Geomorphology
Prof. Pitambar Pati
Department of Earth Sciences
Indian Institute of Technology - Roorkee

Lecture – 35
Coastal Geomorphology - III

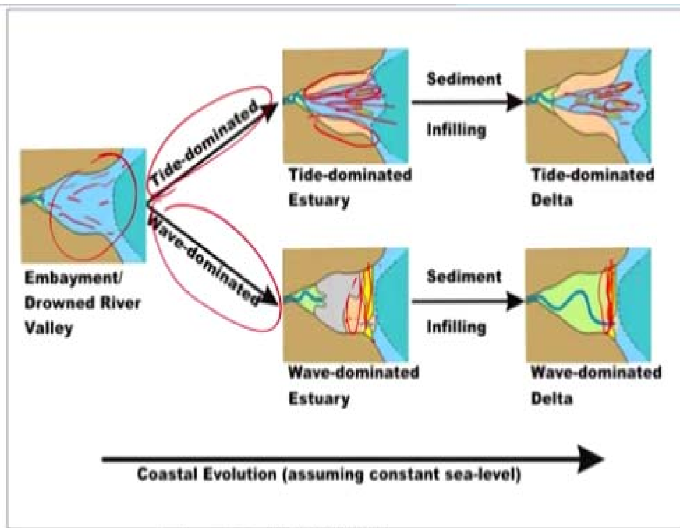
So friends, good morning and welcome to this lecture series of geomorphology and today, we will continue with this coastal geomorphology part 3. So, if you remember our last class, we are talking something about this coastal geomorphology and which we described there are 3 principal agents in the coast they constantly modify the geomorphic process and landforms, so these are mainly the tide, the wave and the wind.

So, wind is everywhere present because it is a junction between these water mass or the huge water mass as well as land mass, so wind will be present everywhere but these 2 other factors like this wave and the tide, some coasts they; out of these 2; one is dominant, so that is why we can classify the coast into wave dominated coast and tide dominated coast, so that is why the landforms; the landforms orientation, their characteristics, their grain size, their structure all those are they are influenced by either tide or it is by wave.

This tide generally, it behaves like a lift to make this or to take this wave to either to this height or to this height. During high tides, this wave action is felt somewhat above 4, 5, 6 meters above or so depending upon the height of this tide and during low tide, the wave action are the level of the wave action that decreases to certain level and we were discussing in the last class, where this in Canada there was the tide action, it is, which is 16 meter height has been recorded.

So that means, if in a high tide, the waves are at a higher level so, the erosional, the transportation whatever this wave action is due to wave action that will be felt at somewhat higher level and during low tide, this wave action will be felt at a lower level.

(Refer Slide Time: 02:59)



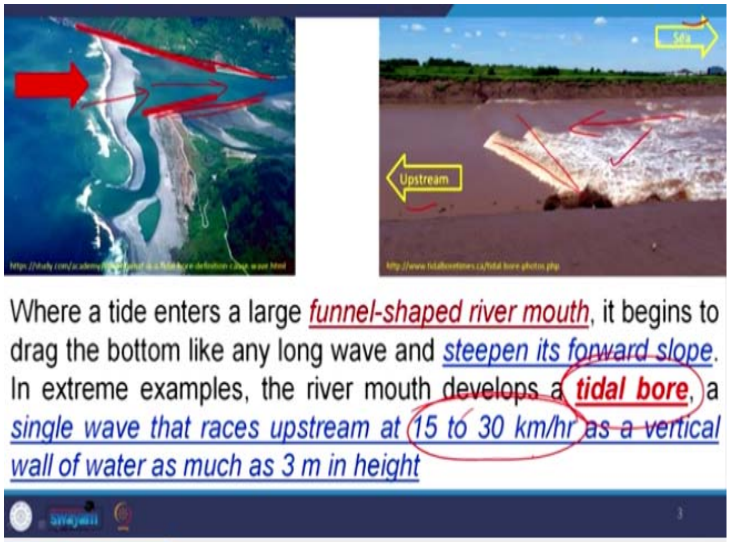
Here, in this figure it is illustrated that suppose, we have a river which is debouching its sediments at the coastal part here, so either this coast is wave dominated or type dominated, depending upon that the landforms in this area will be designed so, so if you see here suppose, this is the river mouth and this is a tide dominated one, so tight it moves up and down like this.

