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Subsurface Exploration: Importance And Techniques Involved

By
Dr. Abhishek Kumar
Department of Civil Engineering
IIT Guwahati

Lecture 4
Geotechnical
Investigations

Dr. Abhishek Kumar
Assistant Professor
Department of Civil Engineering
Indian Institute of Technology, Guwahati
Webpage: http://www.iitg.ac.in/abhiak/

Welcome all to lecture 4, so today we will be discussing in details about geotechnical investigation particularly related to rocks. So myself Dr. Abhishek, and today's lecture 4,
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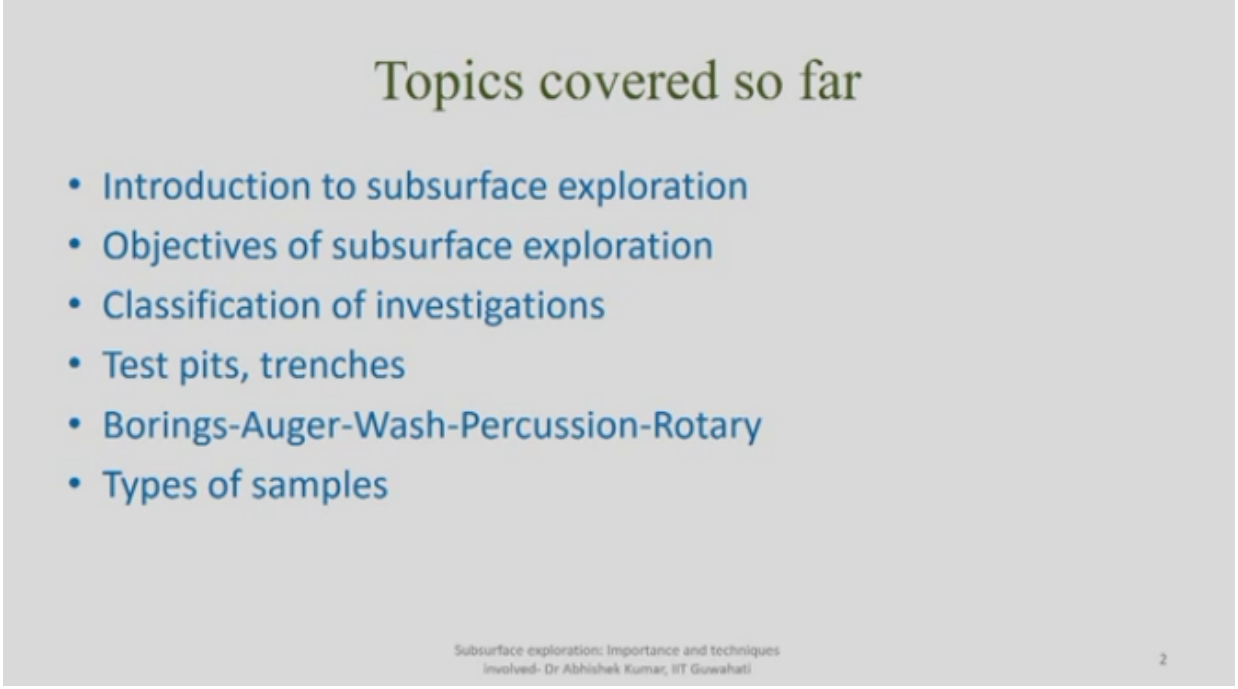

so before going further for the, for today's lecture we will be just discussing what are the topics we have covered so far in the earlier three lectures.

So in the first lecture we talked about the introduction to subsurface exploration, what is the need of subsurface exploration, why we should go for subsurface exploration, then in lecture 2 we discussed about objectives, what are the objective of subsurface exploration and then what are the different classification of investigation depending upon whether it's a new structure, whether it's an existing structure, whether it's safety of adjoining structure, whether it's about finding suitable material for construction purpose.

Then in the last class we discussed about what are the test pits, trial pits, which talks about shallow investigation, preliminary use for small structure or maybe kind of guiding tool whenever we are going for detail investigation, like which method to be used, what will be the level of overburden pressure whether water table is available at shallow depth so on and so forth.

Main advantage is highlighted earlier that in majority of the experimental way of collecting the soil sample, that's soil sample may as we subjected to partial or complete damaged or difference due to change in soil structure, mineral composition, moisture content, that's why majority of the time whenever you are collecting sample of soil by means of sampler or the samples you are getting from test pits are mainly considered representative samples or undisturbed samples which can be used even for consolidation behaviors, study which can be used for shear strength parameter, determination so on and so forth, so that is the benefit if you are going for test pits and trenches, but only limitation is we can go even, we cannot go for deeper depths, and moreover if the soil is collapsible in nature or cohesion less we have to provide some kind of lateral support or bracing which will ensure like during trenching for deeper, I mean comparatively deeper depths the soil will not fall into the trench.

Then we discussed about different kinds of borings, as I mentioned earlier also so boring the principle objective is to proceed the borehole at deeper depth, so depending upon whatever our design consideration, whatever recommendation from field engineers we can collect samples maybe representative or undisturbed sample at different different depths, but since the sampling is not been done throughout the depth, so boring is used so that we can advance borehole quickly and reach a desired depth at which you can collect the soil sample, of course you have to measure the ground water table condition as well.

And then what are the different kinds of samples you generally collect, whether it's representative sample, non-representative sample, undisturbed sample, so those are the topics we had covered so far.
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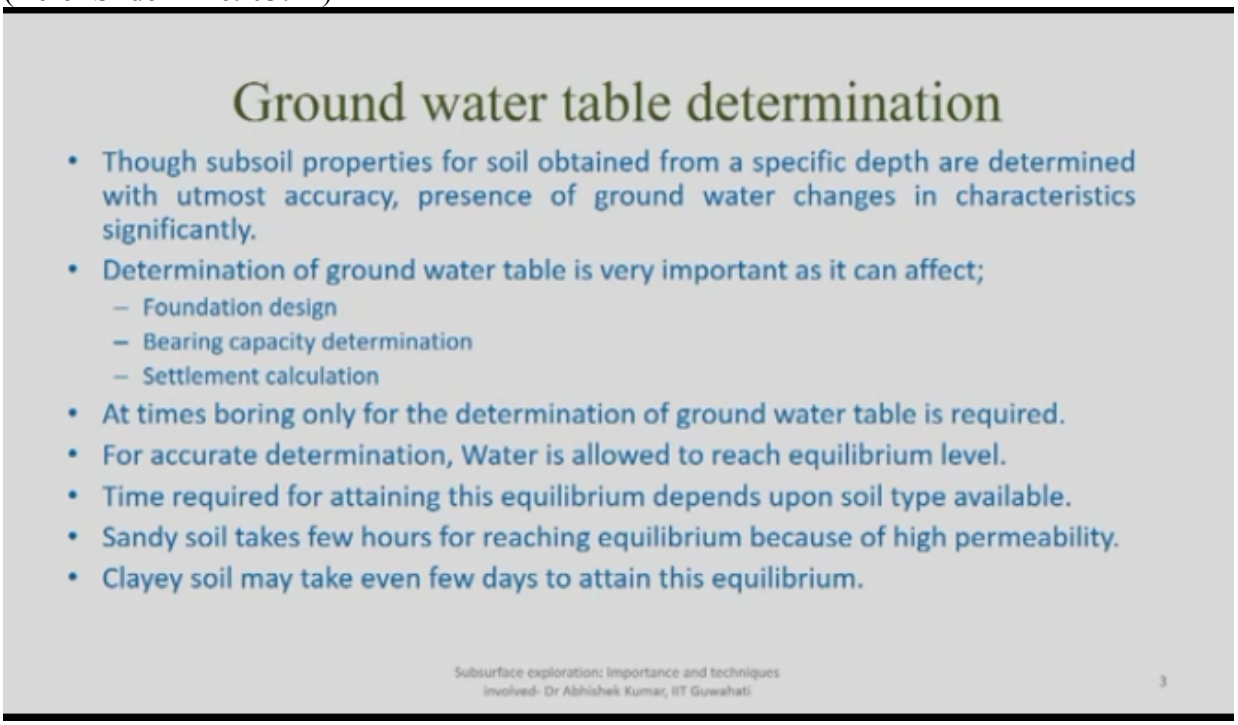

In today's class we will be discussing, last time when we talked about different kind of samples you collect from borings or sampler, I had highlighted like ground water table is also important parameter, but so today's class we will be discussing in detail like what is ground water table determination, and why it is important, so through subsurface properties of soil obtained from specific depth or determine with utmost accuracy, the presence of ground water table in changes it's characteristics significantly, so one is like you are collecting the soil sample from a particular depth, you are determining it's strength characteristics, but whether those characteristics will actually play a role or will actually determine the behavior of the foundation, so that will change drastically when we say it is in presence of water when we say it is in absence of water, so depending upon whether the soil sample collected from a particular depth, whether that particular depth falls below the ground water table or it is above the ground water table, so accordingly your foundation behavior will change, that's what it means to say though whatever soil sample we are collecting, we are determining the laboratory test based soil characteristics properly, but if you are not assessing the ground water table depth properly it

will again lead to some kind of erroneous judgment in foundation design, settlement, bearing capacity and all that.

So that determination of ground water table is very important as it can affect, so first one is foundation design, as I mentioned here so depending upon whatever is the depth of ground water table at times we go for shallow foundation, deep foundation, also if it is completely water logged area it will also help you in understanding whether once we go for foundation, laying whether dewatering is required, whether some kind of confinement from the surrounding ground water table is required or not required and also what, again as I mentioned because of the presence of ground water table the soil behavior changes, so whether in the present condition considering only the soil type if you are proposing for shallow foundation, whether accounting for shallow ground water table, that shallow foundation decision will remain sustainable or not we will, I mean it can change with the condition of ground water table, because the ground water and its effect on the soil which is available in the zone of influence will come finally control the behavior of the foundation, so that's why presence of ground water or ground water table also determines what will be the foundation design.

The second one is bearing capacity determination as I mentioned, the soil in stiff condition or dry condition will behave completely different, from the same soil which is partially a fully saturated, so depending upon how it's behavior is, it's bearing capacity will change because it's bearing capacity is changing so overall the stability of the foundation will change.

The third point is settlement calculation, once the bearing capacity or load settlement curve changes because of the presence or absence of water that will also get us an idea about what will be the total settlement or differential settlement in actual ground condition, so most important is I mean, as important it is to determine the subsoil property accurately based on field investigation, based on laboratory investigation equally important it is to determine groundwater table.

So at times as I mentioned in the next point at times boring and sometime people do only for the determination of ground water table which may not be available like if you have some kind of wells available in the nearby location, if you have some kind of lakes that can possibly give you an indication what is the ground water table level, but at times if you are not having those kind of resource in the vicinity of the site you have to drill a borehole particularly because you are boring here not for collection of soil samples so you can probably go with boring methods and no sampling will be required, so this will give you what is on an average what is the depth of ground water table at your vicinity or at the site.

For accurate determination water is allowed to reach equilibrium, it's not like you remove the sampler and then immediately you start observing ground water table, because it will take some time for ground water table to get saturate, because you are removing the soil sample so I mean there will be some kind of draw down in the borehole with respect to the surrounding ground water table, in general ground water table level, so in order to ensure that whatever ground water table you are reporting in your bore log it is the equilibrium level, like it's not going to change with respect to the time, maybe after 2 hours, after 3 hours or maybe after couple of days if you observe the ground water table it may not show significant fluctuation, so that's

why ground water table determination is only reported once the water reaches an equilibrium, there is no fluctuation is going on there, so the time required to attain this equilibrium, again depends upon what kind of soil available at the level where the ground water table is existing, so if sandy soil is there we know the sandy soil permeability is significantly higher, so the time required for ground water to reach equilibrium in case of sandy soil it will be significantly less, because of permeability the bore pressure dissipation will happen to quickly and then it can reach very quickly to an equilibrium position.

