Elements of Ocean Engineering
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Lecture - 4
Physical Oceanography - IV

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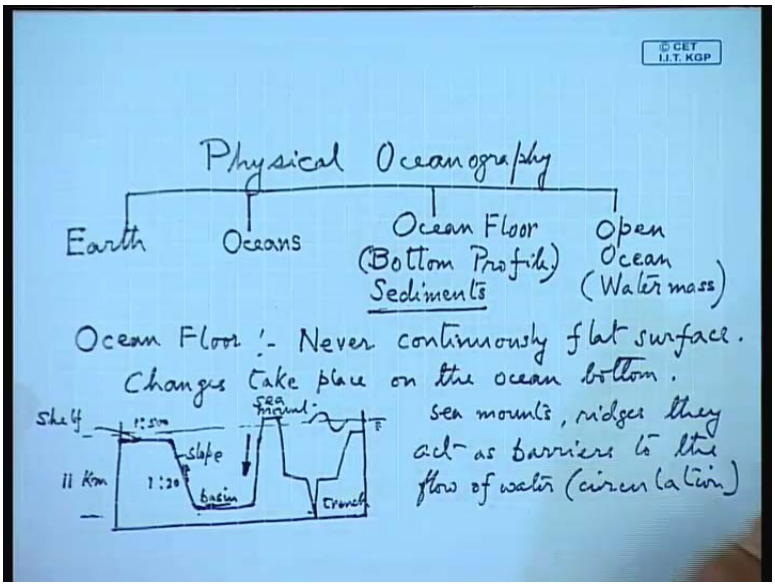

So, welcome to the lecture on physical oceanography that is part 4. So, I have already discussed the earth and the oceans, that is the landmass and the different water bodies. So, today we will discuss more about the oceans sediments. So, physical oceanography, we can divide it into four parts. So, for our discussion let us divide physical oceanography into four parts. So, the first one which we have already discussed is the earth, that is the continents of the earth, the ocean crust. How it is formed, this we have already discussed. So, this and the next is the water mass that is Atlantic Ocean, the Pacific Ocean and the Indian Ocean.

So, these are the basic oceans which we have discussed in the last class. So, this constitutes oceans. Now, today most of the time I will speak about sediments which constitute the oceans floor. So, oceans floor that we have already discussed that it consists of the continental shelf, then slope, then ocean basin, ridges, trenches and all that. So, these basically make up what is called the bottom profile now. So, these are the

bottom features of the ocean floor and the sediments of the constituents. Sediments occupy a large portion of the ocean floor.

So, today we will discuss the nature of these sediments and in later classes, we will go and discuss what is the open ocean, that is the water mass. So, what is the circulation pattern of these water mass waves, the heat budget and also the light etcetera, insulation and all these things? So, these are discussed under the subtitle called Open Ocean. Now, coming to the ocean floor, so the bottom profile we have already discussed. That means the ocean floor is essentially never flat.

So, in the last class we have said that this is never flat, or we can write never continuously flat surface. So, this has to be borne in mind and as a result of this, there is a circulation and changes in the, lot of changes takes place on the bottom features or rather let us write ocean bottom. So, we have already discussed, that is the bottom profile actually consists of the continental. Let us start by the continental slope. So, this is continental shelf and then comes the continental slope, then the lowest part of the seafloor that is called the ocean basin and next, we have the ridges or seamounts.

So, this literally, they can go beyond the water surface and then you have trenches. So, these are going in to depths of the ocean and then again we come across this. So, if this is what sea level, then this is the bottom features. So, this part is called the shelf, then this is our slope and the lowest part is called the basin, and this is a seamount or a ridge and then we have trench etcetera. So, these are some of the prominent features of the ocean bottom.

Now, here we can see that the slope has the minimum depth. So, most of the offshore activity takes place along the shelves, a slope. Actually, this slope is 1 is to 500 on the shelf and on the slope, it is a 1 is to 20. So, this slope with the gradient is quite large. So, in this region, actually the offshore structures cannot be located especially in this region and of course, the basin is very large in depth. So, here we can see the depth can be as I as say 10 kilometers or 11 kilometers, that is the largest depth on the trench.

