Introduction

- Mass wasting

  Rapid downslope movement of rock or soil as a coherent mass

  Includes: landslides, debris flows, slumping, avalanches

- Slope processes

  Materials are always in motion downslope

  All slopes are constantly evolving

  To have a slope ***requires*** an active process

Different types of slopes

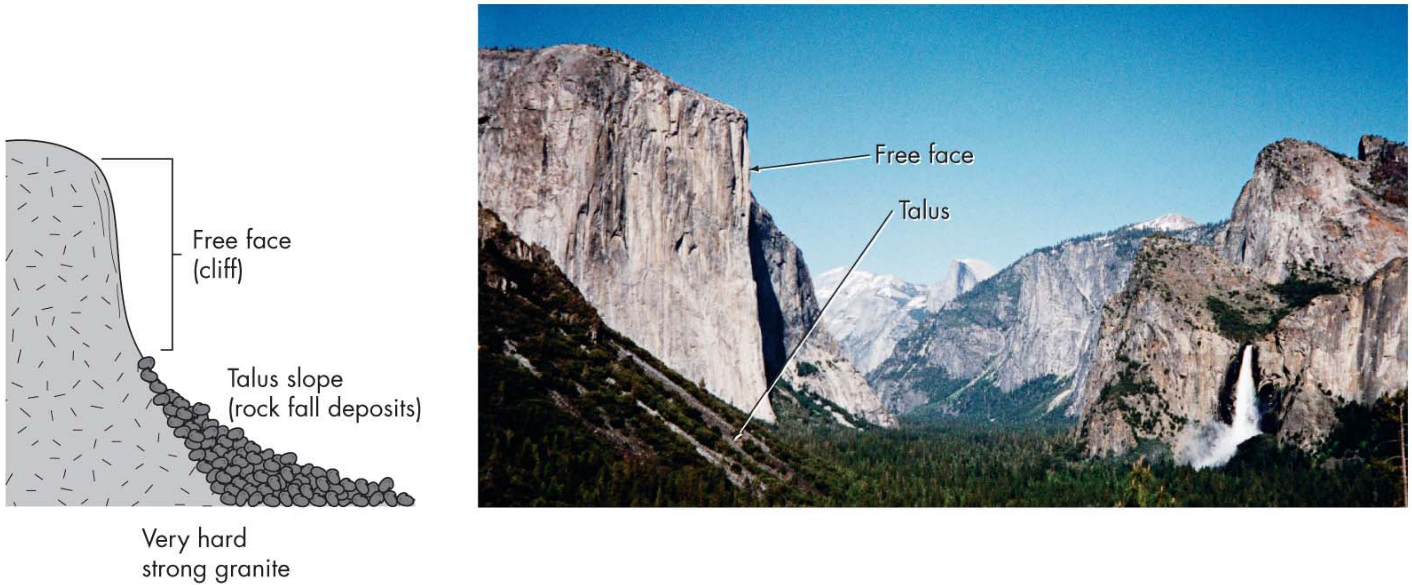


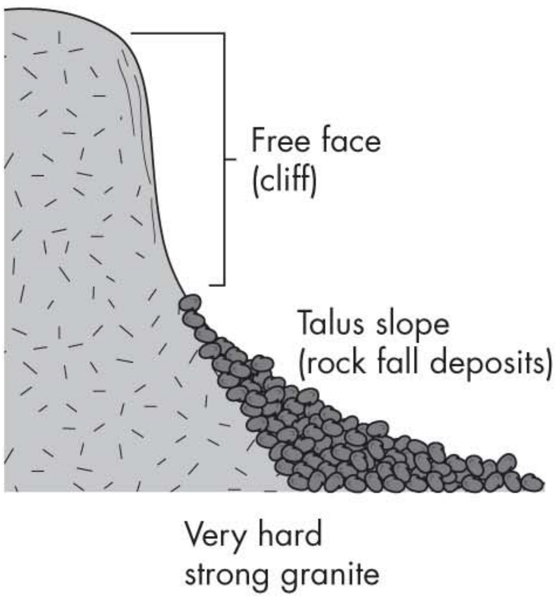
Figure 6.4

Characteristics of slopes

- Segment types depend on material and climate
  - High cliff or free face
  - Talus slope at the base

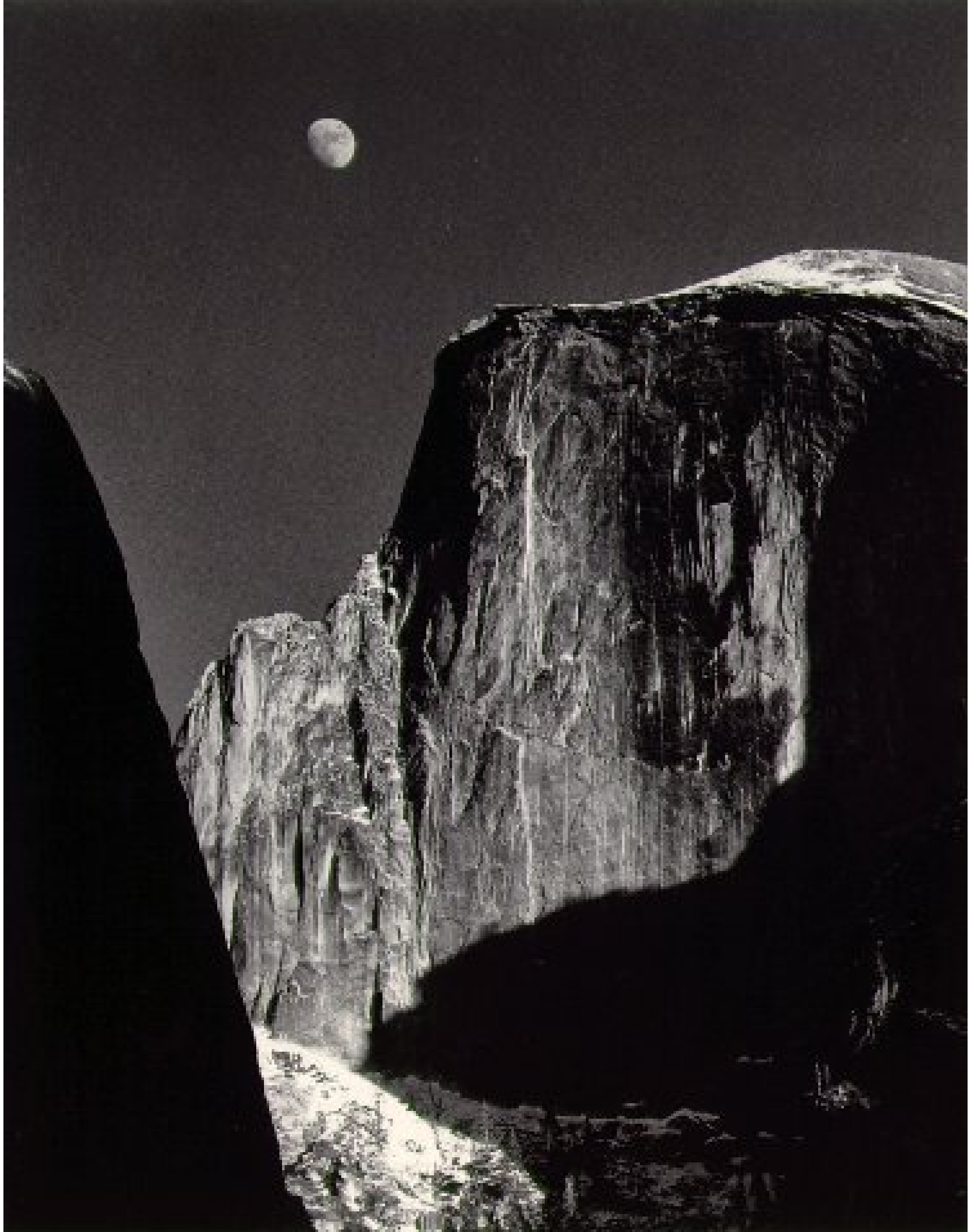
  - Convex slope
  - Straight slope
  - Concave slope

Cliff or free face

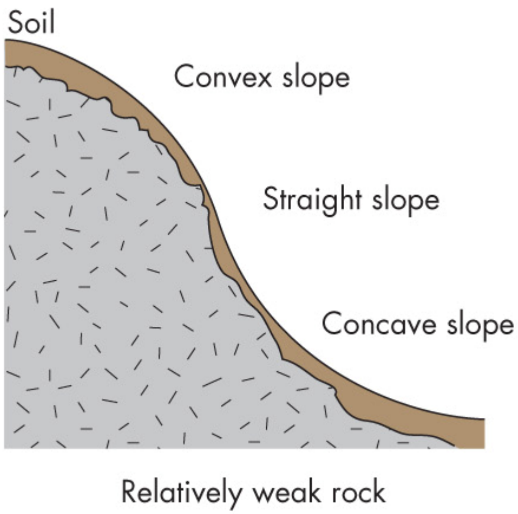


Cliff-forming rocks: granite, cemented sandstone, limestone

Cliff or free face



Rounded slopes



Slope-forming rocks: shale, weak metamorphic rocks,
rocks crumbled by tectonic forces

