LIVING IN THE ENVIRONMENT, 18e

G. TYLER MILLER • SCOTT E. SPOOLMAN

14

Nonrenewable Mineral Resources

Core Case Study: The Crucial Importance of Rare-Earth Metals

- Crucial to the technologies that support today's lifestyles and economies
  - Used to make LCDs, LED light bulbs, fiber optic cables, cell phones, and digital cameras
- Without affordable supplies of rare earth elements, we could not develop cleaner technologies

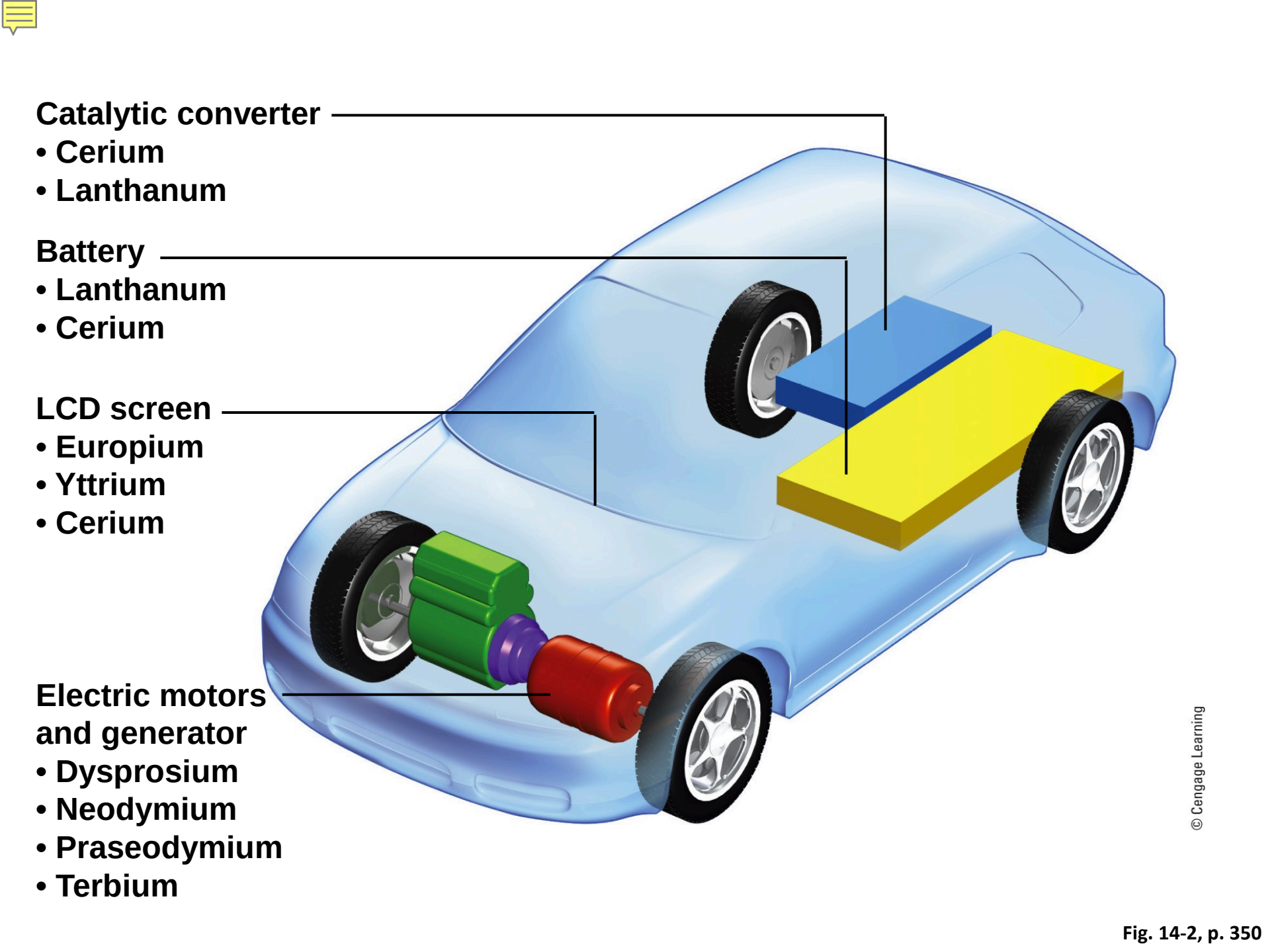

Catalytic converter
• Cerium
• Lanthanum
Battery
• Lanthanum
• Cerium
LCD screen
• Europium
• Yttrium
• Cerium
Electric motors and generator
• Dysprosium
• Neodymium
• Praseodymium
• Terbium
© Cengage Learning

Fig. 14-2, p. 350

14-1 What Are the Earth's Major Geological Processes/Mineral Resources?

- Dynamic processes within the earth and on its surface produce the mineral resources on which we depend
- Mineral resources are nonrenewable
  - Produced and renewed over millions of years mostly by the earth's rock cycle

The Earth Is a Dynamic Planet

- Geology
  - Study of dynamic processes taking place on earth's surface and in earth's interior
- Three major concentric zones of the earth
  - Core
  - Mantle, including the asthenosphere
  - Crust
    - Continental crust
    - Oceanic crust: 71% of crust