And finally, whatever these sediments transported and deposited by the river here due to the tide action, they will form these elongated shapes similarly, the sand, silt, clay whatever the sediment is there now, you see they are forming some of these landforms which are parallel to this tide and if it is wave dominated coast, then whatever the sediments deposited here you see, this orientation, this structure it is parallel to the coast here.

However, it is perpendicular to the coast depending upon the angle not necessary it will be perpendicular or parallel, depending upon this tide action or wave action similarly, the sediment in filling here, the depositional systems if you see here so, these depositional systems mostly they are perpendicular or according to the direction of this tide. Similarly, wave; they are always coming from this oceans and it hits at this coast.

And finally, whatever this landforms they are forming you see, it is parallel to this wave action, so that is why the landforms, the structures and this erosional system, the depositional system of a coast, either it will be dominated by this wave or it is dominated by the tide but wind is present everywhere.

(Refer Slide Time: 05:04)

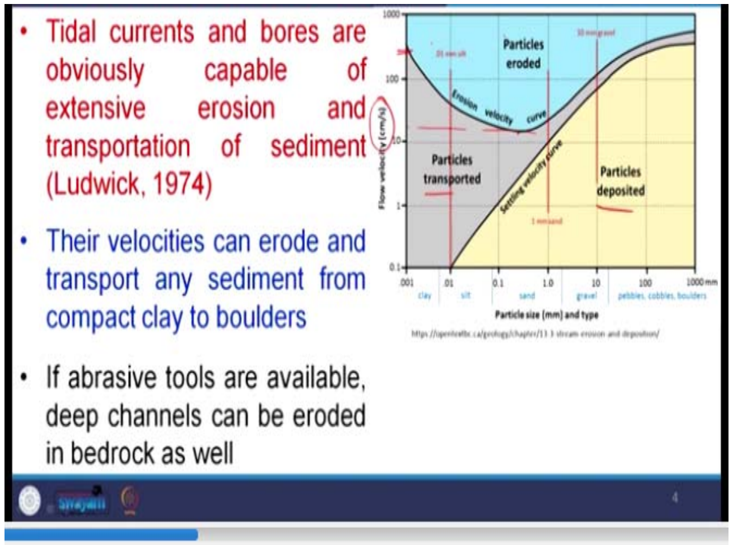


In particular example, another type of structure which is mostly the tide dominated, it is called tide bore or tidal bore. Tidal bore if you see, these 2 photographs are there, the first photograph it is shown, it is a funnel type river mouth and during high tide, water will pass from this direction to this direction with a high speed and depending upon the tide height, the water; the whatever the tide height will be there, the same height the water will go inside the landmass through the river mouth.

And here in this photograph it is shown you see, how the tide is intruding into the river system, this side is the sea and this side is the upstream of this river and you see, this sea water it is intruding with large waves and due to this intrusion, it will create an erosional feature or it will erode this river mouth and finally, with subsequent erosion for a long time, this river mouth will be a deeper one.

So, where the tide enters into large funnel shaped river mouth, it begins to drag the bottom like long wave that is steepens it forward slope, in extreme example is the river mouth which is called the tidal bore. So, tidal bore is a single wave that raise of stream above to 15 to 30 kilometre per hour, it is very important to note it is here, the wave speed it is 30 or 15 to 30 kilometre per hour is a vertical wall of water about 3 meters or more than 3 meter so.

(Refer Slide Time: 07:13)



So, now the question arises if this is the water; speed of water so now, if we transfer this idea, transfer this value into this erosion transportation and deposition field, here if you see we have this erosional field, this transported field and this is depositional field now, you see here the erosion starts and erosion starts around 10, this is 100 so, it will be around 30 or so, 30 centimetre per second.

So, if the water velocity, it is 30 or water speed is 30 centimetre per second that means, the sand particle will start eroding similarly, if it is about 500 centimetre; 500 centimetre I am saying, 500 centimetre per second, then it will erode these gravels and the clay particles but here, we are discussing something about the water speed about to 15 to 30 kilometre per hour. So that means, that much speed is enough to erode any kind of sediment, any size of sediment from the river mouth.

So, that is why due to this high speed of water, so the river mouth is totally eroded and all those sediments being removed from this river mouth and the river mouth becomes clean and becomes deep, so this tidal currents and bores are obviously capable of extensive erosion and transportation of sediments of all kinds because its speed is much, much, much higher than this erosional level, whatever we have defined for the erosion.