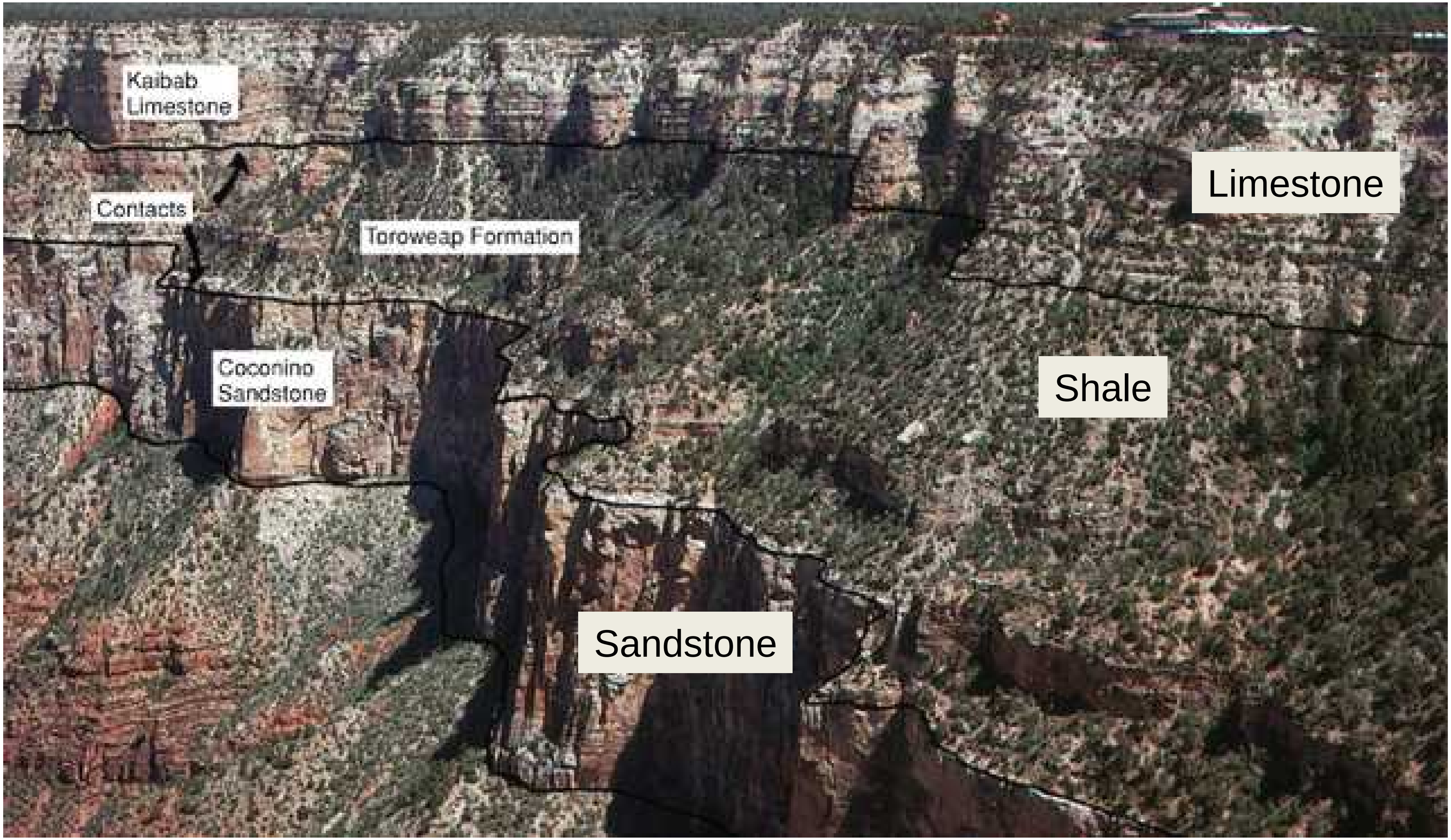
Characteristics of slopes

Cliff-forming and slope-forming rocks

Characteristics of slopes

Cliff-forming and slope-forming rocks

Characteristics of slopes



Types of landslides – Fall

- **Falling**

  Free fall of rocks or sediment

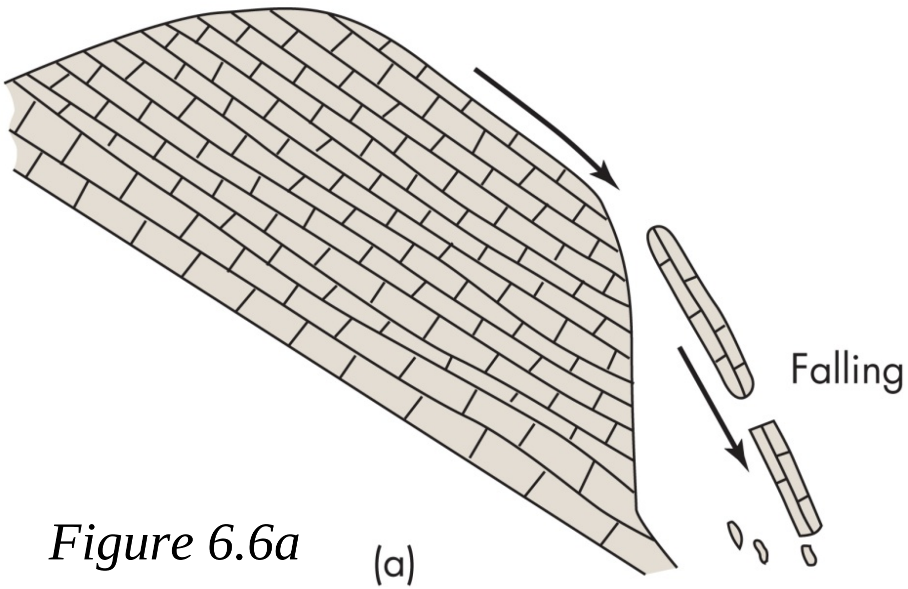


Figure 6.6a

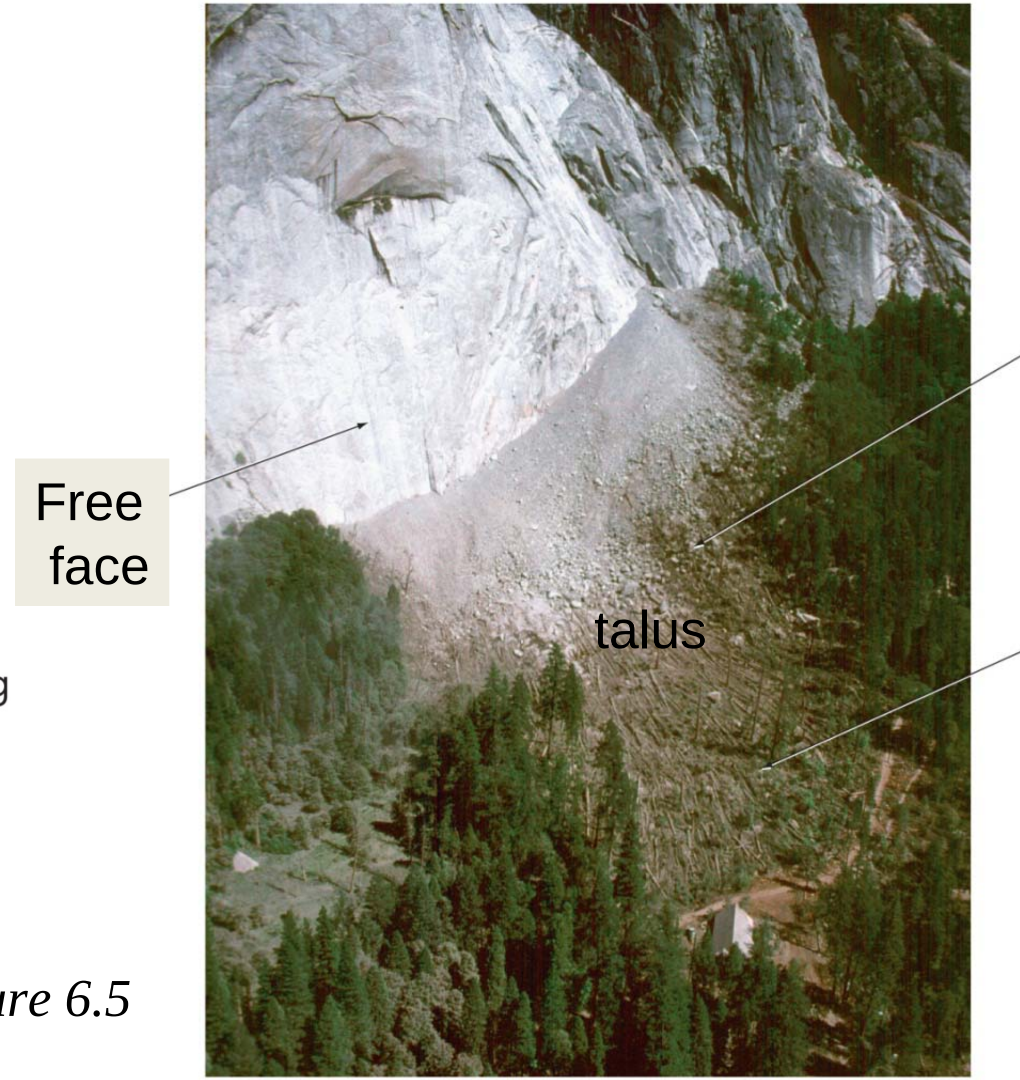


Figure 6.5

Rockfall

Note other boulders in the neighborhood – not an uncommon event

