Essentials of Geology, 11e

Crustal Deformation and Mountain Building
Chapter 17

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Deformation

- **Deformation is a general term that refers to all changes in the original form and/or size of a rock body**
- **Most crustal deformation occurs along plate margins**
- **Factors that influence the strength of a rock**
  - **Temperature and confining pressure**
  - **Rock type**
  - **Time**

Folds

- **Rocks bent into a series of waves**
- **Most folds result from compressional forces which shorten and thicken the crust.**
- **Ductile deformation.**
- **High temperature, soft rock, long time.**
- **Types of folds**
  - **Anticline – upfolded, or arched, rock layers**
  - **Syncline – downfolded rock layers**

Folds

Types of folds:

- **Anticlines and synclines can be**
  - **Symmetrical - limbs are mirror images**
  - **Asymmetrical - limbs are not mirror images**
  - **Overturned - one limb is tilted beyond the vertical**
- **Where folds die out they are said to be plunging**

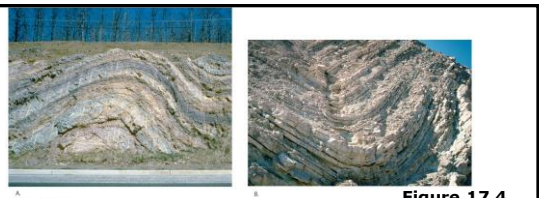


Figure 17.4

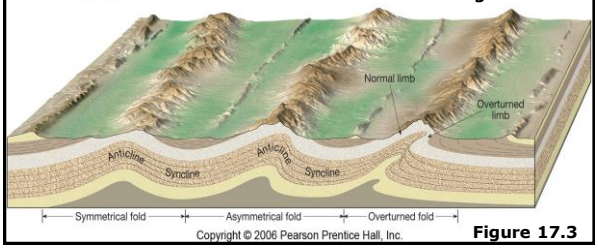


Figure 17.3

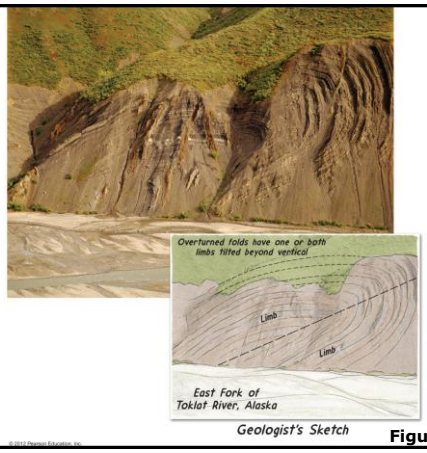
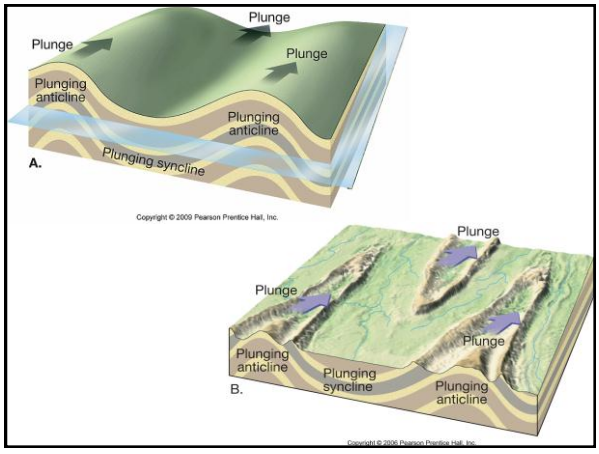


