier is under considerable pressure, it deforms rather than breaks.



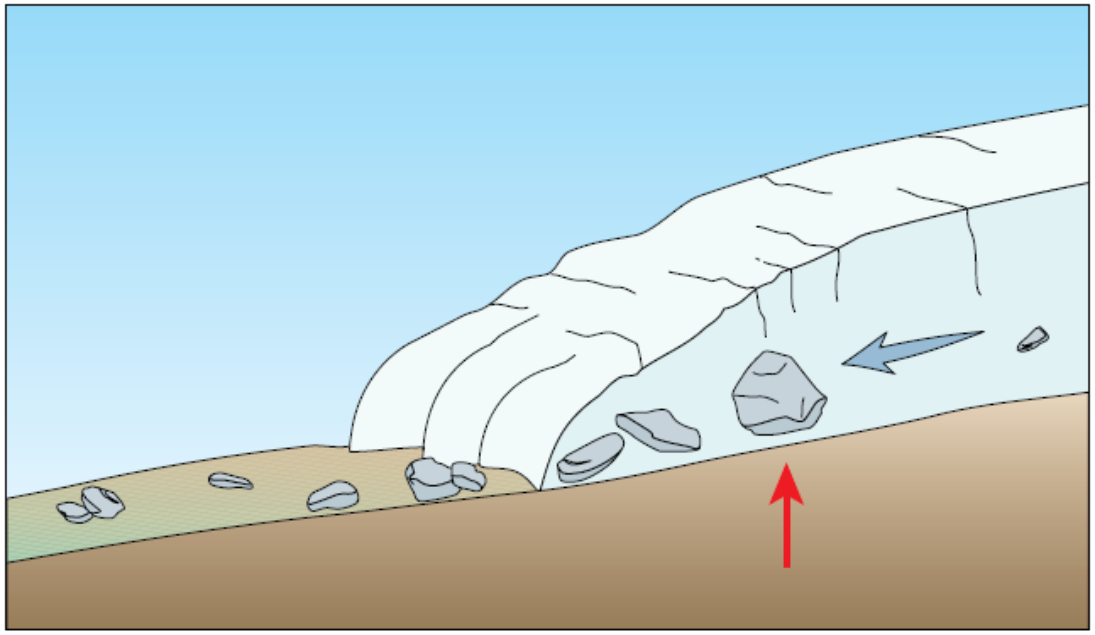
Glacial Formation and Movement

Flow is often erratic and all parts of glaciers do not move at the same rate.

- Fastest movement occurs at and near the surface.
- If a glacier is confined, as in valley glacier, the center moves faster than sides (as in streamflow).

Glacier Flow Versus Glacier Advance

- Flow is the continual movement of the ice toward the edge(s) of the glacier.
- Advance means the forward movement of the outer margins of the glacial body.



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Effects of Glaciers

Erosion by Glaciers

Volume and speed determine the effectiveness of glacial erosion.

Erode by plucking and abrasion.

1. **Glacial Plucking**
   - **Plucking**—quarrying action in which rock particles beneath the ice are grasped by the freezing of meltwater in joints and fractures and pried out and dragged along in the general flow of a glacier.
     - Probably accomplishes a glacier's most significant erosive work.
     - Particularly effective on leeward slopes (those facing away from the direction of movement).

Erosion by Glaciers

2. **Glacial Abrasion**
   - bedrock worn down by rock debris embedded in glacier
   - Abrasion tends to polish when bedrock is highly resistant and dig striations and grooves in less resistant bedrock.
   - Glacial erosion effects are more notable in hilly areas; making entire landscape becomes more angular and rugged.

- **Subglacial meltwater erosion** - Meltwater streams flowing below the glacier not only transport rock; they can also erode smooth grooves and channels into the bedrock.

Transportation by Glaciers

Glaciers are extremely competent in their ability to transport rock debris.

Glacier flour—rock material that has been ground to the texture of very fine talcum powder by glacial action.

- Perhaps most typical component of glacial load.
- Most of load is picked up from bottom, and so carried along there in a narrow zone.
- Alpine glaciers also carry some material on top of ice, where mass wasting from surrounding slopes placed debris.
- Transportation occurs at variable speeds outward or down-valley.
  - Rate depends on season, variations in ice accumulation, and gradient of underlying slopes.

