



Outlines of the Presentation

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4. Description of common metamorphic rock



Classification of Sedimentary Rocks

Sedimentary rock is a type of rock that is formed by sedimentation of material at the Earth's surface and within bodies of water.

Sedimentation is the collective name for processes that cause mineral and/or organic particles (detritus) to settle and accumulate or minerals to precipitate from a solution.

Particles that form a sedimentary rock by accumulating are called sediment. Before being deposited, sediment was formed by weathering and erosion in a source area, and then transported to the place of deposition by water, wind, mass movement or glaciers.

Classification of Sedimentary Rocks

Sedimentary rock is formed by deposition and consolidation of minerals and organic materials and from precipitation of minerals from solution. The processes that form sedimentary rock occur at the surface of the earth and within bodies of water.

Rock formed from sediments covers 70-80 % of the earth's land area, and includes common types such as limestone, chalk, sandstone, conglomerate and shale.

Sedimentary rocks are only a thin veneer over a crust consisting mainly of igneous and metamorphic rocks and constitute a total of 5% of the earth crust volume.

Sedimentary rocks are deposited in layers as strata, forming a structure called bedding. The study of sedimentary rocks and rock strata provides information about the subsurface that is useful for civil engineering, for example in the construction of roads, houses, tunnels canals or other constructions.

Sedimentary rocks are also important sources of natural resources like coal, fossil fuels, drinking water or ores.

Classification of Sedimentary Rocks

The scientific discipline that studies the properties and origin of sedimentary rocks is called sedimentology.

Sedimentology is both part of geology and physical geography and overlaps partly with other disciplines in the Earth sciences, such as penology, geomorphology, geochemistry or structural geology.

The study of the sequence of sedimentary rock strata is the main source for scientific knowledge about the Earth's history, including palaeogeography, paleoclimatology and the history of life.

Classification of Sedimentary Rocks

Mechanically formed: consisting of materials (gravels, sand, silt and clay) suspended in flowing water. The suspended materials are then deposited and consolidated.

Water percolates into cracks and fissures within the rock, freezes, and expands. The force exerted by the expansion is sufficient to widen cracks and break off pieces of rock. Heating and cooling of the rock, and the resulting expansion and contraction, also aids the process. Mechanical weathering contributes further to the breakdown of rock by increasing the surface area exposed to chemical agents.

The mechanically formed sedimentary rocks are of three types:

1. Rudaceous rocks which is the cementing together of boulders, for example, conglomerate.
2. Arenaceous rocks for example sandstone,
3. Argillaceous rocks which is clay rocks for example shale



Clay stone deposited in Glacial Lake Missoula, Montana, USA.



Outcrop of Ordovician oil shale - Northern Estonia.



Cross-bedding and scour in a fine sandstone.



Cyclic alternation of competent and less competent beds in the Blue Lias

Classification of Sedimentary Rocks

Organically formed: Consisting of accumulated animals and plants remains.

Organic sedimentary rocks contain materials generated by living organisms, and include carbonate minerals created by organisms, such as corals, mollusks (Snail, slug, Octopus) , and foraminifera (seawater Organism) , which cover the ocean floor with layers of calcium carbonate, which can later form limestone. Other examples include stromatolites, the flint nodules found in chalk (which is itself a biochemical sedimentary rock, a form of limestone), and coal and oil shale (derived from the remains of tropical plants and subjected to heat).

They are:

1. Calcareous rocks, lime stone
2. Carbonaceous rocks, coal

Classification of Sedimentary Rocks

Chemically formed: this type of rocks is formed by precipitation and accumulation of soluble constituents.

Chemical sedimentary rocks form when minerals in solution become supersaturated and precipitate. In marine environments, this is a method for the formation of limestone. Another common environment in which chemical sedimentary rocks form is a body of water that is evaporating. Evaporation decreases the amount of water without decreasing the amount of dissolved material. Therefore, the dissolved material can become oversaturated and precipitate. Sedimentary rocks from this process can include the evaporite minerals halite (rock salt), sylvite, barite and gypsum.

