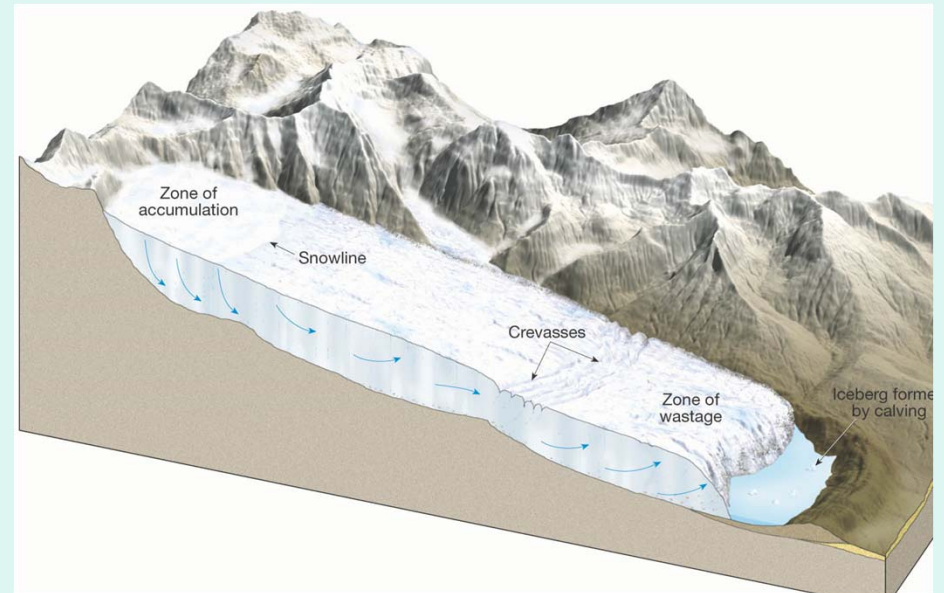


Chapter 4
Glacial and Arid
Landscapes

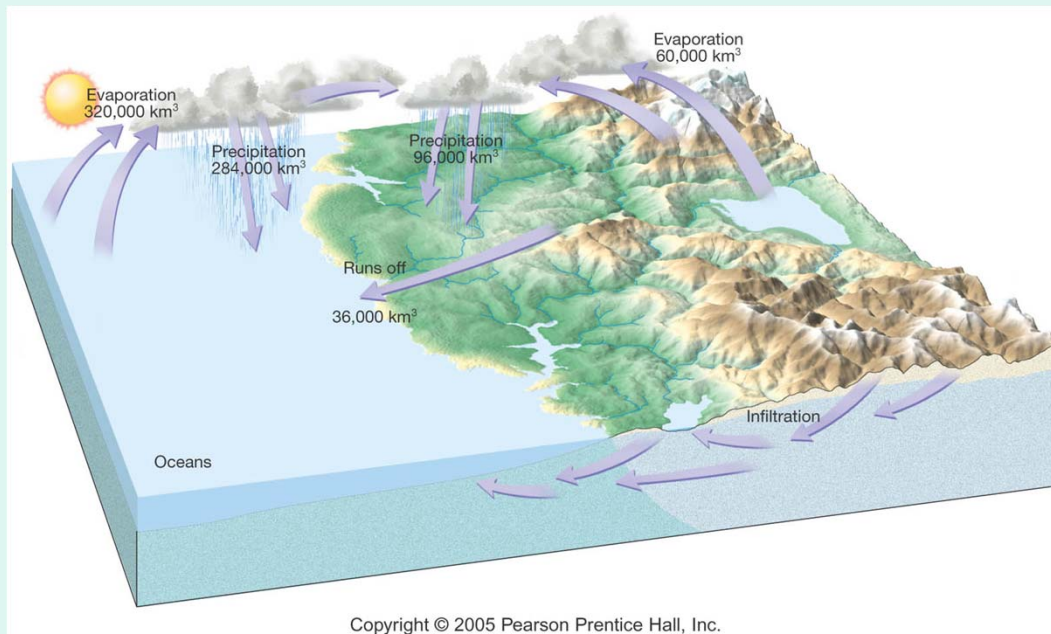
Glaciers

Glacier —A thick mass of ice that originates on land from the accumulation, compaction, and recrystallization of snow

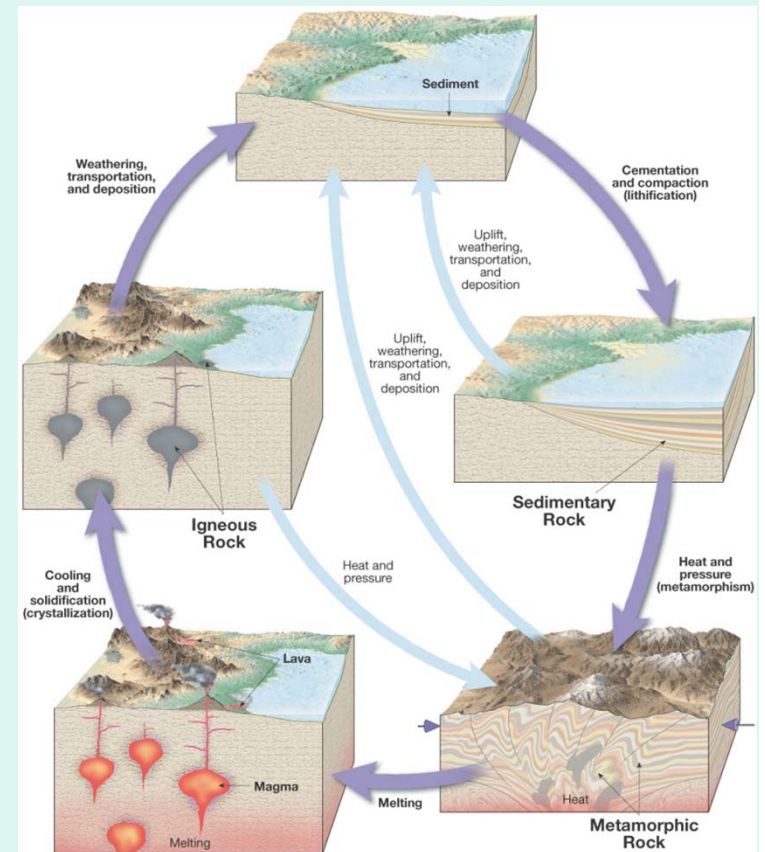


Glaciers

- **Glaciers are parts of two basic cycles**
 - **Hydrologic cycle**
 - **Rock cycle**



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Glaciers

Types of glaciers

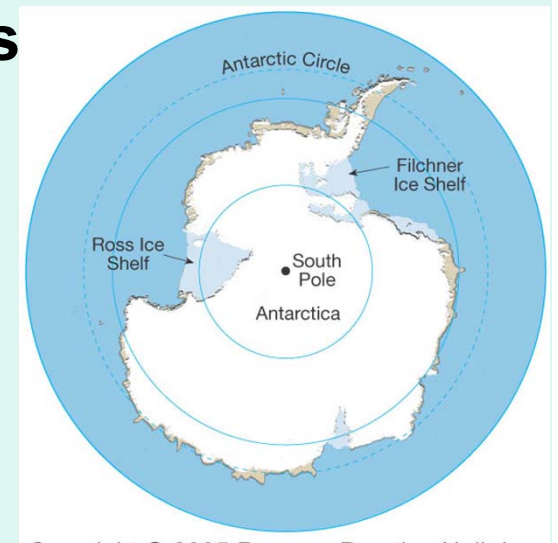
1) *Valley (alpine) glaciers*

Exist in mountainous areas
Flow down a valley from an accumulation center at its head



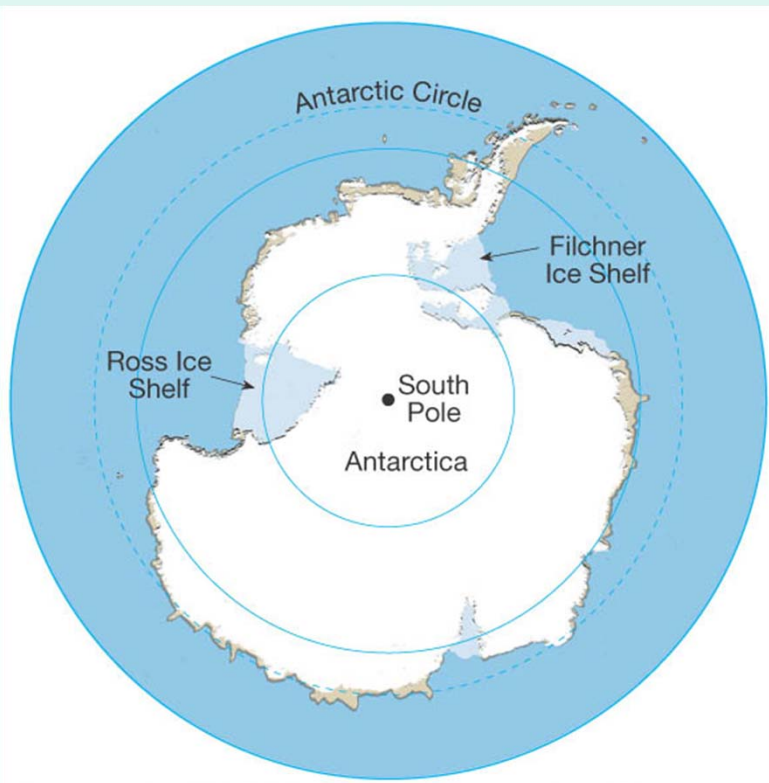
2) *Ice sheets*

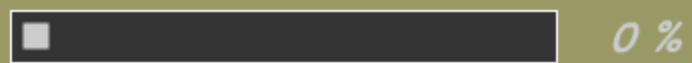
Exist on a larger scale than valley glaciers
Two major ice sheets on Earth are over Greenland and Antarctica



Glaciers

- **Types of glaciers**
 - **Ice sheets**
 - Often called continental ice sheets
 - Ice flows out in all directions from one or more snow accumulation centers

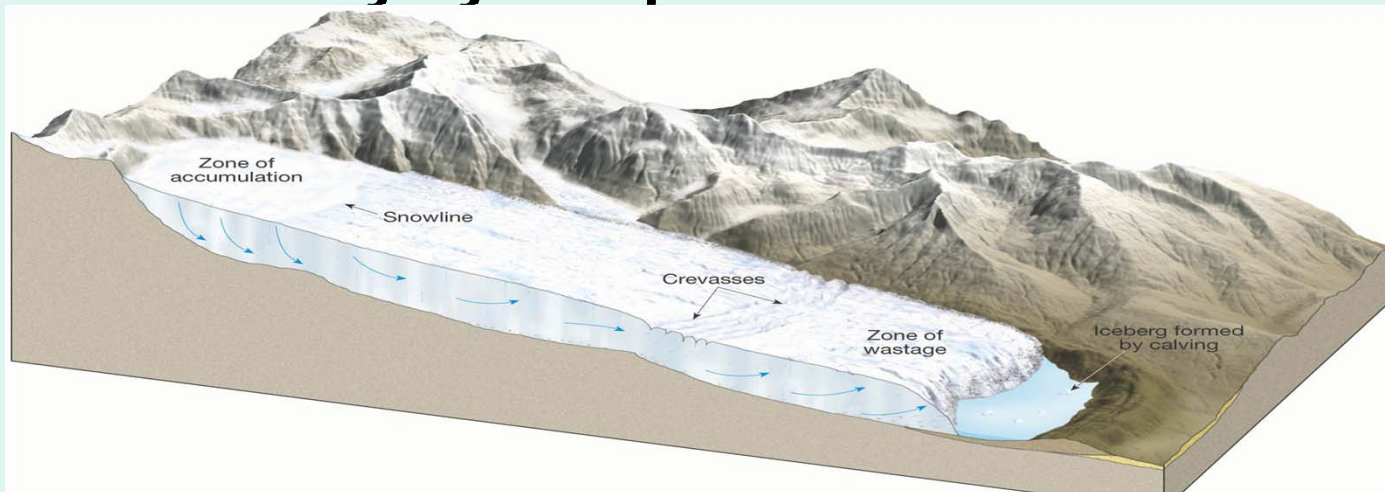




Loading

How Glaciers Move

- Movement is referred to as flow
 - Two basic types
 - Plastic flow
 - » Occurs within the ice
 - *Basal slip*
 - » Entire ice mass slipping along the ground
 - » Most glaciers are thought to move this way by this process



