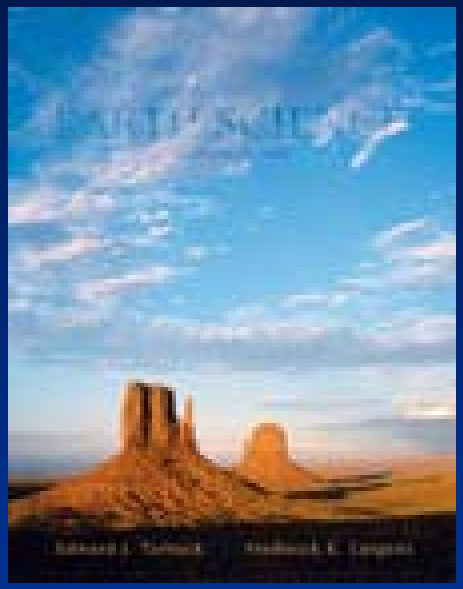


Lecture Outlines PowerPoint

Chapter 3

Earth Science, 12e

Tarbuck/Lutgens

Earth Science, 12e

Rocks: Materials of the Solid Earth

Chapter 3

Rock cycle

- Shows the interrelationships among the three rock types
- Earth as a system: the rock cycle
  - Magma
    - Crystallization
  - Igneous rock
    - Weathering, transportation, and deposition

Rock cycle

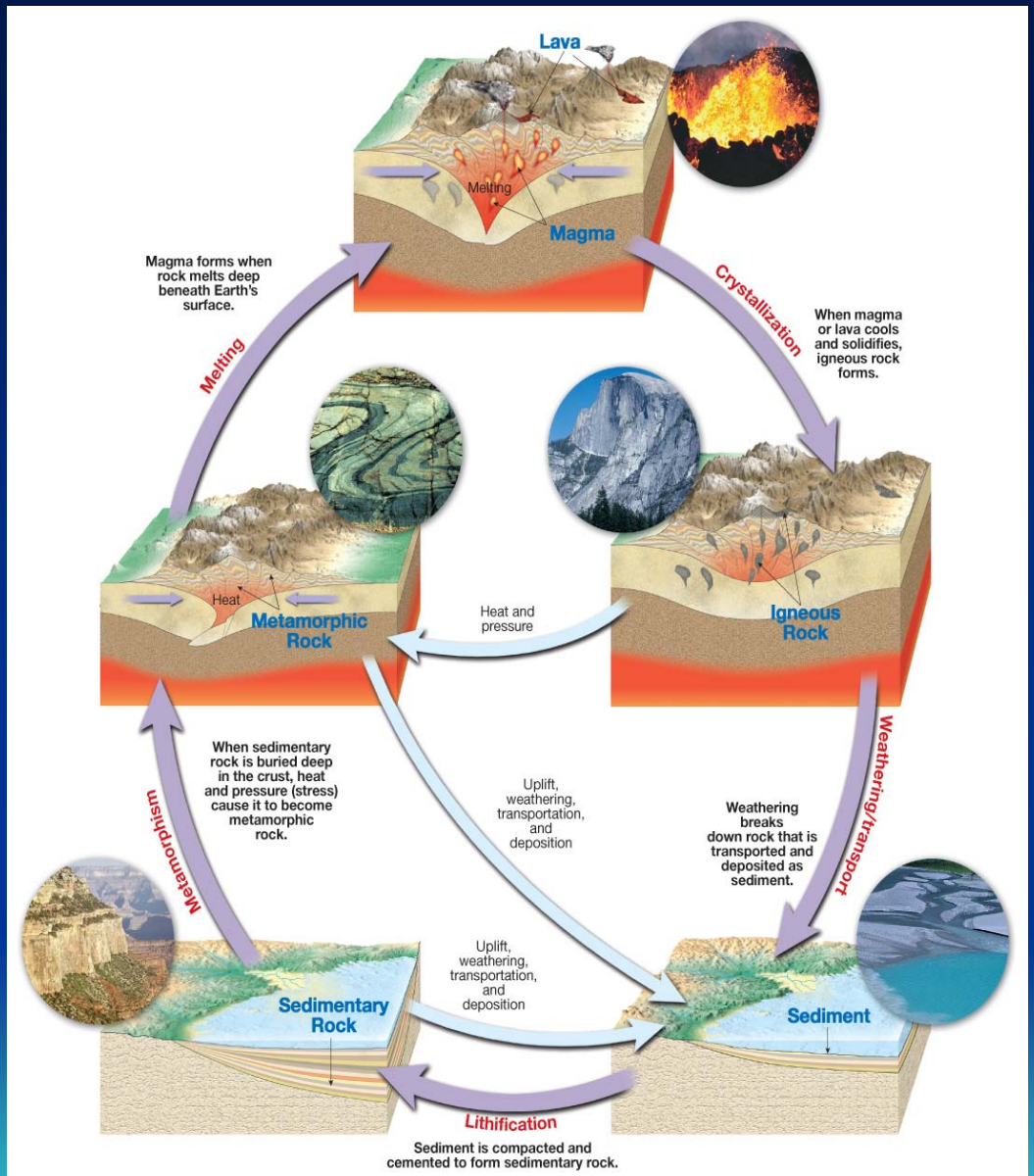
- Earth as a system: the rock cycle
  - Sediment
    - Lithification
  - Sedimentary rock
    - Metamorphism
  - Metamorphic rock
    - Melting
  - Magma

Rock cycle

- Earth as a system: the rock cycle
  - Full cycle does not always take place due to “shortcuts” or interruptions
    - e.g., Sedimentary rock melts
    - e.g., Igneous rock is metamorphosed
    - e.g., Sedimentary rock is weathered
    - e.g., Metamorphic rock weathers