On the other hand if presence of clay as you encounter based on borehole report, then you have to wait for maybe few hours, maybe 8 to 10 hours or may be more couple of days also to, in order to ensure that the water level in the borehole as rigid equilibrium position, and now you can deport whatever is the depth of groundwater table in your bore log, so that will give you proper indication whether it is for sandy soil, whether it is for clay soil, whether the ground water table has reached equilibrium position, because if you do not wait for reaching the equilibrium most of the time it will happen, you will end up in underestimating the ground water table, like you will report ground water table at much deeper depth in comparison to what actual is the depth of ground water in the surrounding region.

So that will, again because if you consider the actual ground water, the soil which is above the ground water table to be dry which is actually not the condition, then you are actually overestimating the strength of the material or soil, and same will have effect on bearing capacity and settlement determination.

So overall the effect of ground water table is important for settlement in bearing capacity determination and in order to forecast proper bearing capacity and settlement behavior of the soil you have to ensure the groundwater table whatever you are determining it is not going to change, so once the boring work is over,
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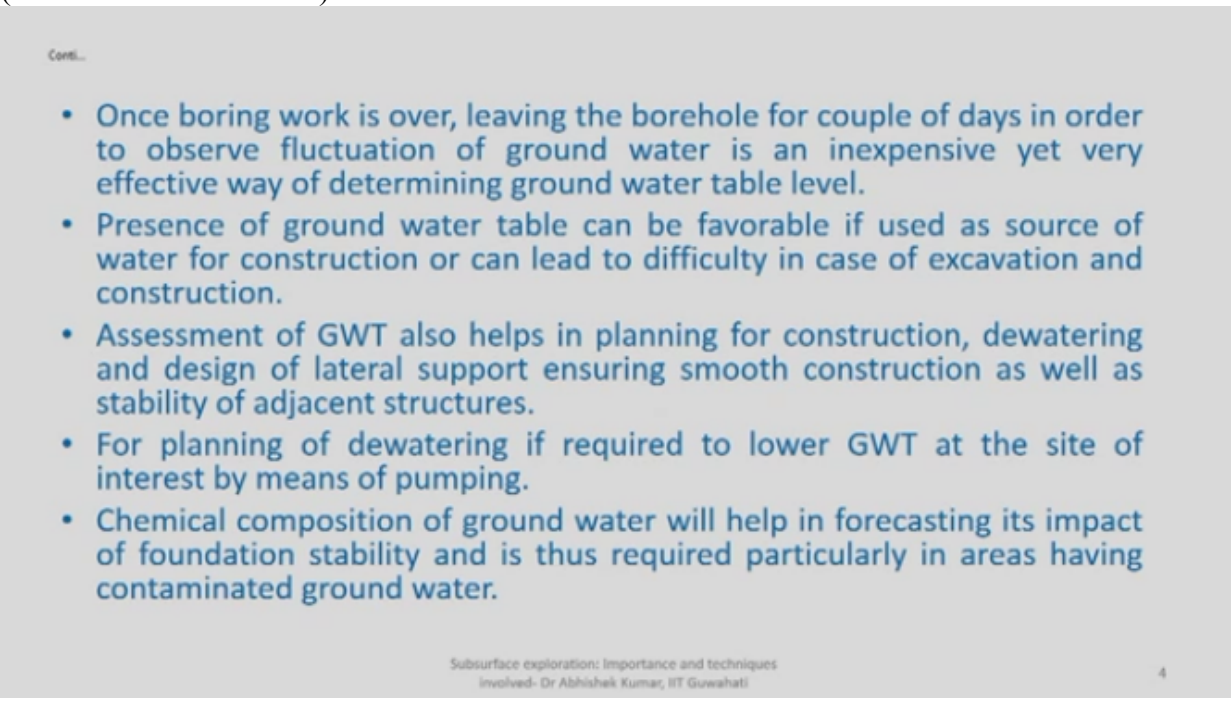

leaving the borehole for couple of days like once you have done the boring you've collected all the soil sample depending upon the depth, you are targeting for 10 meter, 15 meter, 20 meter and more and more than that, so what you do, you will leave the borehole for some time so that the water table in this reaches an equilibrium position you can observe it, rather than going for a separate borehole which is particularly used for determination of ground water table level only, because anyway once you exploring at the site of interest you are going to drill a borehole, so what it means to say you can leave that borehole but you have to make sure like you make safety measures properly there, and then observe the ground water table level maybe after couple of days or maybe after couple of hours because now you are having the soil type available at different depth, so that will possibly indicate whether you have to wait for couple of days, whether you have to wait for couple of hours for determination of ground water table.

And since you are not drilling a borehole separately this will be considered significantly in expensive, rather than going for separate borehole

The presence of ground water table can be favorable if it is used as a resource for construction purpose, so if the ground water table is shallower you need not bring water from surrounding area for, or any other resource for construction and for different stages, or rather it can be used as a source but on the other hand if the ground water table is too shallow and you are going particularly for deep excavations then there will be problem because water starts seeping from the surrounding region once you start excavating below ground water table, so what we'll do it will, because you have removed the lateral support from the adjacent soil, on the phase of the excavation so along with the water, the soil from the surrounding region which probably in majority of the times is not the soil belonging to the owner, I mean to the owner of the site, so what will happen along with the water? The soil from the adjacent site will also start moving, and slowly there will be void underneath the foundation of the adjoining structure which will lead to failure of that structure also.

And moreover is not only about the stability or safety of the adjoining structure, finally the water along with the mix with the soil that is slurry is also getting filled up in your excavated area that will make difficult for you to continue with your exploration program or if you are going for laying a foundation again it will cause difficulty and it will also compromise the safety because finally from the surrounding soil there is seepage going on, so you never know when the entire support will collapse and there can be minor to major accident can also happen, so that's why depending upon what is the role water is playing it can be used as a resource, if you are using for construction purpose it can possess danger or difficulty when you are going for underground excavation and construction purpose.

Assessment of ground water table also helps in planning for construction, like if you know the ground water table is very shallow once I'm going for actual site exploration or excavation thing, then I'll make certain arrangement whether in terms of providing lateral support maybe in terms of some kind of confinement by laying some concrete on the sites as well as the base which will ensure no seepage of groundwater into your construction area or you can go for dewatering or design of lateral support or as well as you can go for, yeah, dewatering by means of some kind of pumping, so whatever water is coming at the site you pump it out on to the, on some other, again in permeable layer so that the water can be drained out quickly at least the

time, at least for time being when some kind of concrete laying or some exploration work is going on, because after that if water again by the time water table starts gaining its original position your impervious layer will be there at the site that will ensure okay, there will not be any further problem because of shallow ground water table.

So that's our assessment, once you are assessing this ground water table, well in advance you can actually be very clear with the planning, you can be very clear whether dewatering is required, you can be very clear whether lateral support is required and you can go for design of what kind of lateral support is required.

For planning of dewatering also if required lowering of ground water table you can do by means of pumping provided you know ground water table is very shallow.

Another thing, nowadays we are seeing like majority of the location, ground water table is contaminated, it can be because of chemical contaminant, it can be some other impurities also, so what is the effect of that contaminated ground water to the soil also or maybe to the foundation material also that will also, if you know the ground water table, if you know the chemical composition of ground water table that will help you in understanding or forecasting what will be its impact on foundation stability and then particularly in case of area where contaminated ground water table is there, so once you know those things in advance you can take suitable measures.

So this was about ground water table, last time we discussed about different kind of soil samples, today we will be discussing about rocks and how you do the sampling,
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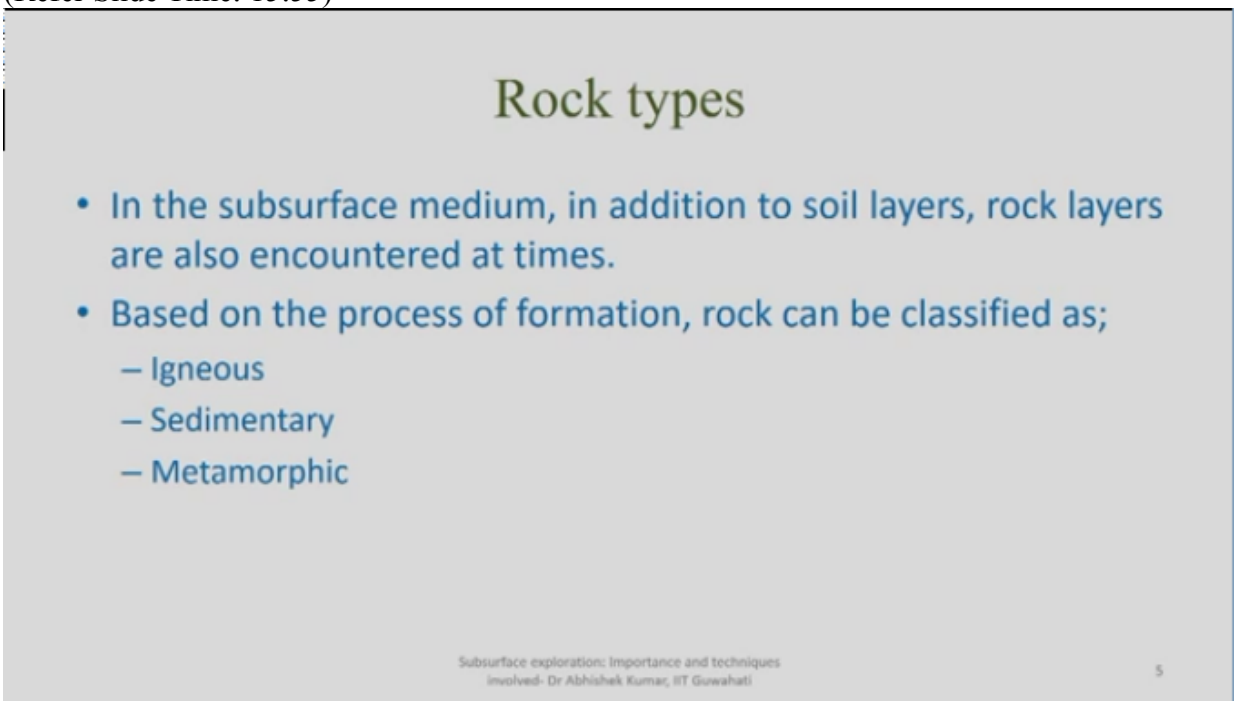

and how you make qualitative and quantitative assessment of the information you are getting from rock samples.

So in the subsurface where the rock comes into picture because at the site where you are targeting for laying or foundation for construction of particular kind of project it's not mandatory everywhere you go, you will find only soil throughout the depth of influence, it may be possible you may find some local boulders or gravel, you may find completely hard rock medium after 2 or 3 meter of soil medium, and you may find only rock medium is available throughout the site of interest, so when you go for boring you have to be aware about what are the ways of colleting sample from soil and what are the ways of collecting sample and rock, and how to examine those sample.