How Glaciers Move

Movement is referred to as flow

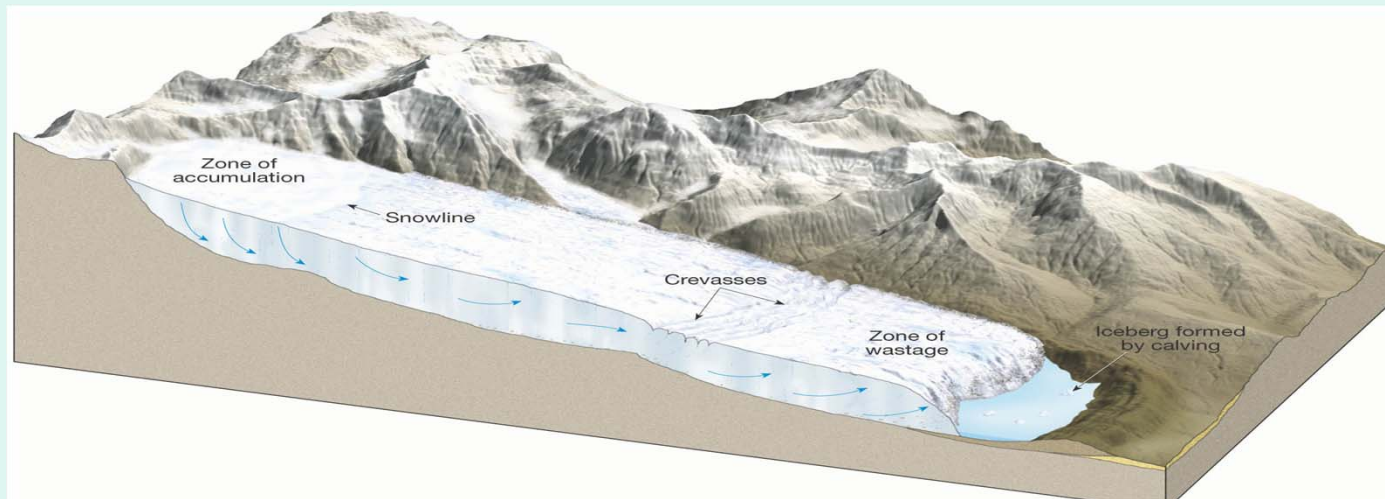
Zone of fracture

Occurs in the uppermost 50 meters

Tension causes *crevasses* to form in brittle ice

Rates of glacial movement

Average velocities vary considerably from one glacier to another



How Glaciers Move

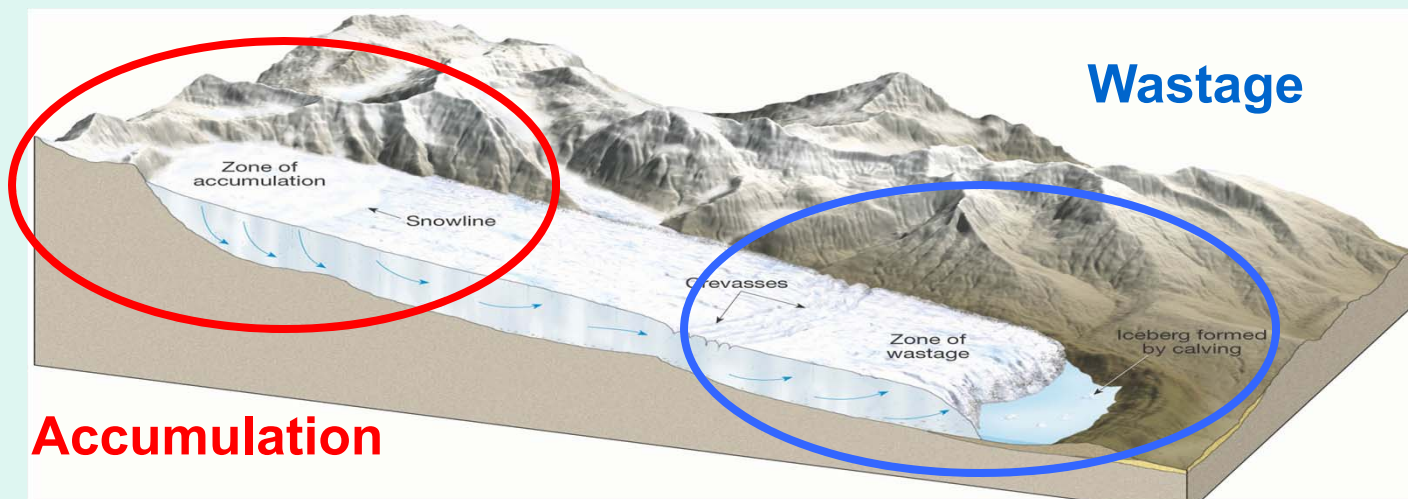
Rates of glacial movement

Rates of up to several meters per day

Budget of a glacier

Zone of accumulation—The area where a glacier forms

Elevation of the snowline varies greatly



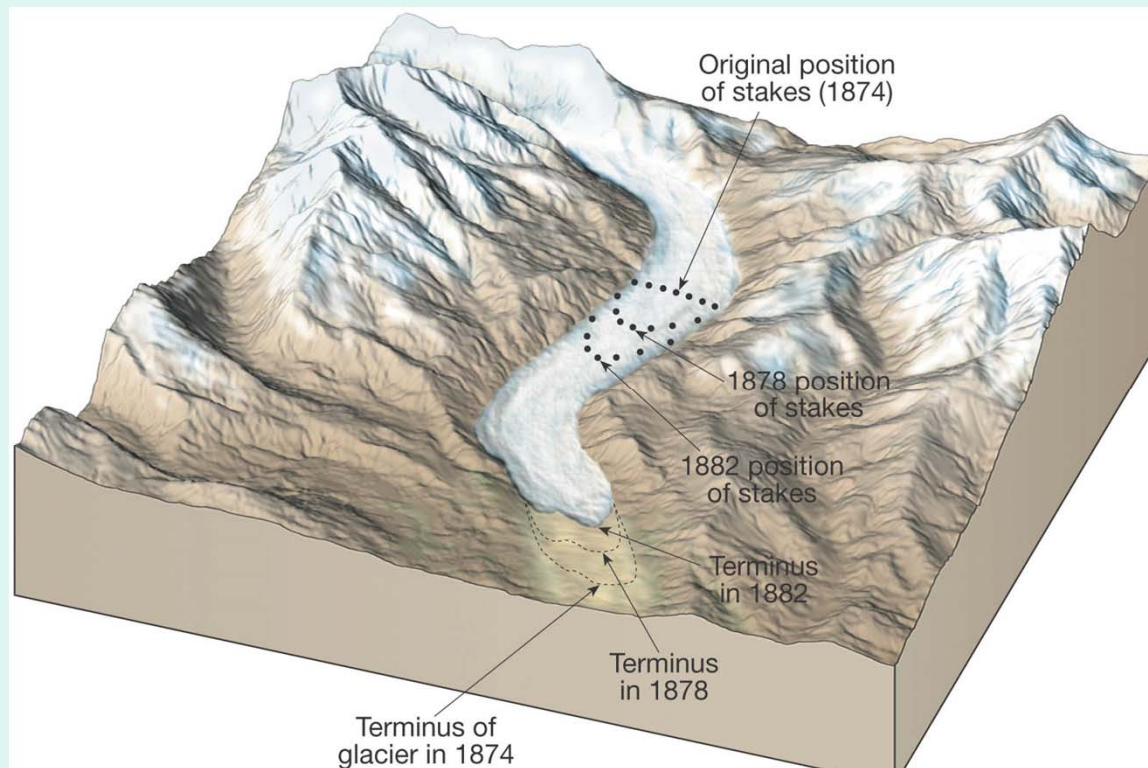
How *Glaciers Move*

Similar to a stream

- Most Friction along edges of valley
- Strong Erosion Power

Different to stream

- Much Slower
- Not restricted to base level



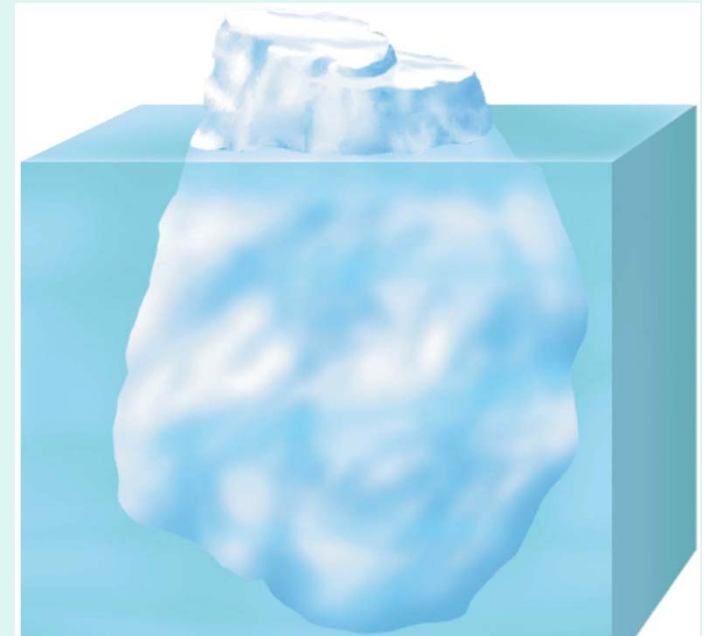
How Glaciers Move

Budget of a glacier

Zone of wastage—The area where there is a net loss to the glacier due to

Melting

Calving—The breaking off of large pieces of ice (icebergs where the glacier has reached the sea)



Movement of Glacial Ice

- **Budget of a glacier**
 - **Balance between accumulation at the upper end of the glacier, and loss at the lower end is referred to as the *glacial budget***
 - **If accumulation exceeds loss (called *ablation*), the glacial front advances**
 - **If ablation increases and/or accumulation decreases, the ice front will retreat**

The Glacial Budget

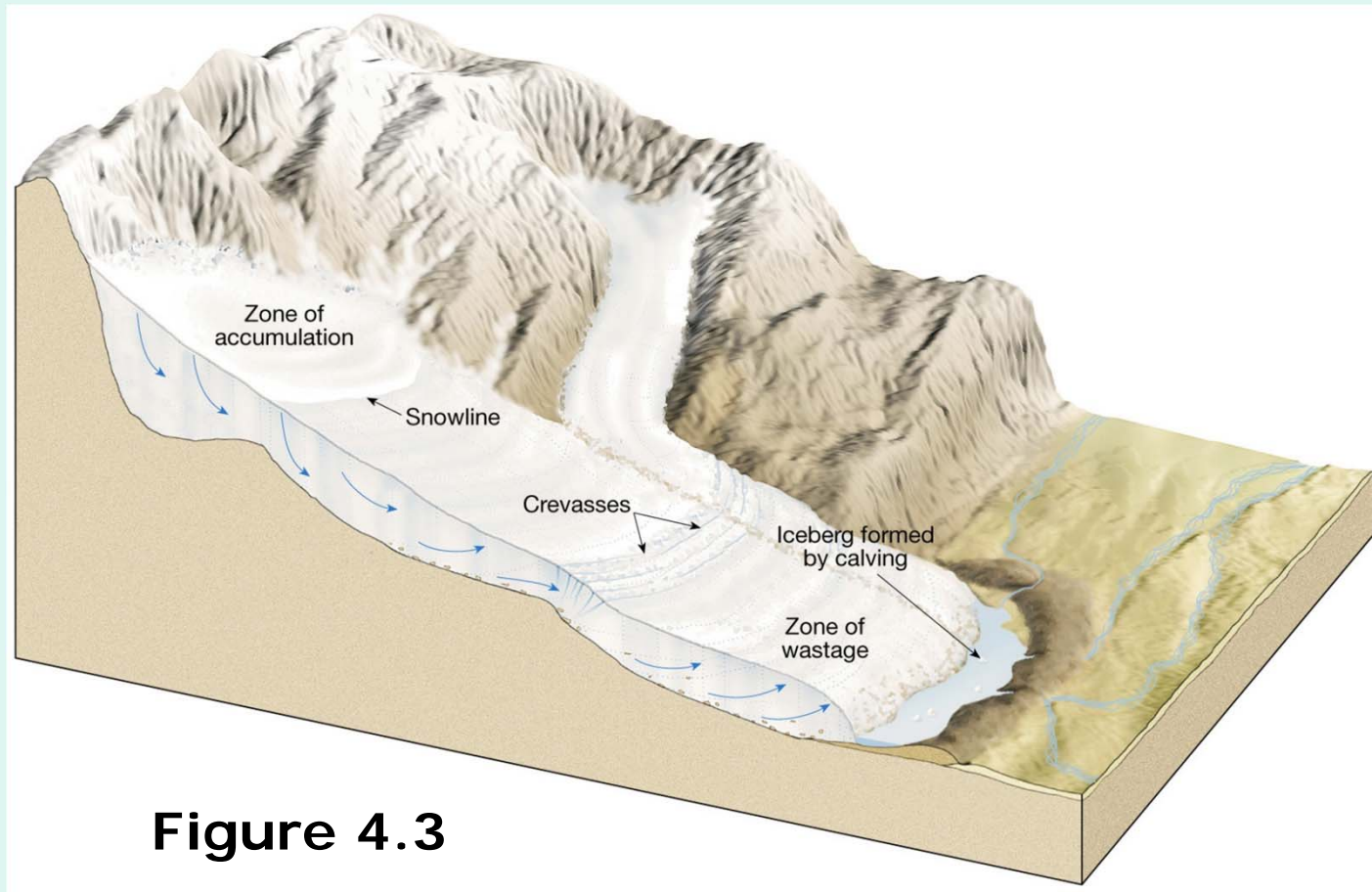
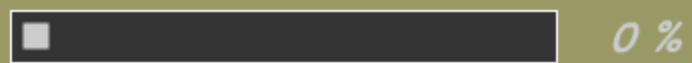


Figure 4.3



Loading

Glacial Erosion

- **Glaciers are capable of great erosion and sediment transport**
- **Glaciers erode the land primarily in two ways**
 - ***Plucking***—Lifting of rocks
 - ***Abrasion***
 - **Rocks within the ice acting like sandpaper to smooth and polish the surface below**

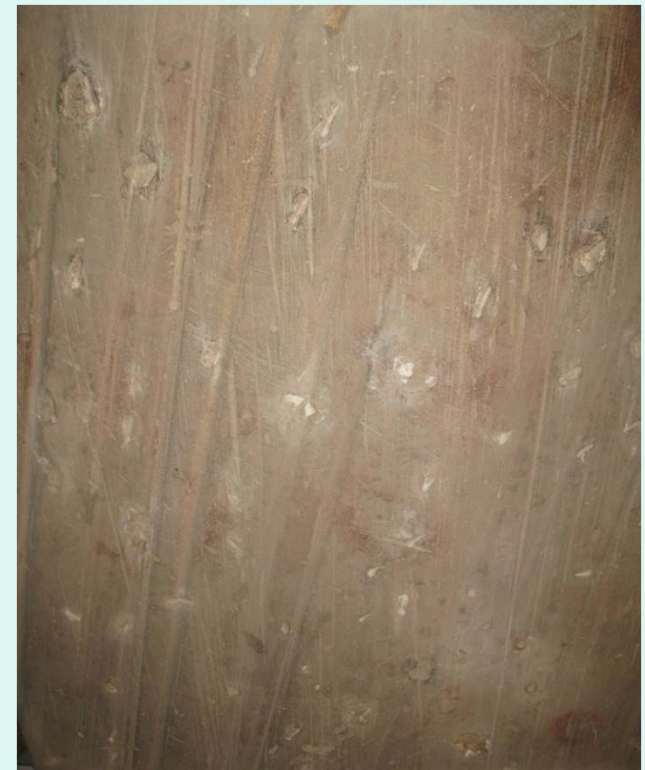


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Loading

Glacial Erosion

- **Glacial erosion**
 - **Glacial abrasion produces**
 - ***Rock flour*** (pulverized rock)
 - ***Glacial striations*** (grooves in the bedrock)



