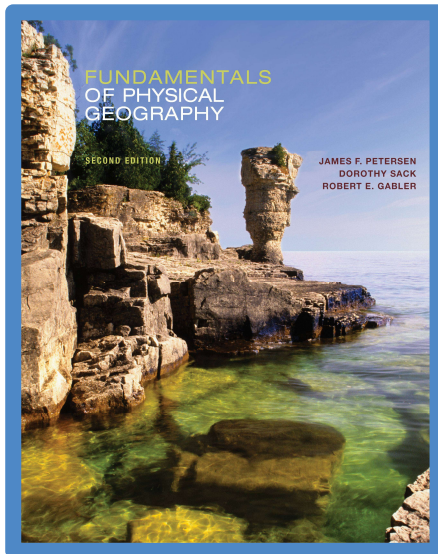


Fundamentals of Physical Geography 2e

Weathering and Mass Wasting

12



- ⌘ Peterson
- ⌘ Sack
- ⌘ Gabler

Introduction

- Exogenic processes
 - Break down and erode rock materials
 - Transport fragments
- Methods of relocation
 - Gravity
 - Geomorphic agents
 - Flowing water, wind, moving ice, or waves

Nature of Exogenic Processes

- Weathering
 - Breakdown of rock material at and near Earth's surface
- Continuum of processes
 - Weathering
 - Erosion
 - Transportation
 - Deposition

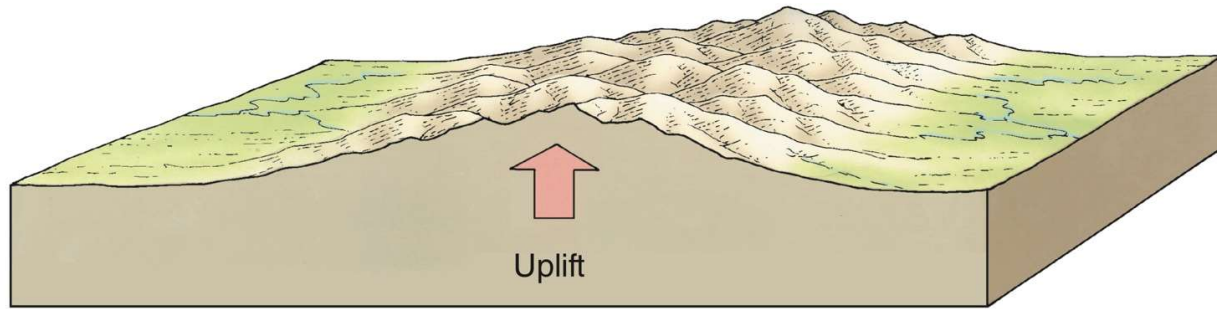


J. Petersen

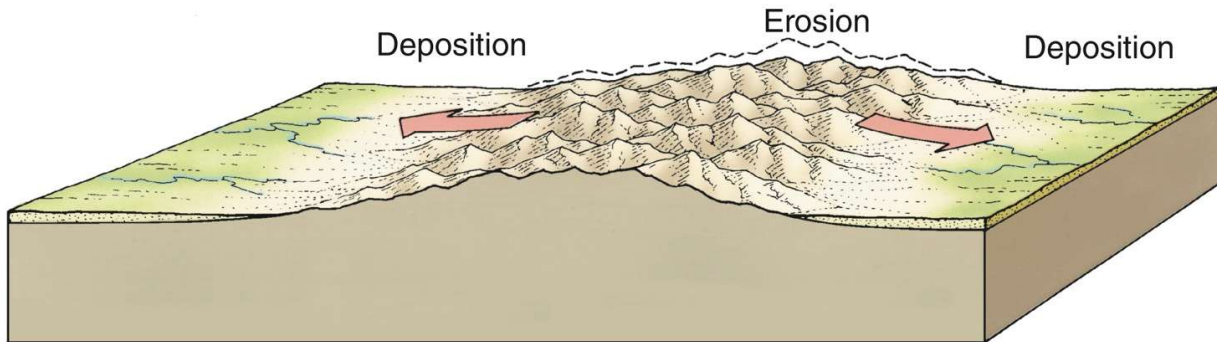
Why are some exposed parts of the boulder darker than others?

Nature of Exogenic Processes (cont'd.)

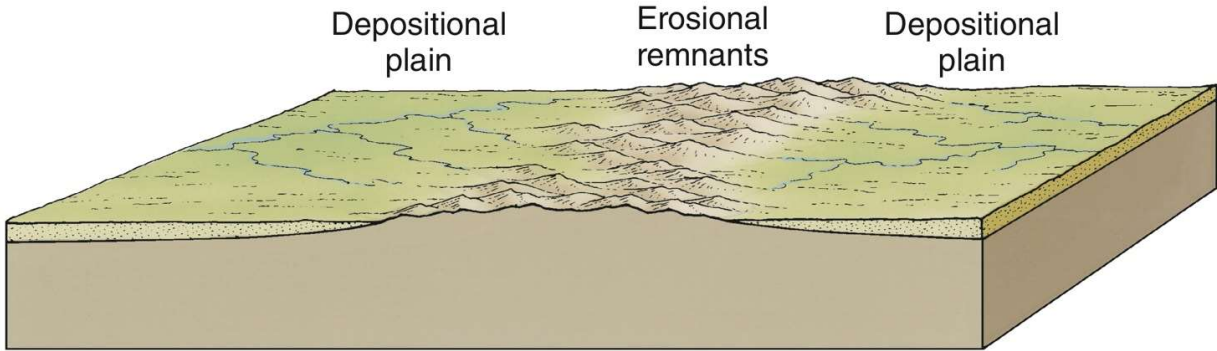
- Mass wasting
 - Movement due to gravity alone
- How do endogenic and exogenic processes together contribute to shaping and developing a landform?