Figure 17.5



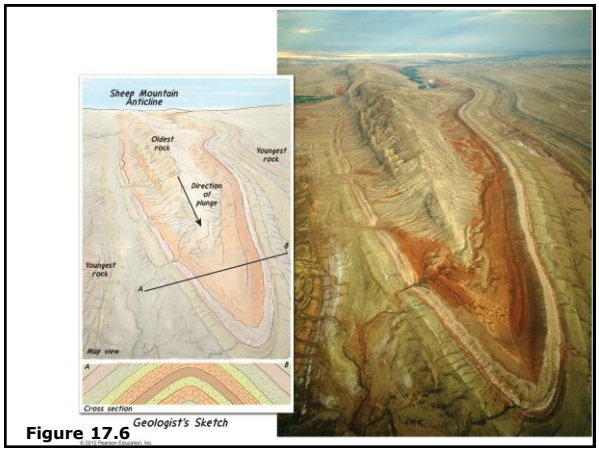


Figure 17.6

Folds

Types of folds:

- **Other types of folds-**
  - **Dome**
    - **Circular, or slightly elongated**
    - **Upwarped displacement of rocks**
    - **Oldest rocks in core**
  - **Basin**
    - **Circular, or slightly elongated**
    - **Downwarped displacement of rocks**
    - **Youngest rocks in core**

The Black Hills of South Dakota are a

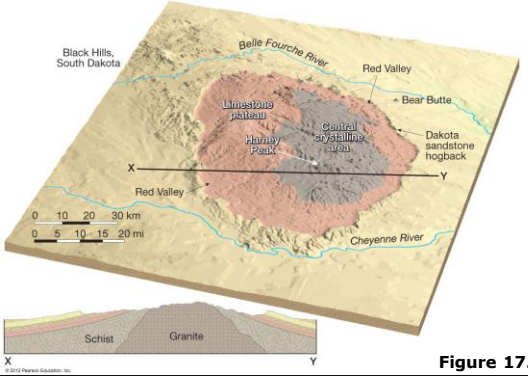


Figure 17.7

The Bedrock Geology of the Michigan Basin

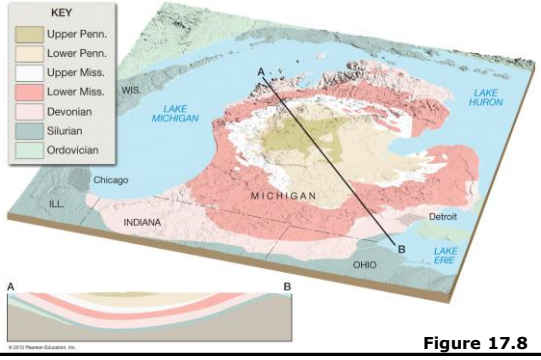


Figure 17.8

Faults

- **Faults are fractures (breaks) in rocks along which appreciable displacement has taken place**
- **Brittle deformation**
- **Low temperature, hard rock, short time**
- **2 Main types of faults (dip-slip, strike-slip)**
  - **Dip-slip fault**
    - **Movement along the inclination (dip) of fault plane**
    - **Parts of a dip-slip fault**
      - **Hanging wall – the rock above the fault surface**
      - **Footwall – the rock below the fault surface**

Concept of Hanging Wall and Footwall Along a Fault

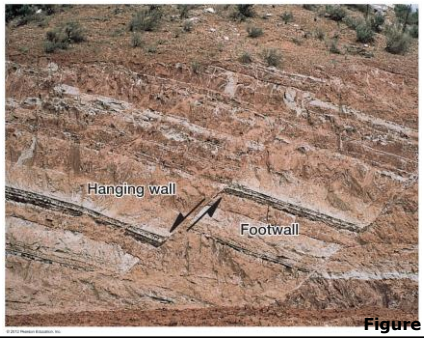


Figure 17.10

Faults

Types of faults:

- **Dip-slip fault**
  - **3 types of dip-slip faults (normal, reverse, and thrust)**
    - **Normal fault**
      - **Hanging wall block moves *down***
      - **Associated with fault-block mountains**
      - **Prevalent at spreading centers**
      - **Caused by *tensional* forces**
      - **Thins and lengthens the crust**