So as I mentioned here in the subsurface medium in addition to soil you can have rock layers also which can be encounter how to deal with the rock layer that we are going to discuss, so before going to how we go for sampling we generally, we should know what are the different kinds of rocks, so rocks based on the method of formation it can be classified as, there are three ways, many of us know also that is igneous rock, sedimentary rock and metamorphic rock, so how you classify,
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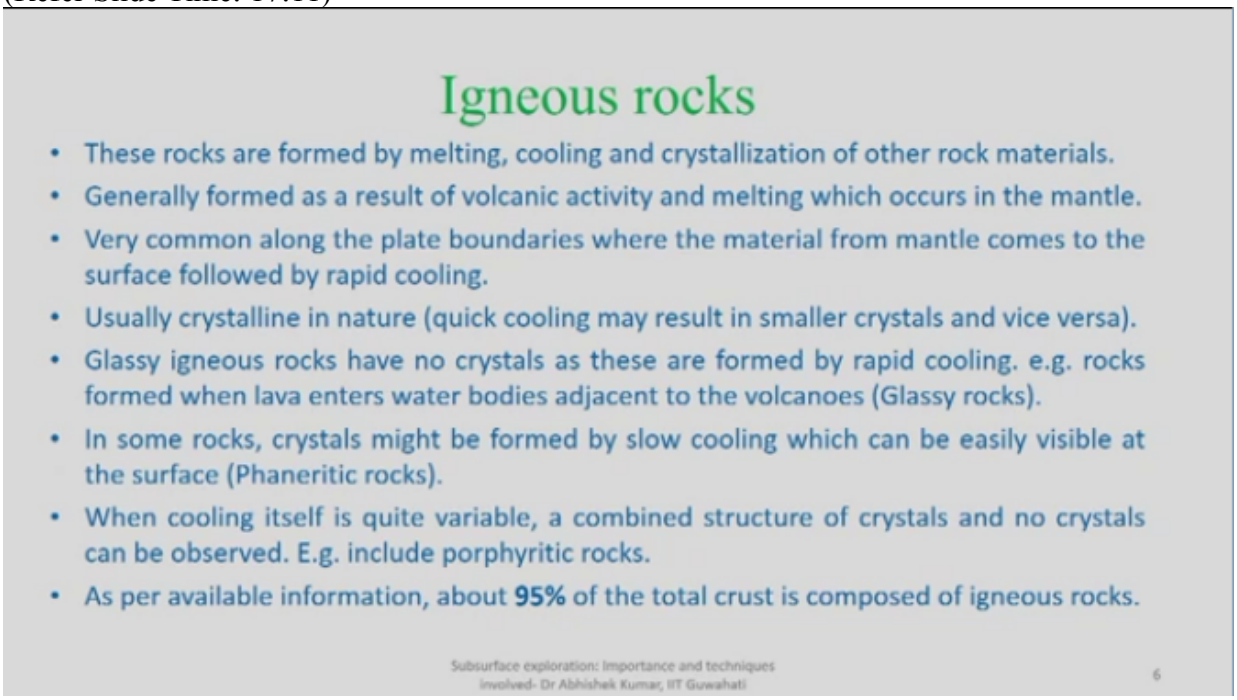

how you differentiate between each of those rocks, so igneous rock these rocks are formed by melting, cooling, and crystallization of other rock material, so whenever there will be some kind of cooling and melting of material, resulting in crystallization depending upon what is the rate at which cooling is happening it will define whether it is coarse, the crystal will be coarse or it will be small crystals, so that is called as igneous rock.

So generally form as a result of volcanic activity, so whatever material coming out from the base of the volcano, it will come onto the surface and depending upon the rate of deposition or the rate of cooling it will become coarse crystal or maybe fine crystal, so generally resulted from volcanic activity and melting which occurs in the mantle, so in the mantle molten material is available which will come through the volcanoes on to the surface it gets deposited, so those are particularly classified as igneous rock, these are very common, particularly in case of plate

boundary because along the plate boundary what happen? Either two plates are moving towards each other, so there will be some kind of starch developing at the interface which will actually create heats, heat at the interface resulting in melting of the material at mantle level.

On the contrary you will be having diversion plate boundaries also, so what will happen? The two plates like Indian plate and some plate which are moving away from each other, so material from the deeper layer particularly from the mantle we start coming on to the surface it will cause, it will create new surface, so those are particularly we are talking about igneous rocks, it will come on to the surface as you know in comparison to the below ground water table the temperature at the surface is significantly lower, so it will start cooling, when it will start cooling then the lava which is coming on to the surface will make igneous rocks, okay.

So usually crystalline in nature as I mentioned earlier, so whenever it's quick cooling then it will result in smaller crystal, when it is slow cooling it will result in coarse crystals, so glass igneous rocks have no crystals, and these are formed by rapid cooling, so cooling is so quick even it does not allow you to go for any kind of crystal formation, generally I mean, generally this is about the rocks which are forming by cooling of rocks or molten material by water bodies, adjacent to the volcano, so from volcanoes some molten material comes out on to the surface, it goes to water bodies so you can understand when it goes to water bodies the rate of cooling is so quick it does not allow any formation of crystals, example is like glassy rocks, you can see like certain rocks which are very shinny in nature, so those are igneous rock which are formed by two rapid cooling of molten material.

In some rocks crystal might be form by slow cooling process which can be easily visible on the surface, so the process particularly when the cooling is happening by means of air, the crystal will be coarse are in nature example is phaneritic rocks, so it will be much cooler.

Then when the cooling itself is quite variable you can say like some, for some time it was too quick, for some time it is too less or maybe certain portion of molten material exposed to very quick cooling, certain portion is exposed to very slow cooling, it will be combination of whether it is a crystal, if it is a crystal whether it's a coarse crystal, whether it's a fine crystal or there is no crystal at all, so depending upon if some there is exposed, some is getting cold by water bodies, some is getting cold by air, again depending upon what temperature of air is available in the surrounding area it can go for even crystal, coarse crystal or fine crystal, example given is porphyritic rocks.

It has to be highlighted here that above 95% of total crust the surface medium, the top most layer of the earth, 95% is composed of igneous rocks, so most of the time because you know like entire earth is divided into great boundary whether it's I mean it's divided into number of plates, and at the interface of each plate there will be either diversion plate boundary, conversion plate boundary or transform plate boundary, so there is always possibility the material from the, either because of the heat generated at the boundary, the material is getting melted and coming on to the surface or when the two plates are moving away from each other, again it will bring some material on to the surface.

And the third one is when the rate of movement along the same plate boundary or the region between two plate boundaries which are moving at different rate of movement, again there will be some kind of slight passive between the plate boundaries which will also bring some material on to the surface possibility is there, so that's why majority of the location like entire earth is divided into number of plates, and at each plate boundary there are always chances you can have some new material coming up and forming igneous rocks, that's why 95% of the earth crust is composed of igneous rocks.

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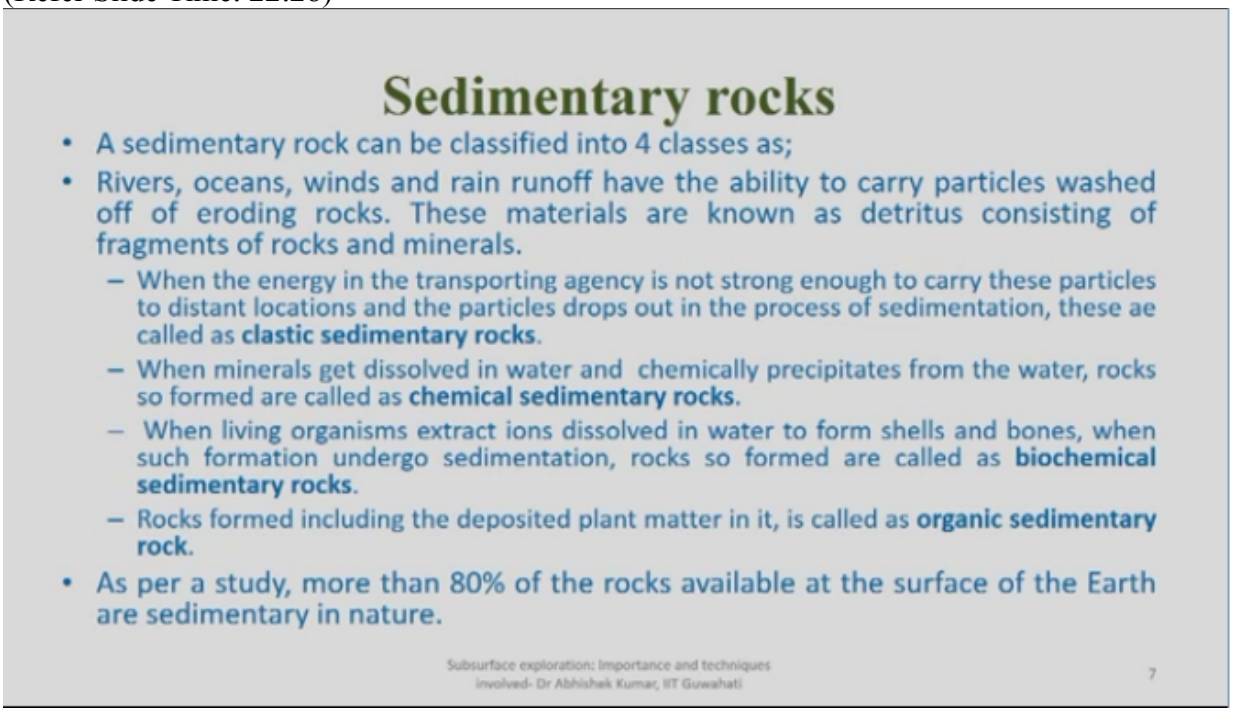

Then you go for sedimentary rock that is second kind of rocks, you know like depending upon the transporting agency, depending upon the chemical and deposition processes involved, a sedimentary rock can be further classified into four categories, but before going into this we should know like what are the agency which is responsible for weathering and erosion, particularly river, ocean, wind and rain have the ability to carry the particle washed away or eroding the particles from the rock, parent rock, they will do I mean because of river water, because of oceanic water, because of wind, and because of rain whenever it comes in contact with any kind of rock layer what we'll do, it will actually wash away from the material or by eroding the material or the kind of deposition on the surface and so on if the process continuous for longer time you can see actually the erosion of material, so these material are known as detritus, consisting of fragments of rocks, and if the rock is containing of minerals also, so mineral will also be there.

When the energy in the transporting, so it's like erosion as well as because of the flow it will be eroding as well as it will be transporting, but over a period of time or over, I mean in the longer course you can see when the energy in the transporting agency it can be wind, it can be water, it can be rain also, when the energy is not sufficient enough to carry those material to further distance is what will happen, at distance location particularly the material will actually drop

from that flow and you start settling at that particular location, so when the same process happens these are known as particularly when the transporting agency is not enough strong to bring those material to distance location it will start processing and it will, particularly the rocks which are formed by this process is known as clastic sedimentary rocks.

Second one is when material get dissolved in water and chemically precipitates from water or rocks, the sedimentary rock which are formed by such process are known as chemical sedimentary rock.

Third one when living organism extract ions dissolved in water to form shells, so that's why you can see in many of the sedimentary rocks there will be rock formation in between, there will be shells or bones, so this is particularly when living organism extract those ions which are available, and then it will go for some kind of sedimentation over a period of time, then you call it as biochemical sedimentary rocks.

Then next one will be the rocks form, rocks form including the deposited plants matter, so it's like again depending upon the composition of the rocks, so when the transporting agencies responsible for settling you call it as clastic rock, when there is chemical precipitation happening you call it as chemical sedimentary rock, when there will be some kind of, the composition may also contains some kind of plant matter you call it as organic sedimentary rock, when there is shells and bones because of the presence of organic material, organism, the sedimentary rock form you call it as biochemical sedimentary rocks, so these are possibly four kinds of ways a sedimentary rock can be formed, everywhere it's happening like sedimentary is getting deposited over a period of time and because of overburden thickness of sediment available at shallower depth, the sediment which is available at deeper depth will get compress, and will form in terms of different certification or layers.

Depending upon the composition you can go for either its biochemical, whether it's organic, whether it is chemical, whether it is clastic sedimentary rock.

As per a study, more than 80% of the rocks which are available at the surface of the earth are sedimentary in nature, so first when we talk about the crystal medium which is about the main medium before, above which you can find majority of the soil location is there, and in between the soil location whatever rock medium is available you can find out more than 80% of the rocks which are available, so remember in the previous when we were talking about igneous rock we were telling about 95% of the crust is made of igneous rock, here we are talking about 80% of the rocks which are available, which maybe at the parent position, which may dislocated to some other location, so overall it's different from the crystal medium, 80% of the rocks which are available at the ground surface or mostly sedimentary in nature.

