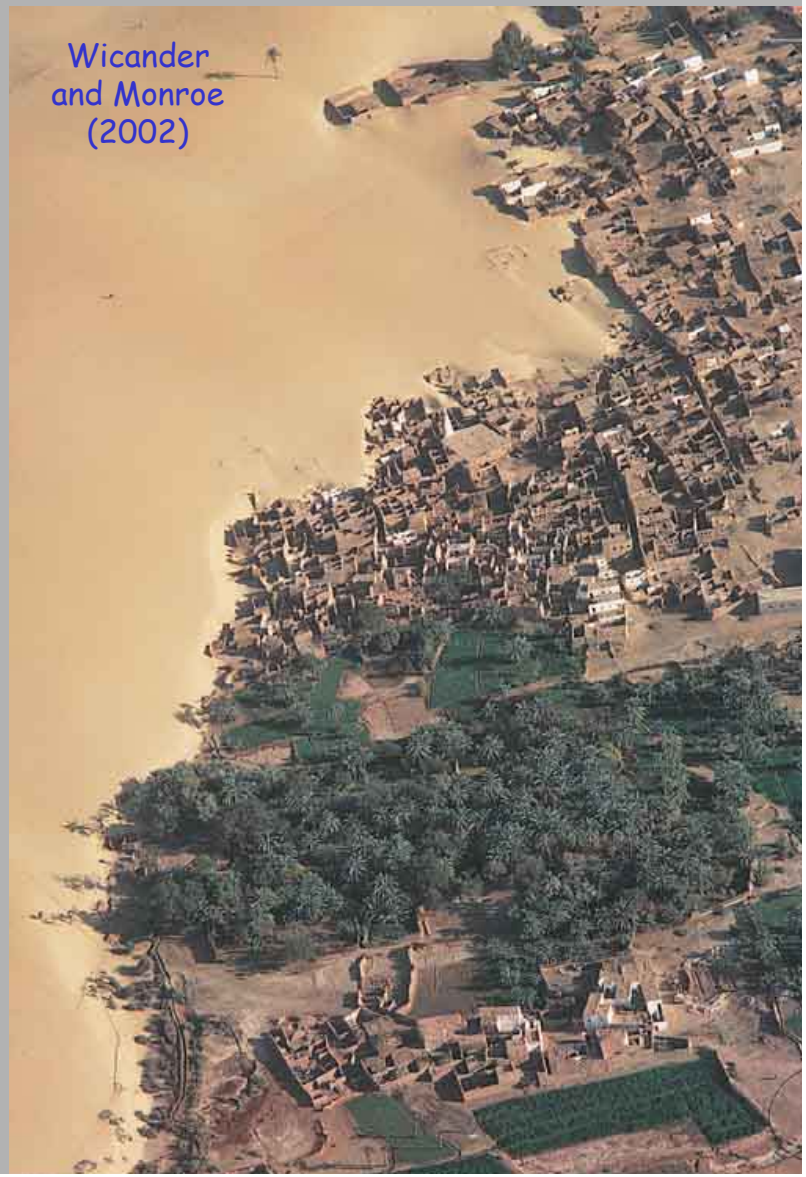
Deserts

- Erosion, transport, and deposition by wind is commonly associated with deserts.
- Deserts are characterized by unique landforms. Understanding the processes by which the wind erodes, transports, and deposits sediment helps explain the distribution and origin of many desert landforms.
- The geographic distribution of deserts is largely controlled by global and regional atmospheric circulation patterns.

Wicander and Monroe (2002)

Why Study Deserts?

- **Deserts cover large regions of Earth and many peoples and cultures are endemic to desert areas.**
- **The expansion of deserts into formerly productive lands is known as desertification. This process claims 70,000 km^2 of productive land each year and extracts a large toll in human suffering.**
- **Deserts expand and contract naturally, but human activities can greatly accelerate desertification. Understanding the factors that control the distribution of deserts and the geologic processes at work in them is important for identifying areas especially susceptible to desertification and for devising strategies for limiting it.**



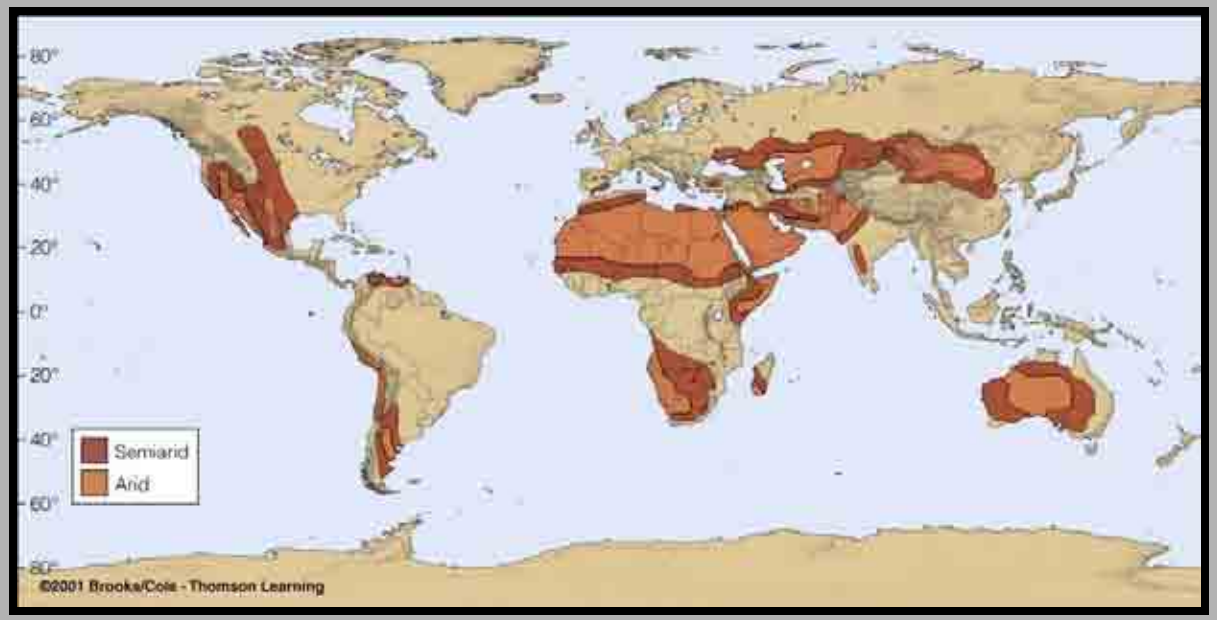
What Are Deserts?

- Arid regions generally described as deserts receive <25 cm of rainfall annually. Deserts are dry, have high rates of evaporation, poorly developed soils, and are mostly or completely devoid of vegetation.
- Average summer temperature for low-latitude deserts is 32° to 38°C. Daytime winter temperatures average 10° to 18°C.
- Most deserts support at least sparse plant cover. Desert plants are small, widely spaced, and slow-growing. Most have wide, shallow root systems to help absorb the dew.

Marshak (2002)

Where Do Deserts Occur?

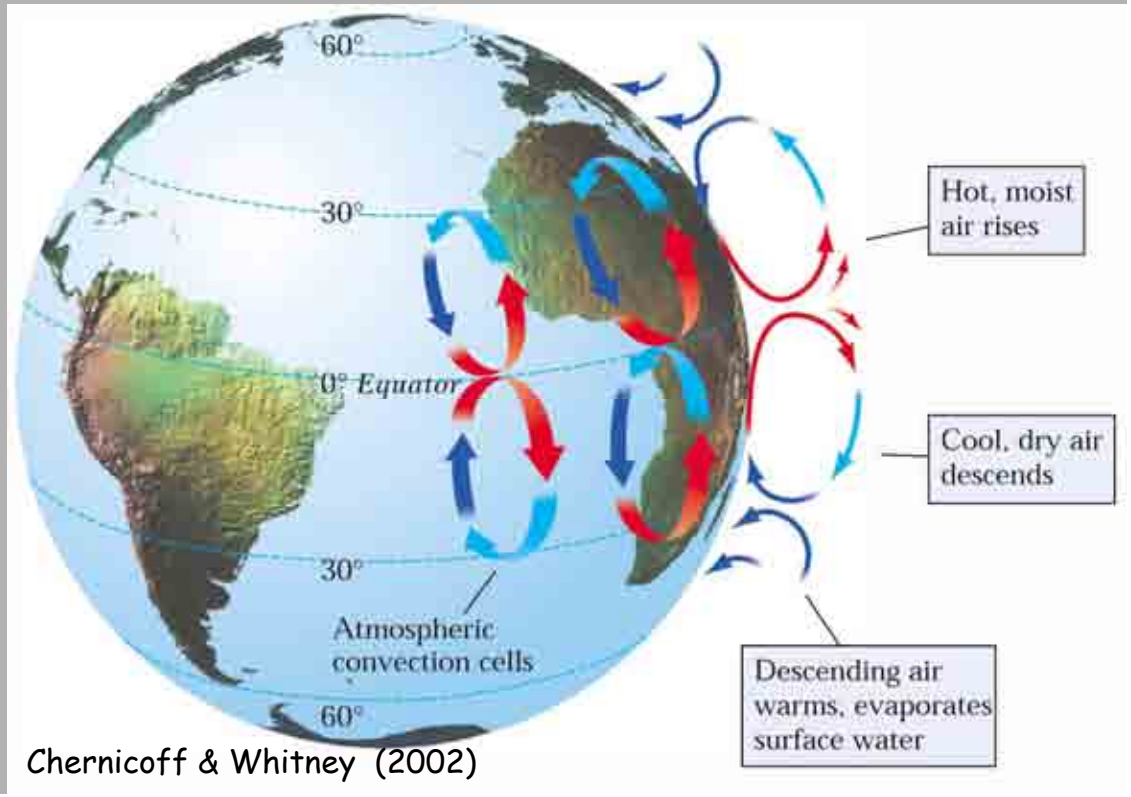
The distribution of dry climates (semiarid and arid) and deserts is controlled primarily by the general atmospheric circulation pattern which produces arid climates & deserts (such as the Sahara and Arabian) along belts centered roughly on 30° north & south latitude. The remaining deserts of the mid-latitudes are rainshadow deserts (such as the Great Basin of North America).



Wicander and Monroe (2002)

Global Wind Patterns

- Warm air is less dense than cold air, and therefore warm air masses have lower air pressure than cold air masses.
- Areas of Earth receiving the most solar radiation, the equatorial region, have low air pressure, whereas polar regions have high air pressure.
- The flow of air from high pressure areas (poles and 30° north and south latitude) to low pressure areas (equatorial region and 60° north and south latitude) produces wind.

