Sedimentary rocks only make up 5% of the Earth's crust, but cover about 75% of the surface of the earth. The raw material for sedimentary rocks comes from weathering. Two basic sources of sedimentary material are:

1. Mineral and rock fragments or clasts produced by mechanical weathering or erosion of rock. Resulting sediment deposits are called detrital, and rocks formed from the sediment are called detrital sedimentary rocks.
2. Dissolved material that precipitates from solution. Rocks formed from this nondetrital or chemical sediment are called chemical sedimentary rocks, and can be derived from either inorganic or biochemical processes.

Transportation and Deposition of Sediment

Sediment is transported from the place of weathering to the place of deposition. During transportation, originally angular detrital sediment particles can be sorted by size and composition, and can become rounded. Agents of sediment transport include water (primary mechanism), gravity, wind, and ice. Processes by which sediment is deposited (sedimentation) involve loss of velocity, evaporation, and/or chemical interactions.

Depositional Environments

Sediment can be deposited in many different environments:

1. Continental
   a) Fluvial - Sediment was deposited by a stream.
   b) Eolian - Sediment deposited by wind (deserts).
   c) Lacustrine - Lake sedimentary deposits.
   d) Glacial - Sediment deposited by ice and meltwater.

2. Marine - Sediment accumulates on the ocean floor in shallow (continental shelf and reef) to deep (abyssal plain) environments.
3. Transitional - between land (terrestrial) and marine environments.
   a) Deltaic - Deposits at the mouth of a major stream.
   b) Beaches, lagoons and barrier islands - Sediment deposited by wind or water.

Lithification
**Lithification** is the conversion of sediment into rock, and results from a number of processes:

1. **Compaction** involves packing together of sediment grains through burial, leading to a reduction in sediment volume by up to 40%. Reduction of volume generally results from the pressure or weight of overlying sediments.
2. **Desiccation** involves the loss of water from sediment pore spaces, typically resulting from compaction but also from evaporation in air.
3. **Cementation** occurs where minerals precipitate from sediment pore fluids to bind to sediment particles together. Most common cements are calcite \((\text{CaCO}_3)\) and quartz \((\text{SiO}_2)\), but dolomite \([\text{(CaMg)CO}_3]\), iron oxides \((\text{Fe}_2\text{O}_3)\), and iron hydroxides \([\text{FeO(OH)}]\) may also serve as cements.
4. **Crystallization** characterizes chemical sediments, and primarily involves formation of interlocking crystals.

**Sedimentary Rock Textures**

Both detrital and chemical sedimentary rocks can show **clastic texture**. Rocks are separated by the size of the clastic particles. Particle diameters are determined by sieving. The **Wentworth Scale** of particle sizes is commonly used:

- gravel: > 2 mm
- sand: 1/16 to 2 mm
- silt: 1/256 to 1/16 mm
- clay: < 1/256 mm

Detrital sediments are also characterized by their **sorting**, the degree to which clastic particle sizes are similar. Sediments are described as **poorly-sorted** if a mix of particle sizes is present, and **well-sorted** if primarily one particle size is present. Sorting takes place during transportation, and particles can be sorted by:

- a) **grain size** - largest particles settle first
- b) **composition** - high specific gravity minerals settle first

The nature of detrital sediments is also indicated by the **particle shape**. Clasts can range from angular to spherical, generally depending on how far they have been transported. The shape of clasts are characterized in terms of:

- a) **Roundness** - degree of edge and corner removal.
- b) **Sphericity** - degree to which the fragment approaches the shape of a sphere.

**Non-clastic textures**, involving interlocking crystals similar to the crystalline texture of igneous rocks, are shown only by chemical sedimentary rocks. These rocks are subdivided according to crystal size as **fine-grained** (< 1 mm), **medium-grained**, or **coarse-grained** (> 5 mm).

**Types of Sedimentary Rocks**

Sedimentary rocks are classified by texture and composition into two major types, detrital and chemical.

A. Detrital sedimentary rocks have clastic texture and can be grouped as:
• Conglomerate and Breccia - Made of gravel-sized particles (>2 mm) surrounded by finer grained material. If larger particles are angular, it is called a sedimentary breccia. A breccia indicates the material has not been transported great distances. Both rocks indicate deposition in a high-energy environment characteristic of streams and beaches.

