ENVIRONMENTAL GEOSCIENCES

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Lecture-28

Description of Common Sedimentary Rocks

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. We are discussing the module 5. In the module 5 we have already discussed about the concepts of the rocks, the magma, its composition and constitution, description of common igneous rocks. Today we will discuss the lecture 4 that is description of common sedimentary rocks. The important concepts will be covered in this lecture about the introduction to sedimentary rocks, formation of sedimentary rocks, classification of sedimentary rocks, texture of sedimentary rocks, structure of sedimentary rocks and common sedimentary rocks.

Now we have seen in the first lecture that we are getting Three important types of rocks: igneous rocks, sedimentary rocks, and metamorphic rocks. Already we have discussed the igneous rocks in the previous lecture. Now we are discussing about the sedimentary rocks. What are sedimentary rocks?

These rocks have been derived from the pre-existing rocks through the process of erosion, transportation and deposition by various natural agencies like wind, water, glacier etc. The loose sediments which are deposited undergo the process of compaction and the resulting products are generally known as sedimentary rocks. Some of the important examples of sedimentary rocks are sandstone, limestone, shale, conglomerates, coal, etc. Now, the formation of sedimentary rocks. Sedimentary rocks are formed by consolidation and cementation of sediments deposited.

It includes the rocks formed by accumulation of chemically precipitated or organically derived material and occurs in layers frequently contains fossils also. The formation of sedimentary rocks take place in three stages. First, the weathering and erosion of pre-existing rocks, second the sedimentation, and third the lithification and diagenesis. During weathering and erosion, the pre-existing rocks and their constituent minerals are

broken down and is termed as sediment. During transportation, sediments are roughly sorted and deposited according to the size.

Bigger rock fragments such as gravel first, Bigger rock fragments such as gravel first settle first, sands are next in order, and clays are deposited in the last. The minerals which are dissolved by water travel in the solution. Now, first is the sedimentation. The process of accumulation of sediments at a site of deposition is called generally sedimentation. Sedimentation is the intermediate stage in the formation of sedimentary rocks.

Second is the lithification and diagenesis. Lithification is a process by which soft and loose sediments are converted into hard and firm rocks. This process is also called as consolidation. During this process, many physical and chemical changes take place within the sediment. Such changes are called diagenetic changes and the process is described as diagenesis.

The diagenesis includes three processes. First is the compaction, second is the cementation and third is the recrystallization. Now first, compaction. It occurs when the weight of the overlying layers compresses the sediments below. As the grains of sediments are pressed closer and closer together, there is a considerable reduction in the pore space and volume.

Fine-grained sediments such as clays are consolidated more effectively by this process. In the figure also you can see the decrease in porosity is there Before, we were seeing loose rocks and soil with large space between particles. But as the overlying layer is just compressing, the rock and soil compacted by the pressure of the rock above and less empty space in between the different types of grains. Now second is the cementation.

When water circulates through the pores of coarse-grained sediment, the dissolved mineral matter is precipitated between the grains, which causes cementation. The most common cementing materials are silica, calcium carbonate, iron oxides and clay minerals. The identification of cementing material is relatively simple matter. Calcite cement will ever face with dilute hydrochloric acid while iron oxide gives the rock a characteristic red, orange or yellow color. Silica, the hardest of the cement, produces the hardest sedimentary rocks.

Third is the recrystallization. Although most sedimentary rocks are lithified by compaction, cementation or a combination of both, some are consolidated chiefly by crystallization of their constituents. Chemically formed rocks such as limestones,

dolomites, salt and gypsum are examples of rocks consolidated by recrystallization. Now on the basis of place of formation sedimentary rocks are of two types. First is the sedentary rocks and second is the transported rocks.

Sedentary rocks, these are the rocks which are having the residual type of deposits that is forming at the site of the pre-existing rocks from which they have been derived. These are not formed by the process of transportation. Such type of rocks are known as sedentary rocks. Second is the transported.

These are the disintegrated and decomposed rock materials and are transported from place of their origin and get deposited at a suitable site. According to the mode of transportation of the deposits, the rocks are subdivided into three types. Mechanically deposited, that is the plastic rocks. Chemically precipitated, that is the chemical deposits. And organically deposited, that is the organic deposits.

Now, some of the important features of the sedimentary rocks are, they are generally soft, stratified. Catastrophically bedded fossils are very common. Stratification, lamination, cross bedding and ripple marks, mud cracks etc. are the usual structures. No effect on the enclosing of the top and bottom blocks. Quartz, clay minerals, calcite, dolomite, hematite are the common minerals.