The rock cycle

Figure 3.2



Igneous rocks

- Form as magma cools and crystallizes
  - Rocks formed inside Earth are called plutonic or intrusive rocks
  - Rocks formed on the surface
    - Formed from lava (a material similar to magma, but without gas)
    - Called volcanic or extrusive rocks

Igneous rocks

- Crystallization of magma
  - Ions are arranged into orderly patterns
  - Crystal size is determined by the rate of cooling
    - Slow rate forms large crystals
    - Fast rate forms microscopic crystals
    - Very fast rate forms glass

Igneous rocks

- Classification is based on the rock's texture and mineral constituents
  - Texture
    - Size and arrangement of crystals
    - Types
      - Fine-grained – fast rate of cooling
      - Coarse-grained – slow rate of cooling
      - Porphyritic (two crystal sizes) – two rates of cooling
      - Glassy – very fast rate of cooling

Fine-grained igneous texture

Figure 3.5 A

Coarse-grained igneous texture

Figure 3.5 B

Porphyritic igneous texture

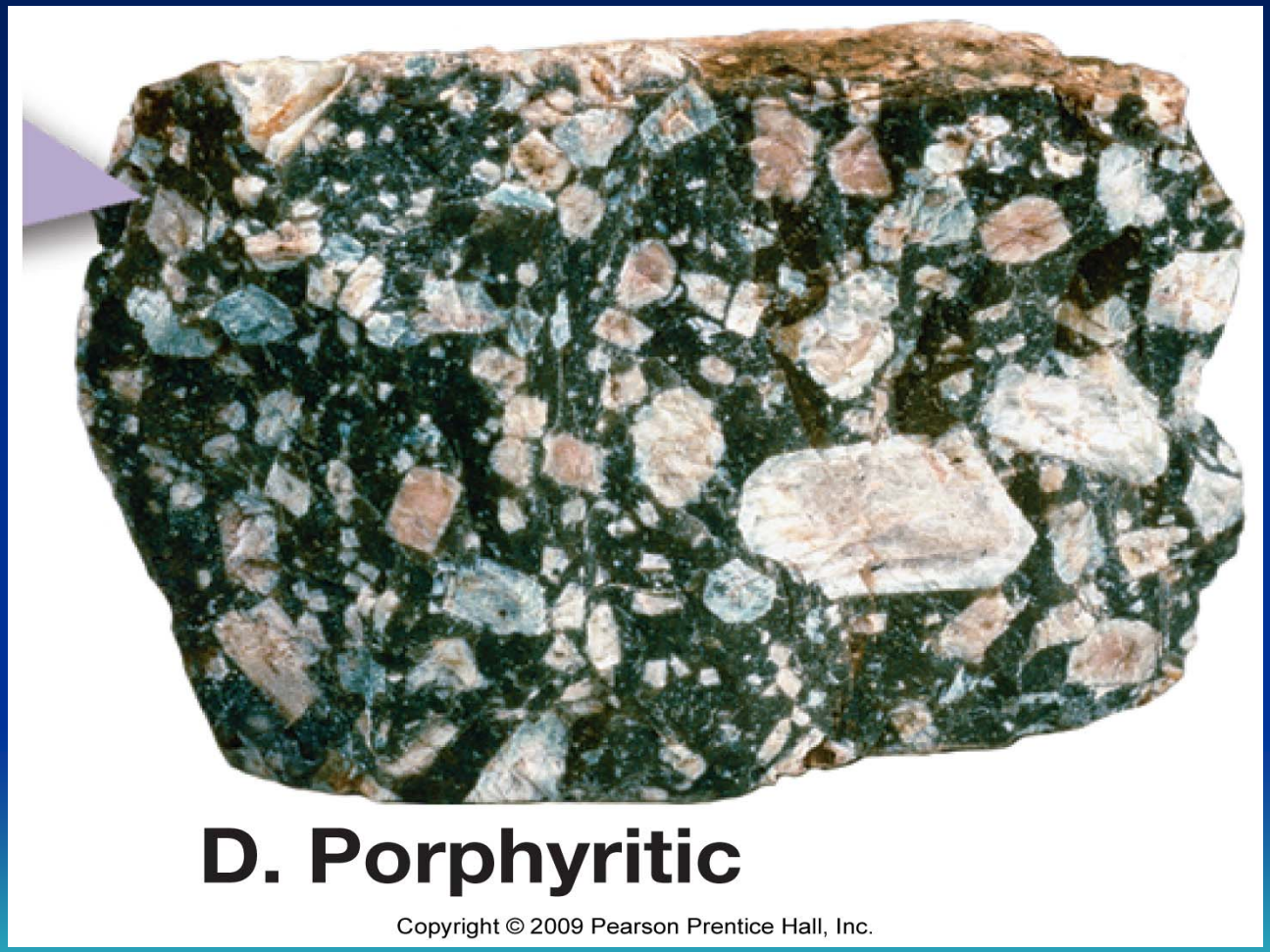


Figure 3.5 D

Obsidian exhibits a glassy texture

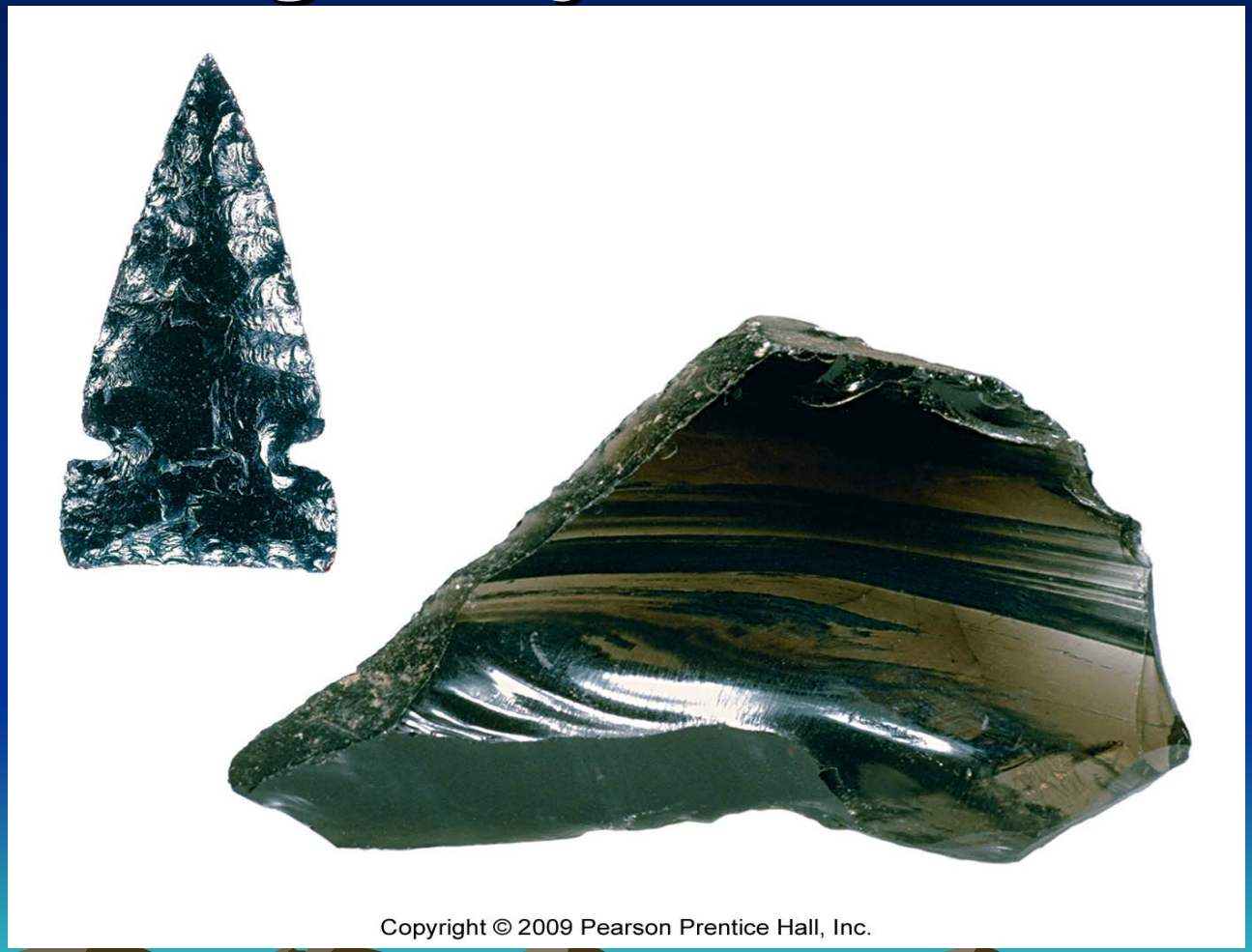


Figure 3.7

Igneous rocks

- Classification is based on the rock's texture and mineral constituents
  - Mineral composition
    - Explained by Bowen's reaction series which shows the order of mineral crystallization
    - Influenced by crystal settling in the magma