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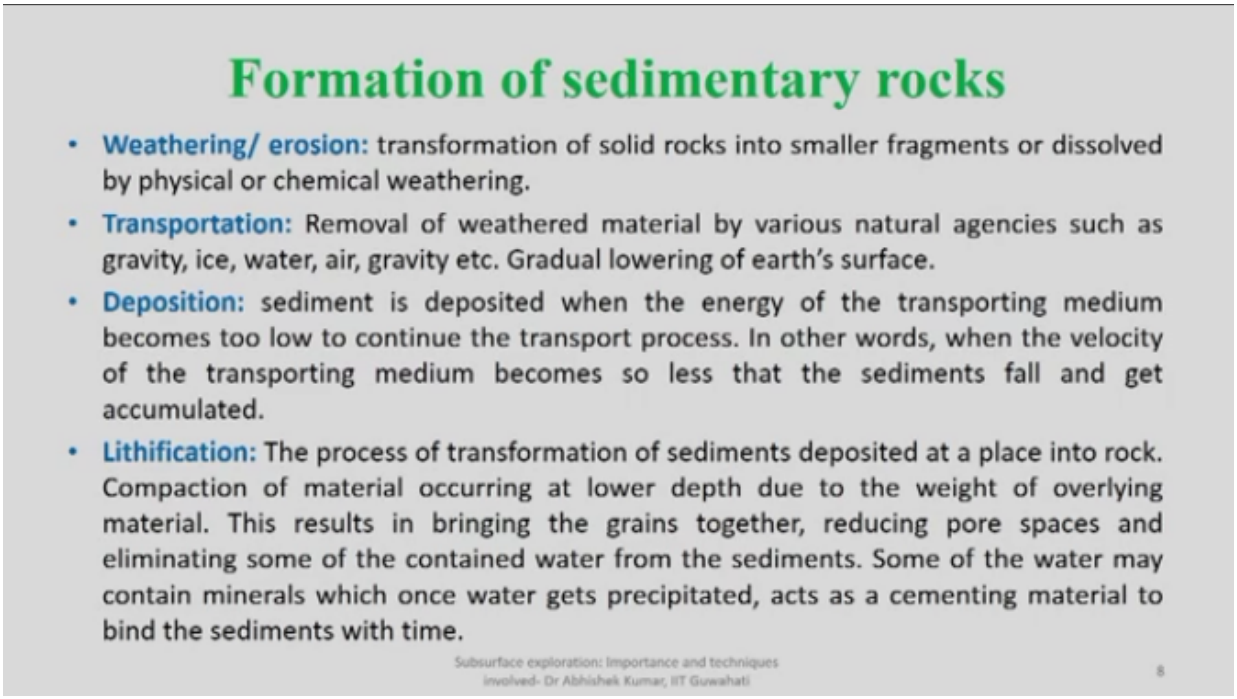

Then formation of sedimentary rocks, so you can go with different ways, first one is weathering and erosion which consist of transformation of solid rocks, so some solid rock is there because of weathering agencies or erosion agency which can be glacier, it can be ice, it can be flowing water, it can be air also, sometimes it can be gravity also as we here and in case of soil formation also, so depending upon the weathering agency involved, the parent rock can be fragmented or can be break down into small particles which may get dissolved by different physical and chemical processes, so this is called as weathering or erosion depending upon whether it's because of the flow it's getting dissolve or fragmentation, it will be called as physical process then because of chemical composition, precipitation its happening, you call it as chemical weathering.

Then transportation, so first we were talking about weathering because of the flow, then second one is transporting it maybe the same agency which is responsible for weathering it maybe a different agency depending upon relative energy each of those agency are carrying, so remember transporting means removal of weathered material by means of natural agencies, different natural agencies can be there as I mentioned earlier also, there can be gravity, it can be ice, it can be water, it can be air also, depending upon again relative like if you go for colder regions even glacier can also be there, if you go for high altitude region gravity can also, can cause and so on and so forth, so whatever the agency is responsible to bring the material fragments from its parental position to the new position where the material is actually getting settle or deposited that is known as transportation.

So these are different stages, once it is like erosion or weathering then the material is getting transported, then third one is deposition, once it is transported then it will start deposition, so sediment is deposited when the energy of the transporting medium, any of the transporting medium which we discussed earlier becomes too less, like the agency is responsible transportation is not having sufficient energy to continue with that phase of transportation, so it will start settling the material unto the that particular location, it maybe nearby location, it can

be distant location also, so it becomes too low or continue the transport process, in other word when the velocity of transporting medium becomes so less that it cannot compromise with the self-weight of the transporting medium material, the material will start settling, it will fall and it will start accumulating.

Then there is lithification, lithification means the process of transformation of sediment deposited at the place into a rock, so what will happen? First of all there was a parent rock because of some weathering agency, there was some kind of fragmentation, there was some kind of erosion happening at the surface, then started transporting by some other agency then it started deposition, so when the deposition, suppose when the deposition started in small layer, then there will be another layer which is getting deposited because the material which was getting weathered it may or may not be available in geological time scale forever, so there will be another material which is getting deposited, so that material will settle above this the layer which was earlier deposited.

And same process if it continues there will be layer after layer deposited one above the other, and considering the load of so if you talk, if you start with the initial layer which was getting deposited maybe after several hundred or thousands of years when more number of layers are there maybe 20, 30 or so, each of them having different thickness depending upon whether weathering agency or dominating of weather eroding depositional agency for dominating in that particular geological time scale, so because of the pressure generated or because of the sulfate overburden layers, the layer which was deposited initially we'll start compressing or which will be transported, which will transform from rock fragments to actual rock formation, so this is called a lithification, so it will start with first layer then the second layer, then third layer so finally at the end you will see there will be some sedimentary rock, so there will, because it is called sedimentary because sediments are there which are getting over the geological time scale it is getting deposited and then consolidate, kind of transformation from rock to, sediments to rock and it's happening layer by layer that is why it is called a lithification the process of transformation of sediment deposited a place into rock.

So compaction of material occur at lower depth due to the weight of overlying material, so whatever material was available at deeper depth you will start compressing because of weight of layers which are available above those particular, so initial it was sediment and then if you consider that particular sediment is under very high pressure of overburden layer it will start forming or it will start coming in more intact form that is called as rock formation.

This brings the materials together reducing pore spaces and eliminating some of the contained water, so it will become more and more intact, there will be reduction in pore spaces, there will be elimination of water which is available, so that will improve it, first one it will reduce to the porosity, so one it will improve the moisture content of the material, and some of the water may contain mineral which once get water get precipitated, okay, so mineral there will be always water mixed with the mineral, so water once it goes out it will precipitate those minerals into the soil and that soil will transform in the rock so, at the end you will be having some kind of cementing material which will bind up all those sediments together and forming the rock, that will again depending upon what kind of chemical composition was there in the soil when it was

getting deposited that will define the mineral composition of the last product that is sedimentary rock.
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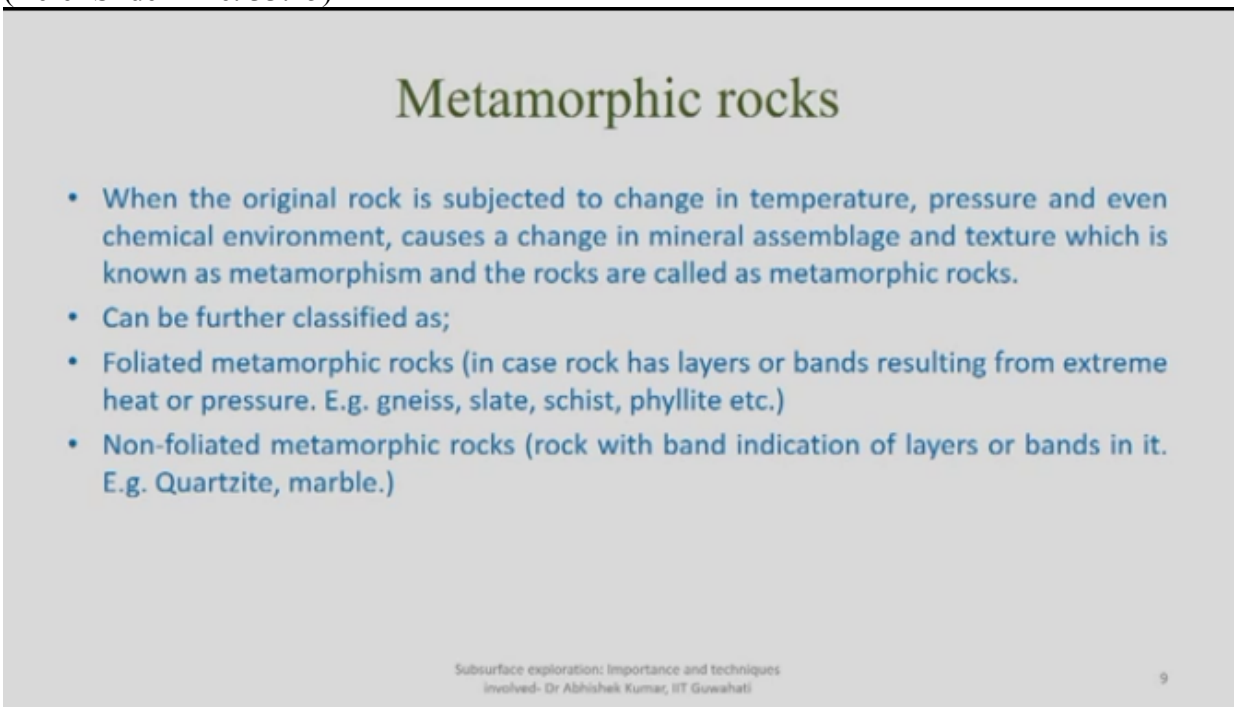

Then we have the metamorphic rock, so when the original rock whether it's igneous or sedimentary rock when it is subjected to extreme temperature, extreme pressure, and even extreme change in chemical environment, it will result in change in its mineral composition and as well as its texture from its original rock, then this process is called as metamorphism and the rock is called as metamorphic rock, so even and initial it was igneous rock or sedimentary rock but because of some external agency which is responsible for extreme change in temperature which was not there when the formation of rock happened, whether it's igneous or sedimentary or pressure which was not there when the actual sedimentary or igneous rock form or even chemical environment that will lead to change in its mineral composition as well as the texture, so the original rock is no more remaining there, this process is called as metamorphism and that's why the rock is called as metamorphic rock.

It can be further classified as foliated rock where you have layers or bands resulting from extreme heat or it's like because of quite fluctuation in the heat, the metamorphism is happening at different different lakes, raids so that's why you can have rocks formation or metamorphism process happening in terms of layers, so that's why such rocks are called as foliated rocks.

Example is gneiss, slate, schist, and phyllite, these are the particularly foliated kind of metamorphic rock, and then you are having non-foliated metamorphic rocks which are form in the terms of band, it may be having band or it may not be having bands here, so those particularly are called like example are quartzite and marble, marble you all see you don't find any kind of bands or layers in it, so those are called a non-foliated rock it should be rocks with no band indication, it should be like no band indication here, okay, so that will be like so far we started with borehole then we know like in the borehole you can have soil, you can have rock so

depending upon what kind of rock is available at different different depths before you know that you should know what are the kind of different kinds of rock available, so today we have discussed like rock means igneous rock which is particularly because of molten material coming from the volcanoes or particularly from the mantle layer on to the surface depending upon what is the rate of cooling, it can be coarse, it can be fine crystal, igneous rock, then we are sedimentary rock depending upon what kind of weathering agency, what kind of deposition agencies are prevailing in the region of your study, there can be more deposition, it can be more erosion in the geological time scale, so same process is happening for maybe the several thousand of years, so that deposition, the final deposited sediment will be transform into the rock because of the chemical which were present in the water, finally the water get precipitated and the chemical is responsible for binding of those kinds of material and forming the sedimentary rock.

