Geomorphology

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Lecture – 40
Coastal Geomorphology - VII

Good morning and welcome to this lecture series of geomorphology. Today we will continue with this a coastal geomorphology and in the last class if you remember once we were talking about this formation of these coastal plains its modifications its coral reefs and something else. So today we will talk about this sand distribution along this coast and how sand migrate how different depositional structures they form due to this sand movement and whether this continuity of the sand movements will break somewhere and if it is breaking what was those components and what are these factors that are responsible for breaking this continuity of this sand silts.

So here if you see if we are taking a cross profile of a sea ward to land then we will find there are 2 major zones of sand generations or this sand movement so one is very close to the shore and another is close to this breaker zone.

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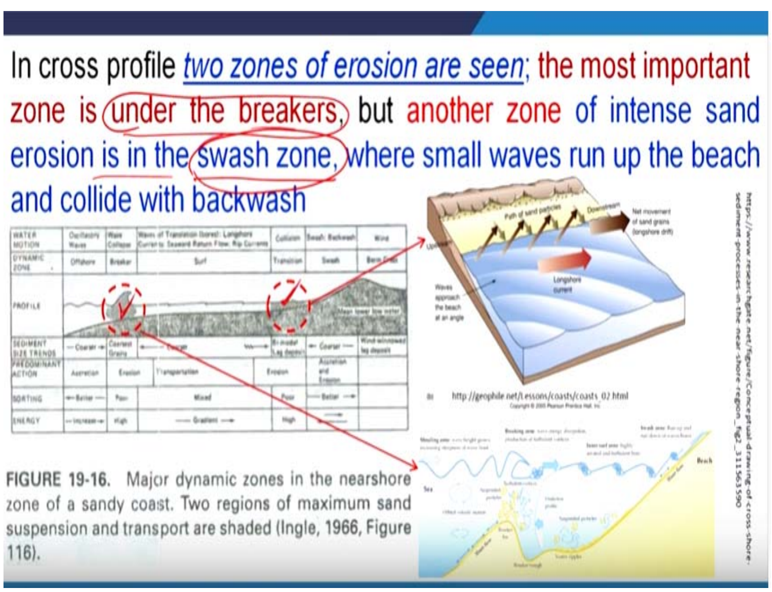

Here it is close to shore and other is close to the breaker zone. So now once there is a breaking waves there is a wave which is breaking somewhere. So that means it produces or it affects it allows tremendous stress on this bottom. So that is why it this sand which is available the free sand which is available comes to the suspension mode. So once this sand comes to the suspension mode it is easily transported towards the coast.

Similarly the another zone where this is intense sand erosion is the swash zone. Swash zone and another is called backwash zone. Swash zone is called other way called it is a fore-wash zone, fore-wash zone means a sand is moving towards coast and backwash zone it is coming away from this coast. So here one zone is the most important is this under breaker and another zone is the swash zone.

So this two zones here and here they produce more sand and there will be sand movement towards the coast where the small waves run up the beach and collide with the backwash. Backwash means those if you see here one is swash another is backwash. Swash is fore-wash that means once wave is moving towards the coast that is fore-wash or swash and it is coming down that is called backwash.

So in these two zones they are responsible for this sand movement to the coast. And those sands which was deposited along this coast they also migrate both along the coast and across the coast. This migration along this coast is due to littoral currents and this migration across this coast due to this swash and backwash. So here in this figure major dynamics zone in the nearshore zone is a sandy coast. Two regions of maximum sand suspension and the transport are shaded here. These two zones are here and the sand transportation and the sand suspension zone are there.

And if you see here the net movement of sand is along this coast it is along this coast it is parallel to the coast however here the sand is moving to an angle and it is coming vertically. So that means this type of movement if you remember when we were talking about creep movement in mass wasting same type of movement but in vertical scale it is in horizontal scale.

So here in a vertical scale that was the creep movement the same type of movement was there and here in the horizontal scale it is the movement along this coast is there. So anyway suppose a sand particle was here with this swash zone it is moving here at an angle and coming vertically.

Similarly it is moving angle and coming vertically. So the net movement is along this coast and this movement due to this littoral current. Now the question arises how this littoral current generates and what is their role in migration of sands silt and formation of this sandy coast.