Figure 6.12

Types of landslides – Slides

- **Sliding**

  Movement of material as a coherent block

  Common along bedding planes or foliation planes

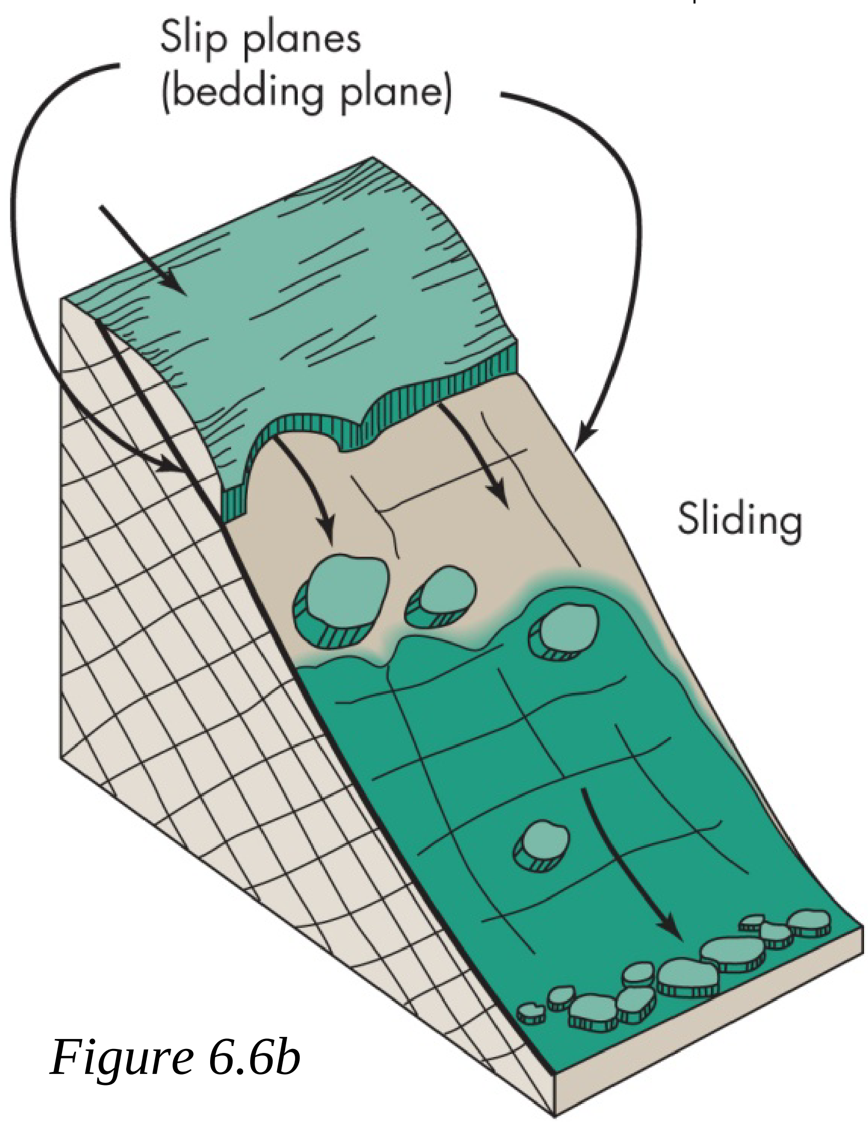
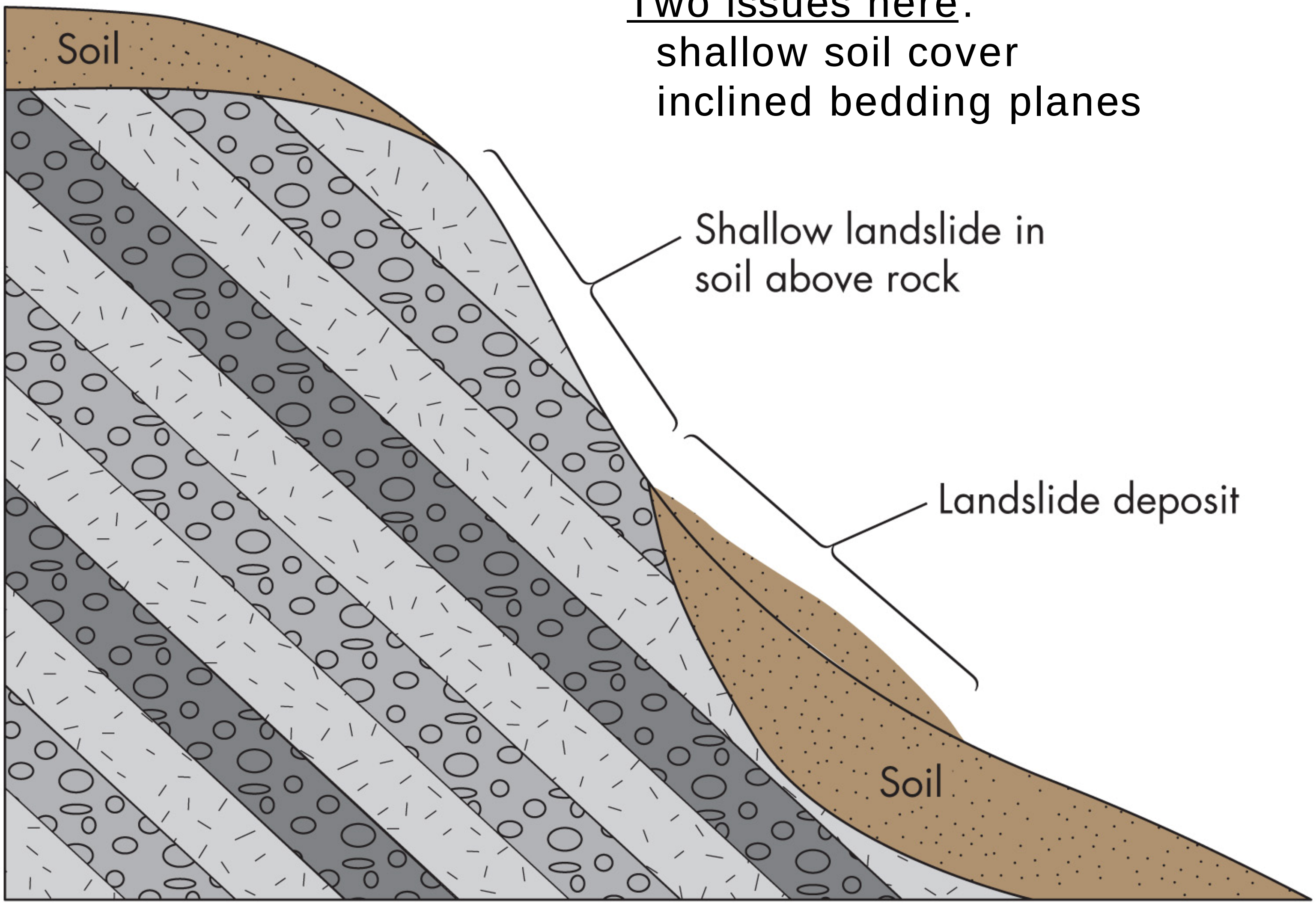


Figure 6.6b

Slope instability

<u>Two issues here</u>:
shallow soil cover
inclined bedding planes



(a)

Figure 6.10

Soil slip

Translational slide (vs. rotational)

