Geomorphology
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Lecture - 30
Dune Classification-I

So friends welcome to this lecture series of geomorphology and today we will discuss about this Dune Classification. So if we recollect the last class when we are talking about this formation of dune or in Aeolian environment we found that the dunes can form depends upon the wind speed, depending upon the sand supply and depending upon the vegetation cover. Second thing that to form a dune we must have a sand body more than this critical size.

That is to 4 to 6 meter spread and sand supply can be continuous so that a dune can form and to form a dune we need more wind speed as compared to formation of a ripple. So as the wind speed increases the whole upper layer of the sand that means this saltating layers and some parts of the upper layer they try to make a shearing action with the sand body. As a result, the whole upper layer moves.

And at the windward side we will find a gentle slope and where this upper side or this lee side we will get a steep slope where this brink point it is called brink point where this sand slides down and forming the dune face and it is stepper in nature. So this way dunes are formed. Though dunes migrate from one place to another place, but its internal structure remain constant.

So the whole dune can migrate dune may deform so it may divide into separate parts and a size of the dune may changes, the shape may changes, but its internal structure remains as it is. So this is all about this characteristics of dune. So in this class we are going to discuss about the dune classification, how the dune look like and how this dunes they form from one dune to another dune and how this wind velocity and directions, sand supply and vegetation.

They affect the size of the dune, they affect the type of dune involved and what the dune can say about the past climatic changes. So first of all dune classification we will deal with the star dunes.

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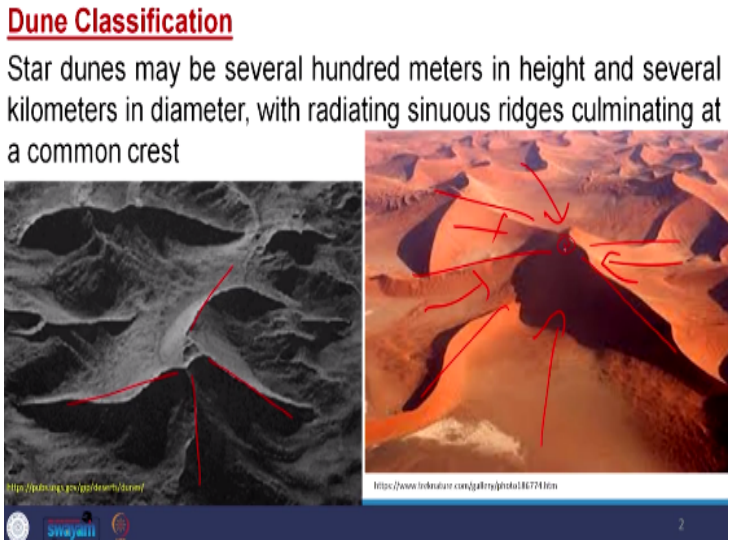

So here if you see this 2 photographs this surface appearance of this 2 photographs it looks like a star that means it is radiating all sides from a center point and the radiating ridge it is sharp ridge and a long ridge which is indicating the wind direction. So that means if you see there are more than that means there are many ridges, sharp and long ridges they are merging at a point or radiating at a point that means it is indicating a variable windblown direction.

From different sides the wind is blowing and merging here and finally it is forming a star dune. So as per this dune migration is concerned this type of dune they do not migrate or it is very little migration occurs instead it increases its size vertically. So with more and more sand addition with more sand supply and this wind velocity or wind speed increase of wind speed its size or its height wise it increases in size.

So star dunes maybe of several hundred meters in height and several kilometers in diameter with radiating sinuous ridge culminating at the common crest. So this is a dune having this radiating system, this is dune having this radiating system. So here it is culminating and the wind direction will be from all sides, all side wind merge at this point and forming the star dune.

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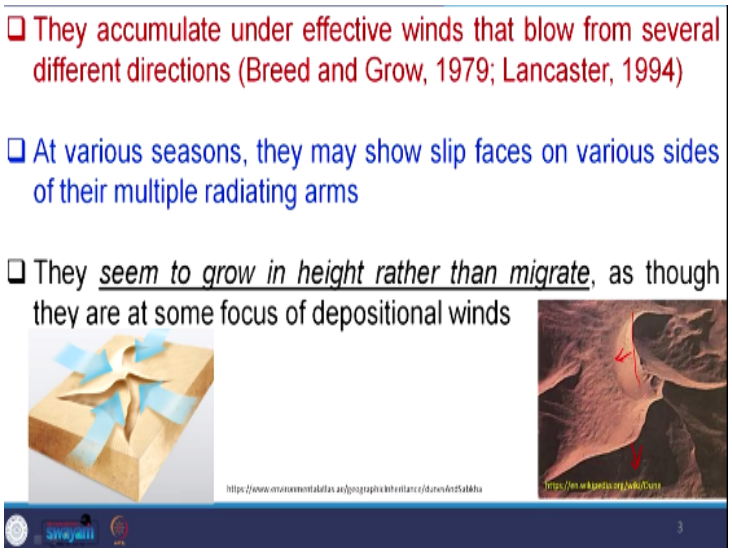

They accumulate under affective wind that blow from several different directions. At various seasons, they may show slip faces of various sides of their multiple radiating arms. So this is important to note here that so though we have a star dune, but at various seasons they may show slip face of various sides. For example, suppose this is the star dune and this is a arm and in this particular case suppose this is the slip face similarly suppose this is the slip face, but that does not mean the slip face will same for the whole season.

So in different seasons different windblown direction changes that is why the slip face changes its direction. They seem to grow in height rather than migrates as though they are at some focus of depositional wind. So that means more and more sand supply, more and more increase of wind speed, they try to grow in height rather than migrating.

