Geomorphology
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Lecture – 31
Dune Classification - II

So here, we are going to discuss in this class, the dune classification in continuation of our earlier class, if you remember when we are talking about this dune classification, we are talking about this longitudinal dunes, transverse dunes, star dunes, parabolic dunes like that, so all those dunes they are defined by this windblown direction and with respect to their structure. So, longitudinal dunes they are parallel to the windblown direction, transverse dune, they are perpendicular to the windblown direction.

Similarly, within that transverse dune, we have barchans, we have parabolic dunes and we have other type of dunes like the star dunes, they are special kind of dune with shows different windblown directions and it grows in height rather than it migrates. So, this was all about your dune classification, so today we are going to discuss some other experts of the dune classification.

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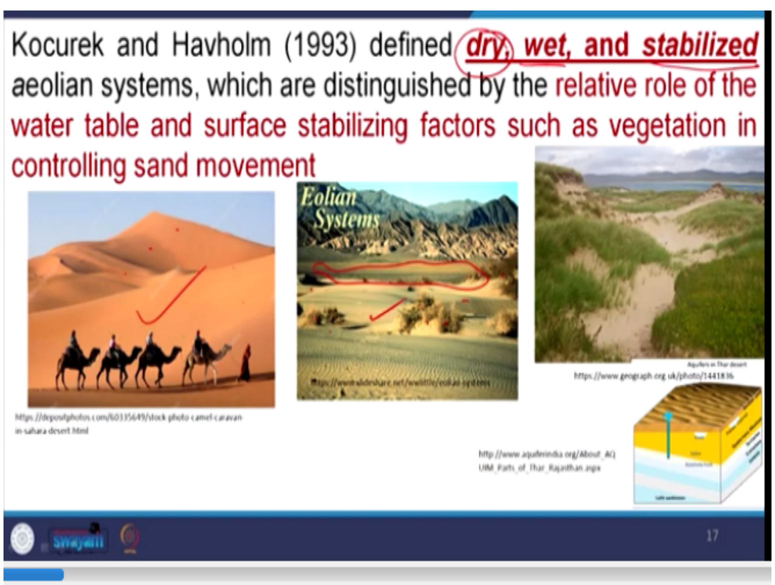

Here, if you see, these 2 gentleman, Kocurek and Havholm in 1993 defined there are the dunes can be classified by dry, wet and stabilised Aeolian system, so what is this dry Aeolian system;

this Aeolian system if you see, 3 photographs representing these 3 scenario, here this is the dry system that means, free sand, free movement of sand, there will be no moisture at all, no vegetation, so that is called dry Aeolian, it means, dry sand is there.

Then wet; wet if you migrate from here to here, this photographs you see, this is the playas and near to this playa, we have certain vegetation that means, this area is wet, then third is your stabilised system. Stabilised system it is; either it is artificially or it is naturally, you see whenever there is a arid environment, dunes migrate frequently and this dune migration creates a problem in our developmental projects.

It may enclose the whole village at time, so that is why there are certain programs through which either naturally or artificially, we want, we always try to stabilise the Aeolian system or stabilise the dunes. So, in that case, there are 2 ways of stabilisation; one and the most effective way is the vegetation, so once we allow the vegetation to grow on the dune surface, the wind's effectiveness will reduced.

And finally, there will be less migration or there will be no migration of the dune further, this is called totally stabilised dunes and other factor is the water table, so if we have water table close to the surface, so that means, by capillary action, this water will move upward and finally, these sands, the adhesive force between this sand will increase and finally, this will resist to blow by windblown.

So, that is why in that case, what will; this case is called stabilised system, so that means, now we have dry Aeolian system, wet Aeolian system and stabilised Aeolian system, so each Aeolian system that plays in characteristic role, either they will allow this dune to form or they will not allow the dune to form that will be discussed here.