Types of landslides – Slumps

- Slumping

  Sliding along a curved plane

  Rotates and slips down along a growth fault or ***slip plane***

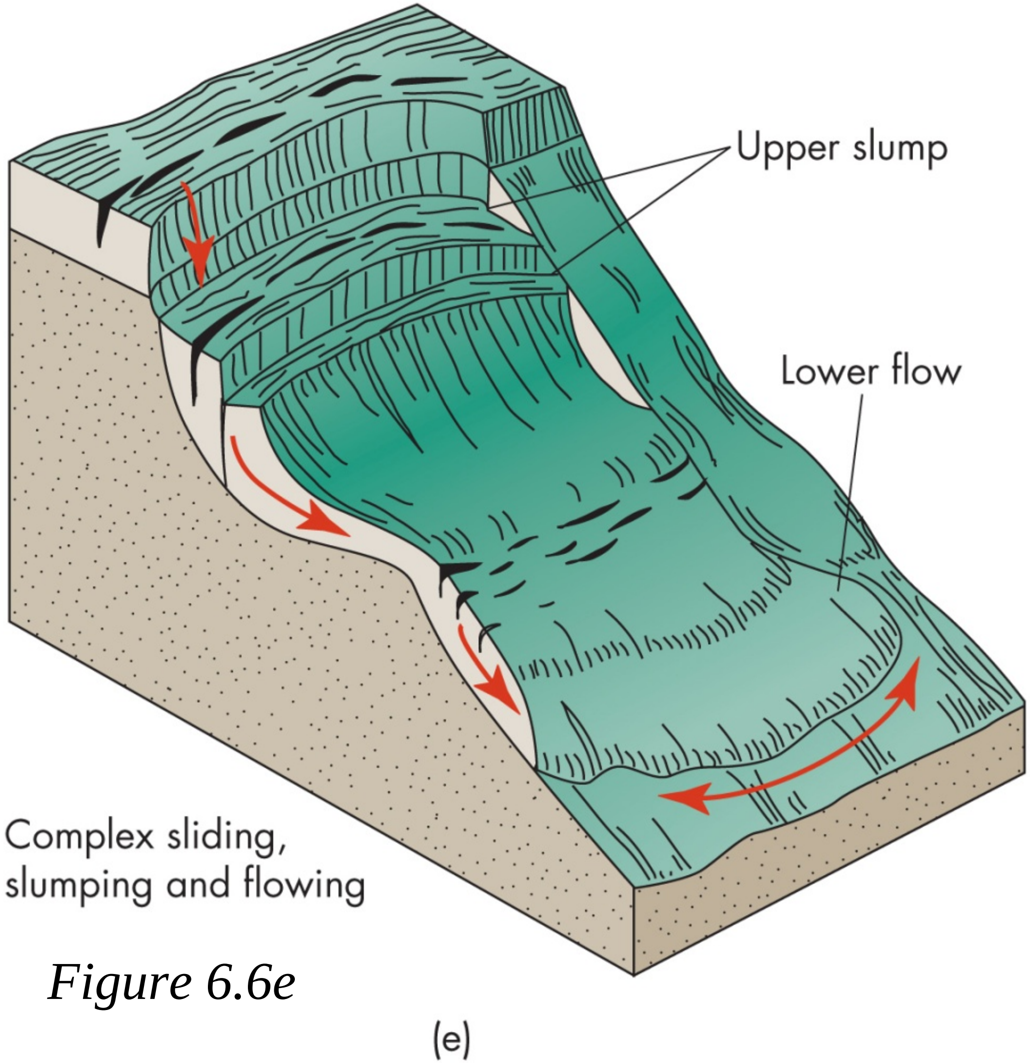


Figure 6.6e

Slumping

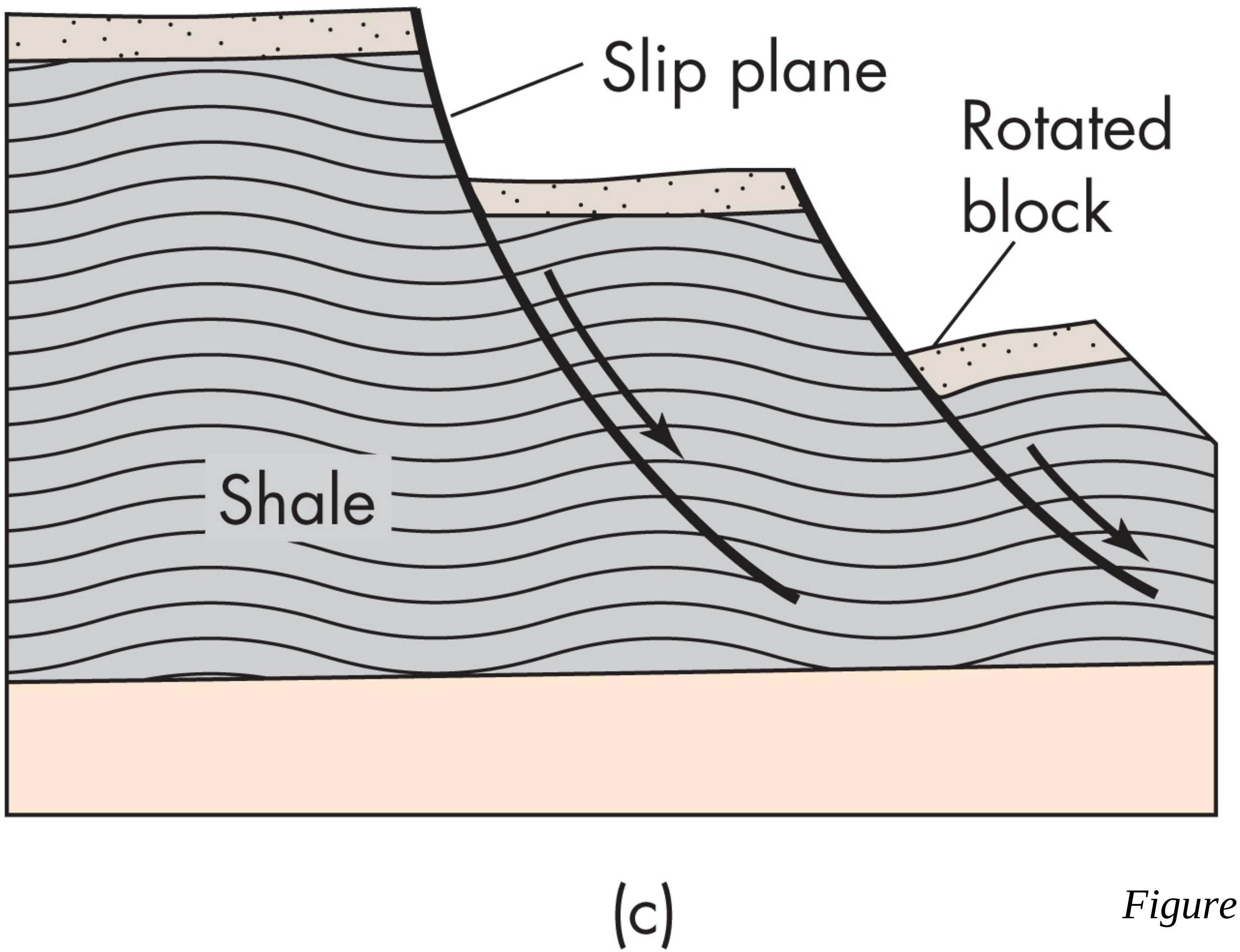


Figure 6.6c

Types of landslides – Flows

- Flow

  Movement of unconsolidated material

  - ***Slow flow*** – creep
  - ***Rapid flow*** – earthflow, debris flow, avalanche