Now the classification of sedimentary rocks. The present classification which is most successful one has been proposed by E.W. Spencer and the basis of classification is the mode of formation of the sediments. Sometimes the products of weathering are carried down by the natural agencies and sometimes they are found at the place of their origin. Accordingly, there are two classes. First is the residual deposits, second is the transported deposits.

Now first the residual deposits. These are also known as sedentary deposits. These are formed due to accumulation and consolidation of those materials which were left as residue during the operation of the weathering processes and transportation. These are the insoluble products of rock weathering which still mantel the rocks from which they have been derived. They include the rock types like Terra-rosa, Laterite, Bauxite.

Now what is Terra Rosa? These are the insoluble residue of clay and other matter left behind after solution of limestone. Laterite, in tropical and subtropical regions, a reddish porous and concretionary material is found to cover vast area. They generally consist of

mixture of hydrated ferric oxide with hydroxide of aluminum in varying proportion. These are called as laterites.

Bauxite, when the aluminous content predominates the colour lightens to yellowish or whitish and the rock become more earthy or clay like. It is also called as bauxite. Next is the transported deposits. These are formed from the materials that have been transported both mechanically by extraction and suspension and chemically in solution. Some organic processes also play active roles in the formation of transported deposits.

The transported deposits are classified into two groups. The first one is the clastic rocks. These are detrital or fragmental rocks and are carried and deposited by mechanical means. On the basis of mode of transport and grain size, the clastic rocks are classified as rudaceous rocks, arenaceous rocks, silt rocks, argillaceous rocks. Now first is the rudaceous rock.

Very coarse grained rocks where the size of the grains are those of boulders. These are transported in traction that is by rolling or creeping. Also known as Rudites. Example is Conglomerates, Breccia. Next is the Arenaceous rocks.

These rocks consist chiefly particles of sand grade composition. They are transported in saltation. Also known as arenites, example is sandstone, arkose, graywacke, grits etc. Silt rocks, here the constituent particles are finer than the common sand and coarser than the clay. They are transported by suspension.

Example is loess. Argillaceous rocks, these are made up of clay particles, usually transported in suspension. Example clay, mudstone, shale, etc. Non-clastic rocks, these are conformed due to the chemical precipitation as well as by biological means. These are generally of two types, chemically deposited sediments and second is the organic sediments.

Chemically deposition, first is the evaporites. It is only due to evaporation and the deposits are like salt and gypsum. Second, through reaction between the components carried in solution, siliceous, calcareous, ferruginous and carbonate deposits are produced in this way. The examples are siliceous deposits, Chert, flint, siliceous sinter, etc., calcaroeus and carbonates, limestone, dolomite, calcsinter or travertine, and ferruginous deposits, iron salts, hematite, etc.

Organic sediments, these are the products of accumulation of organic matter preserved under suitable conditions. They are mainly of five types. First is the siliceous, radiolarian

ooze diatoms are lowly plant, organisms which secrete silica. Second, calcareous, due to biomechanical processes as well as biochemical processes, these deposits are formed. Fossiliferous limestone, chalk, marl, etc. are the examples.

Phosphatic, as calcium phosphate is utilized by certain organisms, especially fish and brachiopoda, the remains of these organisms accumulate on the seafloor forming phosphatic deposits. Ferruginous. by the activities of bacteria, example is bog-iron ore, and carbonaceous, example is coal formations. Now texture of sedimentary rocks. Textures of sedimentary rocks are defined by at least six factors. First factor is the origin of grains.

A sedimentary rock may be partially or wholly composed of clastic, allogenic grains or chemically or organically evolved components, authigenic, giving it contrasting textures. Second factor is the size of the grains. The grain size in the sedimentary rocks vary within wide limits. Accordingly, rocks are divided into fine grain, grain size less than 1 mm, medium grain 1 to 5 mm, and coarse grain greater than 5 mm. The type of weathering, the nature of the parent rock, and the duration of the transport are some factors that cause a variation in the grain size of the sediments.

Now third factor is the shape of the grains. These grains may be round, smooth, spherical or angular and rough. Roundness and sphericity are the indication of a greater amount of abrasion and generally of a large amount of transportation in the case of clastic rocks. Packing of the grains. Sediments may be open packed or closed packed.