Glacial Erosion

Landforms created by glacial erosion

Erosional features of glaciated valleys

U- Shaped Valleys

Hanging valleys

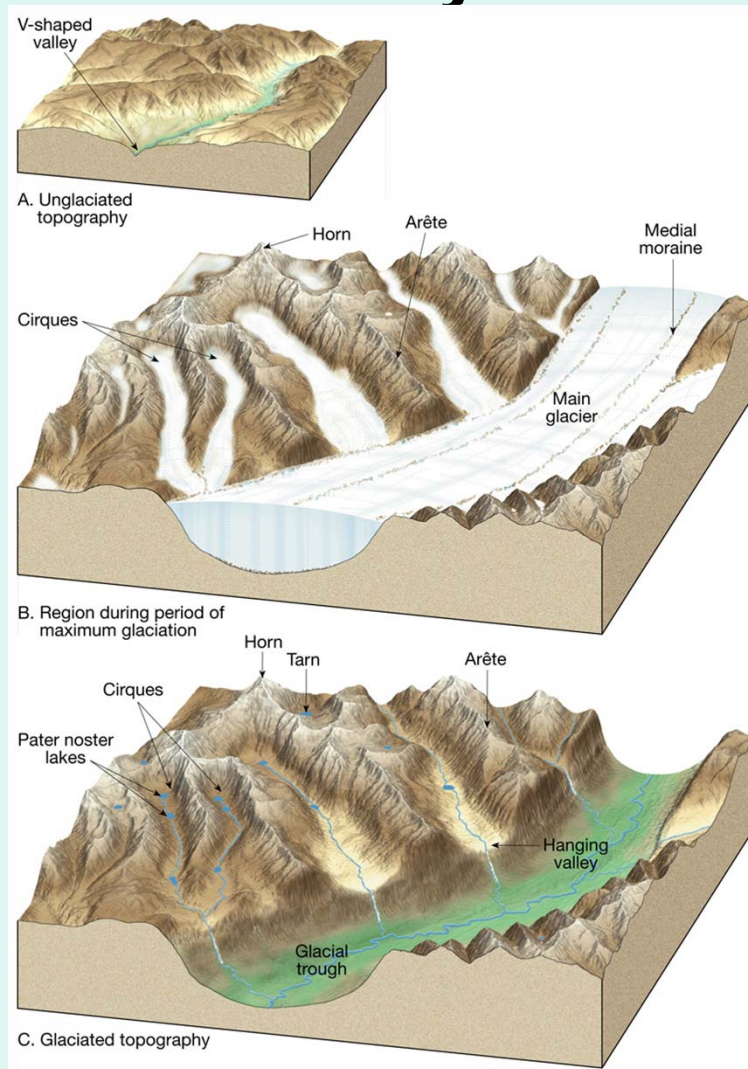
Cirques

Tarns

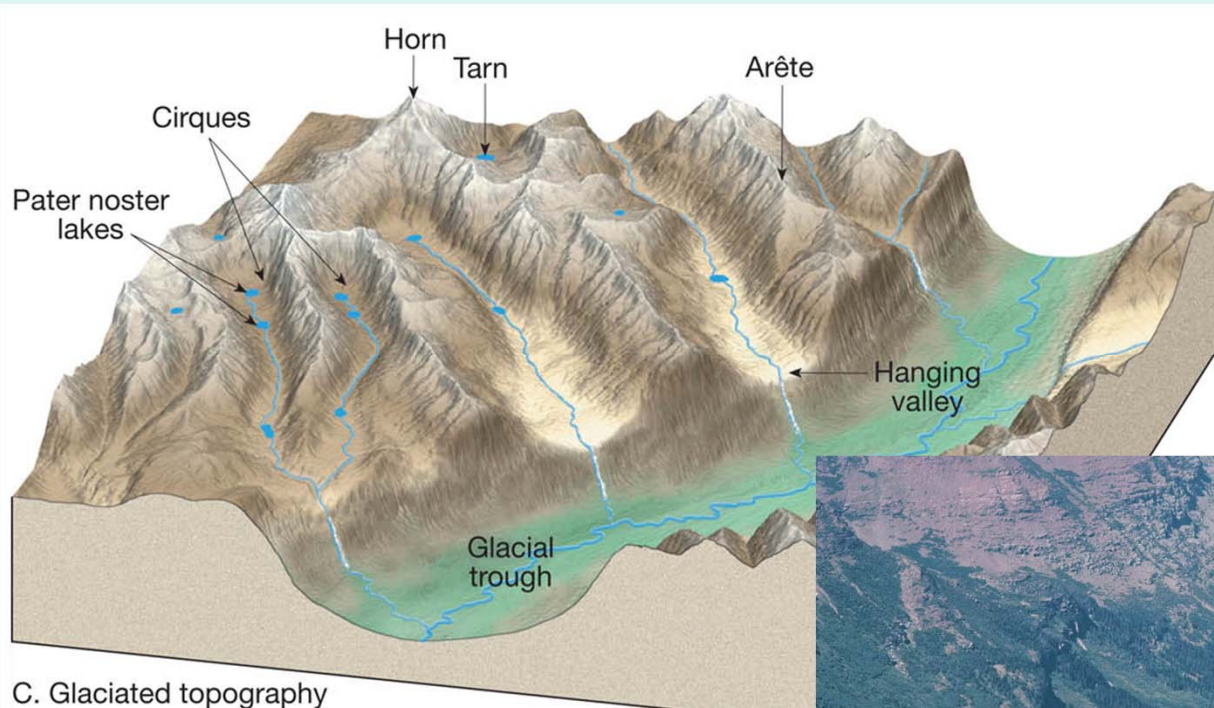
Fiords

Arêtes

Horns



Glaciated Topography



C. Glaciated topography

**U – Shaped
Valley and Pater
Noster Lakes**



Glaciated Topography

U – Shaped valleys

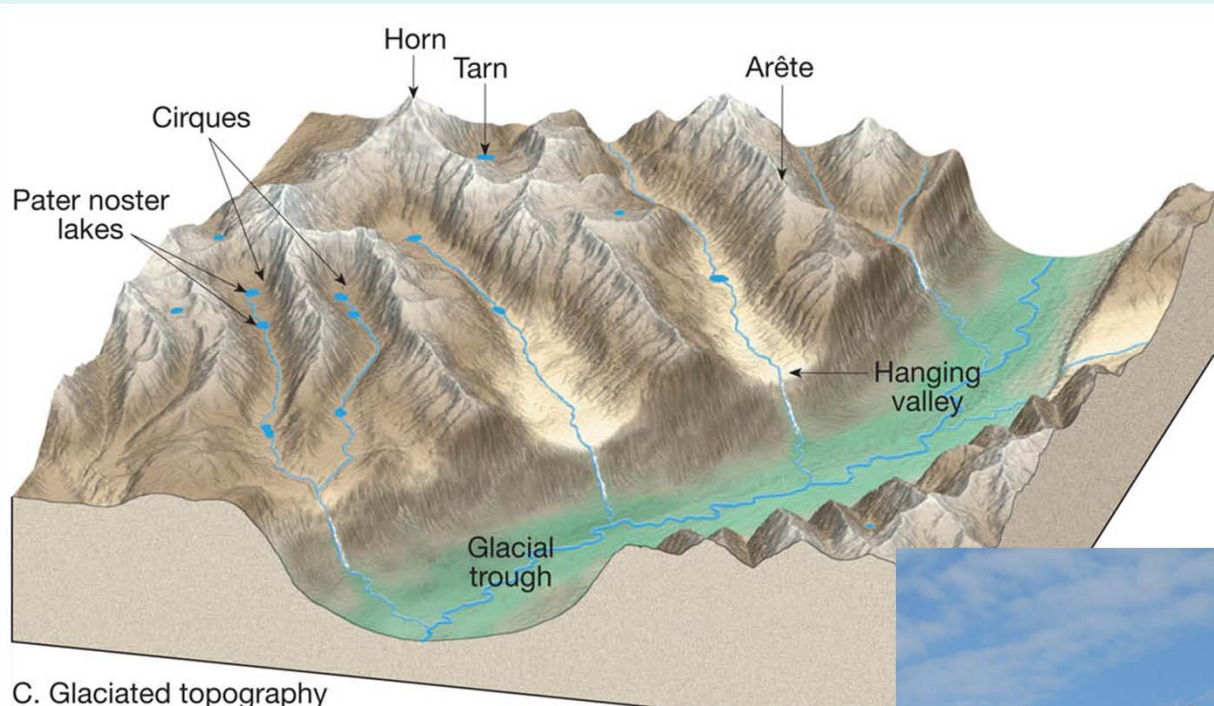


Glaciated Topography

U – Shaped valleys



Glaciated Topography

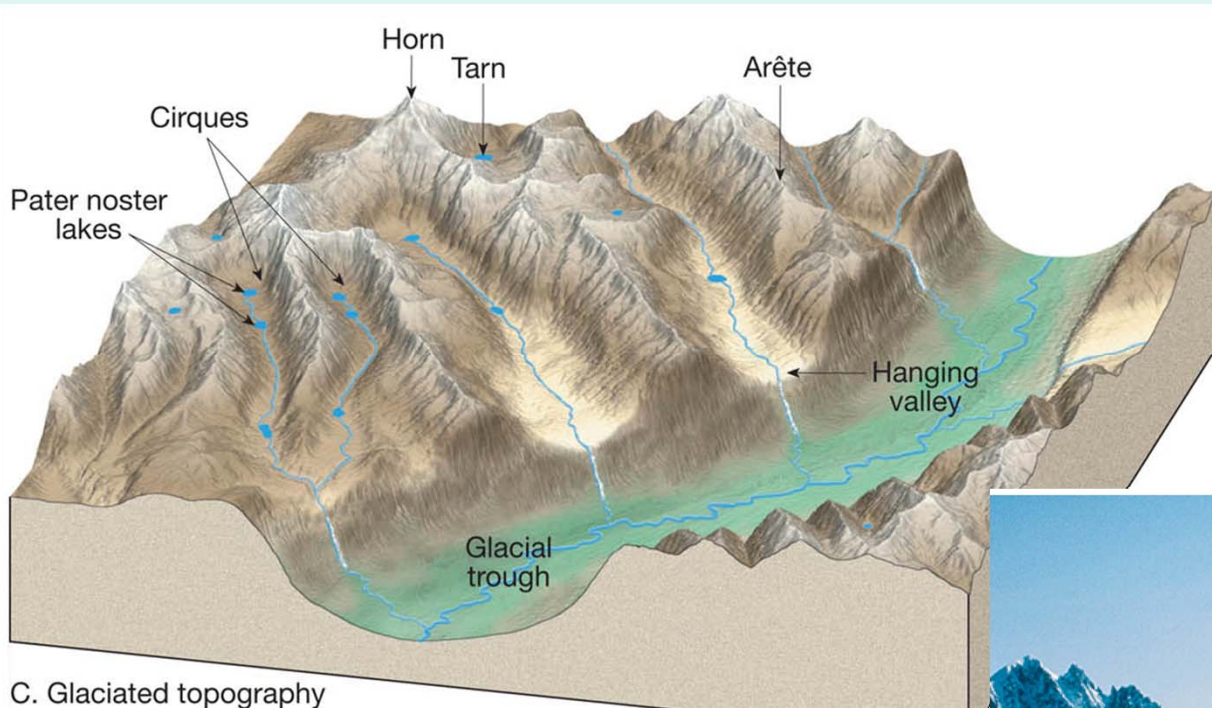


C. Glaciated topography

Cirques



Glaciated Topography

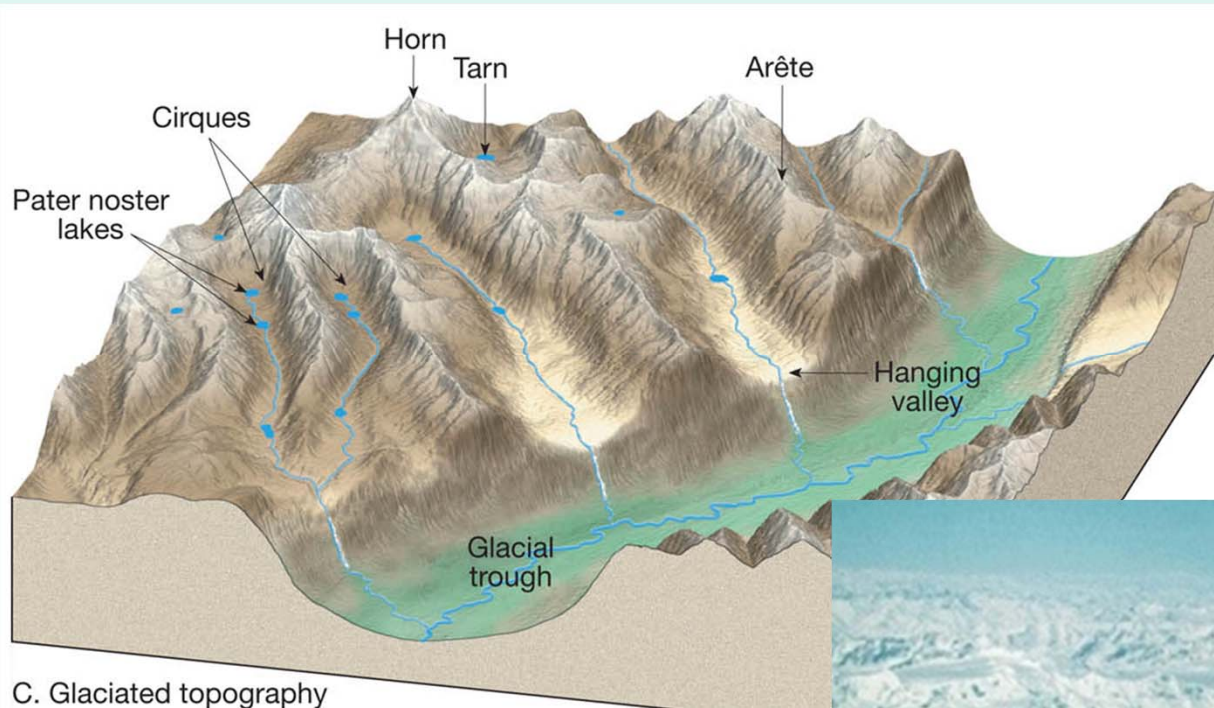


C. Glaciated topography

Aretes



Glaciated Topography



C. Glaciated topography

Fiords



Glaciated Topography

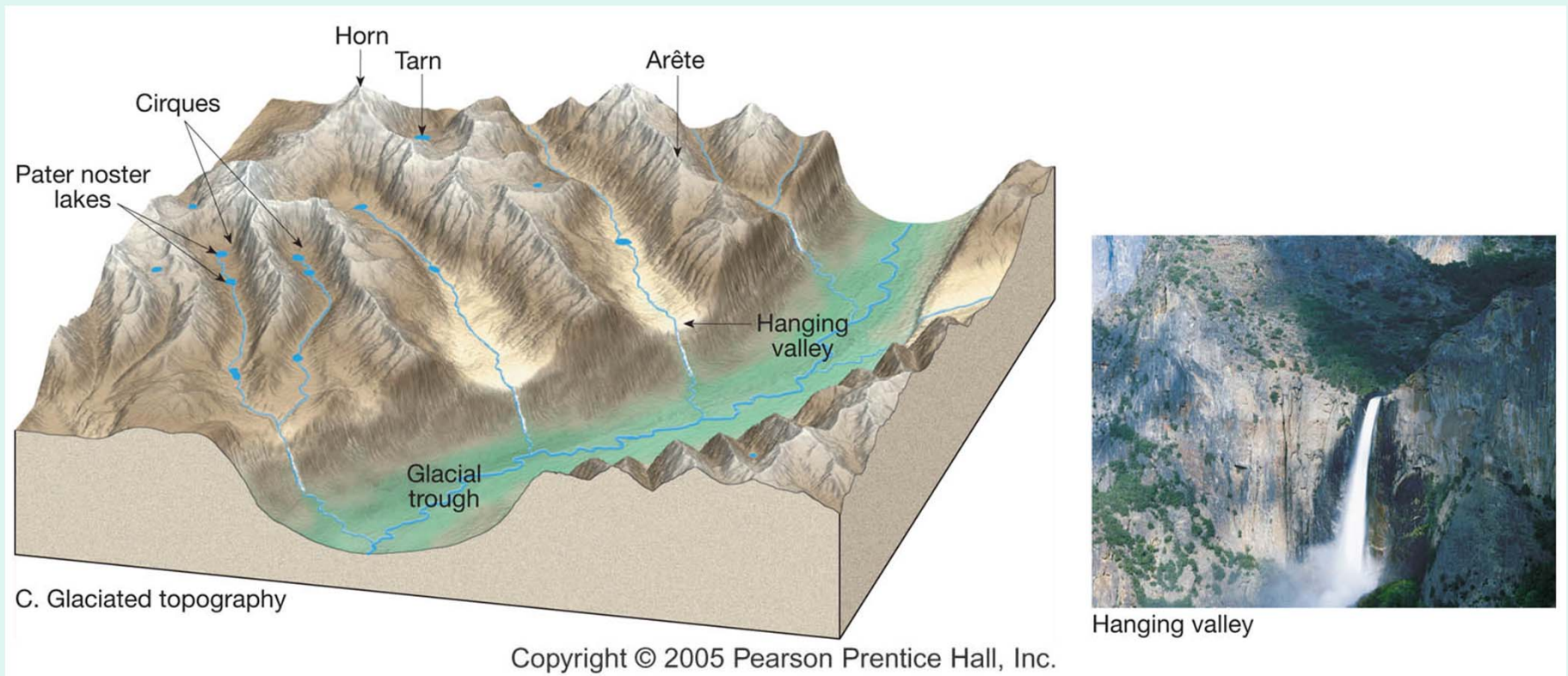


Figure 4.7 C

