Earthquake Geology: A tool for seismic Hazard Assessment
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Lecture – 51
Earthquake Geology: A tool for seismic Hazard Assessment

Welcome back. So, in previous lectures we were talking about the fluvial landforms. Now the another important geomorphic markets which is required to be like we should know is coastal landforms and coastal processes. So, in most of the areas along the coastline you will come across the beaches but along with that the beaches are the most common landforms which one can come across when the coastal region but along with that there are many other features which are the landforms which we should take into consideration.

When we are talking about the signatures if we want to look for the tectonics or climate so we will quickly look at what are these landforms being here we will talk about the deposition landforms and the erosional landforms and how we can take those landforms into consideration towards the end we will also talk about briefly about the corals because coral micro atolls basically tells us about the sea level fluctuation and that sea level fluctuation could be related to your climate or due to the tectonic uplift or subsistence.

So, that also we will look at and some of the landforms which we came across in Andaman and Nicobar, I will try to highlight those. So let us get started about the coastal processes and the landforms and this is a beautiful photograph from Andaman Neil Island.

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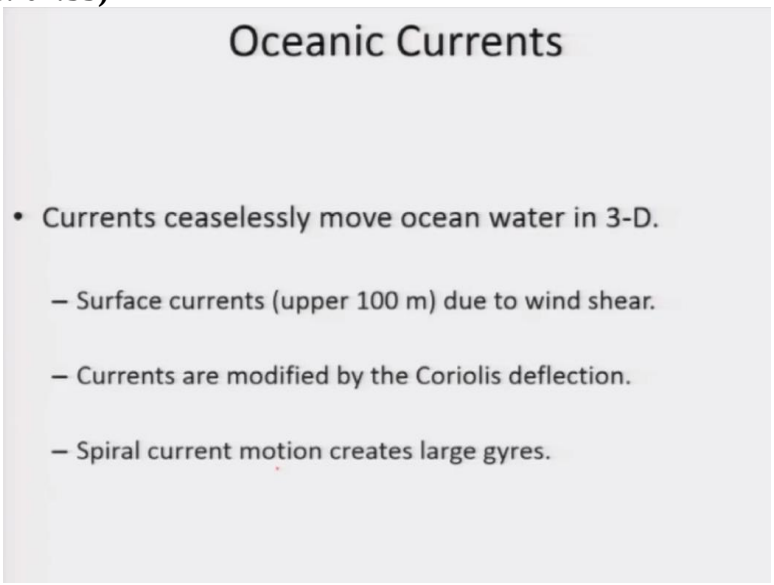

Now oceanic currents usually we see that they are keep developing ceaselessly because they and keep producing the circular pattern. So, currents ceaselessly move ocean water in 3 dimension and the surface current in if you talk about in the uppers 100 meters, they are moved due to the wind shear current currents are modified by also the Coriolis effect plays an important role. Hence, you will find the different direction in terms of the motion in the northern hemisphere and the southern hemisphere and further they keep having a very typical circular pattern in terms of the motion.

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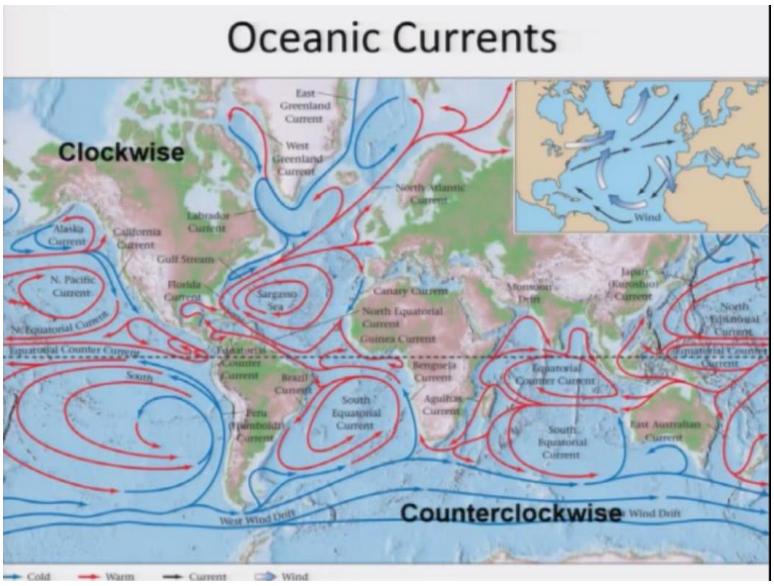

So, if you look at if you divide the globe in the northern hemisphere and southern hemisphere than what we see is the northern hemisphere mostly will have the clockwise circulation of the ocean waters and in the northern hemisphere will have counterclockwise direction.