So, here actually the water mass now in the sea level that is on the surface, we can see the waves. So, waves normally occur wherever there is a difference in the density of the two media. So, here we have air and this water. So, here obviously there will be waves. Now, waves do not occur to large to greater depths. So, as one goes down below the

surface, obviously there is no wave. So, because there is hardly any change in the density, but the circulation also takes place vertically because of slight changes in the density of occurring because of the difference in the pressure. So, circulation can takes take place in this fashion. So, here we can see that this seamount or this iron, whatever it is, is obstructing this flow in the basin.

So, these seamounts or the ridges, sometimes these are called ridges, they act as barriers to the circulation pattern or we can write to the flow of water, that is the circulation.So, this is to be noted that the circulation, there are barriers because of this. Now, coming to one of the features of ocean floor, of course I have not started talking about. So, this constitutes your ocean floor that is the bottom profile. Now, next coming to the sediments. The sediments are constitutes which make up the soil on the ocean.

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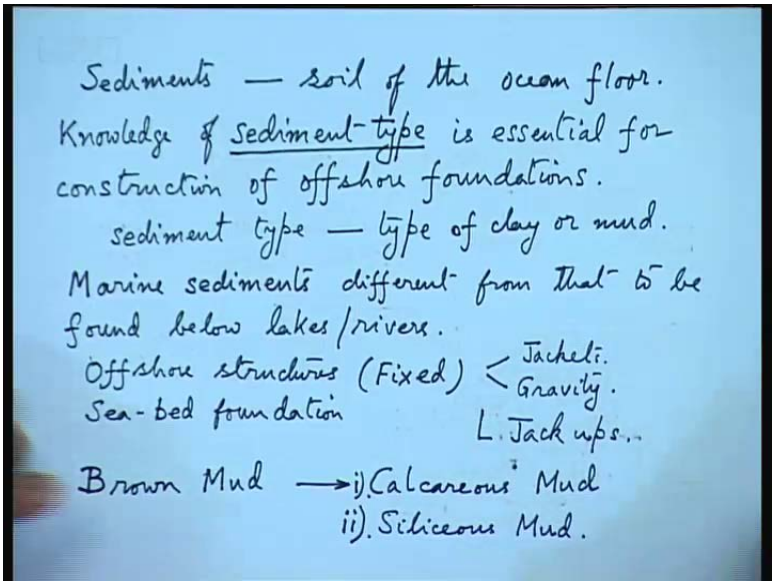

So, sediments are the soil of the ocean or rather we can write of the ocean floor. Now, obviously even one has to construct any engineering structure which has connection with the ocean bottom. So, this is our ocean bottom and one has to make an ocean structure which is piled or having foundation on the ocean bed. Then the knowledge of the sediments is of utmost important. So, knowledge of sediment type. So, this is very important. There is a type of sediments. So, this sediment type is essential for construction of offshore foundations. So, offshore foundations you will find, that means

those structures which have leagues of connections with the ocean floor. They are not floating structures, but they are found on the ocean bed.

So, now these types of structures if one has to make, an offshore foundation, then of course the sediment type has to be analyzed, that is the type of sediments, what type of mud. So, the sediment type means type of clay or mud. Essentially this is based on to this in the layman's language. So, type of clay or mud. So, this has to be analyzed. So, what is the bearing capacity, what is the fictional register, what is the co-efficient? So, all these things they have to be studied from the type of sediments. So, actually marine sediments, they are somewhat different from land sediments or sediments that we normally found on the river bed.

So, marine sediments are different from that to be found below lakes or rivers because of the nature of ocean. Ocean is actually a collection point for the various sediments. It is sort of a sink for your various sediments which are being collected from the land, from the rivers, lakes, glaciers and so on. So, these sediments are different from those you will normally find just below the lakes and rivers. So, one has to carefully analyze the type of sediments before one goes to do the structure rivers or the design of the foundation of the offshore structure.

So, offshore structure, mainly I have told you there are structures which are found on the seabed or ocean bottom, say they are mainly your coastal structure, offshore structures. I am writing in brackets. This is the fixed type. They are called fixed type of platforms. So, these are mainly your jackets type of platform and you have the gravity platform.