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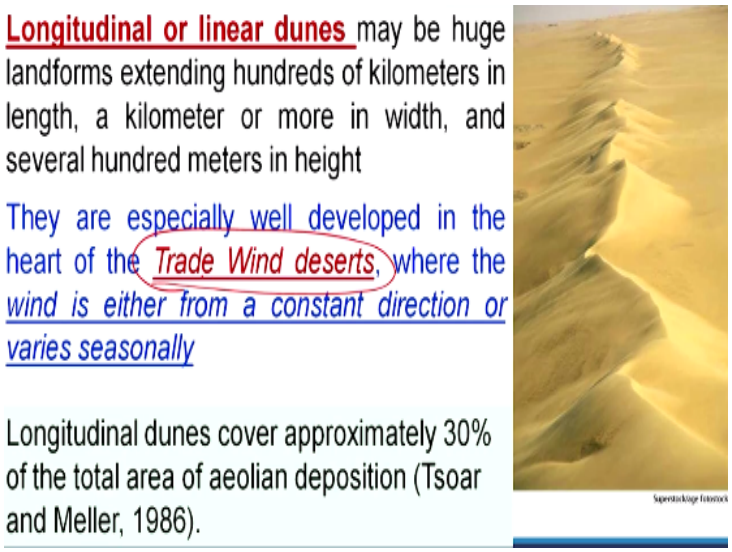

Then second type of classification or second class of the dune is the longitudinal dune. Longitudinal dune that means as the name says it elongated in nature and elongation the direction of elongation is parallel to this windblown direction. So it may be huge landform extending hundreds of kilometers in a length and kilometer are more in width and several hundreds of meter in height.

So now you see it is extending kilometers several hundreds of kilometers even if the entire Sahara entire Kalahari can extend one dune can extend all through its lengths. So they are especially well developed in the heart of the trade wind deserts where wind is either form a constant direction or varies seasonally that means we want to say here the wind should blow in a particular direction for a long time.

So that is why if you see here these dunes mostly they are confined in the trade wind deserts. So parallel to this trade wind the dunes are aligned. Longitudinal dunes covers approximately 30% of the total area of the Aeolian deposition. So that total area is covered 30% that means all through this length of this deserts this type of dune can continue.

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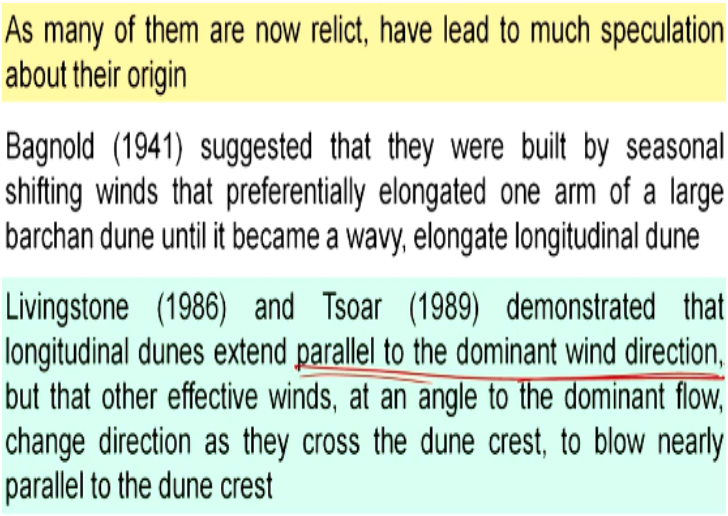

As many of them are now relict have led to much speculation about their origin. So now you see whatever these dune we are looking at nowadays that is the longitudinal dunes nowadays very rarely we are getting the fresh longitudinal dune that means at the present geological condition at present atmospheric circulation do not allow this formation of this longitudinal dunes.

So whatever the dunes nowadays we are studying and getting this characteristics of this and that. So this is all those characteristics are based on the study of the ancient dunes. This gentlemen Bagnold in 1941 suggested that they were built by seasonal shifting of winds that preferentially elongated one arm of a large barchan dune until it becomes wavy, elongated, longitudinal dunes.

So barchan dune what is barchans dune we will talk about after few minutes, but here if you see this gentlemen is a pioneer worker in this arid region geomorphology. He found that these elongations it is a part of the large dune that is barchans and this 2 arms of the barchans they are elongated in a particular direction and the wind direction, but later on this was modified to certain extent.

Livingstone 1986 and Tsoar in 1989 demonstrated that longitudinal dunes extend parallel to the dominant wind direction, but that other effective wind at an angle to the dominant flow. Change direction as they cross the dune crest to blow nearly parallel to the dune crest. So their observation is that longitudinal dunes they are forming parallel to the wind direction and if from other directions the wind is hitting this dune.

So after crossing the dune face it becomes parallel to this elongation direction. So finally more or less we can say this longitudinal dunes are nothing. They are this large long dunes, they are formed during this consistency of windblown direction for a particular time for more than that means for a long time and they are parallel to this windblown directions.

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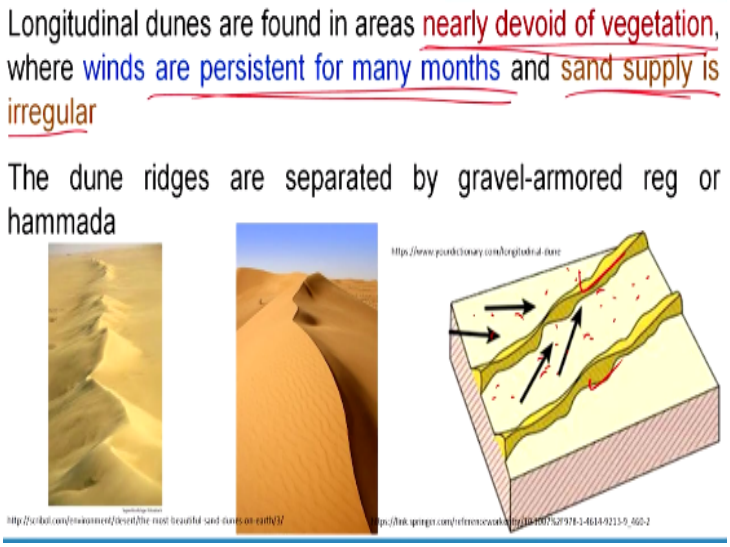

Longitudinal dunes are found in area of nearly devoid of vegetation because you see when you are talking a longitudinal dune of hundreds of thousands of kilometers so that means up to that kilometer, up to that distance if we want to distribute this sand in a linear fashion that means that should devoid of any obstacle. So that means those area having vegetations they will not allow to form such undisturbed dune for a long distance.

