Geomorphology

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Lecture - 38
Coastal Geomorphology-V

So friends good morning. Welcome to this lecture series of geomorphology and today we will discuss about this Coastal Geomorphology we will continue with this series which we are continuing in the previous class. So in the last class if you remember we are talking something about this wave tap experiment on which 3 types of waves were generating. One is the standing wave it is away from this cliff.

And one type of wave which was hitting the coast and that is called the breaking wave which was hitting at this cliff and one is the broken wave which was already broken at few distance away from this coast and was hitting this cliff again and out of this three the later two becomes more effective for the erosion and especially the second one becomes more important for erosion which was breaking at the coast only.

So in the third one though it was eroding this coast retreating the cliff, but its effectiveness is half as the second one and second thing we discussed that during this wave transform to this coast. At the first instance the rate of erosion was less because only water was responsible and the second instance when it was hitting sufficient sand was removed from this cliff. This sand and water this become more effective to erosion.

Because the abrasive power of water increased with the addition of some sand and more and more addition of sand from the cliff this energy is distributed among the sand grains and that is why the later time the weathering power of this water decreased. So this was the summary of this last class.

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So whatever the experiment we were doing in the laboratory only the basal notch we are creating, but here in the real world not only the basal notch we will create because here not only the sand and cement that is artificial we are creating so that does not contain any type of fractures, any type of joints like that because it is freshly constructed material, but in natural sense when you are going to field we will find the cliffs the grains are there the semantic material is there with that.

There will be discontinuous natural discontinuing like the joints, the bedding planes, the cleavage surface. So the weathering surface so there are many other components are there. So here it will not behave as the laboratory sand and cement slurry or cement material we have used for preparation of cliff this same type of behavior will not shown by the field material itself.

So that is why at the most of the real cliffs joints and other discontinuous in the rocks, mass would cause the entire cliff to retreat providing more abrasive sediment, but also increasing the possibility of sediment buffering of wave energy. So that means once we have more joints, more joint planes, the bedding planes, the discontinuity will remove more material as compared to our laboratory experiment.

So more material we are removing that means the less time we are dissipating the wave energy among this material. So that the rate of erosion will decrease first as compared to the laboratory system or the laboratory experiment. Similarly, that material which was removed will create the depositional platform here. So that means the depositional platform will move straight and forming a convex up system. So that is why the coastal retreat will be there and same times the depositional ramp will be developed.

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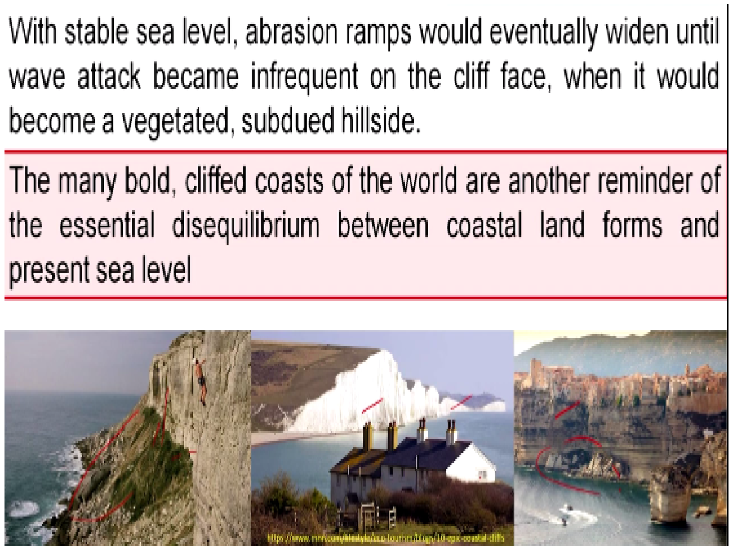

With stable sea level, abrasion ramp would eventually widen until wave attack becomes infrequent on this cliff face. When it would become a vegetated, subdued hillside. So that means when this continue when there will be less frequent wave attack will be there and when cliff will be vegetated so that will be less effect this erosion will be less effected. In many bold cliffed coast of the world are another reminder of this essential disequilibrium between coastal landforms and the present sea level.