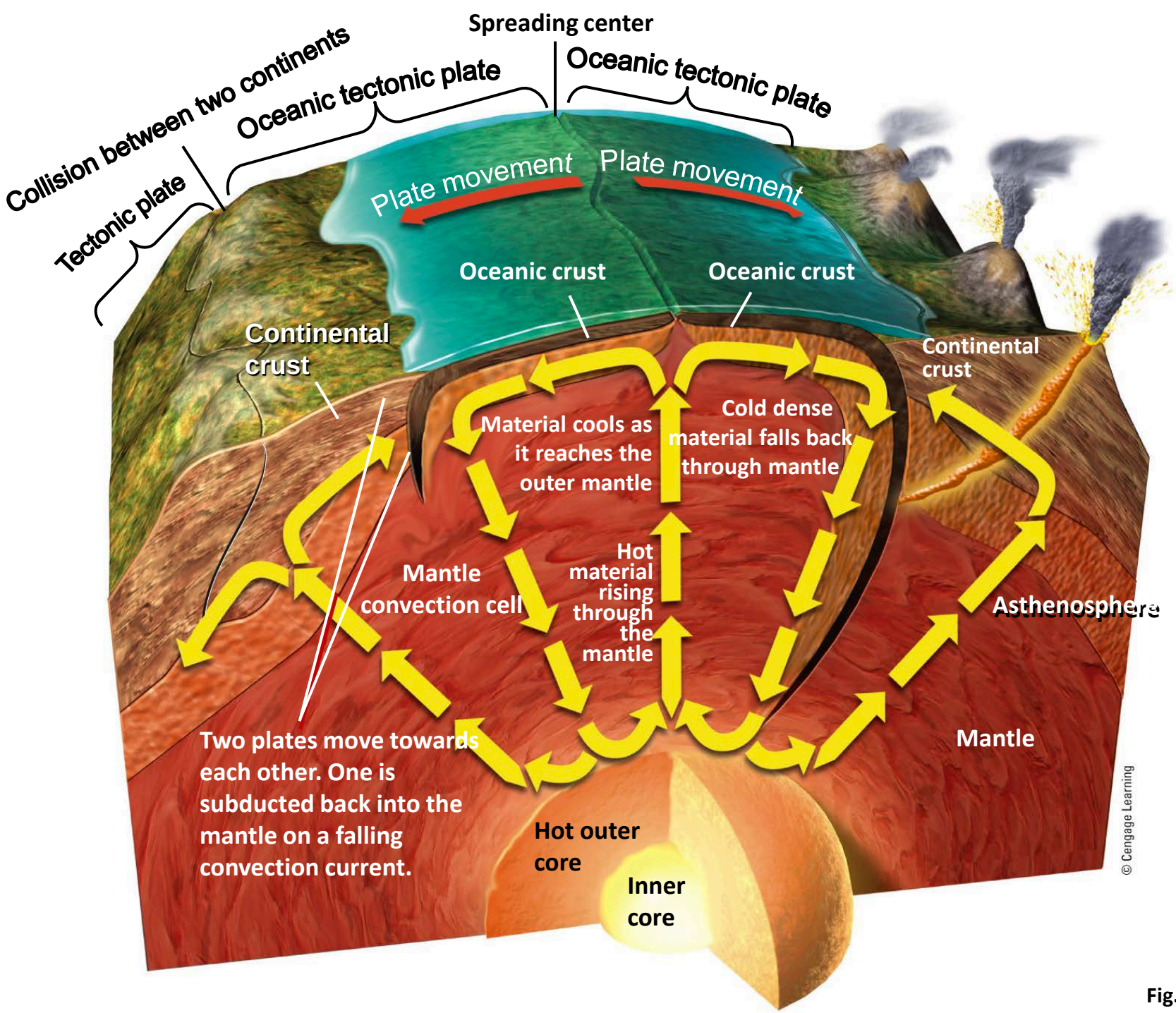

Spreading center
Collision between two continents
Oceanic tectonic plate
Oceanic tectonic plate
Tectonic plate
Plate movement
Plate movement
Oceanic crust
Oceanic crust
Continental crust
Continental crust
Material cools as it reaches the outer mantle
Cold dense material falls back through mantle
Hot material rising through the mantle
Mantle convection cell
Asthenosphere
Two plates move towards each other. One is subducted back into the mantle on a falling convection current.
Mantle
Hot outer core
Inner core
© Cengage Learning

Fig. 14-3, p. 351

What Are Minerals and Rocks?

- Mineral
  - Naturally occurring compound that exists as a crystalline solid
- Mineral resource
  - Concentration that we can extract and process into raw materials
- Rock
  - Solid combination of one or more minerals

What Are Minerals and Rocks? (cont'd.)

- Sedimentary rock
  - Made of sediments
    - Dead plant and animal remains
    - Tiny particles of weathered and eroded rocks
- Igneous rock
  - Intense heat and pressure
- Metamorphic rock
  - Existing rock subjected to high temperatures, pressures, fluids, or a combination

Earth's Rocks Are Recycled Very Slowly

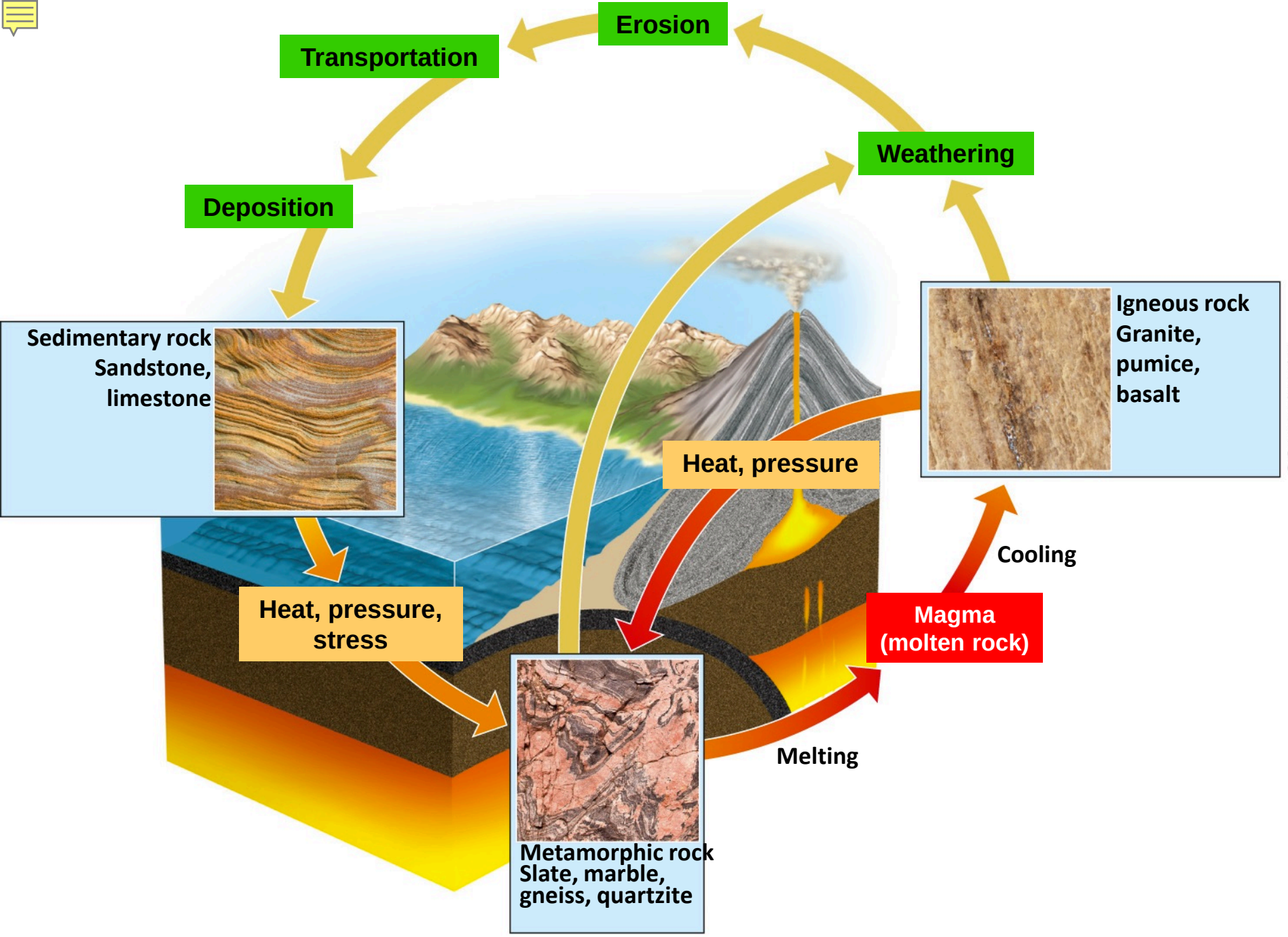
- Rock cycle
  - Rocks are recycled over millions of years
  - Erosion, melting, and metamorphism
  - Slowest of earth's cycle processes

