Geology and Soil Mechanics
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Lecture - 01
Description of Soil, Engineering Geology of Soils and their formation

Welcome to the course Geology and Soil Mechanics. So basically, today we will be talking about the description of soil, engineering geology of soils and their formation. So first I will talk about the objective of this particular course.

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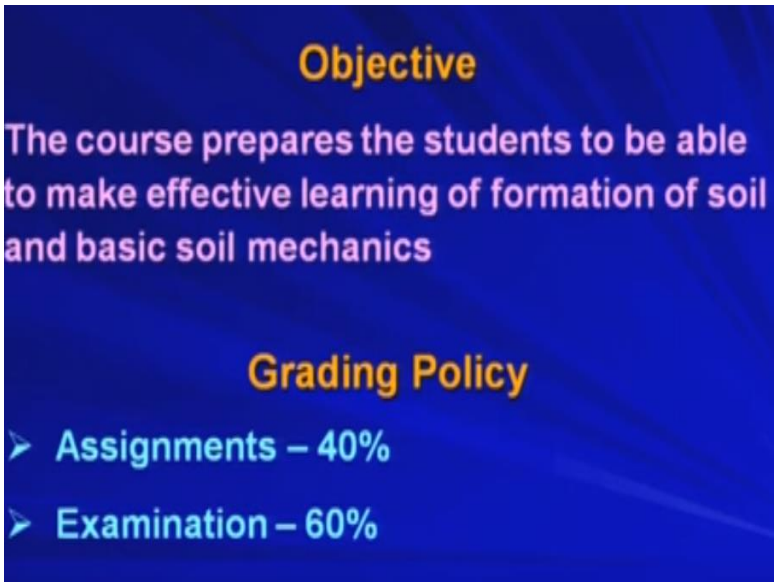

The course prepares the students to be able to make effective learning of formation of soil and basic soil mechanics and the grading policy is like this. So basically, the home assignments will be having 40% weightage whereas the examination will be having 60% weightage.

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Now this is the total course plan. So, in the week 1, the first week basically we will be concentrating on description of soil, engineering geology of soils and their formation. Second week we will be talking about the index properties of soil. Third week we will be talking about classification of soils, soil structure, and clay mineralogy and fourth week soil compaction will be covered.

Then permeability in soil, seepage in soil and flow net construction, so that will take 2 weeks, we will be covering this and then in-situ stresses and criteria for filter design and then in week 8 effective stress principle and soil-water systems capillarity. Then in the 9th week fundamental of consolidation. Week 10 we will consider fundamental of consolidation.

Week 11 also we will be talking about stress in soil and finally earth pressure theories. However, so we will we will be little bit flexible in this distribution. Suppose I mean week 1 and week 2 may be clubbed together and something like that, but overall at the end of the course you will be learning these topics. So however, the I mean this distribution among the weeks will be little bit flexible. Now these are the reference books. So, I am not talking about a particular text book.

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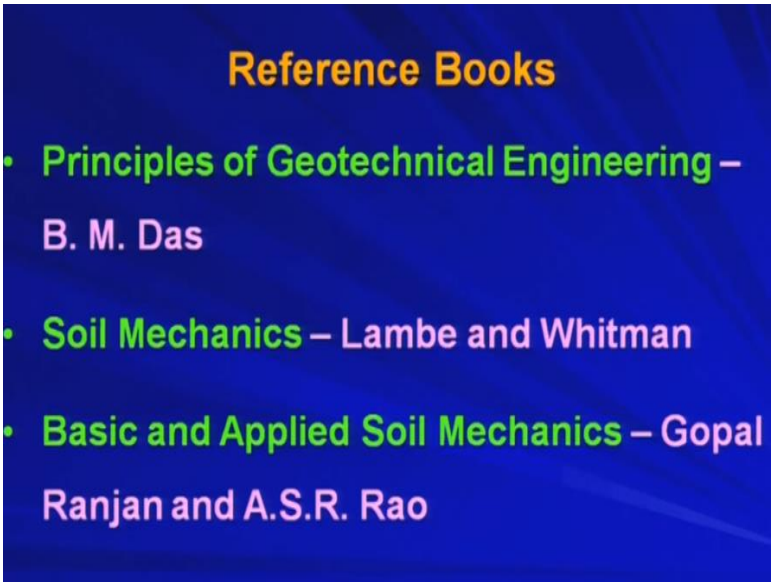

So rather you should have different reference books. Apart from that there are other books available in the market. So, you can refer any classical soil mechanics book which will cover these topics. So, the first one, principles of Geotechnical Engineering by B.M. Das. Then Soil Mechanics, Lambe Whitman, and Basic and Applied Soil Mechanics by Gopal Ranjan and A.S.R. Rao.

Now coming to the actual topic, whatever we thought about initially. First, we should know the geology of the soil, how the soil is getting formed in the atmosphere or in the actual situation. So first we should understand what are the different cycles for a rock to get disintegrated and forming the soil. Now first we will discuss about the rock cycle.