Deposition by Glaciers

Transportation and deposition are probably the major roles of glaciers in landscape modification.

Gave U.S. Midwest one of the world's most productive soils (at the expense of central Canada, where the soil, regolith, and even some bedrock was scoured, transported, and later deposited).

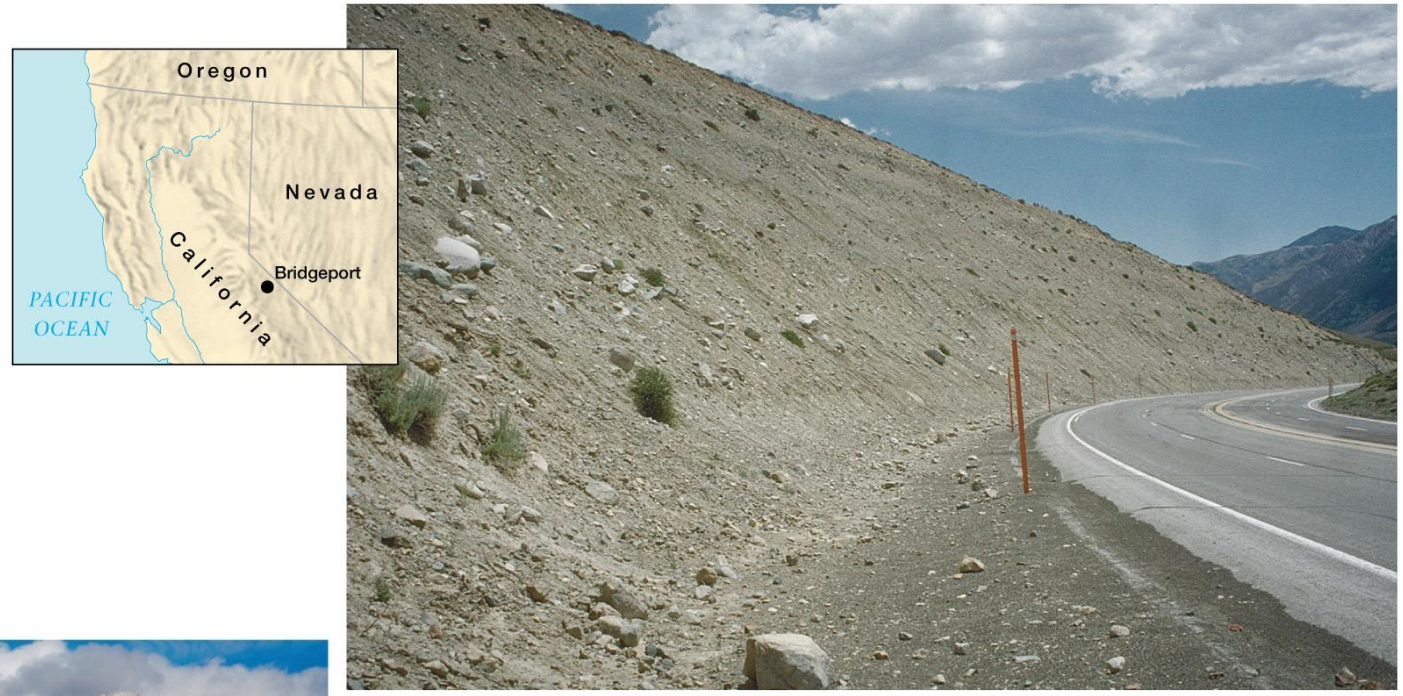
Drift—all material carried and deposited by glaciers.