Then when such sedimentary rock again in geological time scale is subjected to, extreme change in temperature, pressure or chemical composition, so it will transform from its parent rock, whether it's igneous rock, whether its igneous rock, whether its sedimentary rock and the process is called as metamorphism, and the rocks are called as metamorphic rocks, so we have talked about different, two types of metamorphic rock, the one which is having bands called as foliated metamorphic rock and the one which is not having bands called as non-foliated metamorphic rock, so these about the rock.
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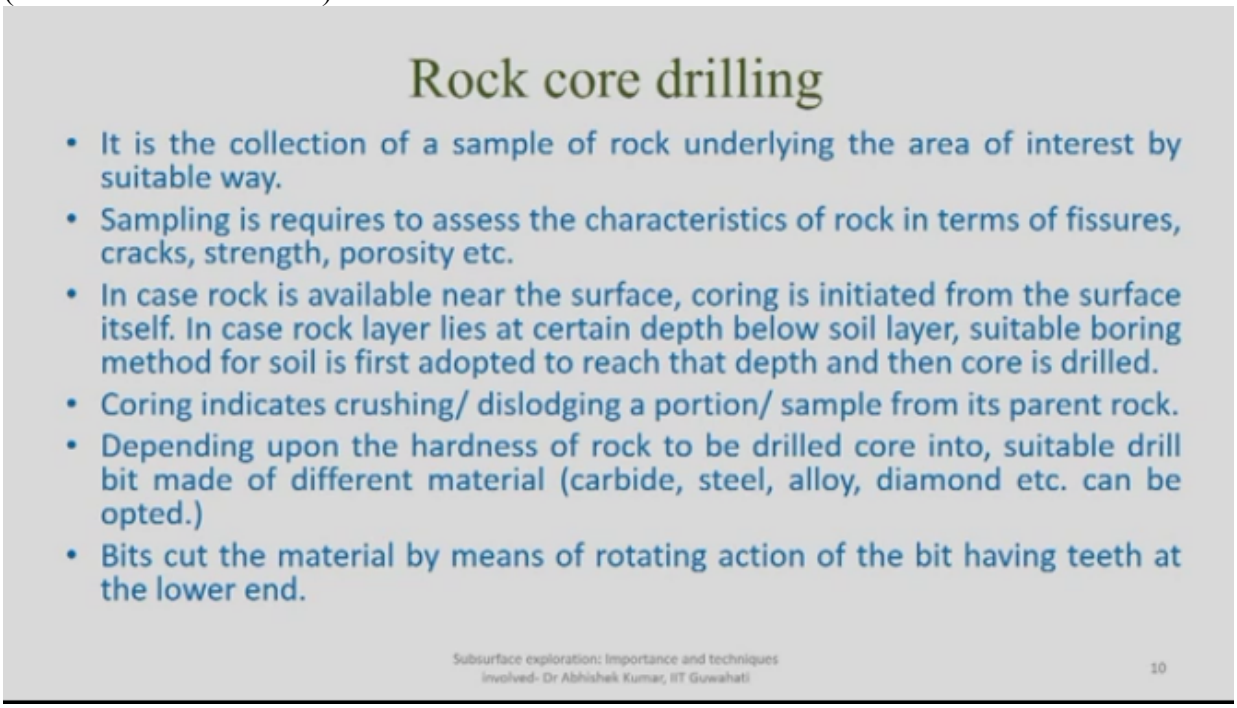

So now you know at different levels there can be possible rock which can be either of the three categories because again in the presence and time scale also whatever we see the soil layer, it is also a part of some kind of deposition and erosion, so that's how you see like sometime when they does terms also, when there is flow of water particularly during floods or during rainy season, so along with the water, along with the wind it will take away some kind of material, and on the contrary you may see at certain location that material was not there, but because of

the flow of water from that particular place, some material from upper course of the river getting deposited, so that's how you can easily understand same thing is you can clearly understand what do you mean by weathering and erosion.

Same thing if it continues for geological time scale it will lead to overall what kind of soil layer which are available at particular location at any site of interest, so now you know what are the weathering agencies, what are the deposition agencies which are responsible for different kinds of rocks available or different kind of soil available in particular region.

Now we go for rock core sampling, so what is rock core sampling? It is a process of collection of rock samples which are available underlying the area of interest by suitable way, sampling is required so that you can collect the rock which is available at that particular depth which may not be actually accessible to you in its natural condition, you bring it onto the surface and you characterize the rock in terms of fishers, in terms of cracks, in terms of its strength, in terms of its porosity also, that will define two things one is what is the media, what is the characteristics of the medium in the elements to the kind of foundation you are designing in terms of project you are targeting for, and second thing this porosity strength cracks will also define particularly in case of tunnels, how suitable is the site for that particular kind of project.

And even in case of porosity, if you are using those kinds of rock for some other purpose like for construction purpose these things will also help in understanding where the how suitable these particular material is, for any kind of concreting or aggregate use.

In case of rock is available near the surface, coring is initiate from the surface, so if this rock is available that is if outcrop is available or some kind of big area which boulder is there you can start the coring from the surface itself, so coring means some suitable way by which you are able to collect the sample of that particular rock, if it is available from the surface you can start from the surface itself, but it is, but in majority of location you see soil layer available but certainly after certain depth in majority of the location you find soil layer will be followed by rock layers.

So in case rock layer lies at certain depth below the soil layer, so even at the surface you are having soil layer, you start boring suddenly you find bore rock if you remember when we are discussing about different kinds of auger there was rock catcher, so similarly that you can use it if it is some local gravel kind of thing, but if it is continues rocky medium then you have to collect the rock sample which is not possible by means of the depth catcher, so you have to go for suitable boring method for initial soil, collection or advancing the borehole, once you reach the layer of rock then you start collecting the core of that particular row, so coring indicates scratching, dislodging a portion or even sampling of rock from its parent rock, so depending upon whether you required sample here you can go for core cutting and bringing out on to the surface and if you are already interested to know what kind of I mean qualitative assessment you can go for crashing or dislodging, dislodging means removal of it by another other means may be by chiseling, by means of breaking so that the material which is coming in between the boring exercise you can actually remove that material, once you bring it on to the surface you will be able to understand better, what kind of rock is available, but it will not give you the sample to be tested further in the laboratory.

Then depending upon the hardness of the rock to be drilled from the core end to suitable drill bits made of different material, if it is very soft you can go probably with carbide bit, bit is very much similar to drilled rod, I mean at the end of the drilled rod there will be some kind of assembly at the lower end there will be some kind of tooth, so when you start rotating your drill rod, those tooth will actually scratch the material from the periphery of the core, and finally you will get the core sample, which will be contained in the drill bit, inside that drill bit which are particularly design for collecting the rock sample, so there depending upon what kind of, what is the strength of the rock available, the hardness of the rock you can go with carbide, you can go with steel, you can go with alloy, you can go even with diamond bits also, of course as the name suggest diamonds, so that means you can only use it because it's very costly also, so but you can use it in case of very hard like granite medium, you can wear other drill bits may not work you can go with diamond drill bits for collecting the sample of coring it.

Bits cut the material by means of rotating action, if I mean lot of drill bits are available on I mean hardware shops also, people who are interested you can actually go there and find out what kind of drill bits people are supplying, not routine hardware shop but maybe more advanced where people particularly, the agencies which are responsible for drilling and coring, they can collect it from there, so this is the drilled rod which actually goes to the depth at which rock sample is available then there will be drilled bit which is attached at the bottom most layer, then you put the drilled bit, that tooth phase on the phase of the rock then you start rotating so it will scratch from the periphery and then once the material is scratch, your drilled rod will be lower and so the same process will be continued for deeper depth, and once you reach desired depth you will actually bring the material onto the surface, so that's called as core.

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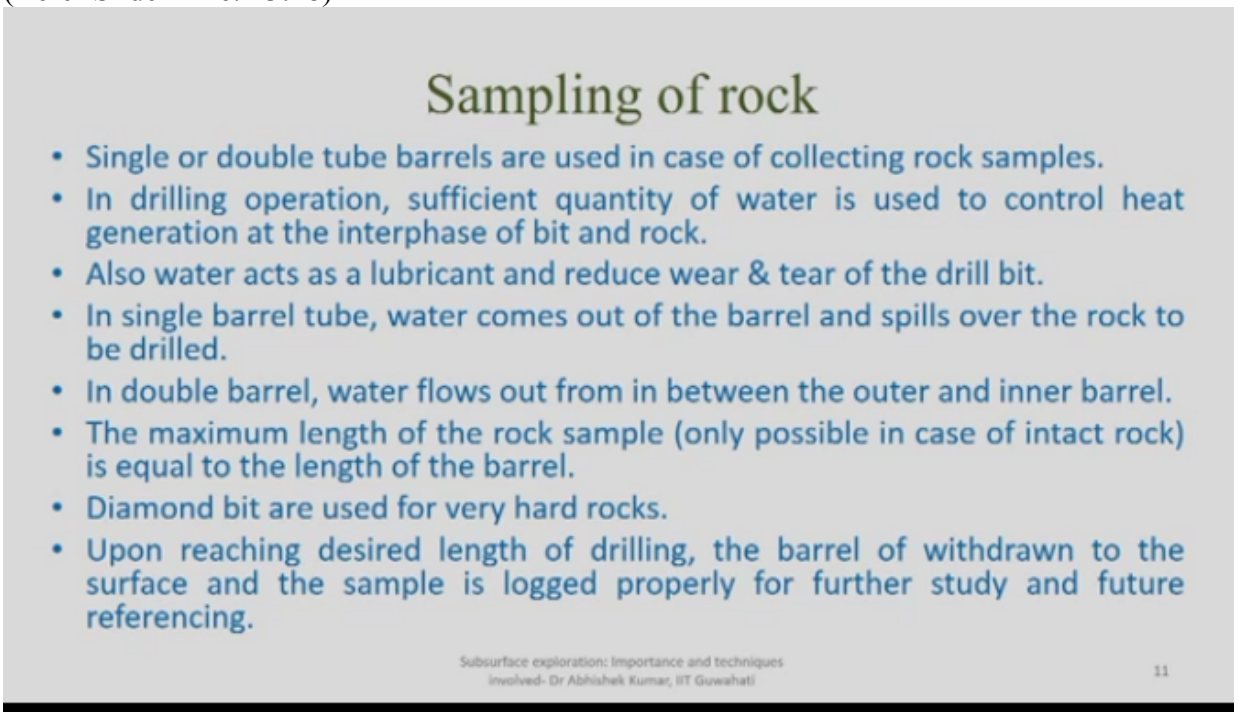

Sampling of the rock, so you can go for double or single barrel or double tube barrel, it can be used for collecting the rock samples. In drilling operations sufficient quantity of water will be required because as the drill bit is rotating lot of heat will be generated, so in order to ensure that heat is will not cause any problem or hindrance in the operation and also to minimize the wear and tear off both sample as well as the drill bit, so water will act as a lubricant, and it will reduce the wear and tear of the drill bit, so it can be used and sufficient quantity of water, so water you have to continuously flow some kind of water there which will reduce or control the heat generated at the interface of the drill bit and the log, and the second one it will be used as lubricant and reduce the wear and tear of the drill bit, so that's why water will be always circulated through it.

In order to circulate the water there will be single barrel, so in single barrel from the single, the only tube available water will be pass through the drill bit, and then the same thing will continue, if you are going with double tube barrel water will be transferred to the one tube and the inner tube will collect the rock sample, so as mentioned in double barrel water comes out the barrel and split over the rock because drill is the test to the bottom so water comes out through this drill bit and spread on to the rock sample, in case of double barrel water flows out in between the outer and the inner barrel, and the inside barrel will contained the rock sample, so the maximum depth of rock sample what you can actually take out depends upon what is the length of the barrel, maybe we're talking about two barrel or three barrel, so these barrels will be used at the bottom most layer whenever you are collecting some rock sample, so whatever is the length of the barrel you can go for, that is the maximum length of the core you can actually drill.

As I mentioned earlier also drilled bit you can only use, you can use particularly for very hard medium because if medium is soften, then you can go for other kinds of drill bits which maybe not be I mean diamond bit may not be require, upon reaching desired depth of drilling the barrel of the, will be withdrawn on to the surface and the sample is logged properly, so you are bringing as I told about soil also, at different different depth you will be having different rocks, soils, same as with the soil, so it's in the rock, so it's not like whatever soil you are encountering maybe at 5 meter and after 5 meter till 30 meter if rock is only available it may not be mandatory like for entire 15 meter you will find same kind of rock, so you have to collect the soil sample and it may be possible because of the fishers, may be because of cracks, may be because of some disturbance caused by mechanical drilling operation, the rock core sample may break in between, so what I mean to say here whenever you bring or whenever you withdraw the barrel on to the surface because of the, because of the cracks available in natural condition, because it was created by drilling operation, entire core will not come so that's why you have to lower the barrel again and again and bring it on to the surface.