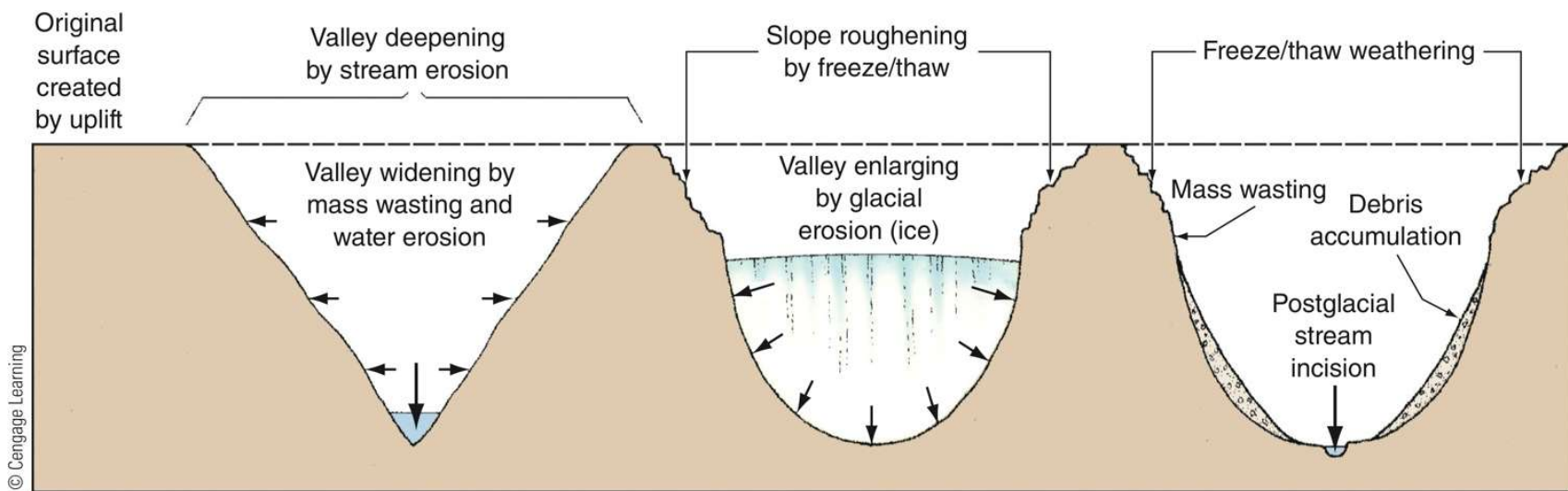
(a) Tectonic uplift



(b) Exogenic processes dominate



(c) Reduced relief



How does the cross-sectional profile of the valley change at each phase?



USGS/Austin Post

© Cengage Learning

Can you identify evidence in this scene of the three phases illustrated in Figure 12.3?

Weathering

- Types of weathering
 - Physical (mechanical) weathering
 - Chemical weathering
- Physical weathering
 - Important to landscape modification
 - Smaller clasts: more easily eroded and transported
 - Breakup of rocks: encourages further weathering



J. Petersen

How might an animal cause physical weathering?

Weathering (cont'd.)

- Types of physical weathering
 - Unloading
 - Erosional stripping of overlying rocks; removal of overlying weight
 - High elevation increases process
 - Exfoliation: removal of outer rock sheets
 - What is an exfoliation dome?

J. Petersen



J. Petersen



Why is granite so susceptible to unloading and exfoliation?

Weathering (cont'd.)

- Types of physical weathering
 - Thermal expansion and contraction
 - Heating and cooling effects: supported by recent desert field studies
 - Granular disintegration: individual mineral grains from a rock

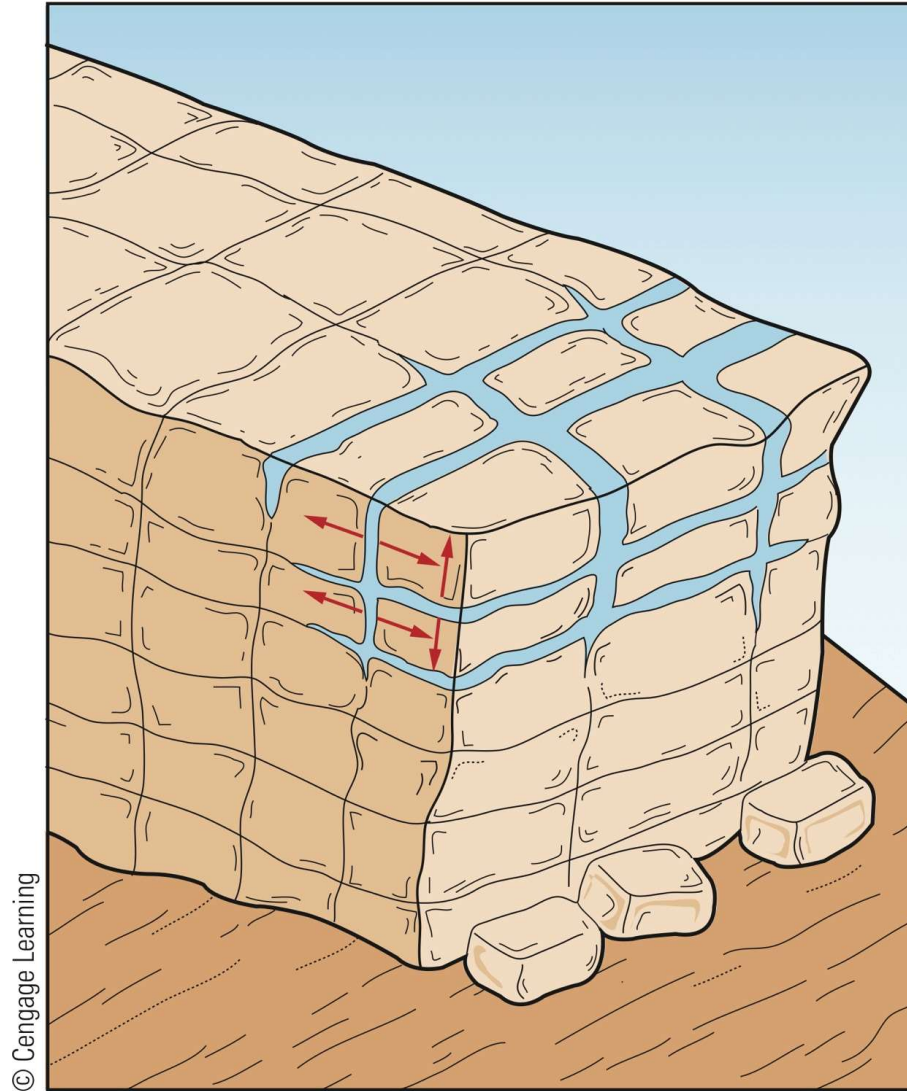


D. Sack

What other evidence exists on the boulder to suggest that it has been subjected to considerable weathering?

Weathering (cont'd.)

- Types of physical weathering
 - Freeze–thaw weathering: frost weathering or ice wedging
 - Water expands when it freezes
 - Why is freeze-thaw weathering not significant at lower latitudes, except in areas of high elevation?



How important is freeze–thaw weathering where you live?

M.A. Schroeder, Washington Department of Fish and Wildlife



Why are many rocks affected by freeze–thaw angular rather than rounded?

Weathering (cont'd.)