We Depend on a Variety of Nonrenewable Mineral Resources

- Ore
  - Contains profitable concentration of a mineral
  - High-grade ore
  - Low-grade ore
- Metallic mineral resources
  - Aluminum
  - Iron for steel
  - Copper

We Depend on a Variety of Nonrenewable Mineral Resources (cont'd.)

- Nonmetallic mineral resources
  - Sand, gravel, and limestone
- Reserves
  - Estimated supply of a mineral resource



Left: Dwight Smith/Shutterstock.com. Center: LesPalenik/Shutterstock .com. Right: ©Bragin Alexey/Shutterstock.com.

Fig. 14-5, p. 353

How Long Might Supplies of Nonrenewable Mineral Resources Last?

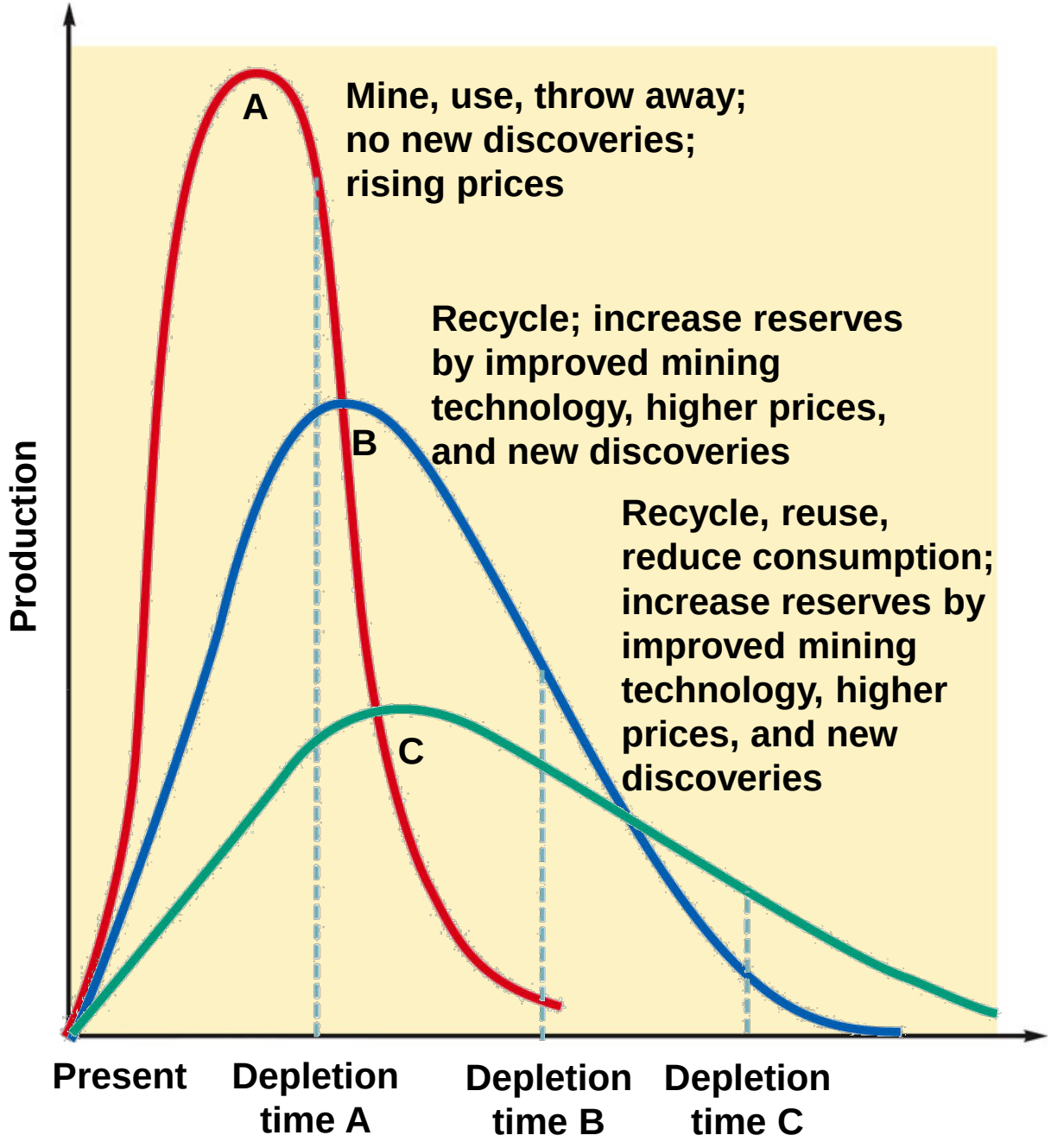
- Nonrenewable mineral resources exist in finite amounts
  - Can become economically depleted when it costs more than it is worth to find, extract, and process the remaining deposits
- There are several ways to extend supplies of mineral resources
  - But each of these is limited by economic and environmental factors

Supplies of Nonrenewable Mineral Resources Can Be Economically Depleted

- Reserves
  - Identified deposits from which we can extract the mineral profitably
- Depletion time
  - Time to use a certain portion of reserves

Nonrenewable Mineral Resources Can Be Economically Depleted (cont'd.)

- When a resource becomes economically depleted:
  - Recycle or reuse existing supplies
  - Waste less
  - Use less
  - Find a substitute
  - Do without



Stepped Art

Fig. 14-6, p. 360

Global and U.S. Rare-Earth Supplies

- Rare-earth elements aren't really rare
- China produces 97% of the world's rare-earth metals and oxides
- The U.S. produces none

Market Prices Affect Supplies of Nonrenewable Minerals

- Subsidies and tax breaks to mining companies keep mineral prices artificially low
- Scarce investment capital hinders the development of new supplies of mineral resources

Can We Expand Reserves by Mining Lower-Grade Ores?