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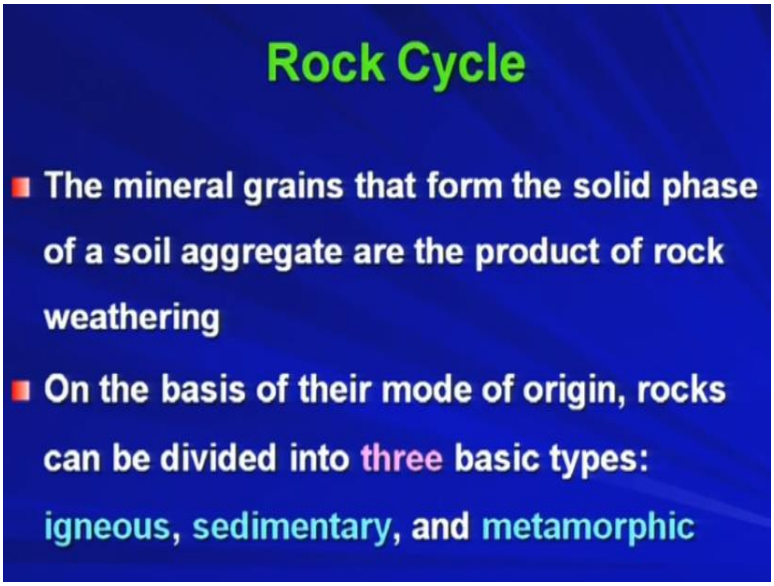

The mineral grains that form the solid phase of a soil aggregate are the product of rock weathering. So, we will be talking about weathering later on, what actually weathering means. So, on the basis of their mode of origin, rocks can be divided into 3 basic types as most of you know about this, that is igneous rock, sedimentary rock, and metamorphic rock. So, these are 3 broad classification of rocks which are generally found in the practical situation.

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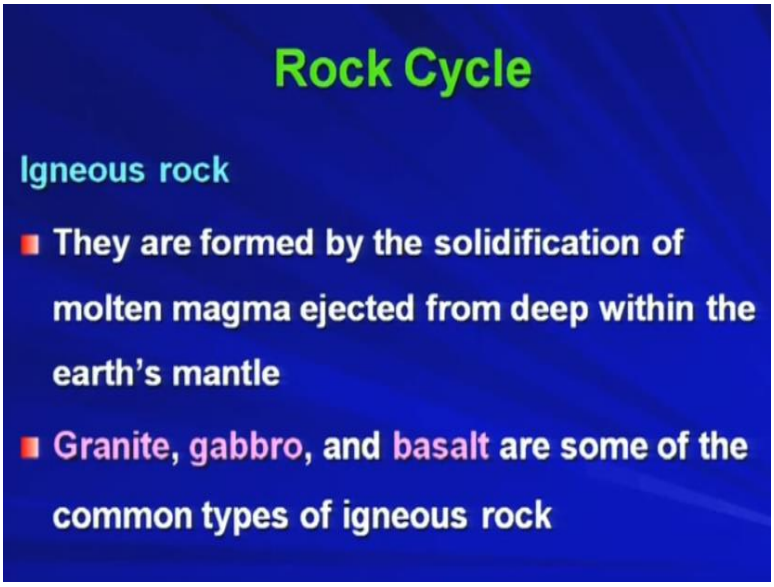

Now coming to the igneous rock. So, they are formed by the solidification of molten magma ejected from deep within the earth's mantle. So, as I mean as you know from some volcanic eruption or something for something like that if you if some molten magma comes out and

ultimately if it solidifies then it will form the rock which will be known as igneous rock. For example, granite, gabbro, and basalt are some of the common types of igneous rock.

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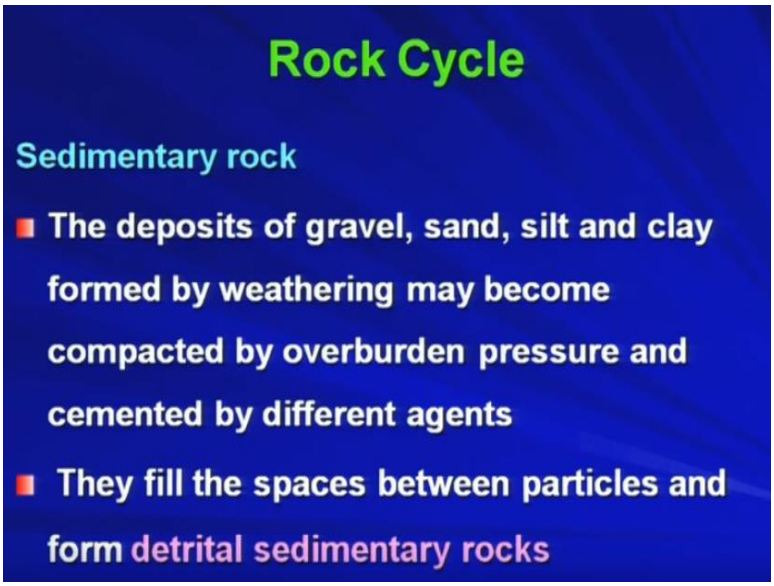

Now coming to the sedimentary rock, what are the different types of rock which come under the classification of sedimentary rock as well as how do you know this is your sedimentary rock. The deposits of gravel, sand, silt, and clay formed by weathering may become compacted by overburden pressure and cemented by different agents.