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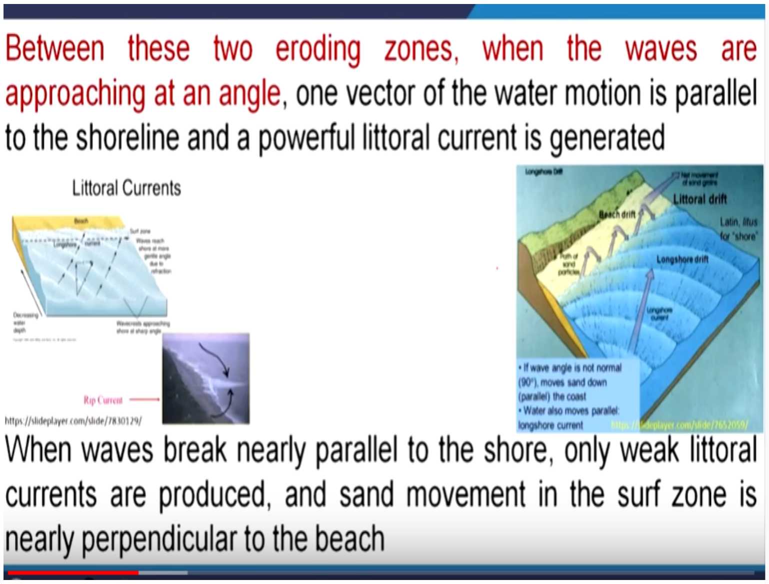

So here between these two eroding zones when the waves are approaching at an angle if you see here these waves are approaching at an angle one vector of this water motion is parallel to this shoreline and a powerful littoral current is generated. Here this reason or the mechanism of littoral current generation has been described that means the wave has to approach this coast at an angle if the wave is parallel or wave is vertical, or wave is at an angle.

So that angle which is wave which is encroaching this coast that wave which is capable of generating a strong littoral current. So when waves break nearly parallel to the shore only weak littoral current are produced and sand movement in this surf zone is nearly perpendicular to the beach. So here if it is perpendicular to the beach that means there will be no littoral recurrent access. So if this wave is backing parallel to the coast that means parallel coast means there is no effective sand movement or effective along the share sand movement is there.

But if it is backing at an angle to this zone angle to this shore that means a strong littoral current is generated and that current is able to transport a huge sand along this coastline and forming this sand sheets. So in a marine environment if you analyze the geological records or this stratigraphic sections you will find a lateral continuity sand to huge distance in terms of kilometers of hundreds of kilometers.

Those continuity of sand sheets uniform nature is due to this littoral current and this continuity it is break by the rivers by other factors like this ridges and these loaches like that. So until unless these barriers are there the sand silt can migrate along this coast to hundreds of kilometer distance So that means I can conclude here that this waves which are breaking at an angle to this coast they are producing strong littoral current which is capable of migrating sand to large distance.

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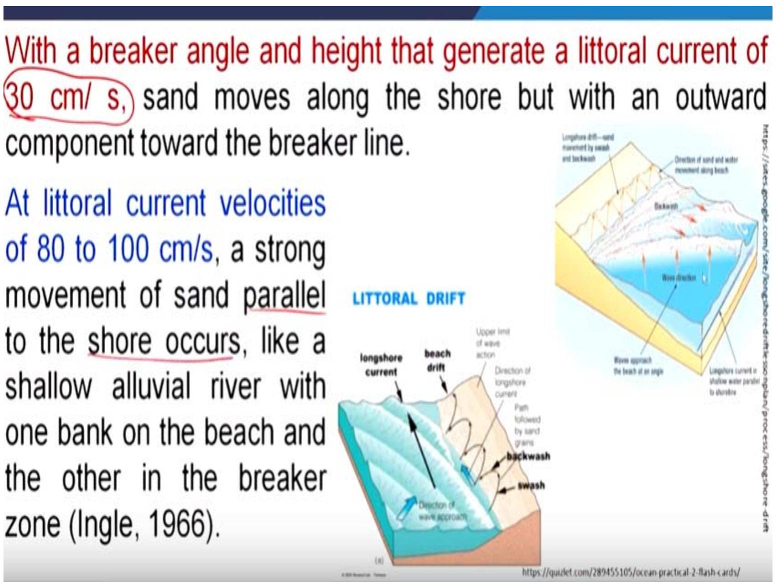

So with a breaker angle and height that generate a littoral current of 30 centimeter per second sand moves along the shore but with outward component towards the breaker line. Here if it is a slow movement suppose a breaker angle and height which is generating a littoral current, but it is 30 centimeter per second that means it is a slow littoral current. So that means slow littoral current will not allow this sand to move along this coast or parallel to the coast instead it will allow this stand to move across this coast.