Classification of igneous rocks

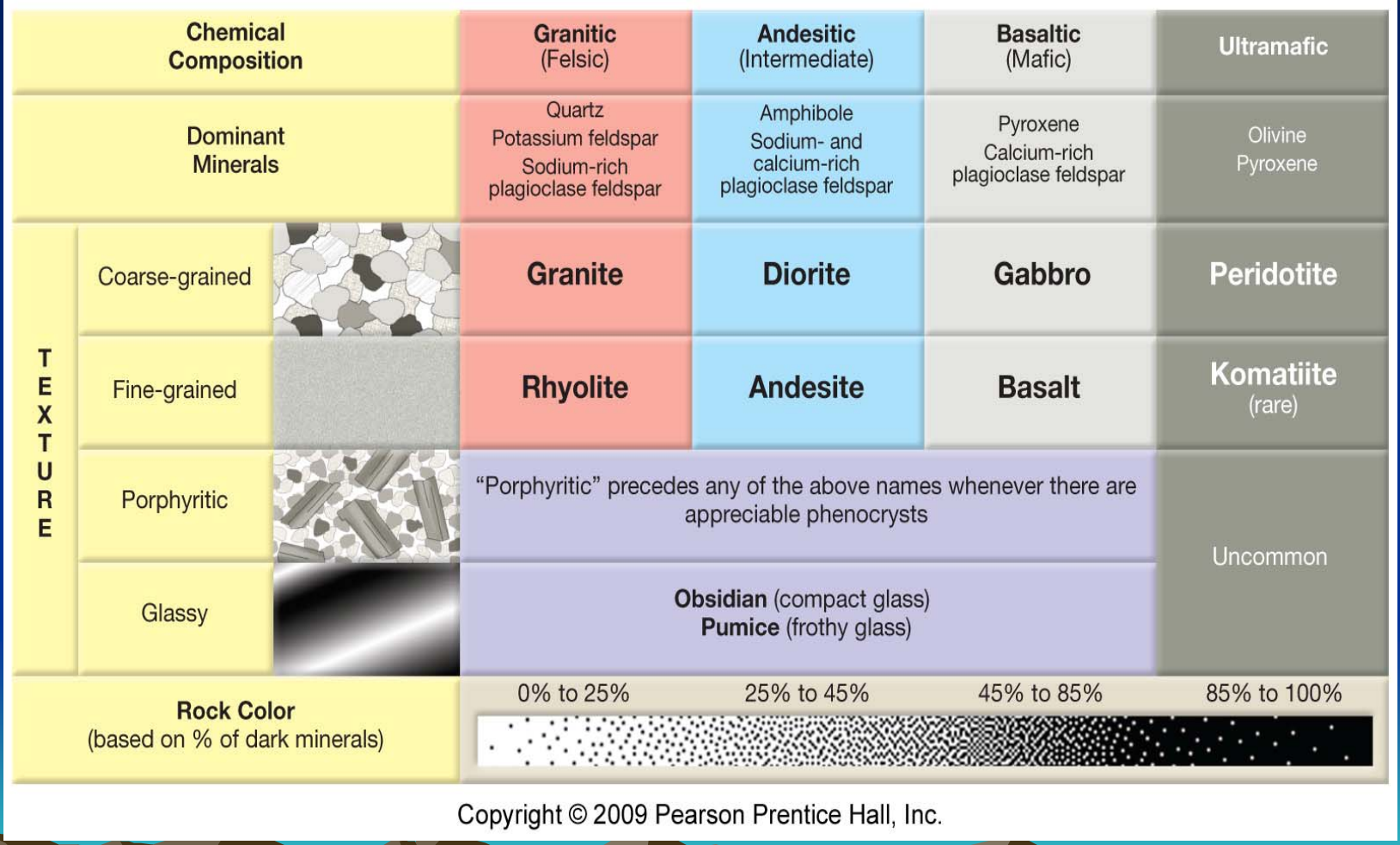


Figure 3.9

Bowen's reaction series

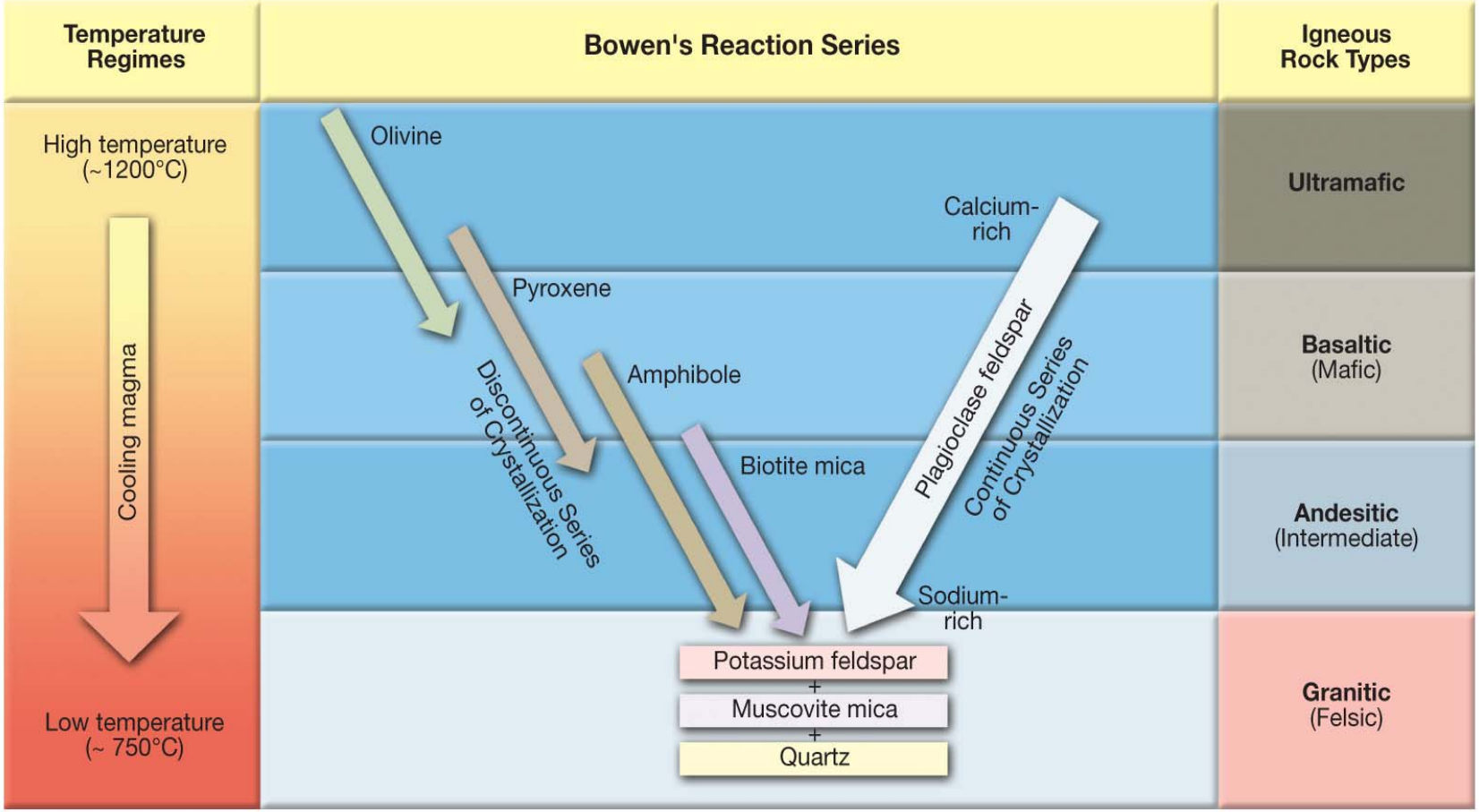


Figure 3.13

Igneous rocks

- Naming igneous rocks
  - Granitic rocks
    - Composed almost entirely of light-colored silicates – quartz and feldspar
    - Also referred to as felsic: *fe*ldspar and *si*lica (quartz)
    - High silica content (about 70 percent)
    - Common rock is granite

