Chapter 6: Sedimentation and Sedimentary Rocks

Fig. 6.18
OBJECTIVES

• Describe how sediment forms and consolidates to produce sedimentary rocks.

• Compare and contrast the textures and compositions of sedimentary rocks and explain how sedimentary rocks vary according to the environment of their deposition.

• Describe the different types of sedimentary rock and the basis of their classification.
OBJECTIVES

• Explain how the composition, fossil content, and presence of sedimentary structures allow us to interpret the origin of sedimentary rocks.

• Identify the various sedimentary features that characterize deposition in continental, coastal, and marine settings.

• Explain the role that plate tectonics plays in sedimentation and the formation of sedimentary basins.
Sediments and sedimentary rocks are formed by “cold” processes.

The characteristics of sedimentary rocks vary by the environment where they are deposited.

The textures and compositions of sediments and sedimentary rocks preserve information about the geologic past.
Sediment is unconsolidated material consisting of loose fragments of bedrock, minerals, shells, and/or crystals that precipitate directly from water.

Depositional environments are the physical settings in which sediments are deposited.

Sedimentary rock can be formed by a variety of processes binding and consolidating sediment together.
From Sediment to Sedimentary Rock

• Weathering transforms surface bedrock (source rock) into sediment.

• Chemical Weathering
  • Strips bedrock minerals of most soluble components, which are transported in solution to lakes and oceans.

• Mechanical Weathering
  • Produces detritus, which is readily removed and transported to lower elevations (by mass wasting or erosion).
Sediment production, transport by erosion agents, and deposition.

Relationship of the sedimentary processes to the rock cycle.
Formation of Sedimentary Rock

- After deposition, sediments go through **diagenesis**, which refers to the physical and chemical processes that occur as sediment is transformed into sedimentary rock.

**Fig. 6.2**

*From Sediment to Sedimentary Rock*

**Lithification:**
Adjacent particles in loose sediment bind together to form sedimentary rock.
From Sediment to Sedimentary Rock

• Biological Processes
  • Bacterial activity
  • Growth/decay of plants and root systems
  • Activity of burrowing organisms

• Physical Processes
  • Compaction squeezes fragments together
  • Compaction reduces pore space

• Chemical Processes
  • Precipitation of minerals from water and other fluids flowing through pore space
  • Cementation
Types of Sedimentary Rocks

- Two Main Groups
  - **Detrital sedimentary rocks**
    - Produced by mechanical weathering, which creates detritus that is transported (usually by mass wasting or erosion), deposited, and consolidated
  - **Chemical sedimentary rocks** (or biochemical sedimentary rocks)
    - Produced by chemical weathering, which extracts soluble components from rock
      - May occur as a result of organic or inorganic processes
Types of Sedimentary Rocks

- Detrital Sedimentary Rocks
  - **Clastic** texture
  - Matrix: finer-grained material between clasts
  - Wide variety of clast composition, grain size, grain shape

**Clastic Textures:**

(a) Granite clasts: a granitic body was exposed in the source area. (b) Feldspar clasts imply that the sediment is near its source. (c) Quartz indicates that the sediment traveled a long distance from its source. (d) Angular clasts implies a short travel distance from source.

Fig. 6.3
Types of Sedimentary Rocks

**Detrital Sediment Transport:** (a) The Missouri-Mississippi drainage basin consists of thousands of streams and covers most of the central and southern United States. (b) Inset shows the development of the Mississippi delta.

Fig. 6.4
Types of Sedimentary Rocks

• Clast Composition
  • Depends on **source area**

• Grain Size
  • **Sorting:** the process by which particles of the same size, shape, or density are naturally selected and separated from dissimilar particles
  • Affected by environmental conditions at deposition

• Grain Shape
  • **Rounding:** transport by running water blunts sharp edges
Types of Sedimentary Rocks

- Chemical and Biochemical Sedimentary Rocks
  - Less common than detrital
  - **Nonclastic** texture
  - Form by precipitation of crystals from solutions when concentration of ions reaches a threshold (**saturation**)

- **Evaporites**: a family of chemical sedimentary rocks formed by precipitation of salts caused by the evaporation of seawater

- **Limestone and Travertine**: form when water with dissolved $\text{Ca}^{2+}$ and $\text{CO}_3^{2-}$ ions experiences a change in composition, temperature, or pH that causes it to become saturated, precipitating $\text{CaCO}_3$
Types of Sedimentary Rocks

- Biochemical Sedimentary Rocks
  - Form by organic processes
  - Commonly contain fossils of the organisms responsible for their formation
  - Example: coal
    - Forms from the compaction of plant remains
    - Provides information on ancient environments and climate patterns
Types of Sedimentary Rocks

• Chemical OR Biochemical
  • Depends on environment of deposition
  • Example: **limestone** (can form in a variety of ways)

![Ooids, oolitic limestone](image1)

![Coral limestone](image2)

*Fig. 6.6*
## Classifying Sedimentary Rocks

Classification by particle size and shape.