So, these two types of platforms, they are foundation on the seabed or ocean bed. So, one has to be very careful when designing the foundation of jacket platforms and gravity platforms or gravity structure. Another type you come to know this already is also called jack ups which also have their support from the seabed in when they (()) bar, of course when they are being throughout or when they are transported there in the floating mode. So, these basically, these three types of platforms, there may offshore seabed foundations.

So, a careful analysis has to be made of this soil type for this foundation before one embarks on the foundation design of these structures and of course, based on the foundation design, the other parts will be designed. Now, coming to the sediments, I

have told you that sediment types are like this clay or mud. So, we will come across brown mud. Now, this brown mud, the mud you will find, they are of three varieties. So, let us write this brown mud.

So, first one you have calcareous. There are two major divisions of brown mud. One is called the calcareous. Calcareous means basically calcium carbonate. So, these are called calcareous mud and the other type, you will find this is called the major types are siliceous calcareous and siliceous mud. These two types of mud are quite predominant and of course, in the siliceous, you will have the divisions. So, in the last class I have given the breakdown of all these calcareous and siliceous mud. So, brown mud, sorry brown mud is calcareous and siliceous.

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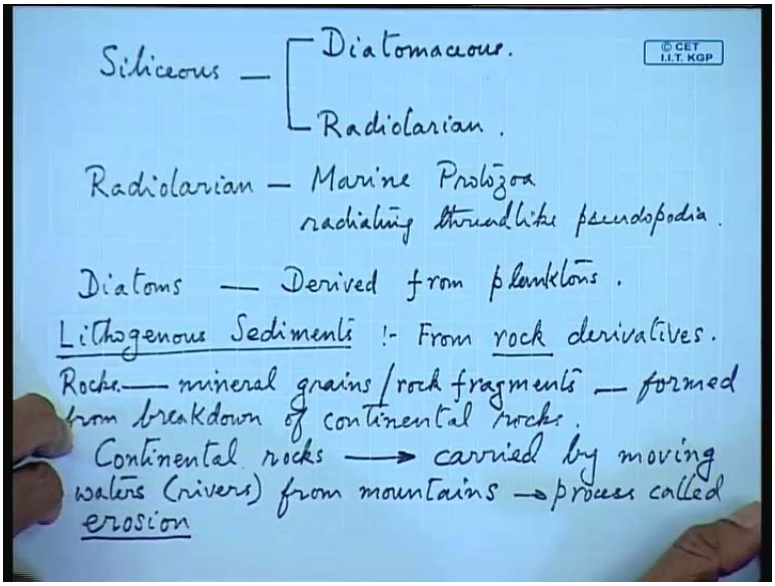

Now, brown mud will be different. Anyway, this division in the last class I have told you. Now is the siliceous. There are two times siliceous consists of diatoms. So, in the last class this was discussed whatever diatom. So, this is diatomaceous and the other one is called radiolarian. So, these types I have discussed that is radiolarian. Now, radiolarian comes from the word radiolaria. So, radiolarian means small marine protozoa. So, in the last class we have talked about small protozoa we are radiating thread like pseudopodia.

So, here the brown, of course the brown mud I think they are actually three types. In the last class we have said the brown mud is one type. Then let us make this two. This is calcareous mud and this is small correction. Then this can also be siliceous. Now,

calcareous occurs in mainly calcium carbonate and then we have the siliceous. Under the siliceous varieties, we have diatomaceous and radiolarian, radiolarian consists of marine protozoa or radiating threadlike pseudopodia and the diatomaceous consist of diatoms. Diatomaceous small consist of diatoms. So, these are derived from planktons. So, rather three types of mud we have discussed in the last class that is the brown mud, calcareous mud and the siliceous mud.

Now, in this class, we will discuss more about the other variety that is your lithogenous sediment. Now, lithogenous means it has come from this word from these are the essentially rock derivatives. So, these are the lithogenous varieties. Now, wherever you find this rock, obviously this is going to be a very hard type of sediment. So, this is your, it gives a lot of bearing support to your offshore structure. So, these are called rock derivatives. Now, the rocks, of course there are various types and sizes of these rocks, but essentially these are mineral grains.