- Types of physical weathering
 - Growth of salt crystals
 - Similar to freeze-thaw weathering
 - Salt crystals: wedge pieces of rock apart
 - Common in arid regions and rocky coastal locations
 - Hydration
 - Water molecules attach to the crystalline structure of a mineral, causing mineral to expand

Weathering (cont'd.)

- Chemical weathering
 - Ions from a rock
 - Released into water or recombine with other substances forming new materials
 - Oxidation
 - Chemical union of oxygen atoms with another substance creates a new product

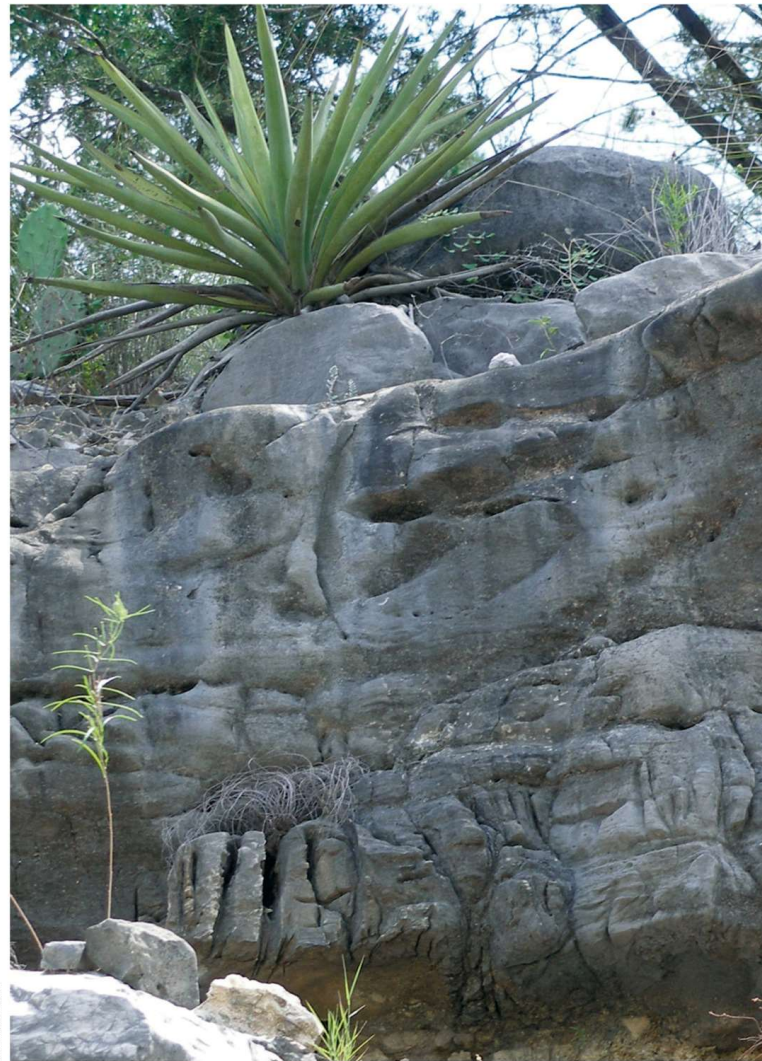


D. Sack

What is a likely chemical formula for the reddish orange substance?

Weathering (cont'd.)

- Chemical weathering
 - Solution and carbonation
 - Minerals that dissolve in water: ions carried away
 - What occurs in the chemical weathering process of carbonation?
 - Hydrolysis
 - Water molecules alone react with chemical components of rock-forming minerals: creating new compounds
 - How does hydrolysis differ from hydration?

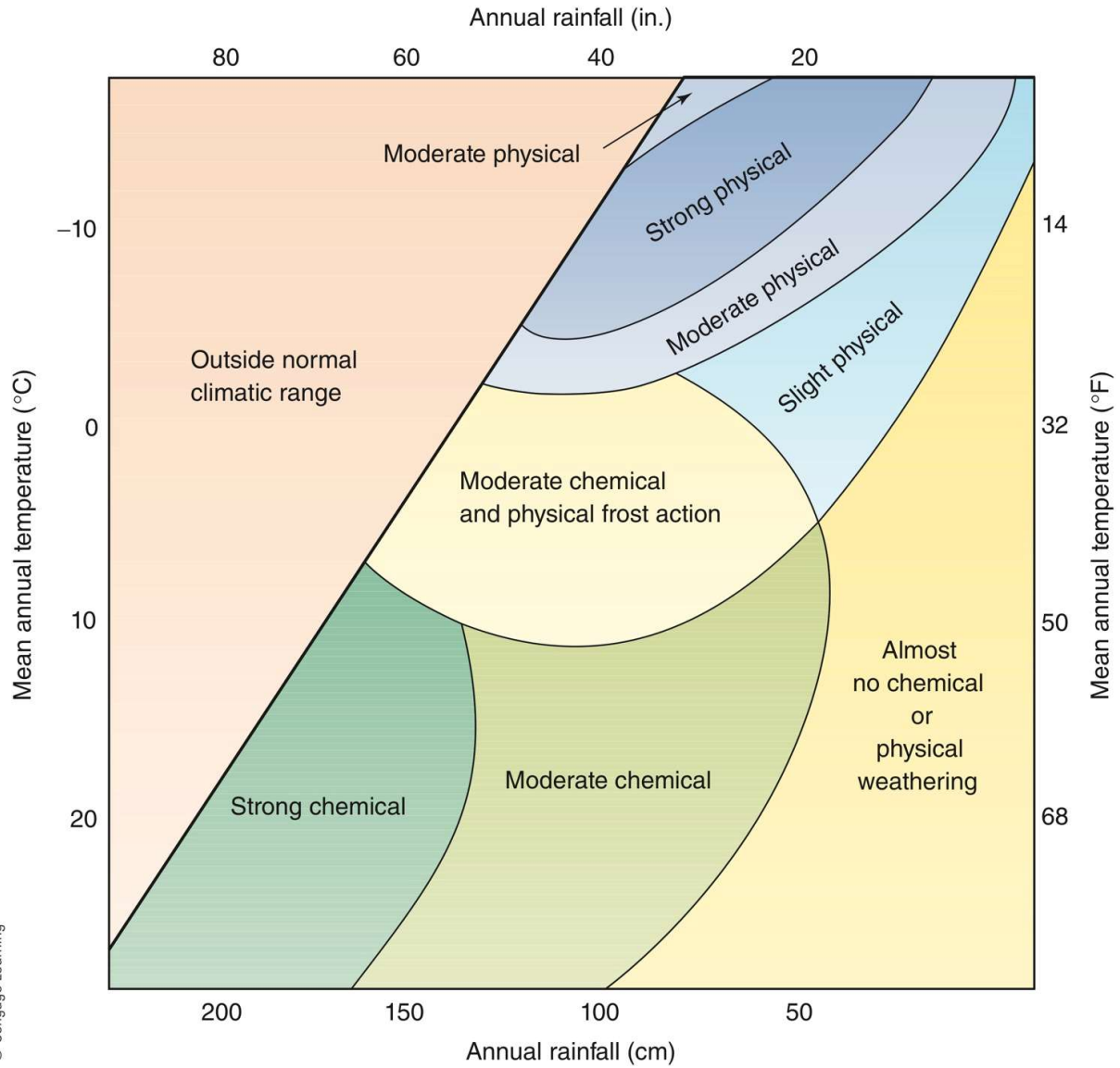


Why does the limestone near the bottom of the outcrop seem to be more weathered than that at the top?