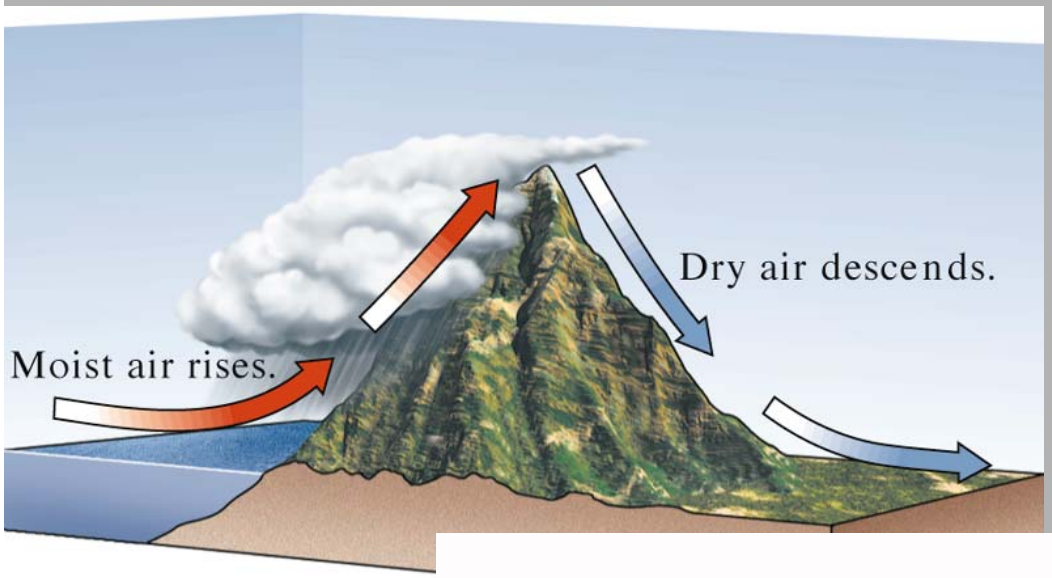


Chernicoff & Whitney (2002)

Four basic desert regions

- Polar deserts – perpetual snow cover, low precipitation and intense cold, e.g. Antarctica and central Greenland
- Subtropical deserts - largest deserts, occur in regions of subsiding high pressure air masses, e.g. Sahara, Kalahari, Australia
- Mid-latitude deserts – located deep within continental interiors e.g. the Gobi desert
  - Rain shadow deserts e.g. the Mojave and Death Valley
- Coastal deserts – lie on the coastal side of large land masses, tempered by cold, upwelling ocean currents, e.g. the Atacama desert, Chile (driest area on earth is a rain shadow & a coastal desert)

Rain-shadow effect.



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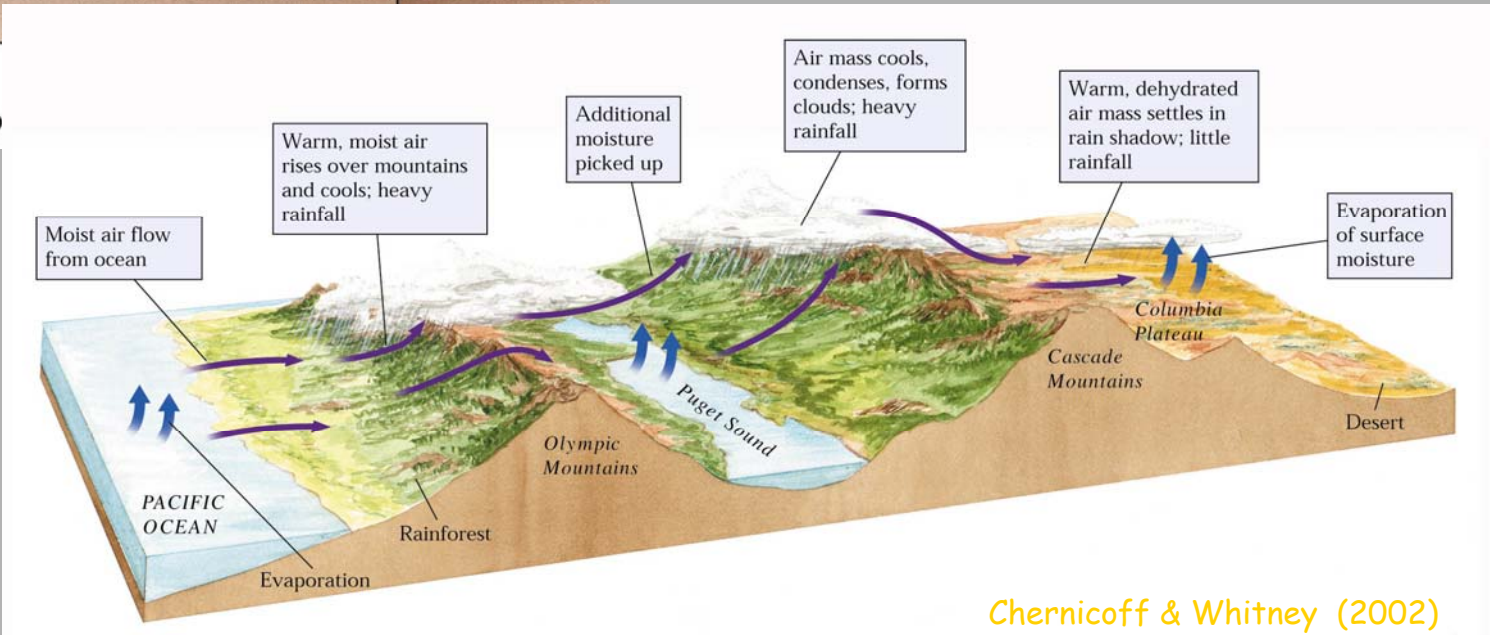
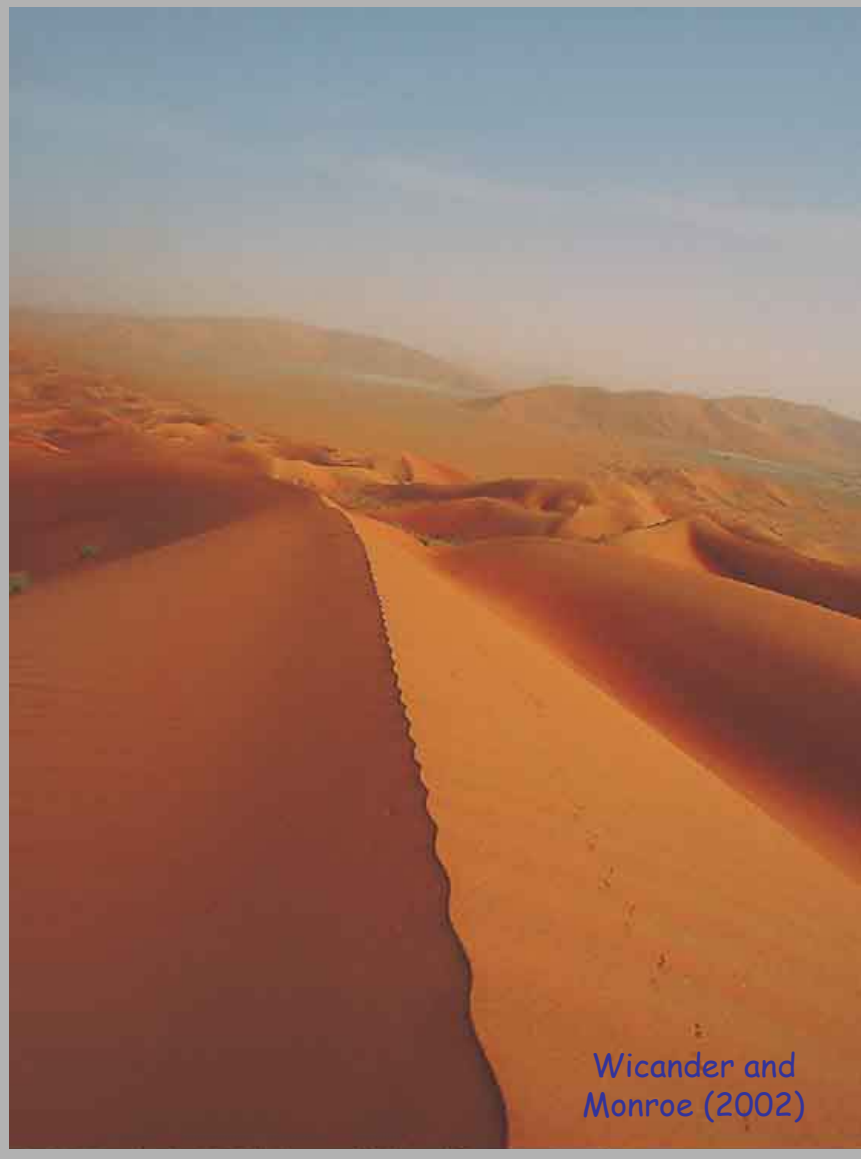


Chernicoff & Whitney (2002)

Characteristics of Deserts

- Most deserts are not covered by sand, but rather consist of vast areas of exposed rock and desert pavement.
- Most erosion in deserts is due to running water. In deserts, most precipitation falls during brief, heavy, localized cloudbursts. Considerable erosion takes place because the ground cannot absorb all the rainfall.
- Many major topographic features of deserts were formed by running water during the wetter climates of the Pleistocene Epoch. Such features have since been modified by the wind.



Characteristics of Deserts

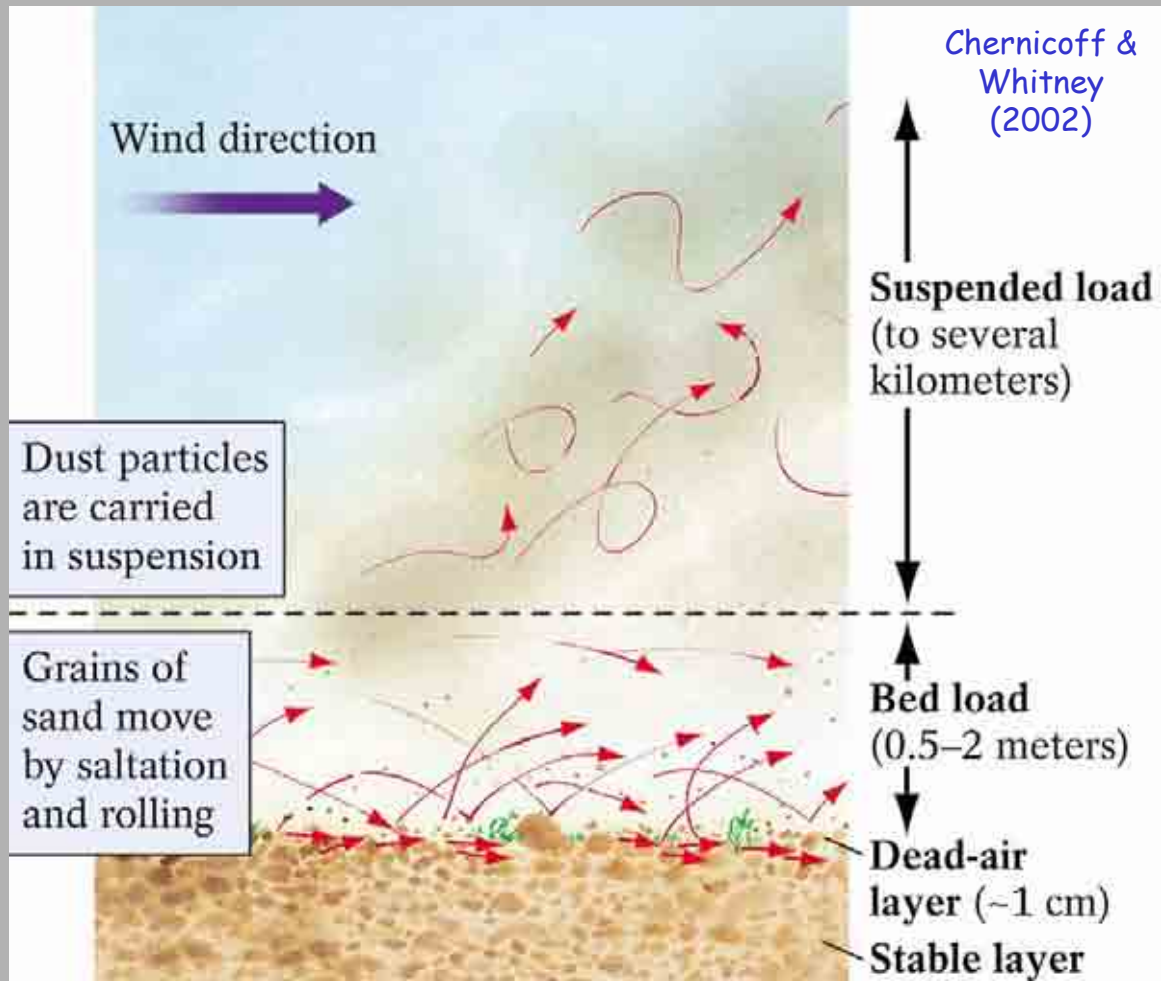
Castle Valley, Utah

- Mechanical weathering via temperature fluctuations and frost wedging is a dominant processes in deserts. The scarcity of water greatly reduces chemical weathering.
- Rock varnish is a thin, shiny red, brown, or black coating on many rock surfaces. The coating consists of iron and manganese oxides precipitated by microorganisms or carried as windblown dust.
- Desert soils are usually thin and patchy because the limited rainfall and vegetation restrict chemical weathering and thus soil formation.