- Factors that limit the mining of lower-grade ores
  - Increased cost of mining and processing larger volumes of ore
  - Availability of freshwater
  - Environmental impact
- Improve mining technology
  - Using microorganisms – biomining
  - Slow process

Can We Get More Minerals from the Ocean?

- Mineral resources dissolved in the ocean
  - Low concentrations
- Deposits of minerals in sediments along the shallow continental shelf and near shorelines

Can We Get More Minerals from the Ocean? (cont'd.)

- Hydrothermal ore deposits
  - Hot water vents in the ocean floor
- Metals from the ocean floor
  - Manganese nodules
- What is the effect of mining on aquatic life?

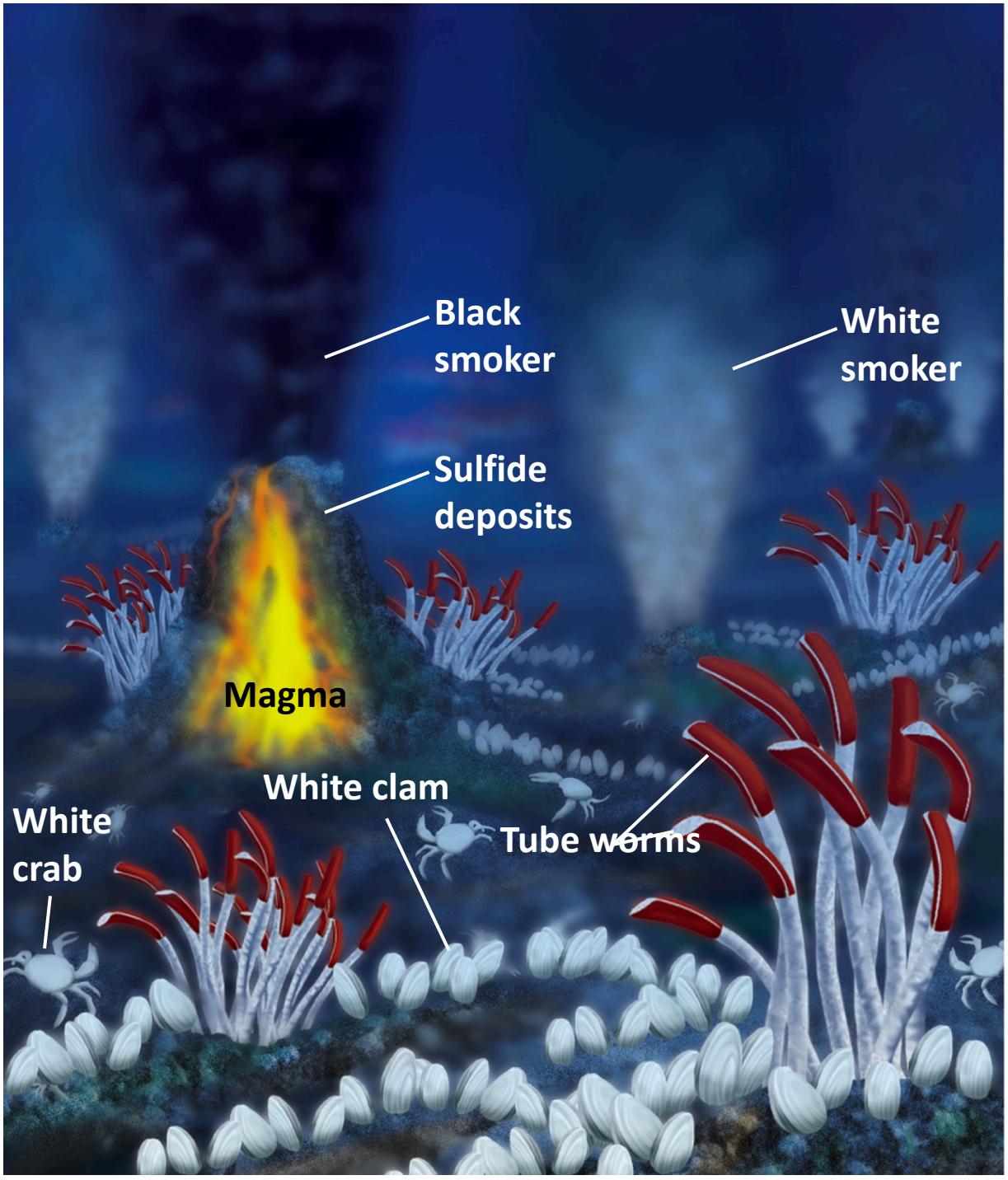


Fig. 14-8, p. 356

14-3 What Are The Environmental Effects From Using Nonrenewable Minerals?

- Extracting minerals from the earth's crust and converting them into useful products can:
  - Disturb the land
  - Erode soils
  - Produce large amounts of solid waste
  - Pollute the air, water, and soil

Mineral Use Creates Environmental Impacts

- Metal product life cycle
  - Mining, processing, manufacture, and disposal
- Environmental impacts
  - Determined by an ore's grade
    - Percentage of metal content

Mining → Metal ore → Separation of ore from waste material → Smelting → Melting metal → Conversion to product → Discarding of product

Recycling

Left: ©kaband/Shutterstock.com. Second to left: ©Andrey N Bannov/Shutterstock.com. Center left: ©Vladimir Melnik/Shutterstock.com. Center: ©mares/Shutterstock.com. Center right: Zhu Difeng/Shutterstock.com. Second to right: ©Michael Shake/Shutterstock.com. Right: Pakhnyushcha/Shutterstock.com.

