Essentials of Geology, 11e

Sedimentary Rocks
Chapter 6

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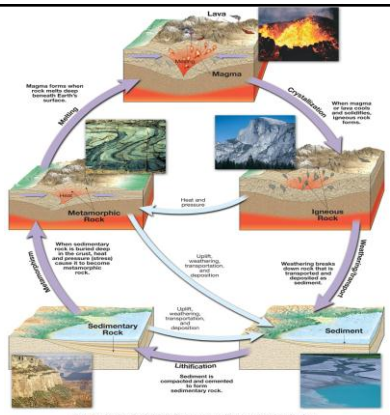


What is a Sedimentary Rock?

- Sedimentary rocks are products of mechanical and chemical weathering
- They account for about 5 percent (by volume) of Earth's outer 10 miles
- They contain evidence of past environments
  - Provide information about sediment transport (water, wind, ice)
  - Often contain fossils
  - Provide storage for groundwater

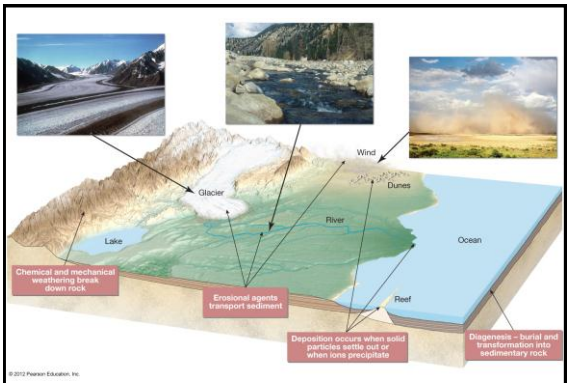


Figure 6.2

What is a Sedimentary Rock?

- Sedimentary rocks are important for economic considerations because they may contain:
  - Coal
  - Petroleum and natural gas
  - Sources of iron, aluminum, and manganese

Turning Sediment into Rock

- Many changes occur to sediment after it is deposited.
- Diagenesis – all of the chemical, physical, and biological changes that take place after sediments are deposited
  - Occurs within the upper few kilometers of Earth's crust

recrystallization or lithification: compaction & cementation

Turning Sediment into Rock

- Diagenesis
  - Includes
    - Recrystallization – development of more stable minerals from less stable ones
    - Lithification – unconsolidated sediments are transformed into solid sedimentary rock by
      - Compaction due to overlying pressure
      - Cementation by calcite, silica, and iron oxide

Types of Sedimentary Rocks

- Sediment originates from mechanical and/or chemical weathering
- Rock types are based on source of material:
  - Detrital (transported)
    - Made up of discrete fragments and particles that are cemented and compacted together
    - Particle size
  - Chemical (in solution)
    - When dissolved substances are precipitated by inorganic or organic processes
    - Mineral composition

Detrital versus Chemical

Detrital Sedimentary Rocks

- The chief constituents of detrital rocks include cement and the following grains:
  - Clay minerals
  - Quartz
  - Feldspars
  - Micas

Remember Bowen's Reaction Series!

- Particle size is used to distinguish among the various types of detrital rocks (figure 6.3)

Particle Sizes for Detrital Rocks

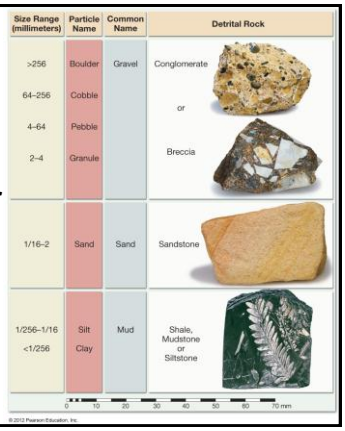


Figure 6.3

Detrital Sedimentary Rocks

- Common detrital sedimentary rocks (in order of increasing particle size)
  - Shale
    - Mud-sized particles in thin layers that are commonly referred to as laminea
    - Most common sedimentary rock
    - Often contains preserved fossil remains
    - Paleoclimate data
    - Low energy depositional environment

Shale

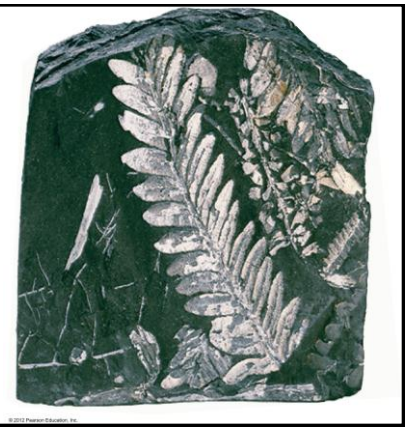


Figure 6.3 (Shale, Mudstone or Siltstone)

Detrital Sedimentary Rocks

- **Sandstone**
  - Composed of sand-sized particles
  - Forms in a variety of environments
  - Sorting, shape, and composition of the grains can be used to interpret the rock's history – "*provenance*"
  - Quartz is the predominant mineral
  - Feels gritty – fine to course sandpaper.

