Geomorphology
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Lecture – 39
Coastal Geomorphology

So friends good morning and welcome to this lecture series of geomorphology today we will continue with this the coastal geomorphology and if you remember our last class we were talking something about this wave tank experiment, the coral reefs and some of these structures or the rock structures how they influence the coastal geomorphology and we concluded that the breaking waves and the broken waves both are more sensitive or more effective for the coastal erosion.

And in initial time there will be less erosion however after few moments or few hours why I am talking about this a wave tank experiment after few hours the erosion will increase because much of this sand particle will be eroded from this coastal cliffs. So the water along with the sand particles they behave as an abrading agent to erode the coast rapidly and at the latter time when much sediment will be added to the system the energy will be absorbed and finally the rate of erosion again it will decrease.

Similarly this eroded material will be transported seaward and will form a convex up topography along this coastal plain and finally this is the depositional topography it will be convex up and it will be within the submerged water. Similarly when we are talking about these coral reefs, we found these are the reefs organic built reefs and they are formed on the hard rock surface and if hard rock surface is not there and the coral reefs are formed.

The coral reef itself behave as a substrate to allow the growth of this coral reef further and there is a leeward side this steep side mostly attached to this rock body and it is the most resistant wave resistant formats wave resistant species they are found along this seaward side and on this flat surface algal mats are developed and those algal mats there are the algal limestones they behave as a binding material to make this coral reef more strong and until unless there is a severe storm activities, tsunami activities, the coral reefs are not destroyed or disturbed and remain there.

So today we are going to discuss about the classification of coral reef and how this classification will be helpful to study this tectonics and climatic influence along these coastal plains.

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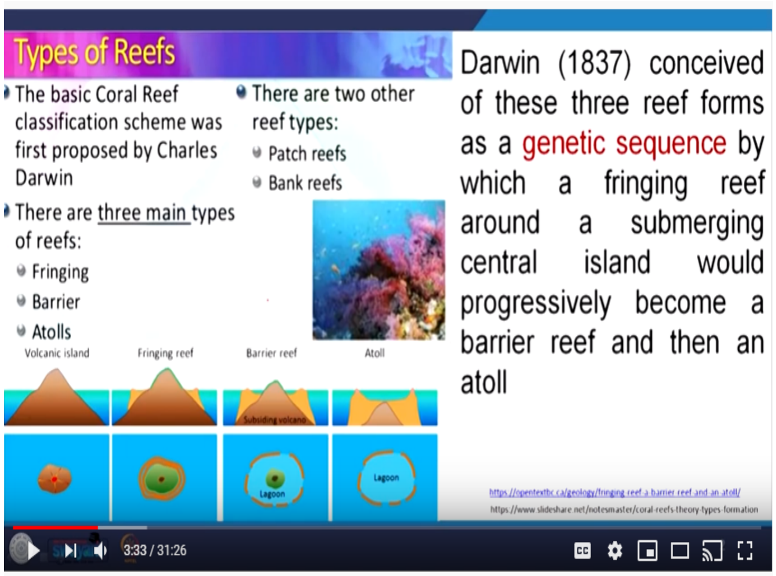

So this classification is quite old, and it is given by Darwin in 1837 but still we are adopting this classification. This classification the main aim to categorize the coral reef into different classes and based on those classes we can predict about this coastal subsidence tectonics and climate, sea level rise, something else. So here the basic coral reef classification was given by Darwin in the 3 main type the fringing reef, the barrier reef and the Atolls.

The fringing reef, if you see this figures given low here suppose we have a volcano and with time we are creating a volcanic island and as we know these coral reefs, they are very sensitive to temperature of water they are basically the warm water species and if it is cold water should not be less than 18 degree Celsius. So if you see if we have an island, a volcanic island that means this region around this volcanic island will be hot and warm water will be there.

So due to this warm water condition you see there is growth of corals in both sides. So you are looking at the cross-section it is not both site it is all round this volcanic island if you see here this is volcanic island the green one and these corals they are growing here. So that means all site at the periphery of this island, so this coral try to grow, and this is a shallow water phenomena because we know these coral reefs, we need a photic zone for the coral growth.