Wicander and Monroe (2002)

Wind Transport

- **Wind is turbulent fluid and transports sediment in much the same way as running water.**
- Wind can transport silt- and clay-size grains as suspended load,
- Sand and larger grains are transported as bedload. Larger grains slide or roll, but sand grains generally move by saltation, intermittent bouncing or hopping. Saltating grains seldom rise more than a meter above the surface.

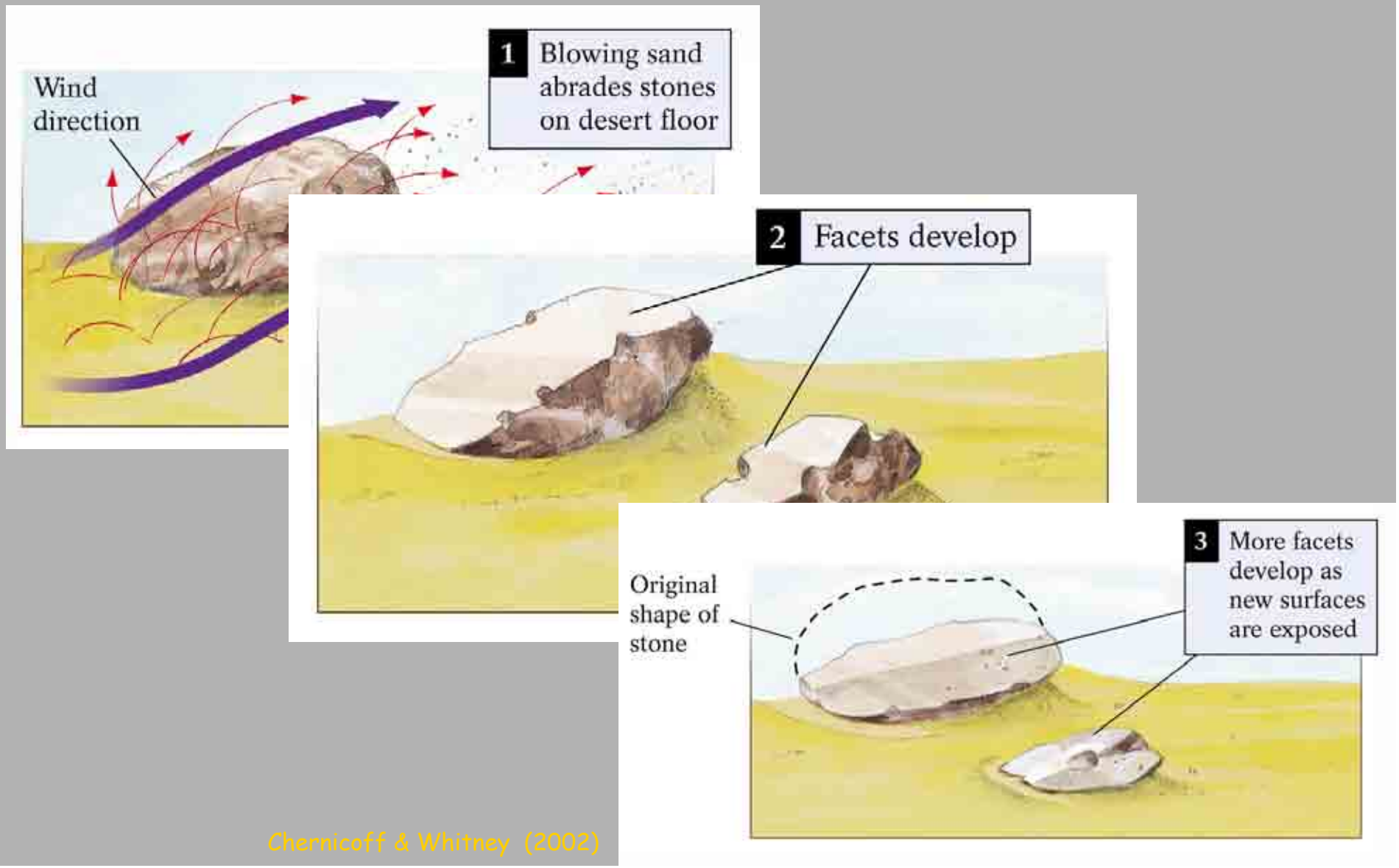


How Does Wind Erode Landforms?

- Although running water is responsible for most erosional landforms in arid regions, wind action produces many distinctive erosional features. Largely because of its low density, wind is an extremely efficient sorting agent. Wind erodes material in two ways: abrasion and deflation.
- Abrasion is caused by the impact of saltating grains and is similar to sandblasting. Abrasion etches, pits, smoothes, and polishes, but abrasion of rocks of varying durability can produce features with bizarre shapes.

Sliding stones of the Playa Racetrack, California. Marshak (2002)

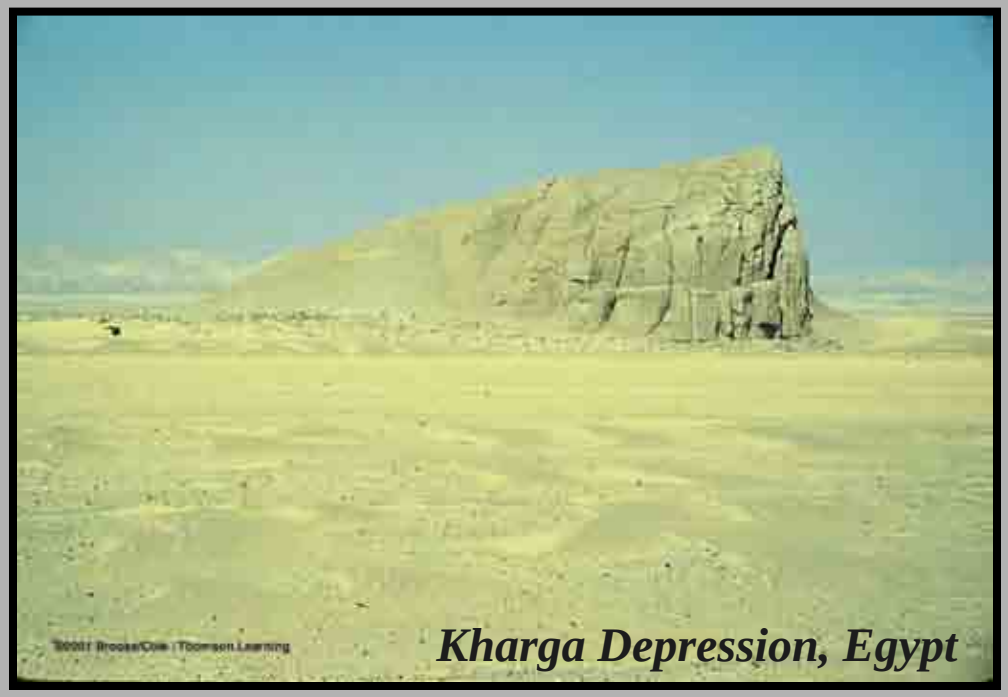
Abrasion & ventifacts



Chernicoff & Whitney (2002)

Abrasion

- Yardangs are elongated, streamlined ridges that look like the hull of an overturned ship. They are often found in clusters aligned parallel to the prevailing wind direction. Yardangs are larger than ventifacts and formed by differential wind erosion and abrasion.

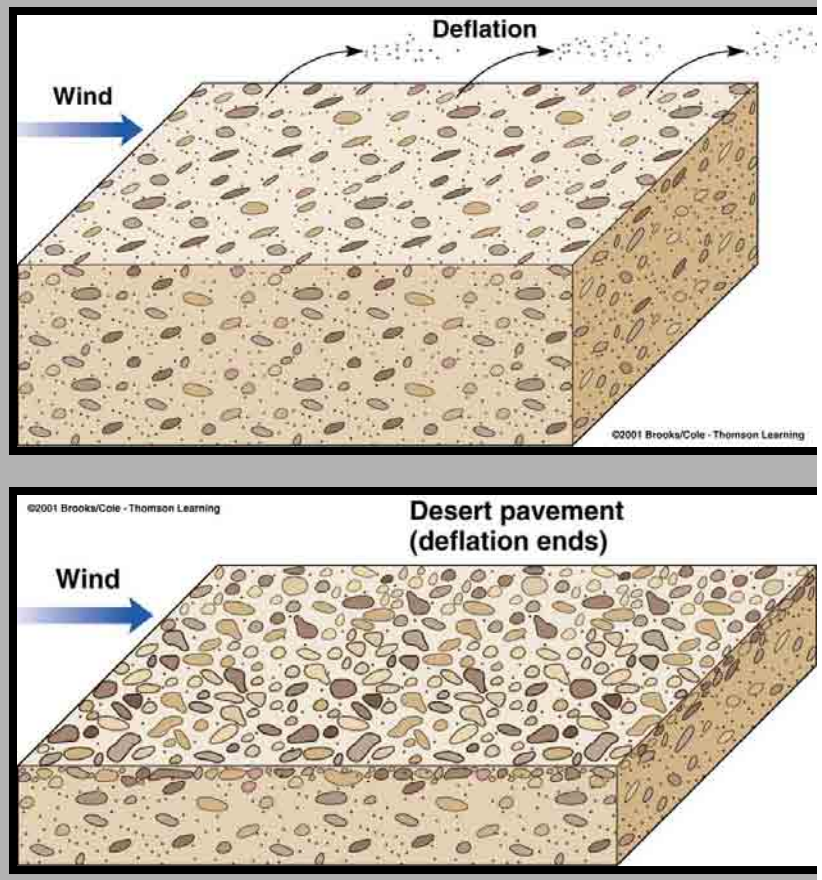


Kharga Depression, Egypt

Wicander and Monroe (2002)