Basically, as you see in the river flow or maybe in the lake deposit or marine deposit basically the gravel, silt, sand, clay, these particles or these materials will be basically sedimented layer wise and finally over the years it will be lying like that and finally it will be forming the sedimentary rock.

They fill the spaces between particles and form detrital sedimentary rocks. So, sedimentary rocks can be classified in 2 categories, one is detrital sedimentary rocks and another one we will be talking about later on. So basically, the detrital sedimentary rocks are formed by filling the spaces between particles whatever I just talked about means gravel, sand, silt like that.

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Then conglomerate, breccia, sandstone, mudstone, and shale are some examples of detrital type of sedimentary rocks. It can also be formed by chemical process known as chemical sedimentary rocks. So, once we have seen the detrital sedimentary rock, now we are talking about the chemical sedimentary rock.

So, these are 2 broad classification under the sedimentary rock head. So, it can also be formed by chemical process known as chemical sedimentary rock such as limestone, chalk, dolomite, gypsum, and anhydrite. So, these are also your sedimentary rock, but that comes under second category which is chemical sedimentary rock.

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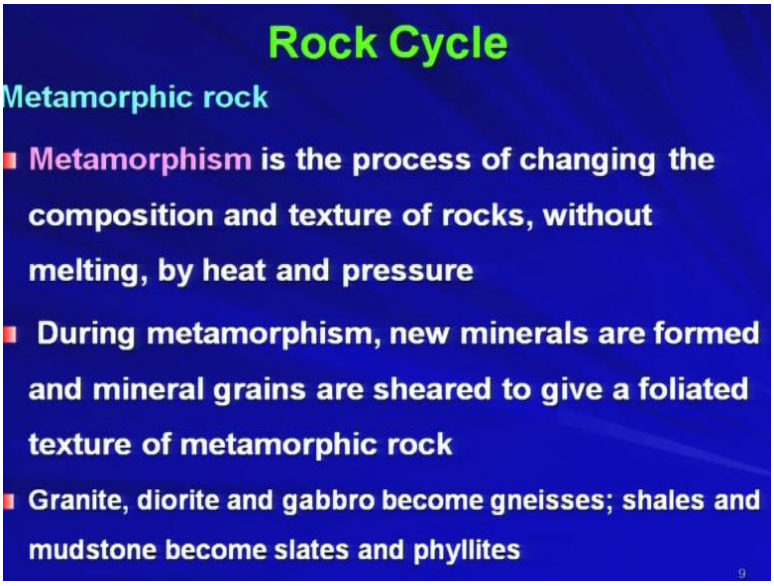

Then coming to the third group of rock that is metamorphic rock, now what is metamorphism. Metamorphism is the process of changing the composition and texture of rocks without melting by heat and pressure. So basically, whatever rocks you have seen so far, igneous rock as well as sedimentary rock, so any kind of rock can be transformed to the metamorphic rock by the process of metamorphism where your texture of rocks will be changing or under the heat and pressure but there will be no melting happening in the process.

During metamorphism, new minerals are formed and minerals grains are sheared to give a foliated texture of metamorphic rock. So basically, during metamorphism you will be having some chemical reaction and you will be you may get some new materials or new minerals okay in the rock formation.

Now granite, diorite, and gabbro become gneisses. So basically, this is the metamorphism process. So, granite, diorite, gabbro these were the igneous rock initially and after the process of metamorphism basically you have got the new kind of rock that is metamorphic rock that is gneisses. Similarly, shales and mudstone which were actually your sedimentary rock so now they had become slates and phyllites.

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Now coming to the weathering process. So basically, one thing is very clear to you that whether you are dealing with igneous rock or whether you are dealing with sedimentary rock and if you talk about the metamorphism process that means if you are talking about the metamorphic rock, basically you have to come across some weathering process.

Now what is that weathering process? So, weathering is the process of breaking down rocks by mechanical or chemical process into smaller pieces and this is the process by which basically you will be getting soil from formed from the rock. So, rock can be transformed under definite weathering process and ultimately it will be disintegrated and forming the soil.

So, weathering is the process of breaking down rocks that means you are going to break down the rocks or you are going to disintegrate the rocks by mechanical process or chemical process, either one of them and ultimately you will be getting very small pieces from a chunk of rock. So, mechanical weathering may be caused by the expansion and contraction of rocks from the continuous gain and loss of heat, which results in ultimate disintegration.

So, what is the mechanical weathering process? So, mechanical weathering process I mean it is caused by the expansion or contraction of rocks. So, rock can be expanded or it can be contracted from the continuous gain and loss. So basically, your temperature is going to vary or the I mean you either the rock is gaining some heat or losing some heat, based on that basically the ultimate disintegration is happening and which is known as mechanical weathering process.