So that is why this nearly that means areas nearly vegetation that is lack of any vegetation covers they are more suitable for the formation of this longitudinal dunes where winds are persistent for many months that means a long duration of the wind blow. For a persistence the consistent direction will be there for long duration the wind will continue for a particular direction and sand supply is irregular.

That means that 3 classification, 3 criteria which are mainly responsible for the dune formation applies here that means it is nearly devoid of vegetation that vegetation should be not there and persistent wind for many months then sand supply is irregular if this conditions satisfy then we will get a longitudinal dune of hundreds of kilometers length and kilometers of wide.

The dune ridges are separated by gravel armored reg or hammada we know that the gravel dominated desert is called reg and the sand dominant desert is called ergs. So here this longitudinal dunes, this elongated sand body they are separated from each other by hammada. Hammada means barren rock and by the reg, reg means this boulders. So that means these are isolated one elongated, isolated.

If you see this figure this is an longitudinal dune. This is a longitudinal dune and it is separate this side this should be hammada either it is hammada or reg will be there either hammada or reg will be there. So that means I want to say these are isolated dunes for long distance of kilometers length, hundreds of kilometer length or kilometers of width form in the area constituting persistent wind direction, irregular sand supply, less vegetation cover. So this is the conclusion about this.

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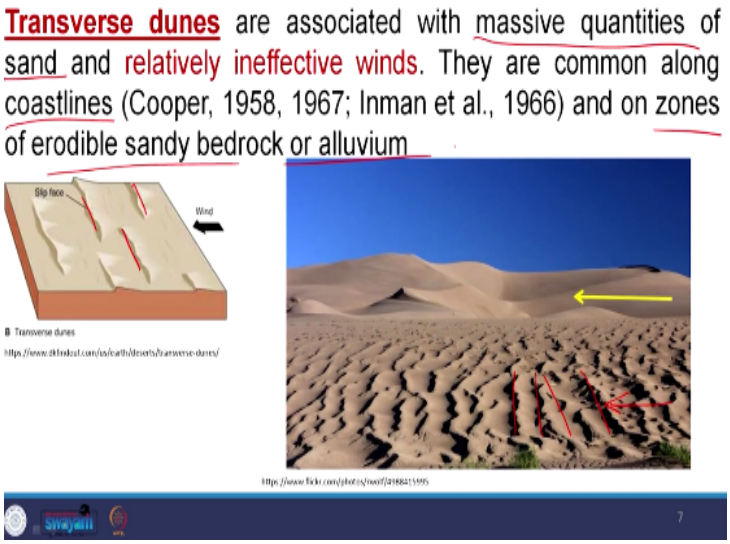

Then another class of this dune is called transverse dunes. Here transverse means it is perpendicular to this windblown direction. So that means in the longitudinal case these dunes were formed parallel to the windblown direction, but here this is classified this dunes they form perpendicular to the windblown direction. For example, if you see in this 2 figures. Here you see this is the dune axis, this is dune axis these are dune axis.

And you see this is the windblown direction that means the sand waves, the dunes they form perpendicular to the windblown direction similarly it is seen also here. They are associated with massive quantities of sand and relatively ineffective wind. They are common along coastlines and on zones of erodible sandy bedrock or alluvium. So that means here you see these dunes they are different from the longitudinal dunes based on this windblown direction.

Based on the sand supply. Here if you see we are getting massive quantities of sand, but here in the longitudinal dunes irregular sand supply. Wind direction is parallel, wind direction is perpendicular and they are forming in this area lack of vegetation, but here they are forming in this area having vegetation likely the coastal plain, coastal plains will be having vegetations.

So that means we will have coastal plain or coast line and those zones of erodible sandy bedrock are alluvium that means those alluviums which are reworked by this wind this glacial outwash plains this other this ephemeral streams of a braided nature. So those areas this alluvial sediments they were reworked by wind action and form this ridges, form this alluvium ridges, form this windblown ridges or the dunes.

So those are mostly the transverse in nature. So these are responsible for massive sand supply.

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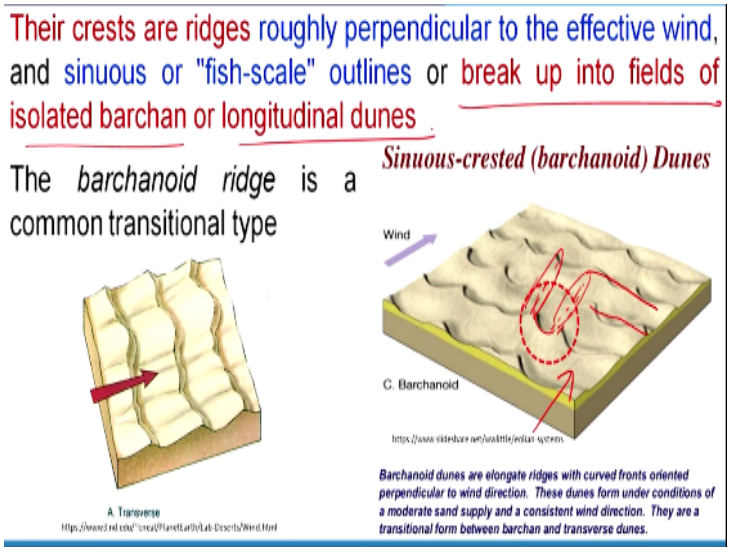

Their crest are ridges roughly perpendicular to the effective wind and sinuous or fish scale outlines or breakup into fields of isolated barchans or longitudinal dunes. It is very interesting to discuss here. You see once we are getting a transverse dune here is the windblown direction, but this transverse dune may break into different types of dune. For example if you see here this side if I elongate it, this may elongate in this way, this horn may elongate in this way.