The density of packing is generally related to the pressure either from above because of overlying strata or from sides. Fabric of the grains, a given sedimentary rock may contain many elongate particles if all or most of the elongate particles are arranged in such a way that their long axis lie in the same direction, the rock is said as showing high degree of preferred orientation. Next is the crystallization trends. Rocks may show perfectly interlocking grains giving rise to crystalline general texture. Now structure of the sedimentary rocks.

Sedimentary rocks are secondary rocks in which the presence of different layers, beds or strata distinguishes them from the igneous and metamorphic rocks. Sedimentary structures are both organic and inorganic in origin. Depending on the mechanism of formation, the inorganic structures are classified as primary structure and secondary structure. Now the primary structures. The primary structures are due to mechanical action of current and depends on the following factors.

These structures show palaeo-current conditions. The second is the rate of supply of sediments. Third is the mode of transportation. Fourth is the environment of deposition and fourth is the top and bottom of beds etc. The primary sedimentary structures include bedding or stratification.

That is, insolubly mechanically transported material is deposited in layers and on the surface of accumulation which may be horizontal or inclined. Stratification may be the result of variations in composition of different layers, colors of layers, textures of layers, and porosity of the layers. These are most conspicuous, particularly in the rocks formed underwater. Glacial, chemical, and biological deposits lack stratification. Aeolian deposits seldom show bedding.

If the individual layers are extremely thin in the structure, then it is known as lamination and the layers is known as laminae. There are two types of laminations, dimictic lamination and symictic lamination. Dimictic lamination where the contact between the two laminae is sharp, symictic lamination where the contact between the laminae is rough. The plane of contact is known as laminating plane. Example is varve.

It is two types, concordant, when the bedding planes are disposed approximately parallel to one another. Discordant, if the bedding planes are inclined to the major lines of stratification. Second is the cross-stratification. Here the beds are found to lie slightly oblique to the major bedding planes and bound concordant bedding. Mostly found in arenaceous rocks, it is formed due to change in the velocity and direction of flow of streams.

Now third is the torrential bedding. It shows an alteration of coarse current bedded material and finer horizontal laminae. Here the forest beds are straight and they characteristically develop in alluvial fans. Next is the graded bedding. In this case there is a gradation of grain size from coarser at the bottom to finer at the top.

It is having a sharp contact with the underlying strata. This in consolidated form is known as turbidites. Next is the ripple marks. These are minute undulations formed due to current or wave action developed on arenaceous rocks. Next is the mud cracks.

These cracks typically develop in clayey sediments due to prolonged exposure to the atmosphere. These are also known as shrinkage cracks or surcracks. They are wider at the top but tapers towards the bottom. Next is the secondary structures. These are the

products of chemical action contemporaneous with sedimentation or shortly thereafter and includes, concretions.

They are spherical to elliptical bodies, usually small of diverse chemical nature than the rocks in which they occur. They include nodules, oolites, pisolites, geodes, etc., Solution structure, irregular openings commonly in calcareous rocks and are produced due to groundwater action, example is vugs. Organic structures, fossils impressions as well as petrified remains of animal or plants are the common organic structures found in sedimentary rocks. Sole structure, these are the structure preserved on the base of a bed which is sharply differentiated lithologically from the bed below

Example is sandstone overlying a sail. Now we will discuss the sum of the common sedimentary rocks. Important sedimentary rocks are sandstone, limestones, shale, conglomerates, breccia and dolomite. Now one by one we will discuss these rocks. First is the sandstone.

Sandstone is a cemented or indurated sedimentary rock with grain sizes between 0.0625 and 2 mm. The constituent grains are nearly rounded and water-borne but may be more or less angular. Composition Quartz is the most common mineral. This Quartz is the most common and the feldspar, garnet, magnetite, mica etc. remains present in it. Presence of cementing material like siliceous, ferruginous, argillaceous etc. are also within it.

Now texture. Sandstone are finer grained clastic rocks in which the component grains show great variation in their shape, size and compaction. The grains may be round or angular in outline, fine or coarse in size and arrangement of loose or dense packed. The shape and packing that is texture of the component grains are responsible for the very important properties like porosity and permeability. In sedimentary rocks we are getting good porosity and permeability with comparison to igneous or metamorphic rocks.

Now the detrital particles that is the clasts may be quartz, rock fragments, volcanic debris, organic material or many other clastic material. The cement that binds the sand grains together may be silica, carbonate, iron oxide or clay minerals. So this is about the texture of the sandstones. Now colour, the colour of the rock depends on large measure on the character of the cement. So the rocks with silica or calcite are usually in light in color, usually white to gray, pale yellow or buff.