So if you see it is not extending much deeper of this island. So however it is restricted here this side is restricted here and around this volcanic island at the shallow water level the coral try to grow. So once they started growing and gradually, they increased their height now we see earlier this was the depth or the height of this coral. Now this is the height of this coral, so with increasing height part of this main sea is cut off from this main water body and now it is restricted here.

If you see it is a restricted environment and forming a lagoon. So this is called barrier reef, barrier that means it is a barrier from mainland to this main sea and a part of this water body main water body it is cut off from this main water. So this is forms a barrier so now these corals they behave as a barrier. So that is called barrier reef. Similarly the third one is called Atoll, Atoll means if you see in this condition, we do not have this volcano or volcanic island existing here, existence of volcanic island their existence of volcanic island is there but here there is no volcanic island.

So now the question is how this volcanic island vanished in between you see there are two reasons, one is once it is a tectonic active environment there are much chance that this volcanic island will subside or there is a chance the sea level increased, or the water level increased, and the volcanic system totally submerged under sea. So either of this case if you see this total system is submerged there is no surface signature of this volcanic island and these corals they are existing here, and it had totally engulfed a lagoon here.

So this is called Atoll so this 3 principal classification one is fringing reef another is barrier Reef and third is Atoll. So this Atoll that indicates either there is a tectonic subsidence or there is a sea level rise. So, Darwin 1837 conceived these 3 reef forms as a genetic sequence by which fringing reef around a submerging central island would progressively become barrier reef and then Atoll.

So this is a progressive increase with time it starts with fringing reef or it starts with volcanic island then there will be development of fringing reef then development of barrier reef then development of Atoll. So it is a sequential format.

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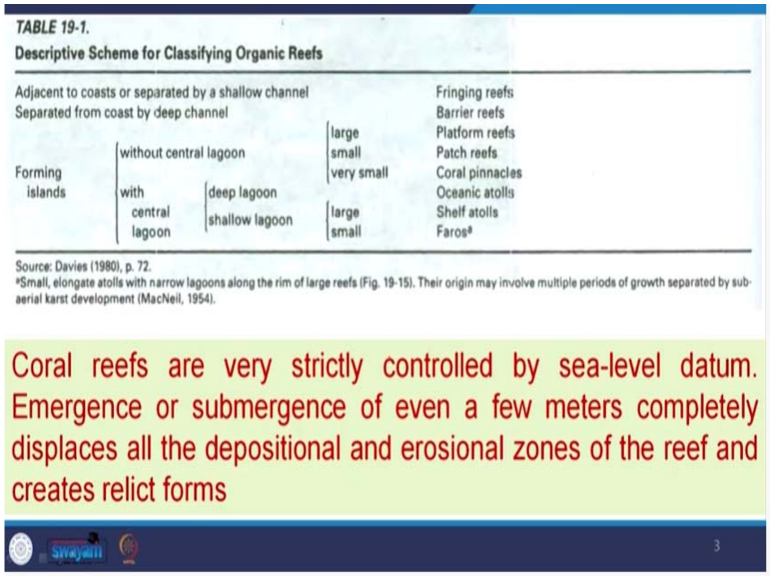

TABLE 19-1.
Descriptive Scheme for Classifying Organic Reefs

Adjacent to coasts or separated by a shallow channel				Fringing reefs
Separated from coast by deep channel				Barrier reefs
Forming islands	without central lagoon		large	Platform reefs
			small	Patch reefs
			very small	Coral pinnacles
	with central lagoon	deep lagoon		Oceanic atolls
		shallow lagoon	large	Shelf atolls
			small	Faros[a]

Source: Davies (1980), p. 72.
[a]Small, elongate atolls with narrow lagoons along the rim of large reefs (Fig. 19-15). Their origin may involve multiple periods of growth separated by subaerial karst development (MacNeil, 1954).

So continuing with this classification we see this classify the organic descriptive scheme for classification of the organic reefs one is it is forming island without central lagoon and with central lagoon. So this is two divisions one having central lagoon and without having central lagoon if we have a central lagoon inside, either it is a deep lagoon, or it is a shallow lagoon. Similarly here if it is deep lagoon or shallow lagoon with a shallow lagoon either it is a large lagoon or small lagoon.