Variability in Weathering

- Major influences on weathering processes
 - Climate
 - Rock type
 - Rock fractures or other weaknesses

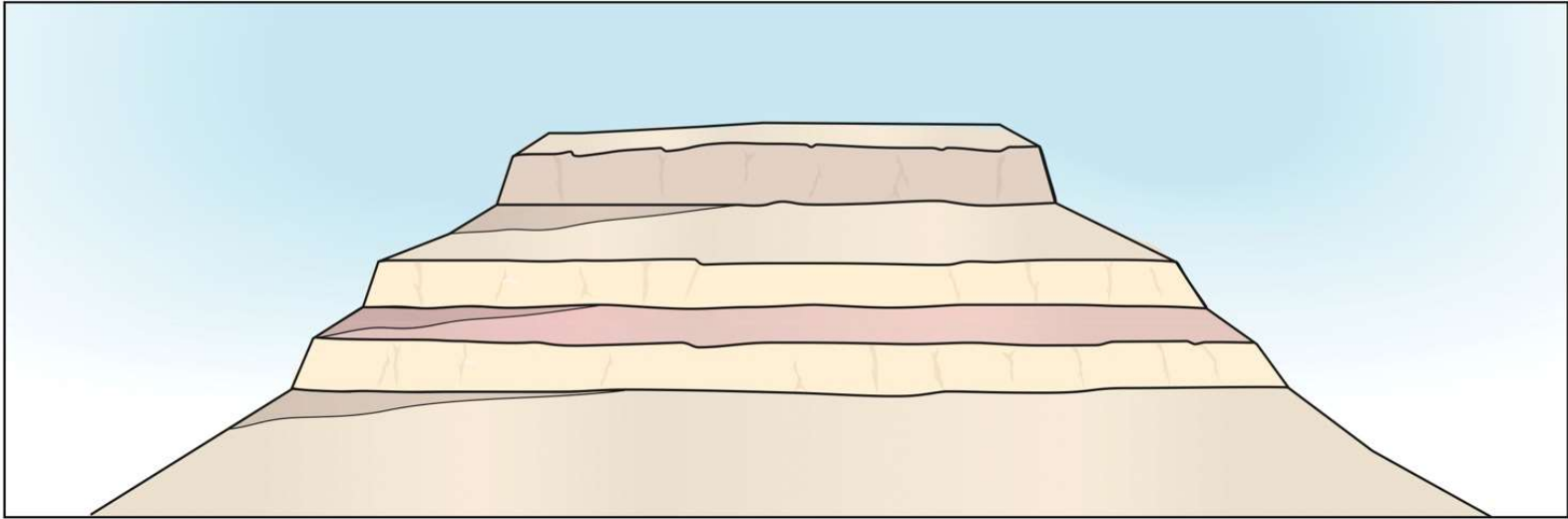
THEORETICAL WEATHERING REGIONS



Variability in Weathering

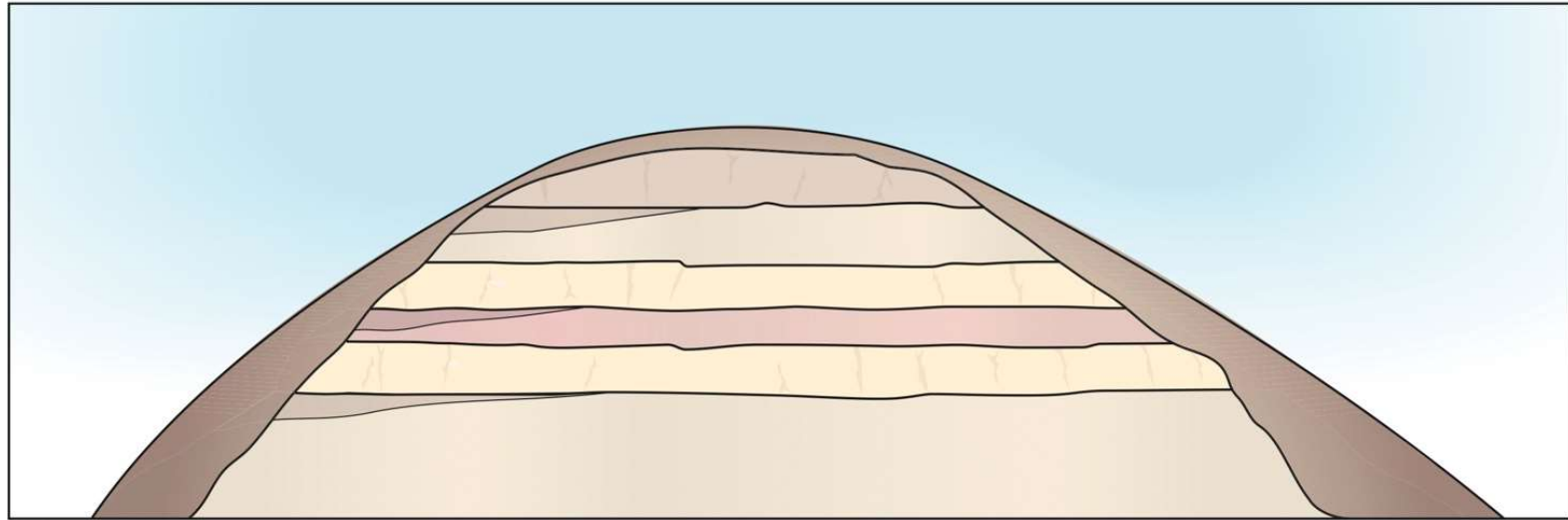
- Climate factors
 - Water: humidity and rainfall
 - Temperature
 - Higher temperatures: faster chemical reactions
 - Daily temperature range impact
 - Acidity of atmospheric moisture
 - Air pollution

© Cengage Learning



(a)

© Cengage Learning



(b)



J. Petersen

What kind of chemical weathering has affected the iron fence?