So if you see there are 3 photograph given on this world coastal system. This is somewhere it is straight, somewhere it is you see whatever the mass wasting is there, material is lying there and here mass wasting and some material is lying here that means it is not the product of this present sea level. It is the product of sea level of changing many times, many times the sea level have changed from this geological past of the present.

So ultimate product what we are looking in front of us. So that means in this world whatever the cliff retreat is there, whatever the cliff situation there, whatever the abrasion ramp is there, what is the depositional platform is there it is not this product of today only. It is the product of subsequent weathering subsequent wave action subsequent material removal and again build up again sea level fluctuation up going and down going of sea level like that.

It is a complete product of many processes that is started from the geological past and continuing at the present time. Now we will discuss about this structural control on shore zone landform structural control how the rock structure whether rock structure is horizontal, rock is dipping, rock is gently dipping it is vertically dipping it is jointed, it is not jointed. So whatever the rock structure along this rock, along this material, along this cliff. How that behaves as defining the coastal geomorphology or the equilibrium or disequilibrium coast generation.

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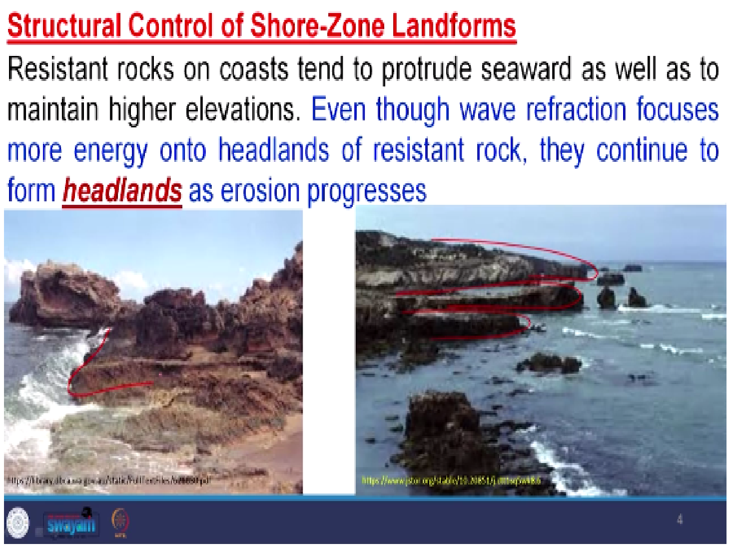

Resistant rock on coast tend to produce seaward as well to maintain higher elevations. Even though wave refraction focuses more energy onto the headlands of the resistant rock, they continue to form headlands as erosion progresses. If you remember when we are talking about the wave advance towards the coast and interaction with this coastal geomorphic system.

We found when there are convex slope that means when there is a convex form of landforms that means that is called headland that means a patch of land which is intruding into the sea. For example, if you see here this is the part of land which is intruding into the sea. Similarly, the part of land intruding into the sea this is intruding into the sea, this sea here is a part of land intruding into the sea.

These are called headlands and we know when we are talking about the wave headlamds towards the headland or towards the coast. Whenever there is headland that means there is a breaker zone available some what below it and somehow distance from this headlands and these headland they behave as wave to converge. So converging wave that means wave is a form of energy so that means wave energy is converging there.

And more energy is converging and more energy it is interacting with the headlands that means more erosion is there. So that means a concave surfaces they are the sides of deposition and convex surfaces of land they are the sides of erosion they are called headlands. So now the question arises if the wave is coming off and is interacting with the system, interacting with the coast these convex side or the headlands they are prone to weather and the concave side they prone to receive sediment to deposit so that after few million of year or thousand of lakh of year there will be equilibrium coast will be generated.

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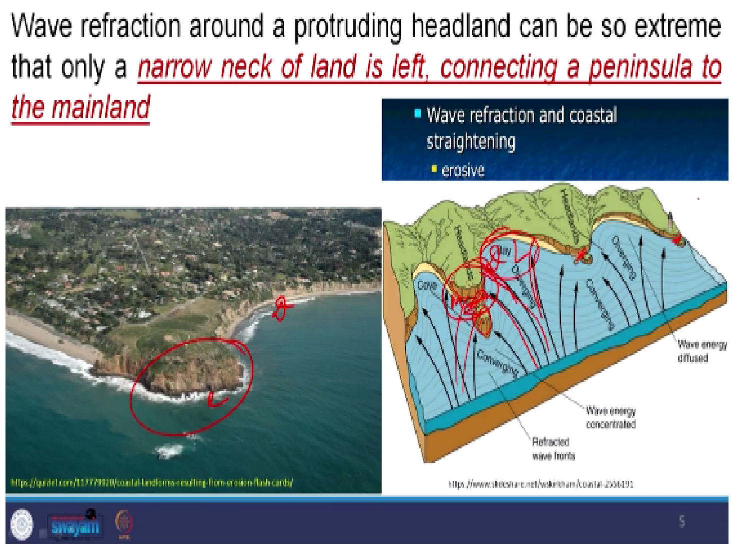