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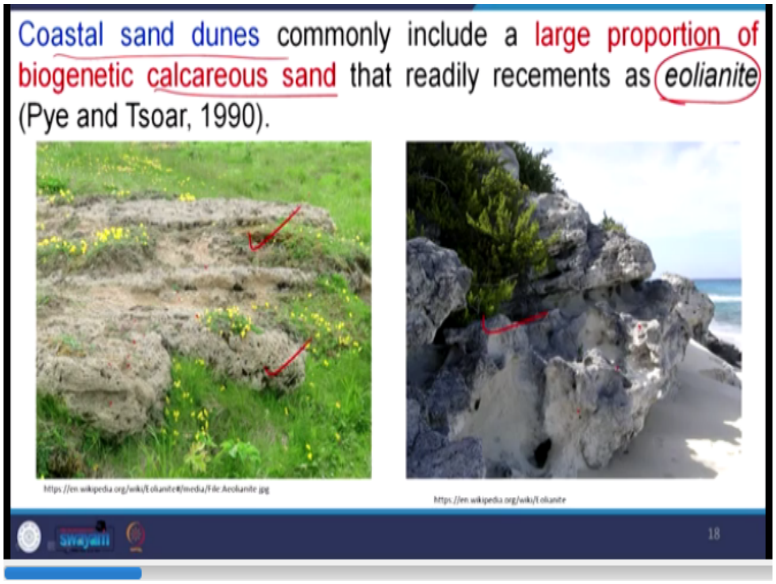

Now, then another part is your coastal dunes, if you move in the coastal area, there is a peculiar type of rock types is called eolianite, so eolianite nothing, it is eolian sediment and it is mixed with organic matter and the organic matter, it may be of animal origin, it may be of plant origin. So, irrespective of that but mostly, this animal origin are calcareous material, like this broken part of the shells or so.

So, that means the organic matter together with sand, they consolidated recrystallize very soon to form a material which is intact and consolidated that is called eolianite. Now, you see coastal sand dunes commonly include large portion of a biogenic calcareous sand that is readily cemented as eolianite. So, if you see these 2 photographs, this is mostly calcareous materials and along mixed with sand and forming a hard pan here.

Similarly, here it is hard but mostly, it is porous and highly permeable, so the whole system is called eolianite.

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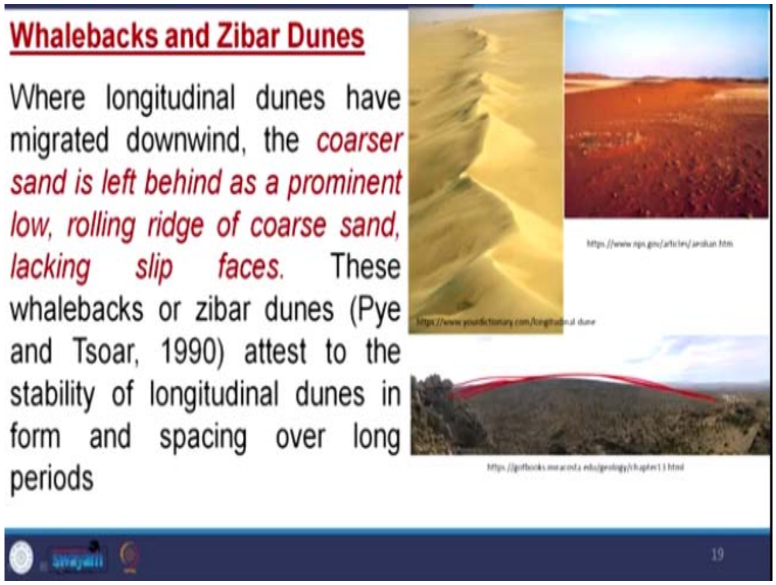

Then, another structure is called whale backs and zibar dunes, so what is whale back? It says, if you see a whale for a distance, the back it look like, this it is, if you see this type of; if you see, you see this is the type of typography, that is called rolling topography. So, how it happened so? Suppose, for example we allow this sand to move or a sand dune, a longitudinal dune to move in a particular corridor.

So, once we know this sand is or the dune material is moving relatively, finer material will move fast and the coarsen material will lagging behind and finally, the boulders, the pebbles, the cobbles that will lagging behind in the system and with continuous addition of this material or if we allow the material to move continuously for a long period, then with more and more lagging material will be accumulated there.

So, as a result with more time, so this type of topography will form, that is called rolling topography, very gently sloping surface that is called rolling topography. So, here the longitudinal dunes have migrated down wind, the coarser sand is left behind as a prominent low, rolling ridge of coarse sand, lacking of a slip face, as it is very gently sloping plane, it will not create any distinct slip face here.