Variability in Weathering

- Rock type
 - Strong rock may be easily eroded in a different environment
 - Quartzite

Variability in Weathering (cont'd.)

- Expanding and contracting soils
 - Soils: inorganic and organic materials, soil water, and soil air
 - Montmorillonite: one of four basic clay minerals
 - Expands and contracts the most
 - Expansion and contraction in soil volume
 - Shifts and cracks roads, sidewalks, and building foundations

The Physical Science Perspective

Variability in Weathering (cont'd.)

- **Structural weaknesses**
 - Chemical and physical weathering
 - Proceed faster along any kind of gap, crack, or fracture
 - Joint set
 - Spheroidal weathering



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National Park Service

D. Sack



With north at the top of this photo, what directions do the two most apparent joint sets trend?

J. Petersen



J. Petersen

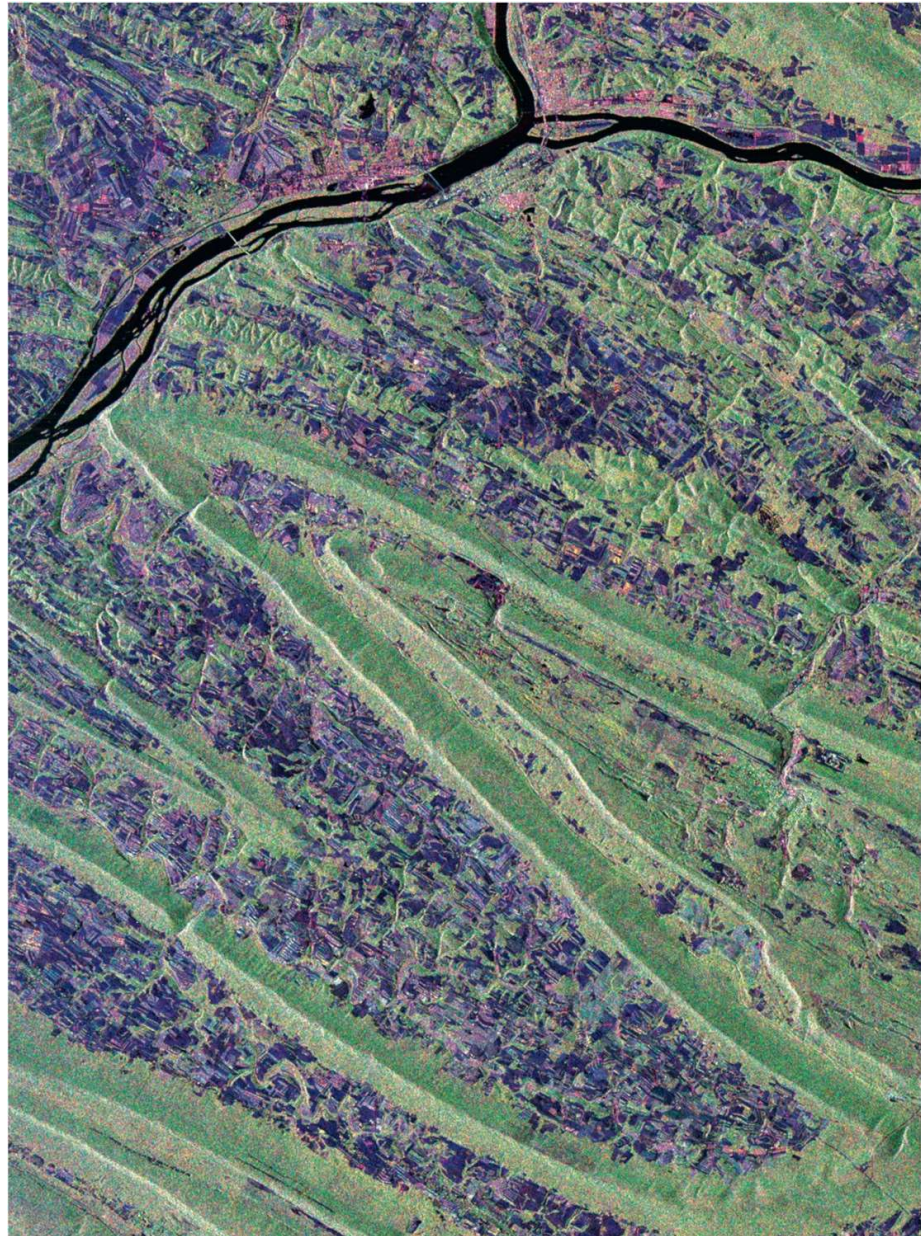
Variability in Weathering (cont'd.)

- Differential weathering and erosion
 - Variation in rock resistance to weathering
 - Impact on landform appearances

National Park Service/Mark Lellouch



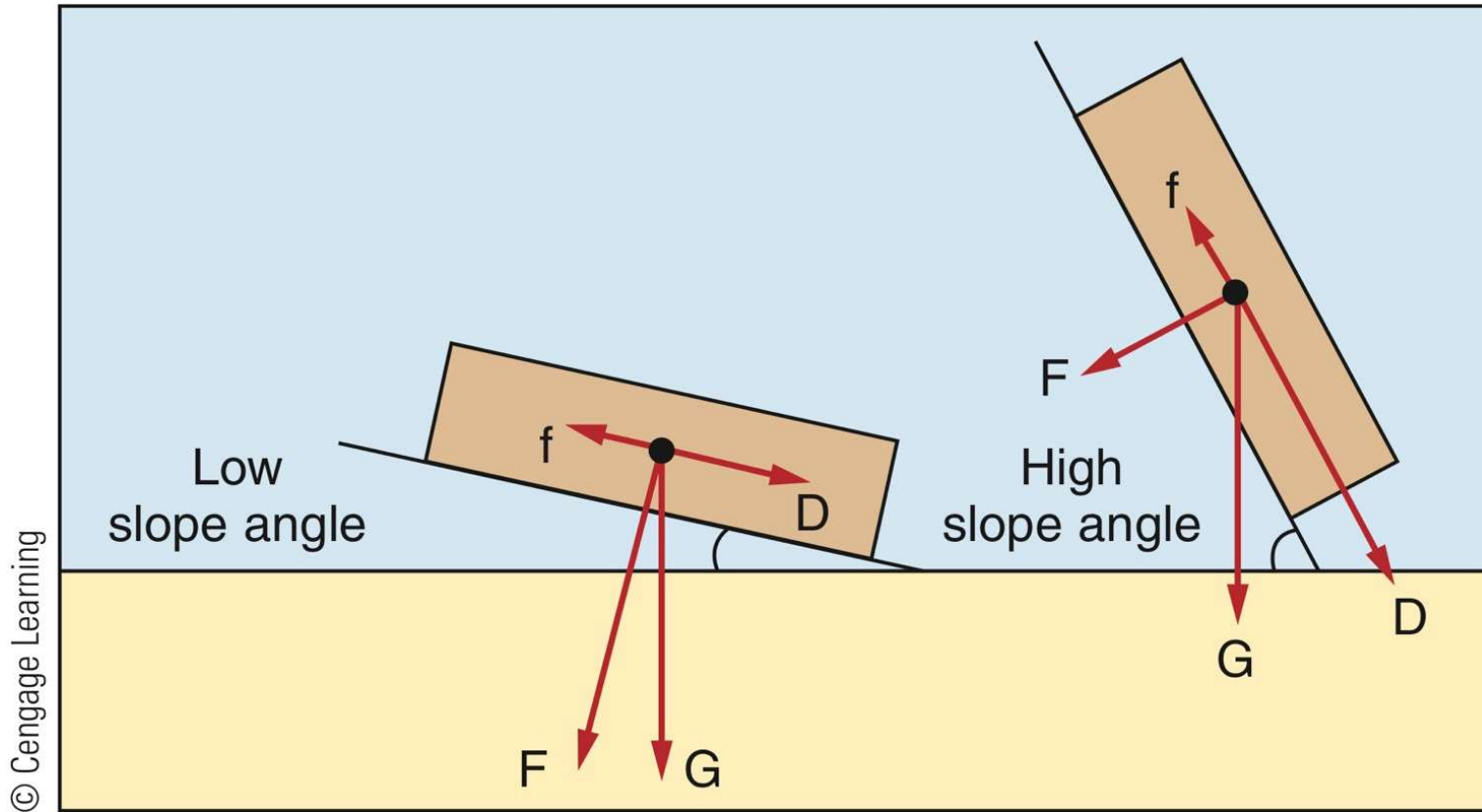
Can you see how the topography of the Ridge and Valley section influences human settlement patterns?