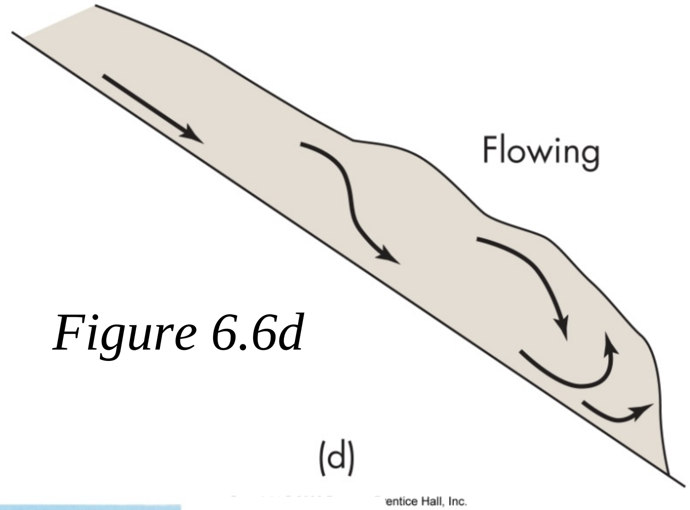


Figure 6.6d

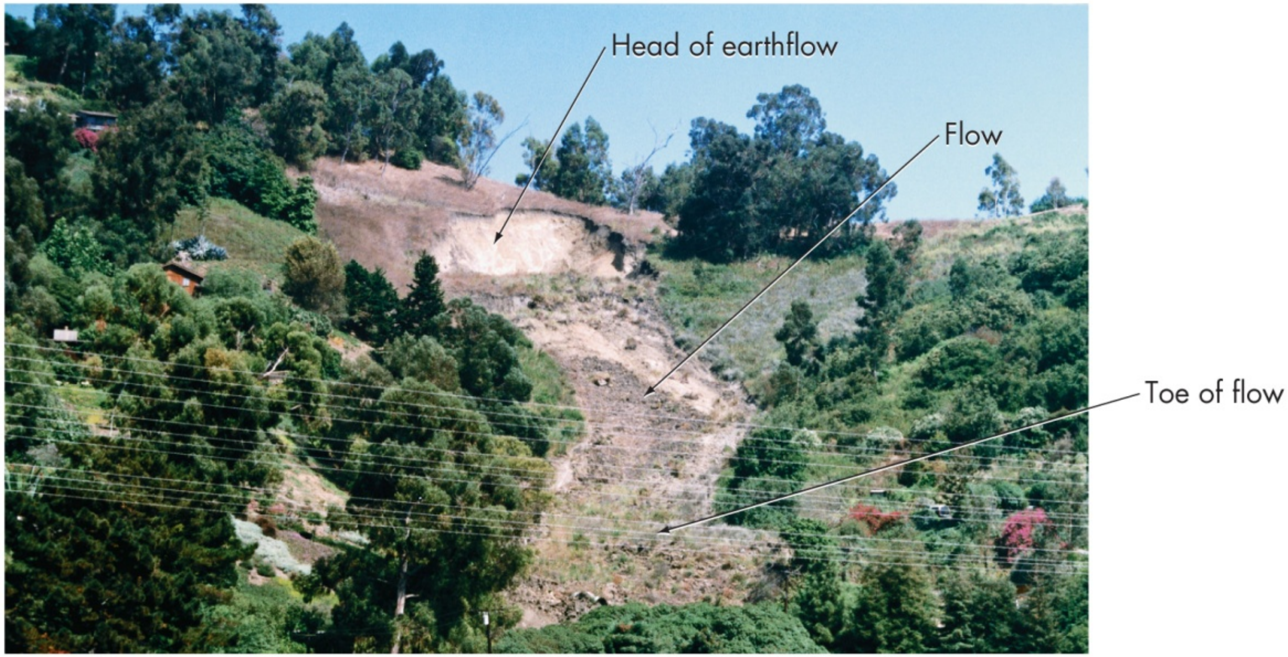
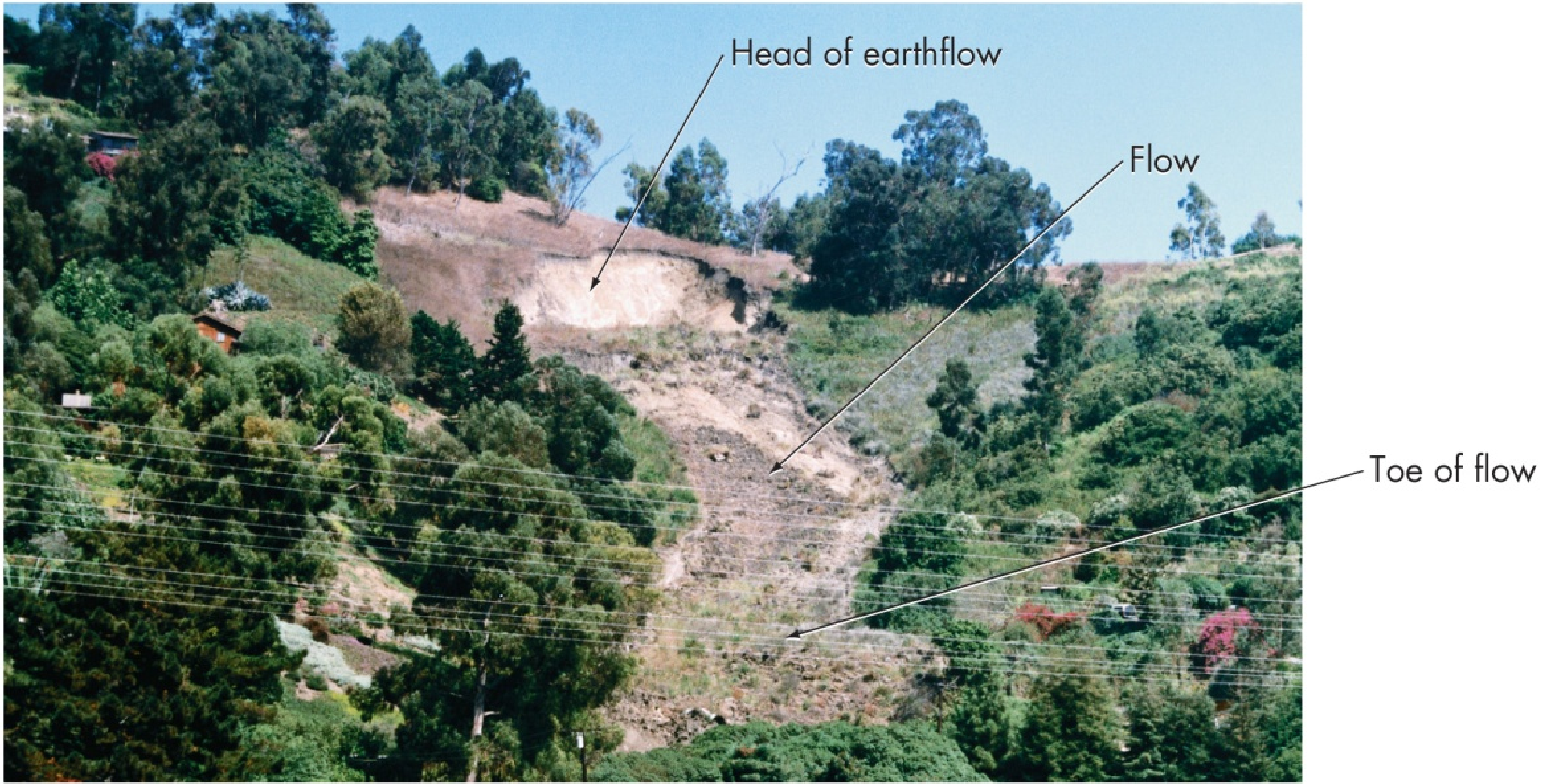


Figure 6.7

Types of landslides – Flows

Commonly associated with water saturation



An earthflow

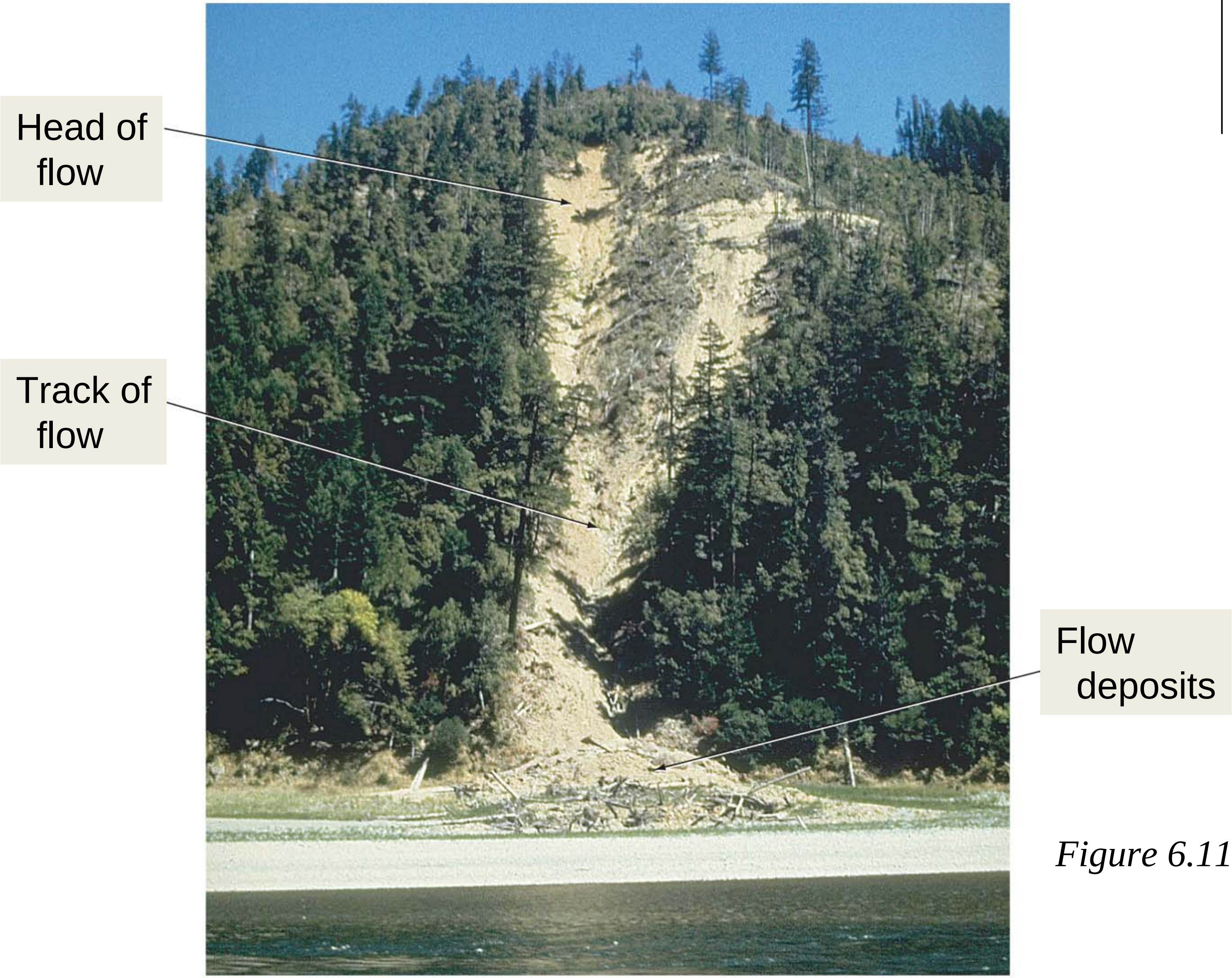


Figure 6.11b

A debris flow (more water)

Summary table in the textbook

TABLE 6.1 Common Types of Landslides and Other Downslope Movements

Mechanism	Type of Mass Movement	Characteristics
Fall	Rock fall	Individual rocks fall through the air and may accumulate as talus.
Slide	Slump	Cohesive blocks of soft earth material slide on a curved surface; also called a rotational landslide.
	Soil Slip	Soil and other weathered earth material slide on a tilted surface of bedrock or cohesive sediment; also called a debris slide or earth slide.
	Rock slide	Large blocks of bedrock slide on a planar surface, such as layering in sedimentary or metamorphic rocks.
Flow	Avalanche	Granular flow of various combinations of snow, ice, organic debris, loose rocks, or soil which moves very rapidly downslope.
	Creep	Very slow, downslope movement of rocks and soil.
	Earthflow	Wet, partially cohesive and internally deformed mass of soil and weathered rock.
	Debris flow	Fluid mixture of rocks, sand, mud, and water that is intermediate between a landslide and a water flood; includes mudflows and lahars.
	Complex	A combination of two or more types of sliding, flowage, and occasionally falls; forms where one type of landslide changes into another as it moves downslope.