Granite

Figure 3.11

Igneous rocks

- Naming igneous rocks
  - Basaltic rocks
    - Contain substantial dark silicate minerals and calcium-rich plagioclase feldspar
    - Also referred to as mafic: *ma*gnesium and *fe*rrum (iron)
    - Common rock is basalt

Basalt

Figure 3.11

Igneous rocks

- Naming igneous rocks
  - Other compositional groups
    - Andesitic (or intermediate)
    - Ultramafic

Sedimentary rocks

- Form from sediment (weathered products)
- About 75 percent of all rock outcrops on the continents
- Used to reconstruct much of Earth's history
  - Clues to past environments
  - Provide information about sediment transport
  - Rocks often contain fossils

Sedimentary rocks

- Economic importance
  - Coal
  - Petroleum and natural gas
  - Sources of iron and aluminum

Sedimentary rocks

- Classifying sedimentary rocks
  - Two groups based on the source of the material
    - Detrital rocks
      - Material is solid particles
      - Classified by particle size
      - Common rocks include
        - Shale (most abundant)
        - Sandstone
        - Conglomerate

Classification of sedimentary rocks

Detrital Sedimentary Rocks

Texture (particle size)		Sediment Name	Rock Name
Coarse (over 2 mm)		Gravel (Rounded particles)	**Conglomerate**
		Gravel (Angular particles)	**Breccia**
Medium (1/16 to 2 mm)		Sand (If abundant feldspar is present the rock is called **Arkose**)	**Sandstone**
Fine (1/16 to 1/256 mm)		Mud	**Siltstone**
Very fine (less than 1/256 mm)		Mud	**Shale**

Chemical Sedimentary Rocks

Composition	Texture	Rock Name	
Calcite, $CaCO_3$	Fine to coarse crystalline	**Crystalline Limestone**	
		Travertine	
	Visible shells and shell fragments loosely cemented	**Coquina**	**Biochemical Limestone**
	Various size shells and shell fragments cemented with calcite cement	**Fossiliferous Limestone**	
	Microscopic shells and clay	**Chalk**	
Quartz, SiO_2	Very fine crystalline	**Chert (light colored) Flint (dark colored)**	
Gypsum $CaSO_4 \cdot 2H_2O$	Fine to coarse crystalline	**Rock Gypsum**	
Halite, NaCl	Fine to coarse crystalline	**Rock Salt**	
Altered plant fragments	Fine-grained organic matter	**Bituminous Coal**	

Figure 3.16

Shale with plant fossils

Figure 3.19

Sandstone

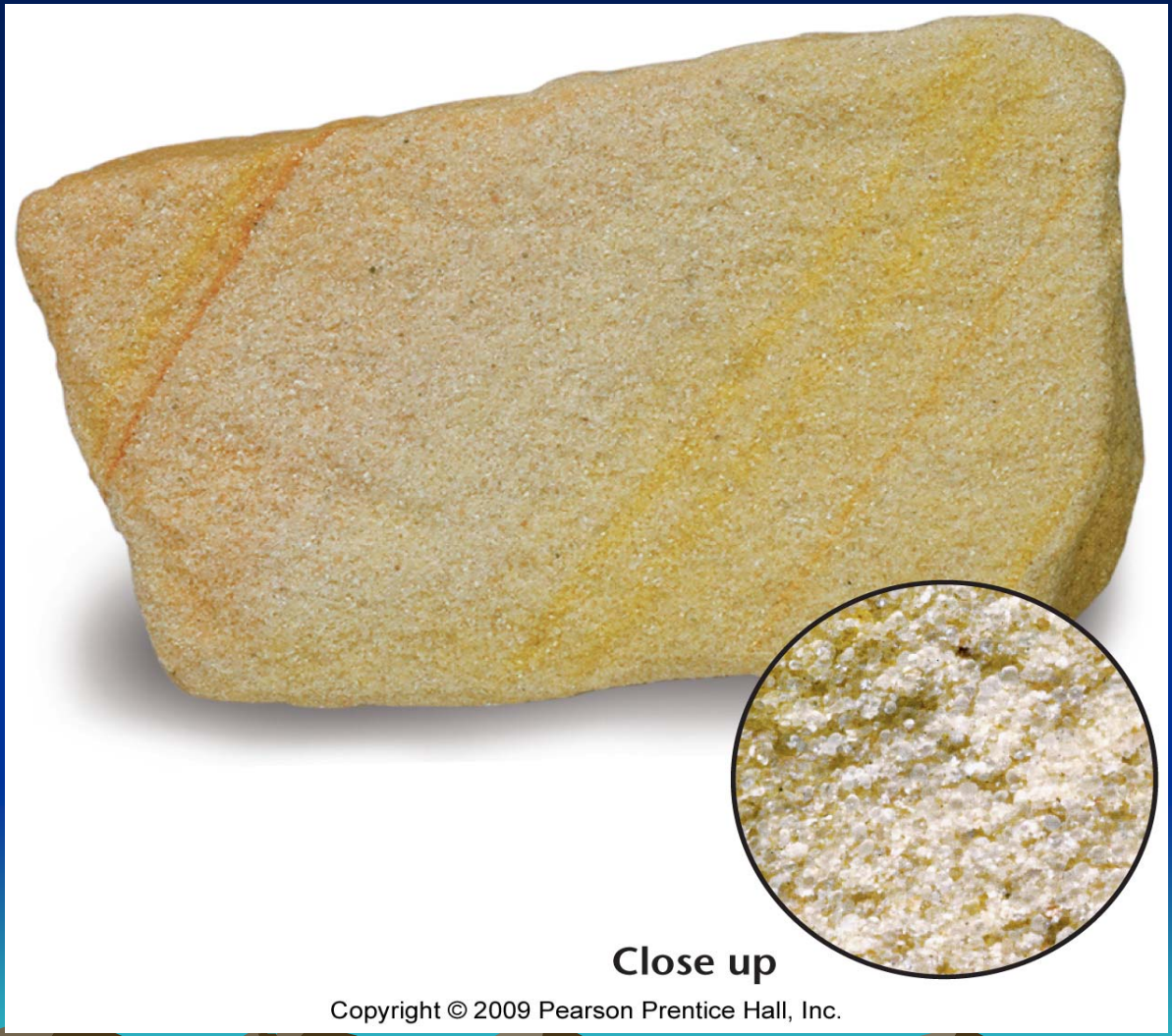


Figure 3.18

Conglomerate

A.