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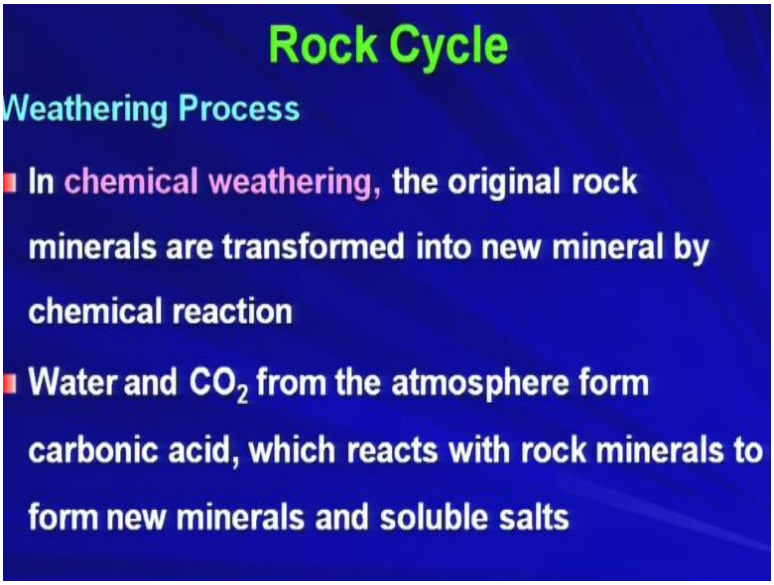

Now what is chemical weathering then? In chemical weathering, the original rock minerals are transformed into new mineral by chemical reaction. So basically, you have some rock and you are allowing the rock to go for some chemical reaction and some transformation in the minerals will be happening and ultimately you will be getting some new mineral which will be known as and this process will be known as chemical weathering.

Like water and carbon dioxide from the atmosphere form carbonic acid, as we all know from the chemistry, which reacts with rock minerals, so whatever rocks are lying in the in the atmosphere or in the in the field right so those rocks will be going under some chemical reaction in presence of water and carbon dioxide which will be forming some carbonic acid and this rock minerals will form some new minerals and soluble salts. So, this is purely some chemical reaction and based on that reaction you will be getting some different mineral as well as soluble salts.

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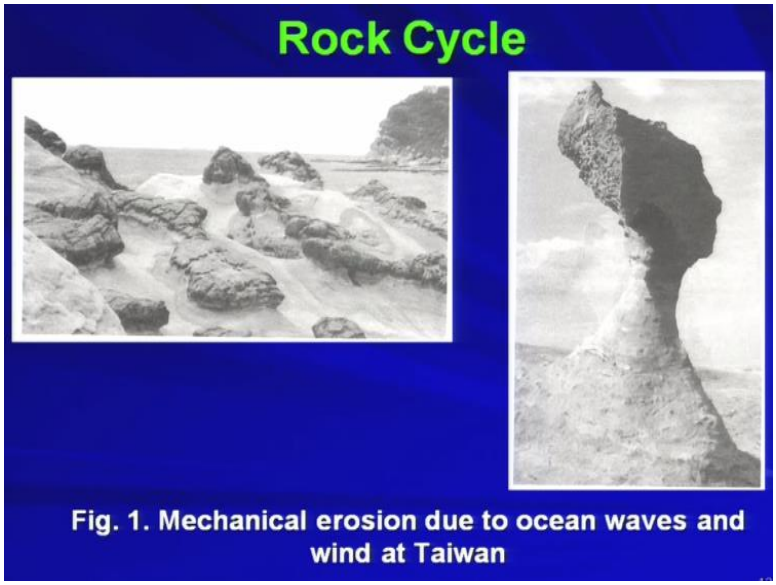

So, these photos will show you the evidence of the mechanical weathering process. As you can see on the left side photo basically this is the evidence of your mechanical weathering process by the ocean waves and you can see the rocks are getting disintegrated by the ocean waves and on the right side basically you will be observing the weathering, mechanical weathering process caused by the wind.

So, as I told you the mechanical weathering process will disintegrate the rock and this disintegration may happen due to ocean waves, wind, rainfall or any kind of mechanical agents.

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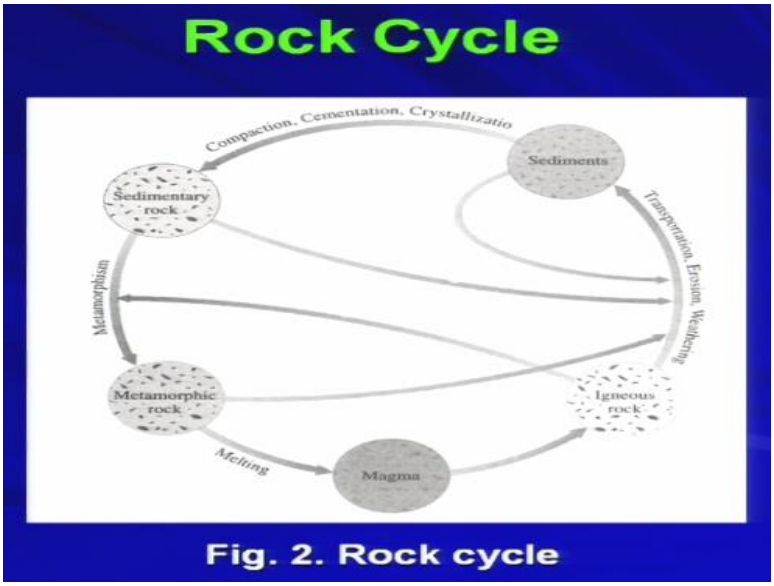

Fig. 2. Rock cycle

Now coming to the actual rock cycle. So, after understanding what are the different types of rocks, how they are getting formed and how they are getting disintegrated by some weathering process and finally they are forming some new minerals, so after understanding all those things let's look at this rock cycle.

