

Ch. 6: Sedimentary Rocks

Chapter Summary

- *Sedimentary rock* consists of *sediment* that, in most cases, has been *lithified* into solid rock by the processes of *compaction* and *cementation*. Sediment has two principal sources: (1) as *detrital material*, which originates and is transported as solid particles from both mechanical and chemical weathering, which, when lithified, forms detrital sedimentary rocks; and (2) from soluble material produced largely by chemical weathering, which, when precipitated, forms *chemical sedimentary rocks*.



- *Diagenesis* refers to all of the physical, chemical, and biological changes that occur after sediments are deposited and during and after the time they are turned into sedimentary rock. Burial promotes diagenesis. Diagenesis includes lithification.

- *Lithification* refers to the processes by which unconsolidated sediments are transformed into solid sedimentary rock. Most sedimentary rocks are lithified by means of *compaction* and/or *cementation*. Compaction occurs when the weight of overlying materials compresses the deeper sediments. Cementation, the most important process by which sediments are converted to sedimentary rocks, occurs when soluble cementing materials, such as *calcite*, *silica*, and *iron oxide*, are precipitated onto sediment grains, fill open spaces, and join the particles. Although most sedimentary rocks are lithified by compaction or cementation, certain chemical rocks, such as the evaporites, initially form as solid masses of intergrown crystals.

- *Particle size* is the primary basis for distinguishing among various detrital sedimentary rocks. The size of the particles in a detrital rock indicates the energy of the medium that transported them. For example, gravels are moved by swiftly flowing rivers, whereas less energy is required to transport sand. Common detrital sedimentary rocks include *shale* (silt- and clay-sized particles), *sandstone*, and *conglomerate* (rounded gravel-sized particles) or *breccia* (angular gravel-sized particles).

- Precipitation of chemical sediments occurs in two ways: (1) by *inorganic processes*, such as evaporation and chemical activity; or by (2) *organic processes* of water-dwelling organisms that produce sediments of *biochemical origin*. *Limestone*, the most abundant chemical sedimentary rock, consists of the mineral calcite (CaCO_3) and forms either by inorganic means or as the result of biochemical processes. Inorganic limestones include *travertine*, which is commonly seen in caves, and *oolitic limestone*, consisting of small spherical grains of calcium carbonate. Other common chemical sedimentary rocks include *dolostone* (composed of the calcium-magnesium carbonate mineral dolomite), *chert* (made of microcrystalline quartz), *evaporites* (such as rock salt and rock gypsum), and *coal* (lignite and bituminous).

- Sedimentary rocks can be divided into two main groups: *detrital* and *chemical*. All detrital rocks have a *clastic texture*, which consists of discrete fragments and particles that are cemented and compacted together. The main criterion for subdividing the detrital rocks is particle size. Common detrital rocks include *conglomerate*, *sandstone*, and *shale*. The primary basis for distinguishing among different rocks in the chemical group is their mineral composition. Some chemical rocks, such as those deposited when seawater evaporates, have a *nonclastic texture* in which the minerals form a pattern of interlocking crystals. However, in reality, many of the sedimentary rocks classified into the chemical group also contain at least small quantities of detrital sediment. Common chemical rocks include *limestone*, *rock gypsum*, and *coal* (e.g., lignite and bituminous).

- *Sedimentary environments* are those places where sediment accumulates. They are grouped into *continental*, *marine*, and *transitional* (shoreline) environments. Each is characterized by certain physical, chemical, and biological conditions. Because sediment contains clues about the environment in which it was deposited, sedimentary rocks are important in the interpretation of Earth's history.

- Layers, called *strata*, or *beds*, are probably the single most characteristic feature of sedimentary rocks. Other features found in some sedimentary rocks, such as *ripple marks*, *mud cracks*, *cross-bedding*, *graded bedding*, and *fossils*, also provide clues to past environments.

- Earth materials that are not used as fuels or processed for the metals they contain are referred to as *nonmetallic resources*. Many are sediments or sedimentary rocks. The two broad groups of nonmetallic resources are *building materials* and *industrial minerals*. Limestone, perhaps the most versatile and widely used rock of all, is found in both groups.