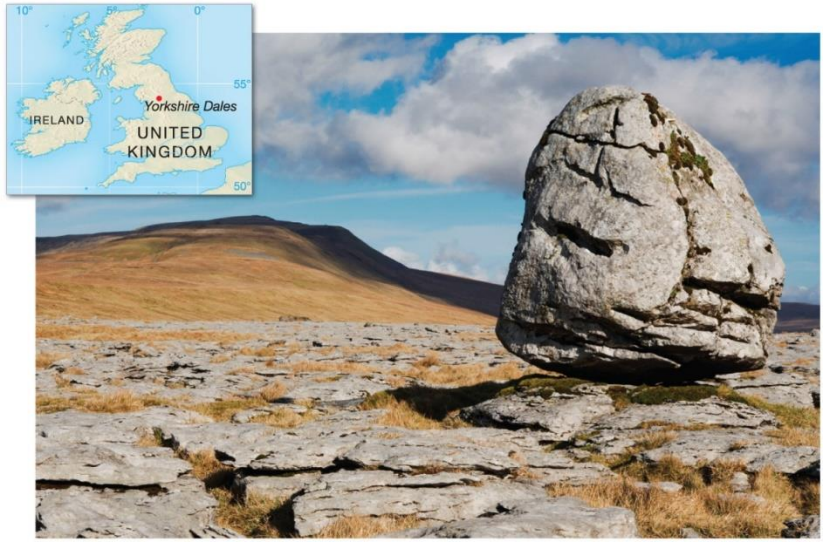
Till—rock debris that is deposited directly by moving or melting ice, with no meltwater flow or redeposition involved.

Glacial erratic—outsized boulder included in the glacial till, which may be very different from the local bedrock.

Till – debris deposited directly by ice
Unsorted/unstratified drift

– Glacial erratic Yorkshire, England.





– Unsorted glacial till, Bridgeport, California.