That means here this swash and backwash the backwash movement will be dominating rather than the littoral current. So in that case the sand along the shore will not move it will move outward component towards the breaker line that means towards the sea it will move but if a littoral current velocity is 82-100 centimeter per second. So a strong movement of sand parallel to the shore occurs like a shallow fluvial river.

So one suppose if you compare suppose the sand is moving along a river it is combined between two banks of a river. Similarly if we are moving this sand along this coast so we are comparing this coast parallel movement of the sand along suppose within a confined river system that when this two coast one is parallel to this shore and another is so that means here one side is your shoreline and other side is the wave.

So through this sand is moving that means if you are taking a cross section it would look like a river. So that means here we are concluding that its strong littoral current to generate which will allow this sand to migrate or to move along this shoreline parallel to the shoreline this littoral current velocities should be 82-100 centimeter per second at least so that a strong littoral current and the parallel component will be there.

The parallel component from the coast parallel component is strong enough to migrate the sand from coast from one part of the coast to another or along this coast. Otherwise if it is a slow movement it would be slow littoral current that is 30 centimeter per second. So rather than parallel migration it the sand will migrate towards the sea or towards the breaker zone.

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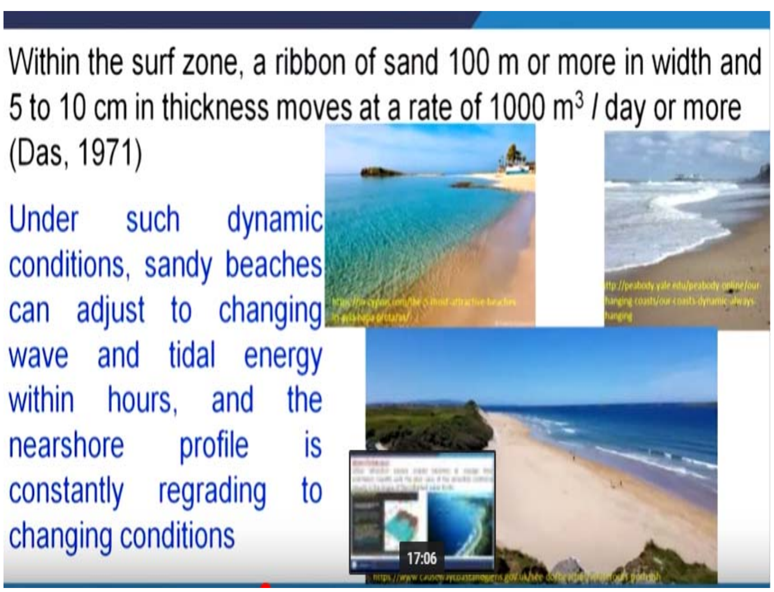

Within this surf zone a ribbon of sand 100 meter or more in width and 5 to 10 centimeter in thickness moves at a rate of 1000 meter cube per day or more. So that means the sand silt migration how much sand is migrating at a particular cross section that is if this current it is on 80 to 100 centimeter per second it littoral current is there. So it will create a sand sheet of 100 meter or more width and 5 to 10 centimeters in thickness and moves at a rate of 1000 meter cube per day.

So this amount of sand can migrate with the 80-100 centimeter per second littoral current. Under such dynamic conditions sandy beaches can adjust to changing waves and tidal energy within hours and the nearshore profile is constantly regarding to change of conditions. So that means I want to say here this is a dynamic condition so depending upon the current velocity this tidal current velocity depending on the littoral current velocity depending upon this wave.

So this condition is dynamic sometimes this sand may migrate some may not migrate. So the constantly profile if minute by minute or hour by hour profile will take across the shore will find the changes. These changes is nothing due to the dynamic behavior of this littoral current these waves the sand supply the breaking waves like that.