A Normal Fault

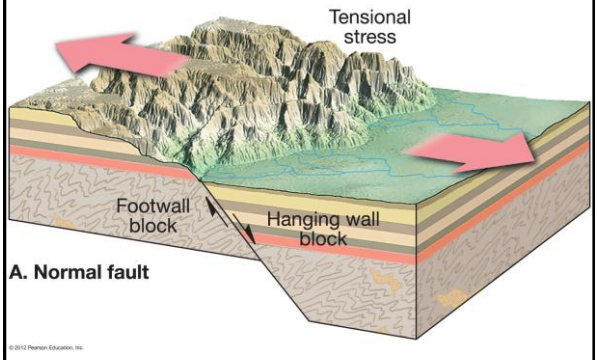


Figure 17.11 A

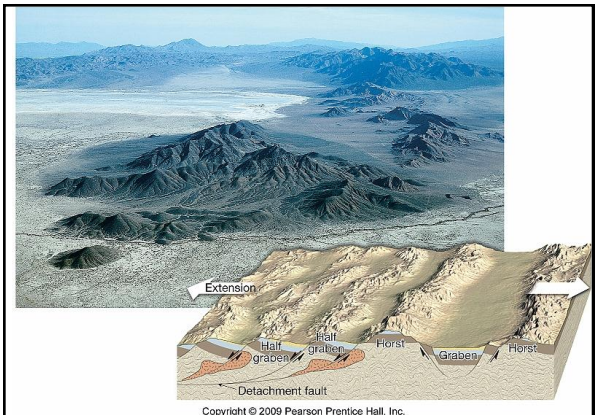


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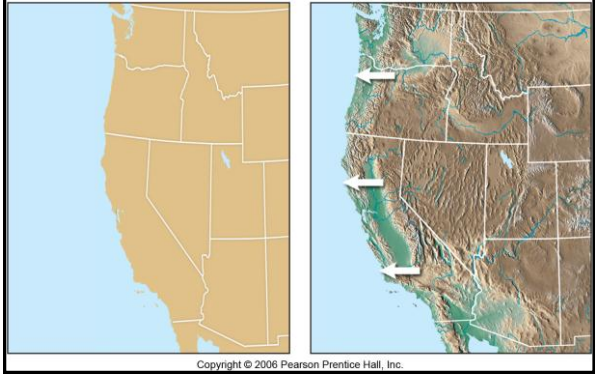
Figure 17.12

Crustal Extension



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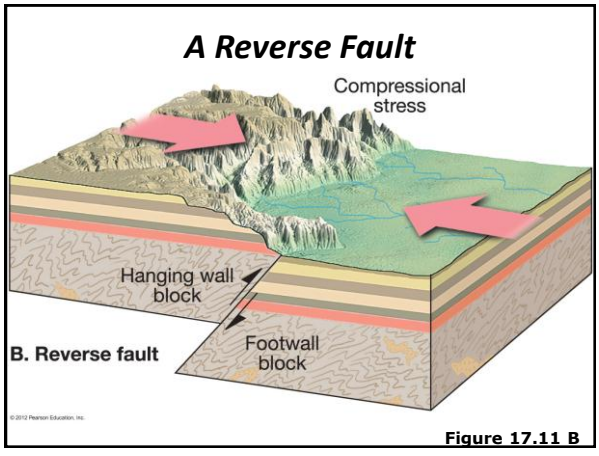
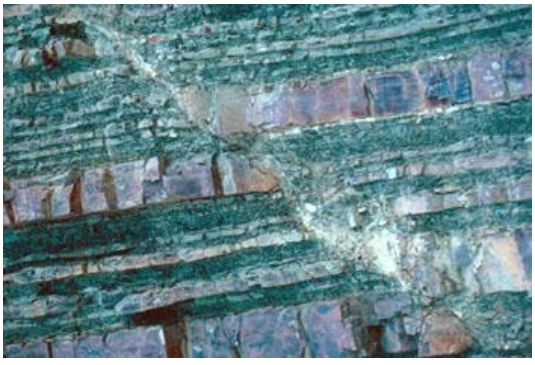
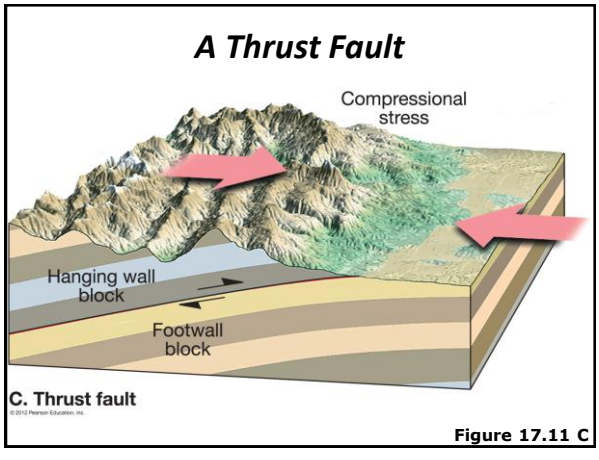
Faults