So now the headlands they are consuming energy and here this main land it is cut off from the mainland with a small neck. Now if you see in this figure you see this is the headland, this is the headland, this is the headland. Now you see here the wave energy they are concentrating here, they are concentrating here. So more energy is concentrated here and energy use you see it is disappearing, it is diverging so here less energy.

So it is less it is more. So more energy we will concentrate that means more erosion will take place. Similarly, here these are the sides of deposition, these are the sides of erosion. Similarly, here this will be the sides of erosion and this should be the sides of deposition. So that means I want to say with more and more energy concentration, more and more erosion of this headlands.

The wave refraction around a protruding headlands can be so extreme that only a narrow neck of land is left, connecting a peninsula to the mainland. Here this is the peninsula that is the mainland it is a narrow neck is existing here through this narrow neck it is connecting to this mainland system.

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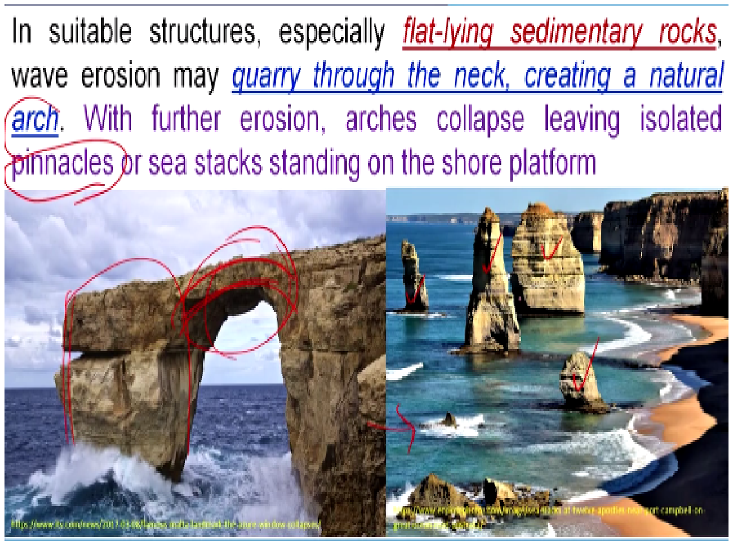

Suppose we have sedimentary rocks very horizontal strata, horizontal strata we have resistant, non resistant type of rocks are there. So in horizontal strata there is a particular or peculiar erosional structure which is found and it is called the arch. If you see here this is called arch. Now you see this is the arch shaped. So with more and more erosion with more and more quarrying of material this arch is removed.

Once this arch is removed with geological time this becomes an independent pillar. For example, if you see here in the second figure if you transfer this idea here now you see this is an independent pillar. So once upon in a geological past it was like this, this arch shaped features was there. So due to more and more erosion this arch has been removed and finally isolated pillars or it is called pinnacles if you see here.

It is pinnacles or sea stack it is standing on the shore platform. So in suitable structures especially flat lying sedimentary rocks, wave erosion may quarry through the neck creating a natural arch with further erosion arch collapse leaving isolated pinnacles or sea stack standing on the shore platform. So this is all about your sea stacks or pinnacles and how the rock structure they are affecting the system.