Similarly without central lagoon either it is a large reef or a small reef or a very small reef. Similarly here it is fringing reef, barrier reef, platform reef, platform means flat topped, then patch reef, patch reef means it is not continuous it is patchy then coral pinnacles then oceanic atolls then self-atolls then feros. So these pinnacles if you remember our last class when we were talking something about this flat top body of a flat top sediment, or it is horizontal sediment like this sedimentary rocks then they form the sea bridge and finally these collapse and forms the pinnacles, chimney-like structures.

Similarly in the coral system they also chimney like structures are there that is called pinnacles. So coral reefs are very strictly controlled by sea level datum, emergence or submergence or even few meters completely displays all the depositional and erosional zones of the reefs and creates relict forms.

Because they are very sensitive to water level, they are very sensitive to climate change they are very sensitive to EH-pH condition or this chemistry of water the temperature of the water you might have heard it nowadays the great barrier reef of Australia it is getting destroyed due to this water chemistry, the severe pollution is there in this ocean. So that the water chemistry is getting changed that is why, these corals nowadays they are not growing at that rate which were earlier.

Similarly some part of this barrier reef are getting destroyed and not new coral reefs are formed nowadays. So they are very sensitive to temperature, water chemistry, water depth so either a meter of rise or meter of fall of seawater that will sense the characteristics of the coral reef, okay. So either they will erode, or they will be formed a new one.

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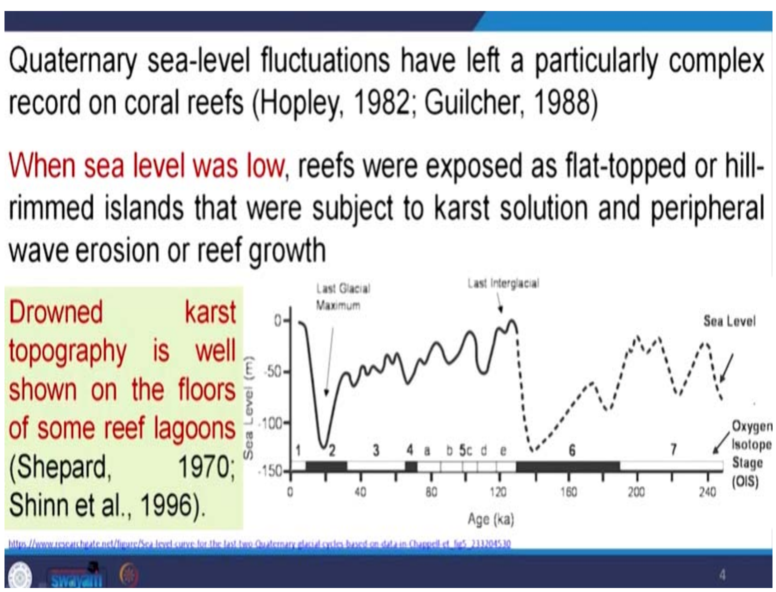

Quaternary sea level fluctuations have laid a particularly complex record of coral reef when sea level was low that reef surface was exposed. So, once you see coral reef as you know that is total limestone. So limestone exposed to the surface that means it will promote for the formation of karst topography. Karst topography when we are talking something about weathering, these limestones, they are very sensitive to chemical weathering.

So that means once the sea level falls during this a glacial period when most of this water was in the glacier form the sea level was below 100 meter or so as compared to the present sea level. So in that level if coral reef was there that means 100 meters surface was exposed. So 100 meter depth surface is exposed that means it was interacting to the atmosphere interacting with the rains and some other types of material.

So that means there was karst solutions karst topography was developed and now you increase the sea level. Now in the late quaternary the sea level has increased and due to increase of the sea level this eroded topography, or the eroded karst topography developed on the coral surface they are again submerged and again the coral reef started forming. So that means we have the evidences of past karst solution topography on this coral surface.

So that means when the sea level was low reefs are exposed as flat-topped or hill rimmed islands that were subject to karst solution and peripheral wave erosion or reef growth. So here drowned karst topography is well shown on the floors of some of the reef and lagoons. So that means the sea level increase and decrease that are affecting this karst topography or the coral topography.