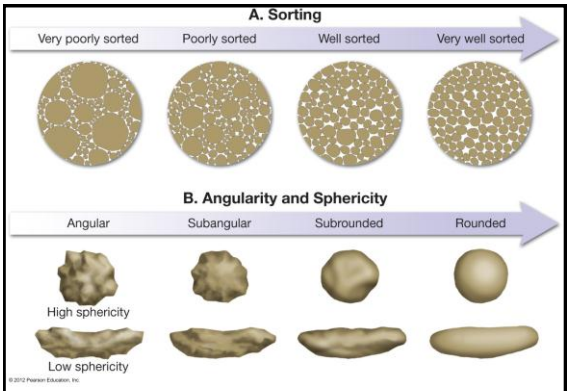


Figure 6.5

Quartz Sandstone

Figure 6.3 (Sandstone)

Sand dunes become sandstones…

Figure 6.6

Detrital Sedimentary Rocks

- Common **detrital** sedimentary rocks
  - **Conglomerate** and **breccia**
    - Both are composed of particles greater than 2mm in diameter
      - **Conglomerate** consists largely of rounded gravels
      - **Breccia** is composed mainly of large angular particles

Conglomerate

Figure 6.3 (Conglomerate)

Breccia

Figure 6.3 (Breccia)

Chemical Sedimentary Rocks

- Consist of precipitated material that was once in solution OR was alive.
- Precipitation of material occurs in two ways
  - Inorganic processes
  - Organic processes
    - biochemical origin

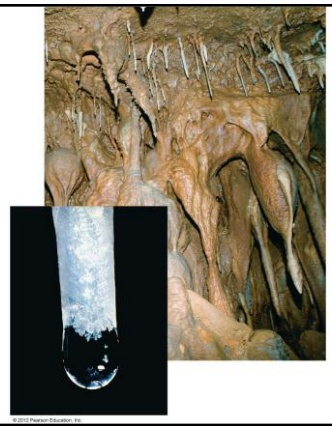
Chemical Sedimentary Rocks

- Common chemical sedimentary rocks
  - Limestone
    - Most abundant chemical rock
    - Composed chiefly of the mineral *calcite*
    - Marine biochemical limestones form as coral reefs, coquina (broken shells), and chalk (microscopic organisms)
    - Inorganic limestones include travertine and oolitic limestone

Figure 6.9 B

Figure 6.11

Organic Limestone - Chalk



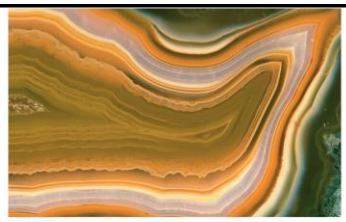
Inorganic limestone-

Travertine

Figure 6.18

Chemical Sedimentary Rocks

- Common chemical sedimentary rocks
  - Dolostone
    - Typically formed secondarily from limestone (added Mg)
  - Chert
    - Made of microcrystalline quartz
    - Varieties include flint and jasper (banded form is called agate)



A. Agate

B. Flint C. Jasper D. Arrowhead

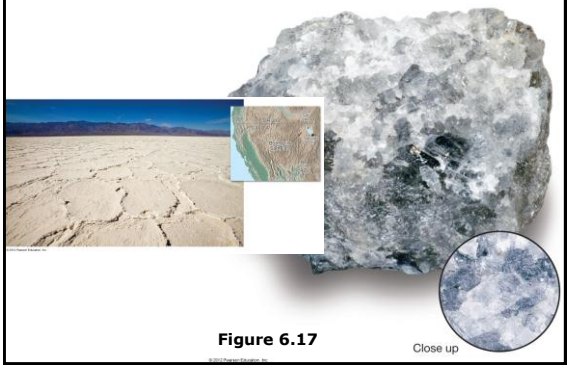
Chert- SIO_2 organic and inorganic

Figure 6.13

Chemical Sedimentary Rocks

- Common chemical sedimentary rocks
  - Evaporites
    - Evaporation triggers deposition of chemical precipitates
    - Examples include rock salt (halite) and rock gypsum

Rock Salt



Close up

Figure 6.17

Chemical Sedimentary Rocks

- Common chemical sedimentary rocks
  - Coal
    - Different from other rocks because it is composed of organic material
    - Stages in coal formation (in order)
      1. Plant material
      2. Peat
      3. Lignite
      4. Bituminous

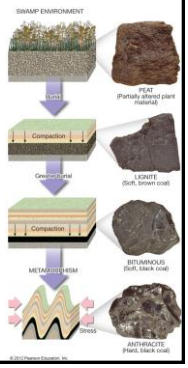


Figure 6.15

Classification of Sedimentary Rocks

Sedimentary rocks are classified according to the type of material.