So, rocks are mineral grains or rock fragments. Now, these are formed from breakdown of continental rocks. Continental rocks, all these rocks are broken down. So, continental rocks are broken down by the action of moving water. Continental rocks, these are carried by moving water somewhere. So, moving water is basically your rivers carried by moving water that your rivers from mountains. So, obviously, in the mountains you will find rocks and wherever in the mountains, you will find glaciers or rivers. So, they carry these rocks onto the sea.

So, this process is called erosion. So, this is to be remembered. So, this always occurs, it is your continuous occurring process of erosion. Now, as a result of this that is the transport of this continental rocks from the mountains by the rivers into the sea, we have large particles. The segregation of the particles are done because by the flow of rivers passing from the shore into the continental shelf. So, large particles.

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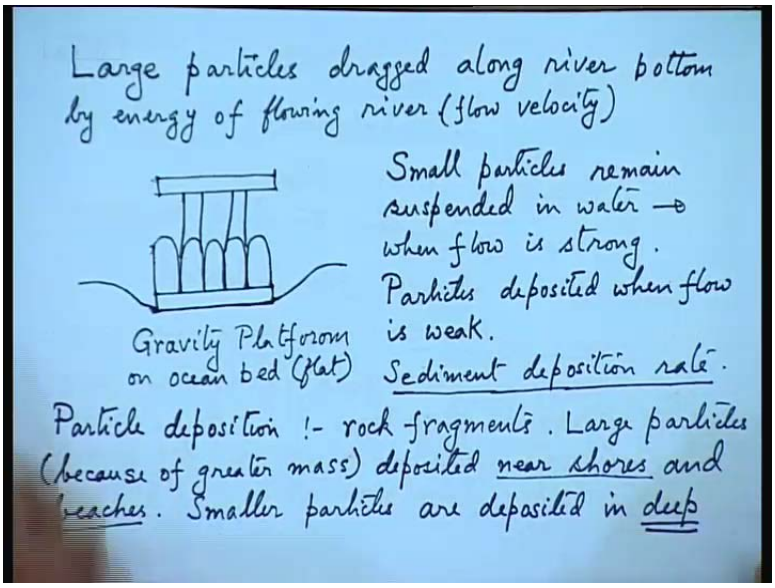

Now, obviously the rock varieties that I was talking about, they are not of a single size. There we have large size, small size and very small size. You will find those are called the sand particles and also, there we have number of types of sand. Coarse sand, fine sand, etcetera and all these things. Now, if one has to study the mechanics have what these large particles; obviously, the large particles will have the mass will be large. There is a large mass.

So, these are never floating or suspended in the water. So, they will try to settle down. So, large particles are dragged along the river bottom. So, they are to be dragged along river bottom by energy of flowing rivers. So, large particles are to be found mostly in the coast. You will find there because of the larger mass they are, then the movement of these particles, movement of these rocks will be very slow because of the larger mass and when the river flow increases, they will try to go towards the outer shelf.

So, these are the mechanics which may come and you will find large particles dragged on along the river bottom by energy of flowing river. Now, talking about the marine foundation, these large sorts of rock particles you will find wherever the gravity platform, especially the gravity platform has to be sighted then these huge rock particles large what particles have to be removed from that sight because the gravity platform or concrete platform has a flat base. So, here just for your convenience say this is are gravity platform.

So, we will talk about these different types of platforms later on. So, this is the kaizon of the platform and if this has to be sighted, then one has to make a base for this. So, these are the columns and these are the kaizons. So, this is you have gravity platform. So, here this diagram you can see that this region is supposed to be flat. So, normally there should not be large rock particles, otherwise this gravity platform cannot be sighted or cannot be located on the ocean bed. So, this is a type of platform which is called a gravity platform on ocean bed and here the ocean bed has to be flat. So, this has to be emphasized that they should not be, we need hard particles or hard-rocks to be found on the ocean bed otherwise the bottom sphere.

So, large particles dragged along river bottom and finally, they usually find where the mouth of the river by energy of the flowing river, that is your flow velocity. So, here we can write this is our flow velocity. So, this is the transport of the large rock particles towards the sea. Now, what happened to these small particles? Now these small particles actually they are in the river. So, they are also flowing with the water. So, they are not having sufficient time to settle. So, small particles, they remain suspended. So, that means, these small particles are basically carried away by the flow.