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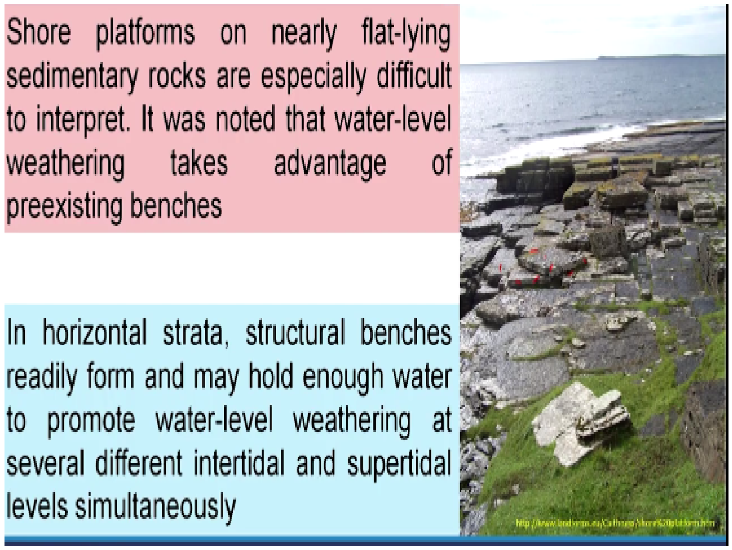

And shore platform on nearly flat lying sedimentary rocks are especially difficult to interpret in terms of that is wave cut platforms. It was noted that water level weathering takes advantage of the preexisting bench. So the preexisting bench is there, terraces is there. So water level weathering that means if water level weathering that is contain water within that. So once water remains within the system.

Because the bedding planes the joint planes they are the weak planes. So water if it remains within that that means it promote further weathering. In horizontal strata structural benches readily form and may hold enough water to promote water level weathering at several different interval intertidal and supertidal levels simultaneously that means we have already discussed once we have the bedding planes are there we have wave like platform is there.

And bedding planes joint planes horizontal strata are there they can contain water within that and water contain within water remaining within that means it promotes the water level weathering. So whatever so far we are discussing about this destructional landform that is erosional landforms. So from now onwards we will discuss about the constructional or depositional landforms along this coast.

Deposition that means we have removed the material through notches, we have removed the material from this mass wasting processes and that material will be redistributed with the wave, with the tide and how at the coast they are forming those landform. In addition to that some of this landforms which are biogenic landform like this the coral reefs how they are forming on this deposited material or the hard rock and that will be discussed here.

And in the constructional landform along this shoreline the organic reef or the coral reefs are the most prominent one. So reefs are shallow water submarine landforms. They are submarine landform and shallow water why shallow water because organism is involved there they will remain within the photic zones up to which sunlight can penetrate. So that means these are the shallow water processes and shallow water landforms.

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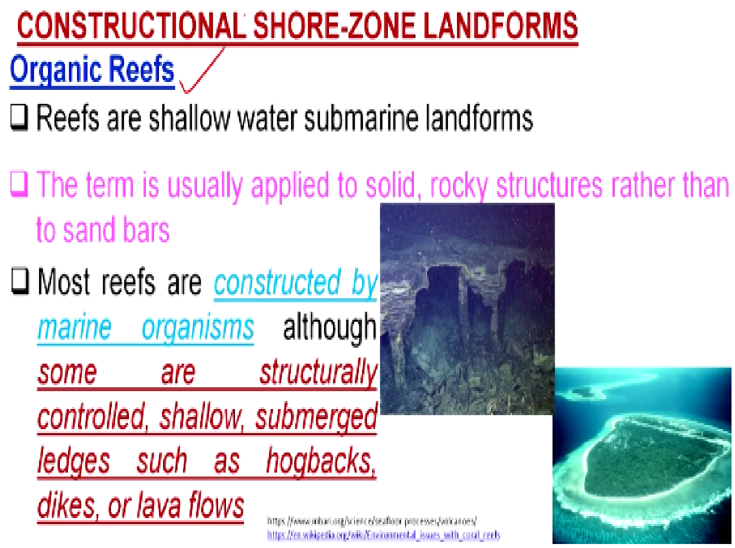

The term is usually applied to solid rocky structures rather than to sand bars solid and rocky structures, sand bars are excluded here. Sand bars they are the dynamic one. At the coast we have already discussed there will be barchanoids there will be transverse dunes are there. So this sand dunes are excluded here and only the rocky structure the hard rock structures they are included.

Most reefs are constructed by marine organisms although some are structurally controlled shallow, submerged ledges such as hogbacks, dikes and lava flows. So these landforms that is this organic landforms they are mostly they are build by marine organisms, but some of this landforms they may formed by this lava flow like the hogback structures and structurally controlled of the paleogeographic landforms are there.