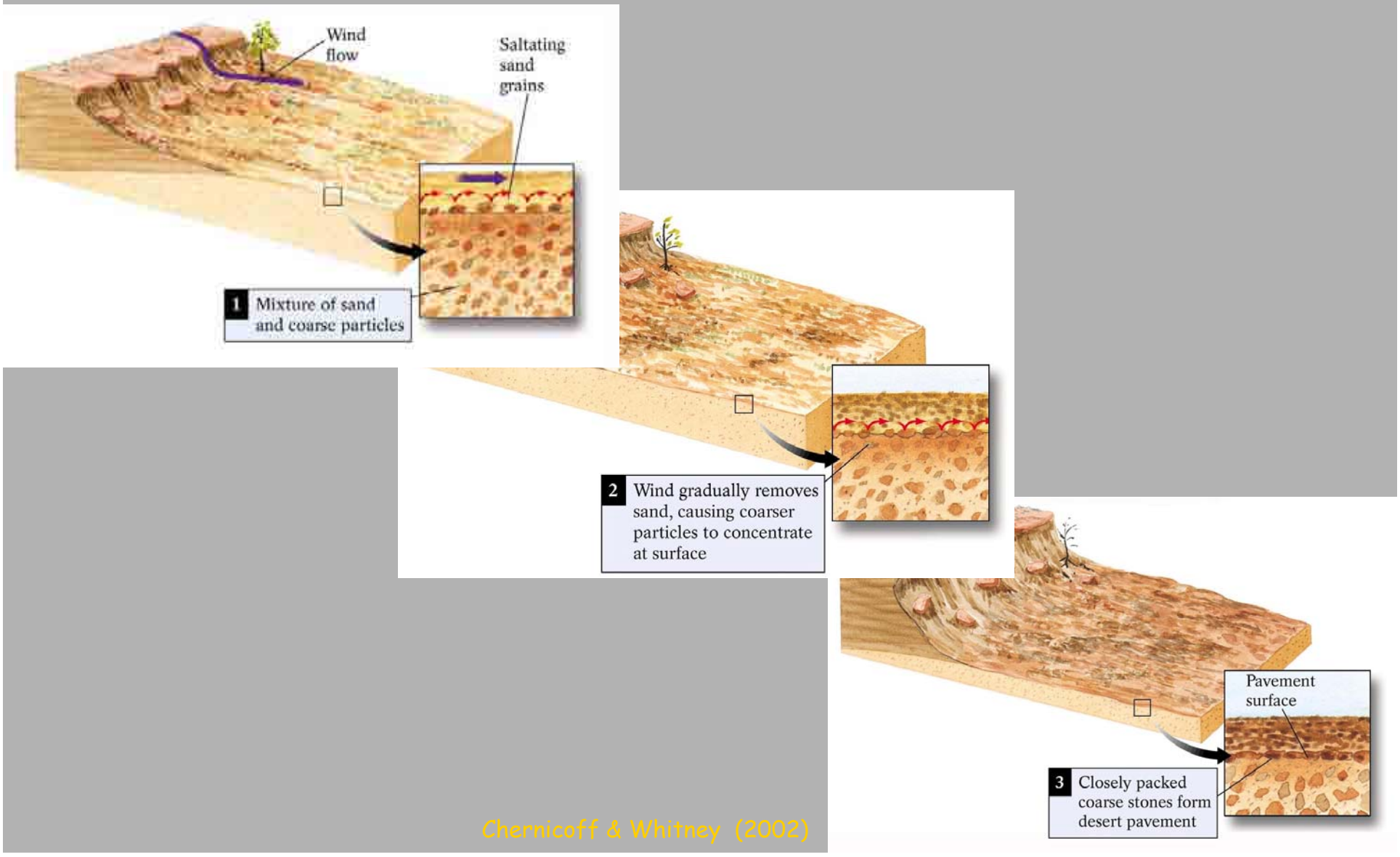
Deflation

Deflation is a mechanism of wind erosion that removes loose surface sediments. Deflation hollows or blowouts form in arid and semiarid regions where deflation forms removes loose surface sediment to form depressions ranging from kilometers in width and meters in depth to small depressions only a few meters wide and less than a meter deep. They are common in the southern Great Plains of the U.S.



Wicander and Monroe (2002)

Desert pavement.



Chernicoff & Whitney (2002)

Desert pavements

Marshak (2002)

Wicander and Monroe (2002)

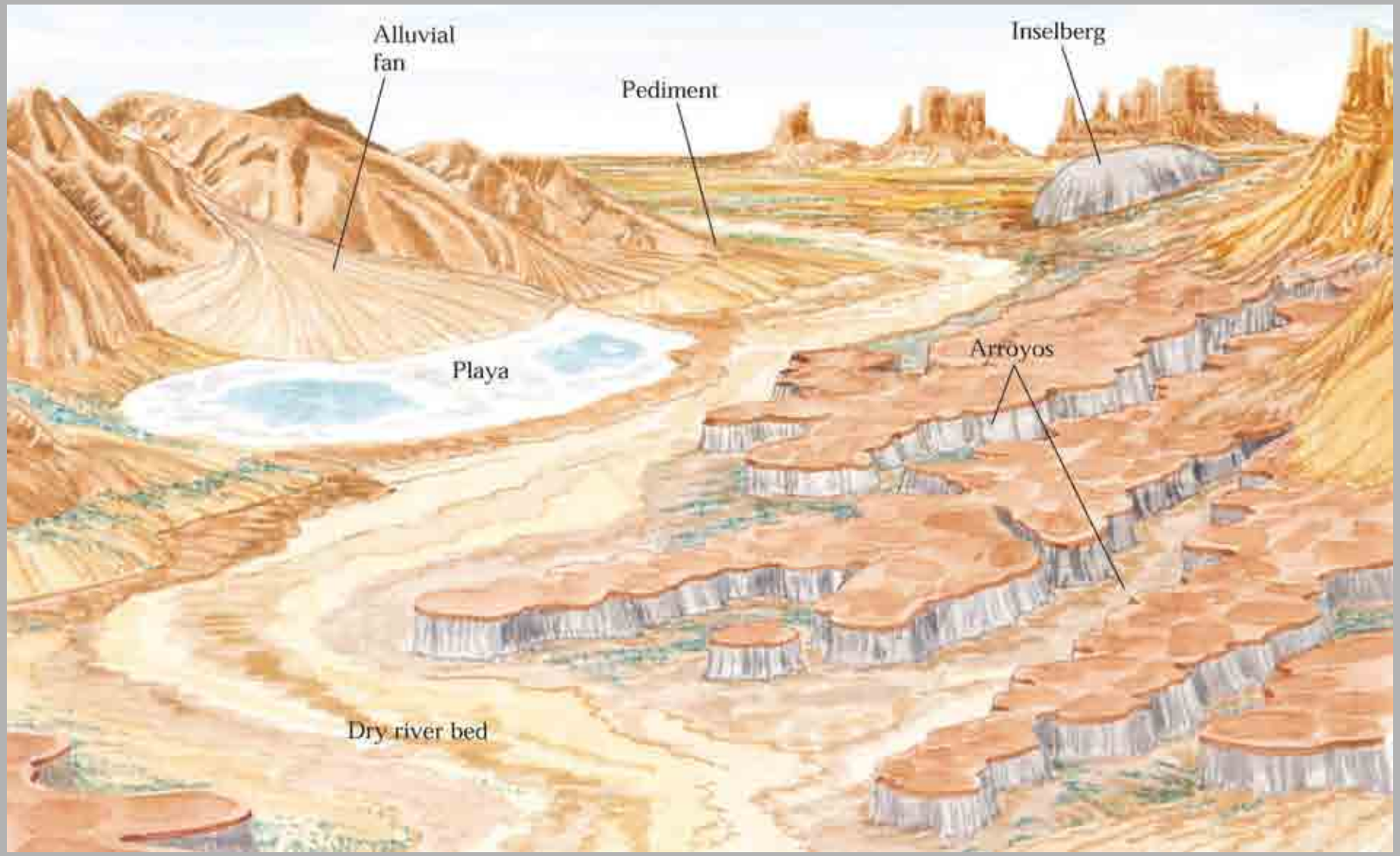
Mojave Desert, Calif.

Where deflation removes sand-size and smaller grains, a surface armored with pebbles, cobbles, and boulders is formed.

Wind Deposits

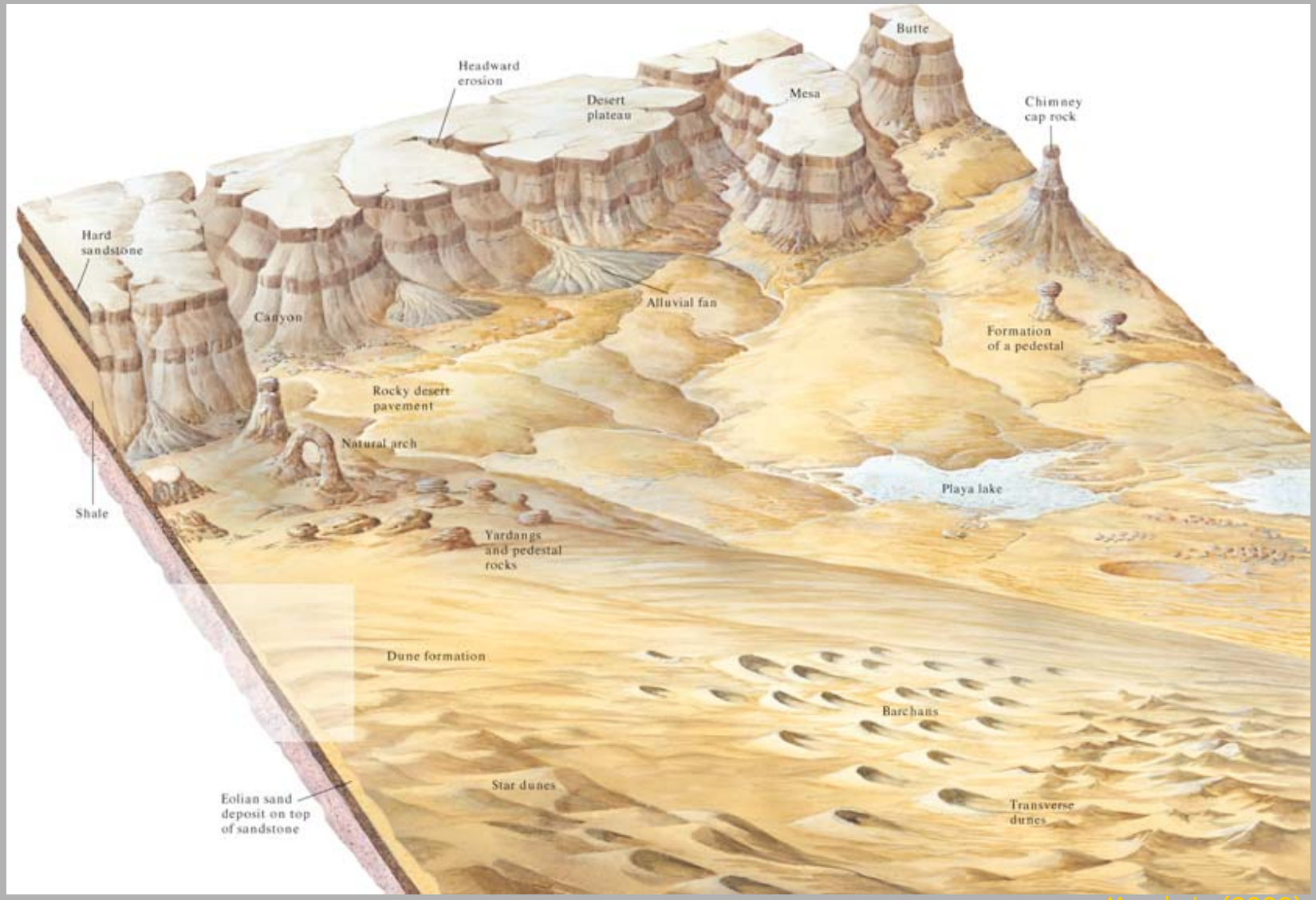
- Wind is a major agent of deposition, producing deposits of two general types: dunes and loess.
- Dunes are mounds or ridges composed of wind-blown sand-size grains usually deposited near their source.
- There are several types of dunes: barchan, longitudinal, transverse, parabolic, and star. The size, shape, and arrangement of dunes depends on sand supply, direction and velocity of the prevailing wind, and the amount of vegetation.
- Loess consists of layers of windblown silt and clay composed of angular grains of quartz, feldspar, mica, and calcite. Loess is deposited over large areas downwind of and far from its source.