These are

1. Carbonate rocks, Limestone, dolomite
2. Sulphate rocks, Gypsum
3. Chloride rocks, salt

Consolidation

Consolidation is a process by which soft and loose sediments are converted into hard and firm rocks. Consolidation is of three types:

1. **Compaction and Dehydration:** The squeezing out of water from the pores of the sediments and its changing to solid mass by cohesion between the particles and pressure from overlying rock is called compaction and dehydration.
2. **Cementation:** Many coarse grained sediments are consolidated by cementation, which is the process of precipitation of some cementing materials, for example, silica, calcium carbonate, iron oxides and clay minerals.
3. **Crystallization:** Chemically formed sedimentary rocks such as limestone, dolomites, gypsum etc are consolidated chiefly by the crystallization of their constituents.

Structural Features

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

Stratification: The deposition of sediments into layer or beds is called stratification. The thickness of a single bed may vary from a few centimeters to many meters. The stratification is formed due to the following.

- I. Difference in the kinds of materials deposited for example shale and lime stone**
- II. Difference in the size of particles deposited for example coarse grained and fine grained sandstone beds**
- III. Difference in the color of the materials deposited for example light grey and dark grey layers of limestone**

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

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

Different types of sedimentary rocks

Conglomerate: The pebbles and gravels on consolidation and cementation produce a rock known as conglomerate. Gravels are deposited for the most part by water. Water circulating through gravel deposits may precipitate out silica, calcium carbonate, or iron oxides, which act as cements binding the gravels together into conglomerates.

Sandstones: Most sand is a water deposit. In arid regions, widespread sands have been laid down by wind action. Volcanic eruptions, glacial action, mechanical and chemical weathering, and organisms produce sands. The sand particles are deposited and then cemented together by materials like silica, calcite, iron oxide or clay. Sandstones may be **siliceous sandstone** that is the cementing materials is silica; it may be **calcareous sandstone** in which the cementing materials is calcium carbonate; **ferruginous sandstone** and **argillaceous sandstone** having iron oxide and clay as cementing materials

Different types of sedimentary rocks

The thoroughly cemented sandstone with quartz are termed as **orthoquartzite**.

Argillaceous rocks: variously called mudstone, claystone, and shale (compacted or cemented) are among the most abundant of sedimentary rocks. It is a laminated fine grained sedimentary rock which is mainly composed of clay minerals and some silt-size grains of quartz.

The claystones, because they are characteristically soft and weak are not suited to most construction purposes. The compacted shale lose strength when wet and are subject to plastic deformation. Under load they are subject to failure by flow. The cemented shales have a strength comparable to concrete but have a relatively high elasticity. Clay stones underlying the sites of heavy structures should be test in both wet and dry conditions. Clay stone has a limited use. It serves as a raw materials for the ceramic industry in some places and also used as raw materials for cement production.

Different types of sedimentary rocks

Carbonate rocks: The carbonate rocks are chiefly the products of marine or fresh water sedimentation. They are predominantly chemical sediments either formed by metabolic process of organism or precipitated inorganically. Mineralogically, the carbonate rocks are comparatively simple. There are two main varieties; the limestone composed chiefly of the calcite, and the dolomite composed chiefly of dolomite.

The carbonate rocks, particularly the limestones, have a very wide use in modern industry. The largest single use is as crushed stone. Limestone is one of the leading dimension stones being utilized both for internal and external work. Commercial lime is derived from the burning of limestone.



Quartzite, a form of metamorphic rock,

Metamorphic Rocks

Metamorphic rocks

Metamorphic rock is the result of the transformation of an existing rock type, the *protolith*, in a process called metamorphism, which means "change in form".

When the pre-existing rocks (sedimentary or igneous rock) are subjected to increased temperature, pressure and action of chemically active fluids, metamorphic rocks are formed. During metamorphism re-crystallization of mineral constituent takes place, as a result new minerals and new texture are produced.

The metamorphic processes generally improve the engineering behavior of these rocks by increasing their hardness and strength. Nevertheless, some metamorphic rocks still can be problematic. Some metamorphic rocks are **foliated**, which means they have oriented grains similar to bedding plains in sedimentary rocks. These foliation is important because the shear strength is less for stresses acting parallel to the foliation.

