Fundamentals of Physical Geography 2e

Arid Region Landforms and Eolian Processes

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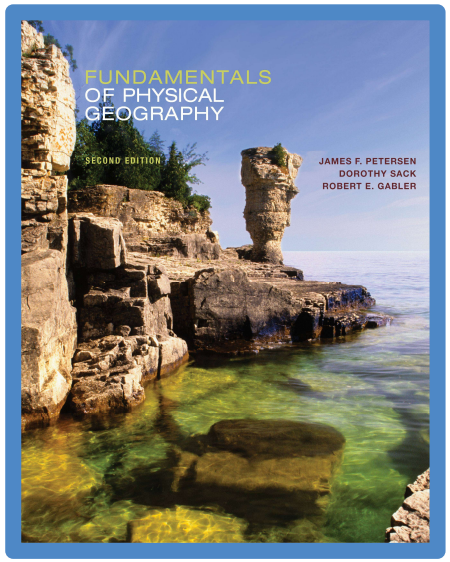


- Peterson
  - Sack
    - Gabler

Surface Runoff in the Desert

- Arid climate landforms
  - Sparse vegetation
  - Low weathering rates
  - Lack of extensive plant root networks
  - Soils
    - Thin, rocky, and discontinuous
  - Surface conditions
    - Very limited interception and low permeability
  - Storms produce surface runoff

J/ Petersen

What are some possible reasons why this terrain is so intensely channelized?

Surface Runoff in the Desert (cont'd.)

- Desert climates
  - Little rainfall
  - High rates of potential evapotranspiration
  - Flash floods
    - Powerful agent of erosion
- Paleogeographic studies
  - Evidence of past wet periods and cooler climates

J. Petersen

Why does the terrain look so much smoother below than above this highest shoreline?

Surface Runoff in the Desert (cont'd.)

- Desert streams
  - Ephemeral flow
  - Why are braided channels common in deserts?
  - Downstream decrease
    - Infiltration
    - Evaporation
  - Ephemeral lakes
    - Disappear and reappear: dependent on rain

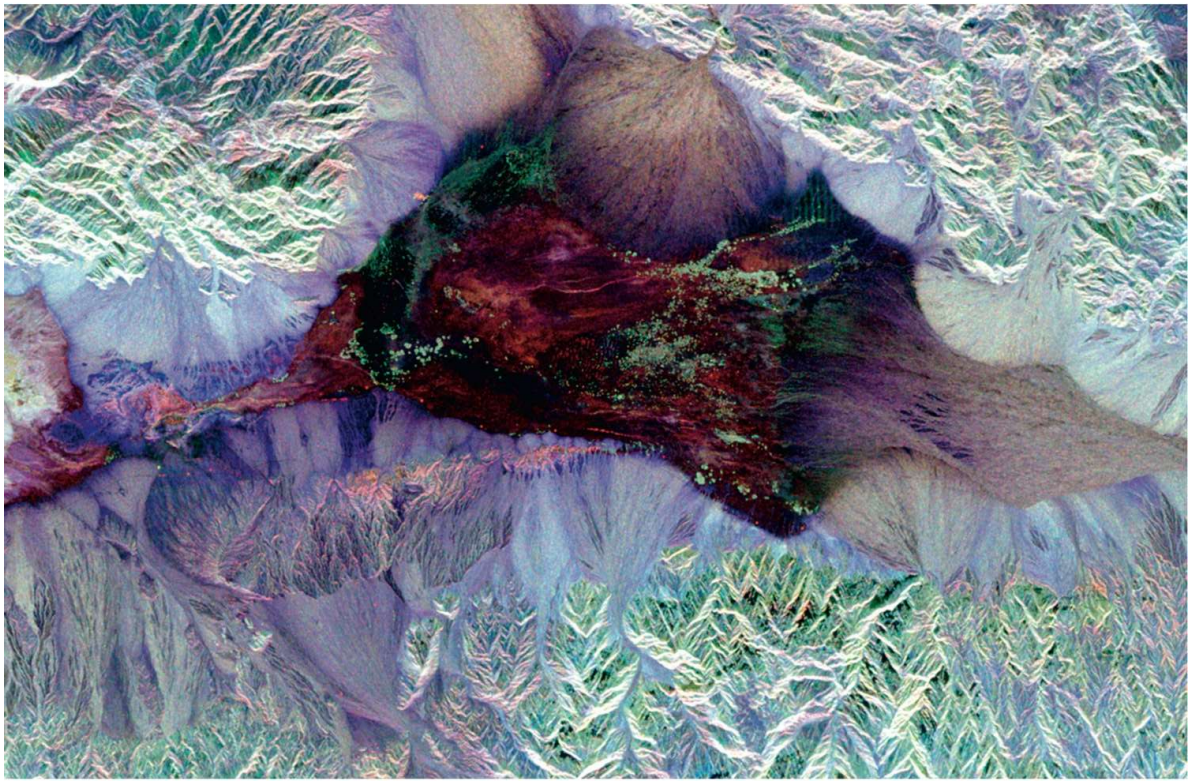
D. Sack

Why do the number and position of the multiple channels sometimes change rapidly?

Surface Runoff in the Desert (cont'd.)

- Desert streams
  - Drainage basins: interior drainage
  - Controlled by regional base level
    - Raised by sedimentation
    - Lowered by tectonic activity

NASA/JPL



Surface Runoff in the Desert (cont'd.)

- Desert streams
  - Origins of many streams
    - Nearby humid regions
    - Adjacent mountain areas
  - Exotic streams
    - Exterior drainage
    - Nile River
    - The Colorado River no longer reaches its ultimate base level. Why?

NASA

Water as a Geomorphic Agent in Arid Lands

- Sheet wash and surface streams remove materials
  - Materials deposited as stream loses volume and velocity
    - Due to seepage and evaporation
- Arid region landforms of fluvial erosion
  - Washes
    - Channels of ephemeral streams
    - Prone to flash floods

D. Sack

Why are washes considered hazardous?

Water as a Geomorphic Agent in Arid Lands (cont'd.)

- Arid region landforms of fluvial erosion
  - Badlands
    - Barren slopes and ridges dissected by a dense maze of steep gullies and ravines
    - Extremely high drainage density
    - How is drainage density defined?
    - Examples: Dakotas, Death Valley National Park in California, Big Bend National Park in Texas, etc.