Desert landforms produced by water.



Chernicoff & Whitney (2002)

Desert Landforms



Marshak (2002)

Deserts Landforms

- Playa lakes form in low areas of deserts following intense precipitation. They are shallow, often saline, and short-lived, lasting from a few hours to several months.
- When the water of a playa lake evaporates, the dry lake bed is referred to as a playa or salt pan. Playas contain mudcracks and salt deposits, some thick enough to mine.

Wicander and Monroe (2002)

Deserts Landforms

- Alluvial fans are common in many deserts, especially the Basin and Range. They form where sediment-laden streams exit steep mountain fronts to deposit their load on the flat desert floor.
- Bajadas are broad aprons of sediment deposited at the foot of steep mountain fronts by coalescing and overlapping alluvial fans. Bajadas and large alluvial fans are sources of groundwater.

Marshak (2002)

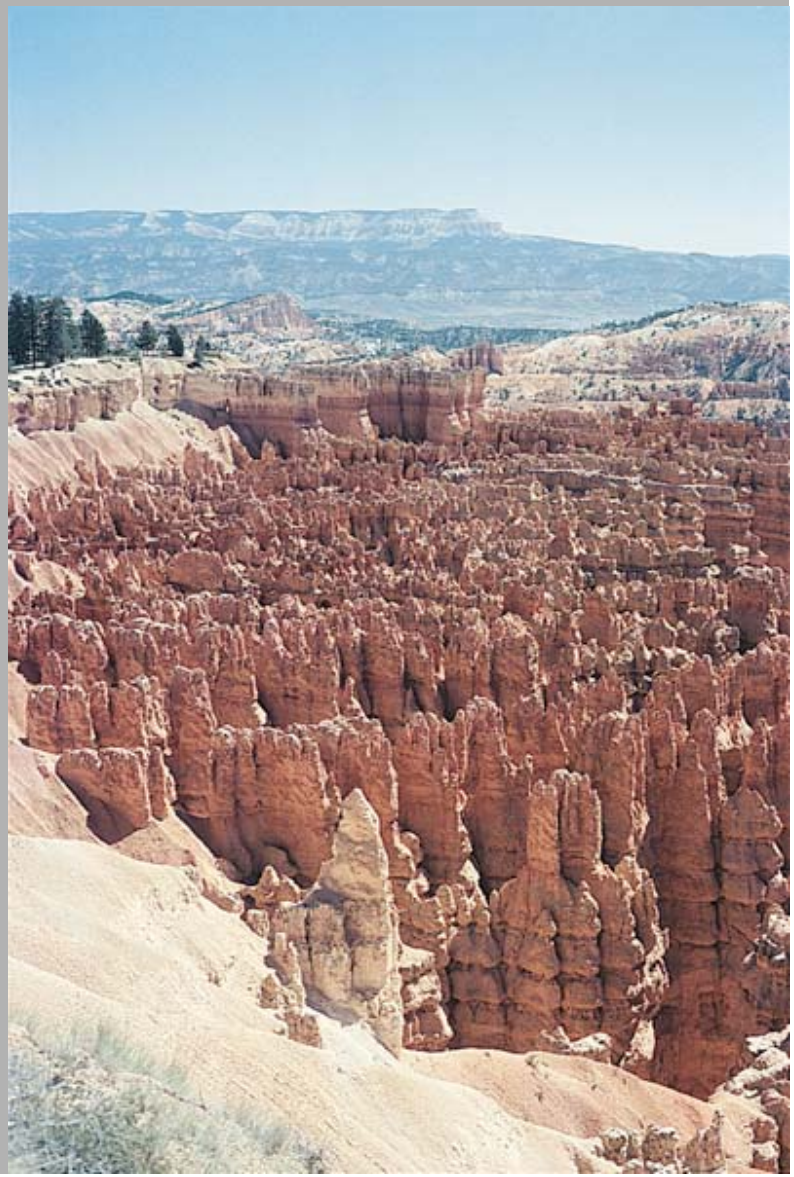
Deserts Landforms

- Mesas are broad, flat-topped erosional remnants bounded on all sides by steep slopes.

Wicander and Monroe (2002)

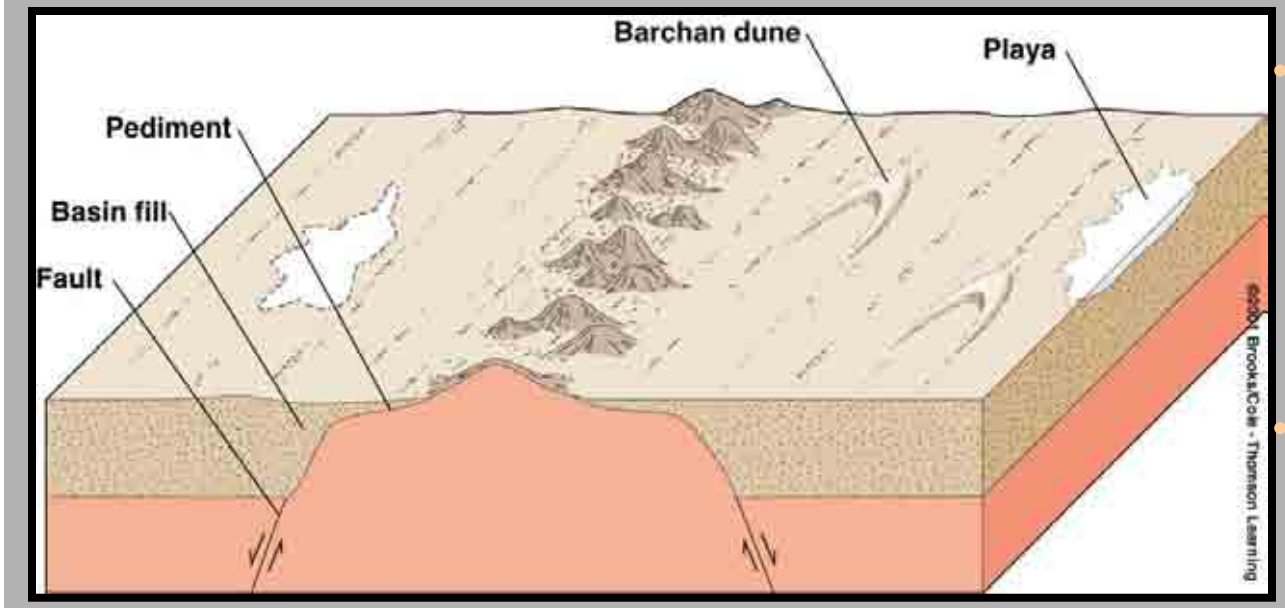
Deserts Landforms

- Buttes are pillar-like erosional remnants. Both mesas and buttes consist of easily weathered sedimentary rocks capped by more resistant rock.



Marshak (2002)

Deserts Landforms

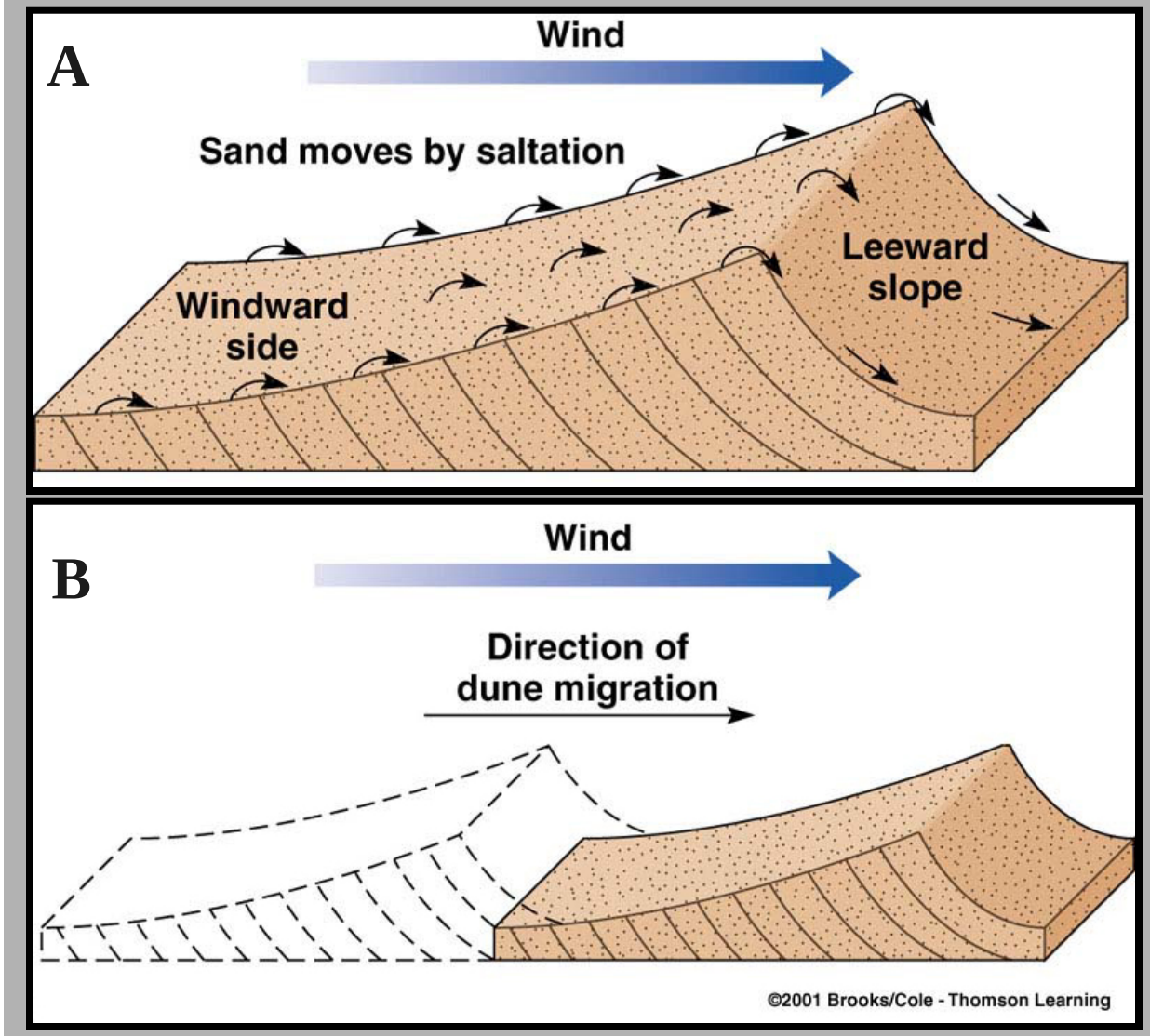


- Pediments are erosional bedrock surfaces of low relief that slope gently away from mountain bases.
- Most pediments are covered by a thin layer of debris, alluvial fans, and/or bajadas.

Mesquite, Nev.