And then finally you will logged it properly, whatever sample you are collecting you will logged it, you will store it properly what depth you had collected, what was the borehole number, what was the depth from which it is collecting, and what time it is collected,
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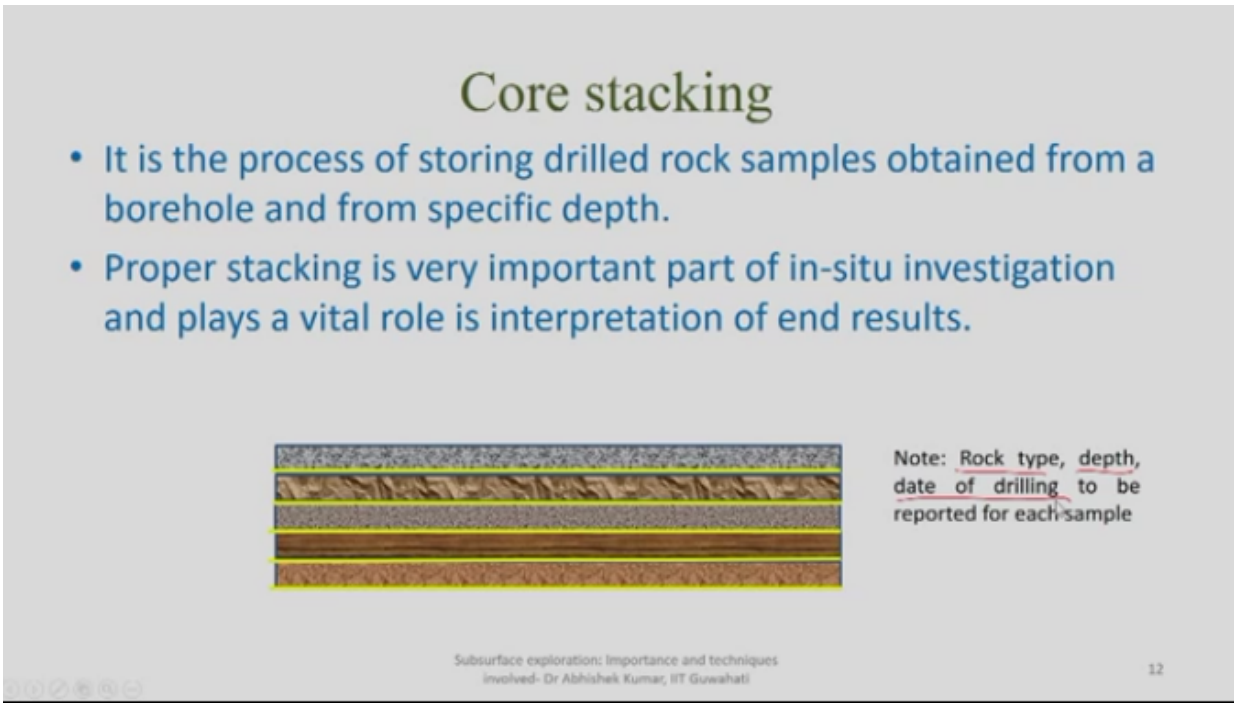

so you can see here the core stacking, you can see in this picture, you can see at different different depths you had collected rock samples, so on this you will actually write what is the rock type, what is the depth from which it is connected and drilled, date of drilling when you started drilling, when you collected the soil samples, so you will actually write here rock type 1, rock type 1 and here 2, 3, it may be possible like you are having more,

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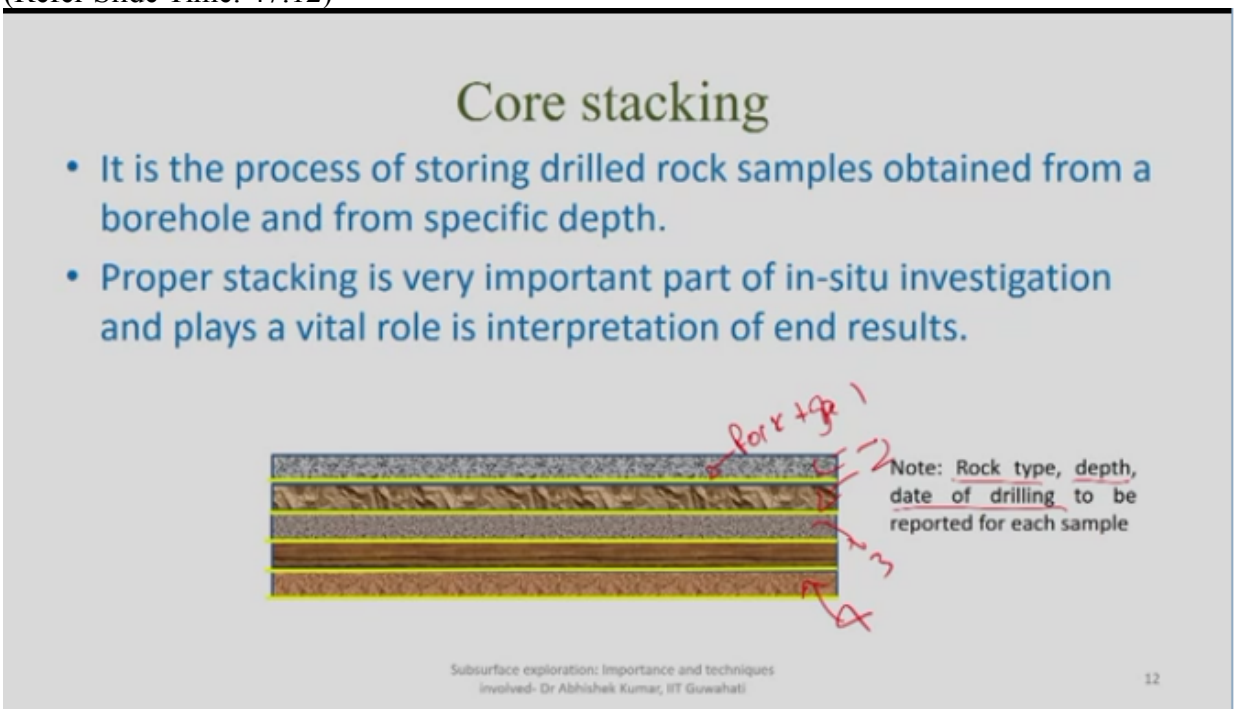

and then I have shown here very intact rock there maybe possibility, there will be some kind of cracks here which will not, which will not able to get you entire core sample at one instant but

there will be some kind of broken material between this because of its natural condition or it may be because of some kind of drilling operation, some crack has developed on the core.

So proper stacking is very important because finally you will collect those sample and you will get to know what kind of rock is available at different, different depths, so this rock information along with the soil information will actually give you overall idea like this is my site of interest, so at this particular layer what kind of soil were there, type of soil and then type of rocks, and considering this is your, entire thing is your shown of influences,
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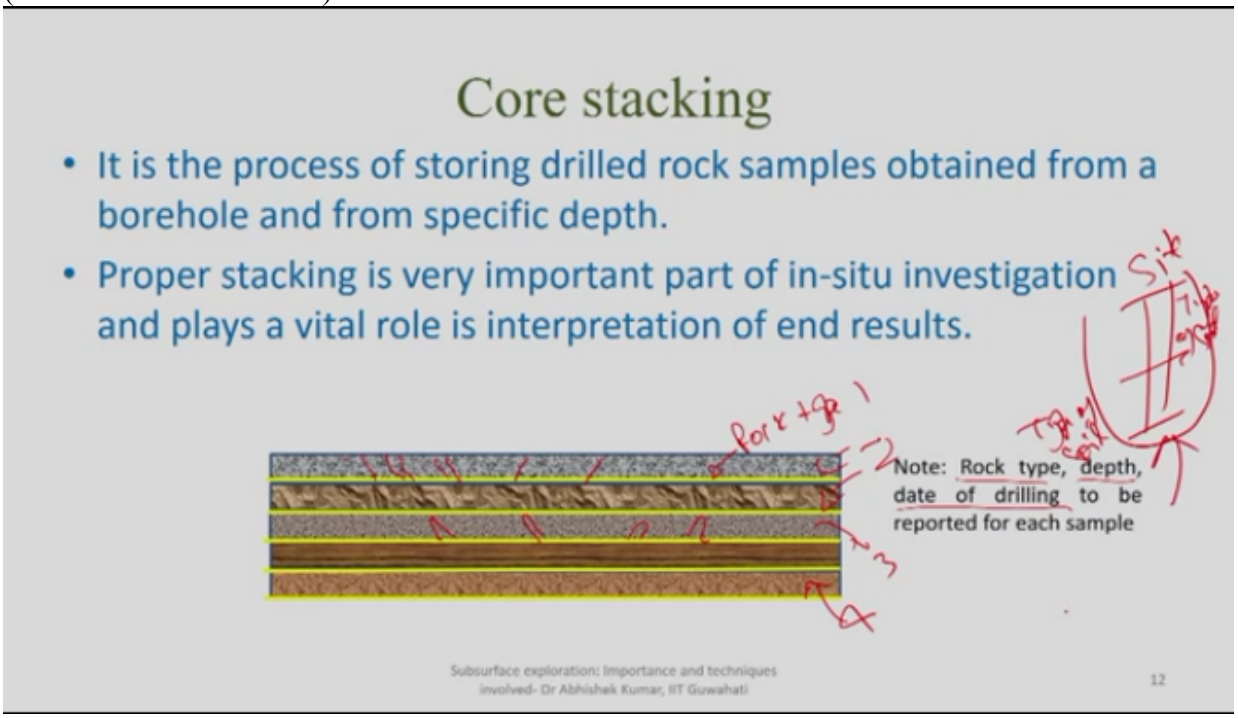

so this entire will control your behavior of foundation, whether in terms of bearing capacity, whether in terms of settlement, okay.

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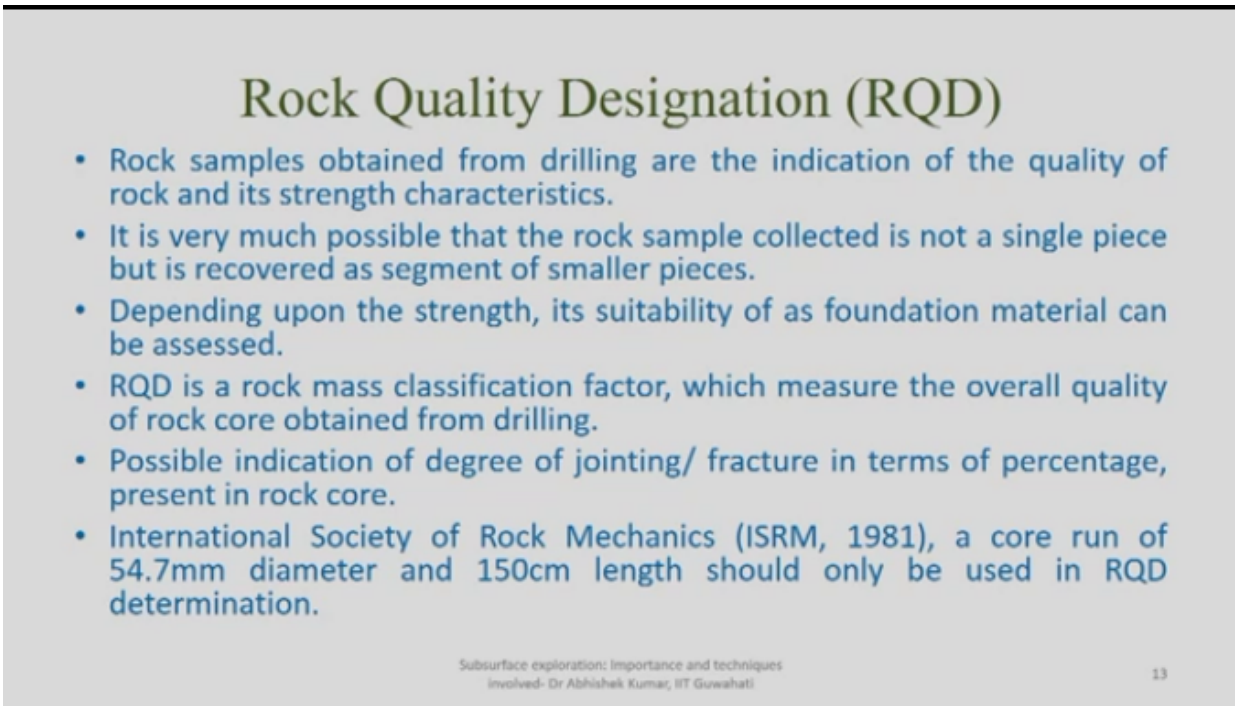

Then we had collected the sample of rock, but how you assess whether the sample is good, whether the sample is bad or so and so forth, so generally we use rock quality designation, rock quality designation will give you an indication depending upon the core information what kind of rock is available whether you can classify rock is very good, whether you can call it as very poor, whether you can call it as fair, excellent and so on and so forth, so this is very important term when you are particularly dealing with rock samples, it's called a rock quality designations so rock samples obtained from drilling are the indication of the quality of rock and its strength characteristics, it is very much possible that the rock sample you are collected it may not come in single piece, but it is recovered as a segment of small pieces, that's what I told in the rock core and stacking, you may get continuous same sample depending upon the length of the barrel or you may get into pieces, you may get some intact piece in between there was small smaller boulders, so all possibilities are there once you collect those samples, so how you will get an idea overall, what kind of soil, what kind of, how will you classify that particular rock, so depending upon its strength because you have, once you classify that will give you what is the idea about strength, what it is suitability over a particular kind of material, foundation material or maybe as construction material.