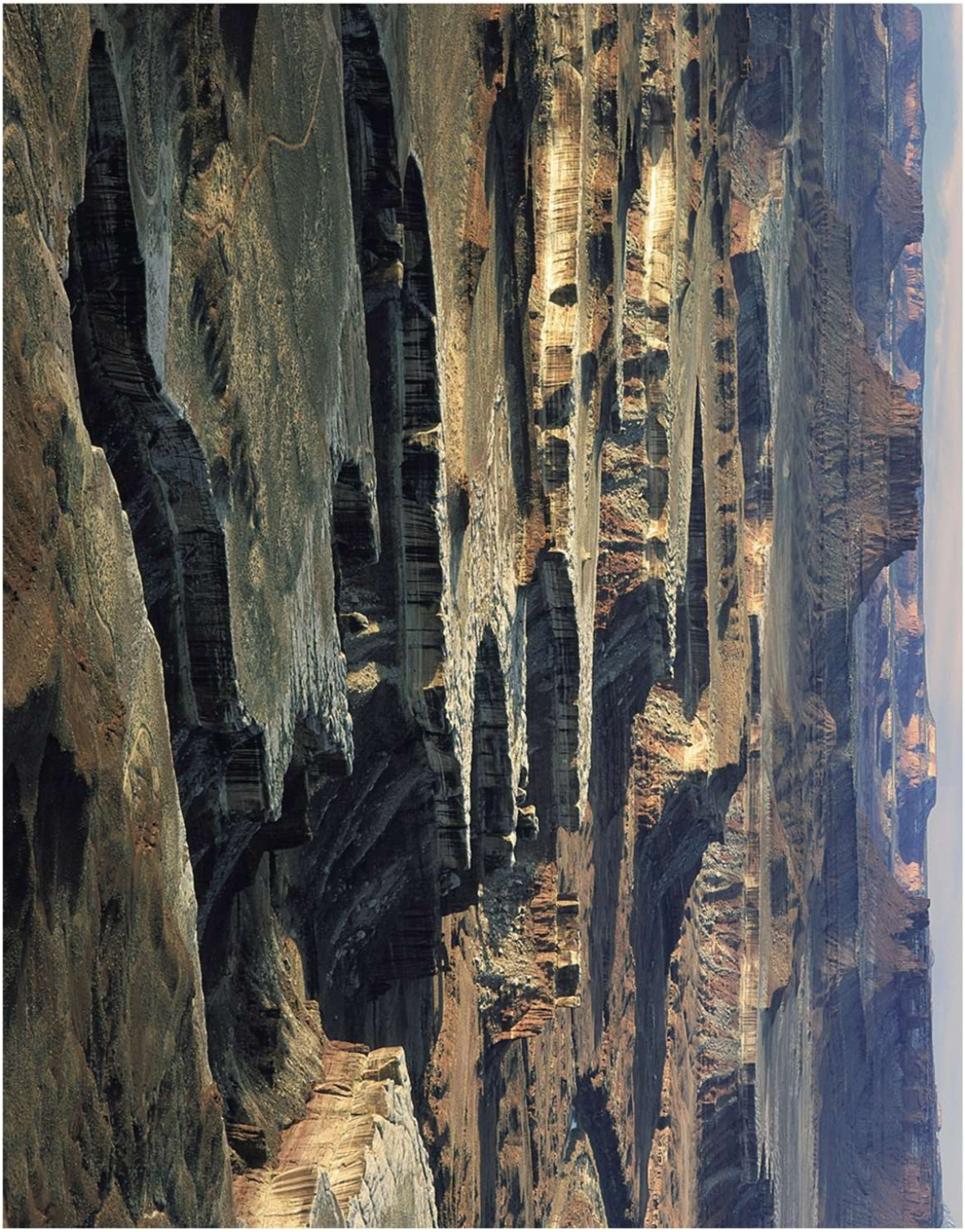
Andrew V. Kearns/NPS

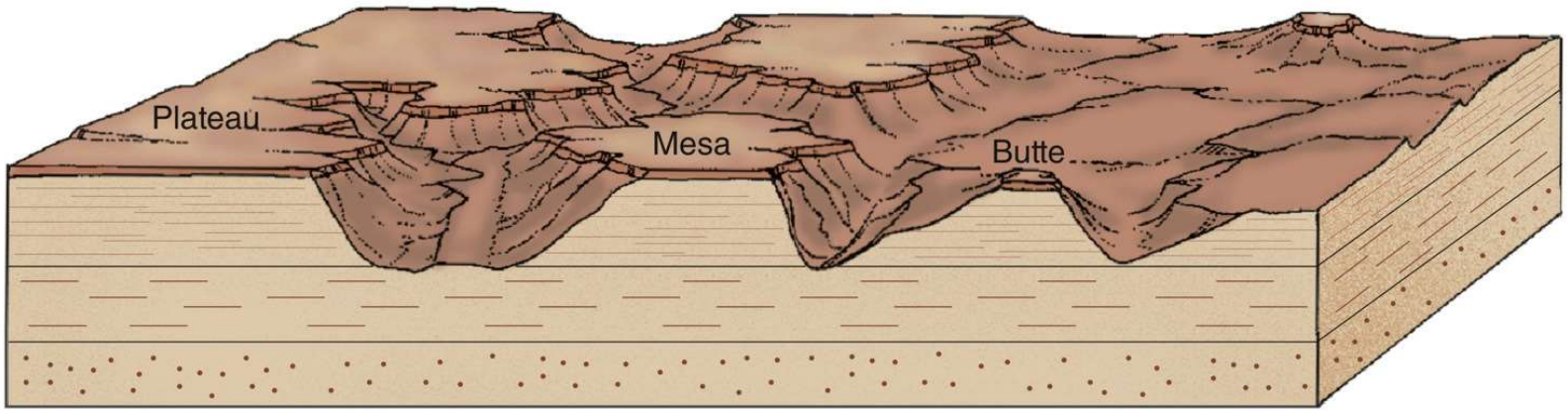
Why is it hard for vegetation to become established on badland slopes?

Water as a Geomorphic Agent in Arid Lands (cont'd.)

- Arid region landforms of fluvial erosion
  - Plateau
    - Extensive elevated region with a fairly flat top surface
    - Tectonically uplifted: Colorado Plateau
    - Caprocks: characteristic of deserts
  - Mesa
  - Butte
  - Pediment
  - Inselberg