The Matterhorn



Glacial Deposits

- **Glacial drift**—Refers to all sediments of glacial origin
 - **Types of glacial drift**
 - ***Till*** —Material that is deposited directly by the ice
 - ***Stratified drift*** —Sediments laid down by glacial meltwater



Glacial Till Is Typically Unstratified and Unsorted



Glacial Deposits

Landforms made of till

Moraines

Layers or ridges of till

Moraines produced by alpine glaciers

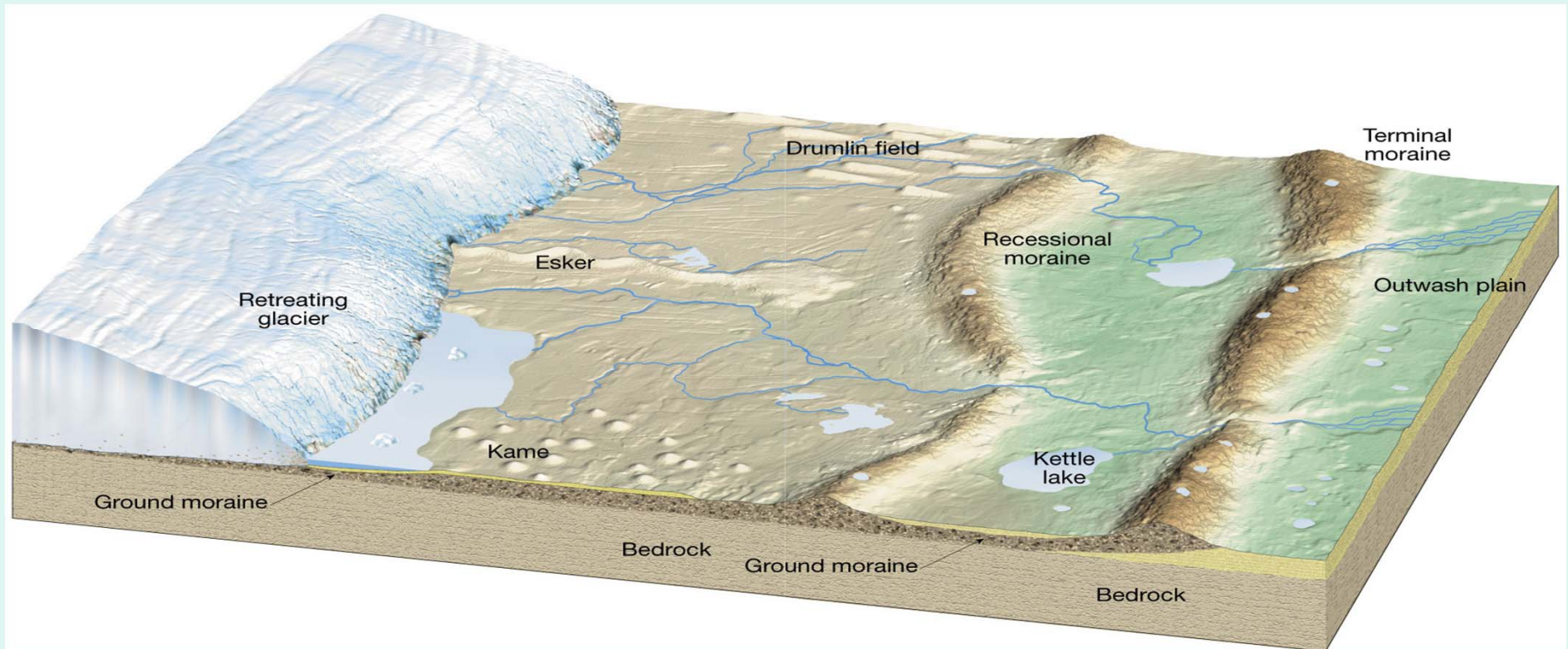
Lateral moraine

Medial moraine



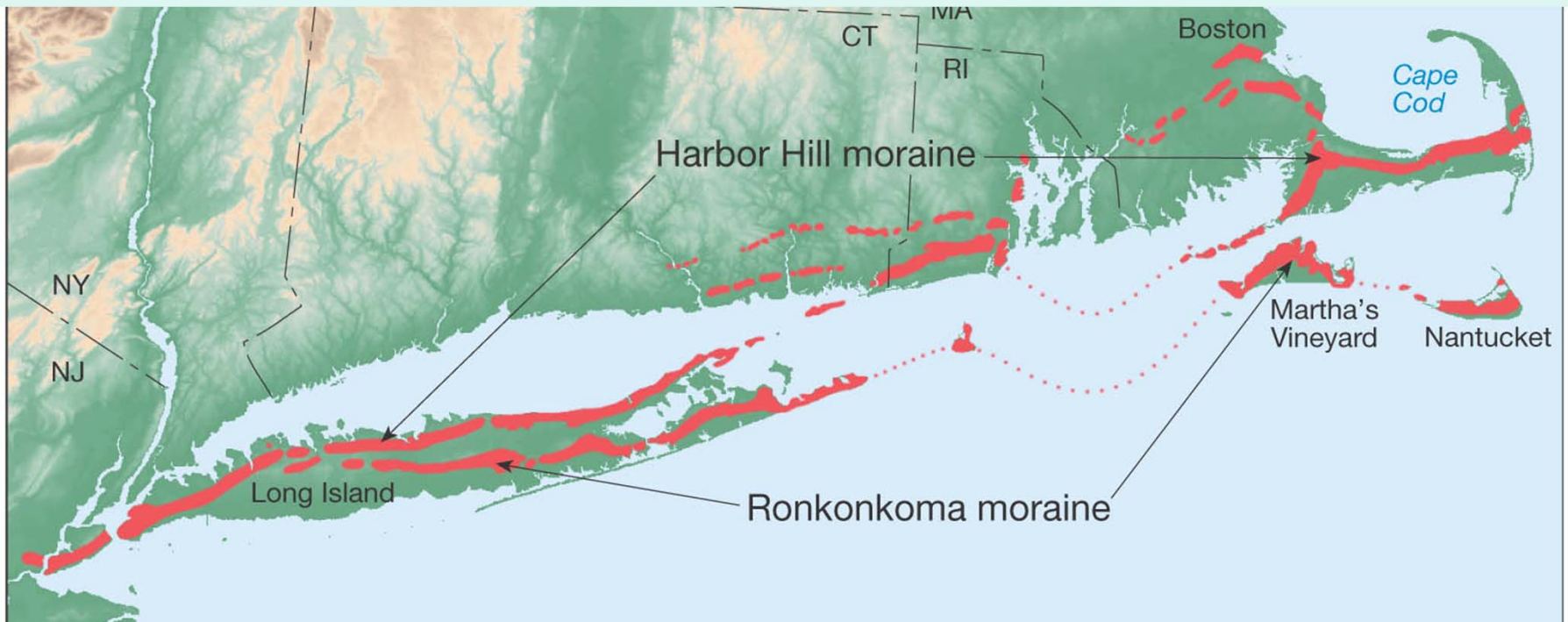
Glacial Deposits

- Landforms made of till
 - Other types of moraines
 - *End moraine*—Terminal or recessional
 - *Ground moraine*



Glacial Deposits

- Landforms made of till
 - Other types of moraines
 - *End moraine*—Terminal or recessional
 - *Ground moraine*