<table>
<thead>
<tr>
<th>Texture (grain size)</th>
<th>Sediment Name</th>
<th>Rock Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse (over 2 mm)</td>
<td>Gravel (rounded fragments)</td>
<td>Conglomerate</td>
</tr>
<tr>
<td></td>
<td>Rubble (angular fragments)</td>
<td>Breccia</td>
</tr>
<tr>
<td>Medium (1/16 to 2 mm)</td>
<td>Sand</td>
<td>Sandstone (if abundant feldspar is present the rock is called Arkose)</td>
</tr>
<tr>
<td>Fine (1/16 to 1/256 mm)</td>
<td>Silt</td>
<td>Siltstone</td>
</tr>
<tr>
<td>Very fine (less than 1/256 mm)</td>
<td>Mud</td>
<td>Mudstone or Shale</td>
</tr>
</tbody>
</table>

Fig. 6.12
## Classifying Sedimentary Rocks

### Chemical Sedimentary Rocks

<table>
<thead>
<tr>
<th>Composition</th>
<th>Texture (grain size)</th>
<th>Rock Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcite CaCO₃</td>
<td>Fine to coarse crystalline</td>
<td>Crystalline limestone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Travertine</td>
</tr>
<tr>
<td></td>
<td>Shells and shell fragments cemented by calcite</td>
<td>Fossiliferous limestone</td>
</tr>
<tr>
<td></td>
<td>Microscopic shells and clay</td>
<td>Biochemical limestone</td>
</tr>
<tr>
<td>Quartz SiO₂</td>
<td>Very fine crystalline</td>
<td>Chert (light colored)</td>
</tr>
<tr>
<td>Gypsum CaSO₄ • 2H₂O</td>
<td>Fine to coarse crystalline</td>
<td>Gypsum</td>
</tr>
<tr>
<td>Halite NaCl</td>
<td>Fine to coarse crystalline</td>
<td>Rock salt</td>
</tr>
<tr>
<td>Altered plant fragments</td>
<td>Fine-grained organic matter</td>
<td>Coal</td>
</tr>
</tbody>
</table>

Classification by composition.

Fig. 6.13
Coal Formation: Initially, peat is formed. Increasing compaction leads to the formation of lignite, bituminous coal, and anthracite.
Interpreting Sedimentary Rocks

• Source Area
  • Identification of individual clasts
  • Mineral content
  • Degree of rounding and sorting

• Fossil Content
  • Provides information on the
    • Age of the rock
    • Depositional environment
    • Paleoclimate

Well-sorted, well-rounded quartz grains

Poorly sorted glacial deposits featuring granite clasts

Fig. 6.5
Interpreting Sedimentary Rocks

• Sedimentary Structures

• **Bedding**: layers of deposited sediment
  • Differentiated by
    • Composition
    • Shape size
    • Sorting
  • Layers are separated by a **bedding plane**

**Bedding**: Sedimentary bedding is spectacularly exposed in the walls of the Grand Canyon, Arizona.
Interpreting Sedimentary Rocks

• Sedimentary Structures (cont’d)

  • **Deltas** form with sediment accumulation at the mouth of a river.

  • **Cross beds** are inclined layers formed by currents of moving air or water.

  • The geometry of the cross-bedding provides information about
    • **Paleowinds**: the direction of ancient winds
    • **Paleocurrents**: flow direction of ancient currents
Interpreting Sedimentary Rocks

**Graded Bedding:** Bedding with systematic changes in particle size, a common feature of sediments deposited by turbidity currents.

Fig. 6.21
Interpreting Sedimentary Rocks

- **Surface Structures**
  - **Mudcracks** (below, left)
  - **Ripple marks** (below, right)

Figs. 6.22, 6.23
Interpreting Sedimentary Rocks

- **Bottom Structures**
  - Occur at the base of beds
  - **Loading**: grooves formed *after* passage of turbidity currents
  - **Fluting**: grooves forming *during* passage of turbidity currents

Flute casts (left), load casts (right)

Figs 6.24, 6.25
Depositional Environments and Sedimentary Facies

- **Sedimentary Facies**: describes an association of sedimentary beds
  - Differing characteristics
  - Deposited at the same time

Fig. 6.27
Depositional Environments and Sedimentary Facies

Major Depositional Environments

Fig. 6.26
Depositional Environments and Sedimentary Facies

• Deposition in Continental Environments
  • Dominated by action of streams
  • Strongly influenced by climate

• Deposition in Coastal and Marine Environments
  • Influenced by velocity and volume of water
  • Beaches, tidal flats, barrier islands, lagoons

Fig. 6.29
Depositional Environments and Sedimentary Facies

• Coastal Environments and Sea Level Change

  • Coastlines change continually as sea level rises and falls.
  
  • A **marine transgression** is produced by rising sea level.
  
  • A **marine regression** is produced by falling sea level.
Sedimentation, Sedimentary Rocks, and Plate Tectonics

• Mountains, formed by plate tectonic processes, provide the gravitational potential for the migration of sediment.

• Plate tectonics explain sedimentary basins, which trap sediment at low elevation.
  • Divergent plate boundaries cause
    • Rift basins when continents start to break apart
    • Thermal subsidence basins if rifting continues
  • Convergent plate boundaries cause
    • Flexural basins from one part of the crust overriding the other, causing the lower crust to flex downward
SUMMARY

• Sediment is converted into sedimentary rock by compaction and cementation.

• Sedimentary rocks can be produced by mechanical or chemical weathering and transport.

• Sedimentary rocks are classified based on particle size and shape (detrital) or composition (chemical and biochemical).

• Knowledge of modern depositional environments allows geologists to interpret the ancient sedimentary rock record.

• Source regions and depositional environments are influenced by plate tectonics.