National Park Service/Canyonlands





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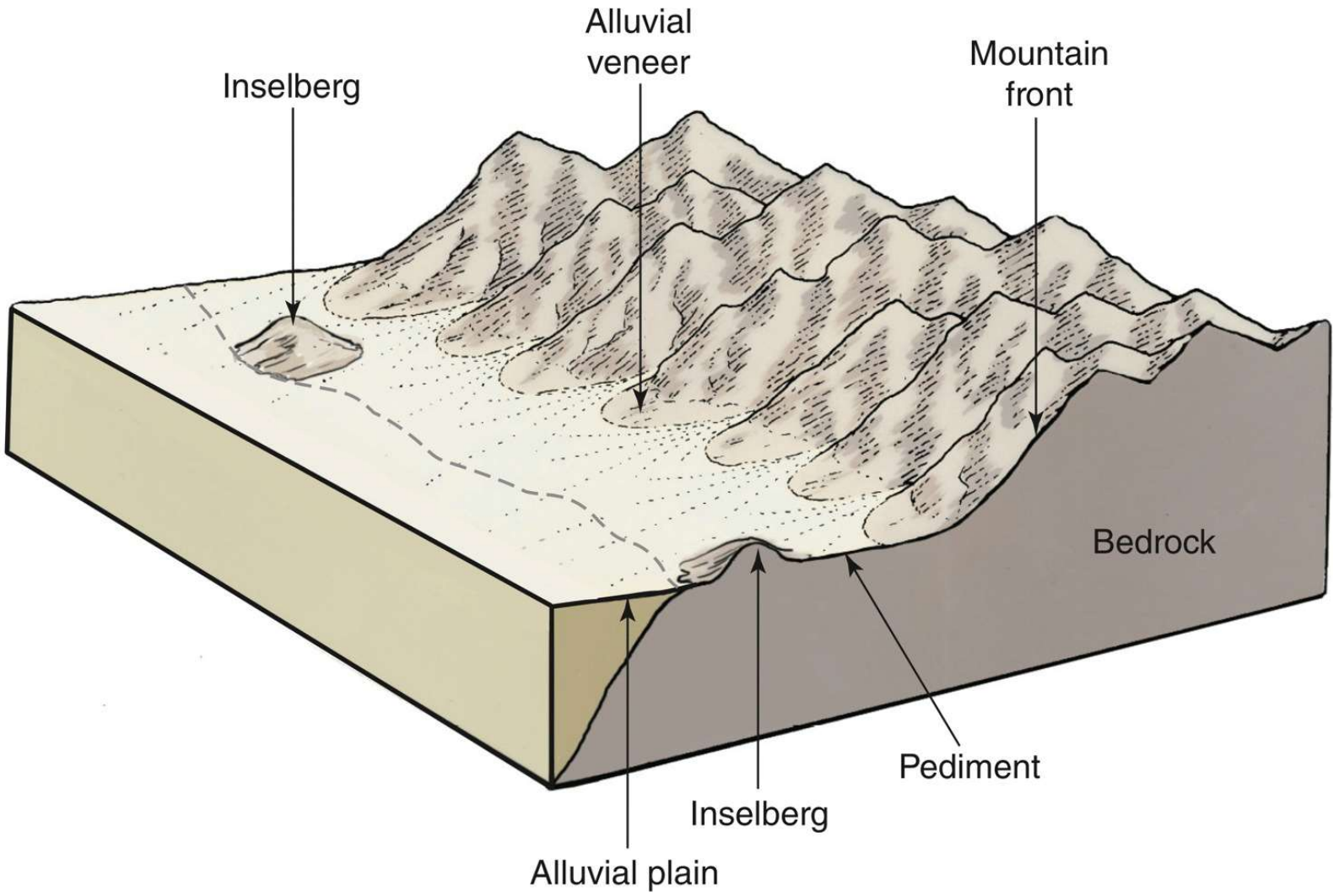


Water as a Geomorphic Agent in Arid Lands (cont'd.)

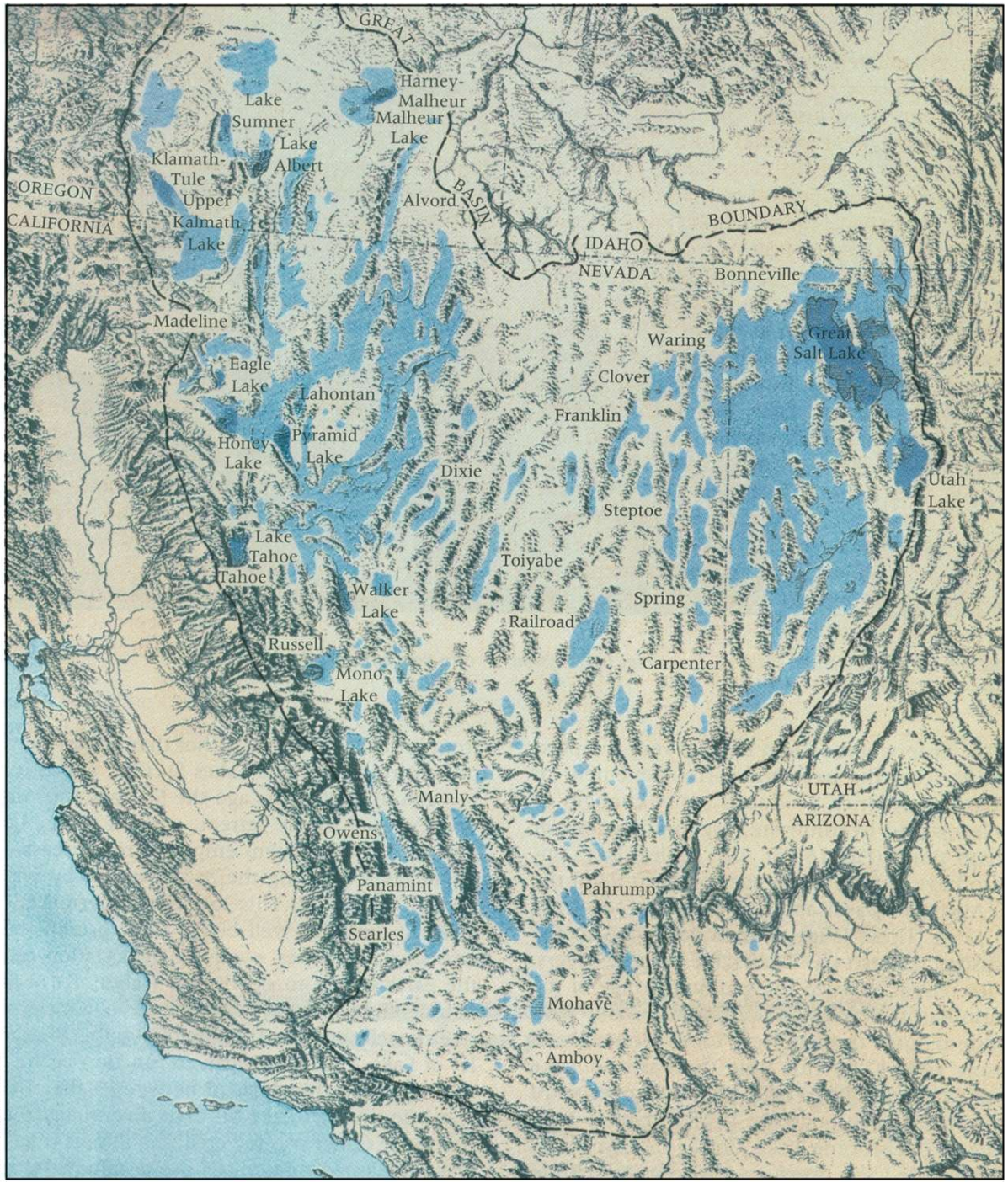
- Arid region landforms of fluvial deposition
  - Alluvial fan
    - Sediment load deposited along the base of the highlands: stream flowing out of narrow upland canyon
    - Fan-shaped
    - Fan apex
    - Sorting of sediments: course sediments near the fan apex
    - Debris flow fans

How do alluvial fans differ from pediments?

Water as a Geomorphic Agent in Arid Lands (cont'd.)

- Alluvial fan
  - Major landform in landscapes consisting of fault-block mountains and basins
  - Bajada
  - Piedmont alluvial plain

Why are there only a few lakes in this region today?