Fall Slide Flow

A complex landslide

La Conchita
California 1995

between Los Angeles and Santa Barbara

at the base of an ancient sea cliff

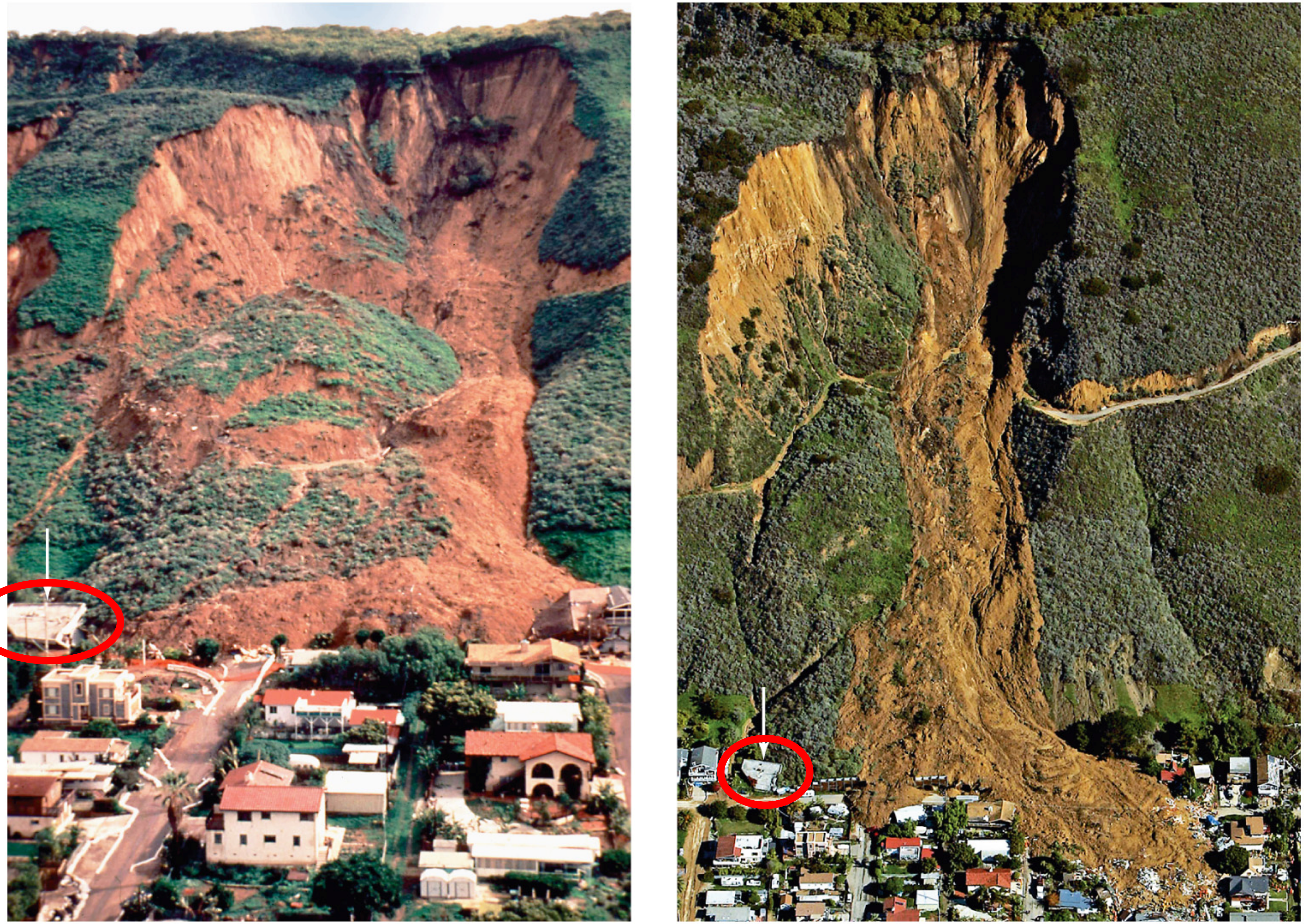
uplift rates of meters per 1000 years

* * * * * * * * * *

Make sure you read about this in the textbook

* * * * * * * * * *

And then again in 2005

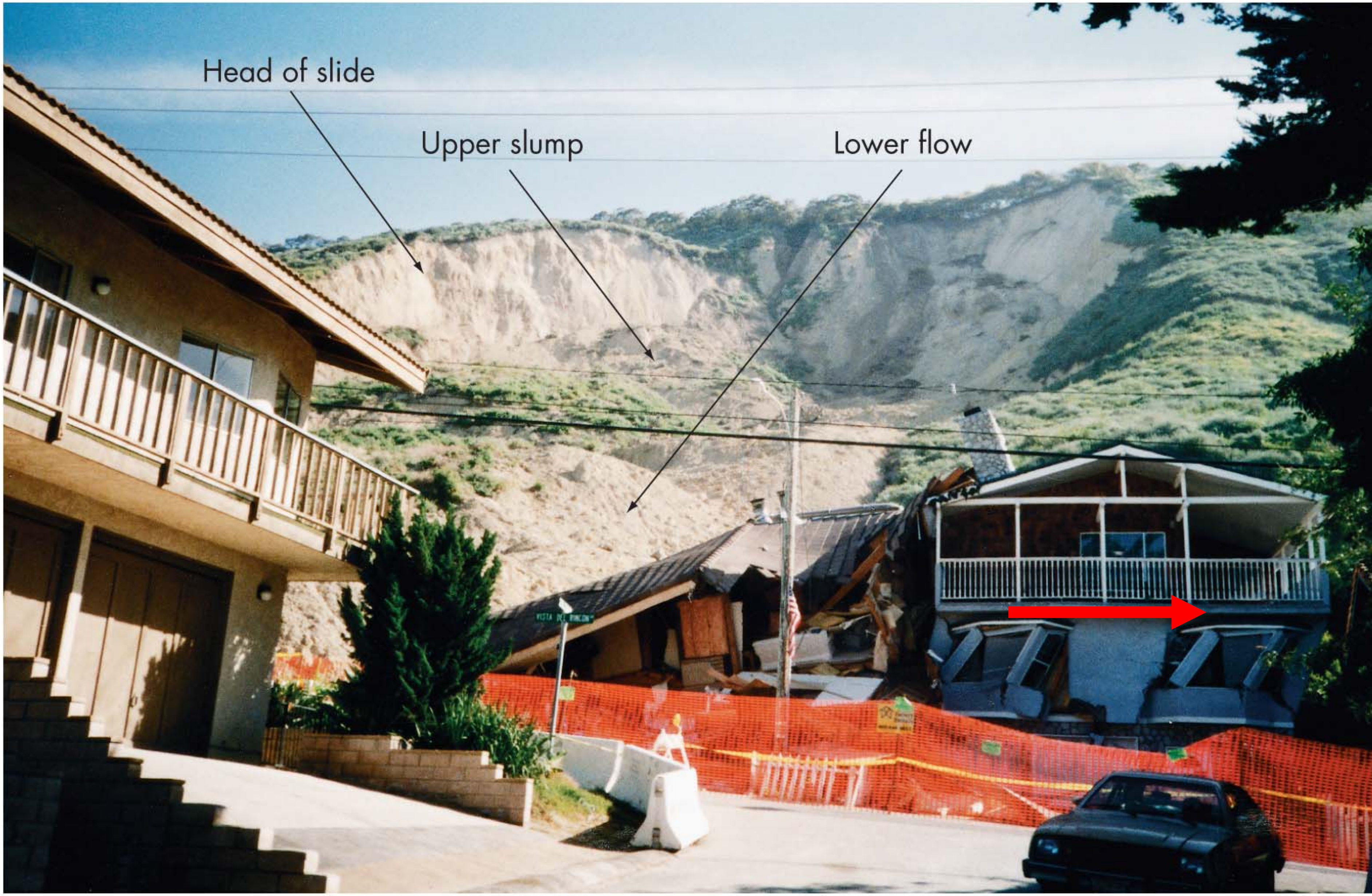


(a) (b)

Earthflow

Would retaining walls help?

What would work?


Head of slide
Upper slump
Lower flow

Forces on slopes

- Downslope driving forces
  - **Weight** of the slope material

- Resisting forces
  - Shear strength of the material

    Compare:

    granite bedrock

    weathered granite

    consolidated sandstone

    dry sand // wet sand

    mud

Forces on slopes

- Type of material and result
  - ***Slope failure*** – weak materials

    volcanic rocks, shale

    earthflows, debris flows, or slumps
  - ***Rock falls*** – resistant rock over weak rock

- Degree of consolidation
  - ***Slumps*** – unconsolidated materials (loose sediments)
  - ***Soil slip*** – unconsolidated materials over bedrock

Forces on slopes: Other conditions

- Steepness of slope // Topographic relief

  Compare Toledo with Boulder, Colorado

- Zones of weakness – potential slip planes

Really Important – Addition of Water

- Permeability

  especially when layers have contrasts in permeability

What does water DO that makes slopes unstable?