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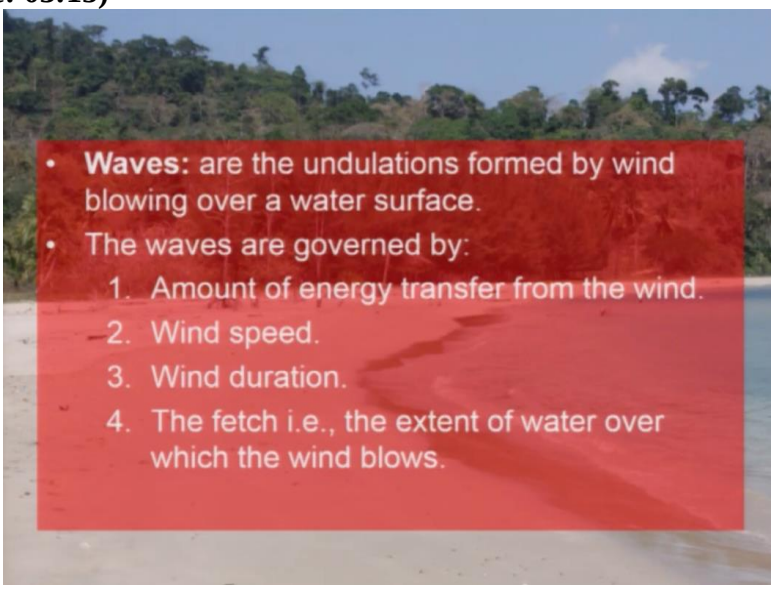

Now, this currents basically and along with that the waves which have been generated and which we see the wave action along the coastal region will play an important role in sculpturing the landforms in this region. So, basically the waves are the undulations formed by wind blowing over the water surface. The waves are governed by followings the amount of energy transferred from the wind, wind speed, then wind duration and the fetch that is the extent of water over which the wind blows. So, this will control the waves which are done in generated an ocean in any ocean.

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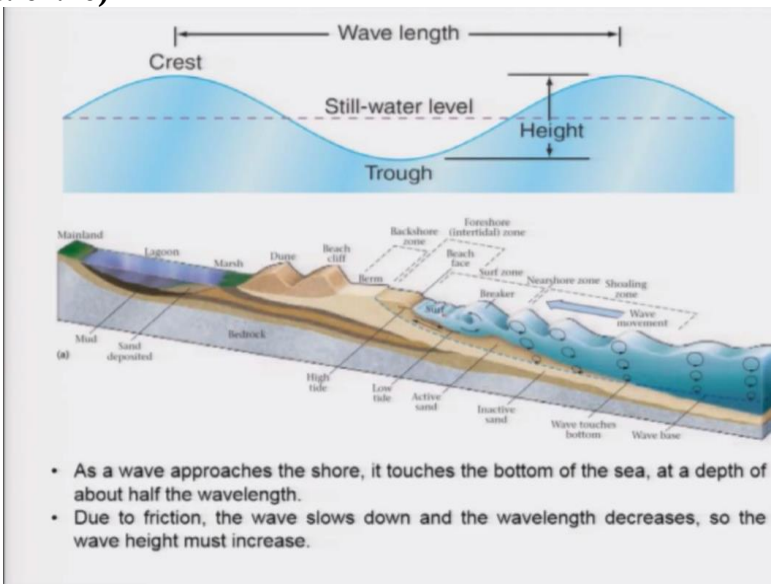

Now, if we look at the wave motion and ocean, then we will see a sort of a very typical sinus nature, you have crest and you have trough here and the height of the wave have been measured with respect to the height between the trough. So, this is important for us because we are going to talk after looking at the coastal landforms we are going to discuss about the tsunamis. So, this is important for us.

So we are the pattern of the motion of the waves are important for us and along with that, the typography that is what we call the bathymetry is also important, which also helps in developing different landforms along the coastline. So, mostly what we see is that we have the beach formation close to the on the onshore region and then further where you have the interaction of the tides. So, basically we will look at the intertidal region and the beach area where the wave comes and goes back and will result into the formation of the beach.

At the same time what we have either we have the deformation of the beach dunes because of the alien activity in the region or the formation of the beach ridges because of again, the high tide and low tide is and behind the beach ridge are the beach dune. Then you will have a marshy area which we term as and back marsh or the Laguna Lake area and then finally you get into the land portion so, the importance which we will consider in our studies when we talk about the tsunami inundation.

And all that, then we are concerned about the high tides as well as the low tide at also and then what is the topography, the coastal topography or coastal geomorphology in that particular region. So, as a wave approaches the shore, it touches the bottom of the sea at the depth of about half the wavelength. So, let us see. So, wavelength basically we will talk about this whole feature. So you have the, the crest trough, and then you have the crest. So this whole portion will be considered as an wavelength of the wave.

And we will learn in the when we are talking about the tsunami that the when the tsunami waves are generated they have very large wavelength they are not as shorter or smaller as compared to what we see in the normal conditions. So, due to friction, the wave slows down and the wavelength decreases and this is what we are talking about when they approaches the coast. And so, the wave height must increase close to the coastal areas.

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So, wave refraction is also an important aspect to which will which plays an important role and information of the coastal landforms. So, the important part is that how the wave approaches and whether the waves are approaching directly or they are getting reflected from the coastline.