What visual evidence indicates that the mountains are eroding, whereas the bajada is a depositional feature?

Water as a Geomorphic Agent in Arid Lands (cont'd.)

- Arid region landforms of fluvial deposition
  - Bolson: closed basin
  - Playa: lowest part of a bolson
    - Playa lake
    - Surface variations: clay pan, salt-crust playas

J. Petersen

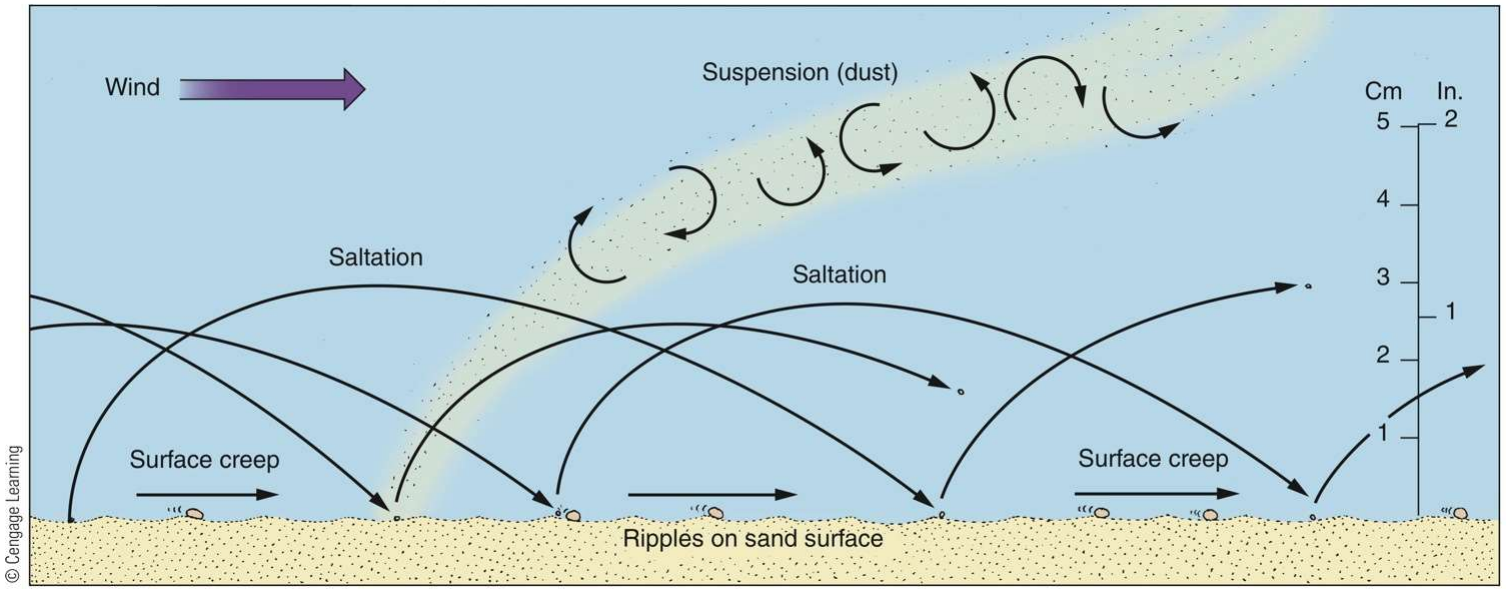
What evidence suggests that the playa in this photo is partially wet?

Wind as a Geomorphic Agent

- Eolian landforms
  - Created by wind
  - Necessary conditions
    - Sparse vegetation
    - Dry, loose surface materials
    - High wind velocity
  - How do eolian processes differ from fluvial processes?
  - Wind deposits
    - Stratified according to changes in flow velocity

Wind as a Geomorphic Agent (cont'd.)

- Wind erosion and transportation
  - Clays and silts
    - Moved by suspension
  - Saltation
    - Particles bounced along the ground
  - Surface creep
  - Ripples



Why are grains larger than sand not generally moved by the wind?

Wind as a Geomorphic Agent (cont'd.)

- Wind erosion processes
  - Deflation
    - Wind picks up and removes small fragments
  - Abrasion
    - Particles already being carried dislodge additional fragments
  - Why are the effects of abrasion limited to a zone close to ground level?
  - Dust storms

NOAA/George E. Marsh Album

Can you suggest a continent that might be a source of major dust storms today?

Wind as a Geomorphic Agent (cont'd.)

- Wind erosion processes – Deflation
  - Deflation hollows
    - Nonmountainous arid regions
  - Desert pavement
    - Mosaic of gravel-sized clasts at the surface
    - Stabilizes desert surfaces

Wind as a Geomorphic Agent (cont'd.)

- Wind erosion processes – Abrasion
  - Ventifacts
    - Individual wind-fashioned stones
    - One or more facets
  - Yardang
    - Wind-sculpted remnant ridge
- Wind deposition
  - Transported distance varies by particle size
    - Larger particles closer to source

Courtesy of Marion I. Whitney

Which side of this yardang do you think is the upwind side, the right or left?

Sand Dunes

- Eolian sand deposits
  - Hills, mounds, or ridges
- Sand seas, small dune fields, or sandy ridges
- What factors influence the topography?
- Active vs. stabilized dunes