So that means it will create a barchan or this will be finally it is converted to a longitudinal dune, it will convert to a longitudinal dune. So that is why it is breakup into fields of isolated barchan or longitudinal dunes that can form. The barchanoid ridge is a common transitional type between this transverse dune and barchan.

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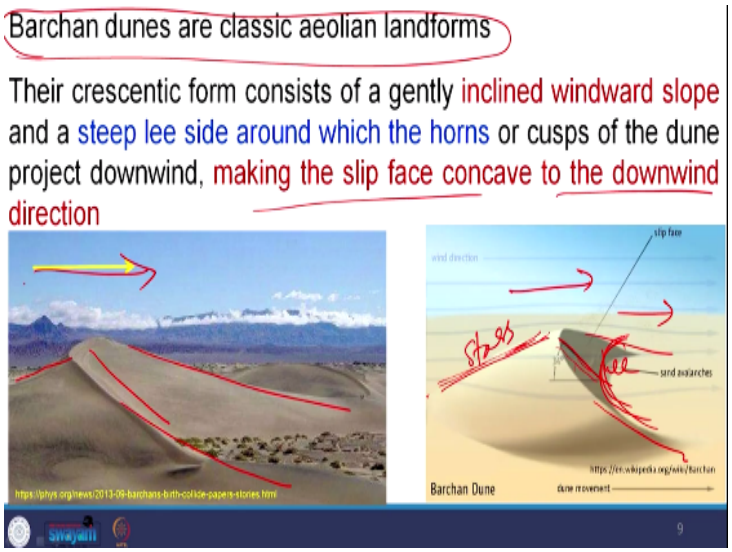

Barchan dunes is the another type of the transverse dune and it is the most prominent and most popular one also. Barchan dunes are classic Aeolian landforms. Here you see this most popular dune whenever we talk about or think about this Aeolian system and dune formation always a picture comes in our mind that dunes would be like this, this. So in that case this barchan comes in our mind.

So this is the most popular type of dune. If you see here their crescentic form consists of gently inclined windward slope and a steep lee side around which the horns or cusps of the dune project downwind, making this slip face concave to the downwind direction. If you see here in this figure this is the upwind direction and this is downwind direction the wind is blowing here.

And here this is gently sloping body and this side is the steep sloping one and this is one horn, this is another horn. Similarly, here you see this is gentle slope and it is steep slope and it is lee side and this is stoss side. So here you see this is the windblown direction. This is called horn and this side there will be free flown and finally we will get some loose sand and this sand relatively compact due to this shearing motion.

And finally this making a slip face concave to the downwind direction. If you see the slip face it is concave and this concavity it is towards the downwind direction. So this is a peculiar kind of dune and most popular dune in the Aeolian system.

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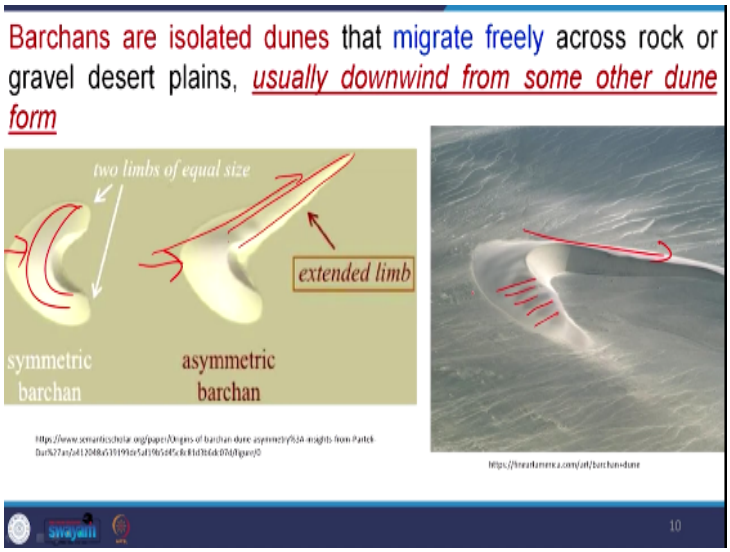

Barchans are isolated dunes that migrate freely across rock or gravel desert plains usually downwind from some other dune forms. So that means the barchans can be divided into different other type of dunes. So based on this wind based on the sand supply or so. For example, you see if this is the windblown direction and we are creating a barchan here. This is the windblown direction and creating a barchan here.

With time you see one limb or one horn is elongated and finally it may convert to a longitudinal dunes also. Similarly, here it may convert to a longitudinal dune. Here you see there are several subdivisions are occurring here. So that means barchans are isolated dune they migrate freely across the rock or gravel desert plain usually downwind form some other dune form. So that means they in the downwind they can be divided into different types of other types of dunes.

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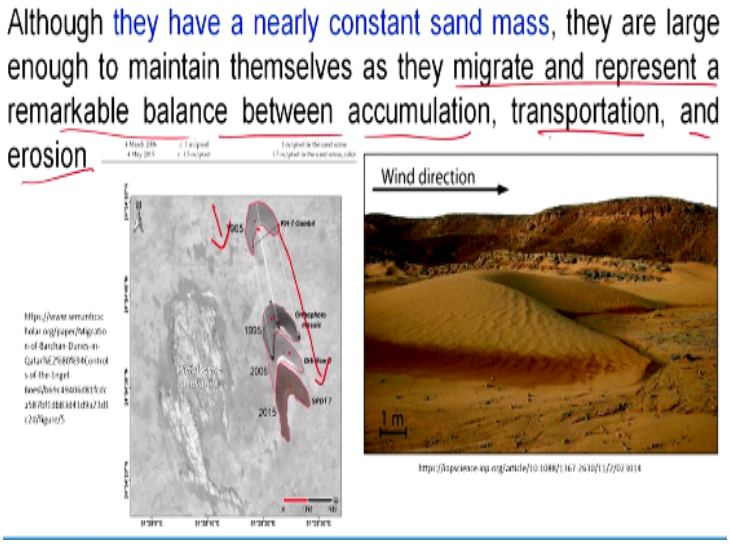

Although they have a nearly constant sand mass, they are large enough to maintain themselves as they migrate and represent a remarkable balance between accumulation, transportation and erosion. Now see here we have we are migrating the system. So this is the downwind direction and from dune here to here, here to here that means though we are migrating very less loss of its mass.