Removing Mineral Deposits Has Harmful Environmental Effects

- Surface mining
  - Removes shallow deposits
  - Overburden deposited into spoils – waste material
- Open-pit mining
- Strip mining
- Contour strip mining
- Mountaintop removal

LianeM/Shutterstock.com

Fig. 14-10, p. 358

Lee Prince/Shutterstock.com

Fig. 14-11, p. 358

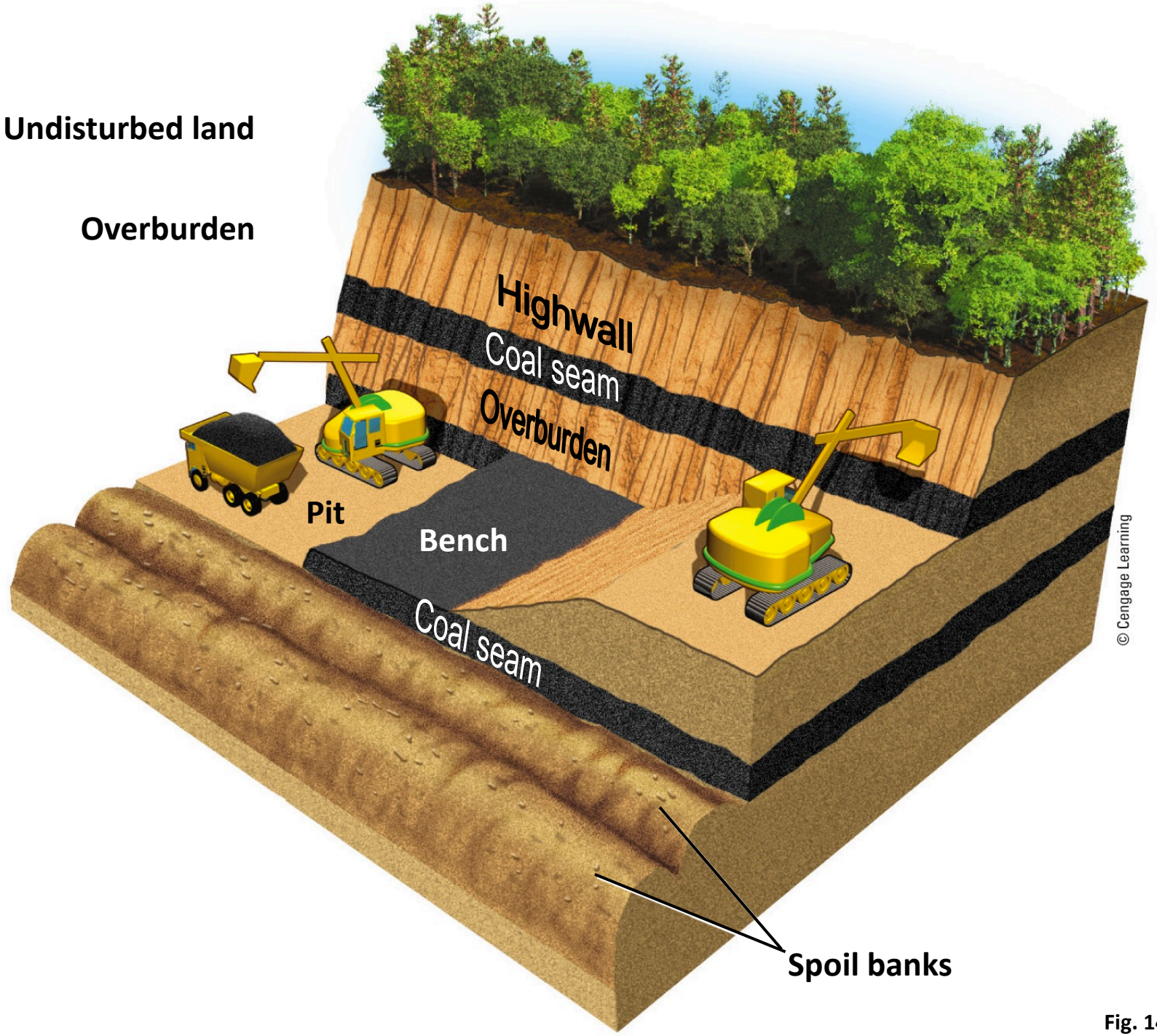


Fig. 14-13, p. 359

Removing Mineral Deposits Has Harmful Environmental Effects (cont'd.)

- Subsurface mining
  - Deep deposits
- Potential problems
  - Subsidence
  - Acid mine drainage

Fig. 14-15, p. 360

Case Study: The Real Cost of Gold

- At about 90% of the world's gold mines
  - Mineral extracted with cyanide salts
  - Cyanide is extremely toxic
- Mining companies declare bankruptcy
  - Allows them to avoid environmental remediation

Removing Metals from Ores Has Harmful Environmental Effects

- Ore extracted by mining
  - Ore mineral
  - Tailings – waste material
  - Smelting using heat or chemicals causes:
    - Air pollution
    - Water pollution

14-4 How Can We Use Mineral Resources More Sustainability?

- We can:
  - Try to find substitutes for scarce resources
  - Reduce resource waste
  - Recycle and reuse minerals

We Can Find Substitutes for Some Scarce Mineral Resources

- Materials revolution
  - Silicon replacing some metals for common uses
- New technologies:
  - Nanotechnology, ceramics, and high-strength plastics
- Substitution doesn't always work
  - Platinum – industrial catalyst

We Can Use Mineral Resources More Sustainably

- Recycling and reuse
  - Lower environmental impact than mining and processing metals from ores
  - Adequate supplies of rare-earth elements in the short-term
  - Substitutes for rare-earth elements

Solutions: Sustainable Use of Nonrenewable Minerals

Fig. 14-17, p. 364

14-5 What Are the Earth's Major Geologic Hazards?

- Dynamic processes move matter within the earth and on its surface and can cause volcanic eruptions, earthquakes, tsunamis, erosion, and landslides

The Earth Beneath Your Feet Is Moving

- The earth's crust is broken into tectonic plates
  - "Float" on the asthenosphere
- Much geological activity takes place at the plate boundaries