They are not being deposited on the river bed, but they have been carried away by the flow of the water. So, small particles, they remain suspended in water. Now, this happens when flow is strong. That means the velocity of the water, velocity of the river is quite sufficient to carry these small particles if there is no flow. That means, these small particles tries to settle on riverbed. So, this is one can observe just take sand, very fine sand. You take a bigger and you find that it is over a large period of time, it is settling. So, that means one has to purify the river water. First thing that we do is the purification is done.

We take the river water or settling tank and there of course the water remains for a large time, and the mud are this small rock fragments settles at the bottom. So, basically in the settling tend, there is no flow velocity, but here you will find in that river, there is a flow velocity and these small particles are carried away. So, this is suspended in the water and they slowly carry them away.

Now, when the wind slow that is particles are deposited. Here particle means the rock fragments. So, particles are deposited when flow is weak. Now, here that means, we are

making some kind of a general study, but actually if one has to study this in detail, one has to know the mechanics of the sediment deposition. This is called sediment deposition rate. This is very important. Sediment deposition rate is if one has to design harbor or navigation channel for a ship.

So, we should see that the harbor does not get choked or the navigation channel does not get clogged over a passage of time. So, here one has to calculate the sediment deposition rate. Now, this of course comes from complex mathematical formula. Of course, you have disk laws. We cannot cover this. This one has to study. So, right now we are interested in this that is the small particles. They remain suspended in the water and they are carried away when the flow is strong, and particles are deposited when the flow is weak.

Now, let us try to see what happened at the continental shelf. So, our main purpose is to see the ocean bottom and what changes are taking place on the continental shelf slope and the ocean bottom. So, this is particle deposition. So, essentially we have termed that these are rock fragments and we have found out that large particles. Now, this is to be noted large particles because of greater weight on mass. Now, what happens to these large particles is that they are deposited near shores and beaches. So, these are deposited near shores and beaches.

So, that means, they always try to settle as quickly as possible. So, once the flow becomes weak, these large particles at once they go down because they have a larger weight, larger gravitational force. So, they come down and quickly settle down at the bottom. Now, the large particles are to be found more near the shores and beaches. Now, these smaller particles. So, smaller particles we have said in our previous lecture that they remain suspended in the water because of this. The smaller particles are deposited in deep waters. So, that means deep water is beyond the continental shelf region.

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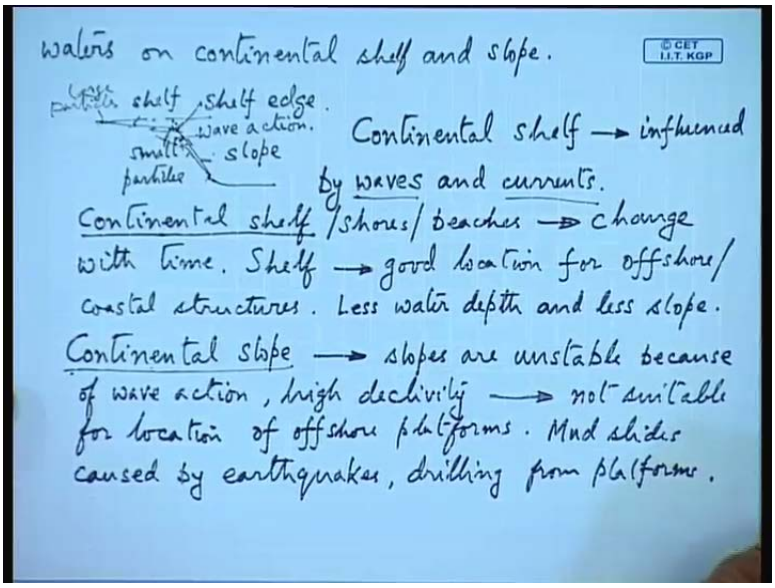

So, largely you will find the waters beyond some in continental shelf, we can write on continental shelf and slope. So, one finds the bigger, large, the larger rocks near the coast, near the shoreline, but you go further away from the shore line. So, this is the continental shelf and this is the slope. So, near these large particles will come, large particles are to be found and it goes more and more deeper into the waters towards this point is called shelf edge, and this is our slope and this is the shelf. So, large particles you will find here and smaller particle you will find arise on the more upwards towards the shelf and near the slope. So, here one finds the small particles. So, this one should remember.