But mostly when we are talking about the organic reefs the coral reefs we are talking about this reef system which are developed by the organisms here and at the base of this organic reef there may be hard rock substrate like basalt, like this hogback structures, like this paleogeographic landforms which are retained at the paleogeographic changes. So that means on the soft rocks like clay, sand on the loose materials these types of organic reefs will not develop.

So whatever the organic reefs so far discussed or so far discovered wild ocean they are developed on the hard rock substrate. Even if it is a small patch of hard rock is there they becomes first to create to initiate this reef system we need a hard rock and once first the initial system is developed again within that reef it becomes again the substrate for the further growth of this reef itself. So the basement for this reef we need a hard rock substrate rather than soft clay or loose sand.

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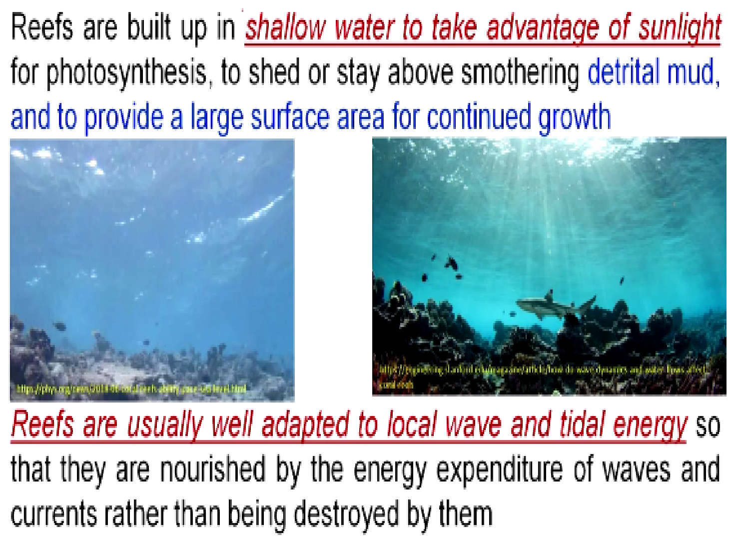

Reefs are built up in shallow water to take advantages of sunlight for photosynthesis to shed or stay above smothering detrital mud and to provide a large surface area for continuous growth. So that means we need a hard rock substrate. Reefs are usually well adopted to local wave and tidal energy. So that they are nourished by the energy expenditure of the wave and the currents rather than being destroyed by them.

So they are so suitably arranged that they absorb this energy rather than destroyed by the energy. They can adjust with the energy condition and they adjust with the waves they can move along this wave, but not detached from their surface. So their growth is likely that they will be in the hard rock substrate they will firmly attached to it, they will adjust themselves with this energy with a wave either wave or tide.

And that will not detach from the system until and unless there will be heavy storms or like that.

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Geomorphic requirement for Coral growth

- Reef growth is best in water that does ***not cool*** below about 18°C during winter months
- Salinity should be close to normal
- Fresh water from rivers or torrential rains is especially ***damaging***
- A hard substrate is necessary for a colony to become established, but small patch reefs can grow on soft sediments and gradually fuse to form a suitable base
- Loose sand is poor for coral growth as is mud

So what are those geomorphic requirement for this coral growth if you see here reef growth is best in water that does not cool below 18 degree Celsius during winter month also. So here the temperature plays an important role. So the temperature should be more than 18 degree that means it is not cold water phenomena. Whatever if you see it is cold water reef and warm water reef

So that cold water means it should be cool than 18 degree Celsius okay and warm water it may be anything whatever the warm water environment are available, but cold water reefs that should not be less than 18 degree. Salinity should be close to normal again salinity should not be hyper saline. So a saline should be there because wild oceans are saline so salinity should be there, but it should be close to normal.

So that means there are particular geographic locations, particular geological conditions there are requirement particular biological condition Eh-pH that should be fixed. So that it will promote for coral growth then fresh water from this rivers or torrential rain is especially damaging. So that means fresh water it should not reach up to their level. So it is a saline but it should not be hypersaline if saline is normal.