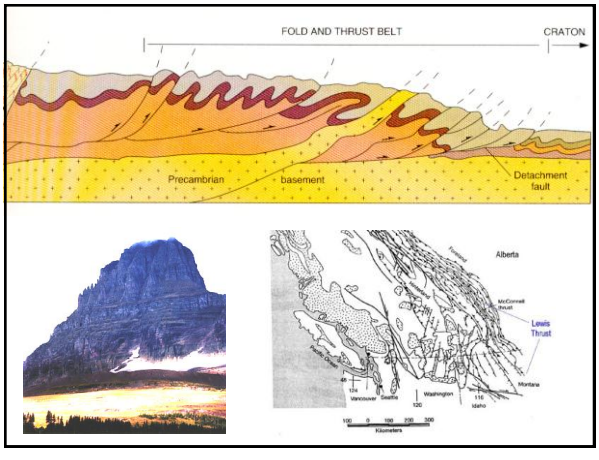
Types of faults:

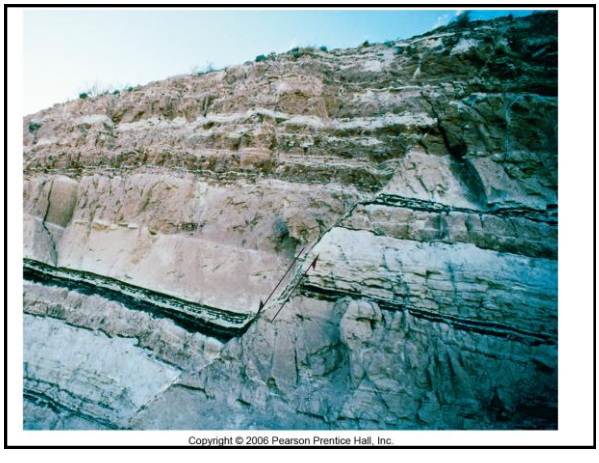
- **Dip-slip fault**
  - **Types of dip-slip faults**
    - **Reverse and thrust faults**
      - **Hanging wall block moves *up***
      - **Caused by strong *compressional* stresses**
      - **Thickens and shortens the crust**
      - **Reverse fault - dips greater than 45º**
      - **Thrust fault - dips less than 45º**











Faults

Types of faults:

- **Strike-slip faults**
  - **Dominant displacement is horizontal and parallel to the trend, or strike**
  - **Transform fault**
    - **Large strike-slip fault that cuts through the lithosphere**
    - **Often associated with plate boundaries**
    - **Right or left lateral**