- Two groups-
  - Detrital
  - Chemical
- Two textures-
  - Clastic
  - Non-clastic

Classification of Sedimentary Rocks

- Two major textures are used in the classification of sedimentary rocks
  - Clastic
    - Discrete fragments and particles
    - All detrital rocks have a clastic texture
  - Nonclastic
    - Pattern of interlocking crystals
    - May resemble an igneous rock

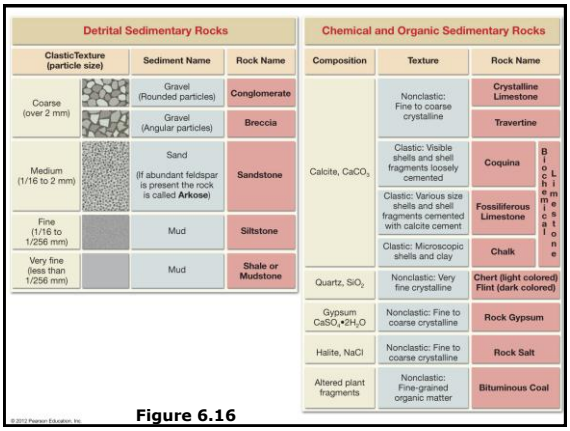


Figure 6.16

Sedimentary Environments

- A geographic setting where sediment is accumulating
- Determines the nature of the sediments that accumulate (grain size, grain shape, etc.)

Sedimentary Environments

- Types of sedimentary environments
  - Continental
    - Dominated by erosion and deposition associated with streams
    - Glacial
    - Wind (eolian)
  - Marine
    - Shallow (to about 200 meters)
    - Deep (seaward of continental shelves)
    - Ultra-fine particles, low energy

Sedimentary Environments

- Types of sedimentary environments
  - Transitional (shoreline)
    - **Tidal flats** moderate to low energy, waves, mud, and dirty limestones.
    - **Lagoons** quiet, mud and clay, fresh and salt water mix.
    - **Deltas** mouth of a fresh water river, moderate energy, sand to silt.

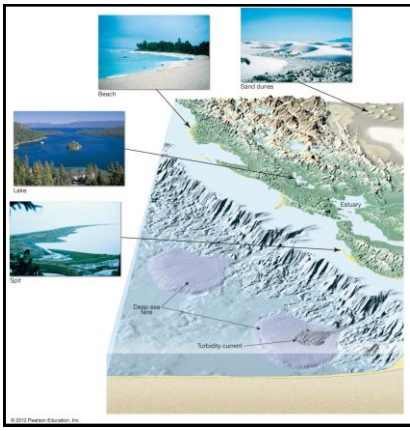


Figure 6.18

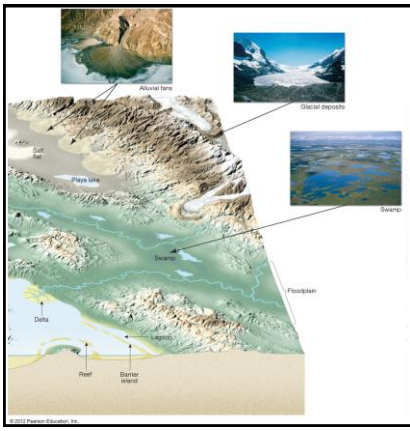


Figure 6.18

Sedimentary Structures

- Provide information useful in the interpretation of Earth's history
- Types of sedimentary structures
  - **Strata**, or beds (most characteristic of sedimentary rocks).
  - **Bedding planes** that separate strata.
  - **Cross-bedding** historic change in wind or water direction.