So that means from here to here the total mass near total mass is transported from here transported again here transported. So that means they migrate and represent a remarkable balance between accumulation, transportation and erosion. So that means the whole system, the whole mass remains near about constant during its migrations.

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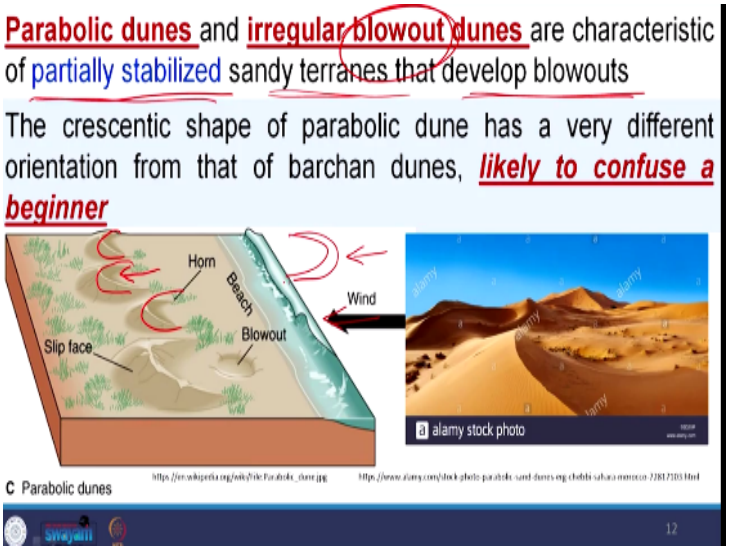

Then comes to another type of dune that is called parabolic dune. So in the other types of dune where we are talking about this longitudinal dunes, we have transverse dune this barchans or transverse barchan is part of this transverse dune. So in that case a barchan in this transverse dune we were hindering to certain extent by this vegetation matter or of some obstacles.

And here this parabolic dune it is another example where some of this vegetal material are there, some of the obstacles are there which are resisting the sand to move completely and forming a parabolic dune and irregular blowout dune it has to be noticed here this is blowout dune. Blowout means if you remember our earlier classes when we are talking about the wind erosion.

There is a terminology blowout we are using that means removing the material, removing the material from one place to another place and this is blowout we say when this deflation the deflation hollow is up to this water table or up to this root zone of this plant that is called blowout. So that means this blowout dune itself says the material which is involved in the formation of the dune is coming from this blowout that is from removal, from the deflation.

So this material is deposited here and it removed from here so this is called blowout dune or it is the parabolic dune. So this parabolic term it is used for its size, for its shape that means by shape if you are looking from the top surface its shape itself indicate it is looking like a parabola. So that is why it is called parabolic dune. There characteristics of partially stabilized sandy terranes that develops blowout partially stabilized.

Partially stabilized that means sand dune stabilization it is a environmental problem or the sustainable development when we are talking about the geomorphology in sustainable development. So in that case we have to stabilize the dune otherwise it will migrate, it will enclose the locality, it will enclose our day-to-day activities. So that is why we have to stabilize it.

So there are many process of stabilization either it is and the most prominent process is by plantation. So that means either naturally or artificially. If some vegetative material are allowed to grow on this dune surface that means it will hinder the wind to blowout this material freely that is why this wind or the dune will be stabilized. So this parabolic dune

they are characteristics features of this area where we have partially stabilized the Aeolian system.

That means there characteristics partially stabilized sandy terranes that develops blowout. The crescentic shape of a parabolic dune has a very different orientation from that of the barchan dunes likely to confuse for the beginners. Here the difference is that in this, this is a parabolic dune, this is a parabolic dune. Here the wind direction is from this direction to this. You see this is the wind direction and your parabolic dune is looking like this.

But had it been a barchan this if this is the wind direction the barchan will be look like this. So that means it is opposite directions and this opposite directions it distinguishes itself from the barchan, but at the beginners we are working very recently we have started working they may not properly distinguish it so should not be there confusion that this is the barchan and this is the parabolic dune.

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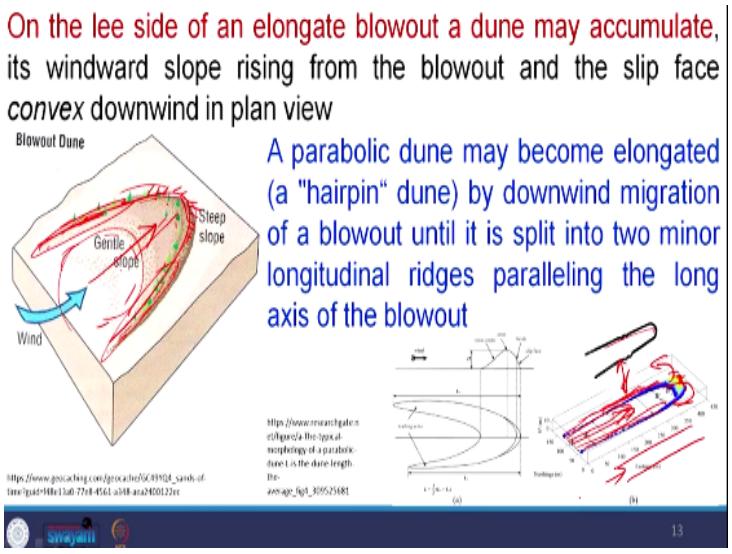

On the lee side of an elongated blowout a dune may accumulate it windward slope rising from blowout and slip face convex towards the plan view. If you see here we have this is the region where blowout occurs and finally the sand is moving and creating a parabolic dune. Here this is the steep slope where slip face occurs this is the steep slope and this side is the gentle slope.