So basically, if you look at this, this is a magma, I mean below the earth I mean crust or this is happening or this is lying in the mantle so basically this magma when it comes out and after solidification basically it becomes igneous rock. Then this igneous rock after transportation, erosion, weathering, after all this activities it I mean creates some sediments then those sediments are getting compacted, cemented, or crystallized and then becomes sedimentary rock and then some sedimentary rock after metamorphism it may become the metamorphic rock and again metamorphic rock after melting if you melt it again it you may get the magma.

Similarly, from igneous rock you can directly go to the metamorphism process and come to the metamorphic rock. Similarly, after sedimentation again you get this loop that is again transportation, erosion, and weathering is happening and again further disintegration is happening and sedimentation is happening. So, this is the cycle.

Then even after sedimentary rock it may come to the transportation, erosion, or weathering process and again sedimentation and goes to goes back to the sedimentary rock. So, this is a kind of cycle. That means you are starting from one, you are coming back to the original position. So, this is known as rock cycle and you need to understand this rock cycle properly to understand the

behavior of different rocks as well as the formation of different rocks, how they are getting formed and how they are getting disintegrated to form our actual material of interest that is soil.

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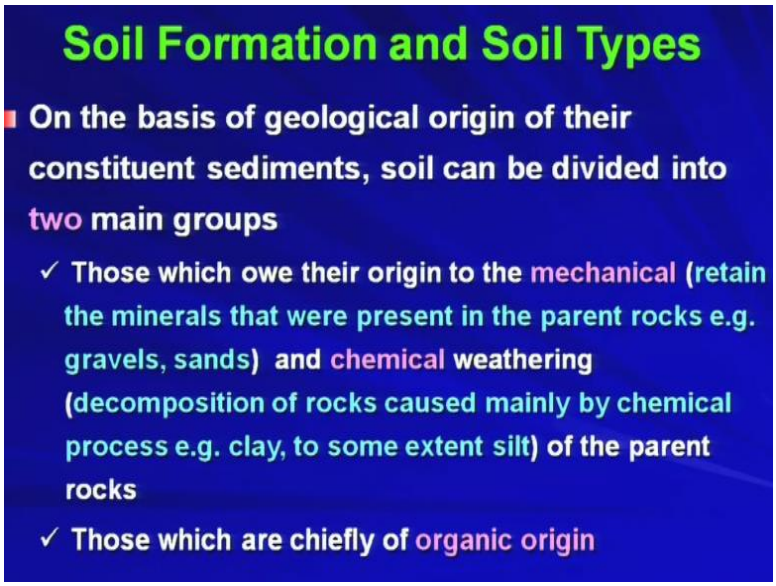

Now coming to the soil formation and soil types, on the basis of geological origin of their constituent sediments, soil can be divided into 2 main groups. Now what are those groups? Those which owe their origin to the mechanical and chemical weathering of the parent rocks. Now when I am talking about the mechanical weathering then it retains the minerals that are present in the parent rocks, example gravels and sands. That means you have some rock.

Now how the soil has soil is getting formed? So, you have the rock. Now you are applying some mechanical weathering process in the rock or chemical weathering process in the rock. So, if you apply the mechanical weathering process in the rock. So basically, it retains its minerals that were present basically in the parent rock like I mean if you consider gravel, sand and all those things they are basically the disintegrated part of the parent rock.

Whereas if you allow the chemical weathering to this rock, basically the decomposition of rocks caused mainly by chemical process though you may get some change in the mineral composition in the rock material or the disintegrated rock material. So, like your clay, to some extent silt. So, we will be talking these materials in more detail in the subsequent lectures.

So basically, what are the different types of soil now you have got after disintegration of the rock? One is gravel, another one is sand. So, these are basically are getting formed by your

mechanical weathering process whereas we can get clay as well as silt which are basically coming from your chemical weathering process of your rock.

Now those which are chiefly of organic origin. Now basically there are 2 groups. As I told you, the first group is getting formed by the weathering process. Another one is chiefly organic origin. That means you have the organic composition in the soil like if you talk about the forest soil and all so they will be having more of organic origin. So that will not be really coming from the disintegration of the rock rather some other organic or the vegetable materials are lying or representing the soil.