So RQD is rock mass classification factor, so they are different factor based on which you can actually assess the quality or the strength of the rock which will give you understanding about how suitable that particular medium in the light of bearing capacity, settlement, construction practice or even permeable, impermeability kind of thing, so possible indication of RQD will also give you possible indication of degree of jointing, fracture, in terms of percentage present in the rock core, so whatever rock core you have actually drilled out by means of drill bit and barrel, RQD will help me in understanding what is the fracture, what is the degree of jointing available.

So international society of rock mechanics ISRM in 1981 suggested, you can go for rock core of 54.7mm diameter and 150 centimeter length that will be the rock core, should be used for RQD determination, so how you determine RQD? Suppose you collected a some rock sample from a particular site, you brought it on to the surface so you will be having different kind of, yeah,

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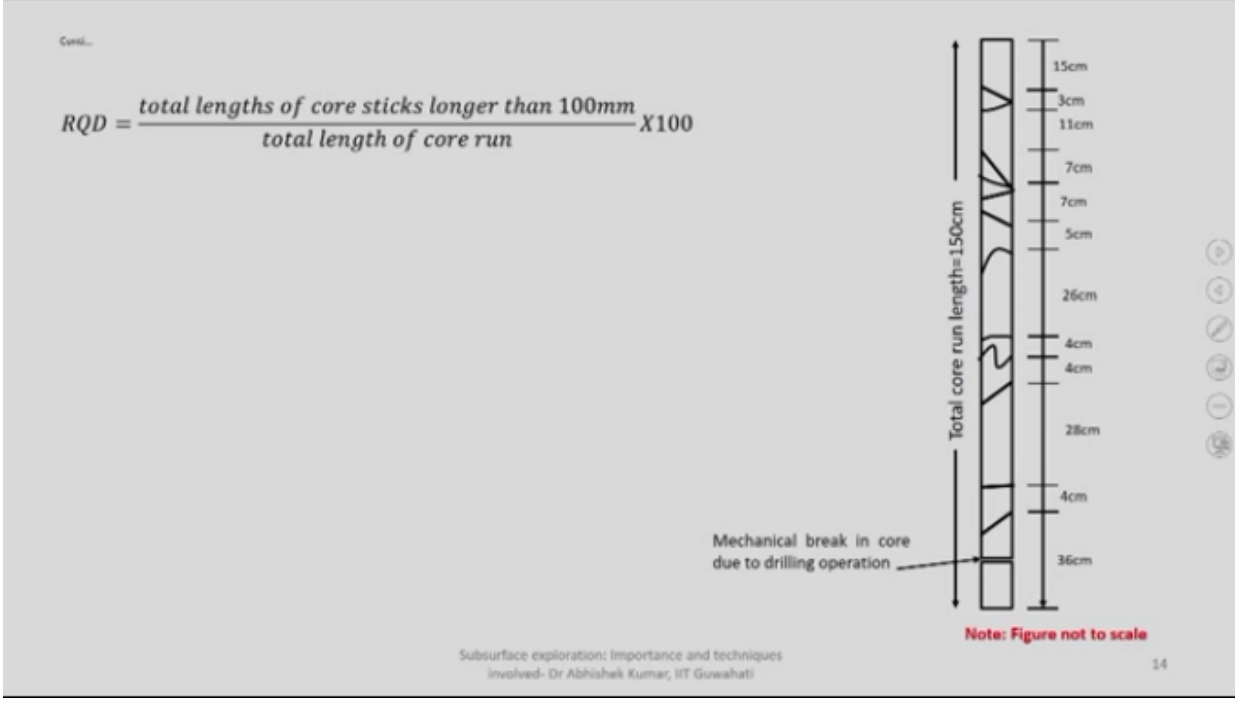

this is you can consider this entire rock core as 150 centimeter is that total length of the core you had actually drilled and brought it on to the surface.

Now you can see here because of mechanical vibration, because of drilling, it was shaking and then it broke this core, but overall this is having some kind of discontinuities or cracks here, here are different, different segments which is actually available in its natural condition below the ground level.

So what RQD will tell you the total length of all course which are greater than 100mm or 10 centimeter, so here based on the core stacking at the surface you can measure actually what is the different, different length of each of this course, between each kind of natural breaking or discontinuity available, this one we will consider as intact part of the core because it has happened because of mechanical breaking or drilling operation, it was not there in natural conditions, so this entire core will not split into two part, it will consider as single core, or single length of core stack.

Now here you consider different lengths are also given here, and starting from the top surface to the bottom you can see here some are 15 centimeter, intact rocks, then there are 3 centimeter because small portion of rock came out, then 7 centimeter, 5 centimeter, 26, so this is again, remember this figure is not to the scale so 36 centimeter and 7 centimeter may not found proportionate to each other, but overall this is the length of the core you were trying to

understand, so in order to determine RQD you will count, how many number of codes are there which are having length of 10 centimeter or more than that, you can see there is 15 centimeter, then 11 centimeter, and 26, 28, and 36 centimeter,
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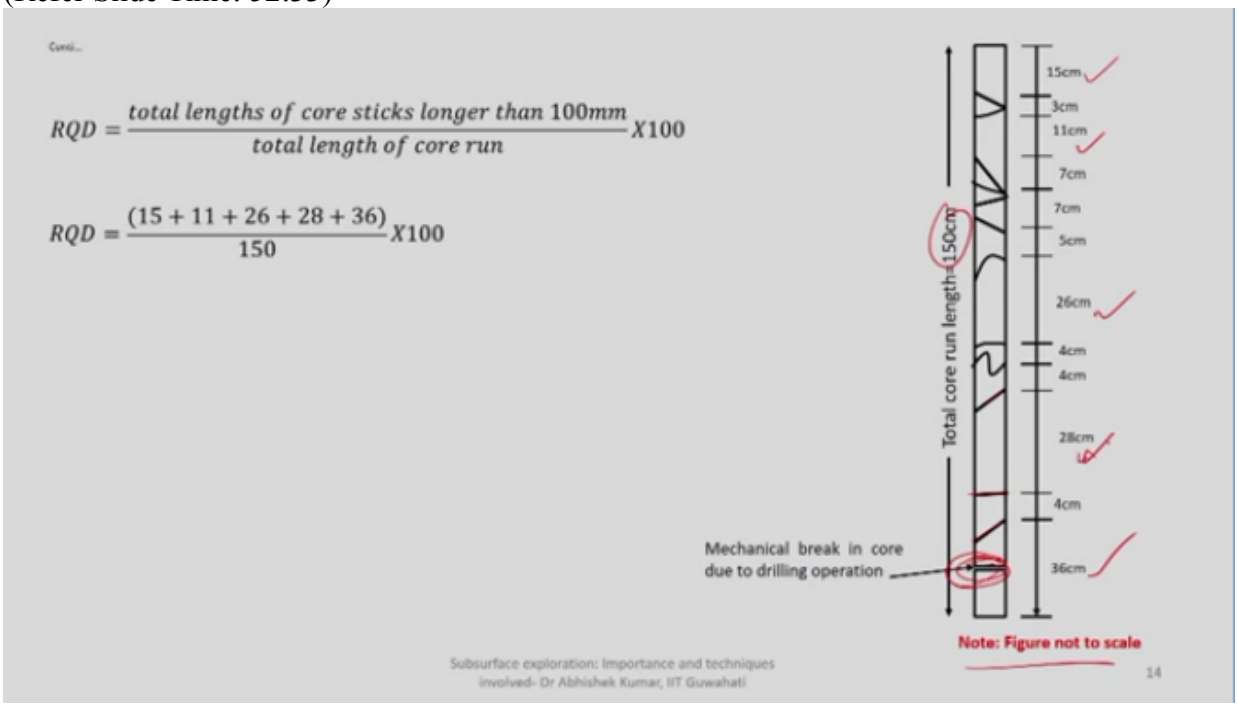

so all those are the cores which are greater than 10 centimeter length individually, you sum it up then divided with the total length of the core that is 150 centimeter, that will give you what will be the value of RQD, it's like 77.33% is your RQD of the rock sample.

Same you can get, you can determine for each and every kind of rock sample, rock core you are determining from different, different depths, so once you know RQD you can actually classify the rock, these RQD's varying from 0 to 25 you will say it is very poor rock,
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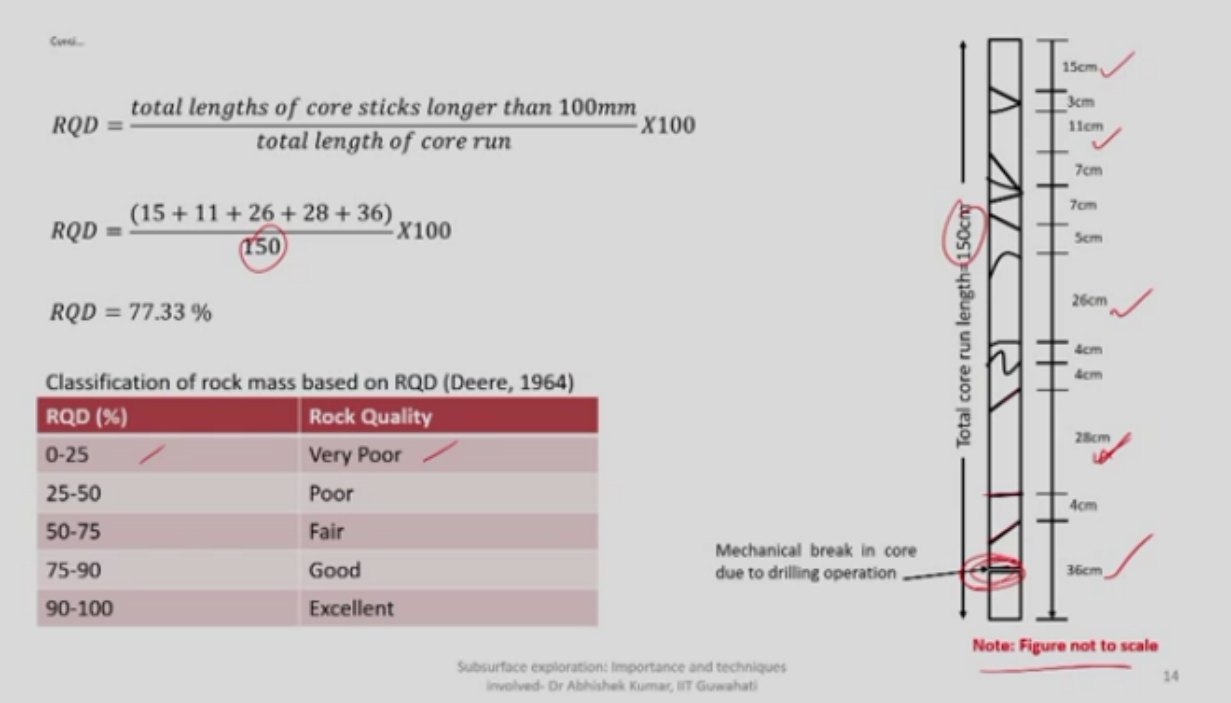

so as suggested here also 0 to 25 means majority of the rock core will consist of small, small fragment, so none of them because it is intact or in smaller, longer length so it will be considered highly weathered rock kind of thing.