These whalebacks or zibar dunes attest to the stability of longitudinal dunes in the form and space over long periods that means, a long period, this type of long; this longitudinal dune will be stabilise here or it will move along this sand, through the same corridor for a long time.

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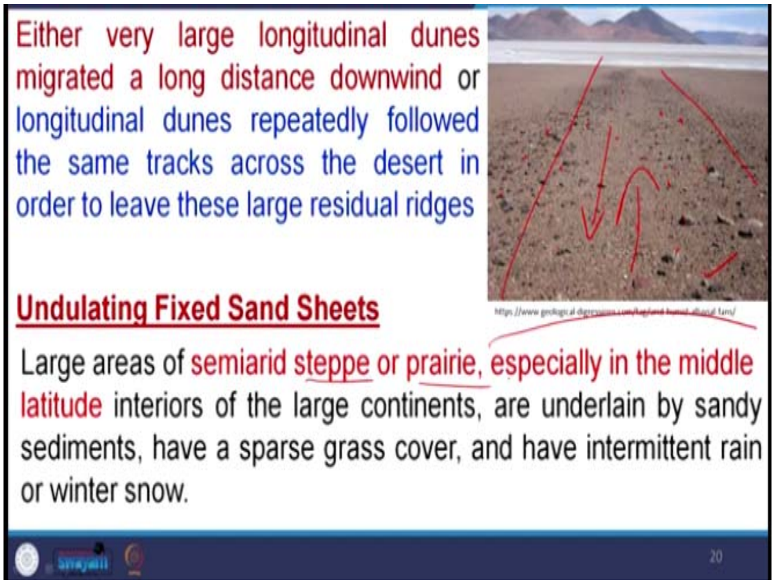

Either very large longitudinal dunes migrated a long distance downwind or longitudinal dunes repeatedly followed this same path across the desert in order to leave these large residual ridges. So now, if you see this photograph here, this is a zone, this is a linear zone which is the; through this linear zone, we are concentrating this pebbles, cobbles or the larger boulders also. So that means, it indicates through this path or through this path, we have allowed to migrate the longitudinal dune for a long time.

Or the reverse is true that means, through this path there are number of longitudinal dunes they have passed through, so as a result, addition of material; lagging material is there. So, as a result we will create a surface which is looking like this, it is very gently sloping body that is called the rolling topography. So, this is all about our dunes now, we will discuss about this undulating or fixed sand sheet.

Now, let us discuss about the sheets, sheet type of structures, so here undulating fixed sand sheet that means, there will be some undulation, this is not planar, this is undulation. See, undulation might be due to blow out, due to vegetation or the presence of some coarser and finer material or that means, accumulation of more sand at a place or less sand at a different place, so that means, irrespective of its nature, it is creating an undulating topography having some thickness that is why its two dimension is more as compared to the 3 dimension.

That si why it is calling an undulating sand sheet type of structure, so these type of structures, this undulating sand sheet that is mostly, that will common in the semi-arid steppes and prairie especially, in the middle latitudes, so interior of the middle latitudes, or in the middle latitudes or interior of this large continents, they are underlain by sandy sediments, have a sparse grass cover and have intermittent rain of winter snow. So, those areas having sandy sediments are there, grass cover is there.

But sparse grass cover is there, so there will be sand movement but that movement is in restricted form, so that means, selective spatial movement that means, some spaces were lack of sandy cover that from that area, sand will blowout and this blowout sand will deposit somewhere else, so that means, if you see from a distance, you will find this type of topography that means, undulating topography, this represents the lower portion that represents the blow out regions.

And the upper portion they represent the deposition region and as there is no sufficient sand supply and the vegetation is there, so perfect dune cannot form here, so that is why it remains as a sheet format that is why it is called undulating fixed sand sheets.