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So how can detect whether a part of this coral reef were eroded, or it is intact as it is. So because we know this unconformity if you suppose one surface is exposed and it is eroded so another sediment is deposited, we are creating an unconformity. Similarly, there was unconformity or there is unconformity within the coral reef surface also because during this is sea level fault the part of this coral system was destroyed, eroded.

And later due to the sea level rise this part surface is exposed and it is again promoted coral reef growth and so this eroded part because the eroded part it is difficult to identify because a below is this limestone and above it the limestone both are, they say organic lime stones. so they can modified by the organism, so it is difficult to identify exactly where this erosional surface lies, development of this sophisticated radiometric dating techniques become unavailable there was no way to evaluate or often even to detect the glacial age disconformity within this coral reef stratigraphy.

So because this total system is organically modified, so this organically modified that means we cannot distinguish whether there is an unconformity existing or not. So that is why by centimeter by centimeter millimeter by millimeter if we do not analyze it the stratigraphic column total coral reef columns, we have to date it centimeter by centimeter scale then we can find where is the age gap.

So those age gaps that determines when this glacial activities was there, and this glaciation was there so that the coral reef was exposed to the surface. So on a longer time scale great barrier reef of eastern Australia which extend almost about 2000 kilometer from 9 degree to 24 degrees south latitude began to grow in the northern part became between 16 to 25 million years and in the central part 10 to 15 million years and the southern part only a few million years ago.

So why is it happening so we have a 2,000 kilometers long straight coral reef and the northern part it is showing older up that means it is 16 to 25 million years and the middle part it is 10 to 15 million years. So gradually we are moving towards northern part the age of this coral reef is decreasing so that means how it is possible a straight coral reef like this this side is older this is middle aged, and this is younger one. So this indicates the tectonics process this indicates the plate movement.

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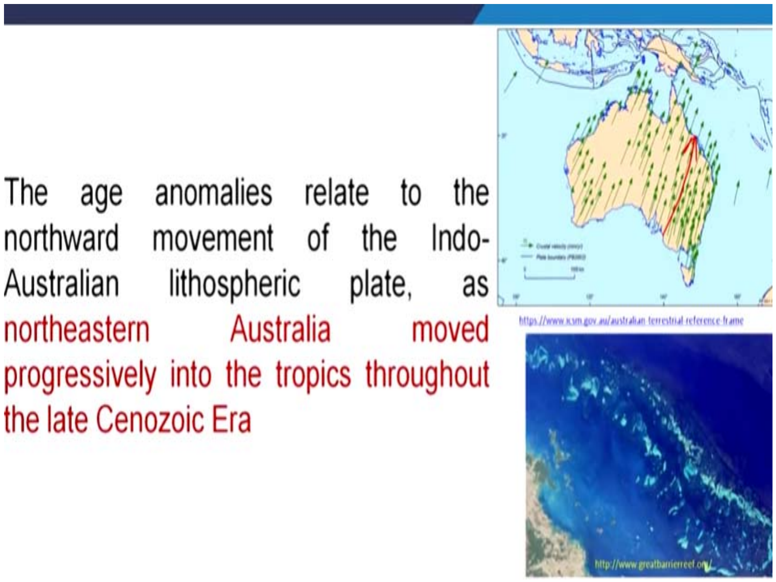

If you see here this Australian plate it is moving northeast direction and here is the reef system great barrier reef system suppose. So now you see once this is coming to warm water climate, so it developed coral reef here. So similarly with time of suppose it is 25 to 16 million years within time it started with 25 million years and it is 16 million years. So with time again this part moved further northward northeast ward.

So due to further movement the coral reef started forming here then further north east to our moment the coral reef started forming here. So that means the age anomalies related to northward movement of this Indo-Australian lithospheric plate. As northeastern Australia moved progressively into the tropics and throughout the late Cenozoic Era. So that means more and more space it is coming under these tropics these coral reefs are getting developed. So that is why there is a great age anomaly from the northern to southern part.