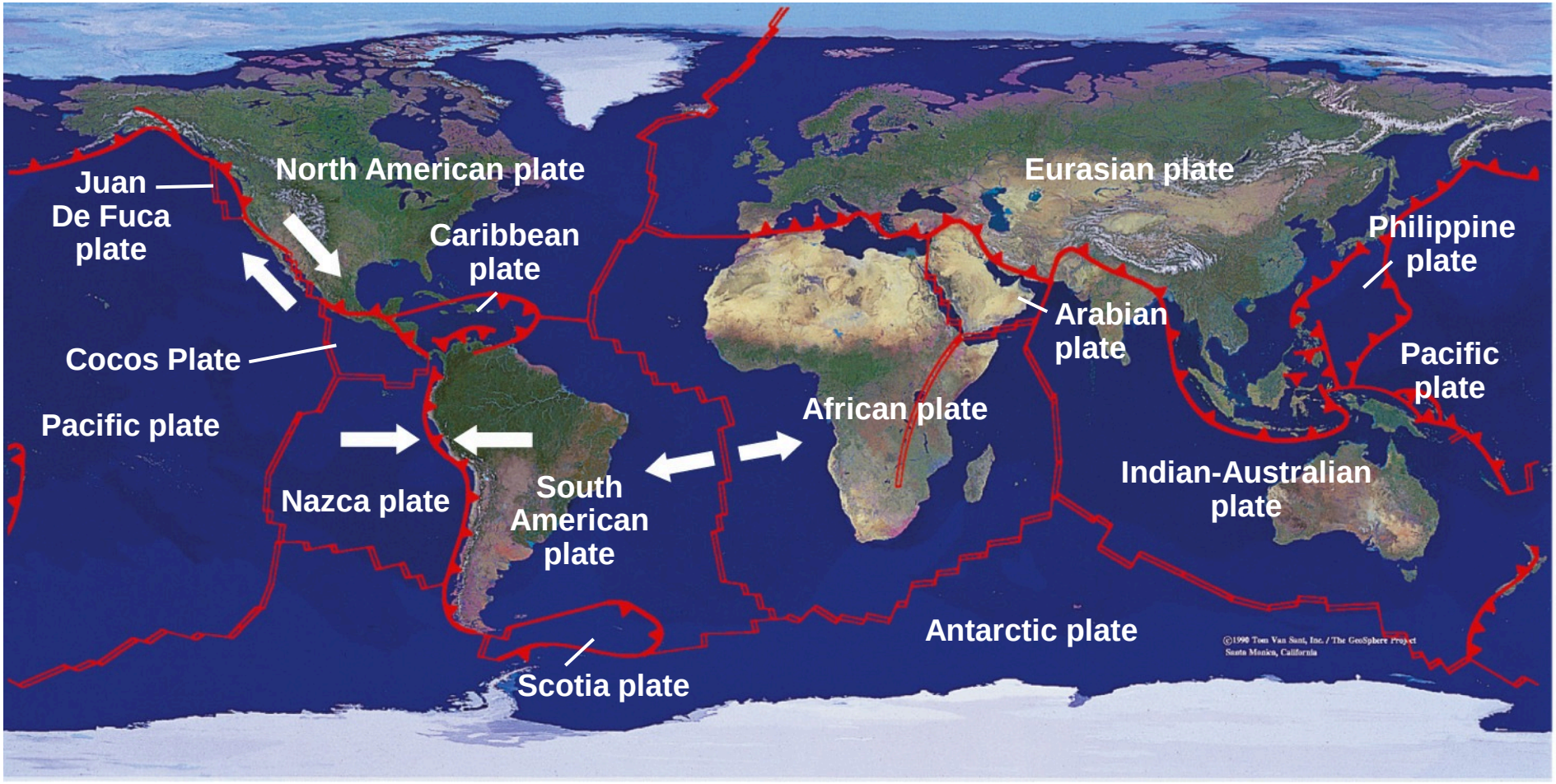


Fig. 14-18, p. 366

Volcanoes Release Molten Rock from the Earth's Interior

- Volcano
  - Magma rising through the lithosphere reaches the earth's surface through a crack
  - Eruption – release of lava, hot ash, and gases into the environment
  - What are the benefits and hazards of volcanoes?

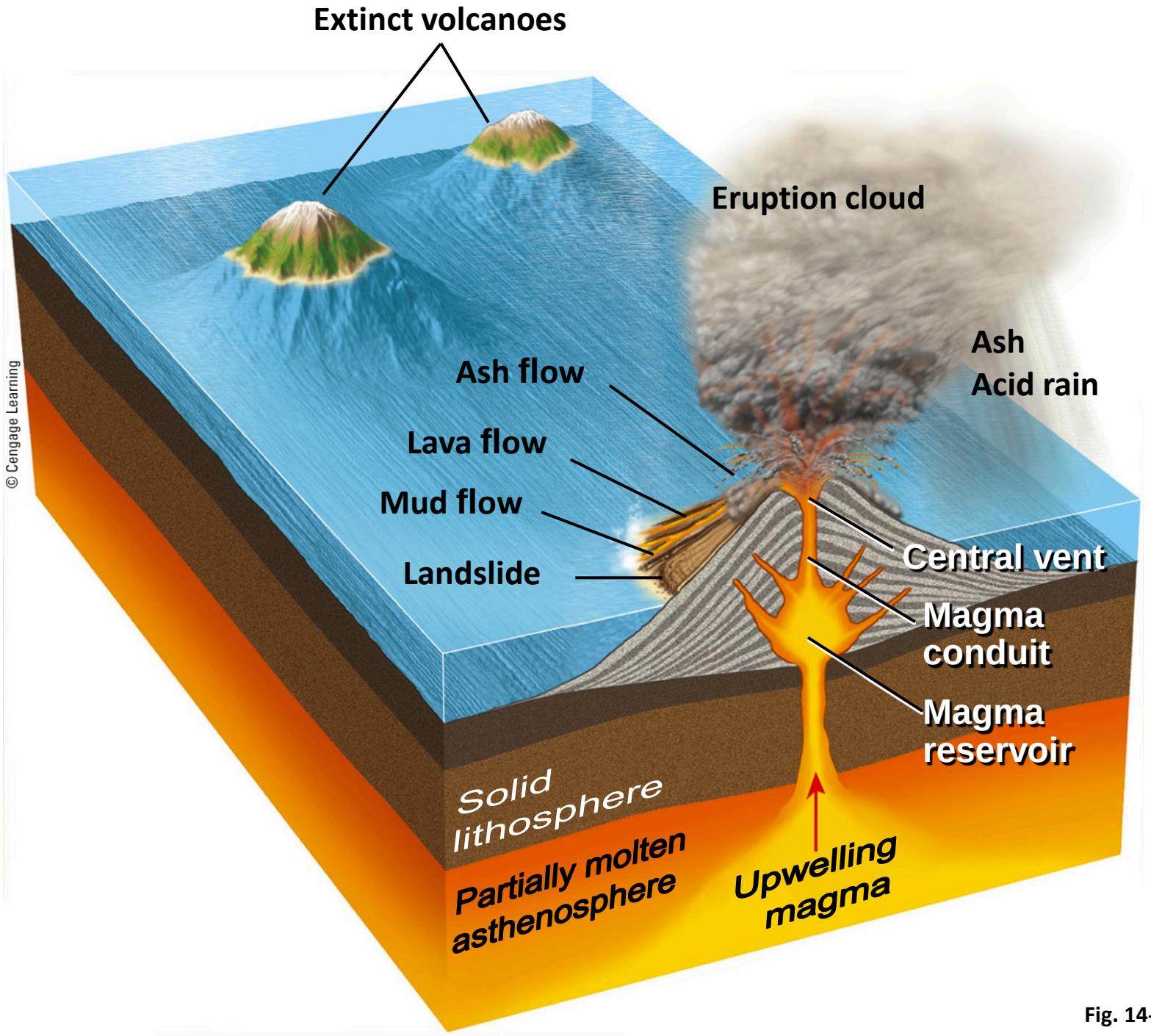


Fig. 14-20, p. 367

beboy/Shutterstock.com

Fig. 14-20, p. 367

Earthquakes Are Geological Rock-and-Roll Events

- Earthquake
  - Breakage and shifting of rocks
    - At a fault
  - Seismic waves
    - Vibrations in the crust
  - Focus – origin of earthquake
  - Magnitude – severity of earthquake
  - Amplitude – size of the seismic waves

Earthquakes Are Geological Rock-and-Roll Events (cont'd.)

