Chapter 1. Sedimentary rock

Introduction

Sedimentary rocks are exogenous rocks (formed at the Earth's surface) that make up 5% of the Earth's crust by volume. They are widespread at the surface (they cover 75% of the surface) in the form of layers overlying metamorphic and magmatic rocks. Sedimentary rocks are of great economic importance: oil, gas, coal and building materials are all sedimentary in origin. They are also of scientific importance: they are the only type of rock to contain fossils. Sedimentary rocks are formed by the accumulation of sediments, most often deposited in superimposed layers or beds known as strata. They result from the accumulation of various sediments, (that's to say) i.e. solid elements (clasts: pieces of rock or mineral fragments, shell fragments, etc.) and/or precipitation from solutions.

Types of sedimentation

Rivers, oceans, winds and rainwater have the capacity to transport particles resulting from the disintegration (destruction) of rocks by erosion. These materials are composed of rock fragments and minerals. When the energy of transport is no longer strong enough to move these particles, they settle: this is the process of sedimentation. This type of sedimentation is known as detrital or clastic sedimentation.

Another type of sediment deposition occurs when materials are dissolved in water and precipitate. This type of sedimentation is known as chemical sedimentation.

A third process can occur when living organisms extract dissolved ions from the water to form shells and bones. This type of sedimentation is called biogenic sedimentation.

So, there are three main types of sedimentary rock: **detrital, chemical and biogenic.**

Stages of formation of a sedimentary rock

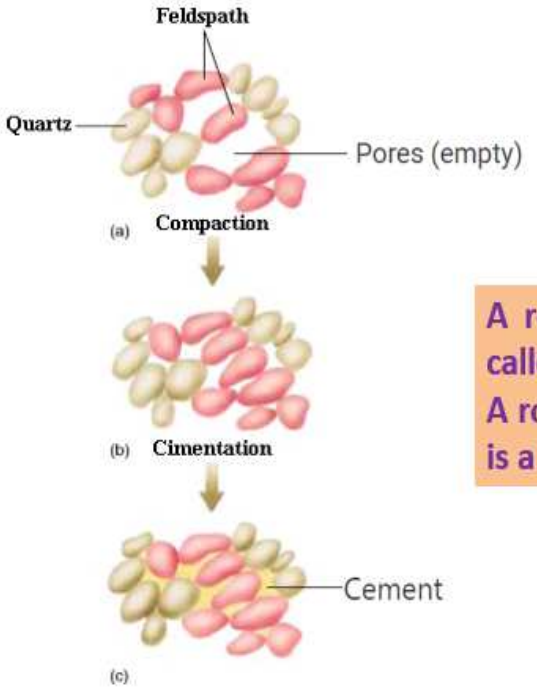
The formation of sedimentary rock involves several stages:

a. **Erosion**: the process of destruction pre-existing rocks. There are two types of erosion: Physical or mechanical erosion: disintegration of rocks into small pieces by physical or mechanical processes. Chemical erosion: the dissolution of chemical elements by water, leading to the decomposition of rocks or minerals. Erosion agents include water, wind, frost and temperature.

b. Transport: sediments resulting from erosion can be transported over great distances by the wind, or by water in rivers or ocean currents.

Deposition: when the speed of the transport agent becomes too low to continue transporting the sediment, the latter is deposited. Deposition takes place in sedimentation basins, usually at the bottom of the sea.

c. Diagenesis: diagenesis is the physical and chemical process that transforms loose sediment into consolidated rock. Diagenesis involves two stages (figure): Compaction: sediments move closer together, with fewer voids or pores between particles, and the elimination of water between pores. Cementation or lithification: sediments are bound together by a chemical cement. The sediment is then transformed into solid rock.



Different stages of diagenesis

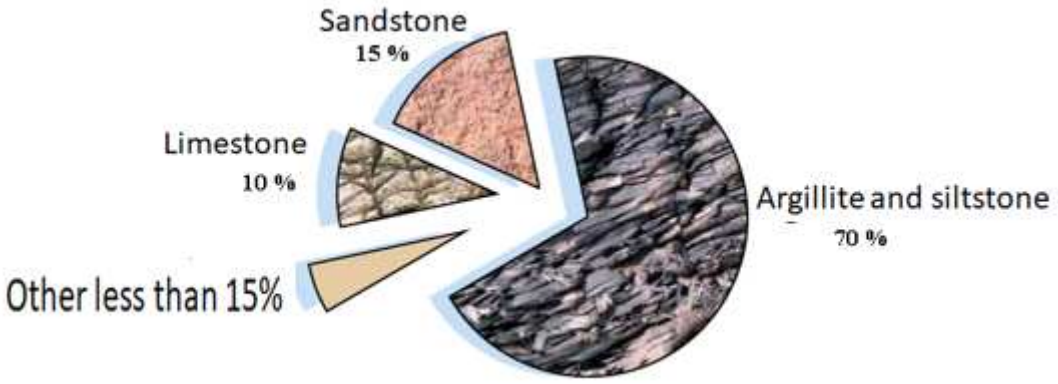
A rock with bonding phases is called a consolidated rock.
A rock without a bonding phase is a loose rock

Detrital or clastic sedimentary rocks

Detrital sedimentary rocks are formed from pre-existing rocks and are made up of rock fragments and minerals. They account for 85% of sedimentary rocks on the Earth's surface.