Forces on slopes:

- Climate
  - Amount and timing of water input (How?)
  - Vegetation on the slope

Arid regions

rock falls, debris flows

Humid regions

complex landslides, earthflows, and creep

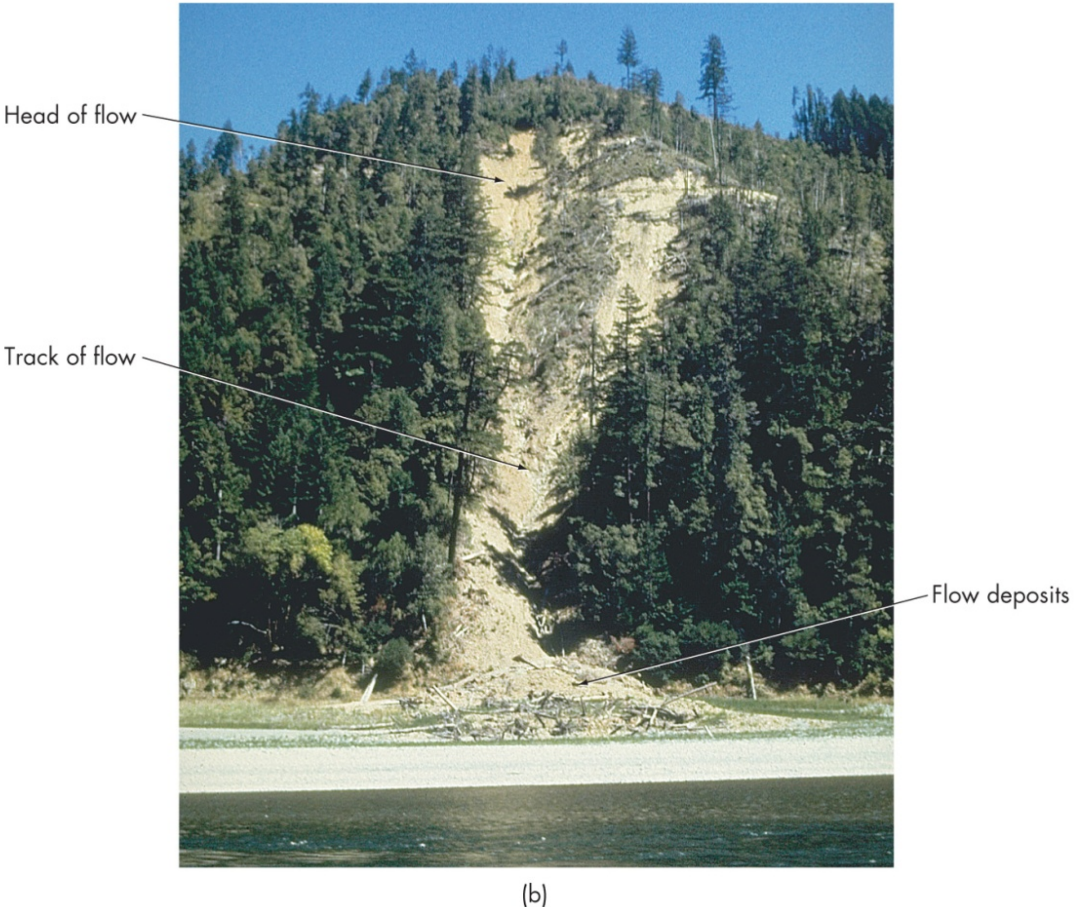


Figure 6.11b

Geographic regions at risk from landslides

Anywhere with significant slopes and mountains

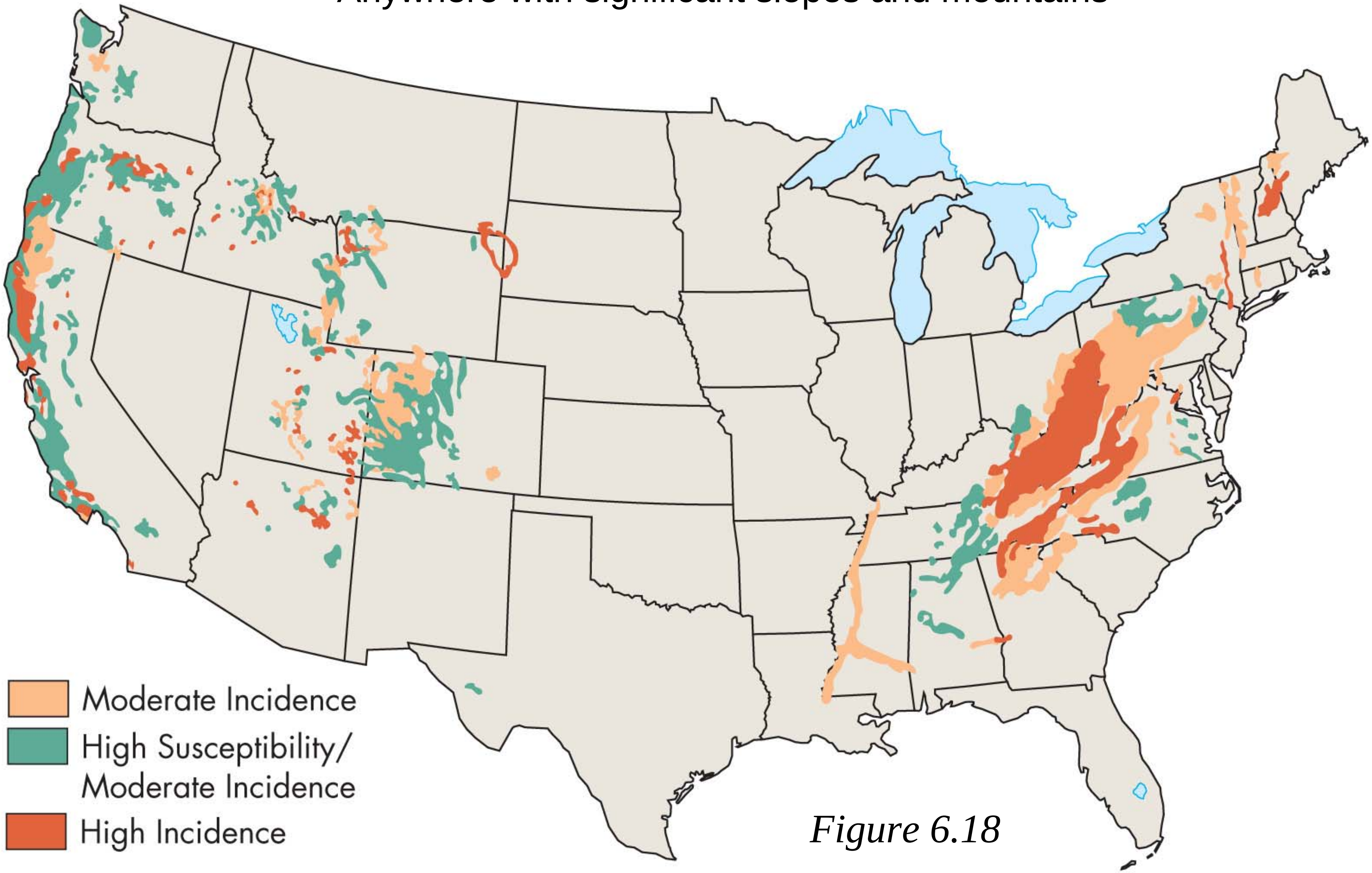


Figure 6.18

Links to other natural hazards

- Earthquakes, volcanoes, storms, and fires may cause landslides.
- Landslides may cause flooding or tsunamis.

Thistle, Utah

1983

Landslide blocks a canyon, floods upstream community

Site of a former landslide, and moved again in 1999

Figure 6.27

Factors that increase landslide potential

- Natural processes
  - Cutbank of a meandering river
  - Shoreline erosion undercutting a cliff
  - Extremes in precipitation

Curve in coastline identifies slide

Santa Barbara, CA

Santa Barbara, CA

Coast of Oregon

Factors that increase landslide potential

Urbanization and development of landslide-prone areas

Tree cutting in landslide-prone areas

Changing global climate patterns

Various effect of urbanization

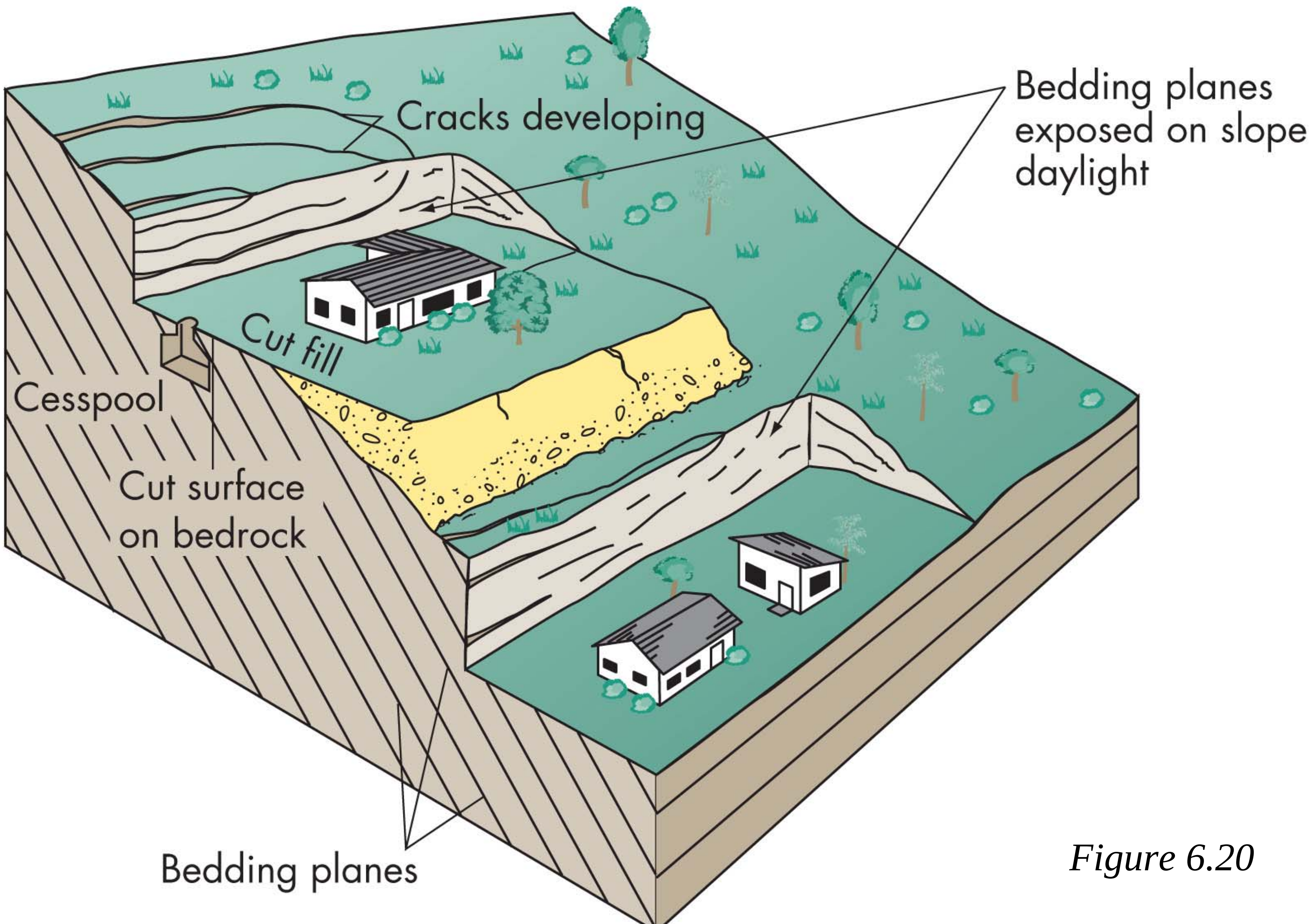


Figure 6.20

Factors that increase landslide potential

- Clearcutting and road construction
  - Increase erosion on unstable slopes
  - Redirect surface drainage
  - Change flow of groundwater