Wicander and Monroe (2002)

Formation & Migration of Dunes



Wicander and Monroe (2002)

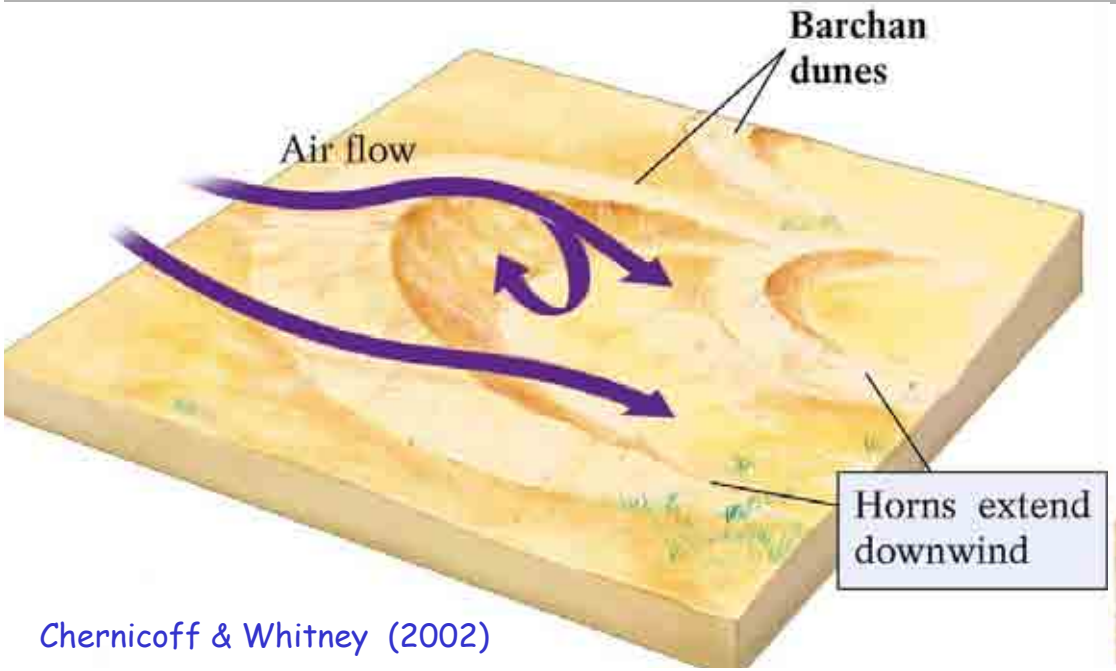
- Most dunes have asymmetric profiles and began formation where wind blows over or around an obstruction. Sand grains move up the gentle windward slope by saltation and accumulate in inclined layers on the steep leeward slope
- Dunes slowly grow and migrate in the direction of the prevailing wind

Cross bedding

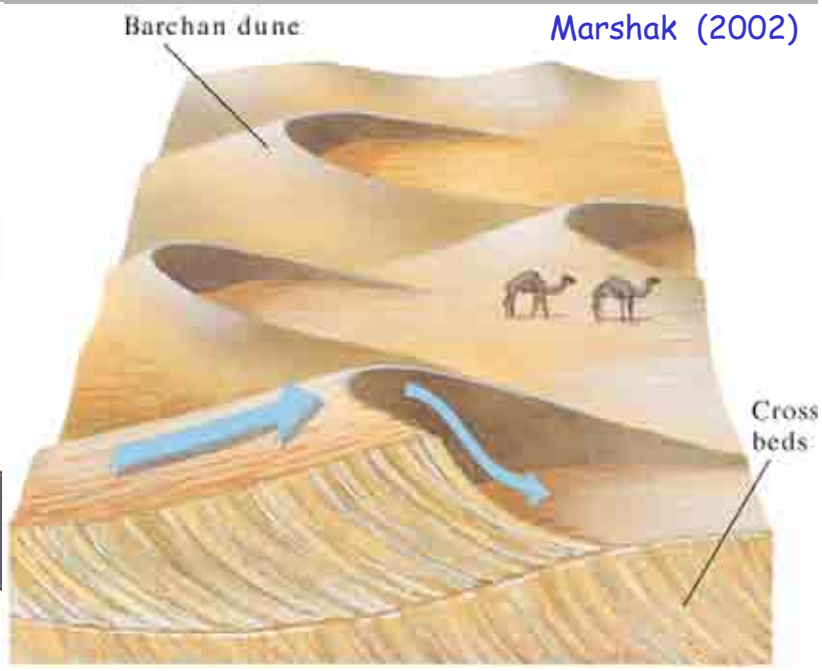
Montgomery (2000)

Dune Types

- Barchan dunes are crescent-shaped with tips that point downwind. Barchans are small, seldom more than 30m in height. They are the most mobile of dunes and can migrate at rates exceeding 10m/year.
- Barchan dunes form on flat, dry surfaces with little vegetation and a limited supply of sand. Formation of barchan dunes requires a nearly constant wind direction.



Chernicoff & Whitney (2002)



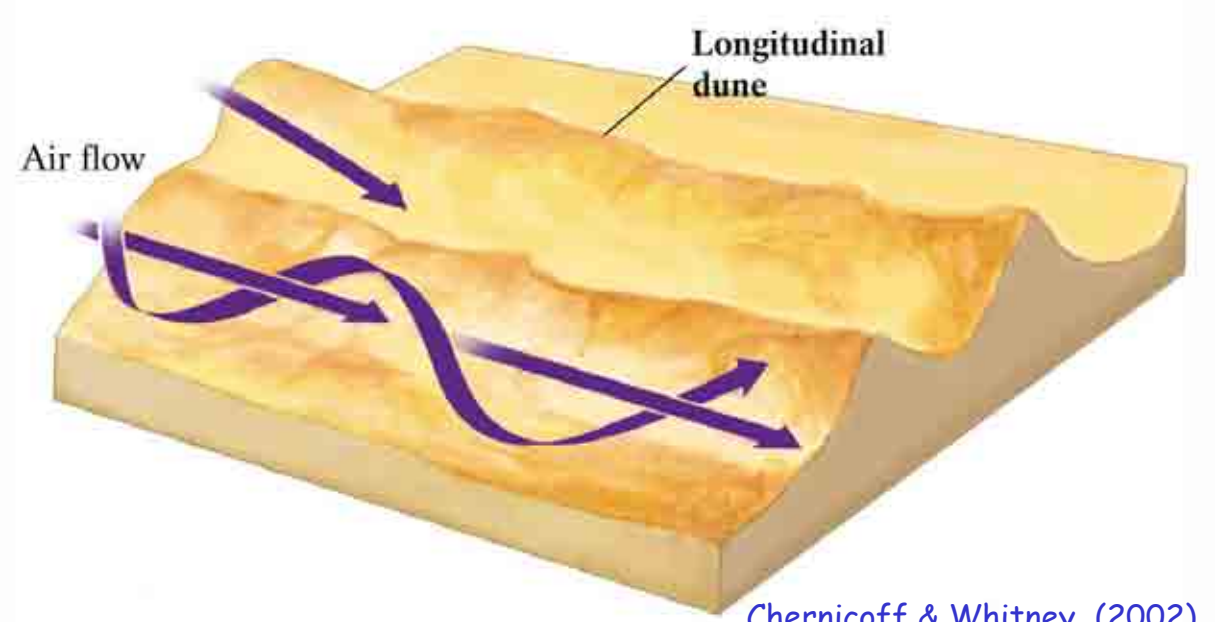
Marshak (2002)

Barchan dunes

Wicander and Monroe (2002)

Dune Types

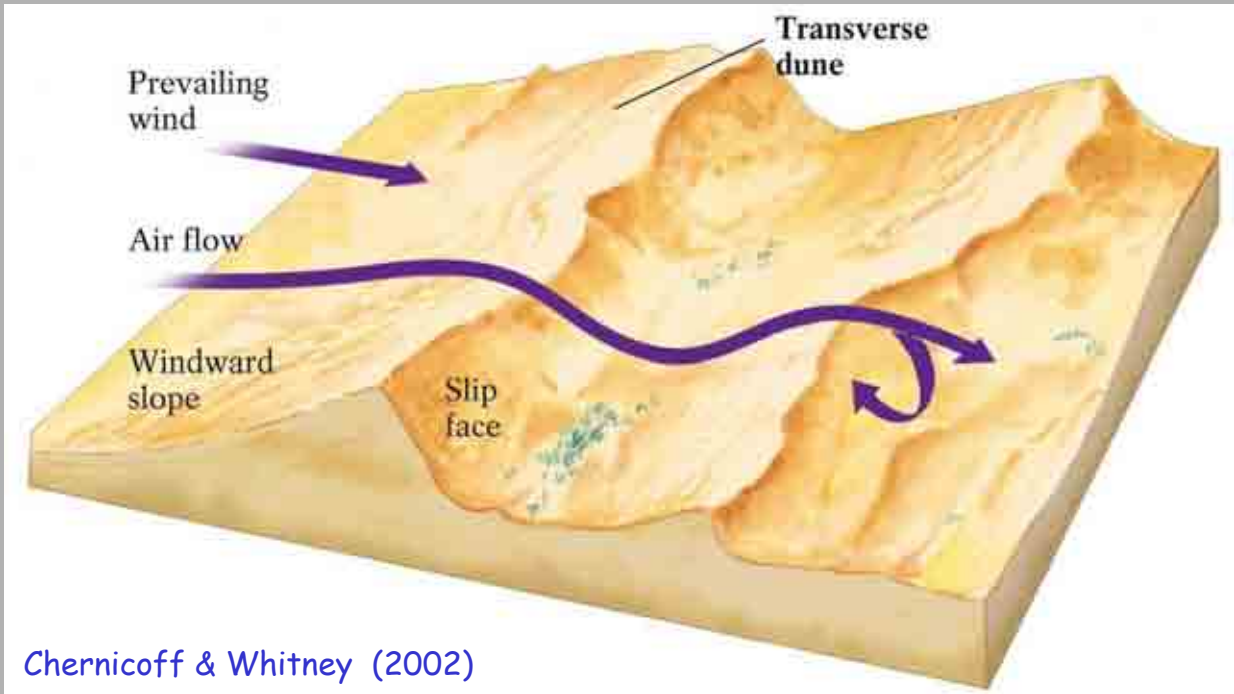
- Longitudinal dunes are long, parallel ridges aligned with the prevailing wind direction. They are from 3 to 100 m in height and can be more than 100 km in length. They form where winds converge to produce the prevailing wind.
- Longitudinal dunes are especially common in central Australia and cover one-fourth of the continent.



Chernicoff & Whitney (2002)

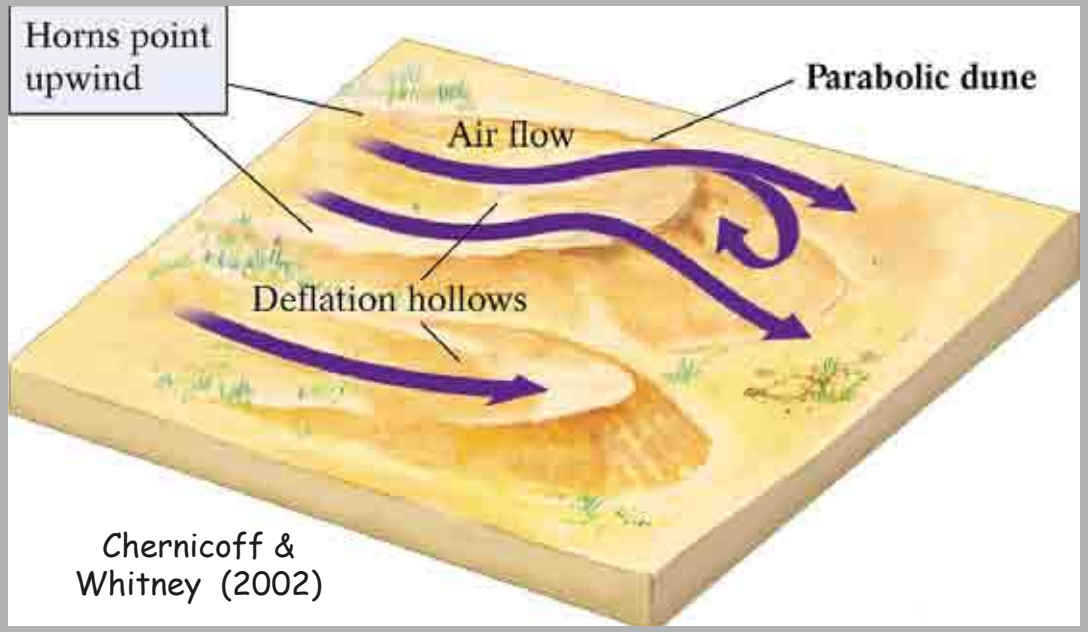
Dune Types

Transverse dunes form long ridges perpendicular to the prevailing wind direction. They form in areas where abundant sand is available and little or no vegetation exists. Crests of transverse dunes can reach 200m in height. The dunes can be up to 3 km in width. Due to their wave-like appearance, transverse dunes are sometimes called sand seas.