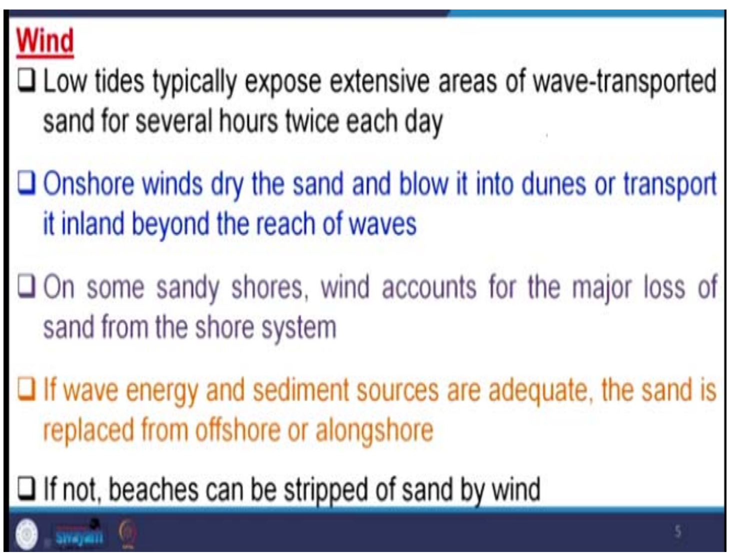
So, their velocities can erode and transport any sediment from compact clay to boulders, so generally, boulders are not found in deltas however, some of these delta which are called fan delta that means, here the sink and the source are nearby, those areas will find this conglomerate, these boulders on these river deltas. So, that means, if abrasive tools are available, deep channels can be eroded in the bedrock as well.

So, that means not only this tide of this much speed or this much velocity can erode this deposited sediment but if we have sufficient amount of angular fragments available that can also erode the bedrock and there are examples in worldwide that the bedrock of this river mouth showing some of the strips parallel to this tide and due to this type of abrasive action of the river of the tides.

Then after this 2, that is the wave and tide, this we have already discussed the wind is present everywhere, most of this wind action in elaborate way we have discussed in our arid zone geo morphological process however, some of these points are very important to discuss here. First is during low tide, this coast is exposed; extensive exposure occurs because water level of this ocean, this goes much beyond and that is why the extensive coast is exposed.

So, this due to this exposure that is twice a day because high tide and low tide they occurs twice a day, so due to this extensive exposure, it forms a free field to act the wind, so wind will act freely on this freely exposed surface, so whatever the sediment it will be there, either sand or silt or clay that will be easily interact with this wind action and will be transported and deposited somewhere else.

(Refer Slide Time: 11:19)



So, onshore winds dry the sand and blow it into dunes or transport it inland beyond the reach of these waves, so whenever you go to this coast, you will find there are dunes. So, dunes are nothing and a dunes that dunes are far beyond the reach of this wave, so those wind; these are these dunes which are formed by wind action and this sediment are supplied by this type of shore.

And on some sandy shores, wind accounts for the major loss of sand from shore system, so not only it will transport landward, it may transport to seaward also because in each day we have in a morning and evening, the day time and an evening time, we have reverse in wind direction, so due to this reversal of wind direction, there will be to and fro transportation of sand, so that is why some of this sandy shores, they totally loss of sand occurs due to this type of wind action.

If wave energy and sediment source are adequate, the sand is replaced from the offshore or along shore, so that means sand it will be transported and deposited either offshore or it is along shore, so that means the depositional system, the geomorphology along this coast will sufficiently change by this wind action, if not beaches can be stripped of sand by wind suppose, we do not have sand.

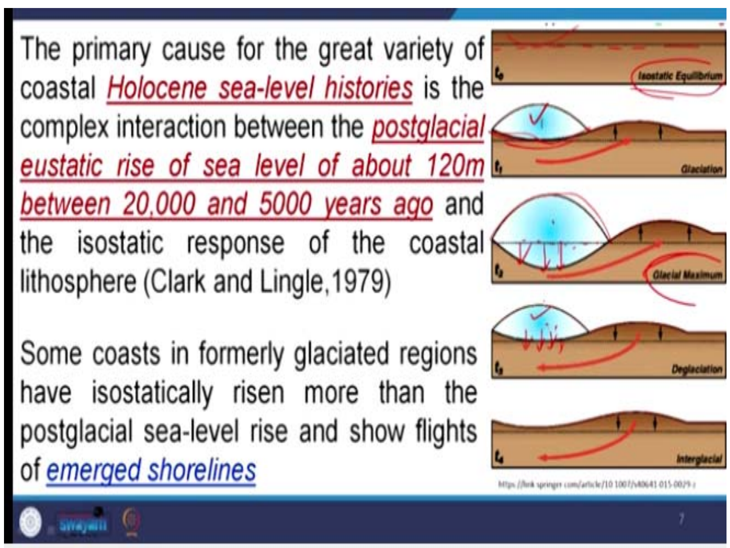
So, once there is no sand, so that means it is totally clean, so beach is stripped off by sand, there is no sand available, only this rock mass or the bedrock is exposed.