Those that contain an iron oxide are red to reddish brown. When a sandstone breaks, it is commonly the cement that is fractured, the individual grains remain unbroken, and the

fresh surfaces of the rock may have a granular appearance and filling. Now, types of sandstone based on dominating cementing agent. First is the siliceous sandstone, cementing material rich of silica. If the cementing material is very dense, formation of compact and homogeneous rocks with fractures are formed.

These sandstones are usually termed as quartzites, commonly ortho quartzites. Second is the calcareous sandstones. Here, carbonates of the calcium, magnesium constitute the cementing material. Third is the argillaceous sandstone. They are generally soft in nature due to the presence of clay in the cementing material.

And the fourth is the ferruginous sandstone. The cementing material is having iron and its components. So these are about the type of sandstones. Now sandstones are subdivided texturally into arenites and wackes on the basis of detrital matrix contents. The term arenite or wax is prefixed with a compositional modifier as in lithic arenite or arkosic arenite, feldspathic wacke or quartz wacke.

So, arkose. Arkose is an arenite with more than 25 % feldspar among the clastic grains. Arkoses are often pink or red because of the large cement of K-feldspar and they may resemble a granite in appearance. These rocks have undergone little chemical weathering. Greywacke is a type of sandstone with grayish green color, clay matrix, poor sorting of sand grains, and abundant lithic fragments.

Flagstones, they are sandstone rich in micas. Uses of sandstones. Sandstones of hard and compact character are most commonly used as the building stones. Sand finds extensive use in industry. Example in foundaries or as glass sands etc.

Distribution. Next two shales, sandstones are the most abundant sedimentary rocks. It is thought that they make up 10 to 16 % of the total sedimentary rocks of the crust. Next is the limestones. Limestones are very important and widespread sedimentary rocks that have formed from chemical as well as organic processes.

Pure limestones are chiefly composed of calcite, calcium carbonate, whereas in common limestones impurities like clays, feldspar, quartz, and pyrite may be present in considerable amounts. Although the calcite may be precipitated directly from seawater, most of the limestone is the result of organic precipitation. If magnesium carbonate predominates, the rock is termed as dolomite. Texture of the limestone. Limestone exhibits a great variety of textures and structures.

These rocks may be compact or loosely packed, hard or soft, clastic or organic structures. The common type of limestones are, first is the chalk. It is the purest form of limestone, characterized by fine-grained earthy texture or white in color. Second is the argillaceous limestone. These type of limestone are dominant in clay.

When the carbonate and clay are present in roughly equal amounts, the rock is called marl. Lithographic limestones. These are compact, homogeneous and extremely fine-grained calcareous rocks. Calc-sinter, it is the carbonate deposit formed by precipitation from carbonate-rich spring water. These deposits are usually known as travertine or calc-tuffa.

Now, next is the shale. This is the another variety of the sedimentary rock, shale. Shales are fine grained sedimentary rocks of argillaceous composition with particles less than 1/256 mm diameter. Now composition. Shales are composed of minute particles of uncertain composition of clay minerals like illite, Montmorillonite and Kaolinite.

Chlorites, Glauconites, Carbonaceous material and Calcareous particles may also be present. Texture of Shales. Shales are characterized by distinct fissility which is defined as the tendency of the rock to split into flat, shell-like fragments. The fissility in shales is in the direction parallel to the bedding and is due to the parallel arrangement of flaky or platy constituents of the rock during sedimentation. Shales are extremely fine-grained in texture that can be determined only by the help of X-ray and chemical analysis. Types of shales. Many types of shales are defined on the presence of, on the presence of accessory minerals.

A few are calcareous shales which contain some carbonates. Carbonaceous shales that are rich in organic matter specially in carbon and are generally black. Alum shales which are rich in iron sulphide, pyrite and sulphate. Oil shales which are actually carbonaceous shales produced by destructive distillation. Now formation. Shales are formed from compaction and consolidation of clays. Actually, the process may start generally due to overlying load, results in squeezing out of water and in causing shrinkage in the mud. Compacted muds that still retain about 10 to 15 % or more of moisture are termed clays.

This moisture may ultimately be removed during further compaction and the resulting compact rock may or may not develop a parting capacity, the fissility. In case the resulting rock shows a fissility, it is sometimes used for a clay rock, having carbon, calcium and magnesium as components besides the usual clay minerals. Uses Shales are

used for brick and tile manufacture. They serve as impervious cappings for oil bearing structures or reservoirs in the crust.