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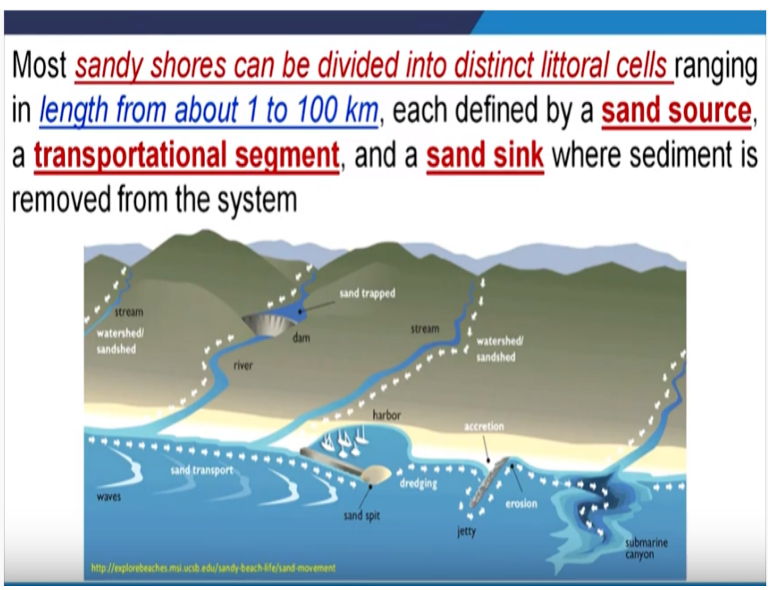

So mostly this sandy source can be divided into distinct littoral cells ranging in length from about 1 to 100 kilometer each defined by a sand scour, transportation segment and a sand sink where sediment is removed from the system. I remember when we were talking about this modeling in the geomorphology our introductory class, we were discussing that this is sand sheet it may not be continuous forever.

So there are some segments or there are some factors that is suppose for example in this figure you see they have the streams or the rivers that are coming and this is this littoral current this is the sand sheet which is forming along this coast now you see this is one separate sand sheet this is another separate sand sheet this is another separate sand sheet like this.

So that means within the sand sheet there are distinct domains. So distinct domains that means it has their own sand production house the sand transports within that and the sand sinks there. So what we will do the suppose for example we are considering here these are the zones where sand is generated because the wave they are hitting here and this coast and generating this sand. So the sand is migrated due to swash and back wash and they are migrating laterally by this littoral current and once they are reaching along this river mouth here.

So this sand is removed from the system either they will migrate from the depending upon the dominance of the tide and the waves so either this sand will be distributed in this way that means from this system we are removing the sand. So that means I want to say this entire length of this sand sheet can be divided into segments and each segment have its own source on a sand source they have some transportation segment they are transported either by swash and backwash and then there is a sand sink where the sand is it removed from the system.

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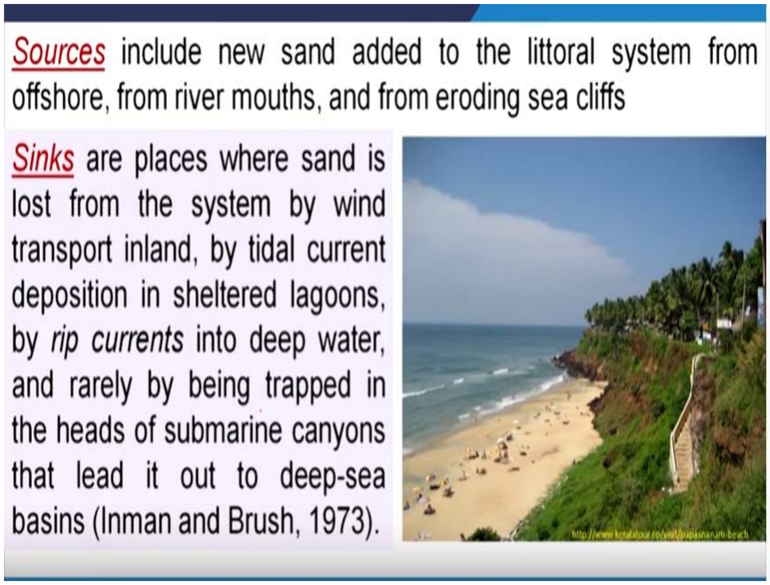

So what would be the source for that source include new sand added to this littoral system from offshore from river mouth and from eroding sea cliffs. So these are the different source either form the offshore that will be added offshore due to offshore current due to this and breakers then from the river mouth it is from these fluvial systems they are contributing sand which is coming from this a continental system and then from the eroding sea cliffs near to the coast from the eroding street sea cliffs added to the systems

So there are 3 resources are there. Similarly sinks, sinks are those places where sand will remove from the system so that means sinks are places where sand is lost from the system by wind transport. So that means wind transportation is another factor during wind transportation sand will be removed upstream it will move from the system and then by tidal current deposition in sheltered lagoons.

