Sedimentary rocks

Sedimentary rocks are formed from the solid debris and the dissolved minerals matter produced by the mechanical and chemical breakdown of pre-existing rocks, or in some cases from the skeletal material of dead plants and animals.

Types of deposits

The nature of a sedimentary rock, and its position in a scheme or rock classification, are partly dependent on these original conditions of transport and deposition. Thus it may be described according to the type of environment in which it accumulated: as a **continental deposit** if it were laid down on land or in a lake by rivers, ice or wind; as an **intermediate deposit** if it were laid down in an estuary or delta; or as a **marine deposit** if it were laid down on a sea shore, in the shallow waters of the continental shelves, or in the abyssal areas of the deep oceans.

Surface processes

All rocks weather on exposure to air and water, and slowly break down to form in situ soils. In most land environments, the soil material is subsequently transported away from its source, and mat then be regarded as sediment; this includes the solid debris particles and also material in solution in water.

Natural transport processes are dominated by water, which can sort and selectively deposit its sediment load. Ultimately all sediment is deposited, mostly in the sea, and mostly as stratified layers or beds of sorted material.

- The **land** is essentially the erosional environment; it is the source of sediment, which forms the temporary soils before being transported away.
- The **sea** is essentially the depositional environment; sediment is buried beneath subsequent layers and eventually forms most of the sedimentary rocks.

Burial of this loose and unconsolidated sediment, by more layers of material subsequently deposited on top of it, eventually turns it into a sedimentary rock, by the various processes of lithification. Subsequent earth movements may raise the beds of sedimentary rock above sea level; erosion and removal of the overlying rocks (to form the source material for another generation of sediments and sedimentary rocks) then exposes the old sedimentary rocks in outcrops in a landscape far removed from contemporary seas and in an environment very different from that of sedimentation.

Sediment transport

The most abundant sediment is clastic or detrital material consisting of particles of clay, sand and rock debris.

Water is far the most important agent of sediment transport. Rivers move the majority of sediment on land. Coarser debris is rolled along the river beds; finer particles are carried in suspension. Water, ability to transport sediment depends on its velocity – larger particles can only be moved by faster flows. Sediment is therefore sorted (to one size) during water transport.

Sediment is also moved in the sea, mainly in coastal waters where wave action reaches the shallow sea bed. Other transport processes have only limited scope

- Gravity alone works mainly on the steeper slopes, producing landslides and colluvium
- Wind moves only fine particles
- Ice transport is powerful, but restricted by climate
- Volcanoes may blast debris over limited distances

Some minerals are transported by solution in water. Organic sediment is rarely carried far from its source.

Sediment deposition

Water or land: Sorted and stratified, mostly sand and clay. Alluvium in river valleys is mostly temporarily, later eroded away, except in subsiding deltas. Lake sediment includes salts precipitated due to desert evaporation.

The sea: Final destination of most clastic sediment. Sorted and stratified in beds, mostly in shallow shelf seas. Turbidity/currents carry sediment into deeper basins. Shell debris in shallow seas, with no land detritus, forms the main limestones.

Slope: Localized poorly sorted scree and slide debris. Wind

Wind: Very well sorted sand and silt, mostly in or near dry source areas, so only significant in desert regions.

Ice: Unsorted debris dumped in the melt zones of glaciers. Localized today but extensive in past Ice Ages.

Volcanoes: Fine, sorted airfall ash, wind-blown over large area; also coarse unsorted flow and surge deposits, mostly on volcano slopes. Collectively known as pyroclastic sediments (=fire fragments).

Lithification

The processes by which a weak loose sediment is turned into a stronger sedimentary rock. Induced by burial pressure and slightly increased temperature beneath a kilometer or more o over lying sediment. The processes of lithification are known as diagenesis by geologists, referring to the changes which take place after deposition. The results of lithification, notably the increase in strength, are reefed to as consolidation by engineers.

Three main processes of lithification:

Cementation: The filling of the inter-granular pore spaces by deposition of a mineral cement brought in by circulating groundwater. Rock strength is largely dependent on the type of cement, which may be silica (strongest), iron oxides, calcite or clay (weakest). The dominant process in sandstones.

Recrystallisation: Small scale solution and redepostion of mineral, so that some grains become smaller and some become larger. Result may be similar to cementation, but may produce stronger mosaic texture. Can also include change of state and growth of new more stable minerals. The dominant process in limestone.

Compaction: Restructuring and change of grain packing, with decrease in volume, due to burial pressure, with consequent reduction of porosity as water is squeezed out. Increase in strength is due to more grain to grain contact. The dominant process in clays.