What is the difference between clastic and detrital?

Detrital and clastic are two different words for the same type of sedimentary rock, but the words have different origins. Detrital comes from the word detritus, which means debris produced by erosion. Clastic comes from the word clast, which means the weathered fragments of other rocks.



Relative abundance of different sedimentary rock types

Classification of detrital sedimentary rocks

Detrital Sedimentary Rocks

ClasticTexture (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	Sandstone (Arkose)*
Fine (1/16 to 1/256 mm)		Mud	Siltstone
Very fine (less than 1/256 mm)		Mud	Shale or Mudstone

*If abundant feldspar is present the rock is called Arkose.

Detrital rock is classified according to sediment **grain size**. Grain size is the average diameter of sediment fragments in sediment or rock. For example, the grain sizes in the pebble class are 2.52, 1.26, 0.63, 0.32, 0.16, and 0.08 inches, which correlate respectively to very coarse, coarse, medium, fine, and very fine granules. Large fragments, or clasts, include all grain sizes larger than 2 mm (5/64 in). These include boulders, cobbles, granules, and gravel. Sand has a grain size between 2 mm and 0.0625 mm, about the lower limit of the naked eye's resolution. Sediment grains smaller than sand are called silt. Silt is unique; the grains can be felt with a finger or as grit between your teeth, but are too small to see with the naked eye.

Chemical and biochemical sedimentary rocks

Chemical sedimentary rocks: are formed by the precipitation or crystallization of substances (ions or mineral salts) dissolved in water. Plants and animals can extract substances dissolved in water to form their tests or bones, and it is their remains that constitute sedimentary rocks of biochemical origin. Sedimentary rocks of chemical and biochemical origin are classified according to their chemical composition.

1. Carbonate rocks

Carbonate rocks are essentially composed of calcite ($CaCO_3$), aragonite ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$). Carbonate rocks rich in calcite (or aragonite) are called limestones, while those rich in dolomite form dolomites. Limestones make up over 10% of sedimentary rocks (Figure). Seawater contains large quantities of dissolved calcium carbonate ($CaCO_3$). Many organisms use this calcium carbonate to form their skeletons and other hard body parts. When these organisms die, ocean currents break up these fragments into smaller pieces called bioclastic sediments. The rock formed by the lithification of these sediments is called bioclastic limestone, indicating that it was formed by biological and clastic processes. Other limestones and dolomites result from the direct precipitation of carbonates (chemical origin): primary dolomites, stalactites, stalagmites, lithographic limestones, travertines.

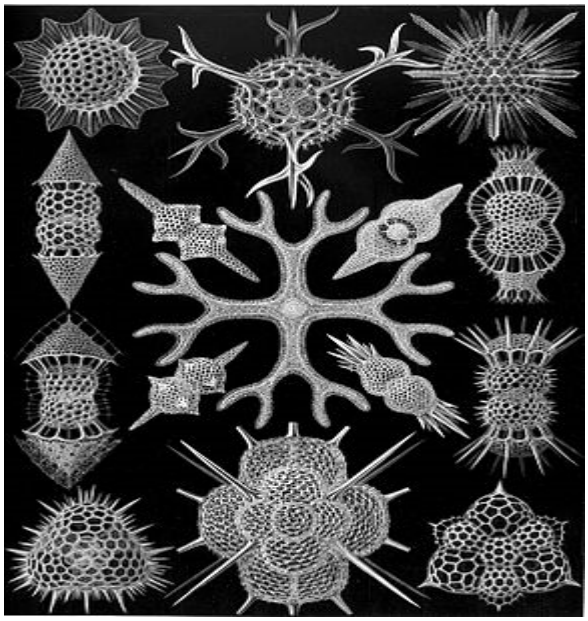
To distinguish between limestone and dolomite, we use the acid test. Limestones effervesce in acid (HCl), whereas dolomites do not.

In general, dolomites always contain a certain percentage of calcite and vice versa, (limestones also contain a certain percentage of dolomite). If the rock contains more than 50% dolomite, it is a dolomite. If it contains more than 50% calcite, it is limestone.

2. Siliceous rocks

Siliceous rocks are sedimentary rocks composed mainly of very finely crystallized silica (SiO_2) (quartz or chalcedony)

Biochemical origin (radiolarites, diatomites = rocks formed by accumulation of organisms producing a radiolarian siliceous skeleton and diatoms).



3. Saline rocks or evaporites

This is a group of minerals of chemical origin, which precipitate as a result of intense evaporation, generally in shallow waters or salt lakes in desert environments.

The main evaporite rocks are gypsum ($CaSO_4$-$2H_2O$) and anhydrite ($CaSO_4$), rock salt or halite (NaCl) and potassium salt or sylvite (KCl).

4. Carbonaceous rocks

Rocks composed essentially of organic carbon compound. The rock formed by the accumulation of plant remains is coal. Microscopic phytoplankton (عوالق نباتية) and bacteria are the main sources of organic matter in sediment. The transformation of organic compound in sediments forms hydrocarbons (oil and natural gas).

5. Iron and phosphate rocks (**Phosphorite**, **phosphate rock** or **rock phosphate)**

Phosphate rocks are essentially of organic origin (animal teeth and skeletons) and are made up of apatite. Iron-bearing rocks are rich in iron oxides such as bauxite.