Temperature must not drop below 18 degree Celsius it should be away from fresh water influence. A hard substrate is necessary for the colony to become established, but small patch reefs can grow on sub sediment and gradually refused to form suitable base. Here hard rock substrate it is requirement is there. If any soft rock it develops, but within few time they will themselves coalescence and form the hard rock for themselves for their growth.

So that means soft rock should not be there rock should be hard. Loose sand is poor for coral growth as in mud as we have discussed there it should be hard rock substrate rather than soft rock. So these are the geological conditions their essential requirement for the growth of coral and formation of coral reef.

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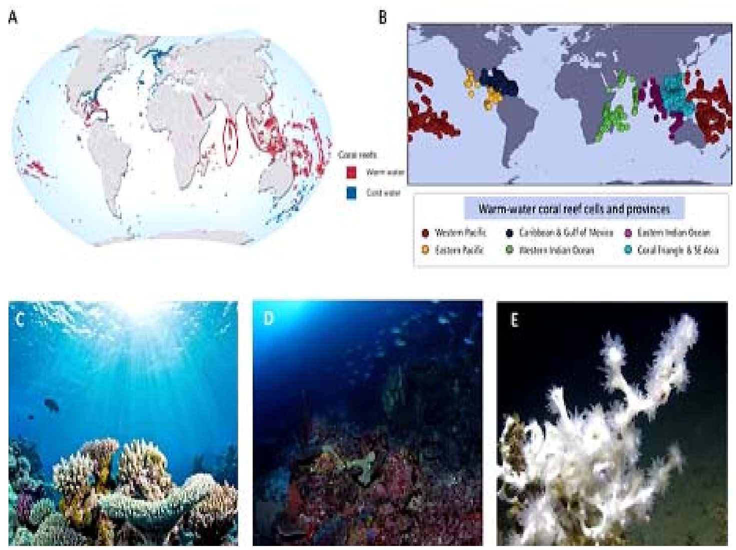

If you see this is wild distribution of coral reef in this map. See in this Indian ocean we have coral reef and this is the great barrier reef in Australia which is moving about to 1,000 kilometer or so and these are this world distribution of this coral reef and finally warm water coral reef and provinces if you see here this type of warm water systems are there that means and cold water it should not be less than 18 degree.

So these are some of this example the colour was given and this is here is a warm water this red lines or the red dots and the cold water this is this blue dots, but cold water once we say cold water that means it should not be less than 18 degree Celsius.

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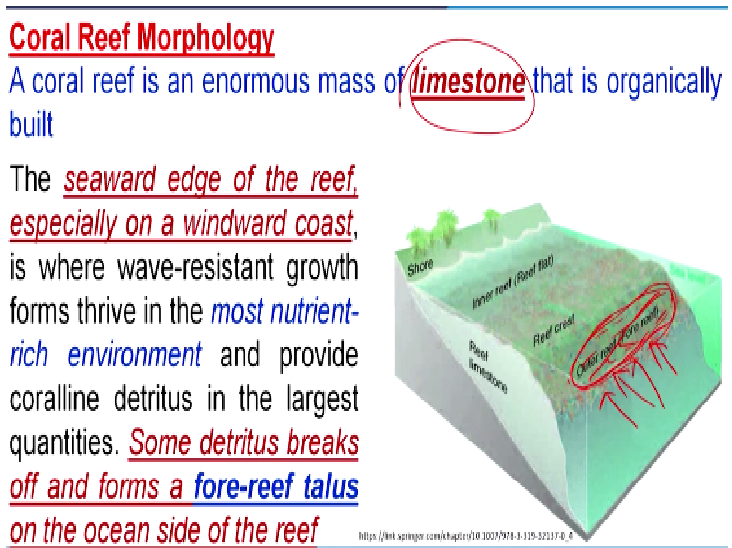

Then we will discuss about this coral reef morphology. What is coral reef morphology? A coral reef is an enormous mass of limestone that is organically built. So it is a limestone that means calcium carbonate. So that means those organisms they grow or they consume calcium carbonate and their body is made up of calcium carbonate so it is in limestone. The seaward edge of this reef especially on the windward coast is where wave resistant growth forms thrive in the most nutrient rich environment.

And provide coralline detritus to the largest quantities. Some detritus break off from the reef, from this main body and form fore-arch talus on the ocean side of this reef. If you see here this is the seaward side and here this whatever the wave energy is coming it is directly hitting here. So here mostly the wave resistant species they are they tend to grow here and this wave resistant faces once there is water is coming and hitting here.