- *Coal, petroleum, and natural gas*, the *fossil fuels* of our modern economy, are all associated with sedimentary rocks. Coal originates from large quantities of plant remains that accumulate in an oxygen-deficient environment, such as a swamp. More than 70 percent of present-day coal usage is for the generation of electricity. Air pollution from the sulfur oxide gases that form from burning most types of coal is a major environmental problem. Through a series of complex reactions in the atmosphere, the sulfur oxides produced when coal is burned are converted to sulfuric acid, which falls to Earth's surface in rain or snow.

- Oil and natural gas, which commonly occur together in the pore spaces of some sedimentary rocks, consist of various *hydrocarbon compounds* (compounds made of hydrogen and carbon) mixed together. Although petroleum formation is complex and not completely understood, it is associated with the accumulation of sediment in ocean areas that are rich in plant and animal remains that become buried and isolated in an oxygen-deficient environment. As the mobile petroleum and natural gas form, they migrate and accumulate in adjacent permeable beds such as sandstone. If the upward migration is halted by an impermeable rock layer,

referred to as a *cap rock*, a geologic environment develops that allows for economically significant amounts of oil and gas to accumulate underground in what is termed an *oil trap*, develops. The two basic conditions common to all oil traps are (1) a porous, permeable *reservoir rock* that will yield petroleum and/or natural gas in sufficient quantities, and (2) a cap rock.

Chapter Outline

- I. What is a sedimentary rock?
 - A. Probably the single most common and characteristic feature is strata (beds or layering), which are the result of mechanical and chemical weathering.
 - B. Account for about 5 percent (by volume) of Earth's outer 16 km (10 miles), but about 75% of all rock outcrops at the surface of the continents
 - C. Contain evidence of past environments
 1. Provide information about sediment transport
 2. Often contain fossils
 - D. Economic importance
 1. Coal
 2. Petroleum and natural gas
 3. Sources of iron, aluminum, and manganese
 - E. Often contain **inclusions** - A solid, liquid, or gaseous foreign body within the rock. Ex: fossils

- II. Turning sediment into sedimentary rock
 - A. A great deal of change can occur to sediment after it is deposited
 - B. **Diagenesis** - all chemical, physical, and biological changes that take place after sediments are deposited
 1. Occurs within the upper few kilometers of Earth's crust
 2. Includes:
 - a. **Recrystallization** – development of more stable minerals from less stable ones
 - b. **Lithification** - unconsolidated sediments are transformed into solid sedimentary rocks by
 1. **Compaction**
 2. **Cementation** by the materials
 - a. Calcite and/or
 - b. Silica
 - c. Iron oxide

- III. Types of sedimentary rocks
 - A. Material originates from mechanical and/or chemical weathering
 - B. Rock types are based on the source of the material
 1. **Detrital** rocks - material is solid particles
 2. **Chemical** rocks - material that was once in solution

IV. Detrital sedimentary rocks

- A. The two chief constituents are:
 - 1. Clay minerals
 - 2. Quartz
 - 3. Other minerals present:
 - a. Feldspars
 - b. Micas
- B. Particle size is used to distinguish among the various types of detrital rocks
 - 1. The silt and sand particles occupying the spaces between larger particles are called **matrix**.
- C. Particle shape is affected by the rock hardness, the transporting agent, and time
 - 1. Harder rocks weather more slowly
 - 2. Water and wind can round sediments, whereas glacial ice tends to produce angular shapes
 - 3. The longer a rock weathers, the more round it becomes.
- D. Common detrital sedimentary rocks (in order of increasing particle size and increasing energy of the transporting agent)
 - 1. **Shale**
 - a. Formed by compaction only, with no cementing
 - b. Formed mostly from clay formed by the chemical weathering of large amounts of feldspar
 - c. Thin layers or "**lamina**" ("**mudstone**" breaks into blocks)
 - d. Most abundant sedimentary rock
 - e. Black color derives from **organic carbon**
 - 2. **Sandstone**
 - a. Form in a variety of environments primarily by cementation
 - b. **Sorting** (similarity of particle sizes), shape, and composition of the grains can be used to interpret the rock's history
 - c. Quartz is the most predominant mineral
 - 3. **Conglomerate** and **breccia** – formed primarily by cementation
 - a. Conglomerate consists largely of rounded gravels
 - a. Breccia composed mainly of large angular particles