- Richter scale
  - Insignificant: <4.0
  - Minor: 4.0–4.9
  - Damaging: 5.0–5.9
  - Destructive: 6.0–6.9
  - Major: 7.0–7.9
  - Great: >8.0
- Largest recorded: 9.5 in Chile, 1960

Fig. 14-19, p. 366

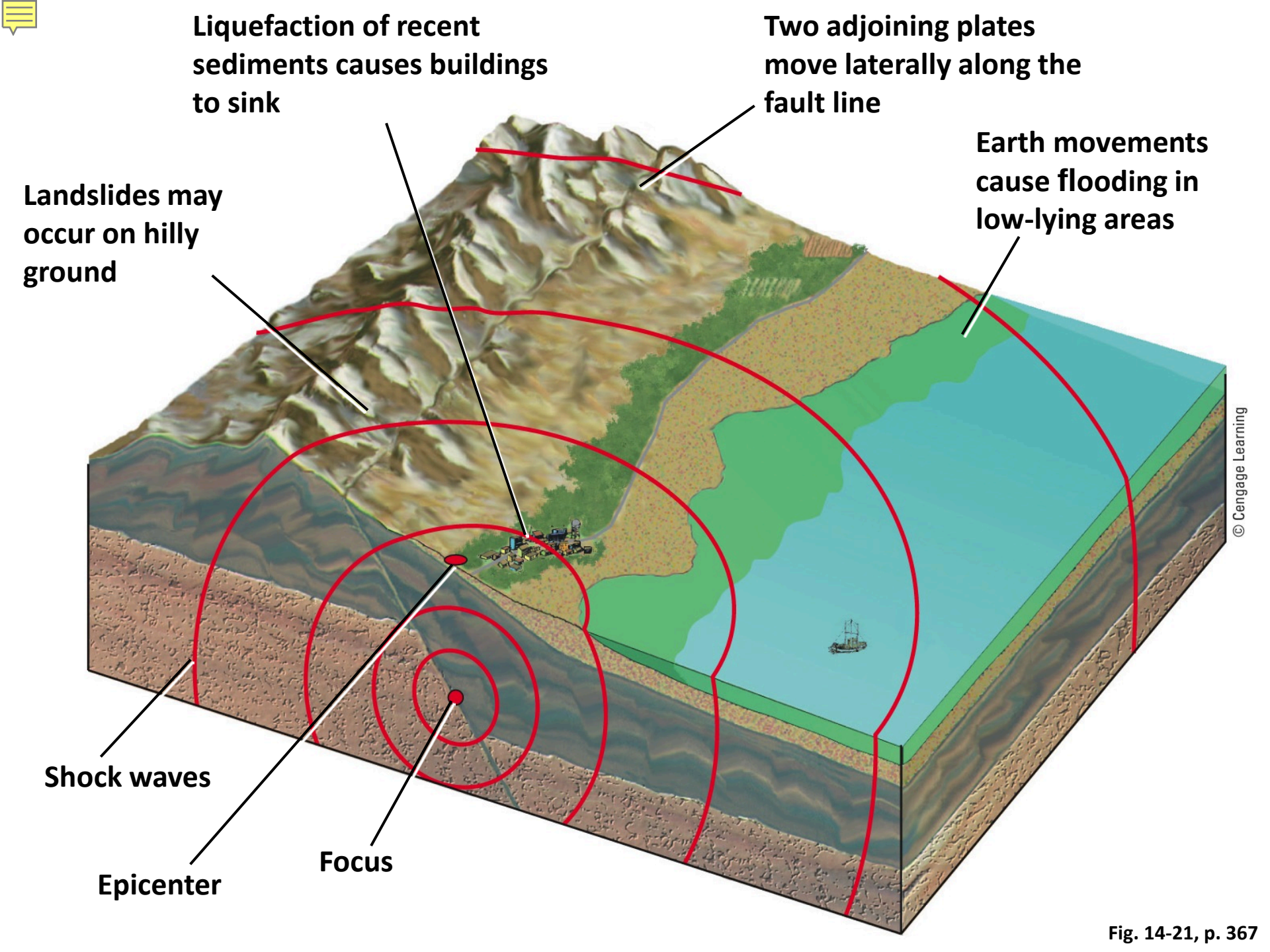


Fig. 14-21, p. 367

AP Photo/Jorge Cruz

Fig. 14-21b, p. 367

Earthquakes on the Ocean Floor Can Cause Huge Waves Called Tsunamis

- Tsunami
  - Series of huge waves generated when ocean floor suddenly rises or drops
  - Travels several hundred miles per hour
- December 2004 – Indian Ocean tsunami
  - Magnitude 9.15 and 31-meter waves at shore

Earthquakes on the Ocean Floor Can Cause Huge Waves Called Tsunamis

- 2011 – Japan tsunami
  - Damaged nuclear reactors
- Detection of tsunamis
  - Buoys in open ocean