Sheltered lagoons are there due to tidal once there will be tide the tidal current will remove sand from here and deposit it in the lagoons then by rip currents into deep water. Rip current is current moving down in the sand will removed from the system into the deep water and rarely by being trapped in the heads of submarine canyons.

Submarine canyons are there so there are chances that the sand is removed from the system that will be trapped within that submarine canyons okay and that led to the deep sea basins. So that means these are these 4 distinct mechanisms or 4 mechanisms through which sand can be removed from the system. Sand can be added sand can be removed within that sand transportation occurs and transportation is due to this backwash and wash zones and due to this littoral current movement.

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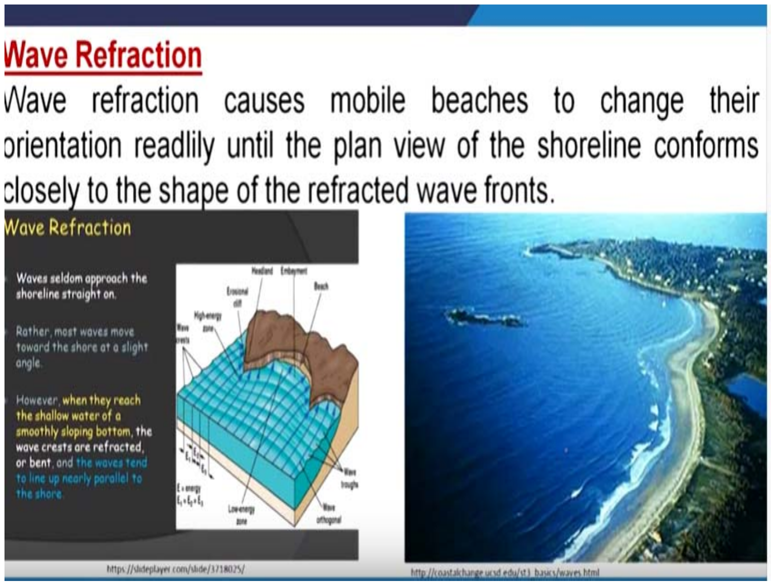

Then we will discuss here about the wave refraction. So we have already discussed about the reflections of these waves when there is cliffs are there wave, they hit along these cliffs and reflect back. Similarly there are wave refraction curves mobile beaches to change their orientation readily until the plan view of this shoreline conforms closely to the shape of the refracted wave fronts.

So that means if you see here, we have waves, and these are these headlands and if you take this profile of the headland it will be like this. So that gradually they are plunging into the sea so in that cases wave refraction occurs and as we know earlier due to this wave refraction maximum energy is concentrated here and here these zones are the wave dissipating zones and here, they are wave concentrating zones.

So that is why these parts will be removed or eroded and the removed material that will be deposited here. So new beach will generate here and here this sands will be removed material will be removed. So wave refraction it causes mobile beach that means one side of the beach will be developed another side beach will be eroded. So this type of movement these type of change in this beaches that is done and by this wave refraction and this shape of this beach how it will look from this aerial view that depends upon at what angle the wave is refracting and at what angle this refracted wave is approaching along this coast.

So the geological time within hundreds of years within thousands of years you will see this shape of this beach is taking that shape which is the dominant angle of wave refraction and how this refracted wave at what angle the retracted wave is approaching to the sea this beach will take that shape. For example, if you see here if you see this is clearly seen that the wave here these are the refracted wave like this and you will see these beach, beach shape is like that.

Similarly here this refracted wave they are like this and here if you see the beach is of that shape. So that means with a geological time the beach will take that shape from aerial view that shape is confined this shape is followed by these shape of this refracted wave from this breaker zone. So that is why in the worldwide if you see this beaches of this worldwide the beaches these beaches. These beach have taken their own shape and the shape is dependent on the dominant angle of the wave refraction.