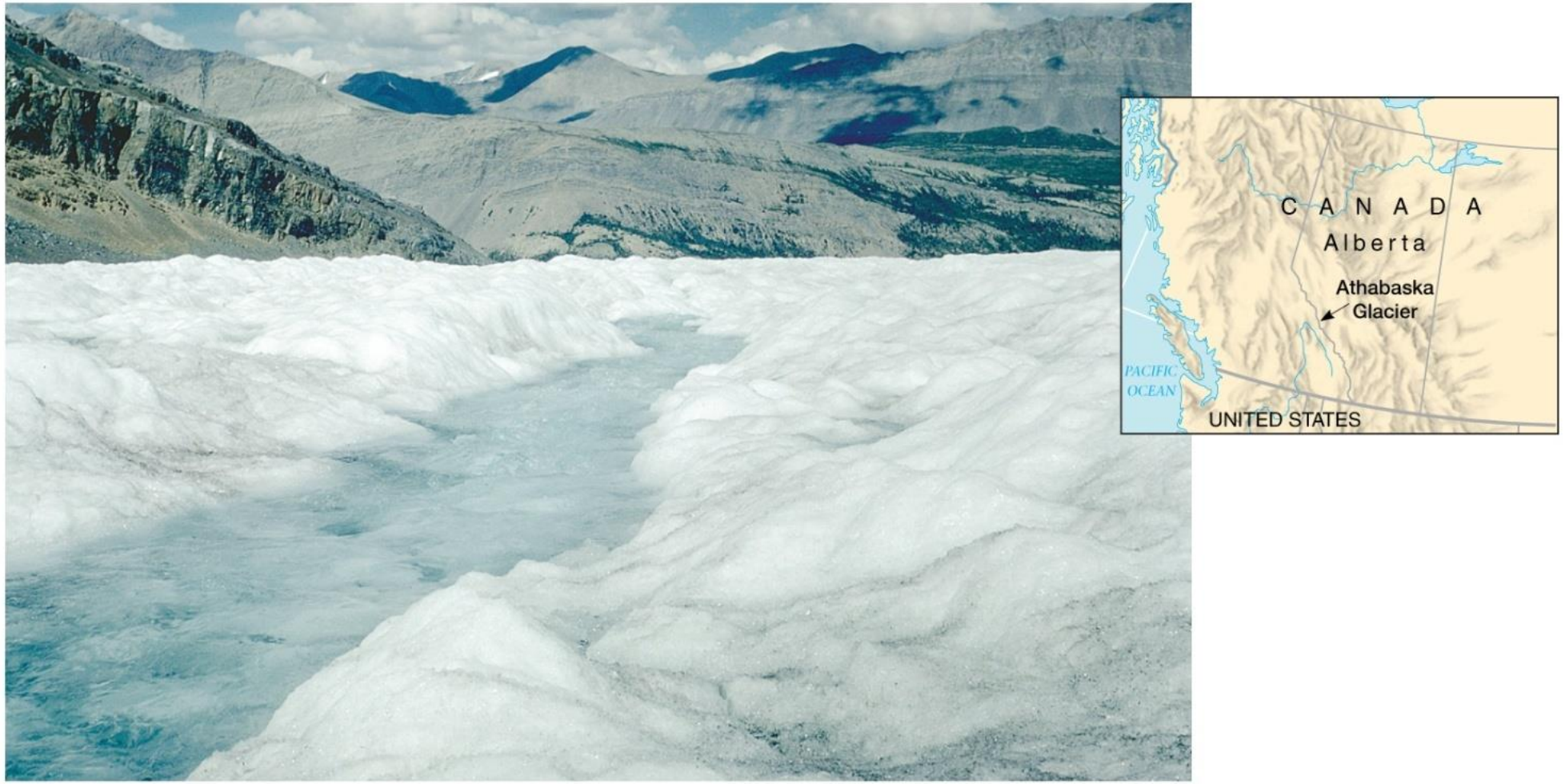
Deposition by Meltwater

Glaciofluvial deposition, through meltwater, occurs around margins of all glaciers and can continue far out into periglacial zones.

Meltwater deposits or redeposits much of the debris carried by glaciers.

Can occur by:

- Subglacial streams issuing from ice, depositing debris;
- Meltwater from glaciers, picking up material already deposited and re-depositing it elsewhere.
- Most of meltwater deposition actually involves redeposition.

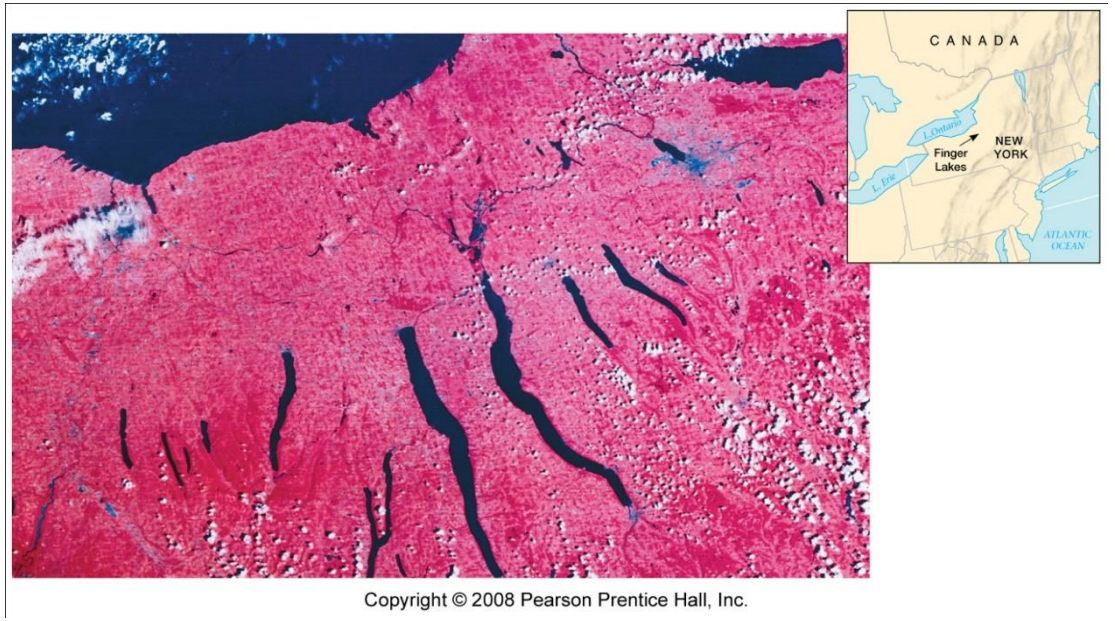


Meltwater stream flowing over the surface of a glacier.

Continental Ice Sheets

Erosion by Ice Sheets

- Ice Excavations (extensive plucking action)
  - Hudson Bay basin
  - Great Lakes basins
  - Finger Lakes



The Finger Lakes of upstate New York.

Deposition by Continental Ice Sheets

Till plain—an irregularly undulating surface of broad, low rises and shallow depressions produced by the uneven deposition of glacial till.

Moraine—the largest and generally most conspicuous landform feature produced by glacial deposition, which consists of irregular rolling topography that rises somewhat above the level of the surrounding terrain.

- **Terminal moraines**—mark the farthest advance of the glacier.
- **Recessional moraines**—mark positions where the ice front had temporarily stabilized.