Now, this part of the shelf. This is the continental shelf and is influenced by what? Continental shelf is influenced very much by wave action, influenced by waves and currents. So, especially in this region, you will find lot of wave action occurs on the shelf. So, shelf and to some extent the slope in this region also lot of wave action takes place.

Now, because of this part of the shelf on the slope and the shelf edge, they are influenced by waves and currents and there the profile changes because of this. So, continental shelf and the shores, beaches change with time because of wave action. So, that means, these are dynamic situation that is you will never find the length of the beach or length of the shore or the extent of the shore to be fixed. Say if you say 100 meters from the land, so it

can be 100 meters or 50 meters. So, it changes. Now, this change takes place because of these waves and currents, more by waves. So, this is to be noted that the shoreline features, the change with time, there is a constant change. It is not static.

So, the continental shelf is very much influenced by waves and current, but these are also the shelf. Shelf is a good location for off-shore structures or one can write coastal structures. Why? Because the reason is that depth of water is low, that is shallow water and of course, the shoreline dynamics will be there, but for family because of less water depth and less slope.

So, these are the two family reasons we one can go for building an offshore structure in the continental shelf. So, in the continental shelf, one finds your jacket platforms etc. This jacket platform and all this gravity platforms will be there. Now, another important thing that is the coming from the shelf as we go further out into the open ocean, you come across the continental slope. Now, as I have told you in this region that the shelf edge that is we have lot of wave action and continental slopes. Slopes are unstable because of wave action, high declivity. So, obviously one should not go for any location of offshore structure on the continental slope. So, this region is particularly not suitable for location of offshore platforms. So, this is to be noted.

So, most offshore structure, coastal structure, one should find of a continental shelf and these slopes you know even slopes are very unstable because of the action high declivity and sometimes you will find mud slides. Now, these mud slides are caused by earthquakes drilling from platform. So, here you will find them because of the nature of the bottom. So, ocean bottom is dynamic in nature. So, constantly the features are changing especially this slope is very prone to your earthquakes and mud slides. So, you will find the slope feature is not like this. After sometime, it becomes something like this.

So, if we locate a structure in this region which is very difficult; that means, the lakes of the structure will be having different lengths first of all, and it will tend to slide off. Now, in this region of course you come to the basin. Basin is the lowermost point of the ocean bed. Also, this slope is not very suitable for location of your offshore structures. Now, what happens to these small particles? I have discussed that those are carried away by the flow that is by the river flow, but where they finally settle. So, these small particles, they

gradually come from the continental shelf and then from the slope and then finally settle near the basin. So, this is your ocean basin and you will find that the smaller particles, they are located on the ocean basin.

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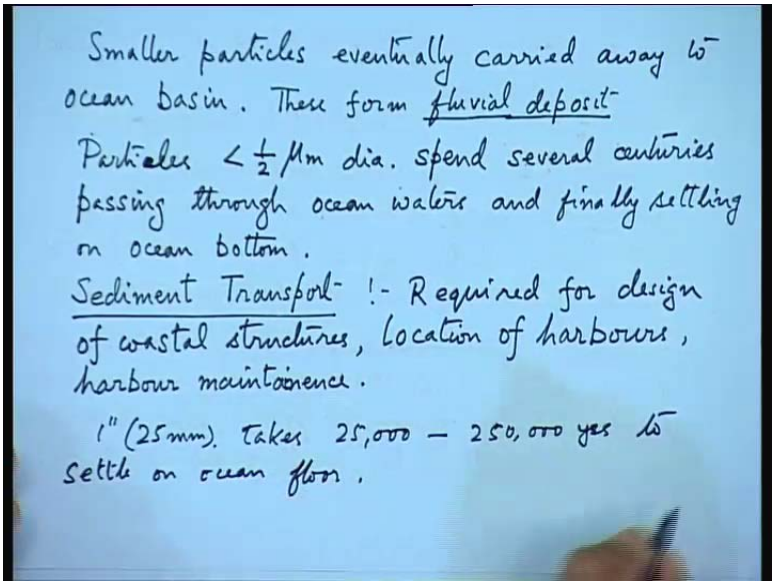

Now, the settling on the ocean basin does not take place in few years. It will take 2000 years. So, small particles eventually carried away to ocean basin. So, this you will find in the ocean basin and these form what is called a fluvial deposit. So, this fluvial deposit consists of these small sediments and also your brown mud. So, these consists largely is two types. Now, particles less than half millimeters or I think micrometers and to a minus 6 diameter. So, this has spent several centuries. So, these particles spend several centuries passing through the ocean waters and finally, settling on the ocean bottom.