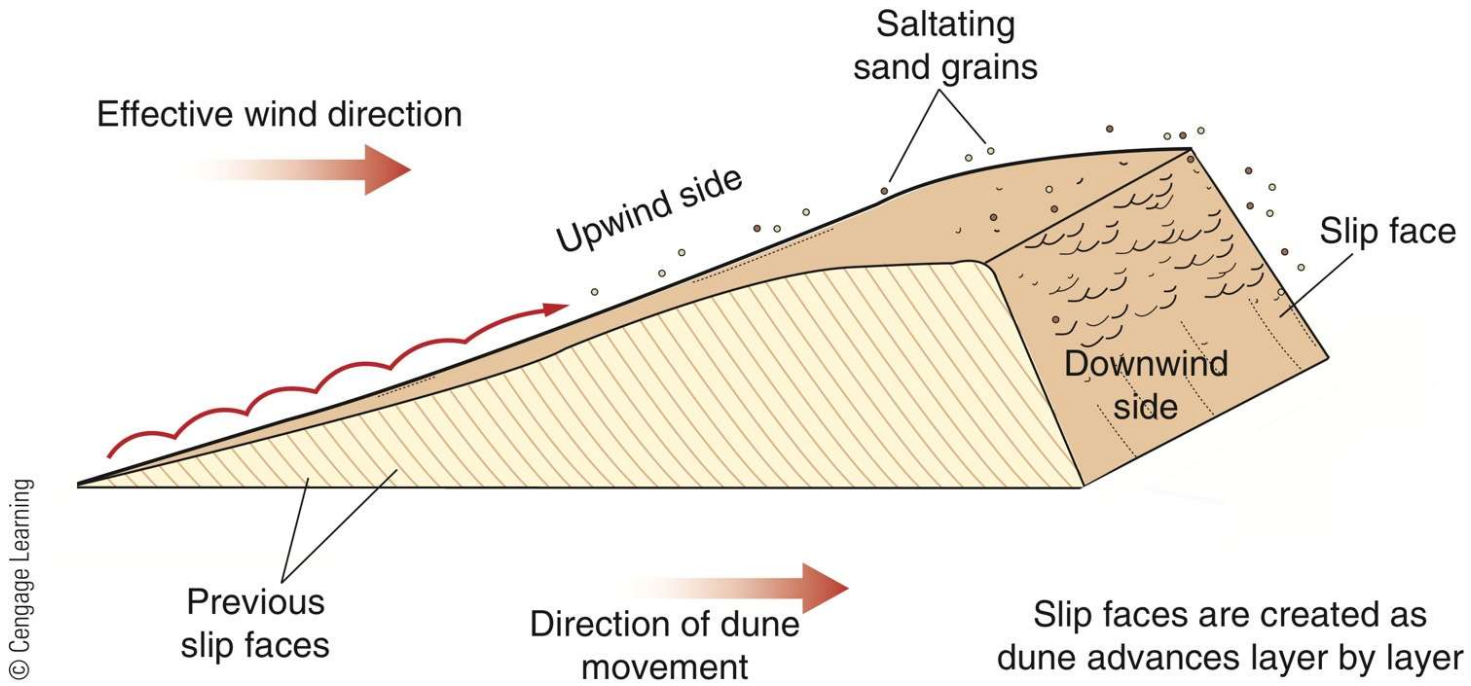
D. Sack

D. Sack

What effect might the trails that are visible on the stabilized dunes have on the dune system?

Sand Dunes (cont'd.)

- Active dunes
  - Sand movement by saltation and surface creep
  - Slip face: angle of repose
  - Speed of movement varies; episodic
    - Larger dunes move more slowly



Why does the inside of the migrating dune consist of former slip faces?

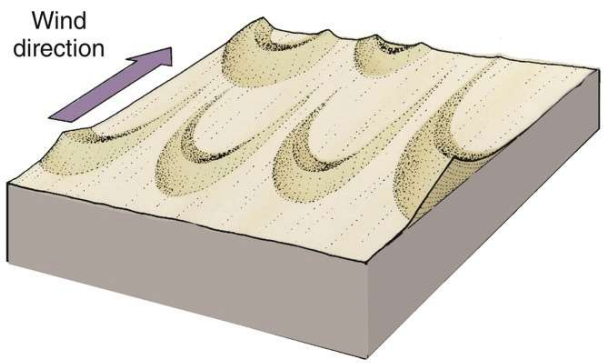
Sand Dunes (cont'd.)

- Stabilized dunes
  - Maintain shape and position over time
  - Vegetation
  - Local blowout
    - Vegetation cover breached

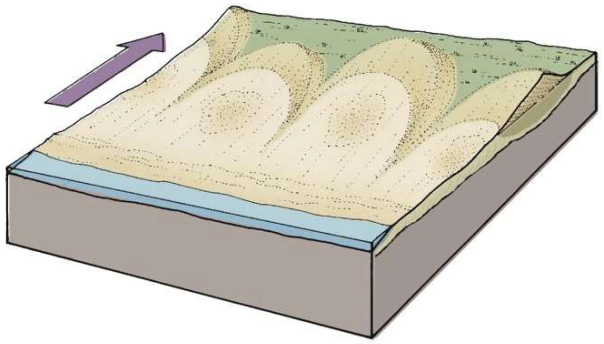
Why are these dunes no longer active?

Sand Dunes (cont'd.)

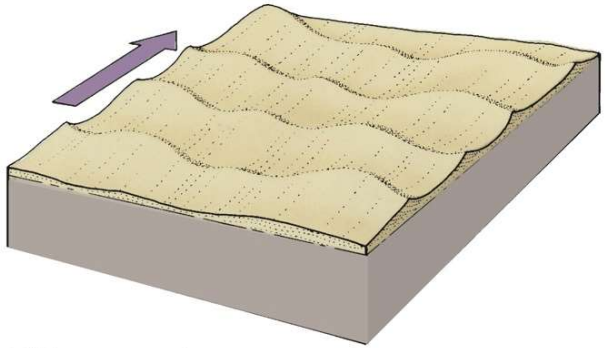
- Five principal types
  - Distinguished by shape and orientation relative to the wind direction
    - Barchans
    - Parabolic dunes
    - Transverse dunes
    - Longitudinal dunes
    - Star dunes



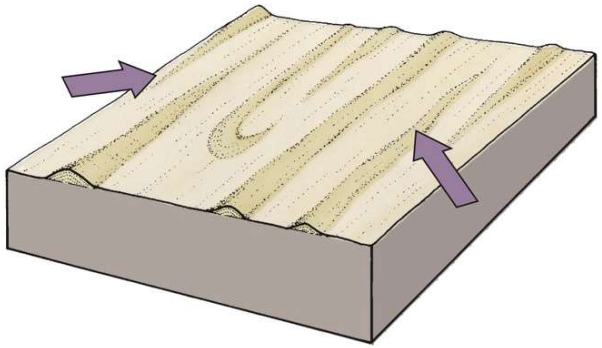
(a) Barchans



(b) Parabolic dunes

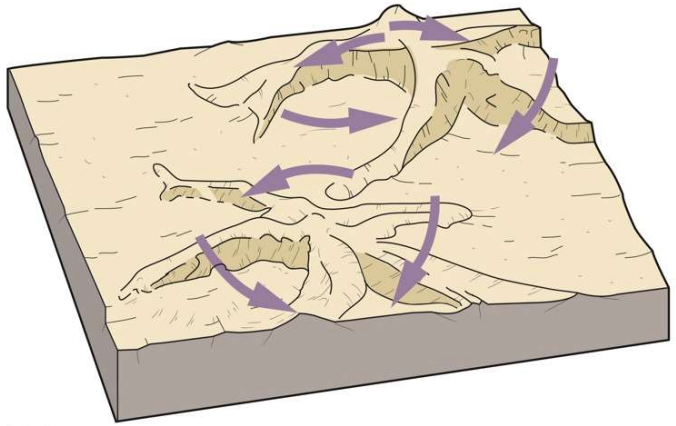


(c) Transverse dunes



(d) Longitudinal dunes

What factors influence which type of dune will be found in a region?



(e) Star dunes

Sand Dunes (cont'd.)