A Strike-slip Fault

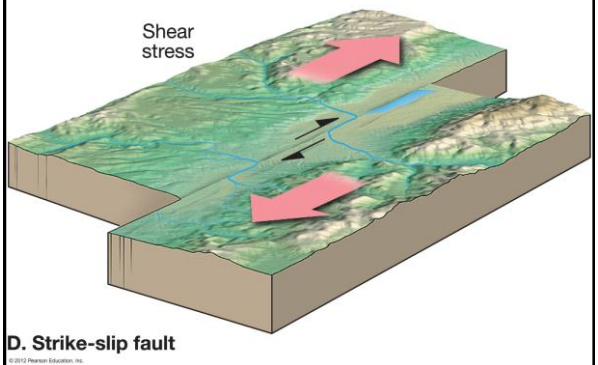


Figure 17.11 D

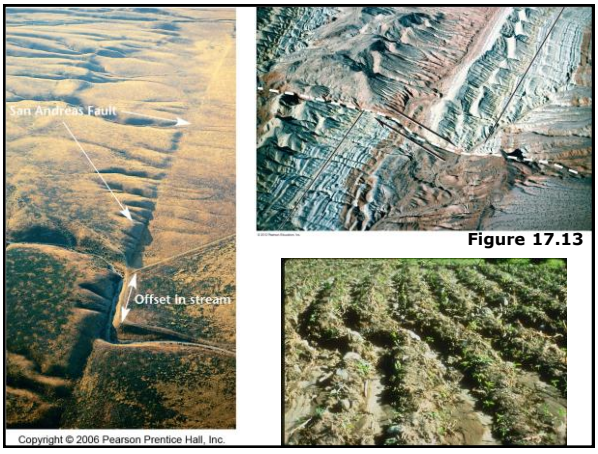


Figure 17.13

Faults

Types of faults:

- **Joints**
  - **Fractures along which no meas- urable displacement has occurred**
  - **Most are formed whe rocks in the outer- most crust are deformed**

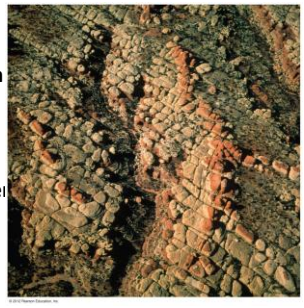


Figure 17.14

Mountain belts

- **Orogenesis refers to processes that collectively produce a mountain belt.**

Figure 17.15

Mountain belts

Mountain building at convergent boundaries (most common):

3 subtypes… O-C C-C O-O

- **Volcanic Island Arc (O-O)**
  - **Oceanic-oceanic crust convergence**
  - **Mafic volcanoes in the ocean**
  - **e.g. Aleutian Islands, AK**

Volcanic Island Arc

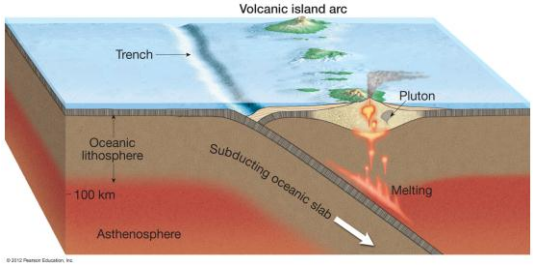


Figure 17.16

Mountain belts

Mountain building at convergent boundaries (most common):

- **Andean-type mountain building (O-C)**
  - Oceanic-continental crust convergence
  - e.g. Andes Mountains
  - Types related to the overriding plate
    - Passive margins
      - Prior to the formation of a subduction zone
      - e.g. East Coast of North America

Mountain belts

Mountain building at convergent boundaries (most common):

- **Andean-type mountain building (O-C)**
  - Types related to the overriding plate
    - Active continental margins
      - Subduction zone forms
      - Deformation process begins
    - *Continental* volcanic arc forms
    - Accretionary wedge forms
    - Examples of inactive Andean-type orogenic belts include Sierra Nevada Range and California's Coast Ranges