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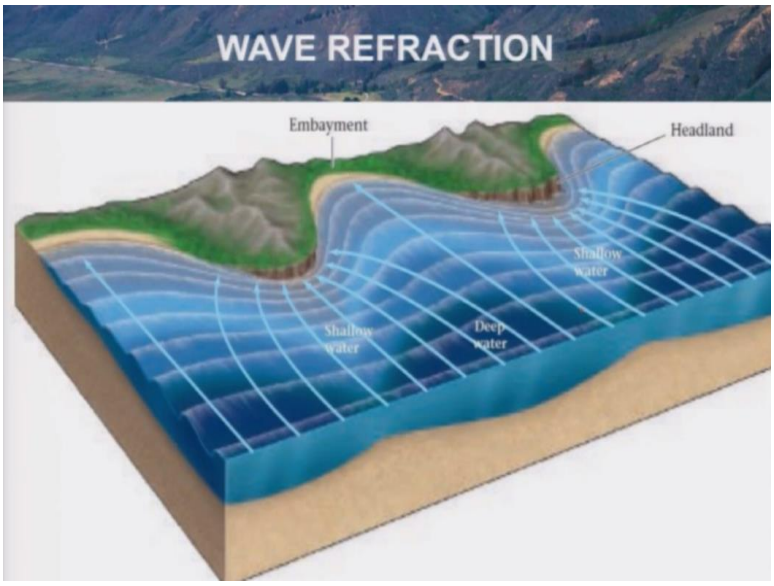

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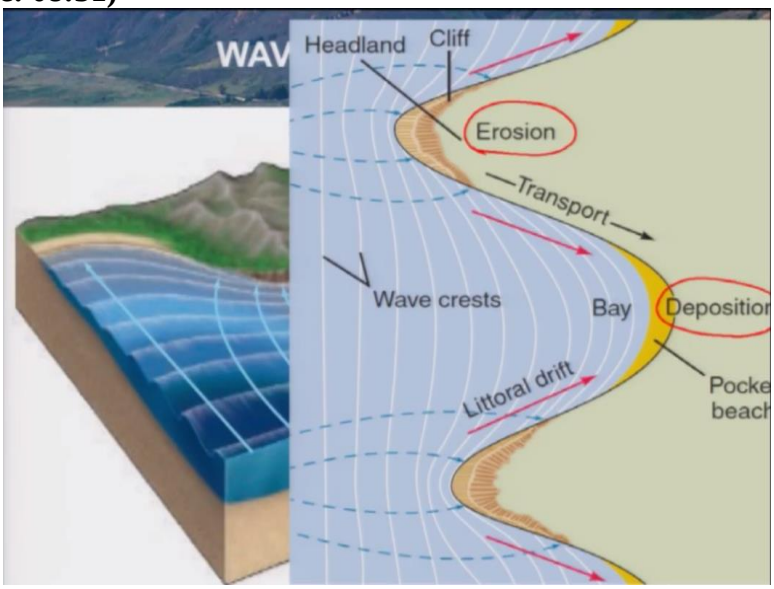

So, for example, if you look at this one here, so, you have the waves which are approaching directly here, whereas, here the waves are getting diffracted or refracted. So, you have the landforms which will be associated with this will be you will have the headlines which will formed in this region various this portion because of the refraction or the deflection of the waves, you will find the formation of the beach and all that in the Bay area.

So, again here what we see is the polishing erosion and the deposition portion. So, if you just recall this 1 then what we have is that this is the Bay area, so we will have to position in here. So, we see that the position here and this portion your headland is your erosion. So, erosion or

something into the formation of cliff cliffy coastline, headlands and then the position in the Bay area or a pocket or we see the beach.

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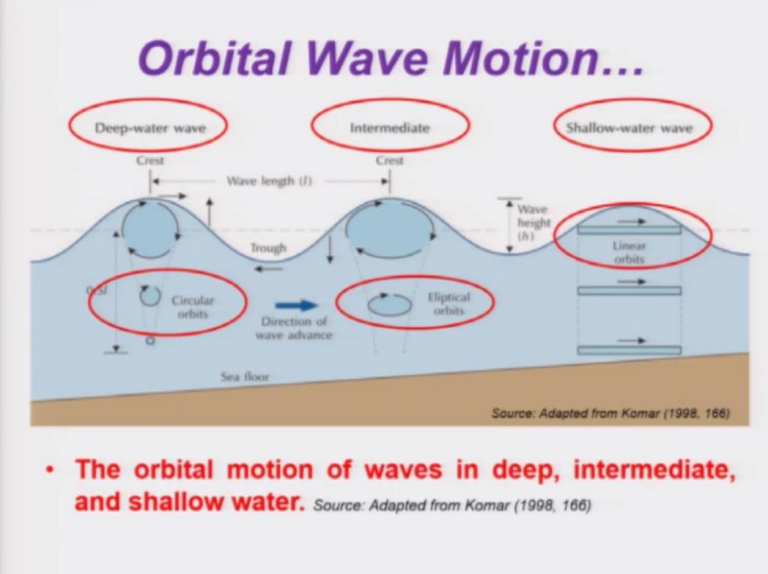

Now the orbital wave motion if you take then the wave motion will vary from place to place right from the deep waters intermediate and shallow waters, it will not be the same throughout. So, this we have discussed initially that we have crest we have trough and crest. So, this will be able to wavelength and so, in the deeper part, what we find is the motion is mostly deeper part we will have circular motion and the intermediate part will have elliptical and in the shallower part will have almost a linear motion.