And this blowout material due to this presence of vegetation this is not able to move completely and they are arranged according to this orientation of this vegetation and this is

the elongated side, this is the elongated branch of this dune and it is forming a parabolic shape. A parabolic dune may becomes elongated to form a hairpin dune if you see here this is a parabolic dune and wind blowing in this particular directions.

And gradually this arms of this parabolic dunes getting longer and longer and this side will be the steep slope face and it is looking like a hairpin. So that is why it is called also hairpin dune. So the parabolic dune may becomes elongated like a hairpin by downwind migration of blowout until it is split into 2 minor longitudinal ridges parallel to the long axis of the blowout.

Now you see here if I allowing again and again wind to blow finally this will be elongate this will grow its elongation this will grow its elongation and this sand will be again divided up to this and from this and finally this will appear like this that means 2 longitudinal dune will form. So that means I want to say either it is barchan it is of transverse dune, it is of parabolic dune with time and with more and more windblown direction for duration of wind blow that will convert it to different types of dunes.

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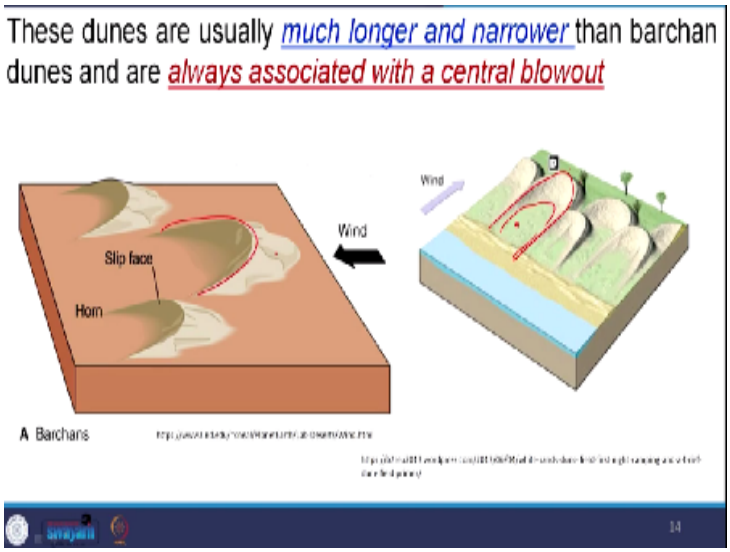

These dunes are usually much longer and narrower than barchan dunes and are always associated with central blowout. This is the difference between this two. If you see here this is barchan and this is parabolic dune. Here it is always associated with blowout, but here we may not need a blowout to form a dune, but as it is blowout is associated with and vegetation is associated with.

So this is creating a dune of elongated nature. However, it is creating a dune of more crescentic nature. Sand dune on coasts except in desert commonly are parabolic and blowout dunes. So desert we do not have vegetations or much vegetation.

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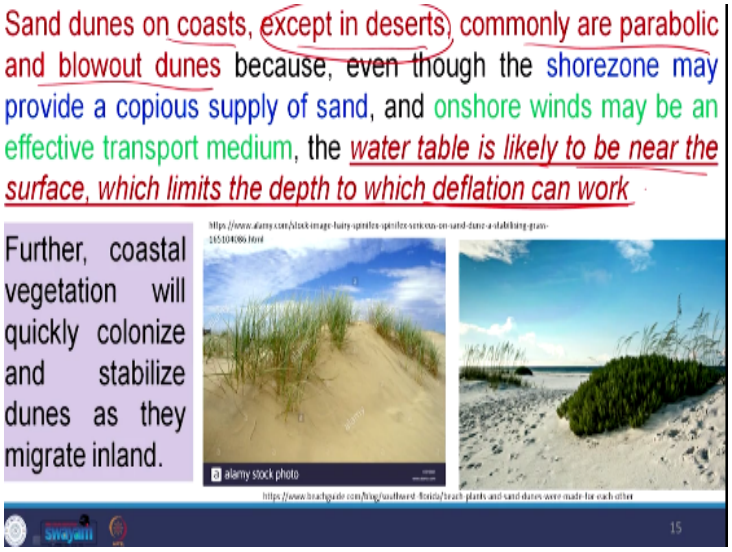

So sand dunes on coast except in deserts, desert is the exception commonly are parabolic and blowout dunes because in coast we have vegetations because even though this shorezone may provide a copious supply of sand and onshore wind maybe an effective transport medium, but the water table likely plays a major role here. So the water table once it reaches up to the water table or there will be capillary water zone.

So that means it will provide a strength to sand to be intact in this position. So it will prevent the sand particles to move. That is why the water table likely to be near to the surface which limits the depth of which deflation can work. So that is why either it is and second thing that once the water table is near to the surface it will promote the vegetation growth. So that is why there will be blowout.

And that is why this sand dunes of coast they are commonly of parabolic and blowout dunes, but in arid regions total complete arid regions like the desert so there are less chance of getting this vegetation cover I think this water table near to the surface. So that is why mostly this parabolic dunes or the blowout dunes they are confined in the coastal regions. Further coastal vegetation quickly colonize and stabilize dunes as they migrate inland.

This is also important topic here or important points here. One is our water table another is the vegetation. So both plays important roles equally important role for blowout to occur and once blowout is there that means we are going to create parabolic dune. This two gentlemen 1993 defined dry, wet and stabilized Aeolian system which are distinguished by relative role of the water table and surface stabilizing factors such as vegetation as the controlling sand movement. One is dry dune that means here free movement.