Orogenesis Along an Andean-type Passive Margin

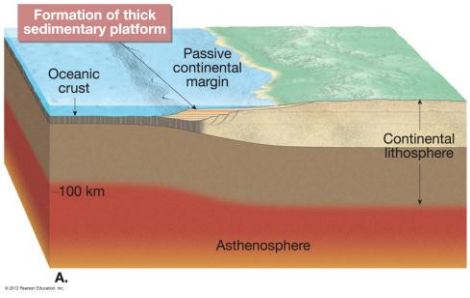


Figure 17.17 A

Orogenesis Along an Andean-type Subduction Zone

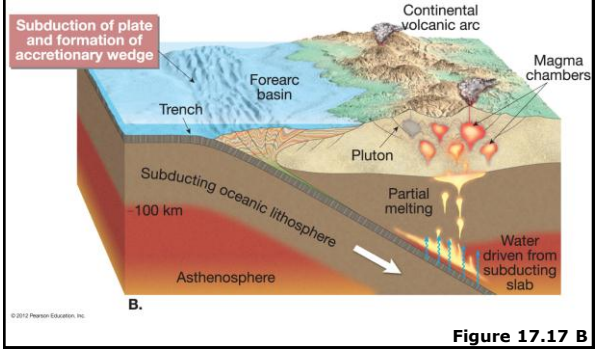


Figure 17.17 B

Orogenesis Along an Andean-type Accretionary Wedge

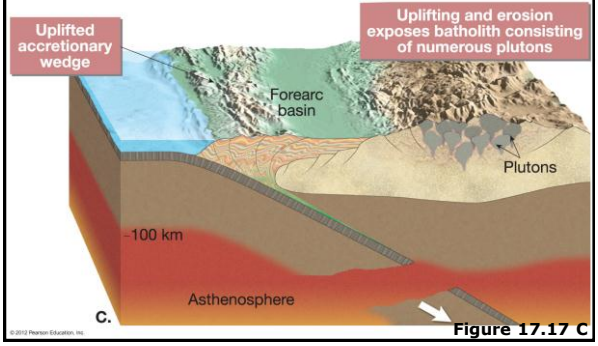


Figure 17.17 C

Mountain belts

Mountain building at convergent boundaries (most common):

- **Continental collisions (C-C)**
  - Where two plates with continental crust converge and compress.
  - e.g., India and Eurasian plate collision
    - Himalayan Mountains and the Tibetan Plateau

Formation of the Himalayas

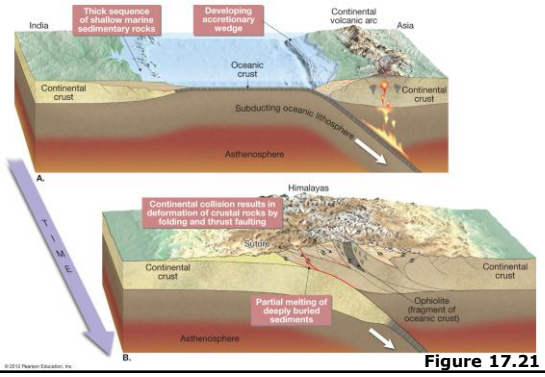
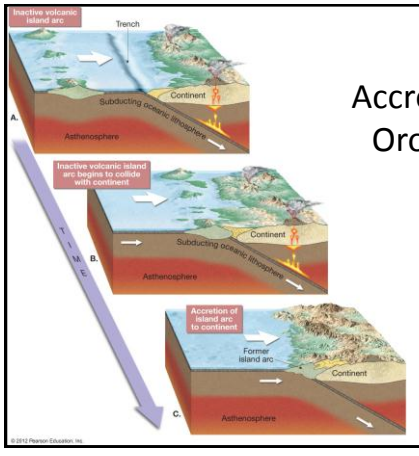


Figure 17.21

Mountain belts

Mountain building at convergent boundaries (most common):

- **Continental accretion**
  - **Third mechanism of mountain building**
  - **Small crustal fragments collide with and accrete to continental margins**
  - **Accreted crustal blocks are called terranes**
  - **Occurred along the Pacific Coast**