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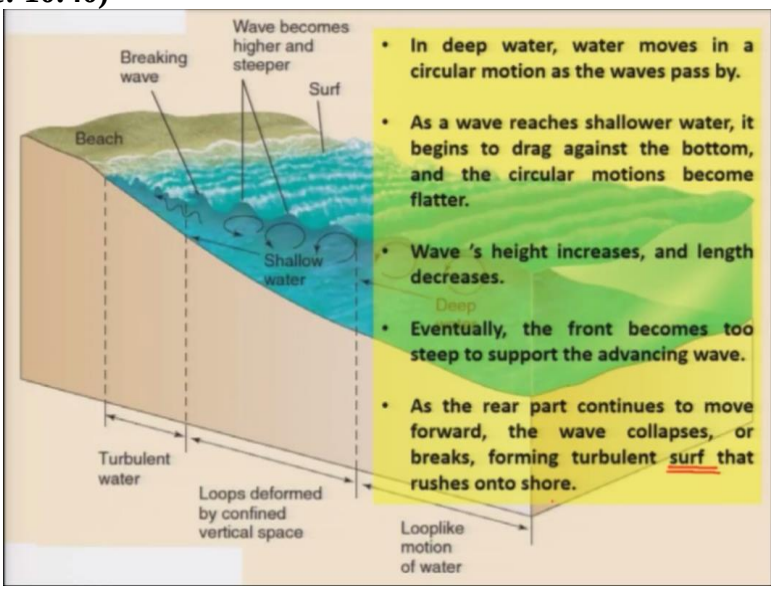

So, again if we look at so, we have circular motion, we have elliptical motion and we will have flee in motion it just waves are going and coming back here. So, deeper waters water moves in a circular motion as the wave passed by as the wave reaches the shallower water it been to drag it begins to drag against the bottom and the circular motion becomes flatter again that leads to the almost linear motion.

So, waves height increases and the length decreases eventually the front becomes too steep to support the advancing wave as the rare part continues to move forward, the waves collapse or breaks. So, that is what we see the breaking in the waves close to the coastal. So, the collapses and the wave breaks forming turbulent surf so this in some areas you will find this there is a formation of surf that rushes on the shore area.

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So, this is an example what we gathered from Andaman. So, this what we have is the headland. So, let us see quickly what are the coastal landforms has to tell us about. So they are related to sea or ocean and the land contact. So landforms are basically the result of one sea level fluctuation, second high sea and during the interglacial period and low sea during glacial period, so this will also be reflected in the coastal landforms and then the sea waves erosion or erosion caused by wave action.

So, mainly the tidal waves will also play an important role in as we have looked one example, in terms of erosion as well as the deposition. So, of the most important is the sea level fluctuation.

So, sea level fluctuation, as I was telling this could be due to the interglacial. That means you are having the warmer climate and glacial you are having cold climate. So, this in this case, the integration, you will have high sea because of more of melting of ice and more water getting into the ocean.

Whereas during the glacial period, it is an older period, so more of glaciation and less water getting into the ocean so this will change the sea level. We will have different landforms which are been created or the level of landforms will be seen at different elevation because of the wave action and then the finally what we see the tectonic moment. So, suppose we are having the coast here and then you have like the land form here.

And then you have the water coming up to this suppose you have now lower down the sea then this portion will get exposed and you will have the ocean somewhere over here. So, then the erosion will take place in this region. So, this can be seen in the normal climatic fluctuations during integration glacial but suppose there is not this change or the area is getting elevated because of tectonic uplift or subsidies then you will have also you will see that the erosion or the wave action will have different level of erosion and that will result into the formation of the landforms at different level.

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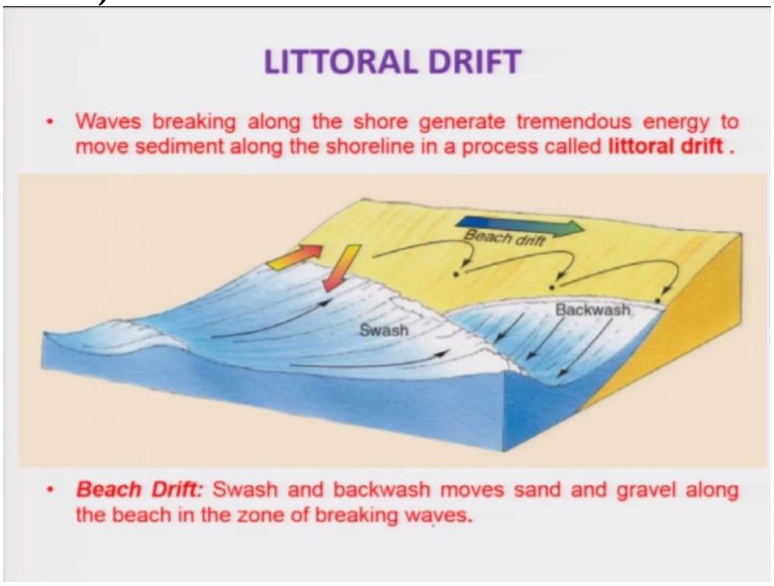

So, before getting into the other details, let us see a few more landforms because that will help us when we are trying to interpret our the palisades signatures or the tsunami signatures in the

coastal region. So littoral drift basically waves breaking along the shore and generates tremendous energy to move sediments along the shoreline in a process called littoral drift. So, you have the sediments coming in and then going back and then like so, the water comes up and then goes down.

So, there is a drift in the, the sediments which will be, which will play an important role in the formation of beaches. So beach drift. So you have swash and backwash. So you are having to wash the water in the sediments coming in and then backwash. So, that moves sand and gravel along the beach in the zone of breaking waves.