Mostly the nutrient supply, mostly nutrient will be here. So that means those areas will be very significant in development of strong coral and mostly this energy that means those corals energy enough to resistant the wave attack. So most powerful coral species they are found in this part of this coral reef.

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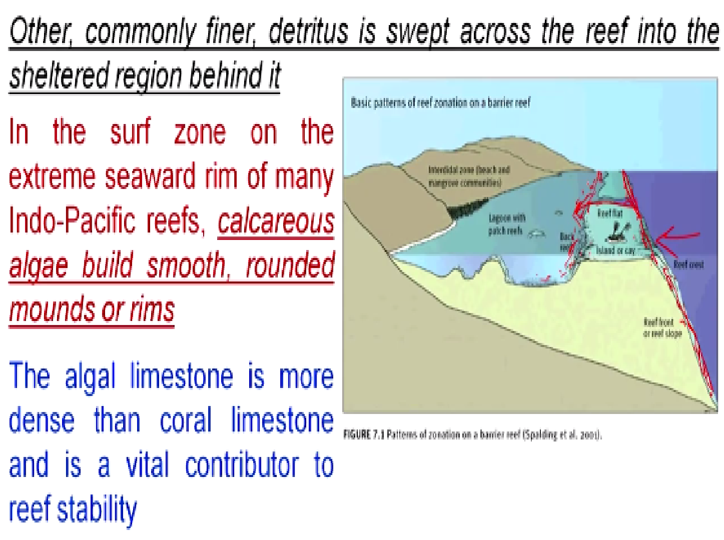

Other commonly finer detritus is swept across the reef into the sheltered region this is wave and this wave resistant basis will be there and some of this detritus which is breaking from the system and it is forming the talus here the submarine talus the coral reef talus and this finer material they are transported this way and forming here this is the back reef system. This finer material which has broken off from this system and it is depositing across it.

And these are the area where this generally the calm and quiet water coral the less resistant corals they are found in here. In the surf zone on this extreme seaward rim of many indo-pacific reefs calcareous algae build smooth rounded mounds on it and this is very important. This calcareous algae once they build up on the coral reef. They becomes a binders they act as binders.

So that means the coral fragments, the coral reefs they bind together and becomes more and more resistant to the wave actions. The algal limestone is more dense than coral limestone and it is a vital contributor to reef stability this algal it is also limestone. So the algal limestone they will grow here somewhere and this algal limestone they becomes a binder to bind this corals together. But the algal limestone is more dense than the coral limestone. Hence it is vital contributor to reef stability.

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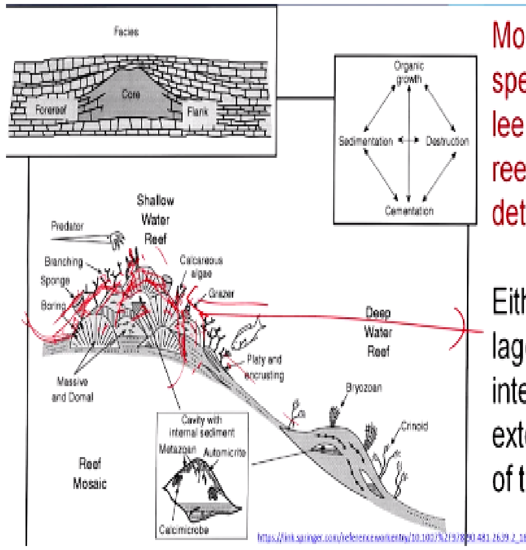

More delicate coral species grow in the lee of the seaward reef, adding more detrital sediment

Either a sandy lagoon floor or an intertidal reef flat may extend from the lee of the reef

If you see these are this calcareous algae and this algal development is there. So once the algal development grow and finally they bind this corals from the top towards their body and this becomes more strong and more resistant for their growth. More delicate coral species is grow in the lee side of this seaward reef adding more detrital sediment. Here this side it will grow here more delicate one either a sandy lagoon floor or an intertidal reef flat may extend from the lee ward side.

You see this is the lee ward side this is top floor side and from here whatever the resistant species will be there they grow and finally these are less resistant species will be towards the this side in the lagoon this side the open sea this is the barrier and this side is the lagoon. So your finer material will be here and this less resistant species will be in this side.