Then 25 to 50 you can call it as poor like slightly better but still the RQD is too less to be call it as good, then 50 to 70 it will be called as fair, 70 to 90 you call it as good rock, and if it is 90 to 100 you call it excellent rock, considering the foundation material, considering it for bearing capacity or other property determination, because finally it is available beneath the ground surface, so finally your load has to come here, so in order to classify whether it is suitable for any kind of purpose you have to determine RQD, so as we have calculated here as for this Deere, 1964 this can be classified this core which is shown here it will be classified as good rock.

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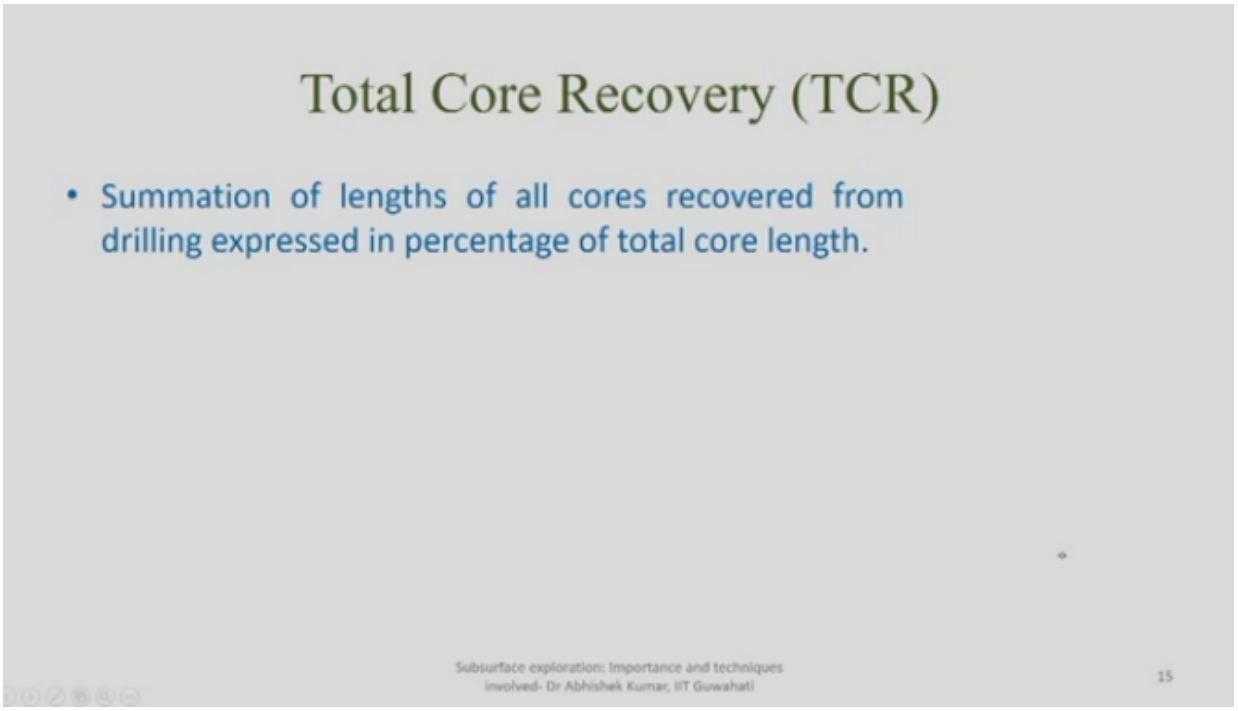

Same way you can go with total core recovery that will give you an indication like overall when you started collecting the core from a particular level, what percentage of core actually you can recover, you could recover? To give you an example like so this is how you define total core recoveries like total length of core even small, small pieces, how many cores you could recover?

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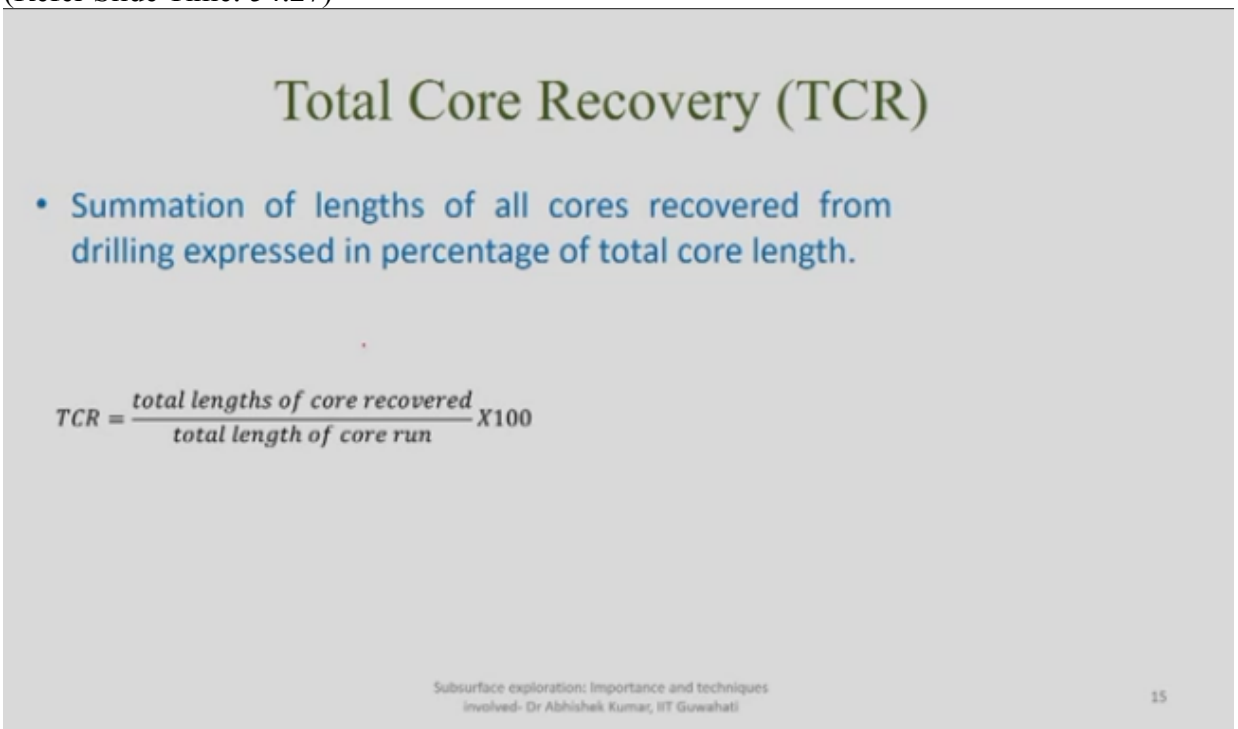

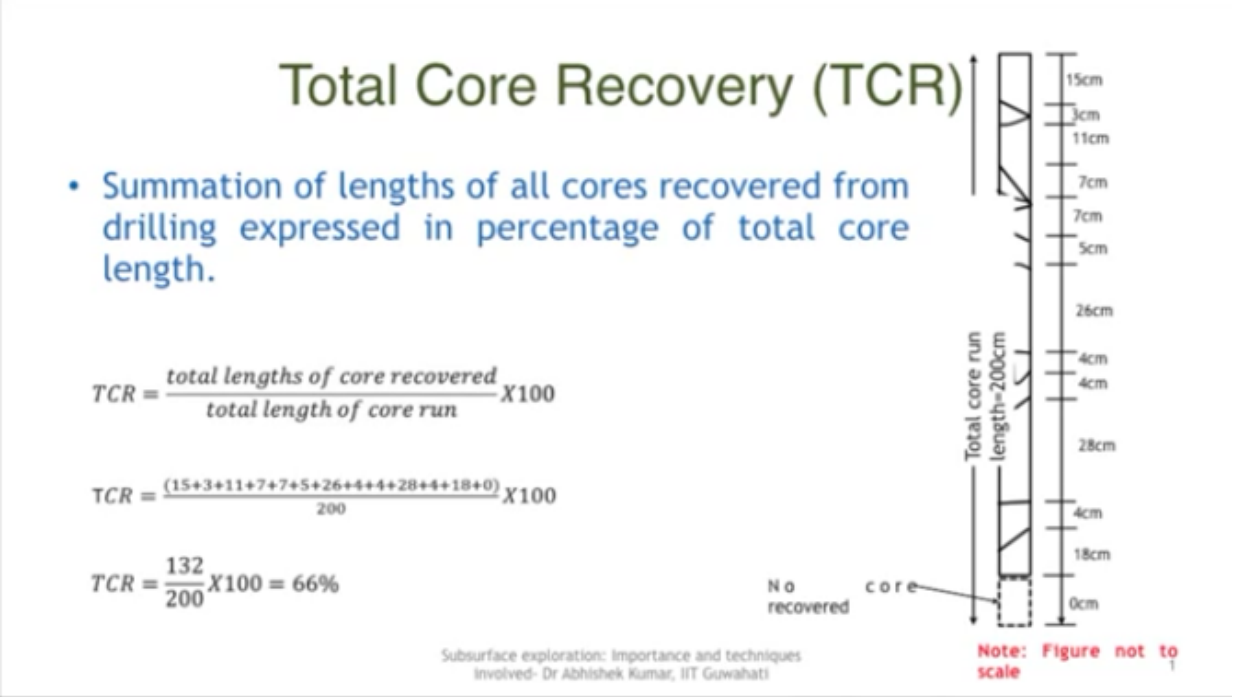

It may be possible you put your barrel for diameter but you may not find any kind of core or it's like two weather rock which may not be available once you brought into the surface, so no core recovered, that will affect, what is the total core recovery? So you have different, different segment, but here in the lower most segment you say there is no recovery, it is less than, so whatever you have recovered, so this is again called as total length of the recovered, so what you will do? Whatever core you have recovered even small, small pieces you will sum up here, and then you will determine what will be the total core recovery, so you can see here 66% core has been recovered, this portion cannot be recovered so you can determine summation of all these parameter that will give you what is the length of the core which could not be recovered whether it was too crushed material, too weathered material which cannot be recovered, so it is like 66% is the total core recovery.

So this is overall, I mean today's class it gives you broader picture what I tried to show here, it's like what are the different kinds of rocks which possibly maybe available at different, different medium, it can be sedimentary, it can be igneous, it can be metamorphic also, because agencies, lot of agencies are involved which are actually governing the processes helping in overall development or origin of the rocks or transformation of the rocks, and such rocks once available at different, different depth, how you collect the sample, how you interpret the sample of the rocks.

So in more classes we will be discussing more interpretation particularly in case of rocks as well as soil, so this is overall, so that's how you can get an idea quantitative assessment about whatever core you have recovered, two important things are there one is determination of RQD and second one as I mentioned here stacking, because if you do not do proper stacking you may find very good RQD, but if you are not reported it properly you will end up in reporting it at very deeper depth which maybe at lower depth of your zone of influence or outside of your

zone of influence, so that will not be proper interpretation, that will not be proper use of outcome of in-situ investigation.

So as important it is to collect the sample, same importance, equally important it is to store it properly so that you can interpret the data equally, so this is about today's class. Thank you very much.

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