Figure 3.17 A

Sedimentary rocks

- Classifying sedimentary rocks
  - Two groups based on the source of the material
    - Chemical rocks
      - Derived from material that was once in solution and precipitates to form sediment
        - Directly precipitated as the result of physical processes, or
        - Through life processes (biochemical origin)

Sedimentary rocks

- Classifying sedimentary rocks
  - Two groups based on the source of the material
    - Chemical rocks
      - Common sedimentary rocks
        - Limestone – the most abundant chemical rock
        - Microcrystalline quartz (precipitated quartz) known as chert, flint, jasper, or agate
        - Evaporites such as rock salt or gypsum
        - Coal

Fossiliferous limestone

Sedimentary rocks

- Sedimentary rocks are produced through lithification
  - Loose sediments are transformed into solid rock
  - Lithification processes
    - Compaction
    - Cementation by
      - Calcite
      - Silica
      - Iron oxide

Sedimentary rocks

- Features of sedimentary rocks
  - Strata, or beds (most characteristic)
  - Bedding planes separate strata
  - Fossils
    - Traces or remains of prehistoric life
    - Are the most important inclusions
    - Help determine past environments
    - Used as time indicators
    - Used for matching rocks from different places

Metamorphic rocks

- “Changed form” rocks
- Produced from preexisting
  - Igneous rocks
  - Sedimentary rocks
  - Other metamorphic rocks

Metamorphic rocks

- Metamorphism
  - Takes place where preexisting rock is subjected to temperatures and pressures unlike those in which it formed
  - Degrees of metamorphism
    - Exhibited by rock texture and mineralogy
    - Low-grade (e.g., shale becomes slate)
    - High-grade (obliteration of original features)

Metamorphic rocks

- Metamorphic settings
  - Contact, or thermal, metamorphism
    - Occurs near a body of magma
    - Changes are driven by a rise in temperature
  - Regional metamorphism
    - Directed pressures and high temperatures during mountain building
    - Produces the greatest volume of metamorphic rock

Metamorphic rocks

- Metamorphic agents
  - Heat
  - Pressure (stress)
    - From burial (confining pressure)
    - From differential stress during mountain building
  - Chemically active fluids
    - Mainly water and other volatiles
    - Promote recrystallization by enhancing ion migration