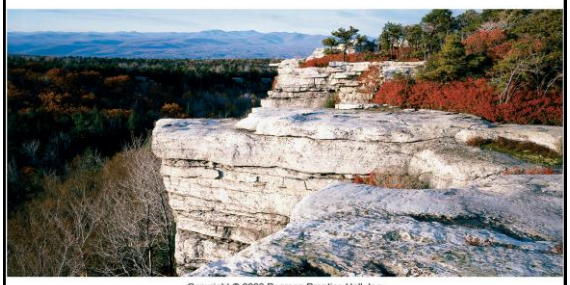


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Figure 6.19

Cross-bedding

Figure 6.20

Sedimentary Structures

- Types of sedimentary structures
  - Graded beds – coarse below fine grains.
  - Ripple marks – direction of wind or water as transporting agents.
  - Mud cracks – paleoclimate data indicating periods of wet and dry conditions.
  - Fossils – preserved hard parts, impressions, tracks, burrows,…

Graded Bedding

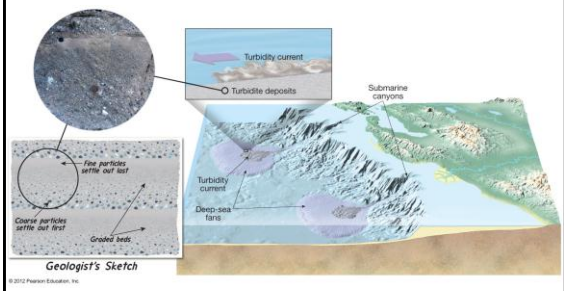


Figure 6.21

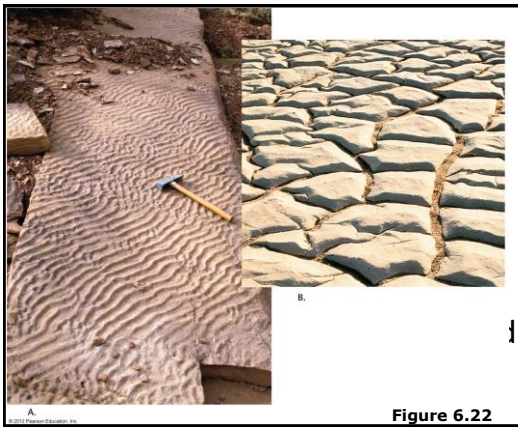
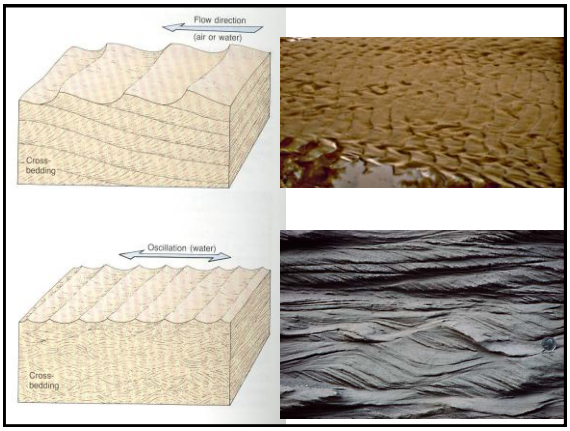
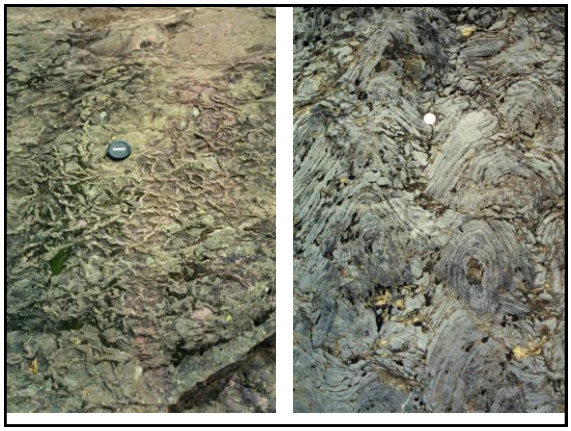


Figure 6.22





Provenance

- Term refers to all aspects of the sources from which a particular sedimentary rock is derived.
  - Composition (weathering effects)
  - Location (distance and direction)
  - Topographic relief (high or low)

"This sedimentary rock was derived from a mountainous andesitic volcanic island are located 100 km east of the depositional area."

Provenance

- **Sorting**
  - Degree of similarity in particle size
  - Well sorted to poorly sorted
  - Transport agent – wind, wave, stream
  - Transport time – short or long

Provenance

- **Shape**
  - Sharp or rounded edges – transport agent (air, water, ice)
  - Degree of rounding – indicating distance traveled or time

Provenance

- **Composition**
  - Predominate minerals (% overall)
    - Unstable minerals under attack
  - Bowen's Reaction Series (Fig 3.20)
    - Weathering is in the reverse order of crystallization

*Substantial weathering and long transport lead to the gradual destruction of weaker – less stable minerals.