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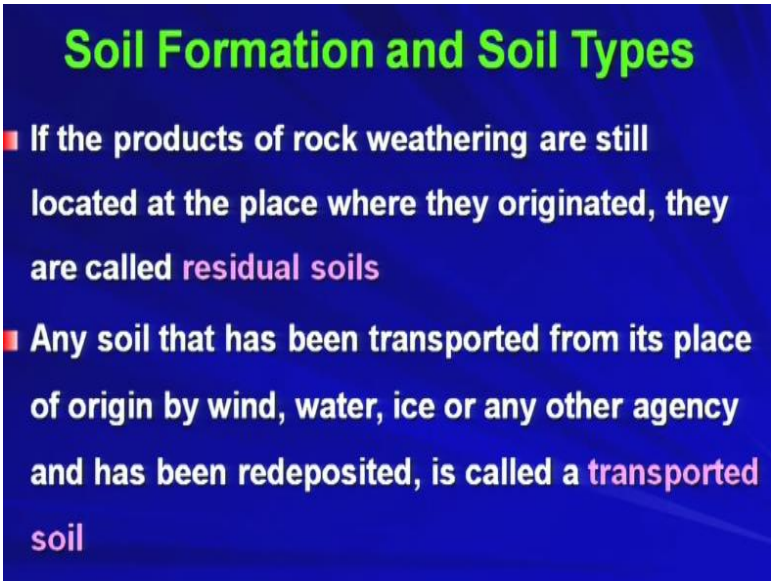

Now if the products of rock weathering are still located at the place where they originated, they are called residual soils. That means you are considering some rock or you see some rock lying over there and after weathering process, it could be mechanical, it could be chemical, but after the weathering process if the disintegrated rock that means soil is located, still located at the same place then that is known as residual soil.

So, you must know I mean if I say if you tell me that this is the residual soil then I will immediately understand the soil has been formed at that location itself by the disintegration of the rock. Then coming to the another type of soil, that is transported soil. Now what is transported soil? Any soil that has been transported from its place of origin, that means where they have formed, now it has been transported by wind, water, ice, or any other agency and has been redeposited in somewhere else, then it is called transported soil.

So that means it is the origin or the formation of the soil is happening somewhere else and then it is getting transported by some agencies or by some agent and ultimately it is getting redeposited at somewhere else and that is known as transported soil.

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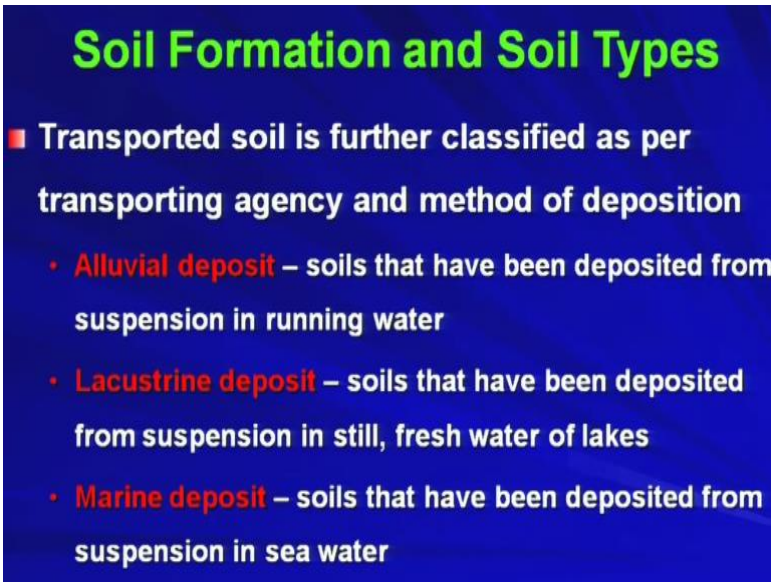

Transported soil is further classified as per transporting agency and method of deposition. First one is the alluvial deposit. Soil that has been deposited from suspension in running water. Suppose if you consider the soil getting formed somewhere else and then it is getting transported by the river water and it is getting deposited somewhere else so it is of course it is a transported soil but the soils that had been which have been transported and by water, fresh water, and deposited in the riverbed that will be known as alluvial soil.

Similarly, lacustrine deposit that is I mean it is known as happening in the fresh water that is in the lake site or something like that that is these are the soils that have been deposited from suspension in still, fresh water of lakes. That means below the reservoir or near the reservoir whatever deposition you are seeing whatever soil deposition is happening so that is known as lacustrine deposit.

Then marine deposit. Soils that have been deposited from suspension in sea water. So, you will be having too much of salt presence in the soil deposit and that is known as marine deposit.

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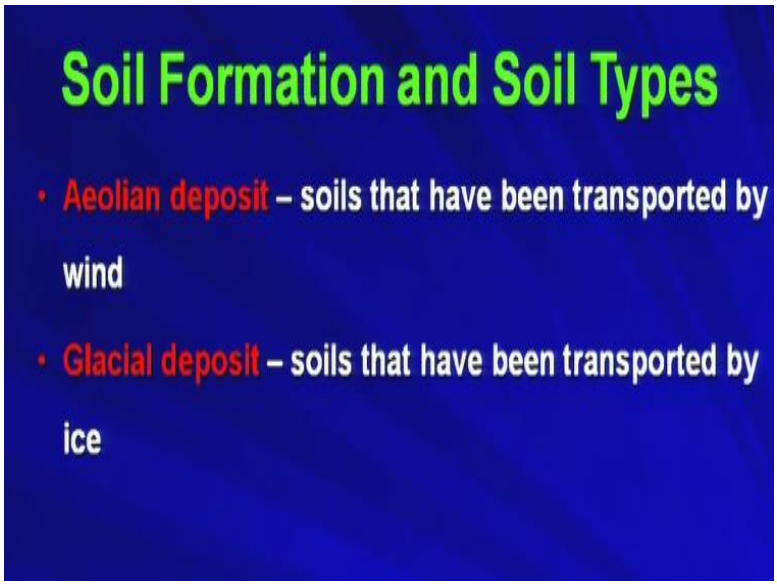