- Barchans
  - Crescent-shaped
  - Two arms (horns) point downwind
  - Main body: upwind
  - Slip face
    - Perpendicular to the arms
    - At the angle of repose

D. Sack

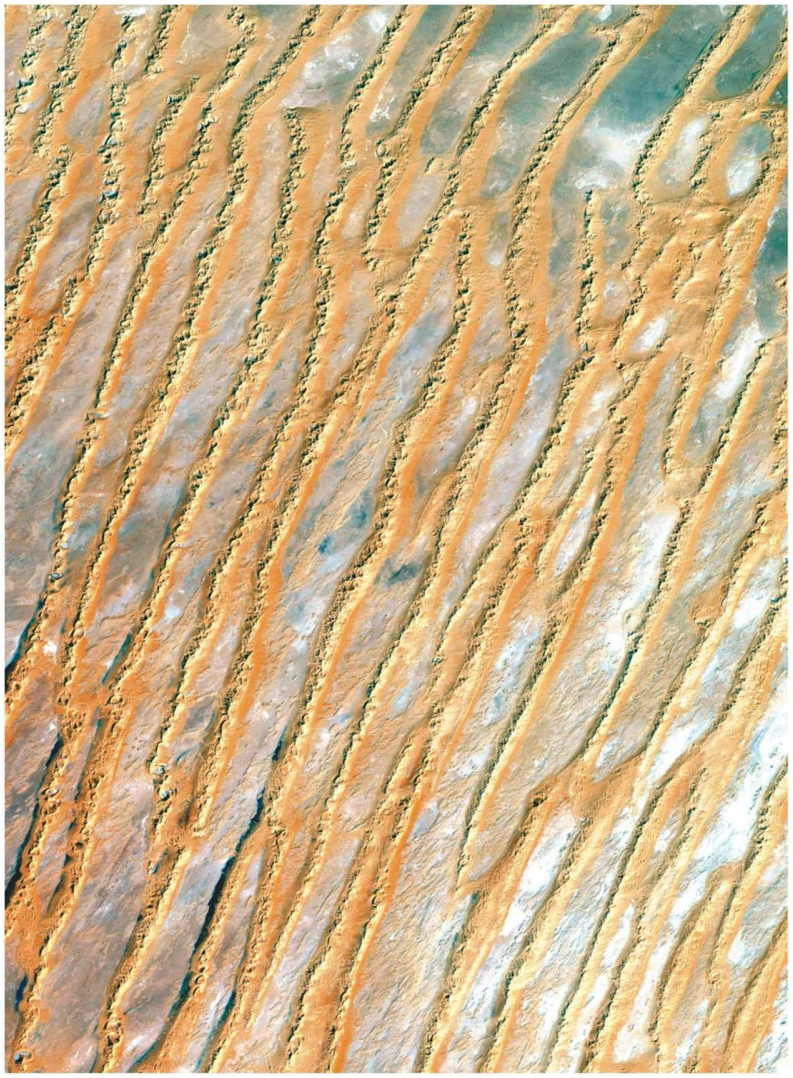
Why do smaller barchans migrate faster than larger barchans?

Sand Dunes (cont'd.)

- Parabolic dunes
  - Crescent-shaped
  - Reversed orientation from that of a barchan
    - Arms point upwind: stabilized by vegetation
- Transverse dunes
  - Gentle upwind slope
  - Slip face at the angle of repose
  - Ridges separated by low swales
    - Trend perpendicular to direction of prevailing winds

Sand Dunes (cont'd.)

- Longitudinal dunes
  - Long dunes aligned parallel to the average wind direction
  - Do not migrate, but instead, elongate in the downwind direction



NASA Earth Observatory, R. Simmon

What is the approximate ground length of the sections of dunes seen on this image?

Sand Dunes (cont'd.)

- Star dunes
  - Pyramid shape with multiple ridges
    - Slip face on each ridge
    - Radiate out from peaklike center
  - Changing wind directions
  - Extremely hot, dry climate

Sand Dunes (cont'd.)

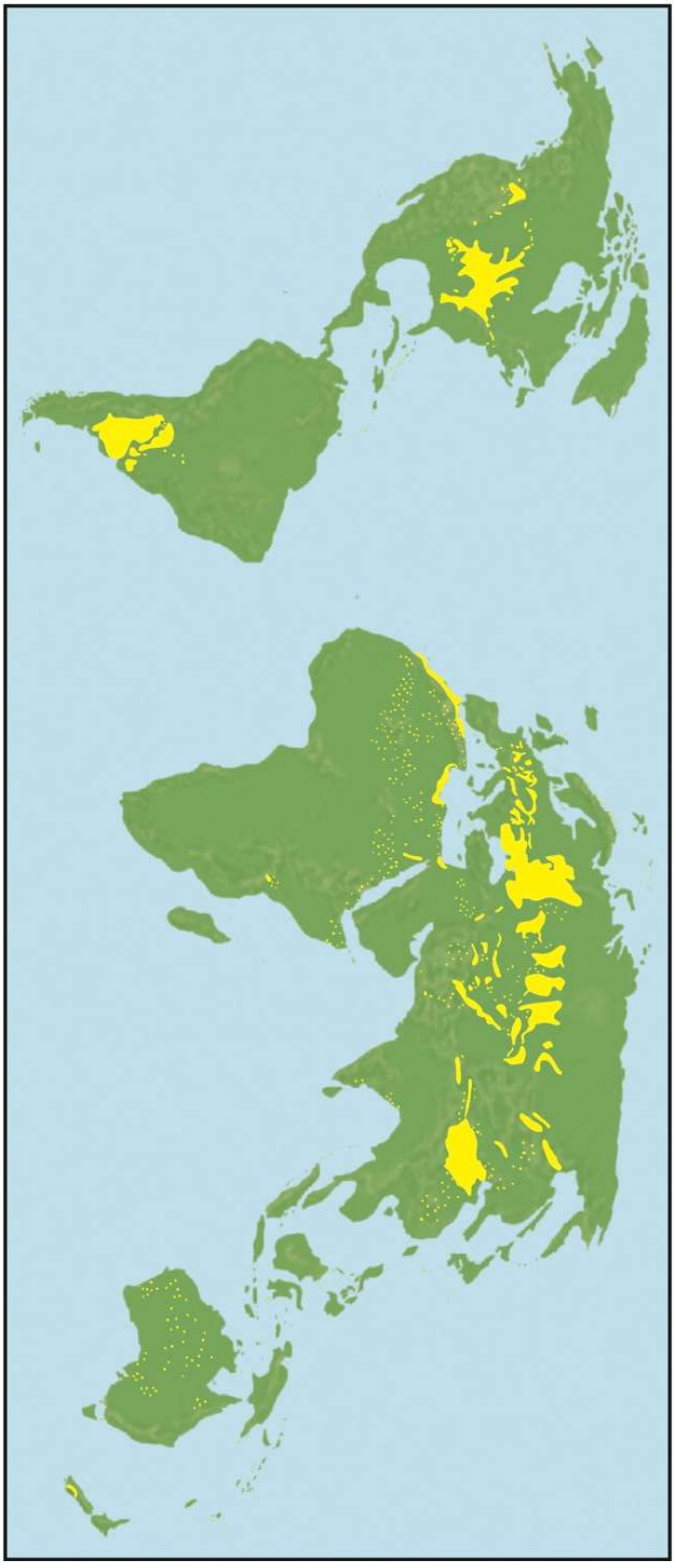
- Dune regions
  - Fragile environments
  - Environmental balance between moving dunes and the plants trying to stabilize them
    - Equilibrium easily upset
  - Why should dunes be left undisturbed?