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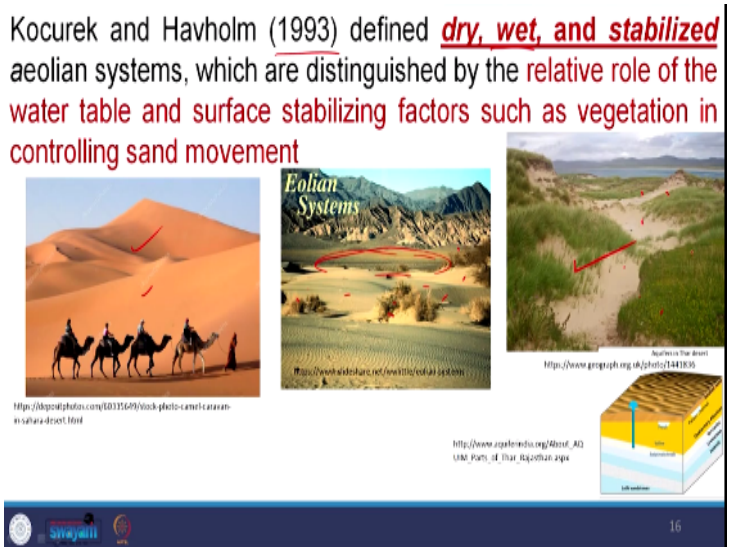

If you see this photographs frequent change in the dune position, frequent change in sand supply it is dry than wet if you see this is the playas near to this playas we have wet conditions. So that means relative stabilized movement is there and this is totally stabilized that means the whole system is stabilized here. So this total the sand surface it is covered by vegetations so this is dry dune, this is wet dune, this is stabilized dune.

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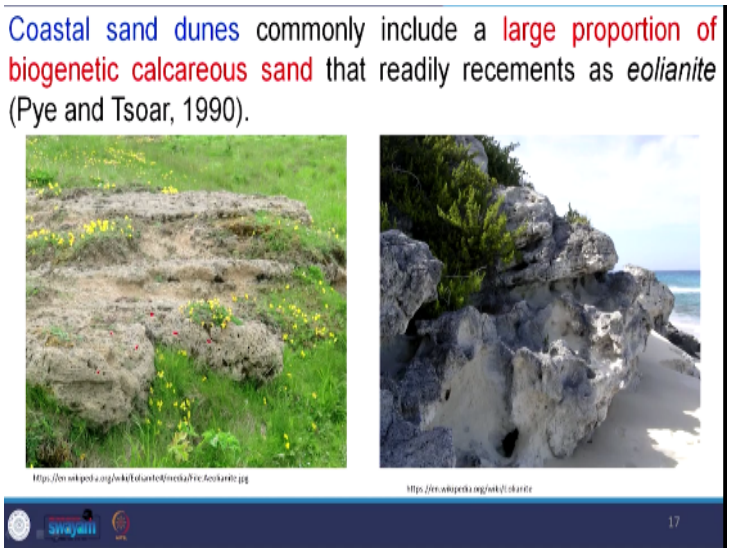

Coastal sand dunes commonly include a large portion of the biogenetic calcareous sand and relatively cement as eolianite. So here if you see in the coastal region if you move you will such type of porous very porous and permeable materials are there then there consolidated to semiconsolidated that is called eolianite and in the eolianite the most abundant constituent is the calcareous material which biogenic origin.

Because we have organism, we have remnants of organism near to the coast either it is plant material or it is maybe animal material. So this whole system is consolidated together and somewhat odd smell you will feel it there. So this is the eolianite.

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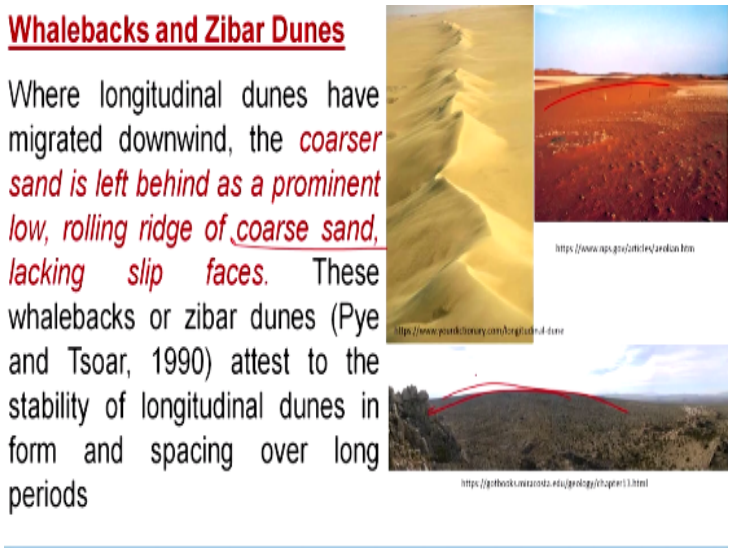

And this is Whalebacks and Zibar dunes where longitudinal dunes have migrated downwind. The coarser sand is left behind as a prominent low rolling ridge and coarse sand lacking slip

face. This whalebacks or zibar dunes attached to stability of longitudinal dune in form of facing over long period. So these are the huge dunes whaleback dune it is the huge dunes are there and it is showing the rolling topography if you see here very gentle rolling topography is there. This is one type of dune.

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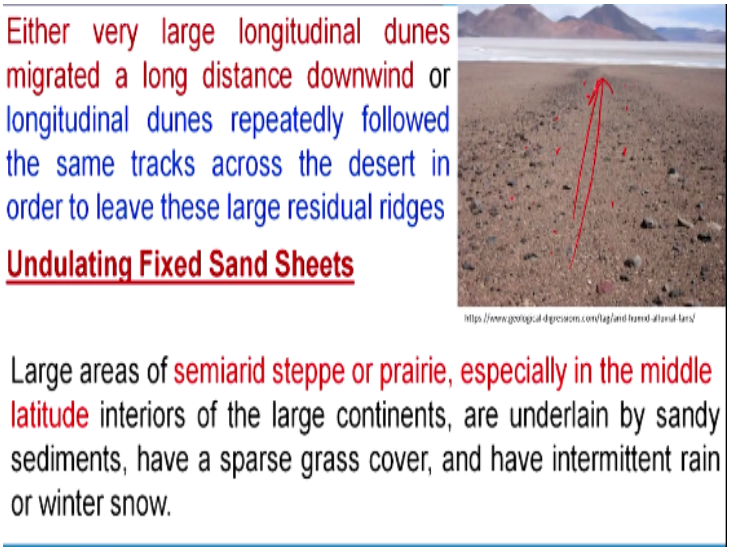

So either by large longitudinal dunes migrated a long distance downwind or longitudinal dunes repeatedly followed this same track across the desert the in order to leave this type of large residual lag. So that means I want to say either this is the way through which the longitudinal dune have passed for a long time or a repeatedly same path has been followed by many longitudinal dunes.