- V. Chemical sedimentary rocks – distinguished largely based on mineral composition
 - A. Consist of precipitated material that was once in solution
 - B. Precipitation of material occurs in two ways
 - 1. Inorganic processes
 - 2. Organic processes (“**biochemical origin**”)
 - C. Common chemical sedimentary rocks
 - 1. **Limestone**
 - a. Most abundant chemical rock
 - b. Composed chiefly of the mineral calcite
 - c. Marine biochemical limestones – made of shell material (most common type by far)
 - 1. **Coral reefs** – cemented corals
 - 2. **Coquina** – large pieces poorly cemented
 - 3. **Chalk** – small shell fragments (smaller than the head of a pin), soft, porous
 - d. Inorganic limestones
 - 1. **Travertine** (caves)
 - 2. **Oolitic** limestone
 - 2. **Dolostone**
 - 3. **Chert**
 - a. Made of microcrystalline quartz, largely derived from the shells of microscopic organisms
 - b. Forms
 - 1. **Flint**
 - 2. **Jasper** (banded form called agate)
 - 4. **Evaporites**
 - a. Evaporation triggers deposition of chemical precipitates – chemical origin
 - b. Examples
 - 1. **Rock salt**
 - 2. **Rock gypsum**
 - 5. **Coal**
 - a. Different from other rocks – made of organic material
 - b. Stages in coal formation
 - 1. Plant material
 - 2. **Peat** (plant remains) forms thick beds under anaerobic conditions
 - 3. **Lignite** (soft, brown)
 - 4. **Bituminous** (soft, black)
 - 5. **Anthracite** (metamorphic - hard, shiny)

- VI. Classification of sedimentary rocks
 - A. Classified according to the type of material
 - B. Two major groups
 - 1. **Detrital** or “clastic”
 - 2. **Chemical**
 - C. Two major textures used in the classification of sedimentary rocks
 - 1. **Clastic**
 - a. Discrete fragments and particles
 - b. All detrital rocks have a clastic texture
 - 2. **Nonclastic**
 - a. Pattern of interlocking crystals
 - b. May resemble igneous rocks

VII. Sedimentary environments

- A. A geographic setting where sediment is accumulating
- B. Determines the nature of the sediments that accumulate
- C. Types of sedimentary environments
 - 1. **Continental**
 - 2. **Marine**
 - 3. **Transitional** (shoreline)

VIII. Sedimentary structures

- A. Provide information useful in the interpretation of Earth history
- B. Types
 - 1. **Strata**, or beds (most characteristic feature of sedimentary rocks)
 - 2. **Bedding planes** (flat surfaces along which strata tend to separate and break)
 - 3. **Cross-bedding**
 - 4. **Graded beds** (particle size within one layer varies from bottom to top)
 - 5. **Ripple marks**
 - 6. **Mud cracks**
 - 7. **Fossils**

IX. Nonmetallic mineral resources from sedimentary rocks

- A. Earth materials not used as fuel or processed for metals. Use of the word “mineral” is very broad.
- B. Two common groups
 - 1. **Building materials**
 - a. Natural **aggregate** (crushed stone, sand, and gravel)
 - b. Gypsum (plaster and wallboard)
 - c. Clay (tile, bricks, and cement)
 - 2. **Industrial minerals**
 - a. Corundum
 - b. Garnet

X. Energy resources from sedimentary rocks

A. Coal

1. Formed mostly from plant material
2. Along with oil and natural gas, coal is commonly called a **fossil fuel**
3. The major fuel used in power plants to generate electricity
4. Problems with coal use
 - a. Environmental damage from mining
 - b. Air pollution

C. Oil and natural gas

1. Oil and natural gas, consisting of various hydrocarbon compounds, are found in similar environments
2. Derived from the remains of marine plants and animals
3. Formation is complex and not completely understood
4. A geologic environment that allows for economically significant amounts of oil and gas to accumulate underground is termed an **oil trap**
 - a. Two basic conditions for an oil trap
 1. Porous, permeable **reservoir rock**
 2. Impermeable **cap rock**, such as shale
 - b. Cap rock keeps the mobile oil and gas from escaping at the surface