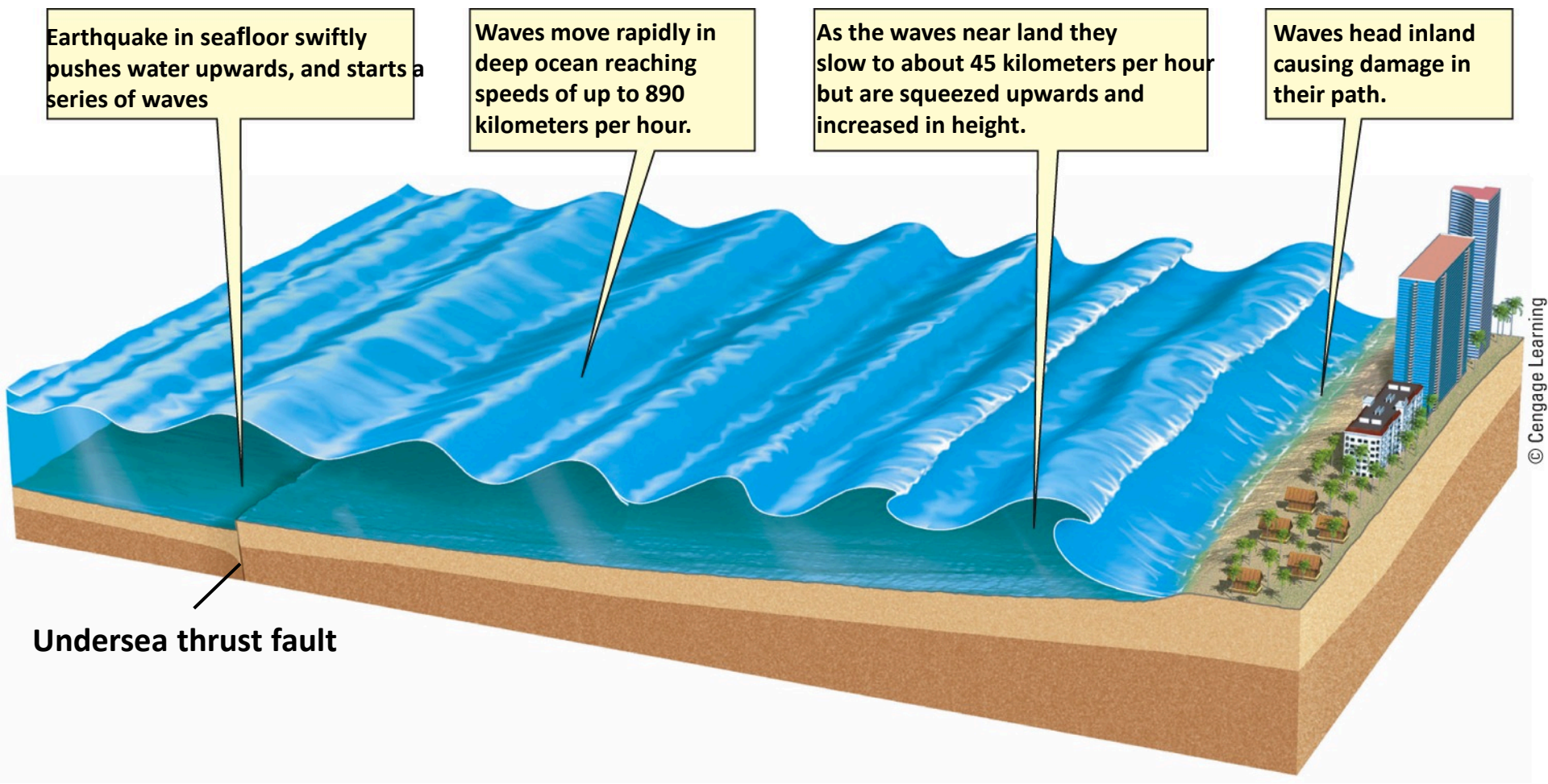


Fig. 14-22a, p. 368

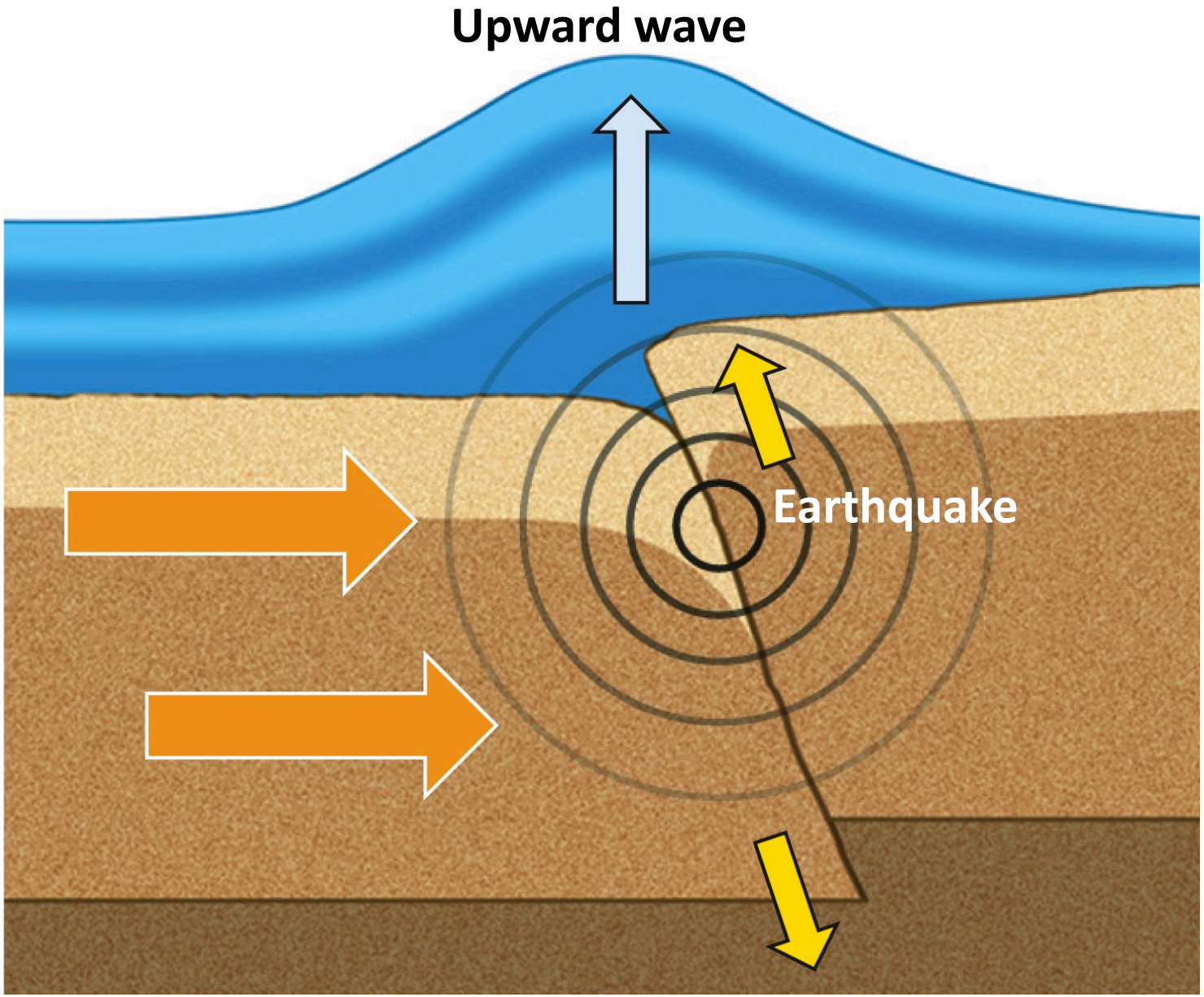


Fig. 14-22b, p. 368