• Sandstones are composed of sand-sized particles (0.06-2 mm), primarily of quartz with some feldspar and rock fragments. Types of sandstone include:
  a. **Quartz Sandstone** - almost pure quartz
  b. **Arkose** - quartz and more than 25% feldspar
  c. **Graywacke** - "Dirty" sandstone containing quartz, feldspar, rock, and clay.

  Both arkose and graywacke indicate a lack of transport and weathering.

• Mudrocks comprise about 40% of all detrital sedimentary rocks, and are deposited in low-energy environments. They are subdivided into:
  a. **Siltstones** are composed of silt-sized particles (0.004-0.06 mm) of quartz and feldspar.
  b. **Mudstones**, which may be blocky or massive in appearance, are composed of a mixture of silt- and clay-sized particles (< 0.004 mm) of clay, quartz, feldspar, calcite, and dolomite.
  c. **Claystones** are massive and composed mostly of clay
  d. **Shales**, the most abundant detrital rock, are similar to a mudstones or claystones except that the rock breaks into layers parallel to the bedding.

B. Inorganic chemical sedimentary rocks originate from dissolved material that is precipitated inorganically. These rocks include:

• **Limestone** made up of calcite. Oolitic, travertine, and tufa forms of limestone are precipitated inorganically; travertine, a freshwater limestone, differs from the other types which are precipitated from seawater.

• **Dolostone** made up of dolomite. Dolostone has been thought to form by the replacement of limestone, although recent evidence indicates that some dolomite may be biochemical in origin. Very little primary dolomite has been found.

• **Evaporites** are sedimentary rock composed of minerals precipitated from evaporated sea water (e.g., gypsum and halite).

• **Silica** can precipitate as quartz, opal, or chert (cryptocrystalline silica including jasper, agate, and flint), and can occur as irregular masses or nodules in other rocks, especially limestone.

C. Biochemical sedimentary rocks originate from dissolved material that is precipitated through the activities of organisms. Include:
**Limestones** that originate as accumulations of shell and skeleton material made up of calcite or aragonite represent the most abundant chemical sedimentary rock. Types of biogenic limestone are:

1. **Chalk**, a powdery accumulation of microscopic plant and animal shells.
2. **Fossiliferous Limestone**, an accumulation of visible fossil organisms. Coquina is a very poorly cemented fossiliferous limestone.
3. **Micrite**, a smooth, dense, microcrystalline limestone.

**Bedded chert** (silica) forms from accumulations of microscopic marine organisms that secrete silica shells around their bodies.

**Peat** (partially decomposed plant material that accumulates in swamps) can be converted to coal (lignite or bituminus) through burial. Coal, however, is not considered a rock by most geologists.
Depositional Environment Analysis

Evidence preserved in sedimentary rocks can allow geologists to infer the events and processes which formed them. Using sedimentary structures and fossil evidence, geologists can infer the specific depositional environment of ancient sedimentary rocks:

A. Sedimentary Structures

1. **Bedding or Stratification**, the most important feature of sedimentary rocks, is layering that reflects changing conditions during deposition. Texture and composition are fairly uniform within a bed. Layering is usually horizontal or sub-horizontal. Original bedding can be obscured or destroyed through sediment flow or the action of burrowing animals. Kinds of bedding include:
   - Laminated bedding consists of closely spaced parallel bedding.
   - Cross-bedding involves non-horizontal bedding caused by wind or water currents, and can be used to indicate top of bed and paleocurrent directions.
   - Graded-bedding represents a progressive decrease in grain size upward through a bed, and can be used as a top of bed indicator. Grading can be caused by rapid deposition from turbidity currents.

2. **Ripple marks**, small waves on the surface of sediment caused by water or wind currents, can in some cases be used as a top of bed indicator. Two forms of ripples are recognized:
   - Wave-formed ripple marks are symmetric ripple marks formed in a surf zone.
   - Current ripple marks, asymmetric ripple marks formed by water or air currents moving generally in one direction, can be used as a current direction indicator.