Chernicoff & Whitney (2002)

Dune Types

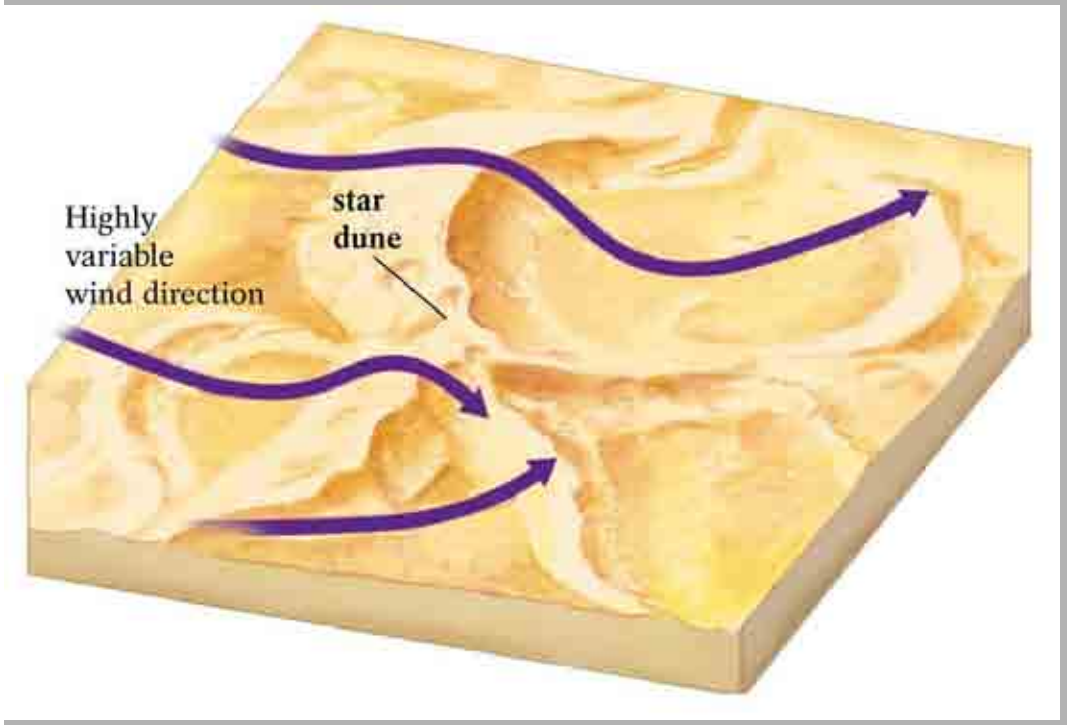


Chernicoff & Whitney (2002)

- Parabolic dunes have a crescent shape like barchan dunes, but their tips point upwind
- These dunes are common in coastal areas with abundant sand, strong onshore winds, and a partial cover of vegetation

Wicander and Monroe (2002)

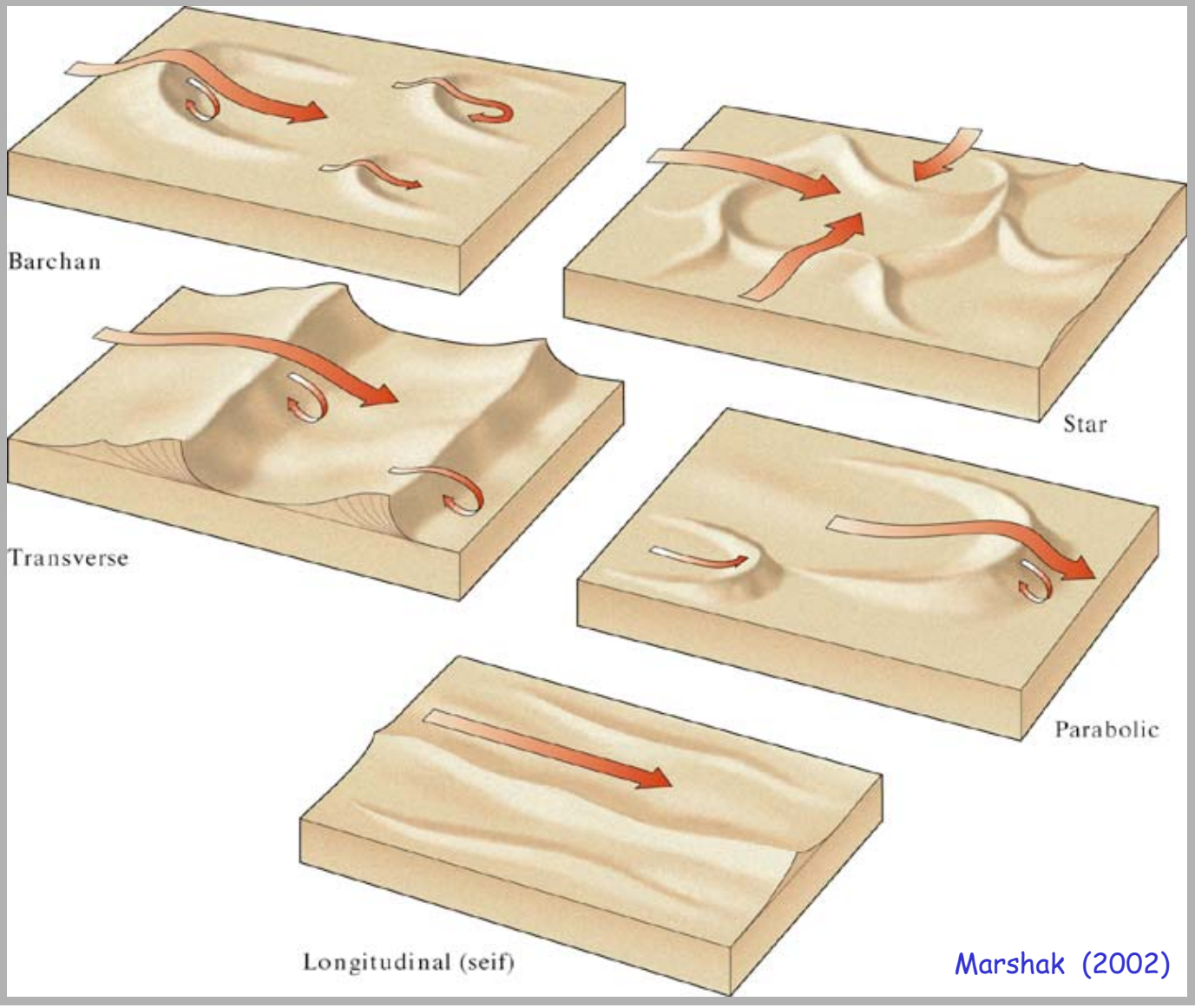
Dune Types



Chernicoff &
Whitney (2002)

- Star dunes resemble a multi-pointed star. These pyramidal hills of sand can reach in excess of 100 m in height. The arms of the stars are formed by radiating ridges of sand.
- Star dunes can remain stationary for centuries and served as landmarks for desert nomads.

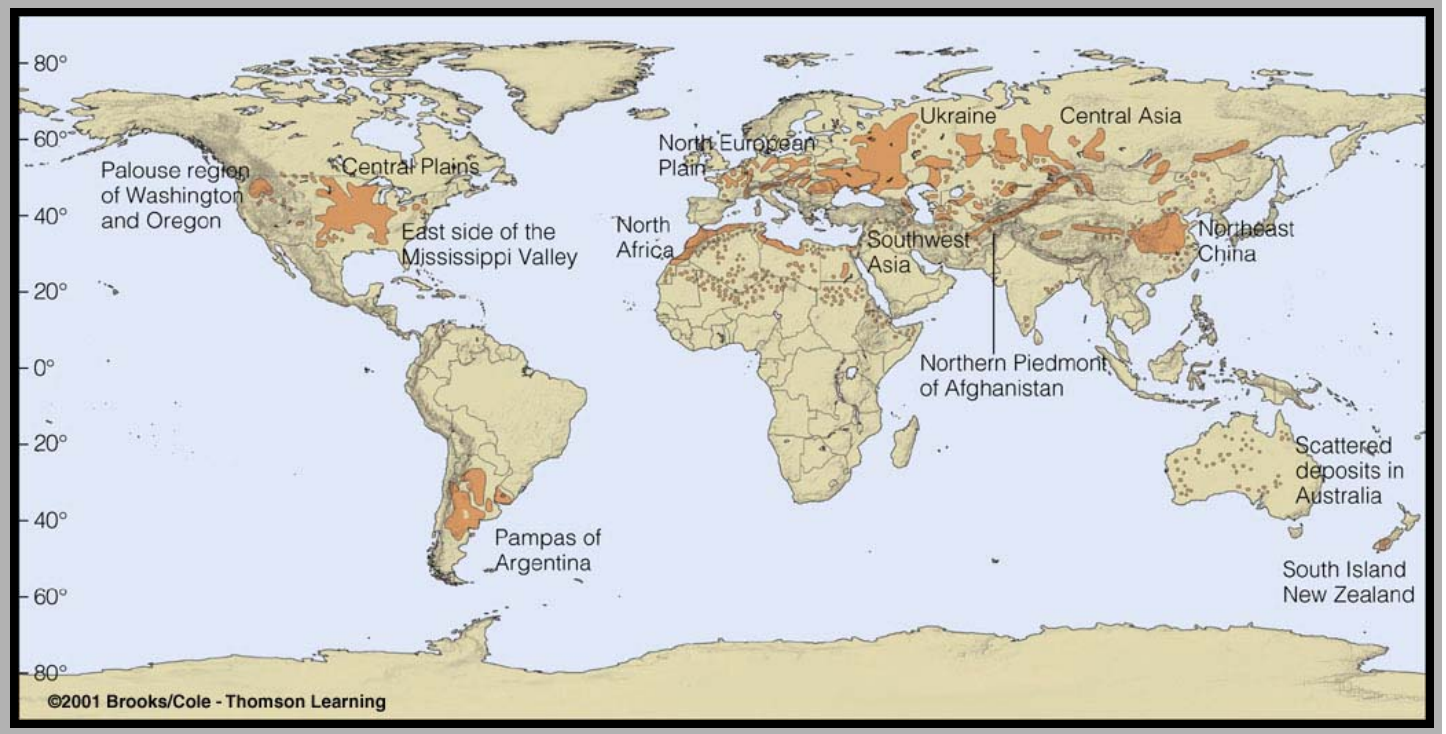
Dune types



Marshak (2002)