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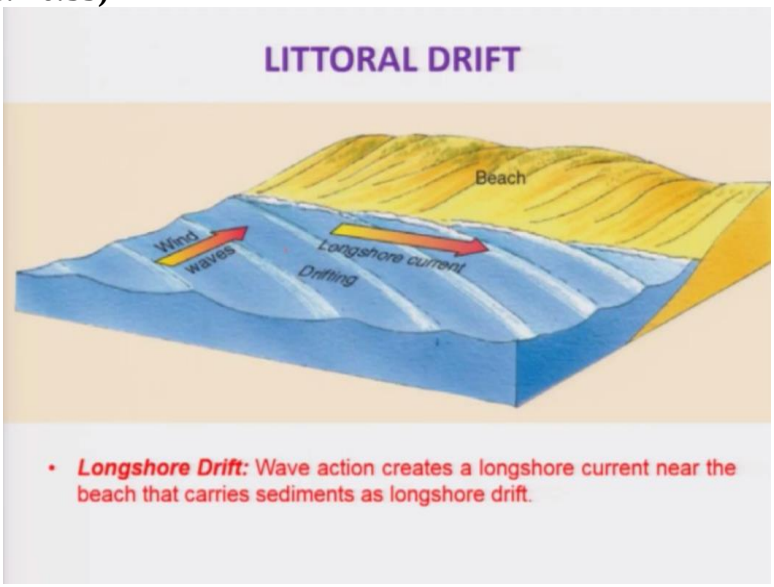

So, a littoral drift if you are you have like a longshore current. So usually the currents or the water will flow of the goes up and comes down like that. So it will keep on having the drift in this direction. So that is what we call longshore drifting are longshore current drifting. So in case of longshore drift, wave action creates a longshore current near the beach that carries sediments as longshore drift. So, like, in some cases, people talks about that if you want to when you are swimming here should not swim straight you should stream in the direction of the longshore currents so that you can easily with less power you will teach the beach.

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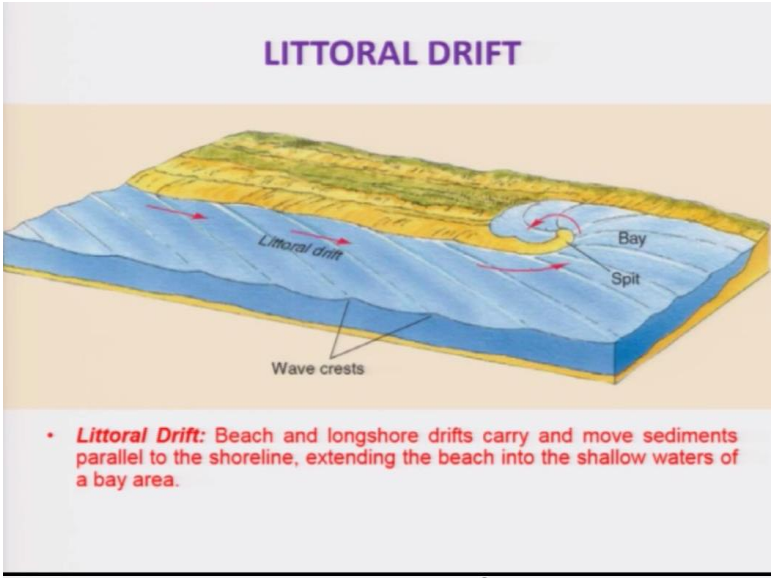

So there is another example here and because of the littoral drift of the wave action waves and the sediments which are carried and getting deposited, you will find the formation of landform which is been termed as spit. So littoral drift beach and longshore drift carries and moves sediments parallel to the shoreline. So, this is the shoreline it will carry them the deposit the sediments parallel to it extending the beach into a shallow waters of the Bay area. And this land form which has been generated, it is been termed as split and the enclosure here, a small one has been it is been termed as the Bay area.

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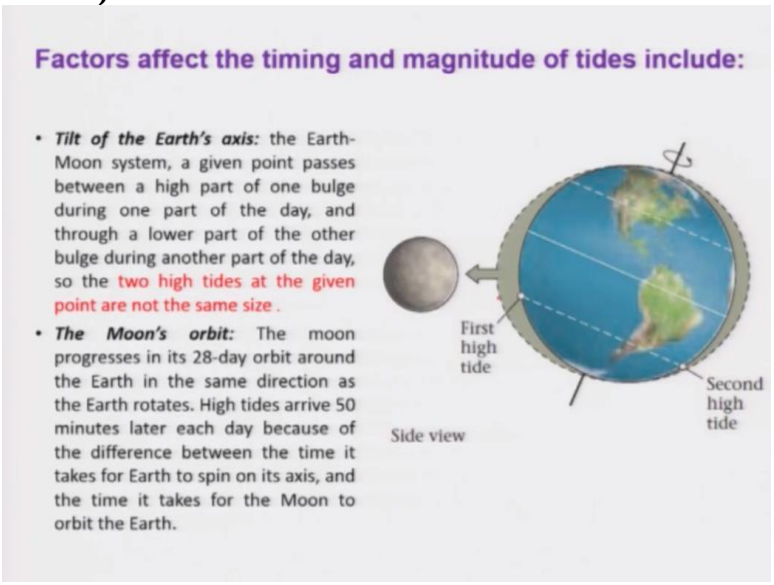

Then another important part which we have I will just quickly browse through is the formation of the tides and we all understand that the tides we have high tides and low tides and we

experienced the high tide and low tide at the same location and that is because of the traction of moon earth.