Variability in Weathering (cont'd.)

- Mass wasting (mass movement)
 - Downslope transport
 - Gravitational force
 - Factors affecting downslope movement
 - Friction
 - Rock strength
 - Slope angle
 - Saturated conditions



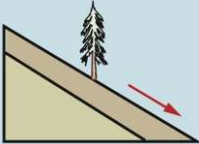
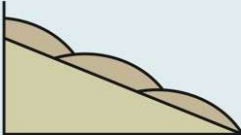
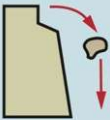
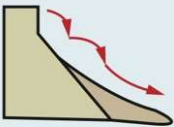
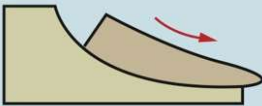
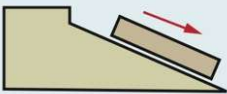



How might vegetative cover or moisture content affect the potential for downslope movement of soil?

Variability in Weathering (cont'd.)

- Materials and motion
 - Categorizing mass wasting events
 - Kinds of Earth materials involved
 - Ways the materials move
 - Terminology
 - Soil, earth, debris, and mud
 - Speed
 - Slow vs. fast mass wasting

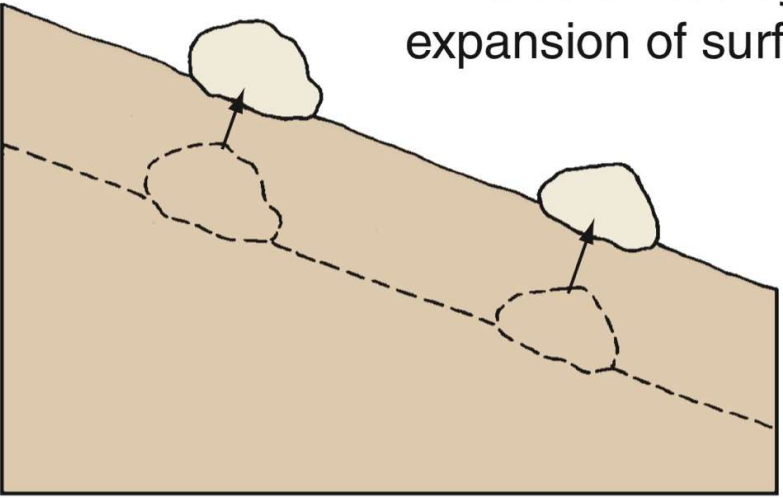
Table 12.1

Motion	Common Material	Typical Speed	Effect
Creep	Soil	Slow	
Solifluction	Soil	Slow	
Fall	Rock	Fast	
Avalanche	Ice and snow or debris and rock	Fast	
Slump (rotational slide)	Earth	Fast	
Slide (linear)	Rock or debris	Fast	
Flow	Debris or mud	Fast	

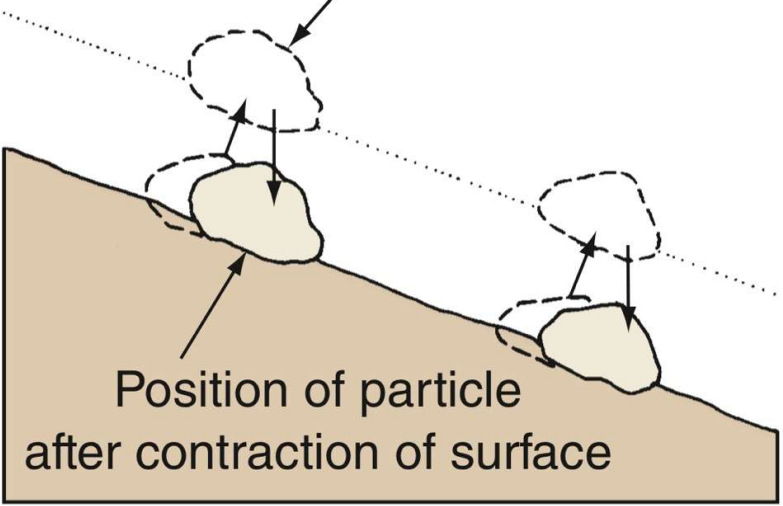
Variability in Weathering (cont'd.)