Distribution of all the sedimentary rocks, shales are most widely distributed with seventy to eighty percent of the sedimentary rocks of the crust. Next is the conglomerates. These are the sedimentary rocks of clastic nature and consist of rounded pebbles, gravels, boulders cemented together. The constituent fragments of size from 2 mm and above, their roundness is indicative of the fact that they have undergone a good deal of transport by water, whereby their original angularities have been removed. The rounded fragments may be of any composition.

They may be mineral or rock pieces. Similarly, their cementing material may be siliceous or calcareous in composition or mixture of these. Now types of conglomerates. They are generally distinguished on the grain size of the round components and terms like boulder conglomerate fragments greater than 256 mm diameter dominate, cobble conglomerates 64 to 256 mm diameter dominate, and pebble conglomerates composed of fragments between 2 to, and composed of fragments between 2 to 64 mm fragments. Now, they are distinguished on the basis of source of fragments

Volcanic conglomerates in which the fragments are of volcanic origin but have undergone transport before deposition. Basal conglomerates which are deposited by sea waves during their advance over subsiding landmasses. Glacial conglomerates in which fragments are of glacial origin. On the basis of lithological composition, conglomerates are often grouped into two broad classes, oligomictic and polymictic. Oligomictic is simple in composition and contains fragments of only few minerals like quartz, chert and limestone, whereas polymictic is always a complex lithology.

Conglomerates formed in alluvial fans and cones provide an example of this type. They are also sometimes known as fanglomerates. Next type of sedimentary rock is the Breccia. Breccia are mechanically formed sedimentary rock which consists of angular fragments of heterogeneous compositions embedded in a fine matrix of the fragments and are generally more than 2 mm in diameter. The angularity of the fragment indicates that these have suffered no transport after their disintegration from parent rock.

Breccia are of following types. Basal Breccia, these are formed by sea waters advancing over a cherty region. Fault Breccia, these are formed by cementation of fragments produced due to breakage of the rocks by the process of faulting. They are also called as

crush breccia. Agglomeratic Breccia, these are the rudaceous rocks in which the angular fragments are of volcanic origin.

Next type of sedimentary rock is the dolomite. It is a sedimentary rock of carbonate composition and is made up of chiefly of a mineral dolomite which is calcium, magnesium and carbonate composition. Ferrous iron is present in small proportions in some varieties like gypsum also make appearance in some dolomites. Formation, the origin of dolomite has been incompletely solved problem. It is widely believed that most of the dolomite deposits have formed by replacement of limestone by magnesium rich solutions.

The replacement might have started shortly after deposition of the limestones or subsequent of their consolidation. Uses, pure dolomite is used as a good source of magnesium. Now, just summarizing this chapter, we have discussed in this chapter about the sedimentary rocks. First of all, we have discussed its introduction, that is sedimentary rocks formed from pre-existing rocks through erosion, transportation, deposition and compaction by natural agencies like wind, water and glaciers. Examples include sandstone, limestone, shale, conglomerate and coal.

Secondly, we have discussed about the formation of the sedimentary rocks. Sedimentary rocks form through weathering, erosion, sedimentation and lithification involving processes like compaction, cementation and recrystallization. They are typically soft, stratified, fossil-bearing and categorized as clastic, chemical or organic based on their mode of formation. Thirdly, we have discussed about the classification of sedimentary rocks. Sedimentary rocks are classified based on the mode of formation into residual deposits.

Example were laterite bauxite formed in place and transported deposits that is clastic rocks like sandstone steel and non-clastic rocks like limestone, coal formed through mechanical, chemical or biological processes. These rocks vary by grain size, transport mechanisms and composition. Then we have discussed about the texture of the sedimentary rocks. The texture of sedimentary rocks is influenced by factors like grain origin, size, shape, packing, fabric and crystallization trend ranging from clastic or authegenic grains to crystalline interlocking structures. Grain characteristics reflect processes like weathering, transport and compaction.

Then we have discussed about the structure of the sedimentary rocks. Sedimentary rock structures including primary that is bedding, cross stratifications, ripple marks and

secondary that is concretions, fossil, sole structures result from mechanical, chemical and organic processes during or shortly after deposition reflecting environmental and depositional conditions. Lastly, we have discussed about some of the common sedimentary rocks in which we have discussed. Sedimentary rocks like sandstone, limestone, shale, conglomerates, breccia and dolomite from through mechanical, chemical or organic processes. They have diverse composition and uses such as construction, industrial raw materials and energy sources.

So these are about the details about the sedimentary rocks. Thank you very much to all.