Glacial Depositional Features

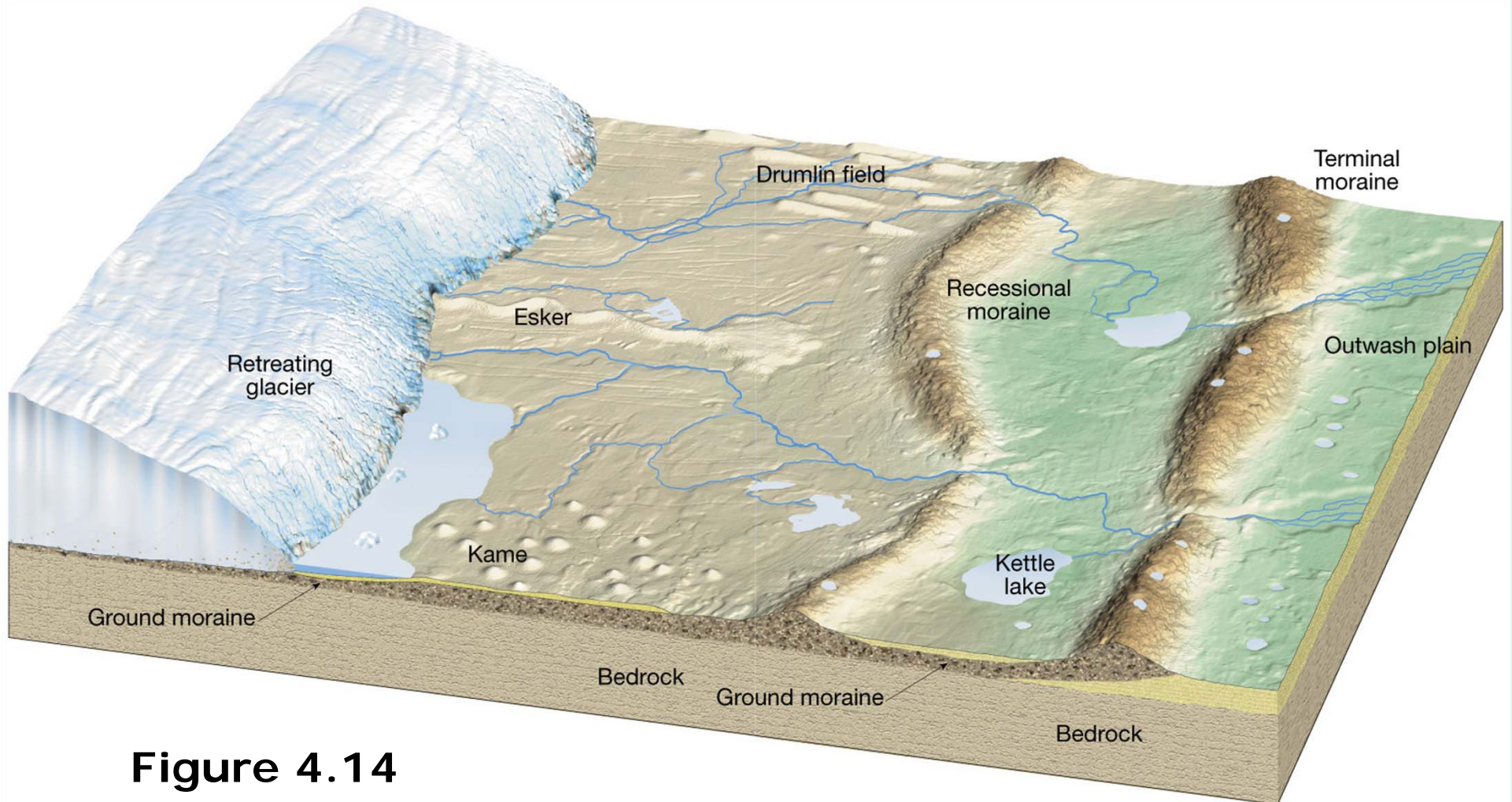


Figure 4.14

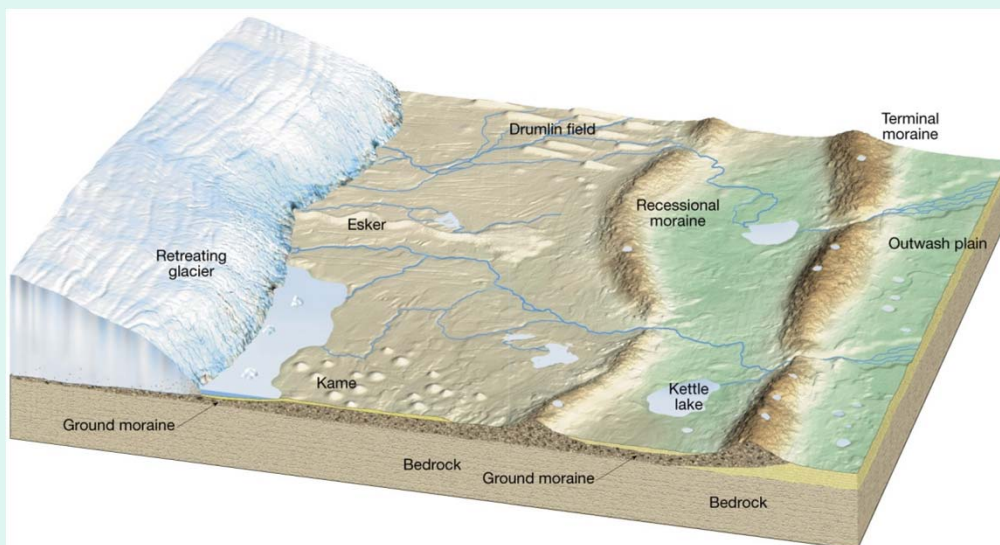
Glacial Deposits

- **Landforms made of till**
 - ***Drumlins***
 - **Smooth, elongated, parallel hills**
 - **Steep side faces the direction from which the ice advanced**
 - **Occur in clusters called drumlin fields**



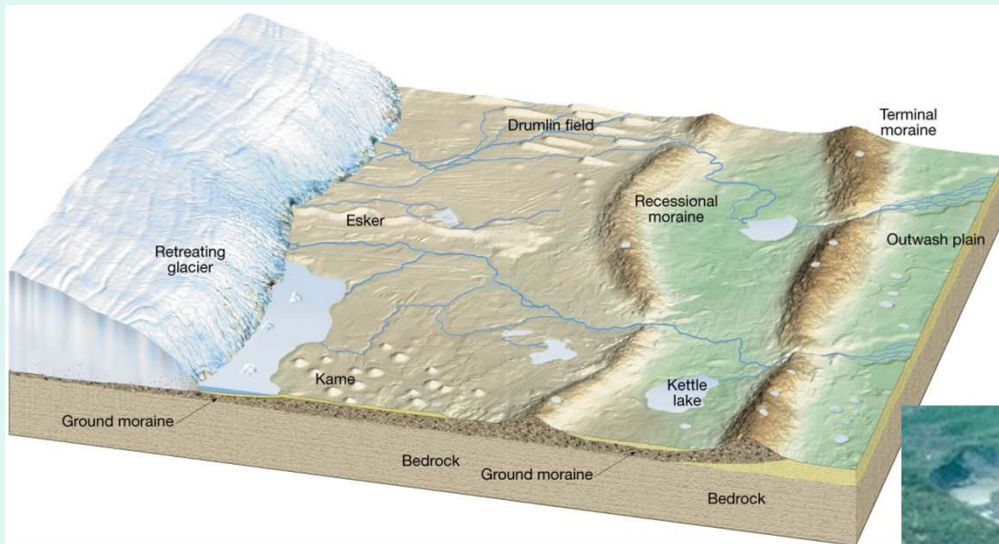
Glacial Deposits

- Landforms made of stratified drift
 - *Outwash plains* (with ice sheets) and *valley trains* (when in a valley)
 - Broad ramp-like surface composed of stratified drift deposited by meltwater leaving a glacier
 - Located adjacent to the downstream edge of most end moraines
 - Often pockmarked with depressions called *kettles*



Glacial Deposits

- Landforms made of stratified drift
 - *More kettles*



Glacial Deposits

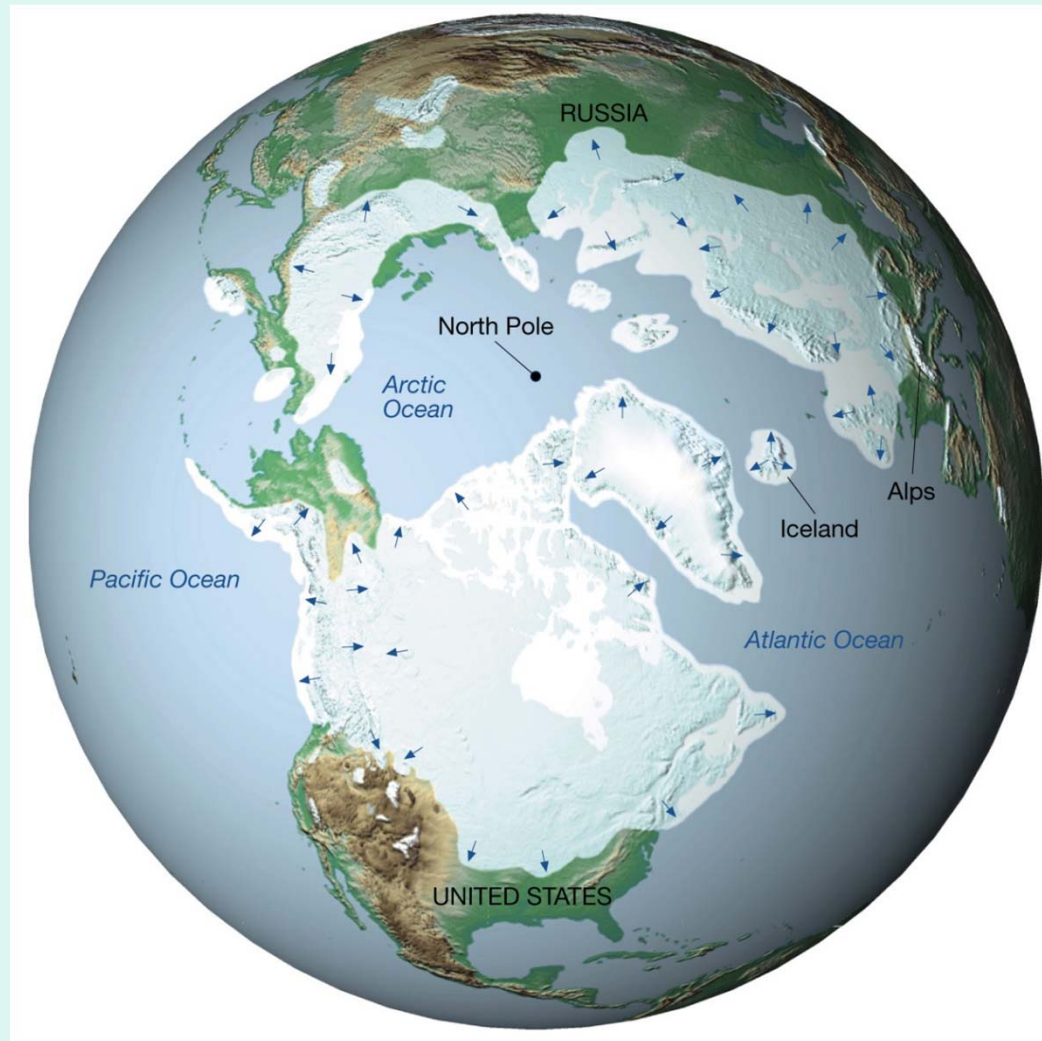
- **Landforms made of stratified drift**
 - **Ice-contact deposits**
 - Deposited by meltwater flowing over, within, and at the base of motionless ice
 - Features include
 - » ***Kames***
 - » ***Eskers***



Glaciers of the Past

- **Ice Age**
 - **Ice covered 30% of Earth's land area**
 - **Ice age began between 2–3 million years ago**
 - **Most of the major glacial episodes occurred during a division of geologic time called the *Pleistocene epoch***

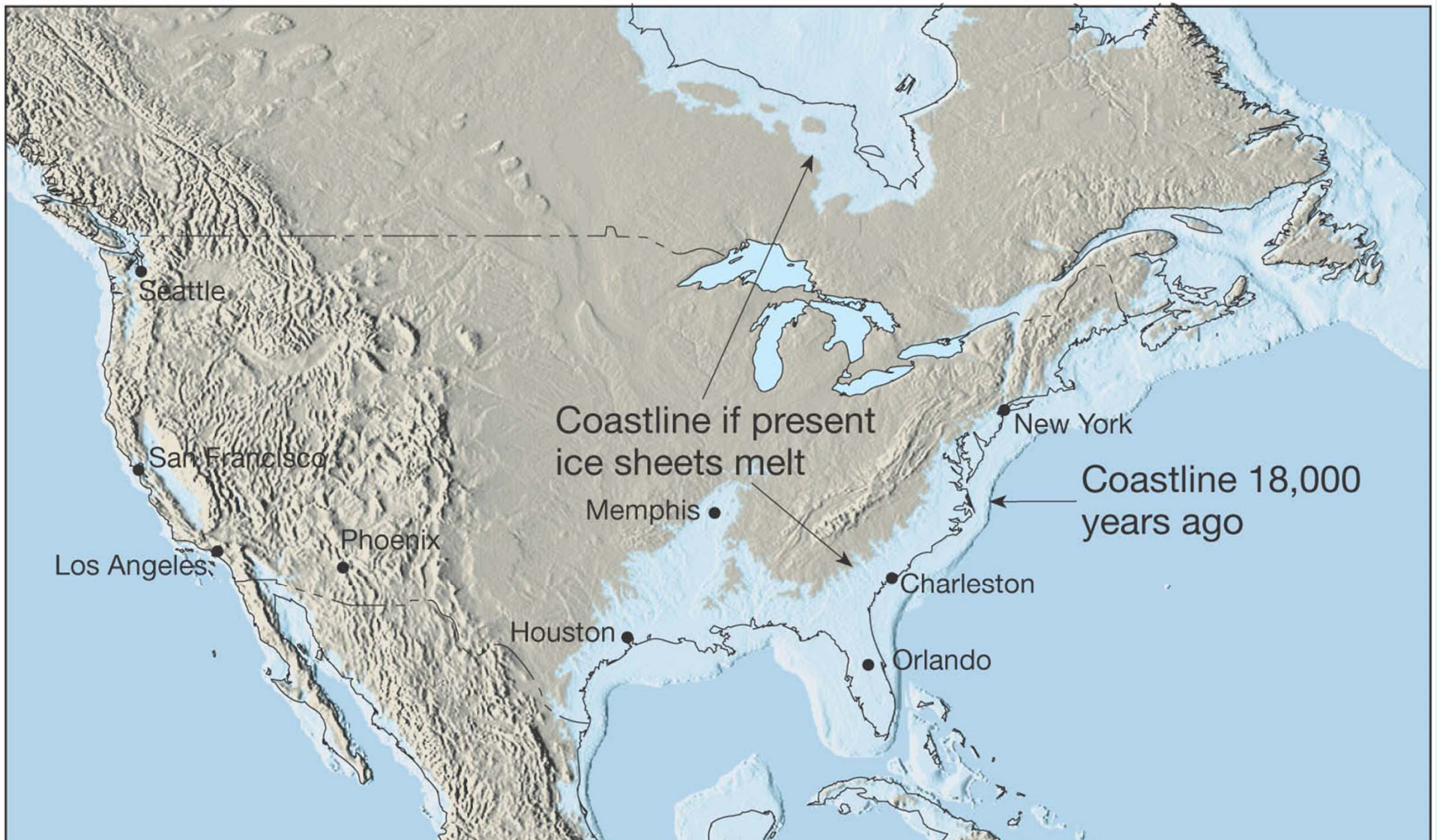
Maximum Extent of Ice During the Ice Age



Glaciers of the Past

- **Indirect effects of Ice Age glaciers**
 - **Forces migration of animals and plants**
 - **Changes in stream courses**
 - **Rebounding upward of the crust in former centers of ice accumulation**
 - **Worldwide change in sea level**
 - **Climatic changes**