- Slow mass wasting
 - Creep
 - Visually imperceptible
 - Most widespread and persistent form of mass wasting
 - Heaving process

Particle lifted by expansion of surface

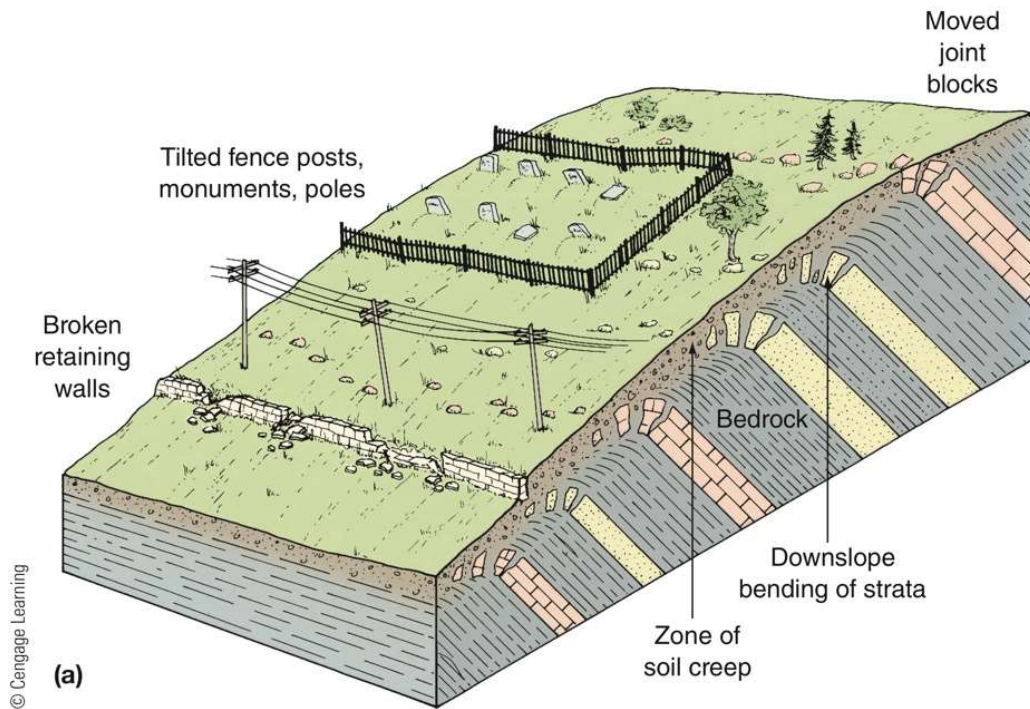


Position of particle when lifted



Position of particle after contraction of surface

Are there places near where you live that show evidence of soil creep?



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J. Petersen

What other constructed features might be damaged by creep?

Variability in Weathering (cont'd.)

- Slow mass wasting
 - Solifluction: soil flow
 - Slow downslope movement of water-saturated soil or regolith
 - High-latitude or high-elevation tundra regions: permafrost conditions
 - Active layer

**How does solifluction
differ from soil creep?**

B. Bradley/NOAA, National Geophysical Data Center



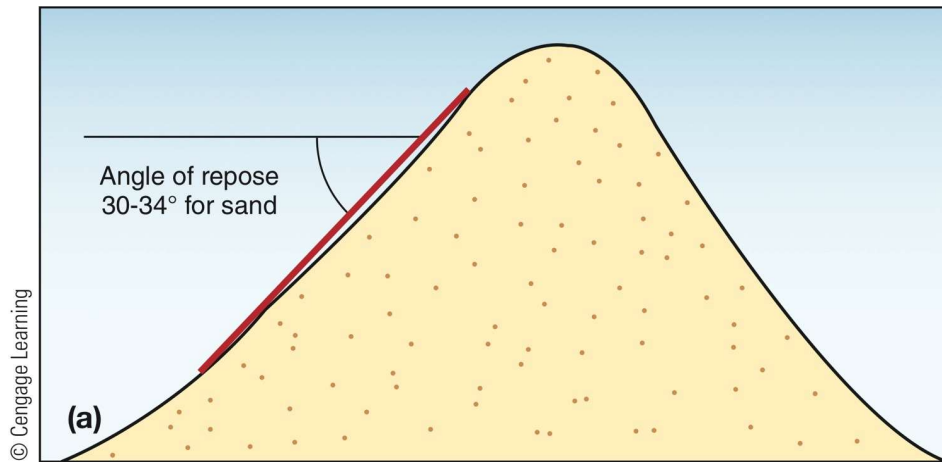
Variability in Weathering (cont'd.)

- Fast mass wasting
 - What factors affect the actual speed of movement?
 - Effects: more dramatic than slow mass wasting
 - Falls
 - Rockfalls: most common type
 - Talus



D. Sack

What weathering processes might be acting on the sandstone beneath the overhang when it becomes wet?



How would the angle of repose of rounded particles differ from that of angular particles of the same size?

Variability in Weathering (cont'd.)

- Fast mass wasting
 - Avalanches
 - Pulverized material
 - Flows rapidly: airborne density current
 - In addition to snow avalanches, what are other types of avalanches?

Courtesy Lynn French, National Snow and Ice Data Center



FEMA/Dave Gatley



Does the evidence in these photos convince you that snow avalanche deposits are not light and fluffy?

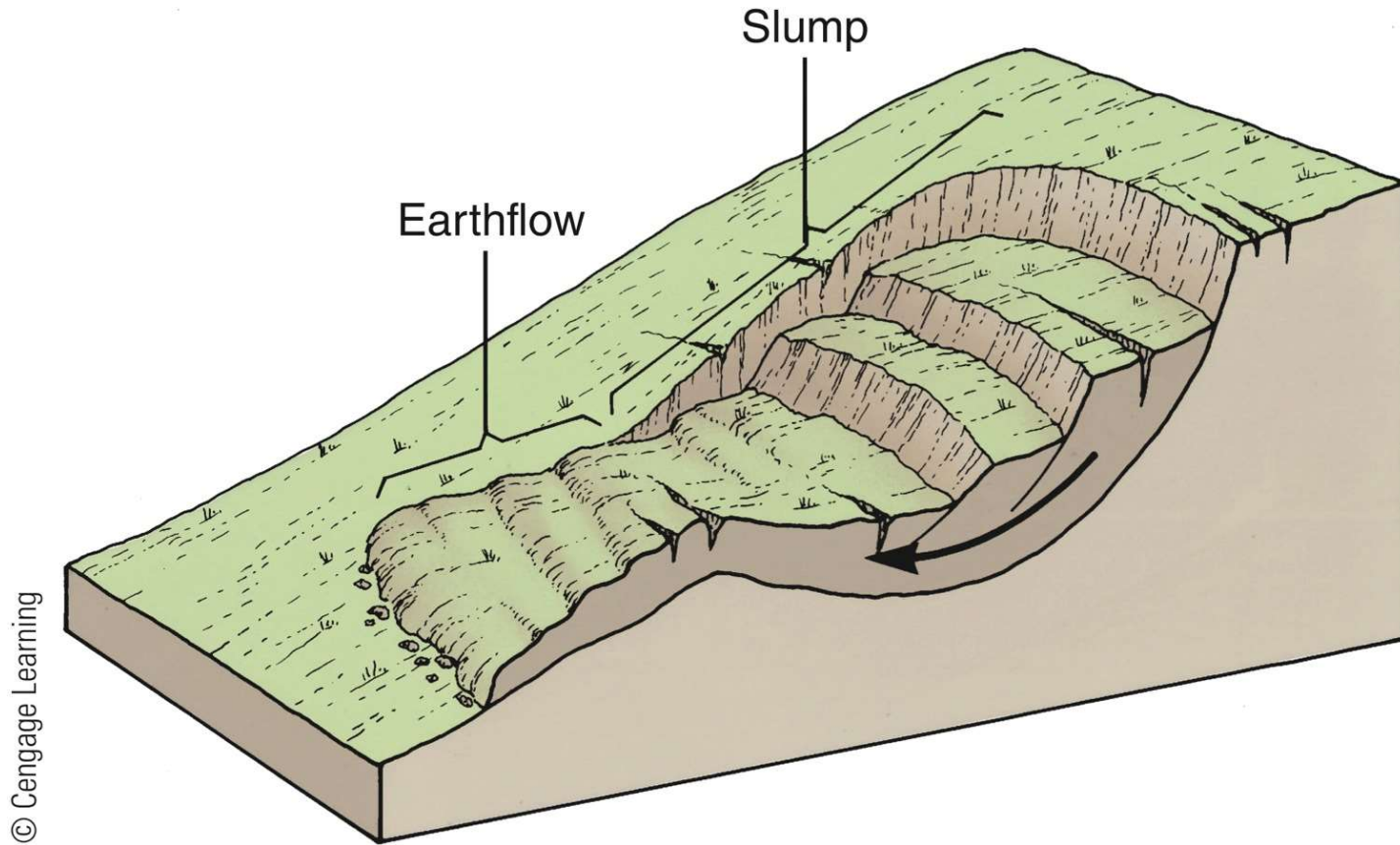
Variability in Weathering (cont'd.)