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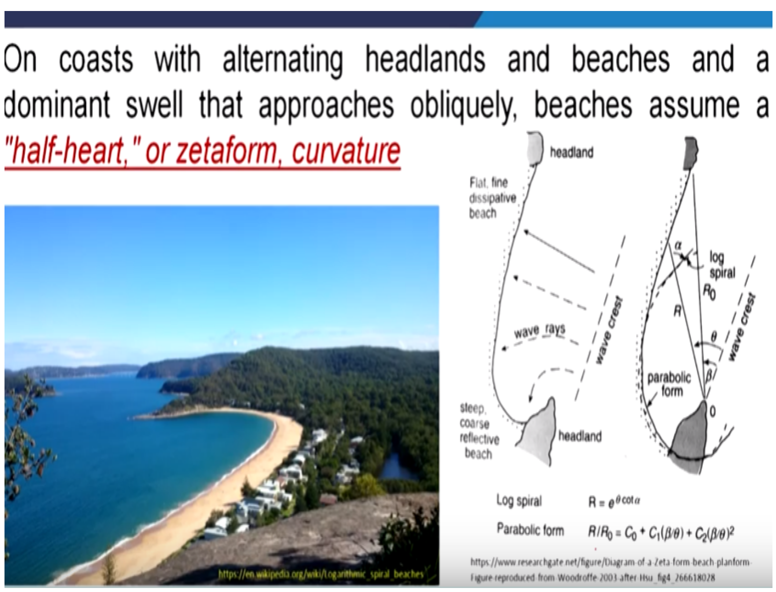

On the coast with alternating headland and beaches and the dominant swell that approaches obliquely, beaches assume to half-hearted or zeta form curvature For example if you see here this is called zeta form curvature for example one is straight and another is curve. Similarly there will be straight then it will be curve like this. So zeta form beach if you see here one end one component will be straight another is curve, and this is headland this is headland.

So within the two headland there is a beach and this wave refraction refracted wave their interacting with this coast and forming this half-hearted shape the half shape will be like this similarly if you see here this is the half-heated shape and this is called zeta form coast zeta form curvature. And zeta form curvature they are mostly formed due to this wave refraction.’

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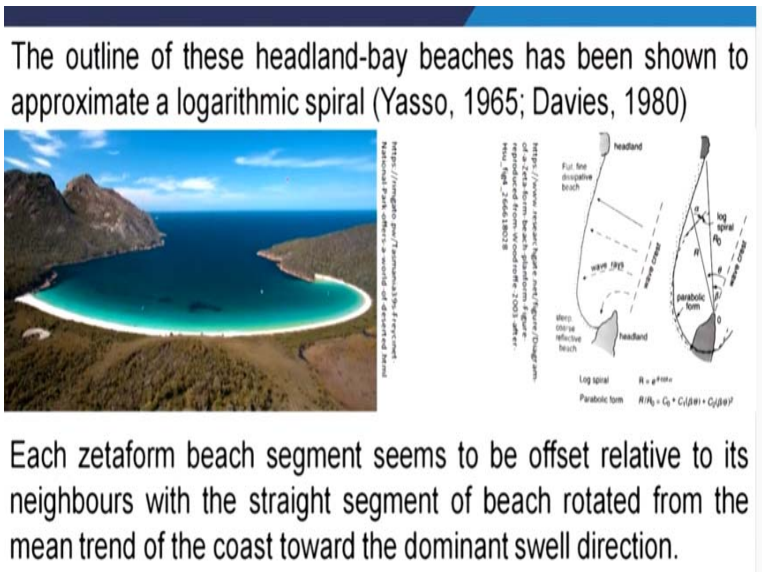

The outline of these headland bay beaches has been shown to approximate a logarithmic spiral and each zeta form beach segments seem to be offset relative to its neighbors with the straight segment of a beach rotated from this mean trend of the coast towards the dominant swell direction.

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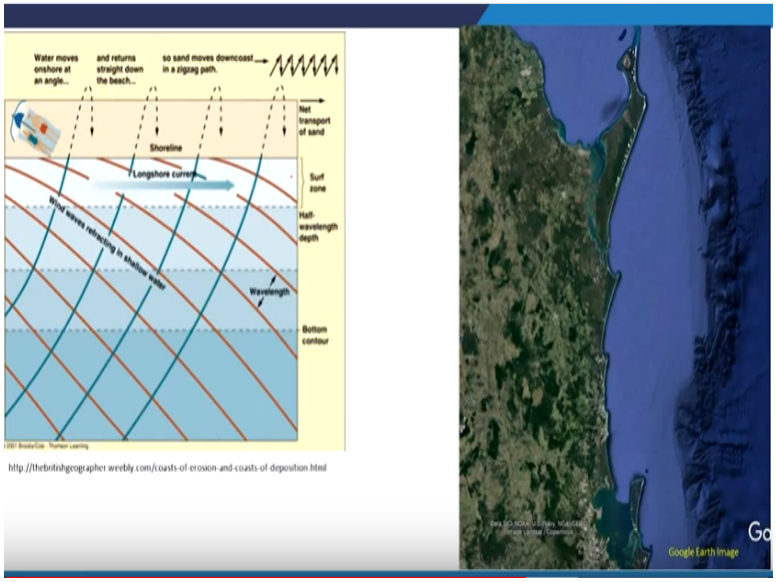