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- ❑ Coral reefs are generally limited in upward growth to mean low-tide level
- ❑ The extreme productivity of the reef provides sediment for many subaerial shore-zone landforms, however
- ❑ Large storms and tsunamis tear away tons of reef-front coralline debris and hurl it over the algal rim onto the reef flat behind (Maragos et al.,1973)
- ❑ Most reef flats are scattered with large blocks of storm-tossed coral rock, often deeply notched by solution

There are certain salient features about this coral reef. The coral reefs are generally limited in upward growth to mean low tide level. So they cannot growth aerially. So their maximum growth is to the low tide level will be there. The extreme productivity of the reef provides sediments for the many subaerial shore zone landforms. However, large storms and tsunamis tear away tons of reef front coralline debris and hurl it on this algal rim in the reef flat behind.

So here it is very important to understand. The extreme productivity of the reef provides sediments for many subaerial landforms whatever the landform if you go to this Mauritius around that area the Islands are there, African islands are there, this pacific islands are there. So this coral reefs they are transported by this wave action the part of the detritus of the coral reef they are transported by this wave action and forming the coast.

So the coast will be very odd smell is there because this everywhere there will be a coral and coral wherever you go you will part of the coral piece of coral is there. So some of this subaerial landform close to this coast they are also formed by the deposition of this coral broken away from the system and if we have large tsunamis so large tsunamis can make it dissect this corals into different pieces.

And broken into pieces and finally that will move landward and it will may distribute within that lagoons with that coral itself within that algal mat itself so that means it is redistribute the systems. Most reef flats are scattered with large block of storm touched coral rocks of deeply notched by the solutions. So that means here if you see this figure whatever the corals develop here if tsunami comes from beside and that means it dissect the material. And it redistribute here and here and here and sometimes it becomes some aerial landform close to the coast are formed by the tsunami activities.

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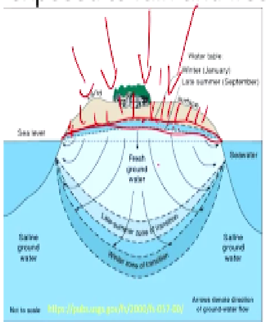
On the reef flat, islands of coralline sand and gravel may build up high enough to support vegetation and storage of fresh water

The carbonate sand and gravel is readily recemented, especially if exposed to rain and fresh groundwater



On the reef flat islands of coralline sand and gravels may build up, high enough to support vegetation and storage of fresh water. This is very interesting to understand here. Now see this is the growth of coral and finally this is the habitable islands and once this type of situations occurs there may be a fresh water table within that coral reef and this fresh water table is due to rain water there will be water percolation and the fresh water will be here.

Why fresh water will be here because fresh water is less dense as compared to marine water. So marine water will be at the bottom and the fresh water will be at the top. So finally it will create this type of situation if the coral reef grows above from this sea level but is not possible but it is only possible if the sea level falls it remains there.

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Major storms can remove any uncemented part of a coral-reef island, but if a mass of debris is not disturbed for a few decades or centuries, it becomes relatively indurated and resistant

Cementation is generally close to the level of mean high tide in the zone of saturation

Because the tide range in tropical oceans is generally less than 2 meters, low platforms of cemented reef rubble are exposed on most eroding shores

These cemented high-tide platforms have been frequently mistaken for emerged reef flats by which a Holocene fall of sea level has been widely inferred.

So major storm can remove an un-cemented part of this coral reef island, but if a mass of debris is not disturbed for few decades of hundreds of years or centuries it becomes relatively indurated and resistant. Cementation is generally close to the level of mean high tide in the zone of saturation because of the tidal range in tropical ocean is generally less than 2 meters low platform of cemented reef rubble are exposed on most eroding shores.

And this cemented high tide platforms have been frequently mistaken by the geologist and they think as if they are the immersed coast line or the Holocene, but this is nothing this is due to this high tide and low tide the cementation occurs up to this level. So this is sometimes mistaken. So whenever you go to the field and you are working in this coastal planes you must be cautious about what actually you are looking at either it is a high tide platform.

Or it is mistaken for the immersed platform due to the decrease of sea level. So I think we should stop here and we will meet in the next class. Thank you very much.