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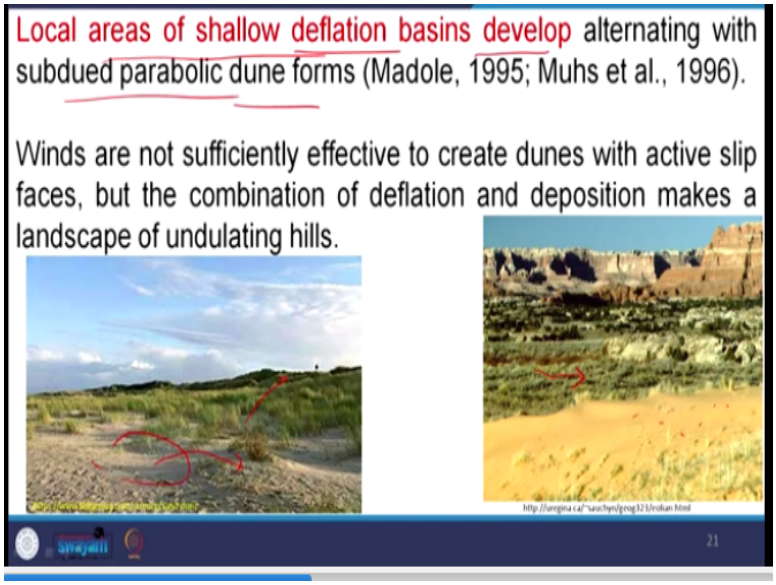

Local areas of shallow deflation basin develops alternating with subdued parabolic dune forms you know when we are talking about dunes, we are talking about when there is vegetation available, when blow out is available; we generally those areas are suitable for generalisation of a parabolic dunes. So, here the same conditions satisfied, we have vegetation cover, we have sand.

So, we are allowing the sand to blow, so that means we are creating some blow out surface that is why local areas of shallow deflation basins develop alternating with subdued parabolic dunes, so we are getting some parabolic dunes here. Winds are not sufficiently active to create dune with active slip faces but the combination of deflation and deposition makes the landscape of undulating hills.

You see here, we have some blow out areas, material is removed and depositing here similarly, material will be removed and depositing here, so that is why we are creating an undulating topography here. Similarly, if you see here, we have some areas, from where this blow out occur and finally, sand is deposited here. So, overall it is creating an undulating topography.

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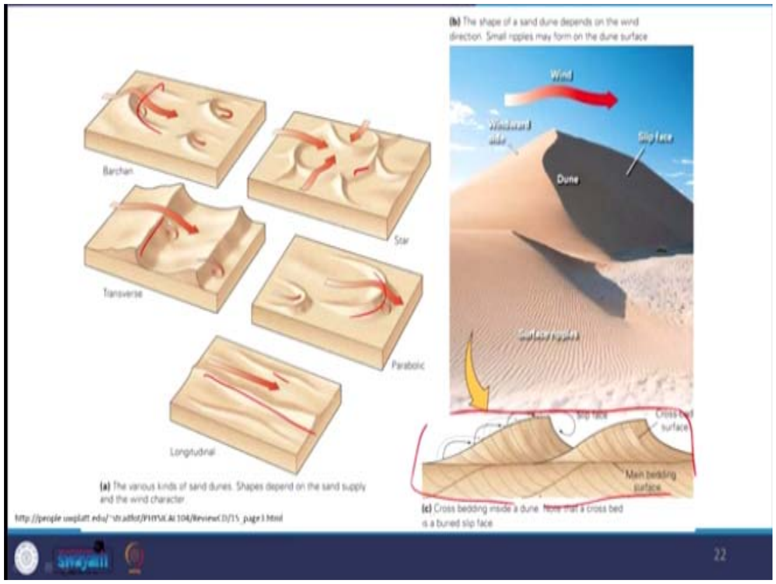

And if you see here, this total sheets says about this combination of different windblown direction and sand supply and summarising how the sand dunes are formed and this is the transverse and this is the longitudinal dunes, this is parabolic dunes and this is barchans, this is star dunes and this is the dune, how the dune migrate, this is a, internal structure is shown here. So, this is all about the summarising sheet or the summary sheet of these dune, we have so far discussed.