*Silicate minerals weather in the order they initially crystallize.

Nonmetallic Mineral Resources

- Use of the word "mineral" is very broad.
- Two common groups
  - **Building materials**
    - Natural aggregate (crushed stone, sand, and gravel)
    - Gypsum (plaster and wallboard)
    - Clay (tile, bricks, and cement)
  - **Industrial minerals**
    - Corundum
    - Garnet
    - Diamond

Uses of Nonmetallic Minerals

TABLE 6.1
Uses of Nonmetallic Minerals

Mineral	Uses
Apatite	Phosphorus fertilizers
Asbestos (chrysotile)	Incombustible fibers
Calcite	Aggregate; steelmaking; soil conditioning; chemicals; cement; building stone
Clay minerals (kaolinite)	Ceramics; china
Corundum	Gemstones; abrasives
Diamond	Gemstones; abrasives
Fluorite	Steelmaking; aluminum refining; glass; chemicals
Garnet	Abrasives; gemstones
Graphite	Pencil lead; lubricant; refractories
Gypsum	Plaster of Paris
Halite	Table salt; chemicals; ice control
Muscovite	Insulator in electrical applications
Quartz	Primary ingredient in glass
Sulfur	Chemicals; fertilizer manufacture
Sylvite	Potassium fertilizers
Talc	Powder used in paints, cosmetics, etc.

Table 6.1

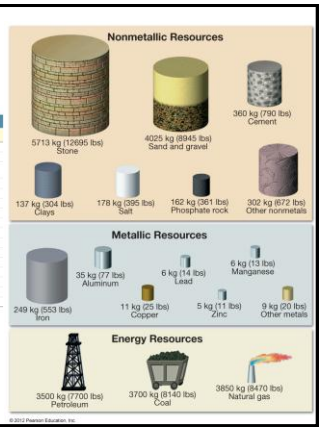


Figure 6.23

Energy Resources from Sedimentary Rocks

- **Coal**
  - Formed mostly from plant material
    - in swampy/bog with limited O_2
  - Along with oil and natural gas, coal is commonly called a **fossil fuel**
  - The major fuel used in power plants to generate electricity
  - Potential environmental problems from mining and air pollution

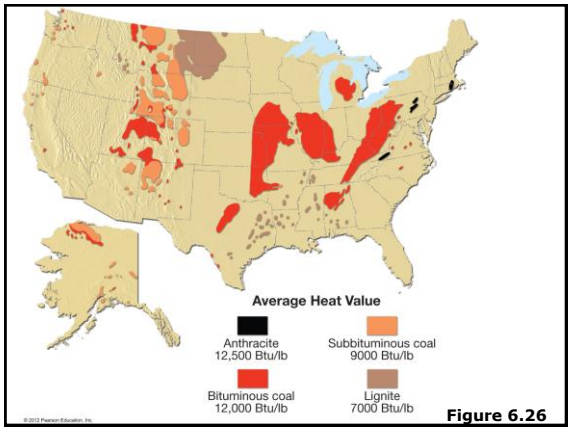


Figure 6.26

Energy Resources from Sedimentary Rocks

- **Oil** and **natural gas**
  - Derived from the remains of marine plants and animals
  - Both are composed of various hydro-carbon compounds and found in similar environments
  - **Oil trap** – geologic environment that allows significant amounts of oil and gas to accumulate

Energy Resources from Sedimentary Rocks

- **Oil** and **natural gas**
  - Two basic conditions for an oil trap
    - Porous, permeable **reservoir rock**
    - Impermeable **cap rock**, such as shale
  - Cap rock keeps the mobile oil and gas from escaping at the surface

Consumption of Energy in the United States, 2008

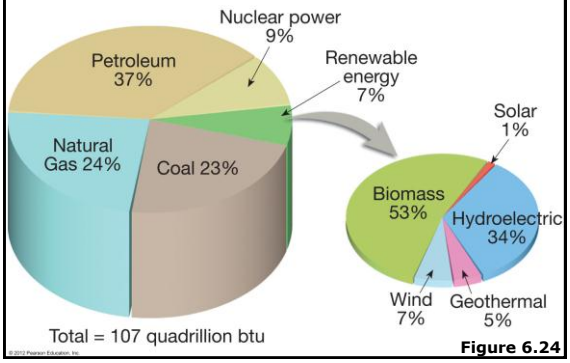


Figure 6.24

End of Chapter 6