(Refer Slide Time: 13:10)

Now, we have already discussed this role of waves, the role of tides, the role of wind in defining the landscape of this coastal system. So, how they works we have already discussed. Now, what are the landforms they formed; either it is tidal land form or it is wind land form or the Aeolian land form or it is wave dominated land form, so what type of land form, how they look like and what are the processes involved in there formation, we will discuss it here.

First is we will start with erosional landforms; erosional shore zone landforms how, erosion zone modified these coastal landforms, we will discuss it here, if you see this photographs given here, this is it is looking like a wall like structure, so this is an erosional land form similarly, here if you see this is a natural bridge that means, it is totally eroded system and this is occurring a natural bridge here.

(Refer Slide Time: 14:26)



So, these are the erosional landforms and what else are there, we will discuss here, so see, this present-day landforms along the coast as we have discussed earlier also, these present day landforms are not the product of present day or the Holocene only, some of these landforms they are relate or exhumed landforms for example, if we see the present day river mouth, we will find there are many parallel bars; parallel bars along this river mouth.

So, those are nothing these are the relate of this coastal system, when the river or the marine was somehow inside the present day landmass similarly, if you go to this Holocene, the initial stage of Holocene or the Pleistocene Holocene boundary, during that time we have maximum coastal place, maximum earth, part of this earth, it was glaciated and once we are loading glaciers at a particular place, we are creating isostatically imbalanced filed.

So, during loading, this part of this crust now if for example, if this is the model given, now here this isostatic equilibrium rise that means, this is the compensation level now, here we are adding ice, so once we are adding ice now, you see we are; here we are creating a depression, now see here we are creating a depression, with more and more loading of ice, we are going much beyond the compensation level.

Because it is the compensation level, so we are going much beyond the compensation level now, suppose due to interglacial period, due to increase of temperature and climatic change, we are decreasing glacier mass. Now, you see the mass of the glacier is decreased, so once the mass of the glacier were decreasing, so that means whatever we have placed here, whatever the land mass or whatever the area we have placed here beyond the compensation level, we will try to increase it, try to move it upward.

And finally, after total deglaciations, we are getting a land mass which is different from this one, now you see this is a deepest because whatever we have lost, we will not recover the 100% somehow we have recovered, if you see here we have recovered from here to here or we have recovered beyond that also but we cannot recover up to this level, this is isostatic deformation.

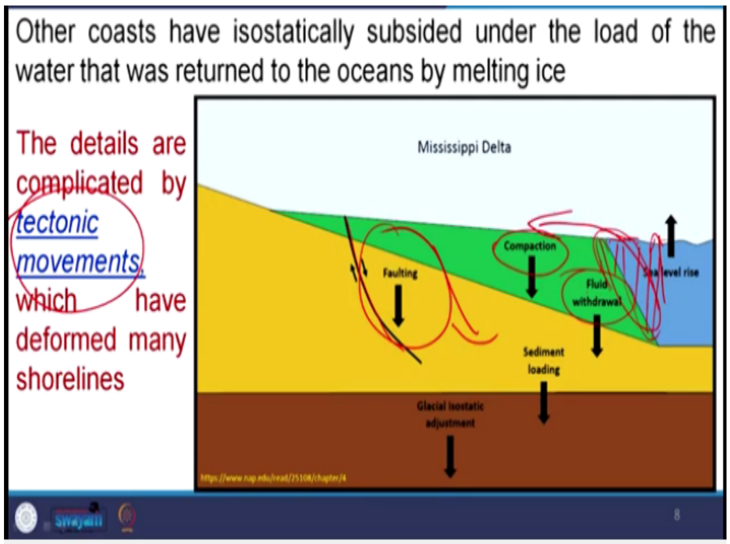
During this glaciation time, there are the huge mass of glacier that accumulated along this coast and due to this accumulation of this glaciers, number of coasts or maximum part of this coast they were submerged or they were compensated that means , they are overcompensated like this. So, that means from last 20,000 years to 5000 years, these types of activities has been noticed along many parts of these coastal landforms or coastal regions.