Metamorphic rocks

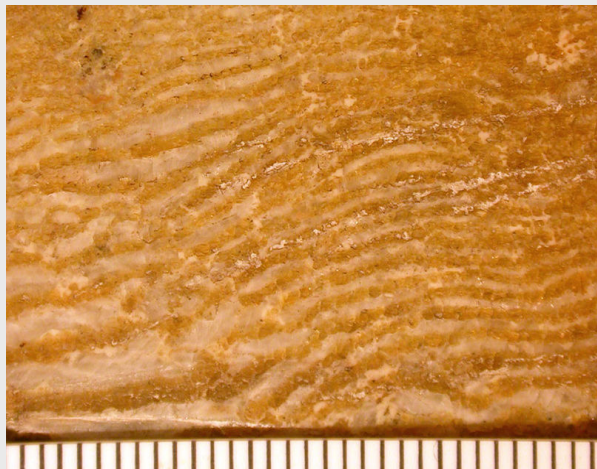
Un-weathered non-foliated rocks generally provide excellent support for engineering works, and are similar to intrusive igneous rocks in their quality. However, some foliated rocks are prone to slippage along the foliation planes. Schist is the most notable in this regard because of its strong foliation and the presence of mica. The **1928 failure St. Francis Dam** in California has been partially attributed to shearing in schist and the **1959 failure of Malpasset dam** in France to shearing in a schistose gneiss.



Folded foliation in a metamorphic rock

Types of Metamorphism

Contact metamorphism is the name given to the changes that take place when magma is injected into the surrounding solid rock. The changes that occur are greatest wherever the magma comes into contact with the rock because the temperature are highest at this boundary and decrease with distance from it. Around the igneous rock that forms from the cooling magma is a metamorphosed zone called a contact metamorphism aureole.



A contact metamorphic rock made of inter layered calcite and serpentine from the Precambrian of Canada

-shale may become a dark argillaceous hornfels,

-Limestone may change to a grey, yellow or greenish lime-silicate-hornfels or siliceous marble,

Types of Metamorphism

Regional metamorphism is the name given to changes in great masses of rock over a wide area. Rock can be metamorphosed simply by being at great depths below the earth's surface, subjected to high temperatures and the great pressure caused by the immense weight of the rock layers above. Much of the lower continental crust is metamorphic.



Mississippiian marble in Big Cottonwood

Different Metamorphic rocks

Marble: Marbles are metamorphosed carbonate rocks, derived from limestones and dolomites. The color of marble is variable, however, if the rock is pure calcite or dolomite marble it is generally white. Various impurities give rise to various shades. Green, pinks and buffs are common shades.

The principal uses of marble are as cut stone for building and ornamental or decorative use.



Different Metamorphic rocks

Slate: Slate is a dense metamorphic rock, with a strongly developed foliation. It is produced by the metamorphism of shale. The rock cleavage, or split-ability is therefore excellent and is the outstanding characteristic of slates. The color of slate varies from iron-tinted reds through various shades of gray and green. The gray shades are due to carbonaceous matter, the greens to chloritic micas. The texture of slates is very fine or dense and foliation is good to perfect.

Slate is used widely in the electrical industries as switchboards.

Different Metamorphic rocks

Phyllite: Phyllite are strongly foliated metamorphic rocks similar to the slates but of slightly coarser texture. Phyllite have shiny luster due the presence of large amount of fine flakes of mica. Phyllite gradually pass into slates which are the first stage in the metamorphism of shale.

It has little use. It is too soft for crushed stone, and too weak for structural uses.

Schist: Schist are foliated metamorphic rocks of medium to coarse texture. They are the product of the same processes of rock flow and recrystallization that produce slates and phyllite. The color of schist vary according to the mineralogical composition, as does also the perfection of cleavage.

Schist has of little use. Because of the foliation, they are generally weak rocks. Some schists especially rich in muscovite are a source of scrap mica.