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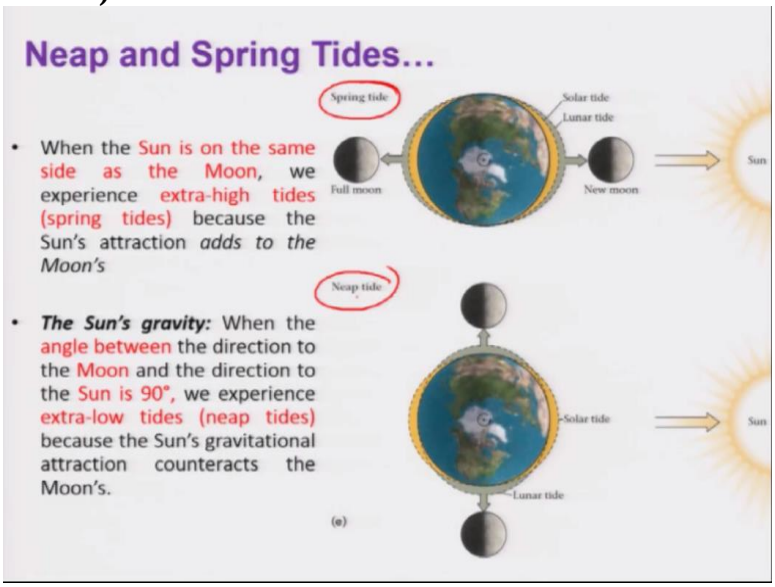

So we have the neap tide and we have spring tides. So the neap tide basically if we take, so you have the neap tides and the high of the this neap tide and spring tide. So, when the sun is on the same side as the moon we experience extra high tide that is what we call as in spring tide because the sun attraction add to the moon so attraction whereas in the case of the neap tide we have the when the angle between the direction of the moon.

And the direction of the sun is about 90 degrees and in that situation we experience extra low tide that is we term that is a neap tide. Now, the high tide or spring tide so mostly this is important for us when we are doing the tsunami surveys or the investigations, because we need to look at that when exactly we will get the lowest low tide that is your neap tide. So, we try to look at the tidal charts and then fix up our plants during out of plants of the survey during that period.

Because then we will be able to expose see the exposed tidal areas otherwise during the full moon or the higher high tides, then we would not be able to look at the tidal regions along the coast. So, for us, this is important, so, we will just go ahead with this. So, just keep in mind about the, the spring tide and the neap tide so, neap tide are the extra low tides and the spring tides are extra high tides or we can say higher tidal level or this is lower tidal level.

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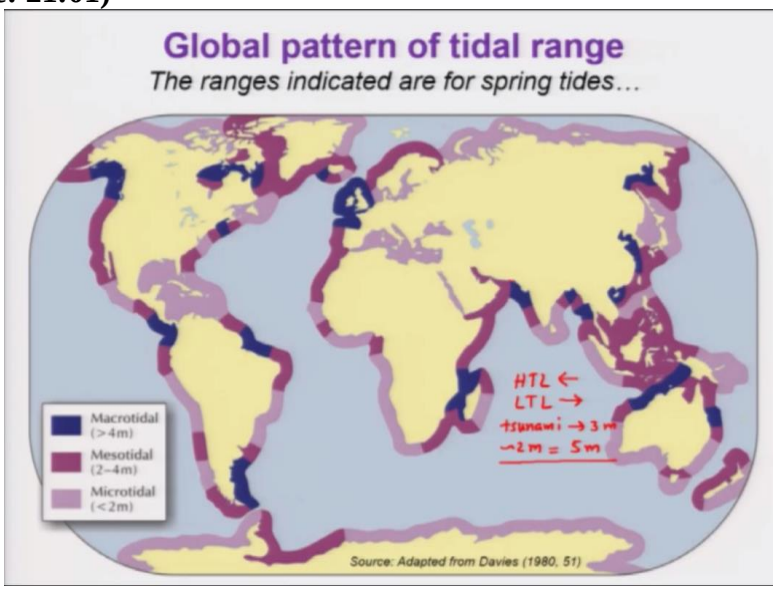

So, different locations will have like different along around the globe will have different tidal range. So, for example, here the dark blue shows the tidal levels which are greater than 4 meters. So and so tidal levels are between 2 to 4 meters and micro tidal is less than 2 meters. Now, this part is important again for us when we are if suppose, you expedience. So, this is the part of the India and this region is the area where you have the highest tidal range which goes above 4 meters and close to this course this is Gujarat region.

And this Gulf of Cambay and this portion is Gulf of Kutch. So, in this area you have more than 4 meters of tidal levels here. Whereas, if you if you move along this then we are having the tidal range which is close to 2 meters in Andaman region. Now this is important for us because now along with the what we were talking about the high tidal level or low tidal level so, lower low tide or higher high tides.

But along with that general the tidal levels are important because when the tsunami is it is been triggered and if the tsunami has been triggered at the high tide level. Then we will have more of inundation in the region. So the or and in the during the low tide region, then the inundation will be comparatively less because whatever the height of the tsunami is, for example, we are having like around 2 meters of the tidal and in the tsunami is also like 3 meters

then the tide levels will be almost like you can add this and then you have 5 meters of tide level which is really, really dangerous. This is just for the example we taking. So, the region of India mostly in this area, we have very high tide levels and we have the, the source for the tsunami from here that is here makran subduction zone.