- Fast mass wasting
 - Slides
 - Cohesive or semicohesive unit of Earth material
 - Continuous contact with the land surface
 - Rockslides
 - Debris slides
 - Mudslides
 - Slumps
 - Landslide



FEMA/Dave Gatley

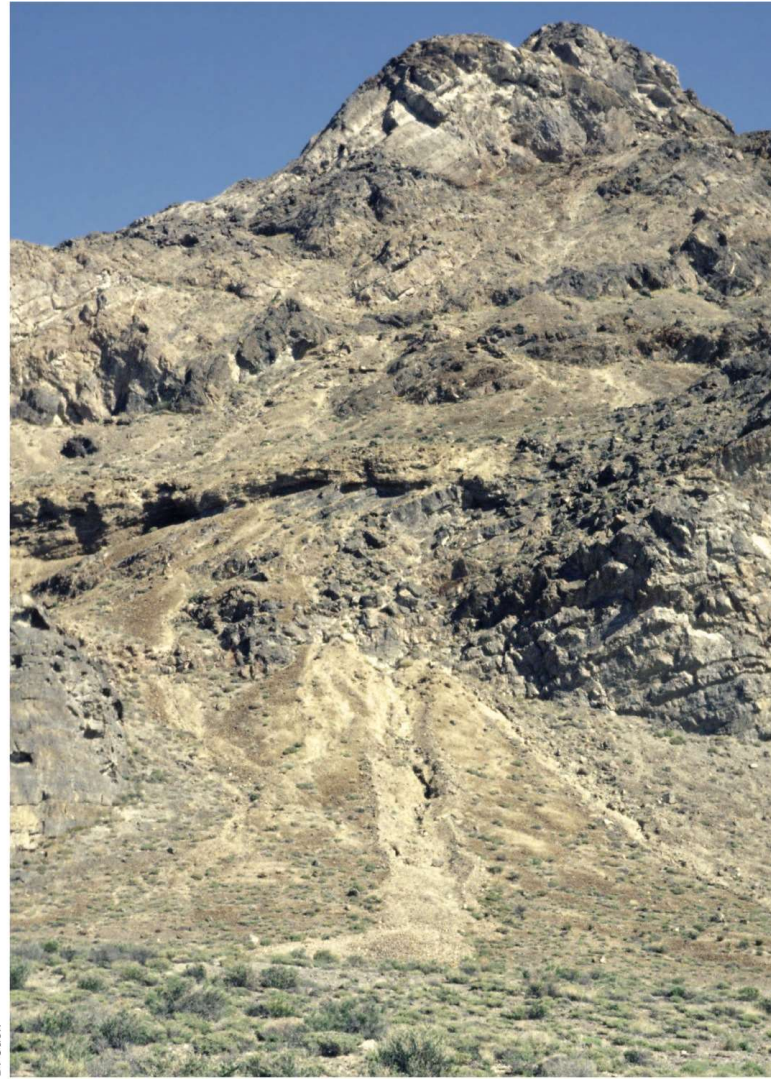
What are some other types of damage that a mudslide might cause in a populated area?



How does the earthflow component differ from the slump component?

Variability in Weathering (cont'd.)

- Fast mass wasting
 - Flows
 - Carry water in moving sediments
 - Earthflow
 - Slump-earthflow
 - How do debris flows and mudflows differ?
 - Flow levees
 - Lahars



D. Sack

What evidence is there to indicate that this is a site of repeated debris flows?



Mark Reid/USGS LHP

Why might a specific site experience repeated slope failures over time?

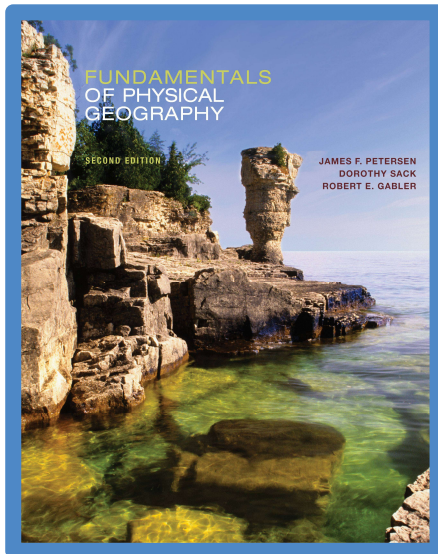
Weathering, Mass Wasting, and the Landscape

- Exogenic processes of weathering and mass movement
 - Critical to soil formation
 - Significant factors in shaping the landscape
 - Human impact and reciprocal effects
 - Slopes
 - Reflection of local weathering and mass wasting

Fundamentals of Physical Geography 2e

Weathering and Mass Wasting 12

<end of chapter>



- ⌘ Peterson
- ⌘ Sack
- ⌘ Gabler