3. **Mud cracks**, polygonal cracks caused by contraction of mud as it dries, indicate shallow water deposition, and can be used as a top of bed indicator.

4. **Sole marks**, which are casts (fillings) of a primary sedimentary feature such as a groove or burrow, can indicate top of bed.

5. **Secondary sedimentary structures** form long after deposition, and therefore do not give clues about how the sediment was originally deposited:

6. **Nodules**, an irregular, knobby-surfaced mineral body of a different composition than the surrounding sediment, usually lie parallel to bedding. Septarian nodules show dehydration cracks that are filled by material of a different composition.

7. **Concretions**, usually spherical and often characterized by concentric layering, are depositional bodies composed of cementing material often found in sandstone.

8. **Geodes**, which generally occur in limestone and shale, are roughly spherical hollow structures formed when a pocket of water in sediment is surrounded by a deposit of silica. Larger crystals of quartz or calcite grow inward from solution.
Fossils represent reserved remnants of ancient plants and give clues about ancient life, evolution, and depositional environment. Fossils allow rocks in widely separated areas to be correlated in time, and form the basis for constructing the geologic calendar. Trace fossils provide indirect evidence of ancient life such as burrows, trails, and tracks. Body fossils are the actual preserved parts (mostly hard parts) of an organism. Most fossils have been dissolved and replaced by other materials like silica and pyrite. Petrified wood is formed when silica replaces cellulose. A mold is the cavity in sediment that a shell once filled; a cast is the filled-in mold.
Sedimentary Facies

Sedimentary rocks tend to change in composition and nature laterally due to changes in depositional environment. Sediment can be deposited in different places at the same time, yet look very different because of a different depositional environment. Sedimentary facies reflect the characteristics of a particular depositional environment. These deposits each have a distinctive set of physical, chemical and biological attributes. Sea level fluctuations can result in a particular facies being deposited over wide areas:

1. **Marine Transgressions** - Sandstone (nearshore deposit) overlain by shale (shallow marine deposit) and limestone (deeper marine deposit) indicates sediment deposition during a time of sea level rise.
2. **Marine Regressions** - Deep marine deposits are overlain by shallower marine and nearshore deposits, indicating sediment deposition during a time of falling sea level.

Changes in global sea level may reflect subsidence or uplift and increased glacial activity.

Sedimentary Rocks and Natural Resources

Sediments, sedimentary rocks and the materials they contain have many uses.

1. **Petroleum and Natural Gas** are hydrocarbons formed from the remains of microscopic plants and animals. The organic matter has been preserved in sediments (the source rock) by rapid burial. With burial, heat and chemical reactions transform organic matter into petroleum and natural gas. After formation, the hydrocarbons migrate upward until they reach the surface or are trapped. A petroleum trap consists of a permeable reservoir rock and an impermeable cap rock. Oil shales (contain at least 1 barrel of oil per ton of shale) and tar sands (sand that contains thick, asphalt-like hydrocarbons) may be important future sources of petroleum.
2. **Uranium ores**, that occur in fluvial (stream-deposited) sandstones containing organic matter, are found in several western states. Uranium dissolved in oxidizing groundwater is transported with the groundwater until reducing conditions cause precipitation of carnotite (a uranium mineral).
3. **Banded iron formations** represent largest source of iron ore in the world, and are found on all the continents. The deposits consists of chemical sediments that are extremely rich in iron. Most were deposited in shallow seas during the late Precambrian (before 2.5 billion years ago) when a lack of atmospheric oxygen allowed seawater to have much higher dissolved iron concentrations. The ores formed when iron was precipitated out of seawater by addition of oxygen from algae (photosynthesis) or bacteria (respiration) living in large colonies called stromatolites. These organisms became abundant about 2.5 billion years ago.
4. Other sediment or sedimentary rock derived resources include:
1. Building materials (sand and gravel, construction; limestone, cement; gypsum, wallboard and plaster; clay, bricks; quartz, glass
2. Halite used as a seasoning and preservative.
3. Clay used in ceramics and kitty litter.
4. Phosphates used for fertilizers, matches, and preservatives
5. Diatomite used in filtration.
6. Coal used for energy and coke in steel production.