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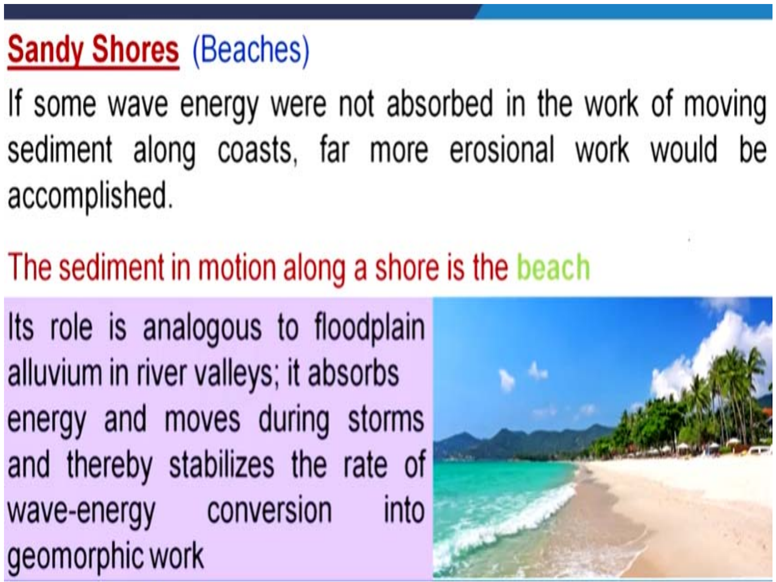

Then we were talking so far about these carbonate coasts something about these structures this erosions and the coral reefs now we will discuss about the sandy source sand so that means those eroded materials which are eroded from this cost the cliffs now they are deposited and distributed and redistributed along this coast. So how they are creating the landforms that we will discuss here, so sandy source that is called beach beach is full of sand and some of this coast is sandy coast some of this coast are rocky coast gravelly coast.

So that depending upon this a material available we can classify this coast into sandy, gravelly rocky like that. So if some wave energy were not observed in the work of moving sediments along the coast, far more erosional work would be accomplished. So the sediments in motion along the shore is the beach. So beach that means this is the region it is near to this coast to few meters or beyond these ocean water or sea water.

So that is coast because the sediments are under constant motion, to and fro motion, lateral motion, vertical motion. So sediments under motion the region is identified as beach. Tts role is analogous to flood plain alluvium in the river valley it absorbs energy and moves during storms and thereby stabilize the rate of wave energy conservation into geomorphic world. We have flood plains, we know within that flood plains this sand migrate the sediments transported.

So that means this river energy is redistributed among the sediments the sediments get deposited they transported and during this transportation they erode materials again they dissipate the energy within that sediments. So that means similarly along this coast the similar type of work this water and the sand together they do they remove the material they are transport it they deposit it somewhere again they rework and redistribute like that.

So it is similar to this floodplain geology and geomorphology, however here ocean is associated, and in flood plain river is associated. So beach can be continuous or can be discontinuous so the discontinuous that means when we are talking about this geomorphic models in our earlier classes you can remember.

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That the coast may be dissected at different places by these rivers. So a coast can be continuous for hundreds of kilometer or it may be dissected into few kilometers or so. Especially, in the Deltaic regions, Deltaic regions when the river is bifurcated into distributaries this coast is this segmented, So the sand silt is segmented, so a continuous beach along a coast is a good a criterion for graded condition as it is a continuous floodplain on the floor of a river valley or a continuous sheet of sediment on a semi-arid pediment.

So here similar environment with similar geomorphic events have been described. So a continuous coast a continuous floodplain a continuous sheet of sediments in pediment. So that means it is indicates the stability if this continuous coast is there that means geomorphological it is a stable, floodplain continuous floodplain is there without any dissection. So it is geomorphological stable continuous sheet of sand sediment on a pediment that means it is geomorphological a relatively stable. So this continuity that indicates the stability of an geomorphic system.