Then Aeolian deposit, that is soils that have been transported by wind. So, it is getting formed somewhere else and then it is getting transported by the agency that is known as wind. So that is known as Aeolian deposit. Then Glacial deposit. Soils that have been transported by ice, simple ice, so that is known as Glacial deposit.

So, depending on different types of deposition, you will be getting different properties. So those things you must remember. I mean otherwise why should we know all those things. Because based on the transporting agency okay you will be getting different properties of engineering properties of the soil.

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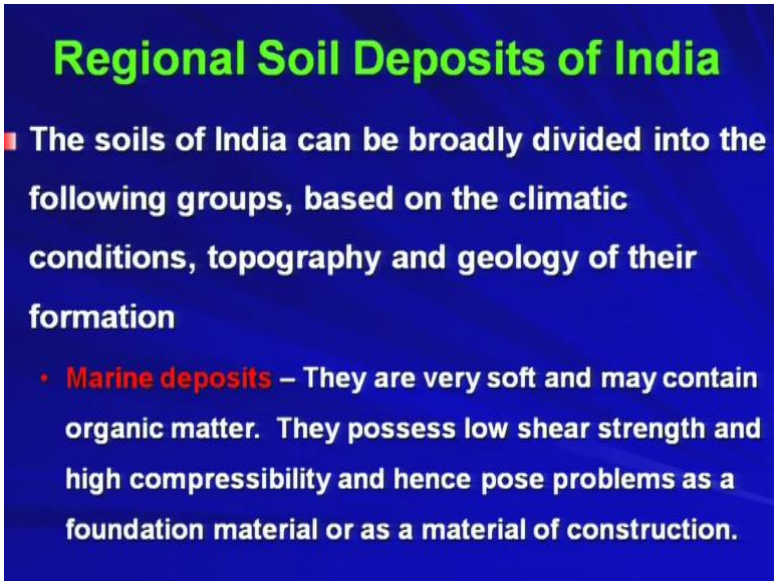

The soils of India can be broadly divided into the following groups based on the climatic conditions, topography, and geology of their formation. First one is marine deposits as I told you. They are very soft, I mean if you see the coastal region of our country, so there basically you will be getting the marine deposit and obviously you have you appreciate or you agree that they are really soft material and may contain organic matters of course.

They possess low shear strength. As of now, the shear strength and compressibility those things have not been covered, but shear strength means some kind of strength which will be provided by the soil to take care of the external load or external force coming on the particular soil deposit.

So, it possesses low shear strength which is not good for any kind of construction and high compressibility that means it is a kind of I mean you have seen some spongy material so it will be having high compressibility like so if the soil material is like that which is having very high compressibility then it is it should not be very good material for the construction and hence pose problems as a foundation material or as a material of construction.

That is very true because if you try to place the foundation on top of this kind of say marine deposit then what will happen because of its softness, very soft soil is there because of its softness the foundation may settle down excessively or due to its compressibility I mean due to its compressibility it will settle down and due to its low shear strength basically you will be getting the failure that means the foundation, if you put the foundation and if you apply the load on top of that it will collapse. So, this material is not at all good for any kind of civil engineering construction.

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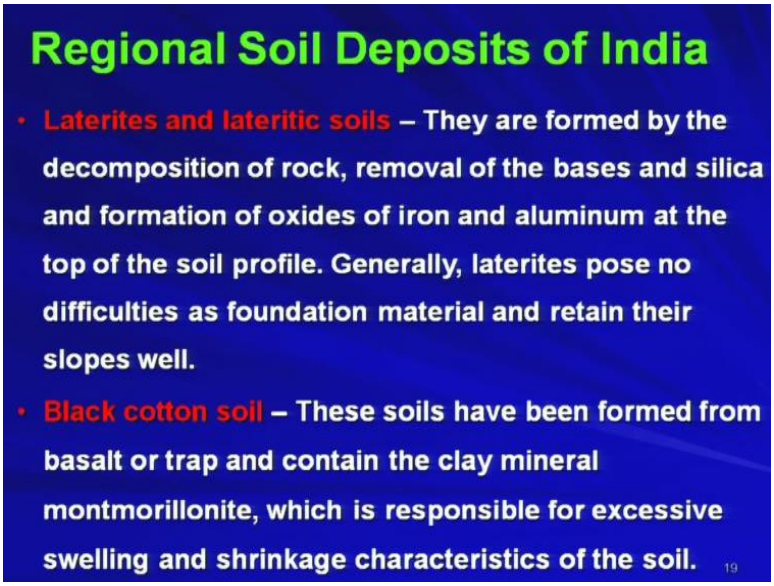

Then coming to the laterites or lateritic soils, they are formed by the decomposition of rock, removal of the bases and silica and formation of oxides of iron and aluminium at the top of the soil profile. Generally, laterites pose no difficulties as foundation material and retain their slopes well. So, lateritic material is a kind of say rocky kind of thing, very hard, very tough material or tough soil so there will be no problem for construction.