So if you see here this is a figure from Eastern Australia or New South Wales you will see the zeta form coast is like this. This type of wave refraction is there so that for a long time if wave interacts the refracted wave interact along these coast and these type of beach are developed and if you see here each zeta form one stretch segment is there another curve segment is there. Similarly one stretch segment another curve segment and each straight segment here it is mentioned each zeta form beach segment seem to be offset relative to its neighbors with the straight segment of beach rotated from the mean trend of this coast towards the dominant swell directions. So this is the science behind it.

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Then if we have a coast, we have refracted waves and each is dominant, so this is independent this is independent and that is why grain size, sorting and beach profiles all changes systematically along each zeta form beach. So that means if you take a profile along here if profile here a profile here these 3 profile will not match here the grain size will be different here are the grain size will be different. So we know this grain size is a function of this wave function of this tide current and the this depending upon this coast characteristics.

So that means for each zeta form the grain size will be different the sorting will be different the beach profile will be different. Each is nearly a closed littoral cell and the sand supply and movement although some sand probably drifts around this down wave headland to nourish the next beach. So here it is it is assumed to be a closed system here it is assumed to a closed system, but it is not too close it is completely closed or closed system.

So there are certain sands that can migrate from this system to this system or it will migrate from this system to this system. So zeta form coast of northern new south wales this figure is taken from google earth in Australia longest beach face of this dominant swell from the southeast and trend obliquely to the line connecting to the headlands. Here from the southeast this wave is coming up and it is refracting here and due to that this type of zeta form. So that means the long axis or this this part it is facing towards the refracted wave and finally it is forming such type of zeta form coast.

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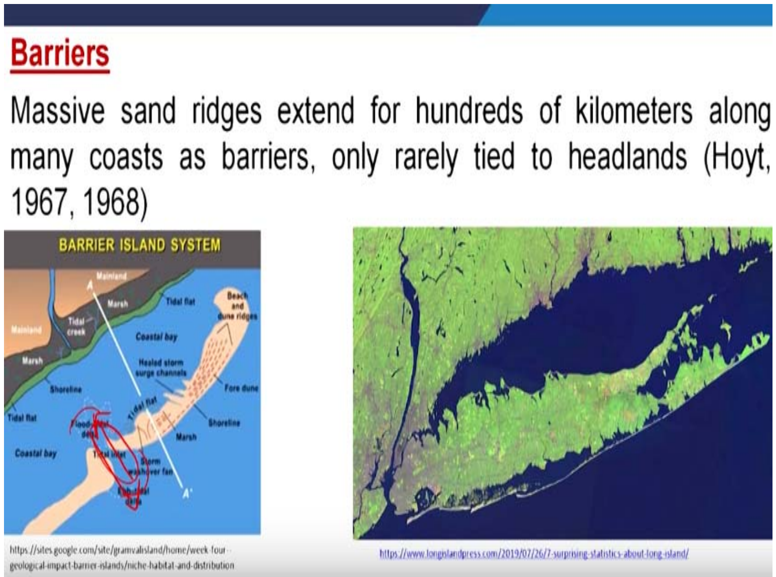

Then another component along this coast it is called barrier. So barrier that means it is like a ridge of the sand that is developed few kilometers or a few meters away from this mainland and this is formed due to this wave action as well this current actions. So again this barrier is not an continuous one there are some breakers there are some breakers within that. So there are some breakers for example this is called tidal inlet.

So during tide during high tide sediment will migrate in this way during low tide sediment will migrate this way. So we will find if ebb tidal delta then flood tidal delta so along this or across this bars across the barrier towards the seaside, we will get this ebb tidal delta and towards the lagoon side this side is the lagoon this is tidal flat. So towards the lagoon side we will find this flood tidal delta.