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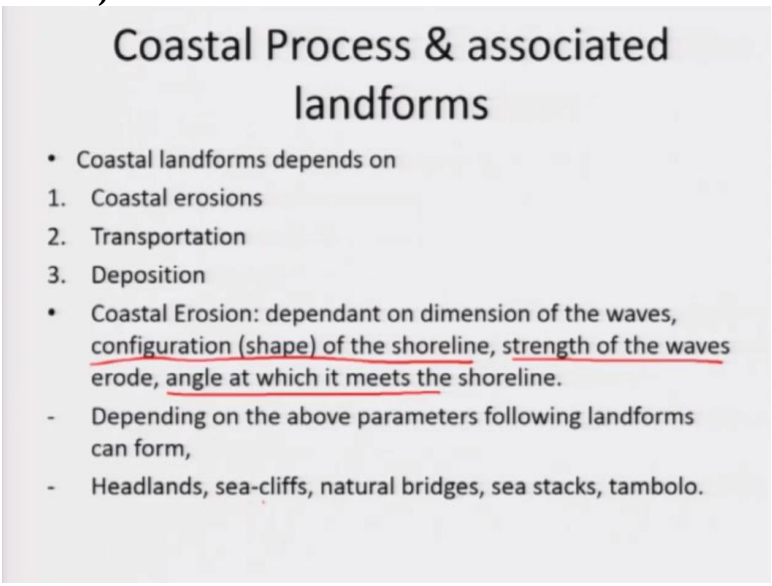

So, we will discuss about that, which are the subduction zones in the in the area now, the coastal processes and associated landforms. So, coastal landforms depend on 1 coastal erosion and then transportation of the material and the deposition. So, coastal erosion depend dependent on dimension of waves configuration shape of the shoreline strength of the waves to erode angle at which it meets the shoreline. So, what we were talking about the waves coming in and getting directly with respect to the shoreline or they are getting refracted.

So, that will add or result into the formation of the landforms either it will erode or deposit. So, shoreline configuration is important along with the this strength of the waves appear. And so, the if you combine this 2 then we will talk about that what angle it will meet the shoreline. Now second depending on the about parameters following landforms can form one is headlands, sea cliffs, natural bridges, seas stacks and tambolo. So we will see one by one a few of them and then we will move ahead this one.

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So, coastal landforms if we look at in terms of the erosional, coastal landforms, then what we see is the sea cliff, shore platforms, notch, sea arch, caves, marine terraces, stacks, and wave cut bench.

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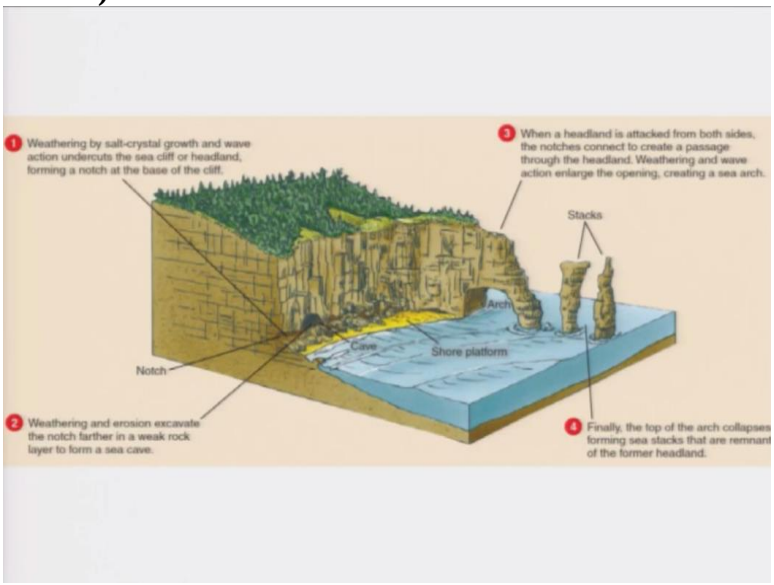

So, this shows the few of them. So, you have like 1 here, what we see as the weathering by the salt crystal growth, an action underrating of this so basically this is showing you the formation of the sea cliffs our headlands and then the undercutting here is the sea notch in my upcoming slides. I will talk about sea notches here and why this is important? And then some locations due to the erosions of the headlands in between this will give an impression of the gateway or the

arcs which have been formed and then we have the stacks, which has been left out eroded portion and looks like and or give an impression of pillars in most of the areas.