Then coming to the black cotton soil, that is the most problematic soil in our country. So, these soils have been formed from basalt or trap and contain the clay mineral montmorillonite. At this moment, I have not talked about the clay minerals so it may not be clear to you what is montmorillonite. Of course, after subsequent lectures it will be clear to you. So, clay basically is formed by different clay minerals.

So, one of the mineral is montmorillonite and that mineral is very problematic particularly in any type of clay. So, it contains the clay mineral montmorillonite which is responsible for excessive swelling. So, if you add water, so montmorillonite is having some property, if you add water it will swell excessively and if you take out water it will shrink excessively. So that means swelling and shrinkage both the things are excessive in this kind of soil.

So, I mean that is why it is also a very problematic soil. Suppose you are placing some foundation on this kind of deposit and if some water is getting added to this kind of soil then immediately it will swell and it will give some swell pressure on the foundation and if you are not designing the foundation based on that then you are gone. Similarly, if during dry season if the water is coming out from the soil it will shrink. That means the foundation will try to

collapse or try to settle. So, both the things or both the times during addition or removal of water this soil will create hell lot of problems.

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Then coming to the alluvial soils, the deposits have alternating layers of sand, silt, and clay as it is quite obvious because this kind of soil you are getting under the running water. So, there is a great deal of variation in the thickness of these layers and their horizontal development. Then coming to desert soils. So, these soils are wind-blown deposits of sand.

The sand dunes have an average height of about 15 m, but can at times be considerably higher. They are formed under highly arid conditions. So, suppose any desert area like Rajasthan or Ahmedabad or this kind of location if you see you may get this kind of soil, desert soil.

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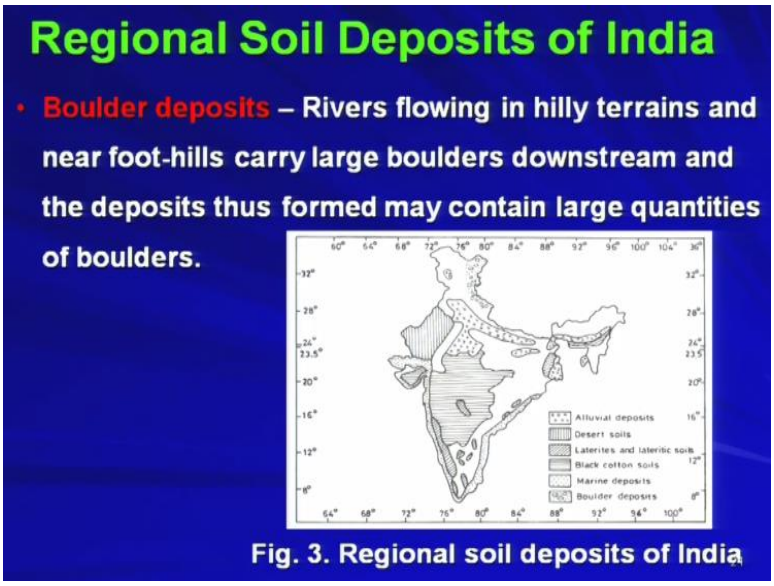

Now boulder deposits, rivers flowing in hilly terrains and near foot-hills carry large boulders downstream and the deposits thus formed may contain large quantities of boulders. So that kind of say generally it is happening or it is getting formed in the hilly region or the region where you have lot of mountains like Himalayas and other things.

Now this is the regional soil deposits of India generally. So as you look at this part so the northern part is completely alluvial soil because lot of rivers are there so and you know the alluvial soil deposit is generally happening on the bed of river so and then coming to the desert soil as I told you, you will get this kind of desert soil maybe in the Rajasthan or in Punjab or somewhere else and then laterites and lateritic soil you will be getting this part the western part of West Bengal and Jharkhand and Bihar area and little bit of Maharashtra and then black cotton soil.

So, you can see the black cotton soil is completely covered in MP and Maharashtra and then part of Andhra Pradesh. So, this is a real problematic soil as I told you and this black cotton soil if it is happening for any kind of geotechnical engineer or the civil engineer then you are not really lucky, let me tell you. So, this black cotton soil should be avoided for any kind of construction, but we are really unfortunate that we have lot of black cotton soil in the country.

Then you will get the marine deposit along the coastal area as I told you. So, this is along the coastal area and you will be getting the marine deposit as well as eastern part of your West Bengal. Then boulder deposits which is generally happening along the mountaineering region or the hilly region.

So, okay, so thank you very much for your patience hearing. So, we have seen the description of soil, engineering geology of soils, and their formation. Thank you.