Consolidation

Consolidation generally refers to the increase in strength in clays , due to their restructuring, improved packing, loss of water and reduced porosity caused by compaction under load; it also includes some cementation and new mineral growth.

Normally consolidated clays have been under a higher load than their existing overburden; these include most clay soils.

Over-consolidated clays have been under a higher load in the past, imposed by cover rocks since removed by erosion; these include nearly all clays within rock sequences. They have lower porosity and higher strength due to their history of burial and exposure.

Classification of sedimentary rocks

The dedimentary rocks may be classified as follows:

Mechanically formed, or clastic or detrital rocks

Consisting of material (gravel, sand, silt and clay) suspended in flowing water. They are of three types:

i) Rudaceous rocks: Bouldery deposits e.g. conglomerate.
ii) Arenaceous rocks: sandy rocks e.g. sandstone.
iii) Argillaceous rocks: clayey rocks, e.g. shale.

Organically formed rocks

Consisting of accumulated animal or plant remains. These are of two types:

i) Calcareous rocks: limestone rocks
ii) Carbonaceous rocks: coal seams

Chemically formed rocks, evaporates

Formed due to precipitation and accumulation of soluble constituents. These are of three types:

i) Carbonate rocks: limestones or dolomites
ii) Sulphate rocks: Gypsum rocks
iii) Chloride rocks: rock salt

Mineralogy of sedimentary rocks

Mineral	Composition	Colour	Hardness	Specific Gravity	Common morphology and features
Quartz	SiO_2	Clear	7	2.7	Granular, no cleavage, glassy luster
Muscovite	$KAl_2AlSi_3O_{10}(OH)_2$	Clear	2.5	2.8	Thin sheets and flakes on perfect cleavage, mica
kaolinite	$Al_4Si_4O_{10}(OH)_8$	White	The clay minerals maximum crystals size only microns across		stable type; include china clay
Illite	$KAl_4AlSi_7O_{20}(OH)_{20}$	White			Dominant type, similar to fine muscovite
Smectite	$(Na,Ca)Al_4Si_8O_{20}(OH)_4.nH_2O$	White			Unstable (variable water)
Calcite	$CaCO_3$	White	3	2.7	Mosaic, shell debris, rhombic cleavage on 3 planes
Dolomite	$CaCO_3.MgCO_3$	White	3.5	2.8	Mosaics and rhombs
Gypsum	$CaSO_4.2H_2O$	White	2	2.3	Bladed selenite; massive alabaster; fibrous satinspar.
Hematite	Fe_2O_3	Red	6	5.1	Widespread coolouring agent
Limonite	FeO.OH	Brown	5	3.6	Widespread coolouring agent; rust, may be yellow
Pyrite	FeS_2	Yellow	6	5.0	Metallic brassy luster (fool's gold), common as cube

Textures of sedimentary rocks

Chemical sedimentary rocks generally have a crystalline texture. Some, however, are formed of fragments, and their textures are dependent on the sizes, shapes and arrangement of these fragments. If the rock has formed from organic debris, then the fragments may consist of particles of shell or wood, but the texture can be described in the same terms as are used for other fragmented rocks

Size of grains

The size of grains is an important textural feature of a terrigenous rocks, as an indication of distance between its source and depositional areas, as well as an easily observes property which may be used to distinguish and classify the rock. The coarsest particles are deposited near the source are, and most of the finest particles are carried in suspension to greater distances before they settle.

On the basis of size of grains, Wentworth proposed the following classification:

size range	**name**	**other names**
256-∞ mm	boulder	
64–256 mm	cobble	
32–64 mm	very coarse gravel	pebble
16–32 mm	coarse gravel	pebble
8–16 mm	medium gravel	pebble
4–8 mm	fine gravel	pebble
2–4 mm	very fine gravel	granule
1–2 mm	very coarse sand	
0.5–1 mm	coarse sand	
0.25–0.5 mm	medium sand	
125–250 µm	fine sand	
62.5–125 µm	very fine sand	
3.9–62.5 µm	silt	mud
1/∞-3.9 µm	clay	mud
1/∞-1 µm	colloid	mud

Degree of roundness

The degree of roundness of grains is related to the amounts of abrasion suffered during transport, and hence to distance travelled from their source before deposition. Roundness is related to the sharpness or curvature of edges and corners of grains. It is also dependent on the size and hardness of the grains and the violence of impact of one against another. The degree of roundness is important property in sand being used to make concrete, or for other engineering purposes.

A property associated with roundness of grains is **sphericity**, which defines the degree the particle or grain approaches the shape of a sphere. Equidimensional particles have a greater prospect of becoming spherical during transportation than other shapes of particle. Sphericity is controlled by direction s of weakness such as bedding planes or fractures. It is also related to size, in that the larger the grain above 8 mm, the lower the sphericity. The relationship of rounding to particles less than 2 mm of high and low sphericity is given in the following figure.