So this sand barrier this is also not permanent it migrates from one place to another. Along this coast it migrates across the coast also it migrates. So its stability and instability there depends upon the wave action depends upon the tide depending upon the sand supply. So all of those factors that combinedly work together to say whether this tidal barrier or this barrier will be sustained for what geological time or to what extent.

So massive sand ridges extend for hundreds of kilometers along many coast as barriers only rarely tied to headlands. So that does not mean so they need to headlands to tie between that. So they are independent they may or may not associated with the headlands, but they are their existence depends upon this wave and tide action and the sand supply to the coast. This is the satellite imagery if you see here and this is the barrier it is generating, and 1 barrier is again divided into 2 different segments.

So how this will happen either 2 barrier will consider to form 1 or they will divide into 2. ,1 variable divided in 2 that depends upon this mechanism of this sand supply mechanism of the wave action , the tidal action and river action like that.

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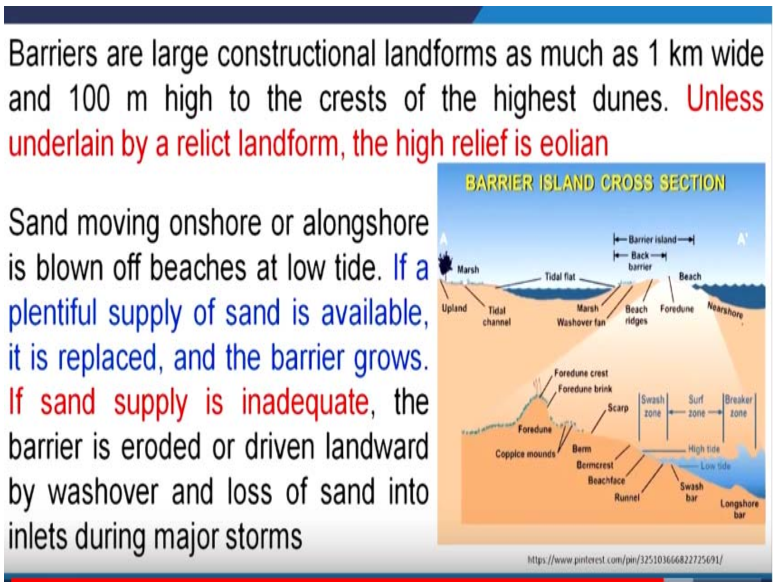

So barriers are large constructional landforms they are depositional landforms as much as 1 kilometer wide 100 meter height to this crest of the highest dune. Unless underlain by a relict landform the high relief is eolian. It is very much important to understand here so here you see this is a profile now see this is a barrier and through this barrier this part of this lagoon this is the lagoon, and this is the main sea.

So the lagoon is cut off from this main sea or lagoon is formed due to this presence of this barrier and its height is hundreds of meter and its length is hundreds of kilometer and width is about 1 kilometer or more. So at the top part of this barrier the free sand is there that can easily be moved by this wind or this near shore wind action. So that is why this drier parts which is above this mean sea level these are frequently modified by this wind action or eolian action.

So that means one part which is stable which is water saturated so it is heavy and another part which is the upper part which is a dry that is migrating that is continuously migrating due to eolian action. So sand moving on shore or along shore is blown of beaches at low tide and if a plentiful supply of sand is available it is replaced, and the barrier grows if sand supply is inadequate this barrier is eroded or driven landward by wash over and loss of sand into the inlets into or during major storms.

So now it is to understood here very clearly that the sand at the beach environment sometimes it will be redundant, or it is covered by this high tide and sometimes it will be exposed to due to the low tide. So once it is in the low tide condition is there so during low tide this eolian action are very prominent. So the sand will migrate from one place to another place so that is why if this sand supply is continuous sand supply is sufficient then barrier will grow.

Otherwise if the sand is not sufficiently supplied so this size of the barrier will gradually decrease and finally there will be a loss of sand from this barrier and eventually the barrier will vanish. So this is the mechanism how the barrier either it will grow, or it will vanish that depends upon this sand supply, depends upon the wave action, depends upon the wind action.

So I think we should stop here and the next class we will talk about more about how do the barrier grows and what is the mechanism, how to what extent the barrier can migrate and what is role to control or to contribute to the coastal geomorphology. So thank you very much we will meet in the next class.