Loess

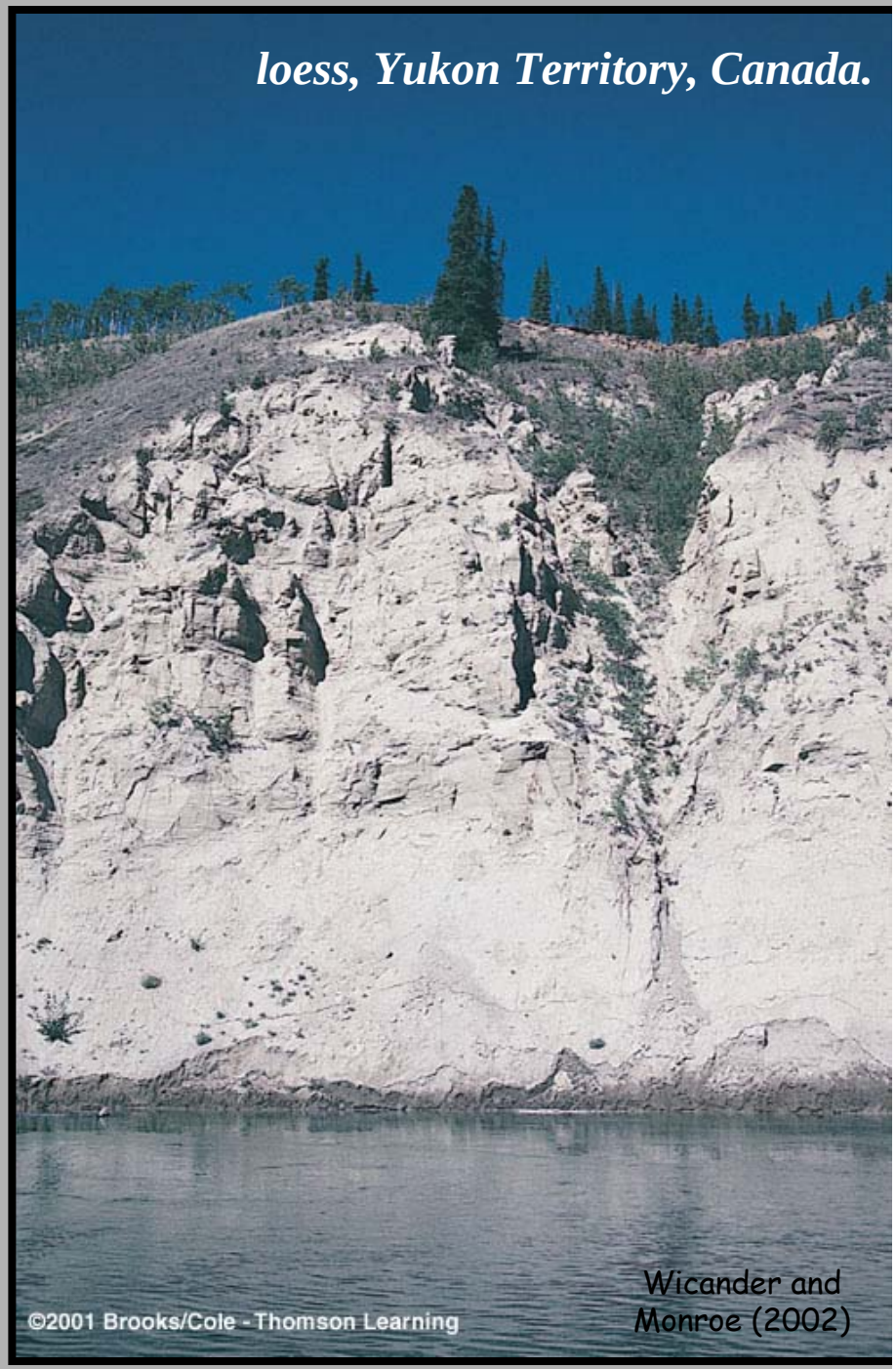
Loess, windblown silt and clay, is derived from three main sources: deserts, Pleistocene glacial outwash, and floodplains in semiarid regions. Loess covers 10% of Earth's surface, 30% of the U.S., and large areas of Asia, Europe, and South America.



Wicander and Monroe (2002)

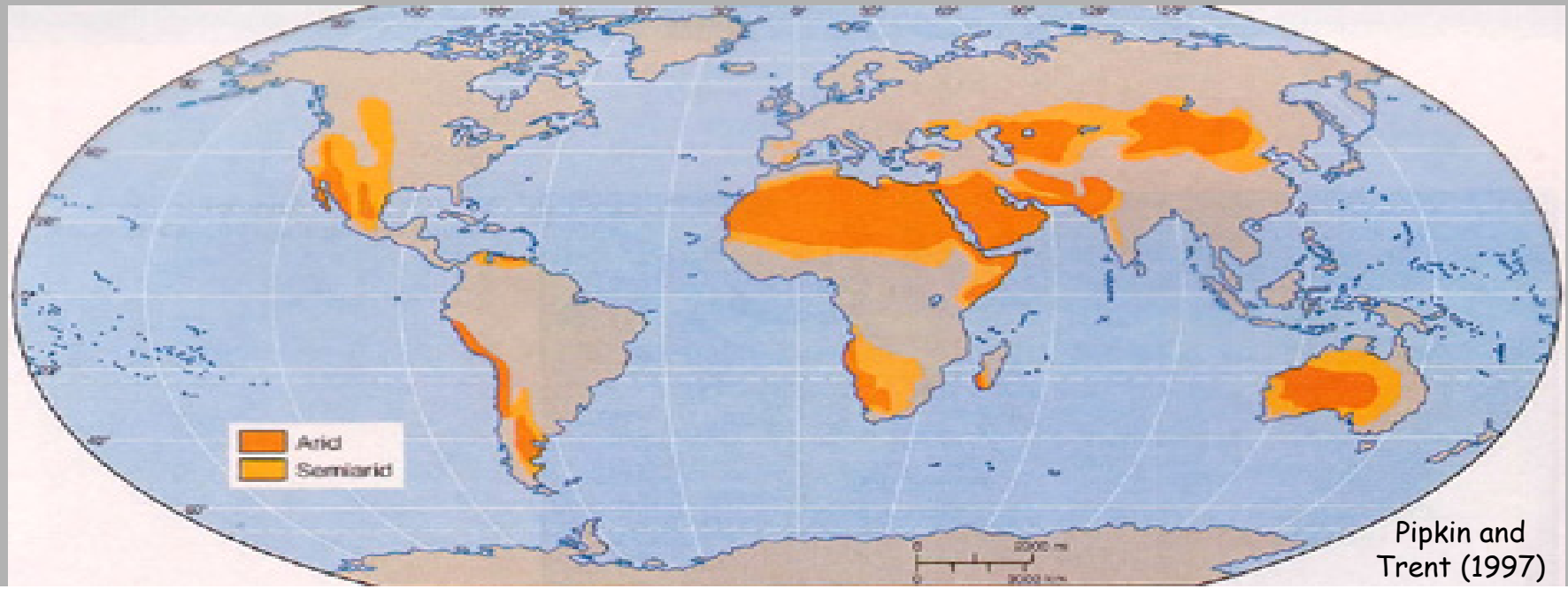
Loess

Loess is easily eroded, due to its unconsolidated nature. Areas of eroded loess are characterized by steep cliffs and rapid lateral and headward stream erosion. Loess-derived soils are among the world's most fertile. Indeed the world's major grain-producing regions correspond to areas with large loess deposits, such as the Great Plains of North America.



Desertification

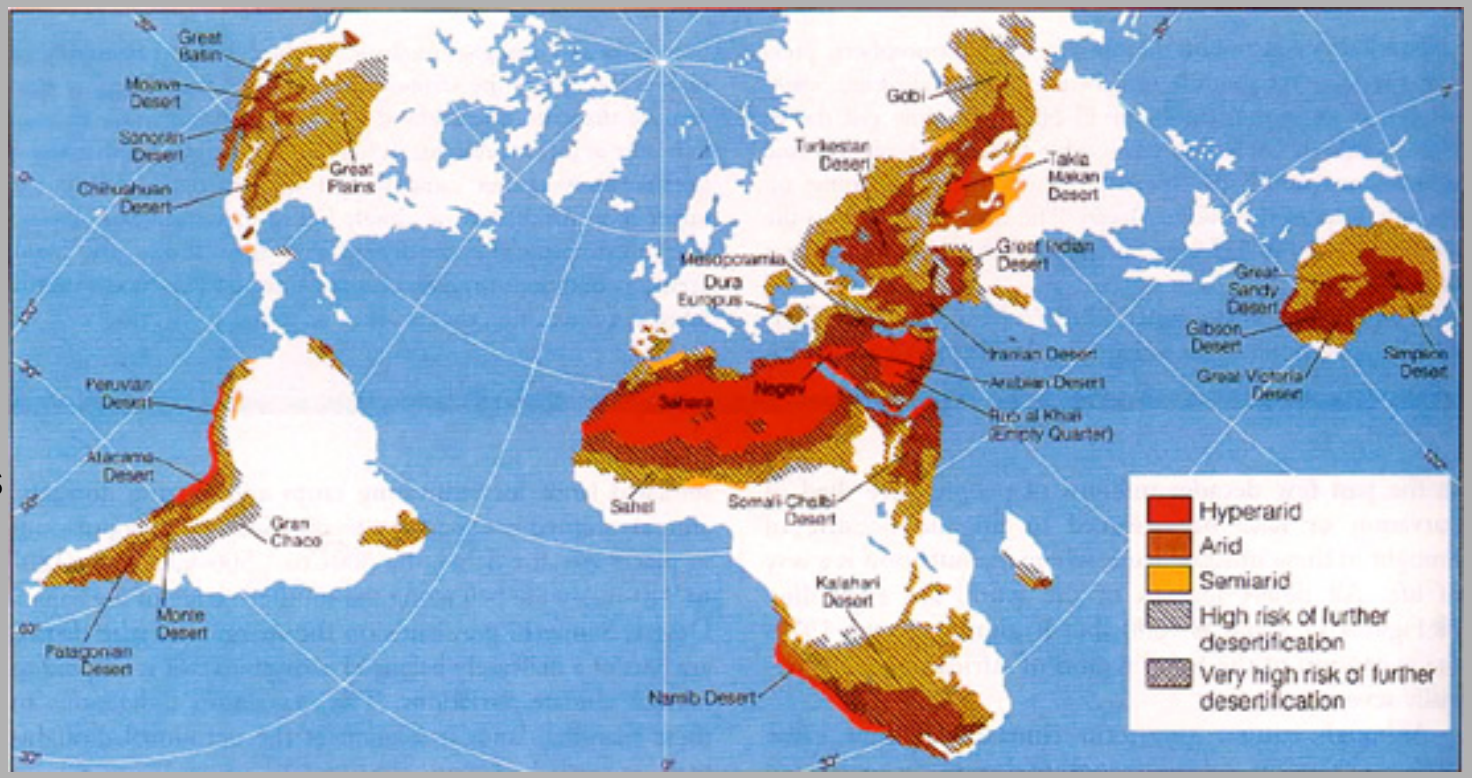
- Deserts resulting from human intervention can be termed deserts of infertility. They are typically associated with mid latitude deserts but are a response to human misuse not climate.
- Semi-arid grasslands on the borders of mid-latitude deserts can be significantly affected by grazing, cutting of trees for firewood and poor farming practices.



Pipkin and Trent (1997)

Desertification

- This can cause the desert to expand into the semi arid lands in a process known as desertification.
- The expansion and contraction of deserts is a natural response to global climate change, however human activity has accelerated the process.
- Globally deserts are advancing at ~70,000 km^2 per year
- In the past few decades millions have died of starvation or been forced to migrate because of drought in these regions



Pipkin and Trent (1997)

Desertification

- The effects of desertification can be numerous
  - Erosion of soil
  - Loss of fertility as the uppermost organic rich layer is removed
  - Loss of structural quality as the sun bakes the soil causing additional run off and reduced soil moisture
- Once damaged it can take centuries to restore semi-arid lands to their original state, however planting trees, proper utilisation of water resources and establishing ecological protective screens can slow or reverse the process.