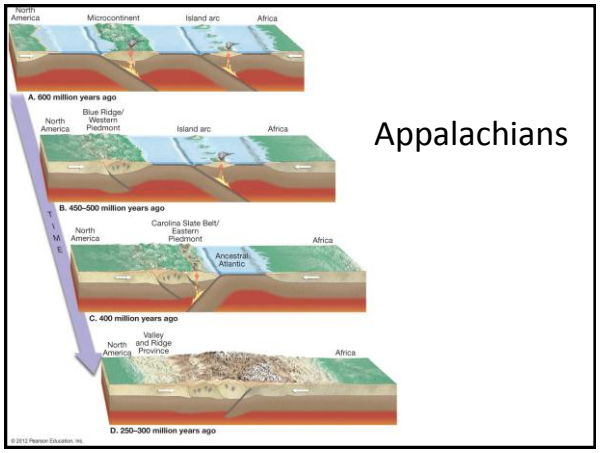


Accretion and Orogenesis

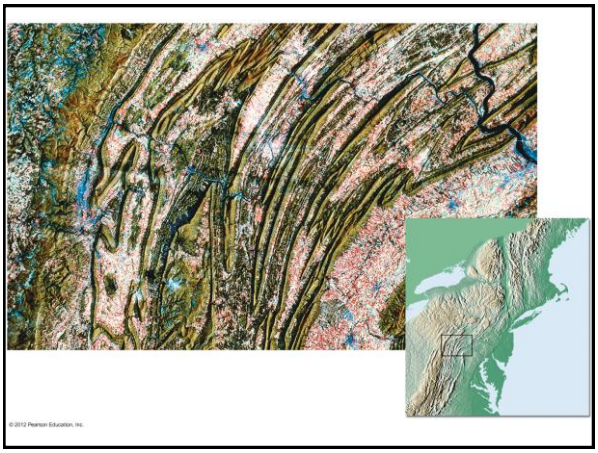
Figure 17.19

Accreted Terranes Along the Western Margin of North America

Figure 17.20



Appalachians



Mountain belts

- **Buoyancy and the principle of isostasy**
  - **Evidence for crustal uplift includes wave-cut platforms high above sea level**
  - **Reasons for crustal uplift**
    - **Not so easy to determine**
    - **Isostasy (2 main points)**
      - **Concept of a floating crust in gravitational balance**
      - **When weight is removed from the crust, crustal uplifting occurs**
        - **Process is called isostatic adjustment**

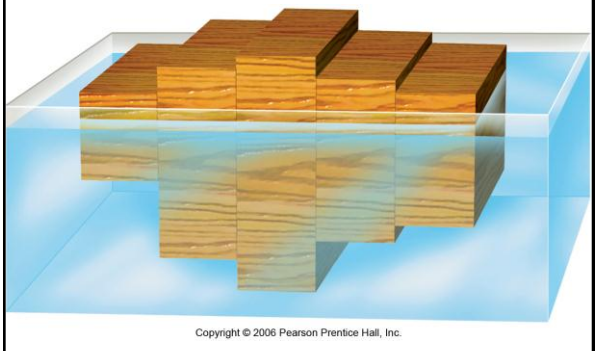


Figure 17.26

Erosion and Resulting Isostatic Adjustment of the Crust

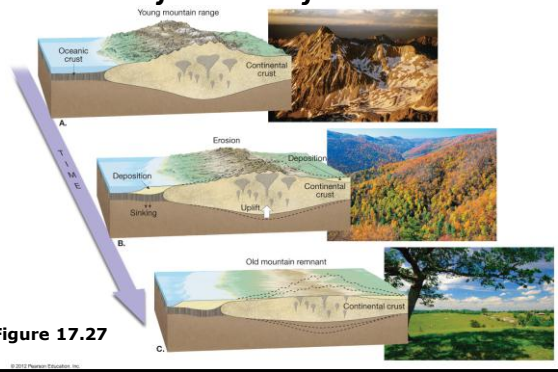


Figure 17.27

End of Chapter 17