Origin of pressure in metamorphism

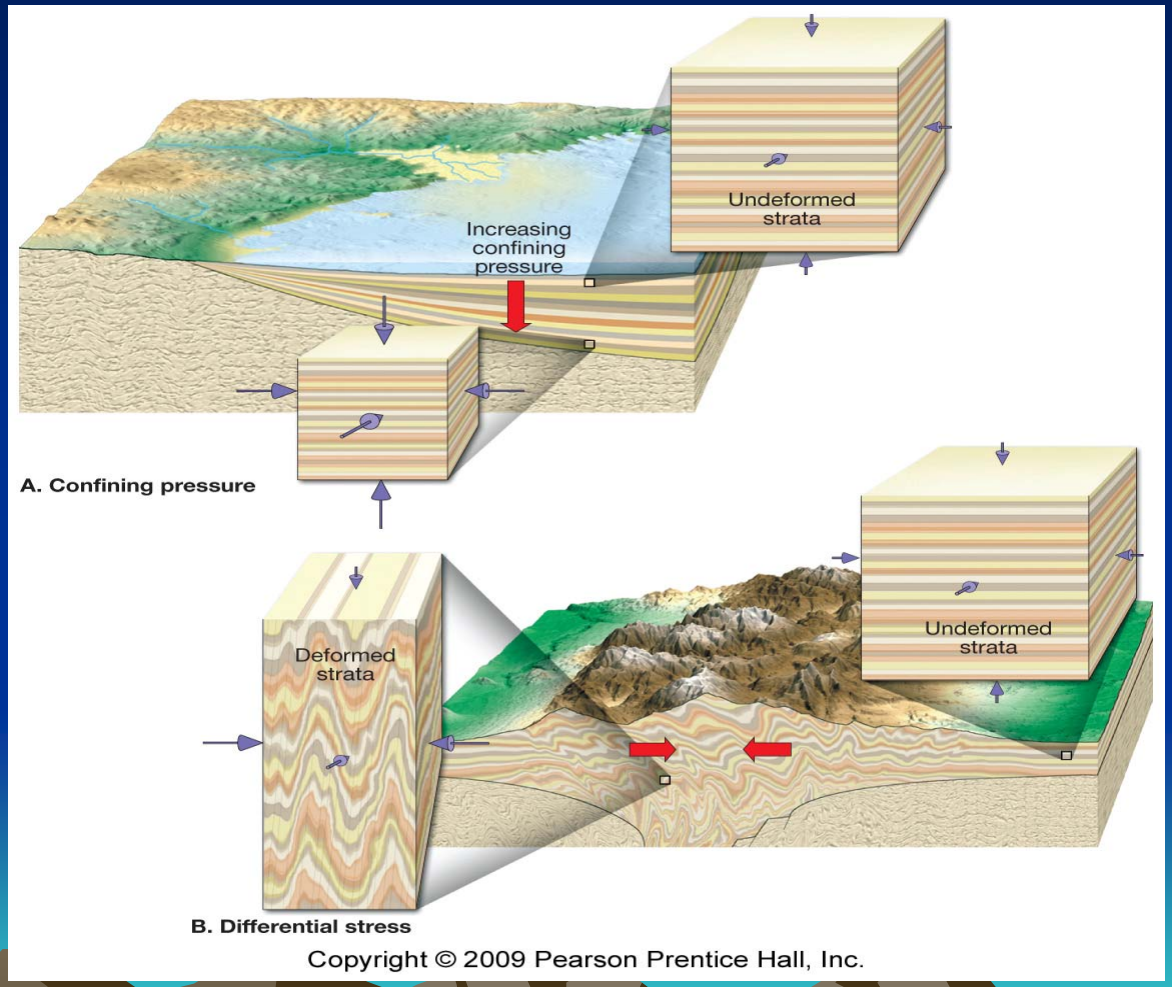


Figure 3.27

Metamorphic rocks

- Metamorphic textures
  - Foliated texture
    - Minerals are in a parallel alignment
    - Minerals are perpendicular to the compressional force
  - Nonfoliated texture
    - Contain equidimensional crystals
    - Resembles a coarse-grained igneous rock

Development of foliation due to directed pressure

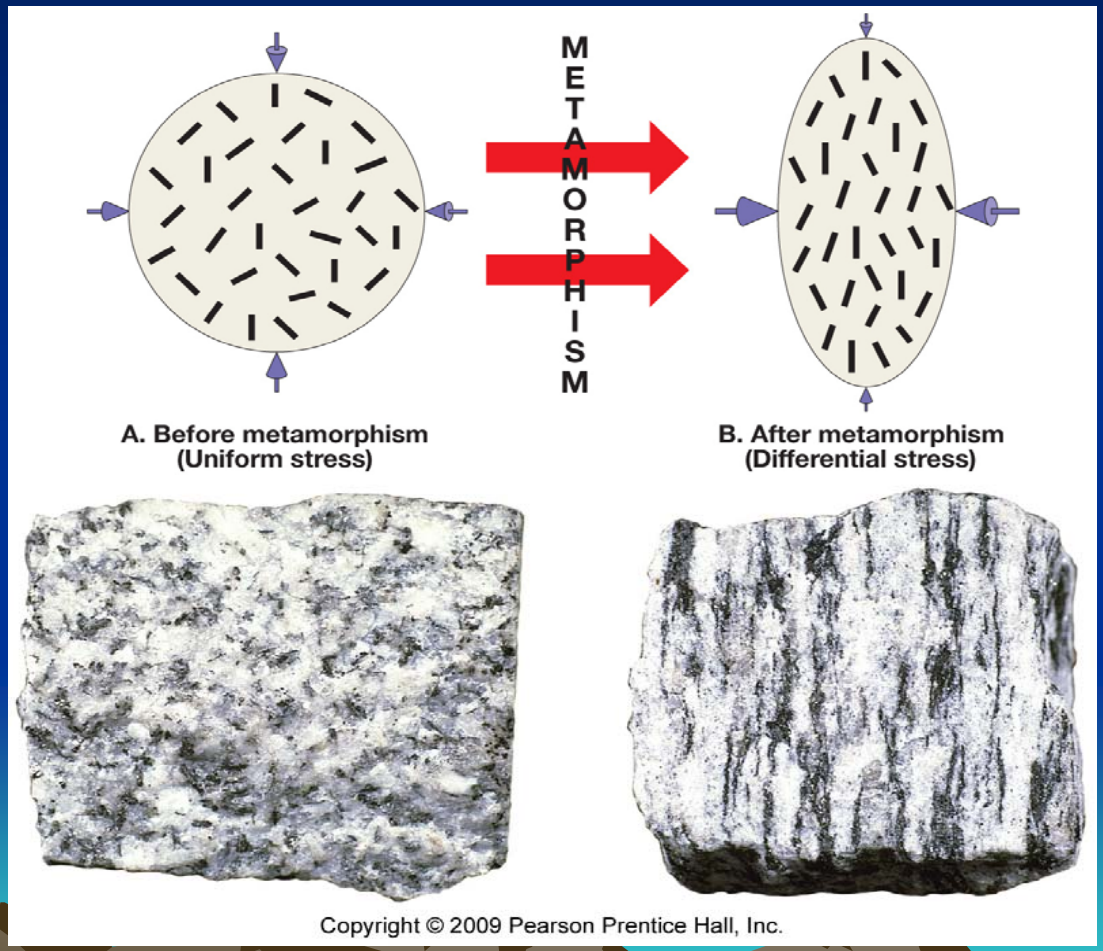


Figure 3.29

Metamorphic rocks

- Common metamorphic rocks
  - Foliated rocks
    - Slate
      - Fine-grained
      - Splits easily
    - Schist
      - Strongly foliated
      - “Platy”
      - Types based on composition (e.g., mica schist)

Classification of metamorphic rocks

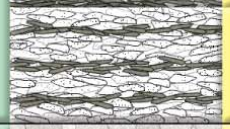
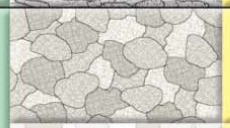
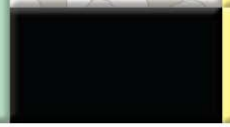
Rock Name		Texture		Grain Size	Comments	Parent Rock
Slate	Increasing Metamorphism	Foliated		Very fine	Excellent rock cleavage, smooth dull surfaces	Shale, mudstone, or siltstone
Phyllite				Fine	Breaks along wavey surfaces, glossy sheen	Slate
Schist				Medium to Coarse	Micas dominate, scaly foliation	Phyllite
Gneiss				Medium to Coarse	Compositional banding due to segregation of minerals	Schist, granite, or volcanic rocks
Marble		Nonfoliated		Medium to coarse	Interlocking calcite or dolomite grains	Limestone, dolostone
Quartzite				Medium to coarse	Fused quartz grains, massive, very hard	Quartz sandstone
Anthracite				Fine	Shiny black organic rock that may exhibit conchoidal fracture	Bituminous coal