Sand Dunes (cont'd.)

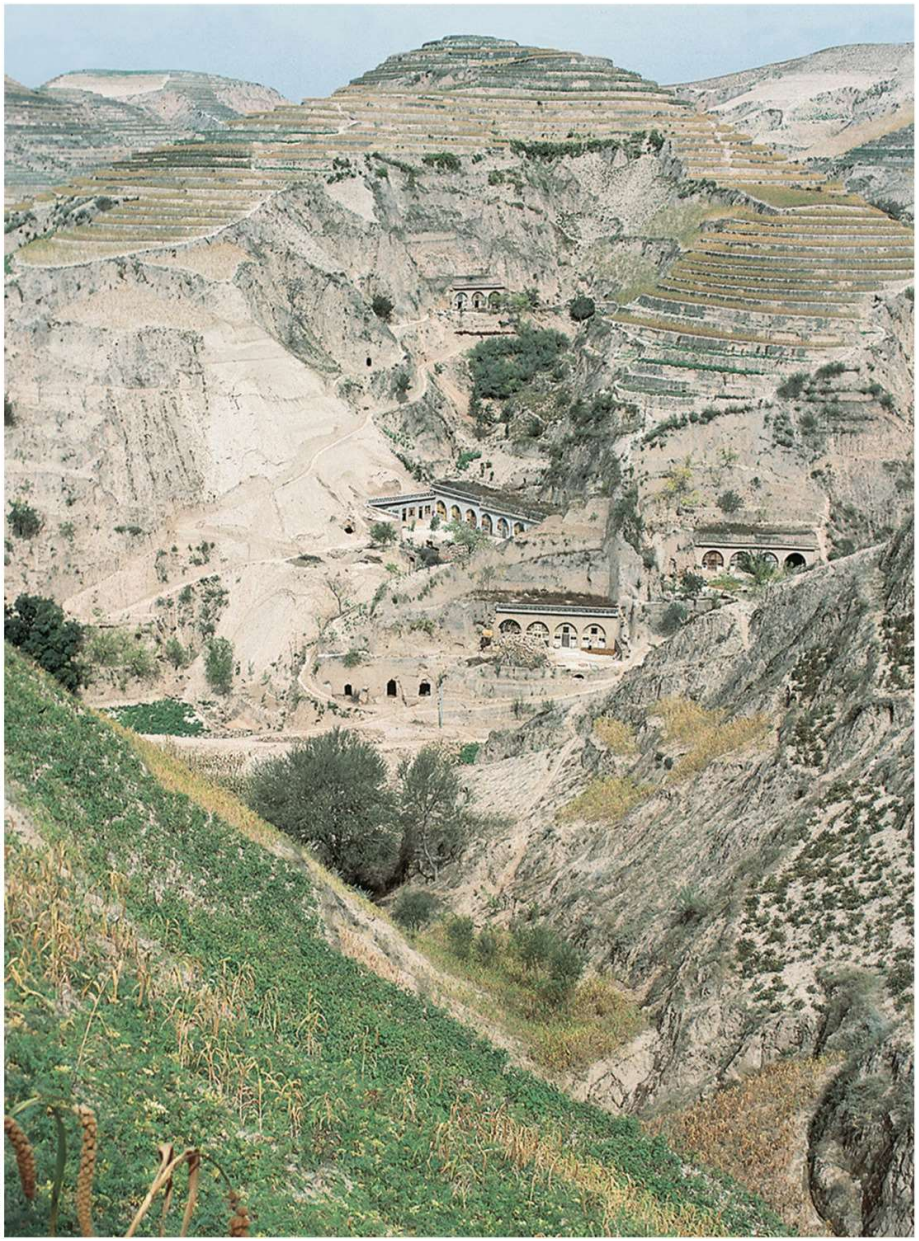
- Off-road vehicle impacts on desert landscapes
  - Damage desert biota
    - Kill and injure plants, animals, and insects; hearing loss by animals; pollution; grass and range fires
  - Desert surface compaction
    - Greater erosion
  - Recovery from damage
    - Requires long periods of time

Loess Deposits

- Widespread areas
  - Deposits of dust-sized particles of clay and silt removed by deflation
- Varying thicknesses
- Sources of dust
  - Deserts
  - Glacier deposits
- High calcium carbonate content



Where did the sediments found in this loess originate?



Landscape Development in Deserts

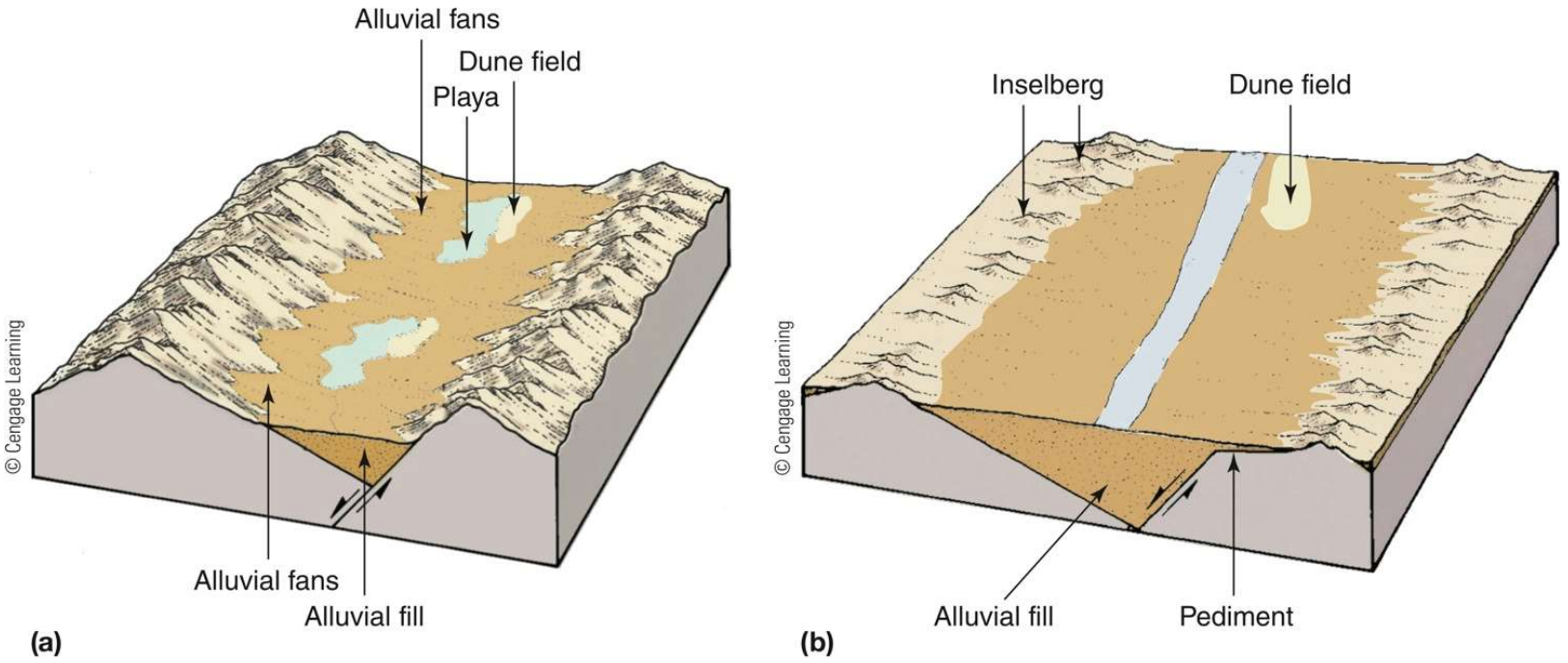
- Weathering and mass movement processes
  - Fluvial processes predominate
- Major differences as compared to humid climates due to:
  - Expanses of exposed bedrock
  - Lack of continuous water flow
  - More active role of the wind