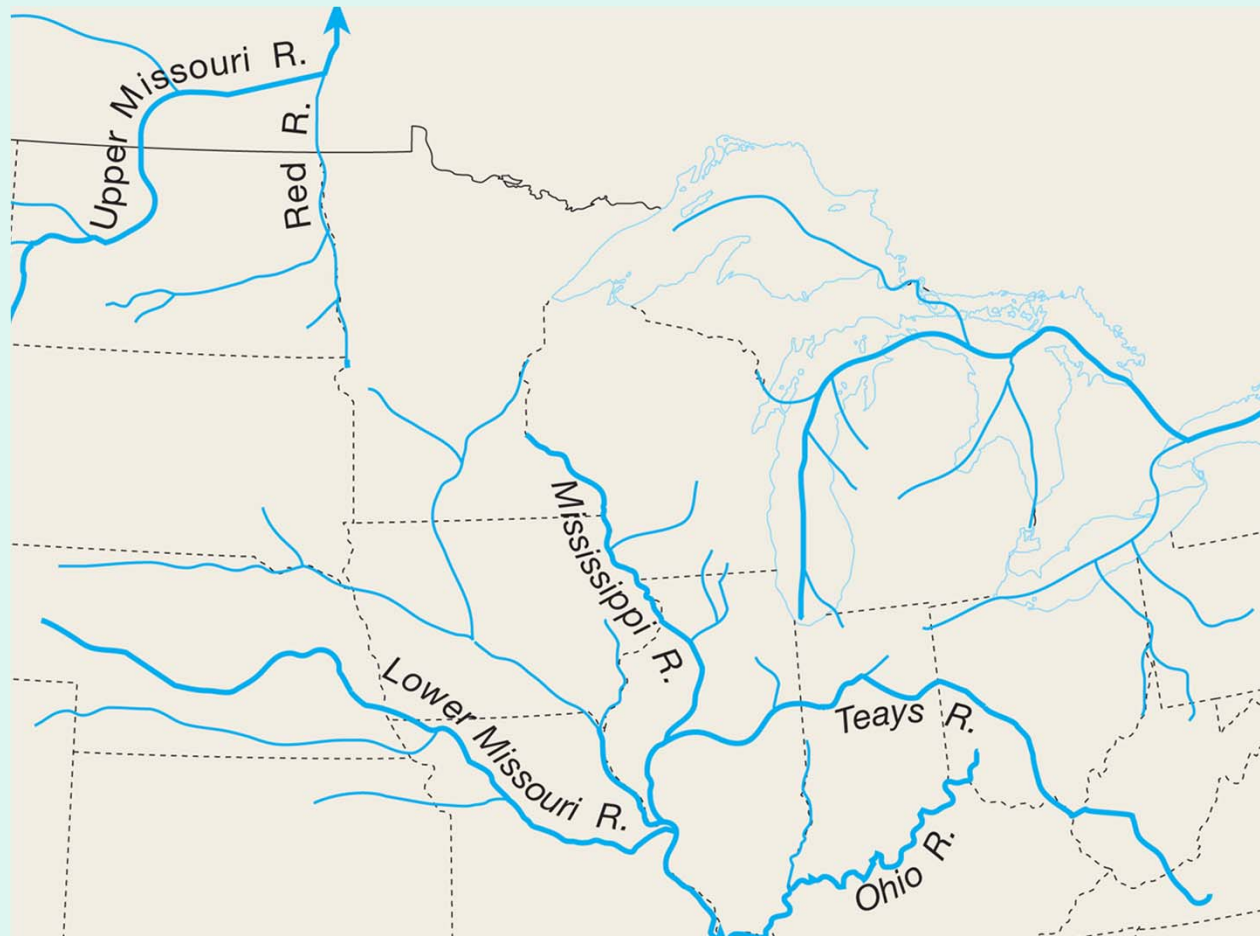
Glaciers of the Past



Glaciers of the Past

Significantly Changed Drainage Patterns

Pre-Glaciation



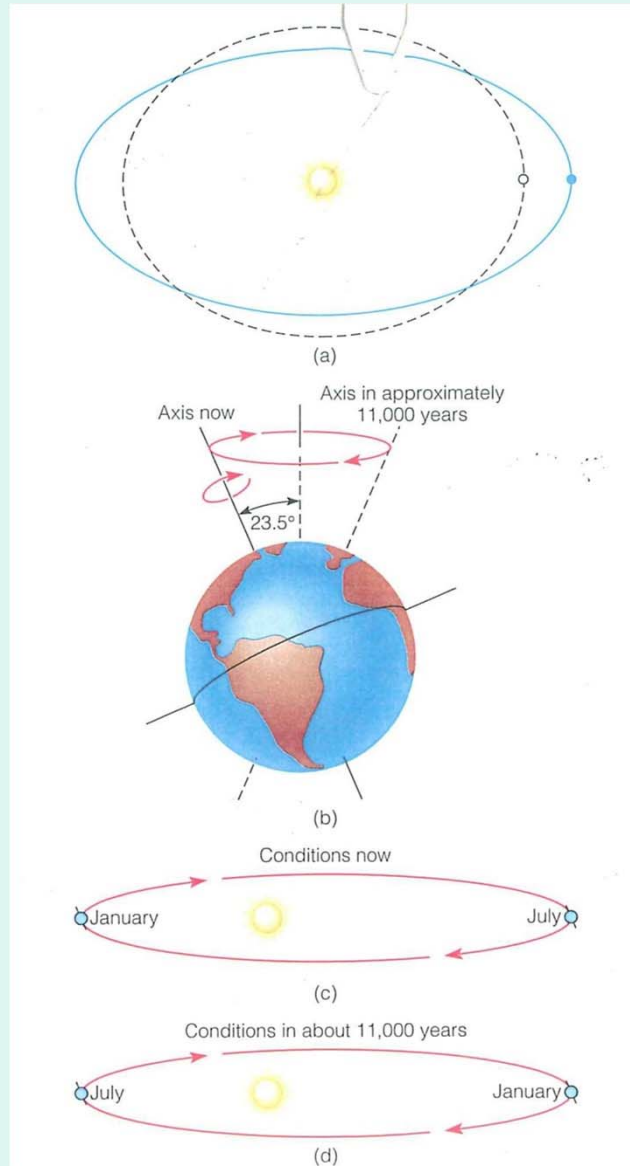
Glaciers of the Past

Significantly Changed Drainage Patterns

Post-Glaciation



Causes of Glaciations??



Cool Glacier Stuff

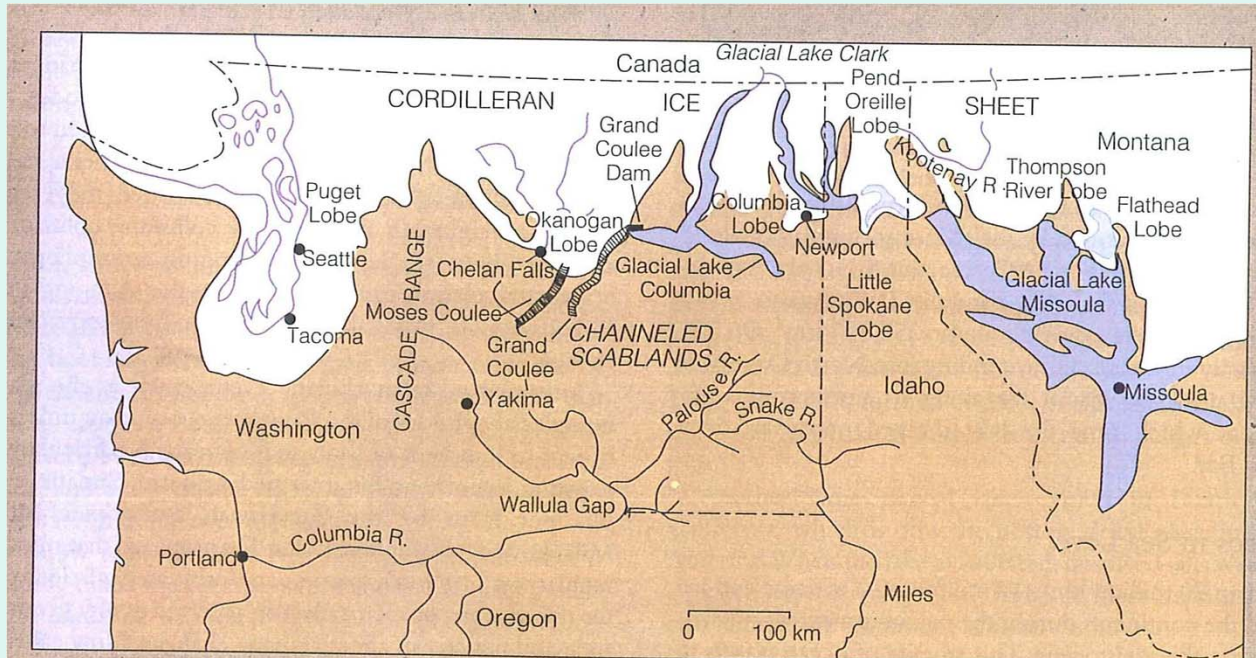


FIGURE 2 These gravel ridges are the so-called giant ripple marks that formed when glacial Lake Missoula, drained across this area near Camas Hot Springs, Montana.

Deserts

- **Dry regions cover 30 percent of Earth's land surface**
- **Less than 25 cm / year**
- **Distribution and causes of dry lands**