Upslope and downslope hazards

Figure 6.13

Road undercut by stream meander

Figure 6.15a

Reducing landslide hazard

- Drainage control – minimize infiltration

Surface drain

(a)

Soil cement being applied

(b)

Figure 6.22

Reducing landslide hazard

- Grading

- Slope supports and retaining walls

Figure 6.25

Stabilizing slopes

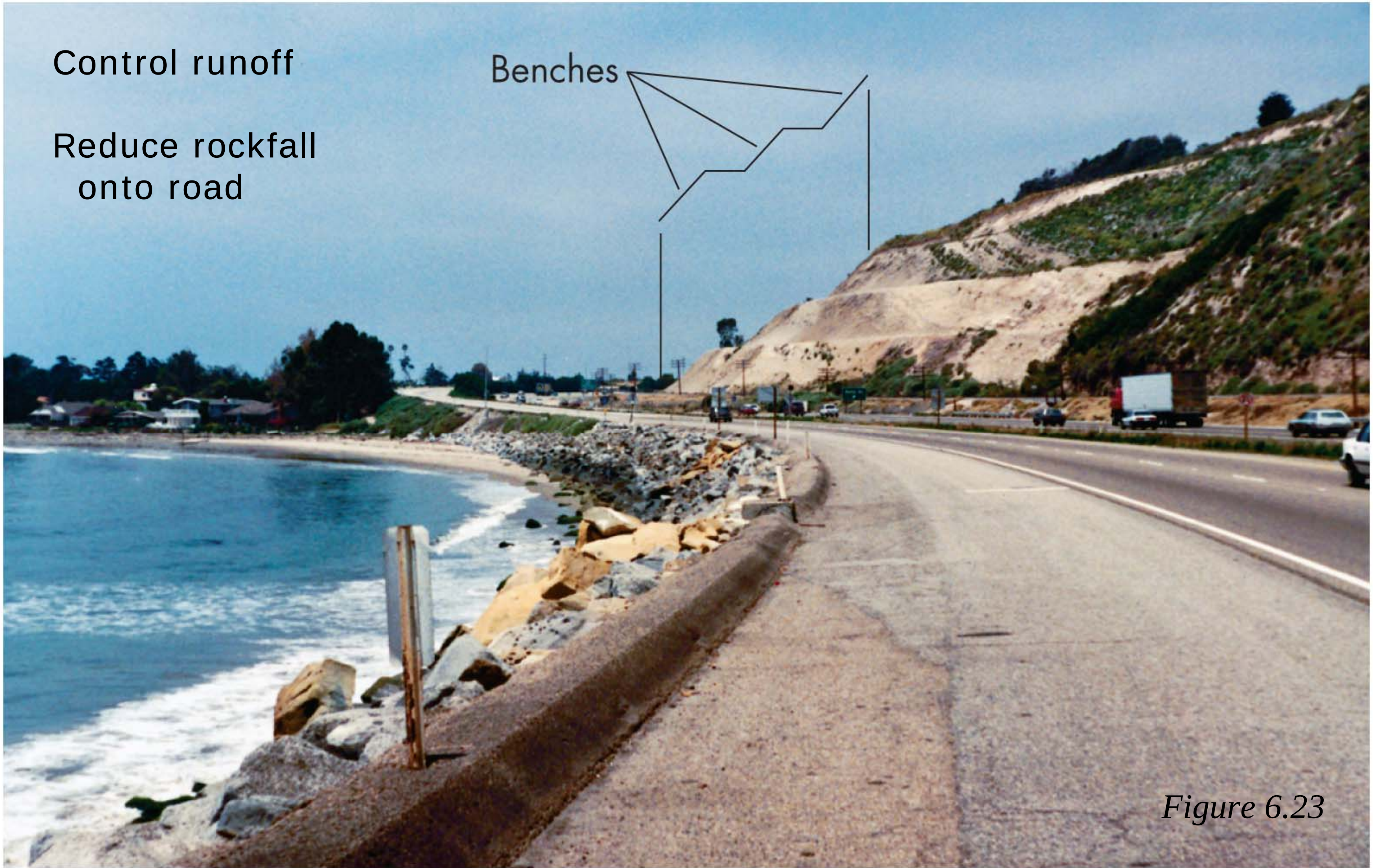


Figure 6.23

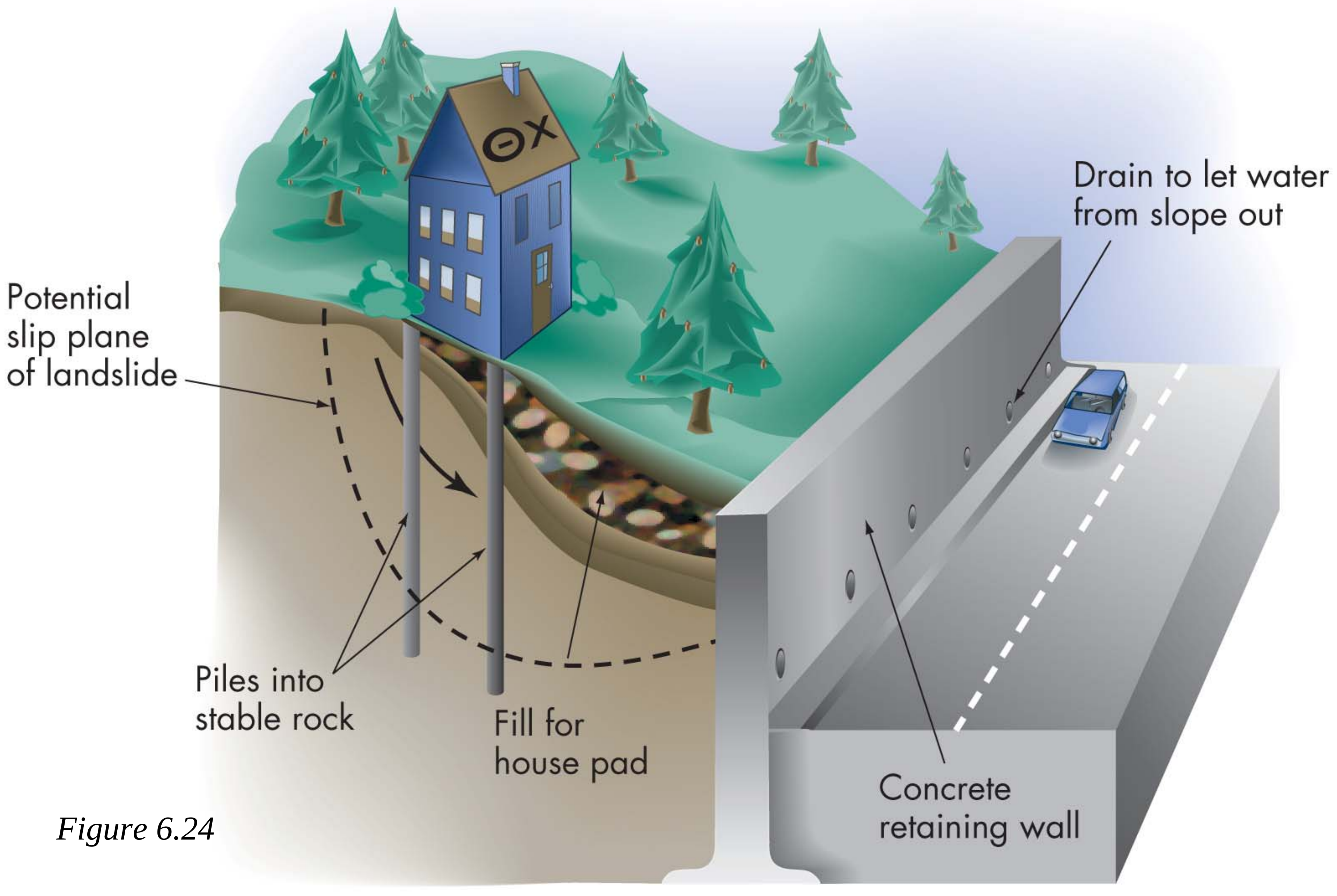

Drain to let water from slope out
Potential slip plane of landslide
Piles into stable rock
Fill for house pad
Concrete retaining wall

Figure 6.24

Architecture & engineering

Architecture & engineering

Architecture & engineering

End