Landscape Development in Deserts (cont'd.)

- Basin and Range region: western North America
  - The Great Basin: Nevada
    - Interior drainage
    - Active tectonism
  - Fault-block mountains
    - Desert basins
    - High ranges: orographic precipitation
    - Active tectonism: uplift exceeds erosion
    - Fluvial deposition

Landscape Development in Deserts (cont'd.)

- Basin and Range region
  - Fault-block mountains
    - Bajada: coalesced alluvial fans
    - Playas: lowest part of the basin
    - Local dune fields
  - Tectonically less active areas
    - Pediments
    - Inselbergs
  - Mohave desert: California
    - Extensive desert plains


Alluvial fans
Dune field
Playa
Alluvial fans
Alluvial fill
(a)
Inselberg
Dune field
Alluvial fill
Pediment
(b)
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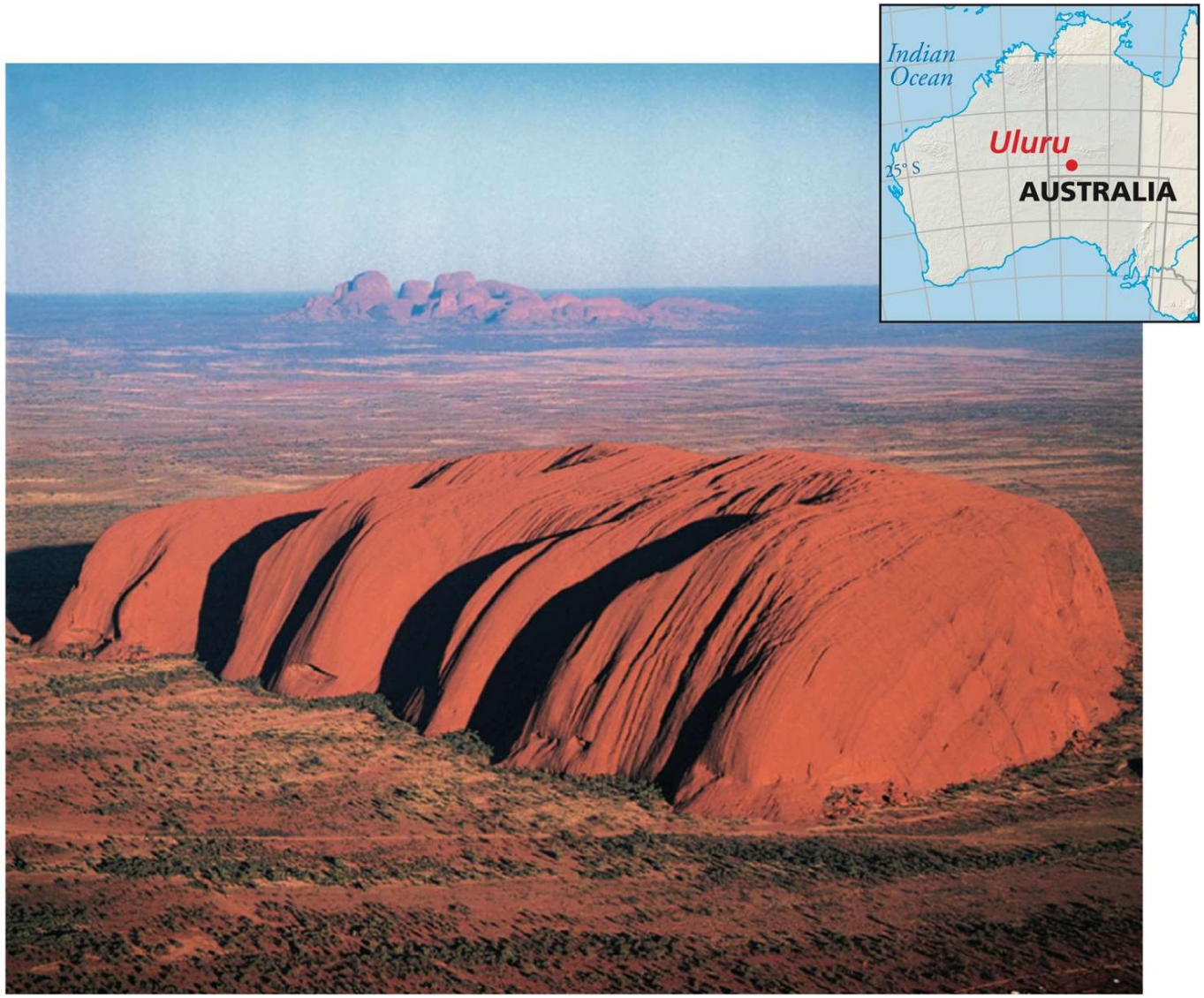
Landscape Development in Deserts (cont'd.)

- Variations of geologic structures and geomorphic processes
  - Stable deserts
    - Inselbergs surrounded by extensive desert plains
    - Hollows, playas, washes, etc.
    - Large longitudinal dunes
  - Desert and eolian areas
    - Unique characteristics and scenic beauty
    - Importance of preserving and protecting them



Explain how inselbergs form.

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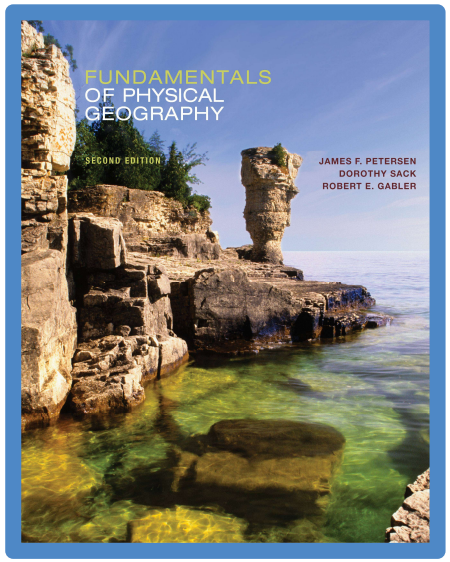

- Peterson
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