And suppose, we have like this, we have a system where marine transgression or the sea level is rising and this system is also rising due to isostatic imbalance or isostatic compensation, sea level is also rising and this is also rising but suppose, the sea level rise is less or rate of sea level rise is less than this up-liftment, so that means we will say those sea level rising is there but still marine regression.

Because here this; due to this compensation, due to this a melting of the glacier this is rising at a faster rate as compared to these rise of sea level, so that is why here though sea level is rising but still we are not getting marine transgression, we are getting marine regression. Similarly, reverse case is also true suppose, it is moving up at a slower rate as compared to the sea level rise.

So, that means sea level rise is higher than this rate of up-liftment, so that means we are getting marine transgression, so some coast in formerly glaciated regions have isostatically risen more than this post glacial sea-level rise and show flight of emerged shoreline. So, here marine regression and once marine regression is there, coast is emerged, so emerged shoreline is there.

(Refer Slide Time: 19:35)



It has some other effect also, of now imagine due to deglaciation, the water level is rising, so water level is rising for example, here once water level is rising, it is pressurizing here on the coast because you see, here where pressurizing on the coast, if the coast is under tremendous pressure and the second thing that coast we know, if it is a depositional system and it is deltaic region or whatever if it is sedimentary system that means, we have pore spaces.

Similarly, if we have fractured rocks or fracture bedrocks that we have pore spaces is filled with the water. So, now you see suppose, we are increasing sea level and we are creating pressure here, so once we are creating pressure, the pressure is transferred inland, so that means there will be compaction, there will be fluid withdrawal, so that means the system will compact down, the system will squeeze.

So, once the system will squeeze, the fluid pressure is removed, the fluid pressure decreasing, so that means we are creating some of these faults. So, that means water level rising on the sea or mass of water increase in the sea also create some faults, some fractures along this coast. So, once this fracture develops, so that means it will move down; this block will move down finally, there will be invasion of sea into the coast.

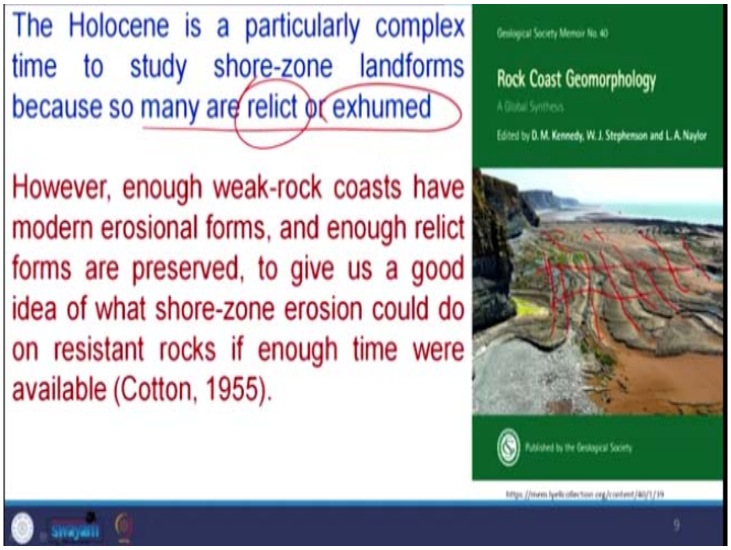
And present day it is happening along this east coast of India also, so now we have some basement faults, they were active or somewhere active in the geological past. Now, once we are increasing the sea level, it is putting pressure on the coast and due to this overloading, the some of these faults they are becomes active at the present day and with the loading of water level, with loading of sediments due to overloading, so there will be failure along this fault.

And finally, there will be marine transgression, so here is it is another coastal; coasts have isostatically subsided under the load of this water that was returned to this ocean by ice melt, so during glaciation we have that means, we have due to loading, we have isostatic imbalance similarly, during deglaciation due to melting of ice, increase of water similarly, we have isostatic imbalance.

So, details are complicated by this inclusion of tectonic movement also, so not only this isostatic imbalance by glaciation and deglaciation that affect the coast, so tectonic is another culprit which added the system either due to up-liftment or in subsidence. So, tectonics has also deformed the shore line because if you see our east coast of India and west coast of India, that still straight.

So, the straightness is due to these activities of this faults, the basement faults, deep seated faults are there, so those deep seated fault in particularly, the east coast they were formed during this India and Antarctic extension, the separation or the rift, similarly in the west coast India Africa rift, they were form, so tectonics also plays an important role to shaping this coast in addition to this wave, this tide, this wind, this rivers, whatever the geomorphic agents working in together along this coast.