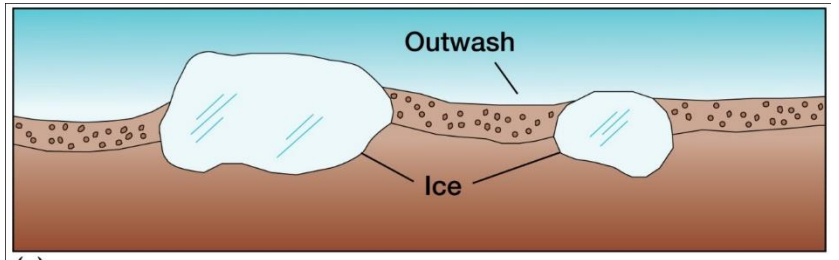
Ground moraine—mark where large quantities of till were laid down from underneath the glacier.

Deposition by Continental Ice Sheets

Kettle—an irregular depression in a morainal surface created when blocks of stagnant ice eventually melt.

Drumlin—a low, elongated hill formed by ice-sheet deposition. The long axis is aligned parallel with the direction of ice movement, and the end of the drumlin that faces the direction from which the ice came is blunt and slightly steeper than the narrower and more gently sloping end that faces in the opposite direction.

- Depositional features subsequently shaped by erosion.
- Usually occur in groups, sometimes in hundreds.
  - Central New York and eastern Wisconsin have the greatest concentrations.



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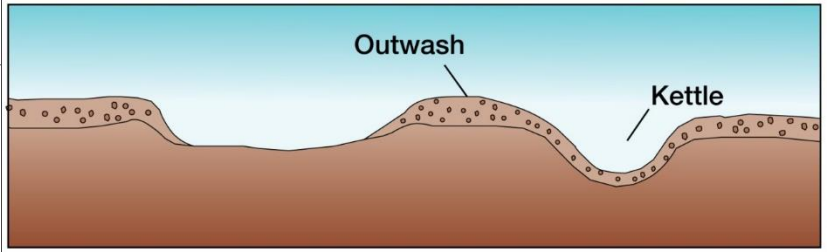

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Drumlin west of Rochester, NY

Mountain Glaciers

Don't reshape the terrain as much as ice sheets do.

- Mountains channel the movement of mountain glaciers.
- Produce a rugged landscape as opposed to the smoothing and rounding of terrain accomplished by ice sheets.

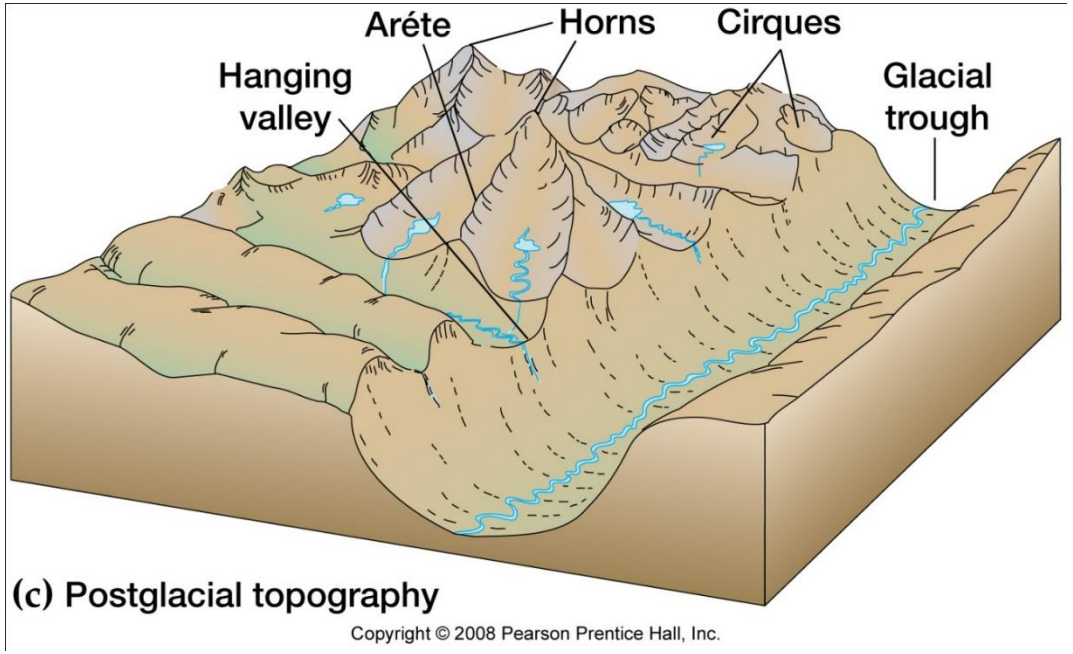
Development and Flow

- Both highland icefields and alpine glaciers advance downslope, **usually finding path of least resistance down preexisting stream valley**.
- Highland icefields can extend broadly, submerge all but uppermost peaks, and extend into a series of lobes that move down adjacent channels.
- Alpine glaciers usually form in sheltered depressions near heads of stream valleys.