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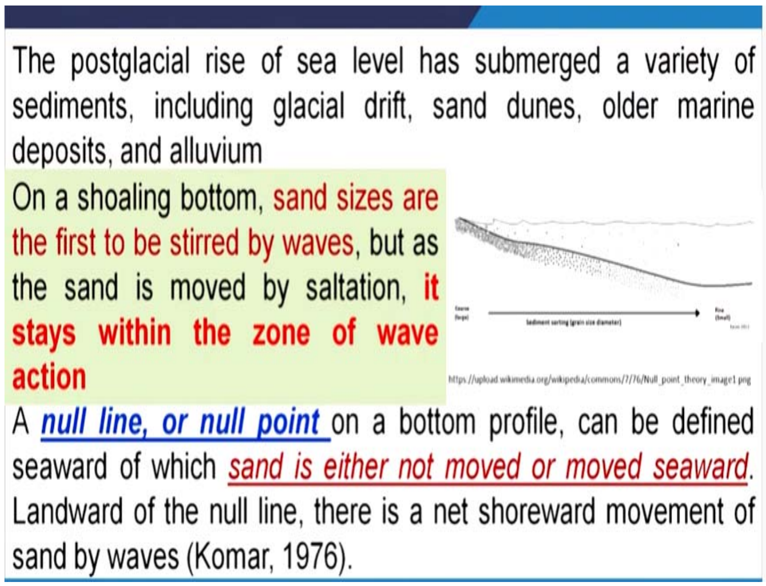

The post-glacial rise of sea level have submerged a variety of sediments including the glacial dripped sand dunes and older marine deposits and alluvium On a shoaling bottom sand size are the first to be stirred by waves. But as the sand is moved by saltation it stays within this zone of wave action here it is important to understand. We have wave action along this coasts and wave action some wave have certain energy.

We know from this earlier classes that we need less energy to pick up sand we need more energy to pick a clay particle and a gravel particle from this bottom of this sediment so with a minimum energy we can pick up sands from this madam within the sediments. So once the sand comes to this water, so it remains there until unless this wave action becomes calm and quiet. So it in the saltation process it moves so once it moves it interacts with the other one with the other sand particles it interacts with these clips, it interacts with the other metals, so it erodes.

So there is a line or there is a point in a profile that is called null line or null point. So if you see here this is the profile you are moving from this continentward to seaward within this profile there is a point that is called null point and, in a line, it is a line it is not a point. So in a cross section it is a point in if you are so looking at the surface from the surface from the aerial view it will be a line it is called null line and it is called a null point.

So what is that, an null line or a null point on a bottom profile can be define seaward of which sand is either not moved or moved seaward, landward of this null line there is a net shoreward movement of sand by wave action. So that means it so this is a point that depends either sand will move or not move. So sand will move towards the coastline or sand will not move towards the sea so that is called null line.

So null line is based on the sand distribution. So if you are moving along is or across this course that means from continent ward to seaward. So if you are moving there you will find a particular zone will be there particular line will be there. So in this particular line you will not find sand towards the sea but all sands are here towards the coastline so that is called this null line or the null point. So each profile have different position of these null points.

So if you are joining those points with the successive profiles then we can find this null line. So that means that indicates here this null line indicates this is the position whether either sand will move towards the coast or sand will not move towards the sea, so that is called null line. So that means that indicates indirectly the wave action, to what extent the sand can be in the saltation more within this water, the vibrant of this waves.

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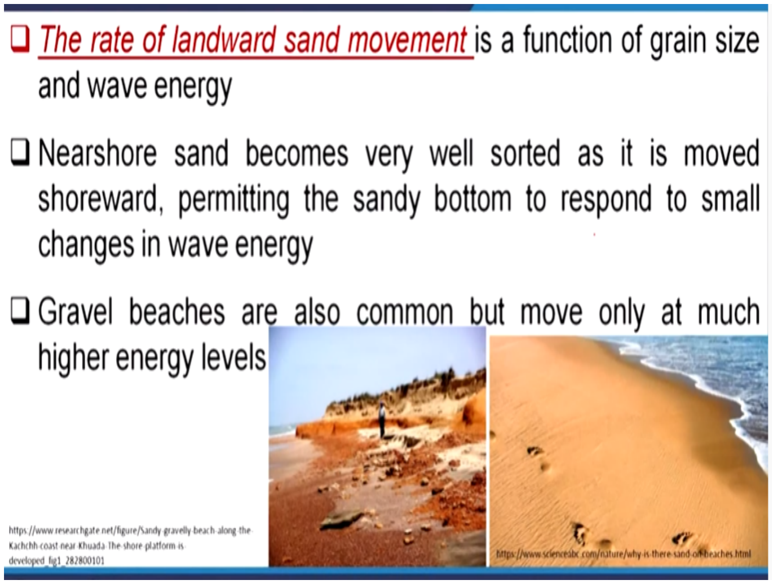

So there are certain salient features given here, the rate of landward sand movement is a function of grain size and wave energy. The landward movement of sand is a function of grain size grain size; larger grains will not move and similarly the wave energy how much energy of this wave is there, high energy waves they can move even if larger particles towards the coast. Then near shore and becomes very well settled as it moved shoreward permitting the sandy bottom to respond to small changes in wave energy.