Degree of sorting

The relative homogeneity of a rock is expressed as its degree of sorting, a well sorted rock consisting of similarly sized particles. In contrast, a poorly sorted rock has a wide range of particle sizes (that is grades). It should be noted that, in engineering practice, a soil such as gravel, containing a wide range of sizes (grades), is said to be **well graded**, and that 'well graded' is opposite in meaning to 'well sorted'.

Structural features of sedimentary rocks

Structural features of sedimentary rocks are of great value in determining their origin. The chief sedimentary structures are as follows.

1. Stratification
2. Lamination
3. Cross-bedding
4. Graded bedding
5. Ripple marks
6. Marks in dessicated sediments
7. Concretions

Stratification

The deposition of sediments into layers or beds is called "stratification". The thickness of a single bed may vary from a few centimeters to many peters. The planes dividing different beds are called "bedding Planes". The stratification is formed due to the following:

i) Differences in the kinds of material deposited, e.g. shale and limestone beds.
ii) Difference in the size of particles deposited, e.g. coarse grained and fine grained sandstones beds.
iii) Differences in the colour of the material deposited, e.g. light grey and dark grey layers of limestones.

Lamination

Thin bedding, less than one centimeter in thickness, are called "lamination". It is usually found in fine grained sedimentary rocks like shales.

Cross-bedding

It is also called current *bedding* or *false bedding.* Cross bedding is the minor bedding or laminations which lie at an angle to the planes of general stratification. This structure is found in shallow water and wind formed deposits.

Graded bedding

When a sedimentary bed shows a gradation in grain size from coarse below to fine above, it is said to be graded. Such type of bedding is called "graded bedding". This structure is commonly found in grayweckes.

Ripple marks

Ripple marks are the wavy undulations which may be seen on the surface of some sedimentary deposits. These are produced by the action of waves and currents in shallow water. They may also be formed on the deposits formed by wind. Ripple marks are of two types

i) Asymmetrical or current ripple marks
ii) Symmetrical or oscillation ripple marks.

The oscillation ripple marks are useful in determining tops and bottom of deformed beds.

Marks in Desiccated sediments

The sediments which have undergone repeated wetting and drying may show "mud cracks" and "tracks" of terrestrial animals"," percussion marks of hail and rain and impression of ice or salt crystals". These markings are most commonly preserved as casts.

Concretions

Concretions are variously shaped masses or nodules of mineral matter found within a sedimentary rock. Their shape may be round, elliptical, oval, lenticular, or irregular. Concretions generally consist of calcium carbonate or silica and often possess an internal radiating o concentric structure. They are formed by the deposition of mineral matter from percolating solutions about a nucleus.

Description of common sedimentary rocks

Conglomerate

The pebbles and gravels on consolidation and cementation produce a rock known as conglomerate. The pores of a conglomerate are filled up with a matrix which is composed of fine sands, rock particles and some cementing material.

Breccia

A breccia is a rock resembling conglomerate but having angular fragments instead of rounded pebbles.

Sandstone

A sandstone is mainly composed of sand size grains of quartz which arecemented rogether. The cementinbg material may be silica, calcite, iron-oxide or clay. Depending upon the nature of cementing material, sandstones may be classified as follows.

i) Siliceous sandstone: Sandstone in which the cementing material is silica.
ii) Calcareous sandstone: Sandstone in which the cementing material is calcium carbonate.
iii) Ferruginous sandstone: Sandstone in which the cementing material is iron-oxide.
iv) Argillaceous sandstone: Sandstone in which the cementing material is clay.

Shale

It is a laminated fine grained sedimentary rock which is mainly composed of clay minerals and some silt-size grains of quartz. Shales may be calcarious, carbonaceous, and ferruginous depending upon whether they contain calcium carbonate, carbonaceous matter, or iron-oxide. Shale are often soft and can be scratched by a knife.

Mudstone

Unlaminated clayey rocks are called mudstones.

Limestone

Limestones consist chiefly of calcite and dolomite with varying amounts of impurities such as chalcedony or clay. Some limestones may also contain calcarious shells of marine organisms. Limestones are are very fine grained and show in some cases pisolitic or oolitic structures. Limestones are identified by their softness, their fossil content, and by their effervescence in dilute hydrochloric acid.

Marl

Impure limestone which contain mixture of clay and calcarious matter, are known as marls.

Dolomite

Dolomite is a magnesium limestone which is composed of double carbonate of calcium and magnesium. It is distinguished from ordinary limestone by its greater hardness, greater specific gravity, and inferior solubility in hydrochloric acid.