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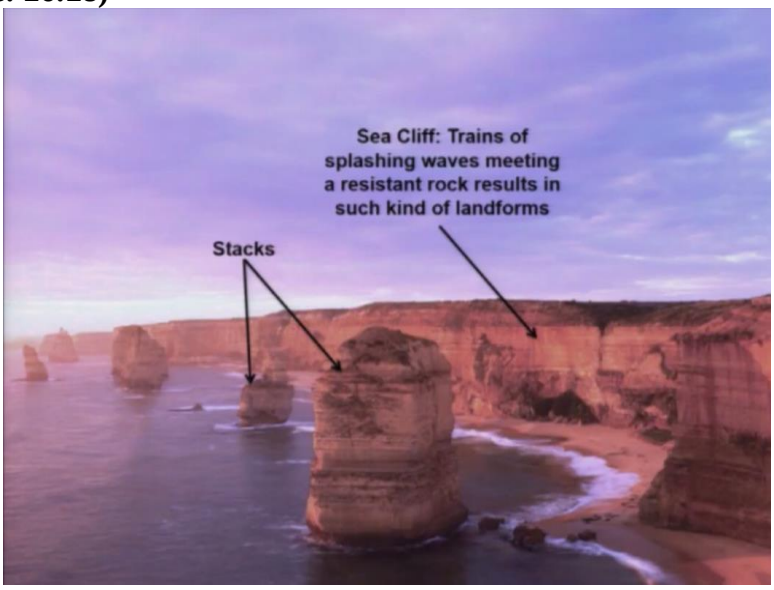

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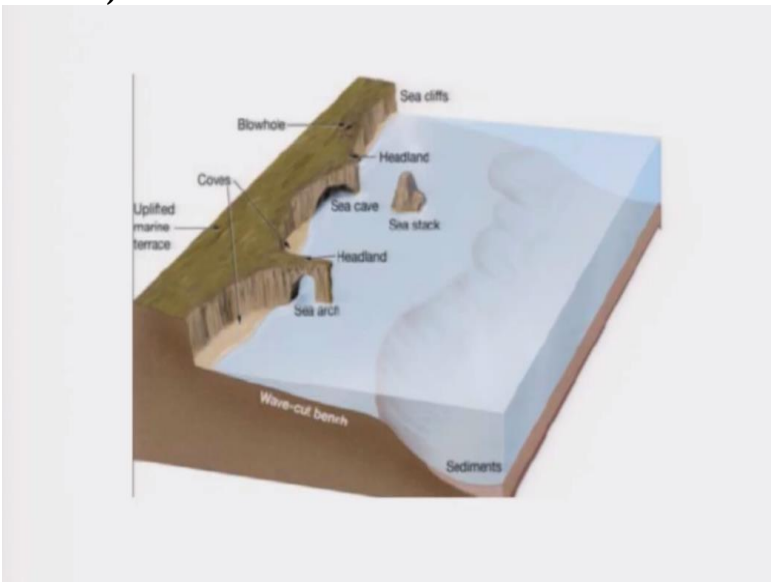

So, this is an example again of the cliffy sea banks, you have stacks here. So, you have this one is your cliff sea cliffs and these are your stacks. This comes under the erosional landforms. So, arc or the gateways we have the sea arcs headlands sea caves, sea stacks and so on. And along with that, the one of the important is what we call the flat surface again which is the part of the sea cliffs game is the your uplifted marine terraces.

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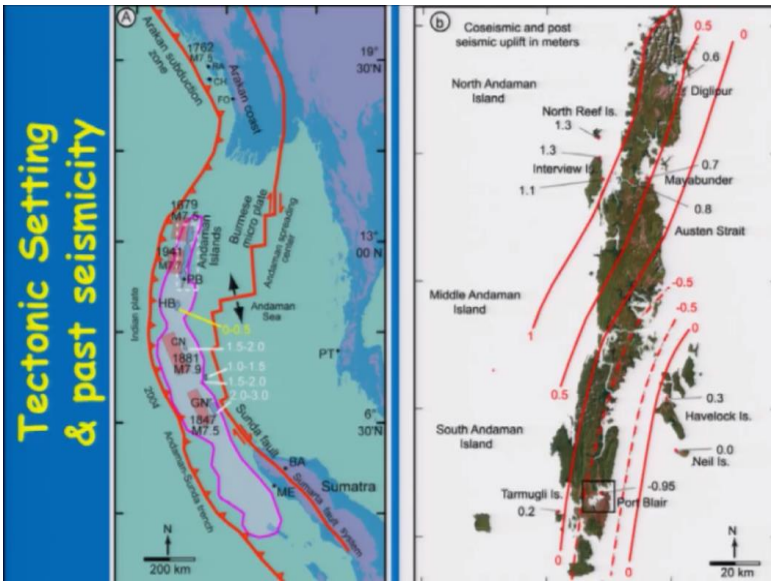

So let us talk few examples from Andaman so this is what we have the tectonic setting of Andaman we have Andaman Islands he is right up to this the southernmost tip of Andaman and then we get into the Sumatra area and this portion is the trench. So if I take the cross section here, then we have the plate subducting below and this portion is riding on the top. So Andaman is setting somewhere over here like that so this was Andaman and Nicobar Island chain. So, before we get into that, very quickly, I will just talk about this.

So, what we did in 2000 after 2004 earthquake, we surveyed this whole area. And we, measured the change in the land level because of the tectonic movement because 2004 Andaman earthquake was one of the largest earthquake so far experienced here, as per as the historical data, but of course, we found many more of similar magnitude. But what we did was then we measured the land level change which took place around here.

And in this particular area, we also collected the data which were been like the collected by different teams. And what we found was this was the zero line, the pivotal line where no change took place, but this portion because of the push from the side that is from this side here the plate which is subducting below. So the island got tilted. So this portion which is showing the, the minus sign the Medias which subsided and this portion which shows with the positive 1, I have got uplifted.

And I will discuss this in further detail when we are talking about Andaman. But in the next lecture we will talk more about the devotional landforms as well as erosion landforms quickly. Thank you so much.