Figure 3.30

Metamorphic rocks

- Common metamorphic rocks
  - Foliated rocks
    - Gneiss
      - Strong segregation of silicate minerals
      - “Banded” texture
  - Nonfoliated rocks
    - Marble
      - Parent rock is limestone
      - Large, interlocking calcite crystals

Gneiss typically displays a banded appearance

Figure 3.31

Metamorphic rocks

- Common metamorphic rocks
  - Nonfoliated rocks
    - Marble
      - Used as a building stone
      - Variety of colors
    - Quartzite
      - Parent rock – quartz sandstone
      - Quartz grains are fused

Marble – a nonfoliated metamorphic rock

Figure 3.31

Resources from rocks and minerals

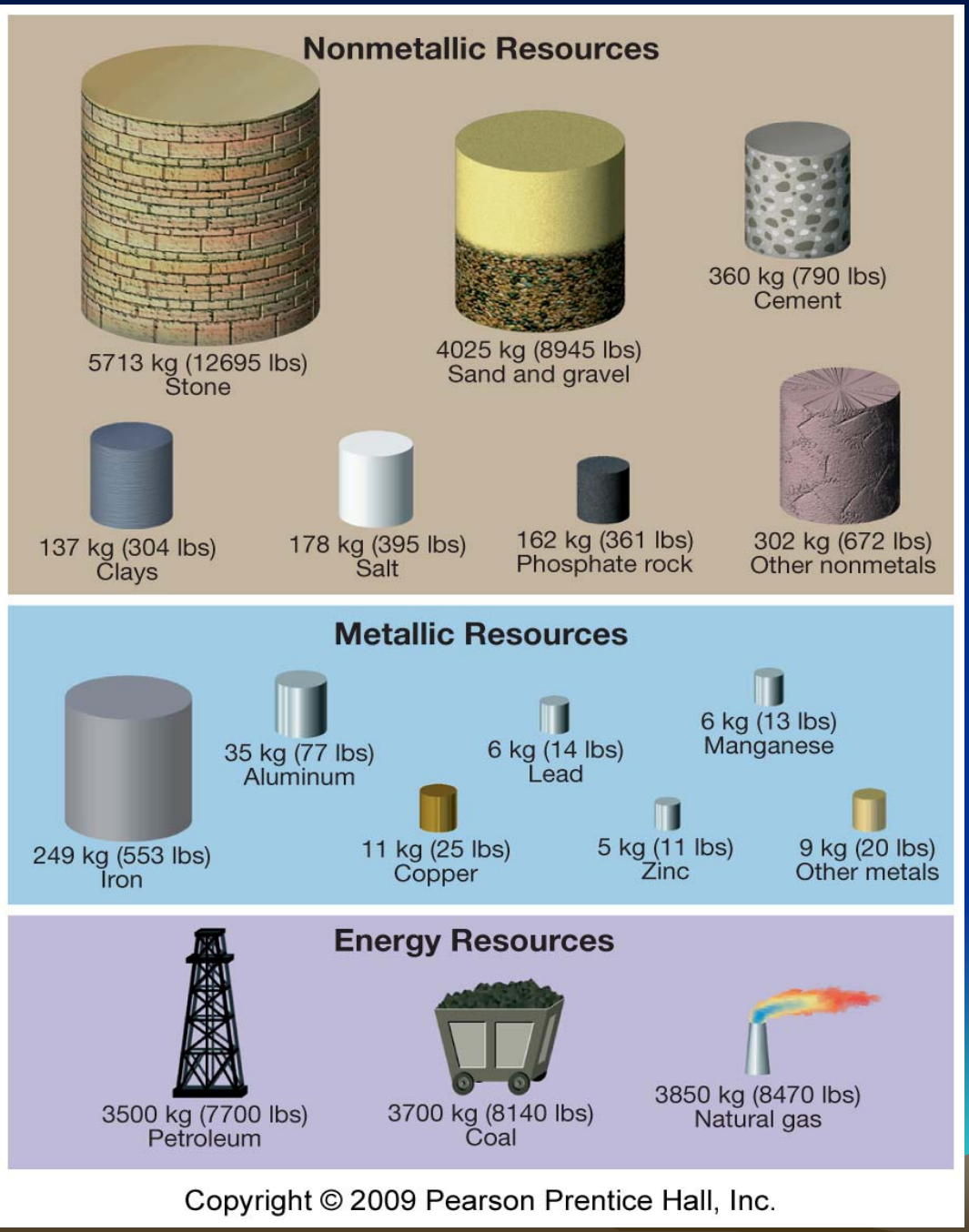
- Metallic mineral resources
  - Gold, silver, copper, mercury, lead, etc.
  - Concentrations of desirable materials are produced by
    - Igneous processes
    - Metamorphic processes

Resources from rocks and minerals

- Metallic mineral resources
  - Most important ore deposits are generated from hydrothermal (hot-water) solutions
    - Hot
    - Contain metal-rich fluids
    - Associated with cooling magma bodies
    - Types of deposits include
      - Vein deposits in fractures or bedding planes, and
      - Disseminated deposits which are distributed throughout the rock

Resources from rocks and minerals

- Nonmetallic mineral resources
  - Make use of the material's
    - Nonmetallic elements
    - Physical or chemical properties
  - Two broad groups
    - Building materials (e.g., limestone, gypsum)
    - Industrial minerals (e.g., fluorite, corundum, sylvite)



Mineral Resources

Figure 3.C

End of Chapter 3