Aeolian energy you can remember when we are talking about the Aeolian system this saltation it subtracts, or it creates a sorting difference, larger particles one side this smaller particles another side. Similarly this near shore sand becomes very well sorted wave settlements equal grain size or new or equal grain size it is moved shoreward. Gravel beaches are also common but move only a much higher energy level, because we need higher energy to pick up a gravel.

Similarly we need higher energy to pick up a clay particle, so that is most of our beaches most of these world beaches they are sandy, rather than gravely because we need high energy it is occasionally occurs during flooding, during tsunamis, during storms, we get occasional high energy which is required for the picking a gravel and redistributing from one place to another. But this normal energy distribution along this world coast it is suitable for sand movement and sand grain distribution. So that is why most of this coast in world you will find it is sandy rather than gravelly.

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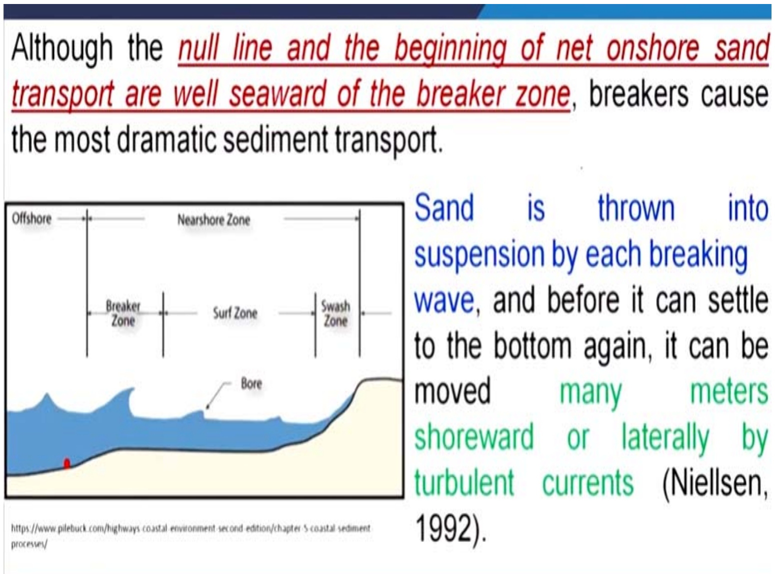

Although the null line and the beginning of this net onshore sand transport are well seaward of this record zone, breakers cause the most dramatic sediment transport. Here you have to understand this point, where the null line stands, or this null point stands in the profile for example if you see here this is the profile, we are coming from this continent towards sea and this is the breaker zone here this is the breaker zone the wave breaks here.

So the null point is somewhere here below this breaker zone. So now if we have null point beyond this breaker zone. So we should have most of the sand there only rather than here, but it never happens. So why it never happens if you see once there is a breaker zone the energy of this wave is breaking into different smaller waves. So here it is a high hit area that means a hits the most the wave energy dissipates most here.

So once this wave energy dissipates this hits and it is creates a shearing moment on the sand particles or this bottom. So this is a high shear stress, this sand comes in a saltation more within that water. So once this sand comes in the saltation mode, it will move here in and finally sand is thrown into suspension by each breaking wave. Here the wave breaks down and this system that means this one this sand comes in the saltation or the suspension mode that is before it can settle to bottom again, it can be moved many meters forward and laterally by turbulent currents.

So that is why though we have a null point here but around this there will be distribution of sand this is due to the high energy waves and this is the breaker zone once it comes to saltation mode that will move here and there. So this defines this sand movement how this sand will be distributed in those zones. So I think we will stop here and well meet in the next class. Thank you.