So that is why this lags are remaining in a linear fashions. So that is undulating fixed sand sheet so this undulating fixed sand sheets are there, separated by this type of gravel beds. Larger area of semi arid steppe and prairies especially in the middle latitude interiors of the large continents are there underlain by sandy sediments have a sparse grass cover and have intermittent rain and winter snow and those regions are mostly responsible for this type of formation of this type of topography.

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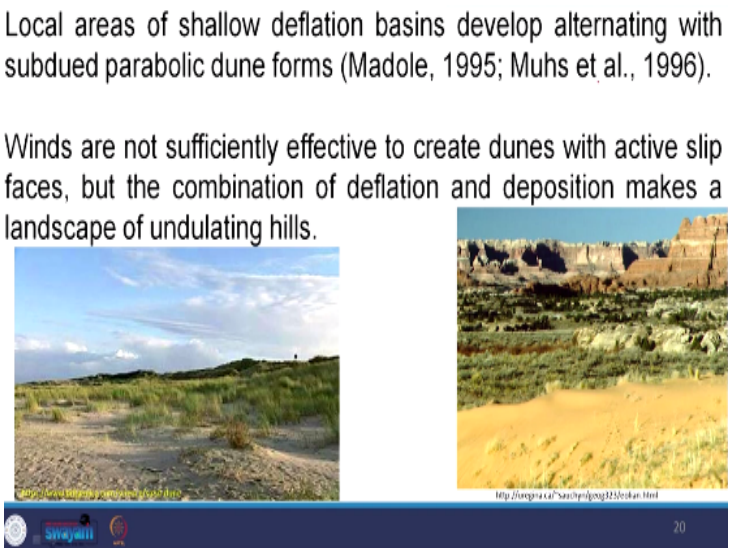

And local areas of shallow deflation basins develop alternating with subdued parabolic dune forms. Winds are not sufficient effective to sufficiently effective to create dunes with active slip face, but in combination of deflation and deposition makes a landscape of undulating hills. So that means these are the wind actions through which different shape of this dunes we are getting, different size of this dune we are getting, different structures we are getting within the dunes.

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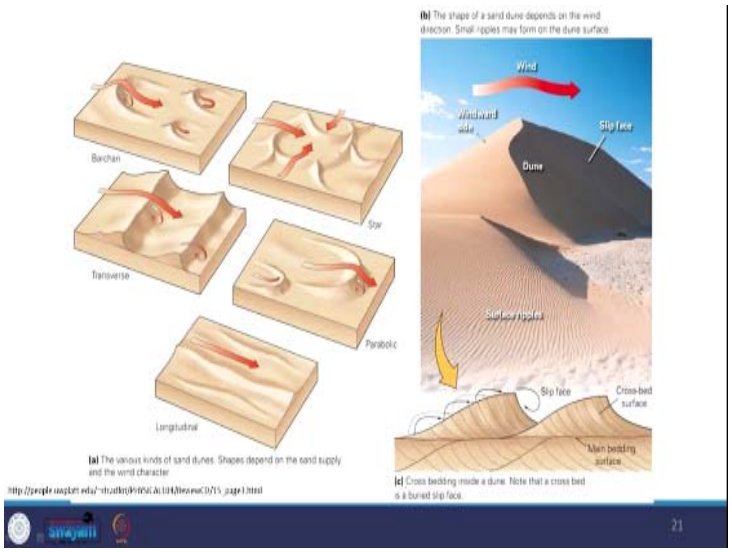

And if you summarize it here there are different types of dunes depending upon the wind directions, depending upon the sand supply, but irrespective of its nature after migration also the internal structure of the dune remains constant.

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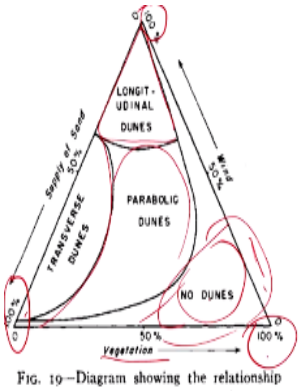

FIG. 19—Diagram showing the relationship between dune forms, aggressiveness of vegetative cover, supply of sand available to the wind, and strength of the wind. It is assumed that the wind blows almost constantly from one direction.

Dune Type	Definition and Occurrence	Illustration (Arrows Indicate Wind Direction)
Barchan	Crescent-shaped dunes with horns that point downwind. Dunes exhibit a gently inclined windward and a steeply inclined leeward slope. Isolated dunes migrate along hard, flat desert floors with constant wind speeds and limited sand supplies.	
Transverse	Dunes with long, wavelike ridges that are perpendicular to the effective wind direction. Common in areas of large sand supply, weak winds, and little vegetation. Often found along coastlines but may grade inland to barchan dunes.	
Parabolic	Hairpin-shaped dunes that open upwind. Formed from the accumulation of sand along the leeward and lateral margins of a deflation basin. Occurs in areas with intermediate sand supplies and wind speeds and moderate vegetation.	
Longitudinal	Dunes with long, straight ridges that are parallel to the predominant wind direction. Found in barren areas where winds are persistent and the sand supply is irregular. Dune ridges are separated by desert pavement.	

And here I can conclude that we have this wind 100% wind and we have vegetation 100%, we have sand supply 100%. In this triangle if you see this portion is occupied by longitudinal dunes. This is transverse dune, this is parabolic dune and here no dune. No dunes means we have vegetation 100%, we have wind less wind or zero wind or less than 50% wind. So in that case we are getting no dunes.

So even if sand supply will be there but due to vegetation, due to less wind we cannot create a dune there. So to form a dune we should have we must have that sufficient wind speed so and sufficient area should be there and critical more than the critical area should be there and from which the sand sheet will move and create a dune. So I think we should stop here. Thank you very much.