Erosion by Mountain Glaciers

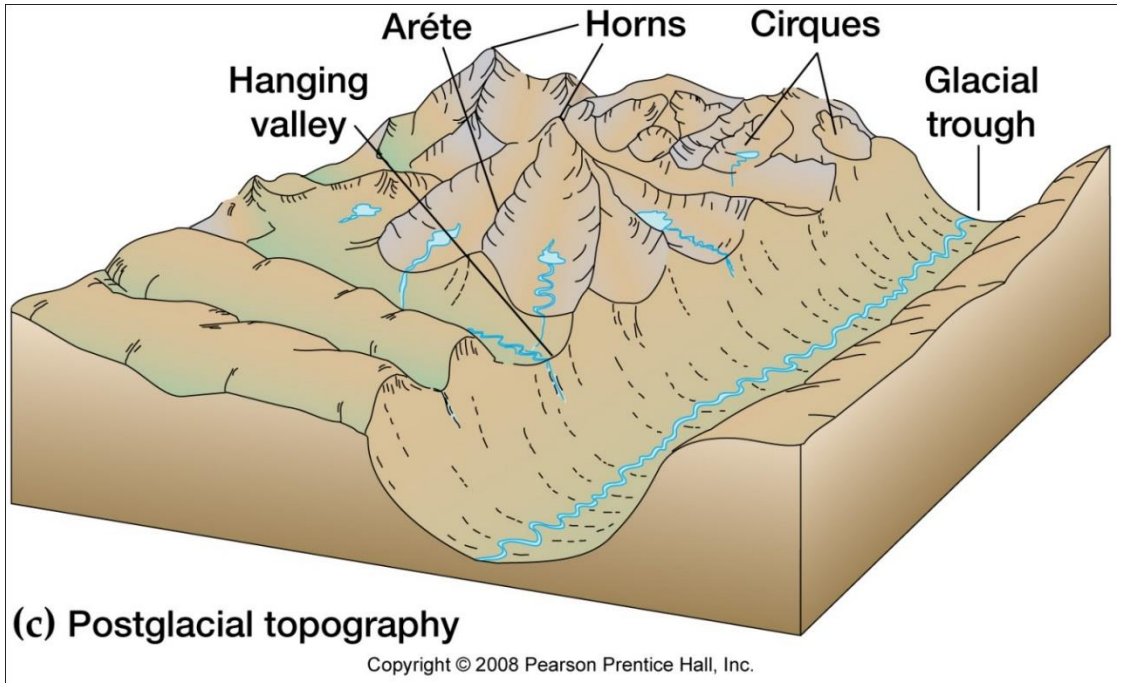
Highland icefields and alpine glaciers can dramatically reshape topography.

- **Cirque**—a broad amphitheater hollowed out at the head of a glacial valley by ice erosion.
  - Basic landform in glaciated mountains, marking place where alpine glacier originated, being quarried out of mountainside, though precise mechanics of formation are unknown.
- **Arête**—a narrow, jagged, serrated spine of rock; remainder of a ridge crest after several cirques have been cut back into an interfluve from opposite sides of a divide.



Erosion by Mountain Glaciers

- **Horn**—a steep-sided, pyramidal rock pinnacle formed by expansive quarrying of the headwalls where three or more cirques intersect.
- **Glacial trough**—a valley reshaped by an alpine glacier, usually with a relatively straight course with a fluctuating gradient.
- **Hanging valley**—a tributary glacial trough, the bottom of which is considerably higher than the bottom of the principal trough that it joins.



Exam 3

Due August 1st, 2021 @11:59 PM

20 Questions, 5 points each

Total 100 points

15 multiple choice

5 short answers

Password will be given in the class