So, I have told you that anything which occurs in the ocean is very large. They have very large time gap or the time interval is very large passing through ocean waters and finally, settling on ocean bottom. Now, a thorough study has to be done about what we have just now described is called sediment transport. Now, this is very important. Sediment transport is very important. It is required for design of coastal structures. What else is it important for? Design of coastal structures, location of harbors and the last one obviously is harbor maintenance. So, harbor maintenance is the concept of grazing.

So, this segment transport analysis has to be done because of that. So, these are the types of sediments. So, just you want to come to this statistic. So, 1 inch of this sediment that

is 1 inch is 25 millimeters takes say 25,000 to 2 lakhs 50,000 years for formation to settle on ocean floor.

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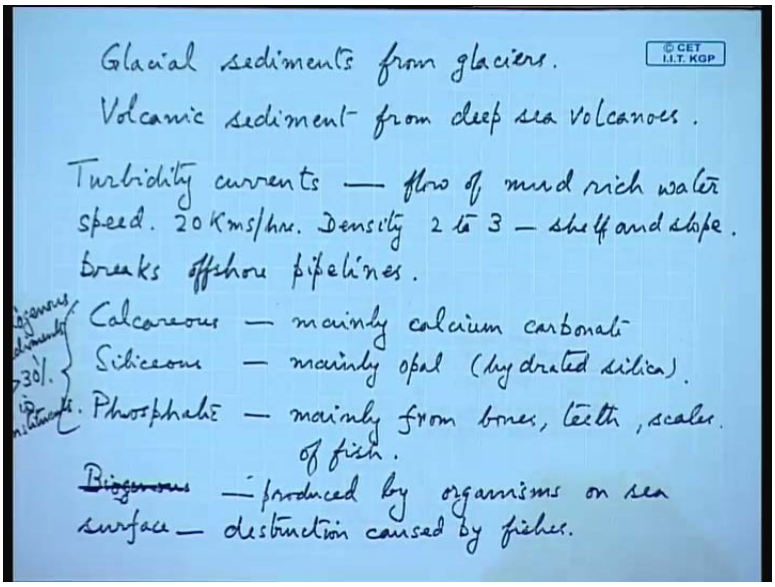

Now, besides this we have glaciers sediment that is coming from the glaciers. So, these are called glacial sediments from glacier that is the river of ice. So, you will find volcanic sediment from deep sea volcanoes. So, these are the other two types of sediments which are normally to be found on the ocean bed. So, besides this we have discussed in the last class.

I have told that other thing on the continental slope you will find is turbidity currents. So, these are flow of mud rich water speed. One can have in the turbidity current is 20 kilometers per hour density that is 2 to 3. So, these occur mostly along shelf and slope. So, breaks offshore pipelines. So, these are to be noted and this is a treat as we have already analyzed that is the calcareous variety. So, mainly calcium carbonate, then we have siliceous. So, this is mainly opal that is hydrated silica.

The last one is phosphatic. So, these are mainly from bones teeth. Then you have scales of the fish and biogenous is derived from organisms on sea surface. So, these three I think constitutes the biogenous sediment. So, these three we have they are called biogenous sediments. Now, one thing is to be remembered that this should be, constituent should be greater than 30 percent biogenous constituents or bio constituents.

So, biogenous you find phosphatics opal is hydrated silica. So, these three constituents calcareous, siliceous and phosphatic, they constituent your biogenous sediments.

So, these are normally produced by living organisms on sea surface and dissolved destruction caused by fishes that is this is some of the smaller fishes that is the flesh are eaten by this large fish or the bones that drop into the ocean floor. So, they constitute these biogenous sediments. What is to be remembered is the constituents are greater than 30 percent. So, this is largely is the end of the sediment. In the next class, I will tell you about the androgynous sediment and with that we will close.

So, thank you very much.