Two climatic types are commonly recognized

- *Desert* or arid
- *Steppe* or semiarid



Desert and Steppe Regions of the World

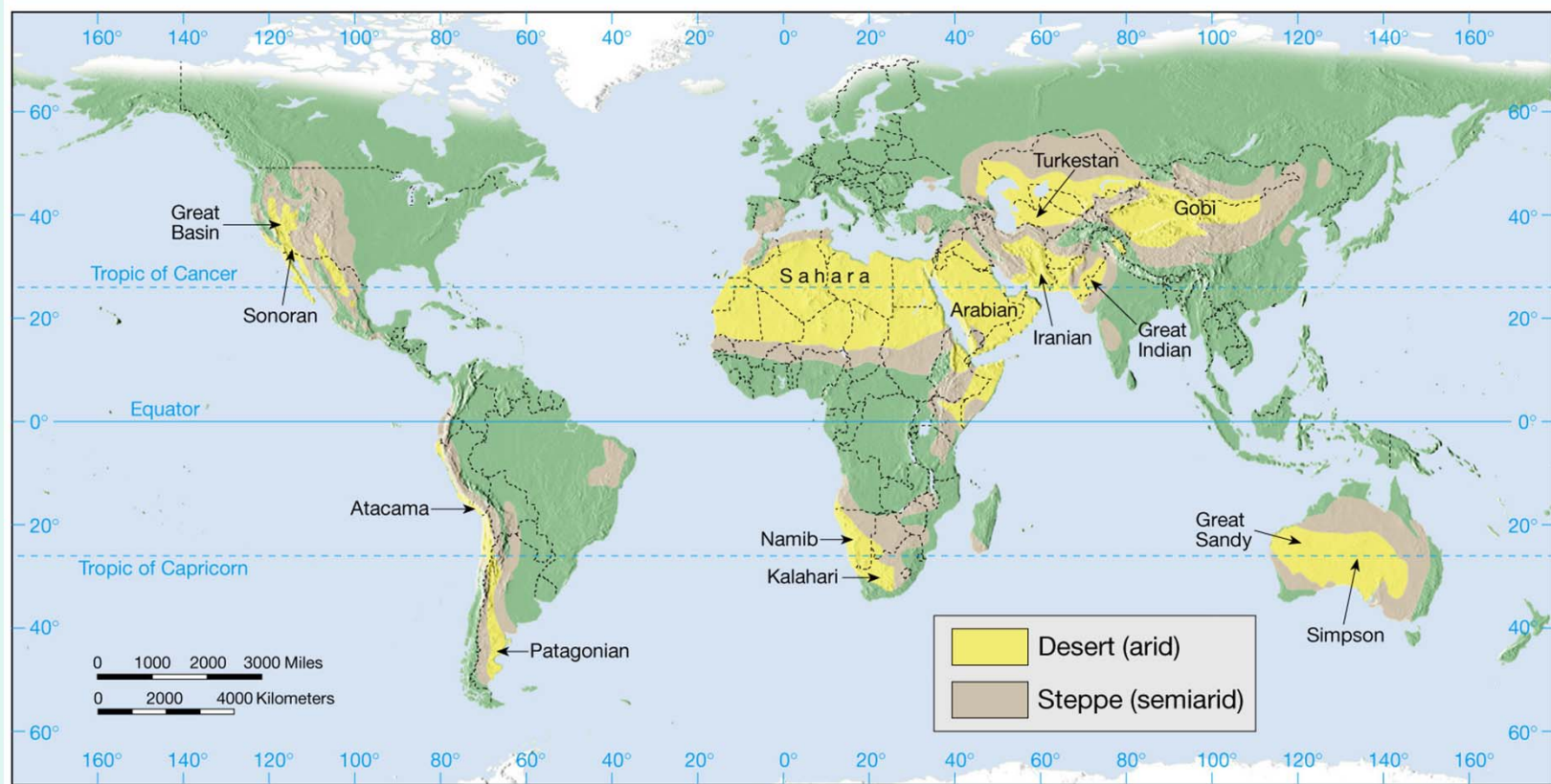


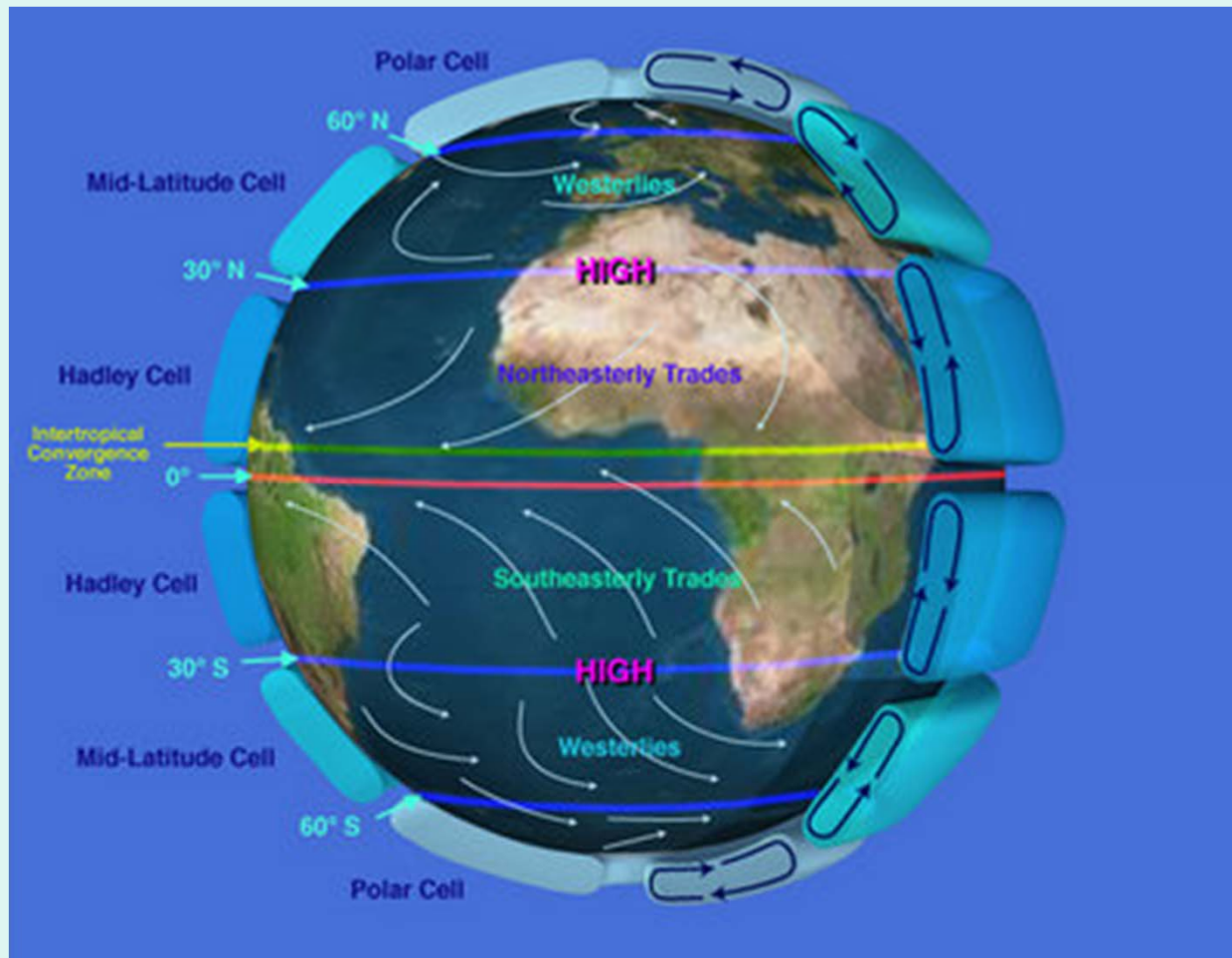
Figure 4.19

Deserts

- **Dry lands are concentrated in two regions**
 - **Subtropics**
 - **Low-latitude deserts**
 - **Areas of high pressure and sinking air that is compressed and warmed**

Deserts

- Dry lands are concentrated in two regions



Deserts

- **Dry lands are concentrated in two regions**
 - **Middle-latitudes**
 - Located in the deep interiors of continents
 - High mountains in the path of the prevailing winds produce a *rainshadow desert*

Rainshadow Desert

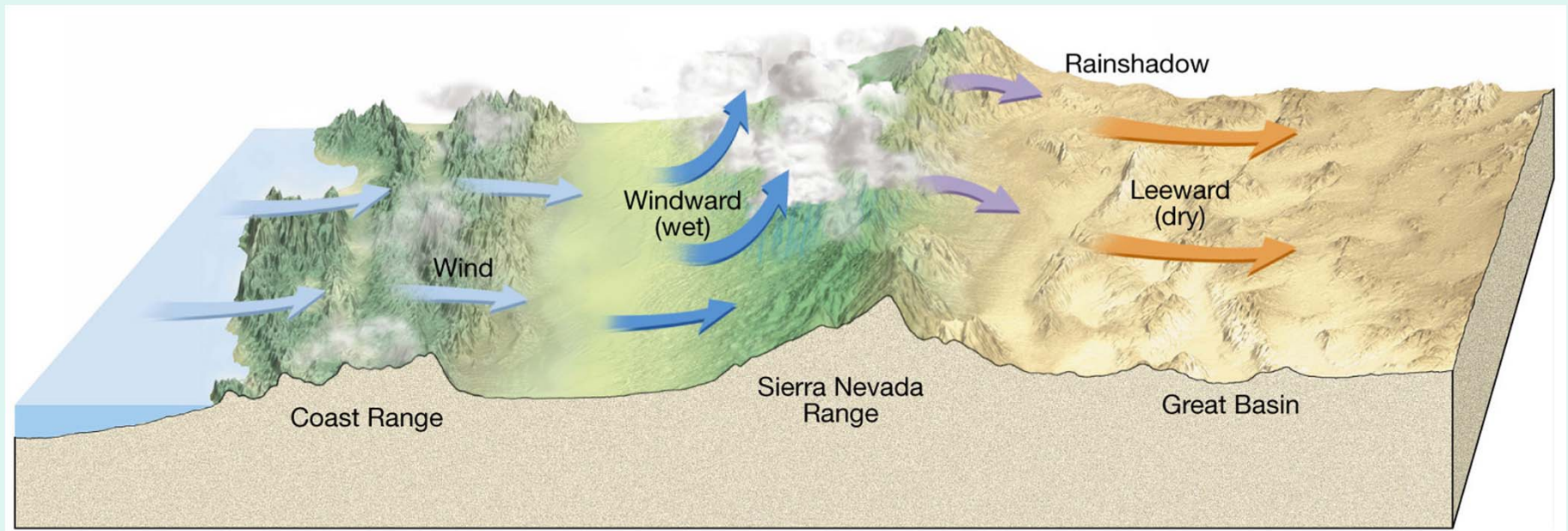


Figure 4.21

Deserts

- **Role of water in arid climates**
 - **Most streambeds are dry most of the time**
 - **Desert streams are said to be *ephemeral***
 - **Carry water only during periods of rainfall**
 - **Different names are used for desert streams in various region**
 - » ***Wash* and *arroyo* (western United States)**
 - » ***Wadi* (Arabia and North Africa)**

A Dry Channel Contains Water Only Following Heavy Rain



A.



B.

Figure 4.22

Deserts

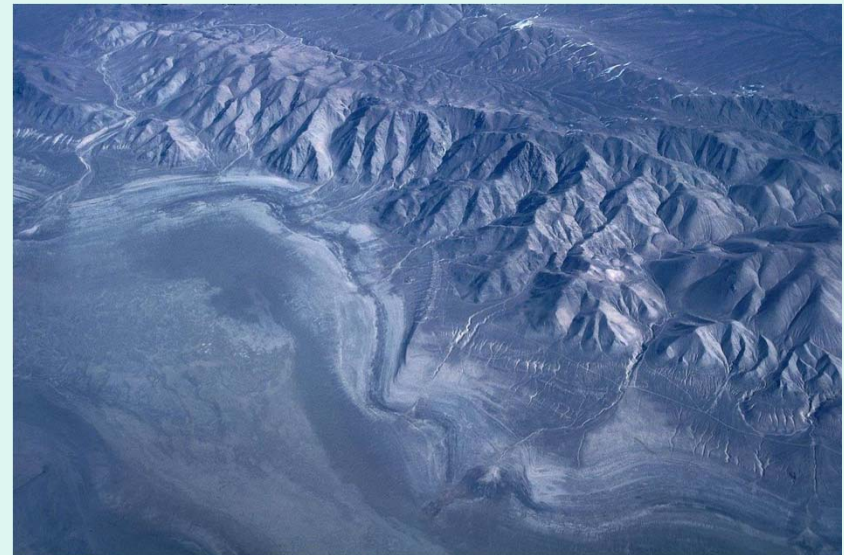
- **Role of water in arid climates**
 - **Ephemeral streams**
 - Different names are used for desert streams in various regions
 - » ***Donga*** (South America)
 - » ***Nullah*** (India)
 - **Desert rainfall**
 - Rain often occurs as heavy showers

Deserts

- **Role of water in arid climates**
 - **Desert rainfall**
 - **Because desert vegetative cover is sparse, runoff is largely unhindered and flash floods are common**
 - **Poorly integrated drainage systems and streams lack an extensive system of tributaries**
 - **Most of the erosion work in a desert is done by running water**

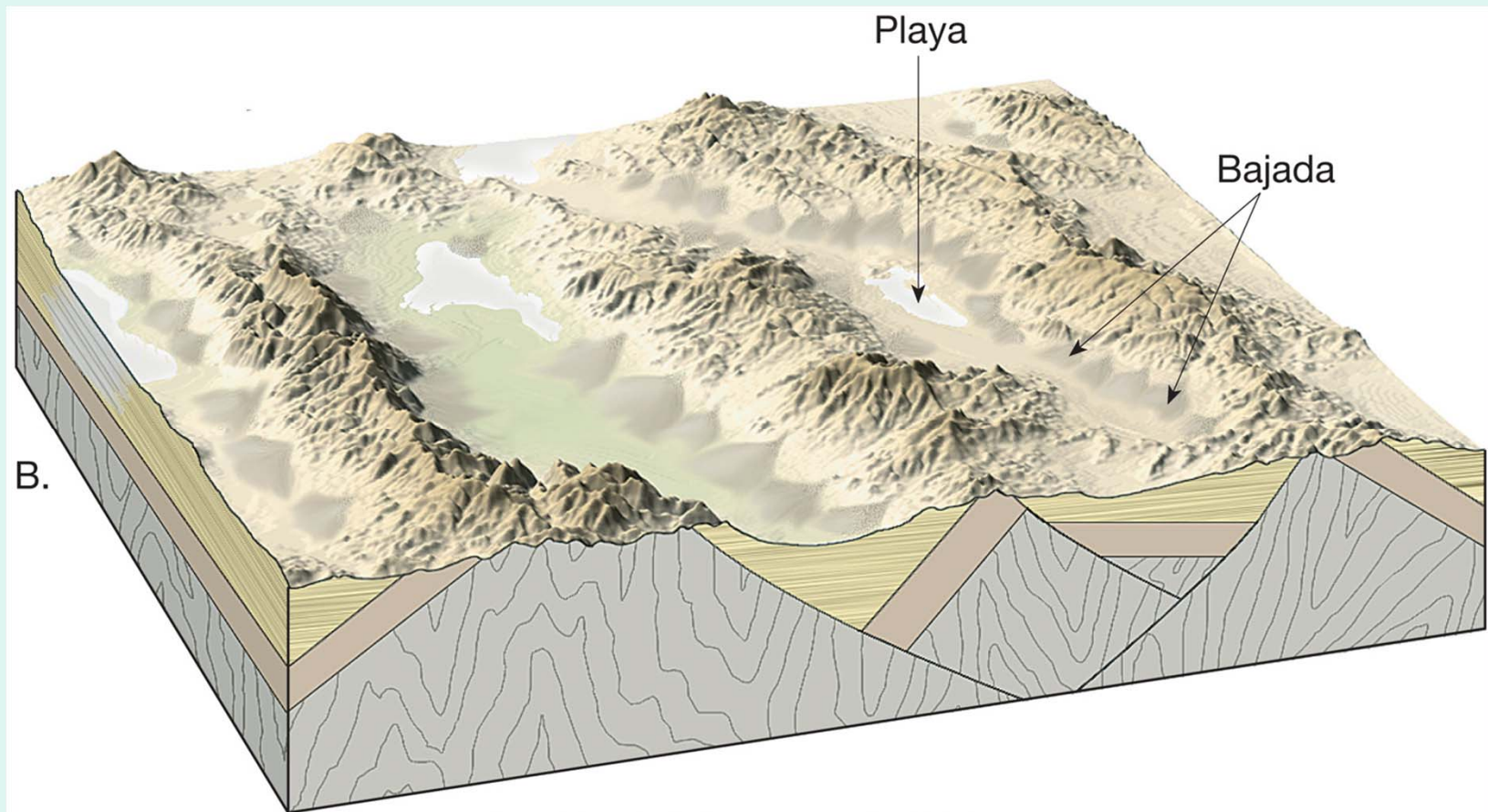
Basin and Range: Evolution of a Desert Landscape

- **Characterized by interior drainage**
- **Landscape evolution in the Basin and Range region**
 - **Uplift of mountains—Block faulting**
 - **Interior drainage into basins produces**
 - *Alluvial fans*
 - *Playas and playa lakes*