(Refer Slide Time: 23:27)



The Holocene is particularly a complex time to study the shoreline landforms because some of these landforms are relict or exhumed, so relict land forms are there for example, here if you in this photograph you see, these are the striations of these glacier movement, this is the coast and it is this is this present day coast, there is no glaciation at all but these glaciation; this glacial tractions, they are formed during the last glaciation.

So, this present day coastal geomorphic agents they are trying their level best to make it plain, so that is why most of this coastal landform along this present coast, they are for a relict one, they are the evidences of last few geological times within the geological times there are few events they are recorded in this; along this coastal region. However, enough weak rock coasts have modern erosional landforms and enough relict forms are preserved to give us a good idea of what shore zone erosion could do on resistant rock if enough time was available.

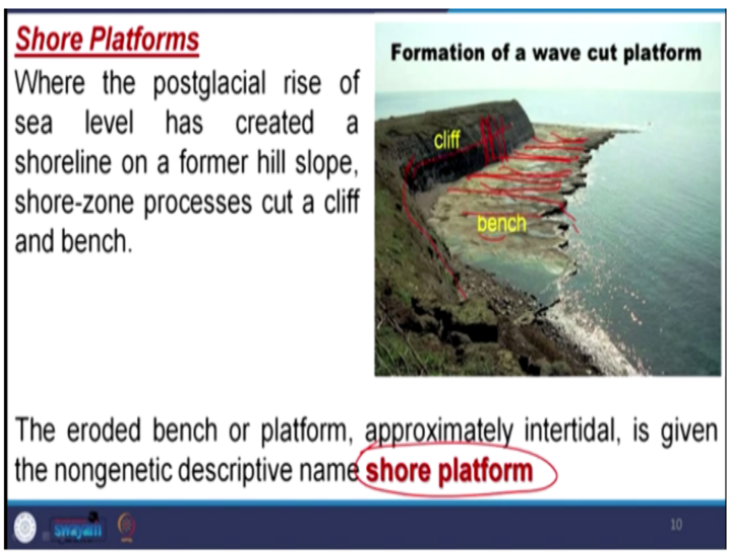
So, 2 types of rocks; one is soft rock, soft coast like the chalk and other type that is in Indian system like the one side is basalt, another side is khondalite and charnockite and some of this world coast they have chalks along their coast, so that means if soft rock is there, the rate of coastal geomorphological change will be very rapid and if it is hard rock is there, it will be difficult or the coastal geomorphic change will be there.

But the rate of change will be different as compared to the soft rock, so very important and the first ever point to discuss here is these shore platforms, so we have if you remember we have discussed the pediment during our arid zone geo morphology, pediment itself says a long history about this arid zone system similarly, this shore platform has to say a long history about this coastal processes, which is going on.

So, this shore platform it itself the name says, it is a platform that means, it is a planar structure, it is very gentle sloping gentle sloping body of rock or bedrock and which is merging along this coast and to this water as well as to the landmass. So, it may be devoid of any brecciated rock or devoid of any fragments or sediments or may contain thin pile of sediment or may not contain any rock fragments that means, total bedrock is exposed.

So, depending upon this coastal characteristics either it is wave dominated or the tide dominated or the frequency of waves and tides and all and this rate of erosion from these cliffs you know, mass wasting so, all those parameters combine work together here to define whether what type of shoreline platform is going to occur.

(Refer Slide Time: 26:55)



So, where this post-glacial rise of sea level has created a shoreline on a former hill slope, shore zone processes cut off a cliff and bench, we have 2 types of landforms; one is it is cliff that is near about vertical or very high angle of slope here and another is a bench, here you see this part is bench and it is very low sloping surface. One is this is called cliff and this is called bench.

The eroded bench or platform approximately intertidal in given the non-genetic descriptive name which is called shore platform, so shore platform is the lower part here, this is approximately intertidal, this is very important to discuss here, this is an intertidal region that means, during low tide we have water level much below it and during high tide, we have water level probably at this level.

So, this shoreline platform it defines the intertidal region and during high tide, there will be sediment movement towards the cliffs and during low tide, the sediment movement will be away from the cliff or from cliff towards the oceanward, so that is why due to this frequent movement of sediment or these rock fragments we will get some of these erosional feature like stripes on these bench. So, shore line platform or slope platform weathering and erosion, we will discuss it in the next class I think, so I stop it here and we will meet in the next class.