Basin and Range: Evolution of a Desert Landscape

- **Characterized by interior drainage**

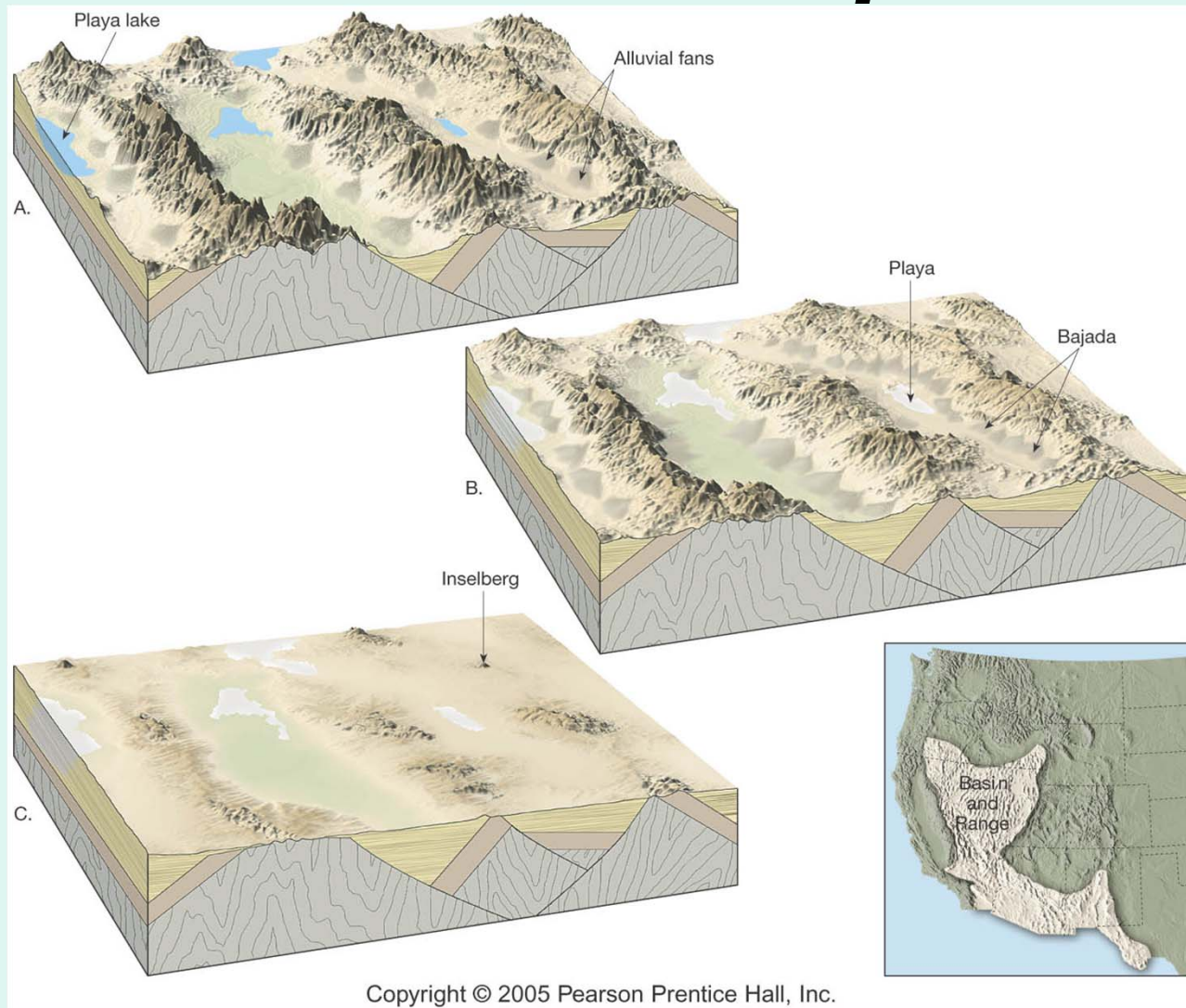


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Basin and Range: Evolution of a Desert Landscape

- **Landscape evolution in the Basin and Range region**
 - **Ongoing erosion of the mountain mass**
 - **Produces sediment that fills the basin**
 - **Diminishes local relief**
 - **Produce isolated erosional remnants called *inselbergs***

Basin and Range: Evolution of a Desert Landscape



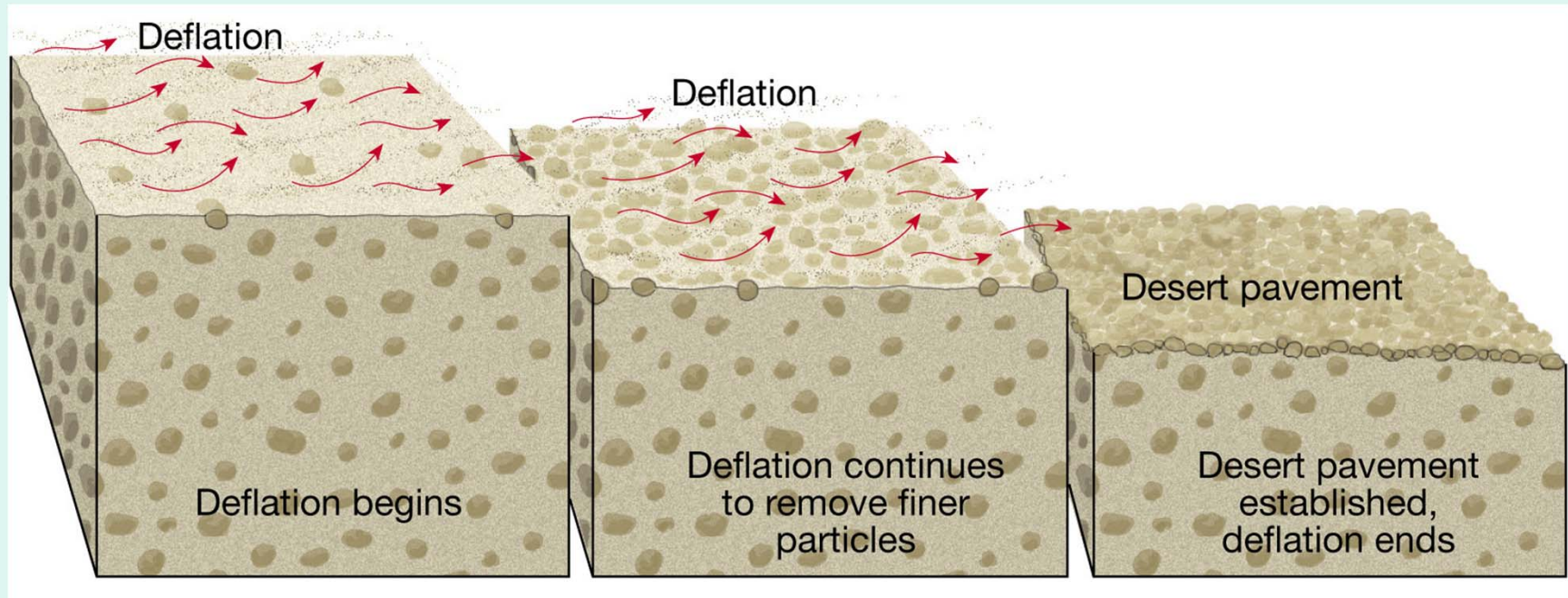
Inselbergs in Southern California



Wind Erosion

- **Transportation of sediment by wind**
 - **Differs from that of running water in two ways**
 - **Wind is less capable of picking up and transporting coarse materials**
 - **Wind is not confined to channels and can spread sediment over large areas**

Formation of Desert Pavement



Wind Erosion

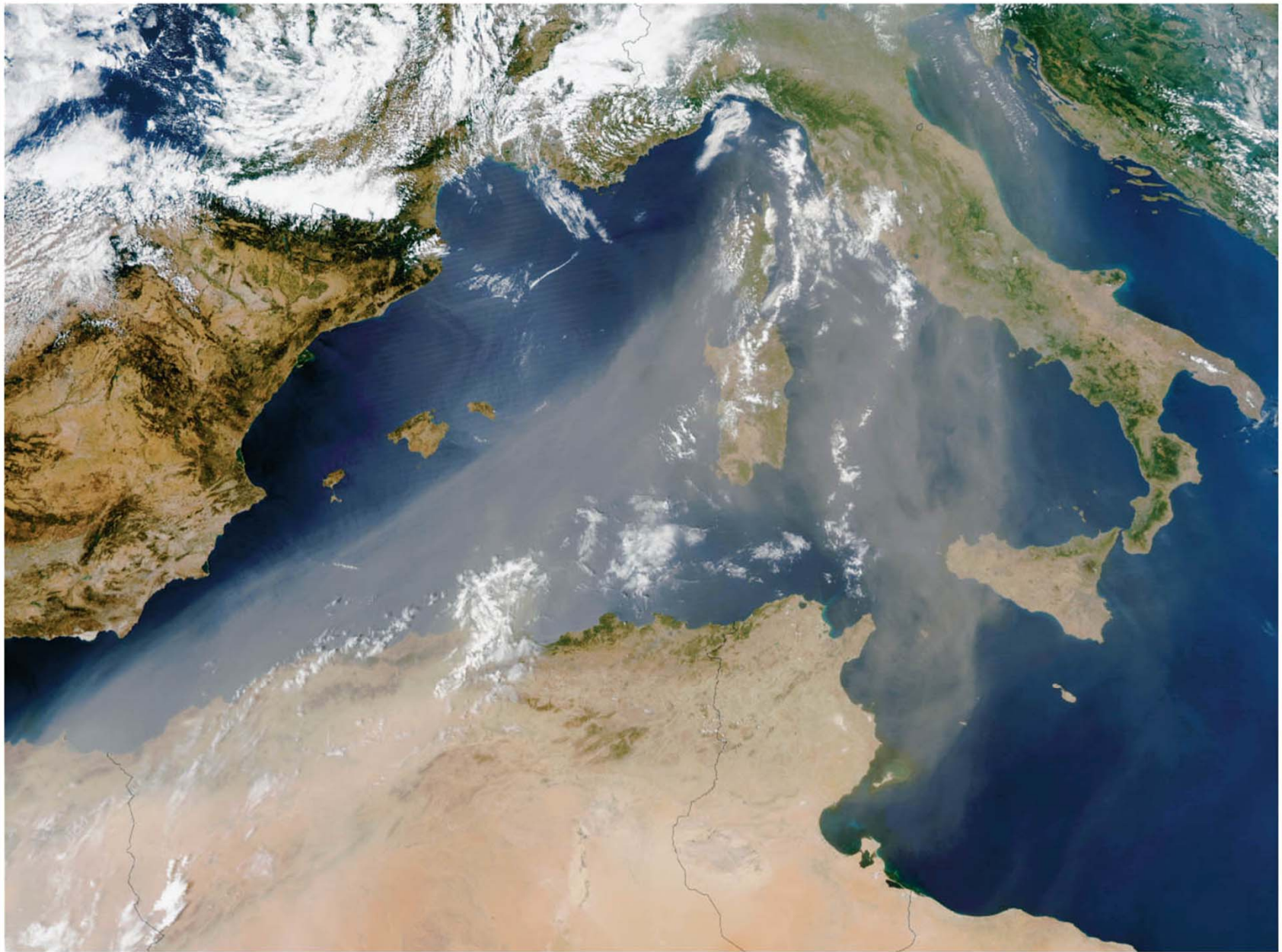
- **Transportation of sediment by wind**
 - **Mechanisms of transport**
 - ***Bedload***
 - » ***Saltation***—skipping and bouncing along the surface
 - » **Particles larger than sand are usually not transported by wind**
 - ***Suspended load***



Wind Erosion

- **Mechanisms of transport**
 - ***Deflation***
 - » **Lifting of loose material**
 - » **Deflation produces *blowouts* (shallow depressions) and *desert pavement* (a surface of coarse pebbles and cobbles)**
- **Wind is a relatively insignificant erosional agent when compared to water**

04_25A



A.

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04_25B



B.

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Wind Deposits

- **Wind deposits**
 - **Significant depositional landforms are created by wind in some areas**
 - **Two types of wind deposits**
 - 1) ***Dunes***
 - » **Mounds or ridges of sand**
 - » **Often asymmetrically shaped**
 - » **Windward slope is gently inclined and the leeward slope is the *slip face***

Sand Dunes in the Western United States



Sand Dunes in the Western United States



Wind Deposits

- **Wind deposits**

- 2) **Two types of wind deposits**

- ***Loess***

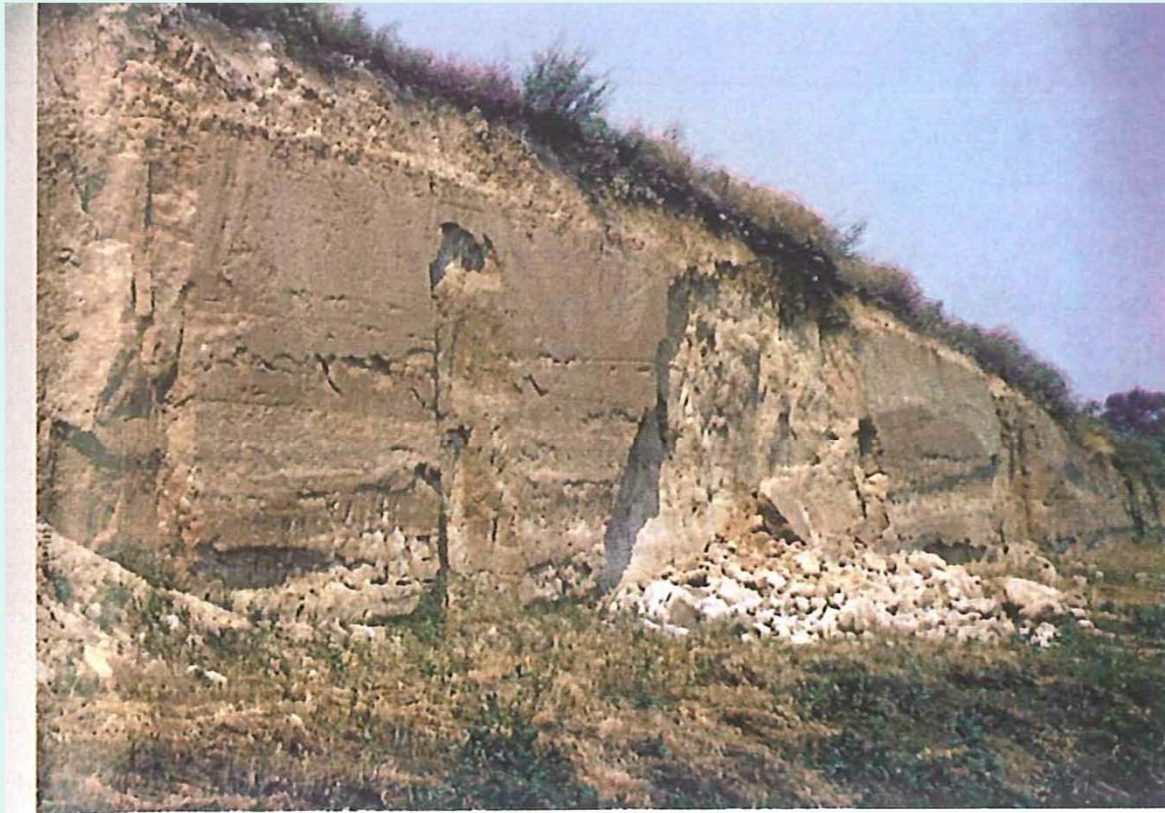
- » **Blankets of windblown silt**

- » **Two primary sources are deserts and glacial outwash deposits**

- » **Extensive deposits occur in China and the central United States**

Wind Deposits

- **Wind deposits**
 - *Loess*



A.

End of Chapter 4