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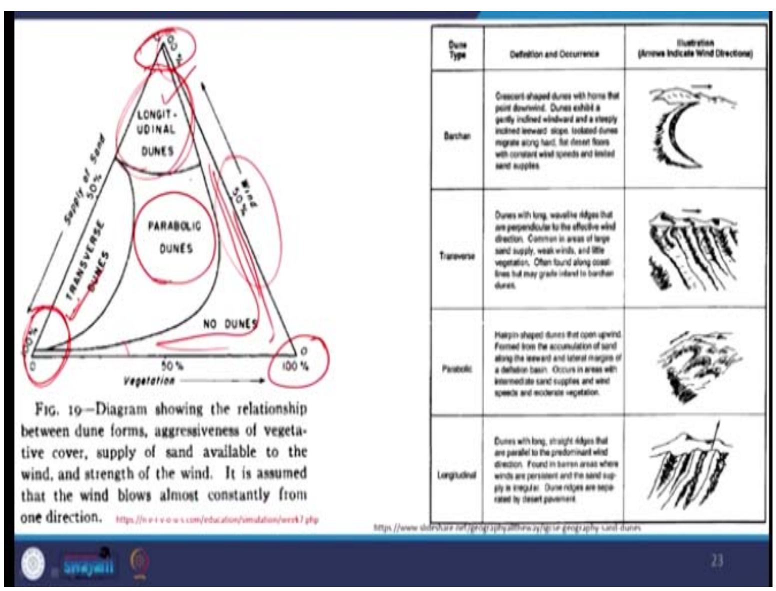

And here as we are expecting that there are 3 main factors they are responsible for dune form, their effective role is discussed here now, you see we have a triangle having 3 vertices; one is 100% vegetation, so 100% vegetation that means, we are along a dune to stabilise or the area which is a stabilised area that means, it is providing sufficient cover or sufficient resistance to wind to remove a sand particles from its surface.

So here, they have 100% wind that means, very high wind speed is there, then it is 100% sand supply that means, sand supply is sufficient for that. So, now you see, if I have confined in these 2 parts, so here we are getting transverse dune, where maximum sand supply is there, massive sand supply that means, here 100%, then if the windblown is 100%, then we are creating longitudinal dunes.

Here, we are getting transverse dune and here this portion we are getting parabolic dune but if you see, here in this region, no dunes that means, you see we have 100% vegetation and we have sand supply, if it is sand supply is there, vegetation is there, there will be known dune form. Similarly, wind speed, if it is less wind speed, this side wind speed is less, so though sand supply with be there but less wind speed, then dune will not formed.

So that means, these 3 factors that with different permutation and combinations, they collectively decide whether the dune will form or not and what type of dune will form or not, okay, so this is all about your sand dunes.

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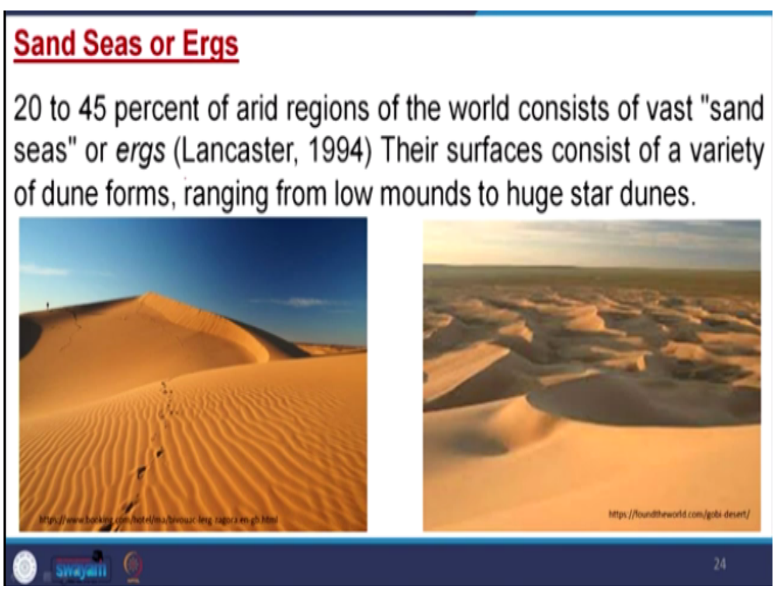

Now, come to sand sea or ergs; sand sea, that means, if you see this is representing 1000's of square kilometres of area, it is covered with sand, so that means, 20 to 45% of this arid region of the world consist of fast sand sheets or that is called ergs, their surface consist of a variety of dune forms ranging from this mounds of huge star dunes and ripples like that. So, that means, I want to say, this whole area, the whole arid region, it is composed of totally sand.

And this, that means, it is looking like a sand sea, ocean of sands, this is called ergs, so these areas mostly, so that means, those areas which is representing sand seas, there are certain factors which are responsible for its accumulation and the most prominent factor is their lithology, how lithology plays a major role in accumulating of this sand, we will discuss here.

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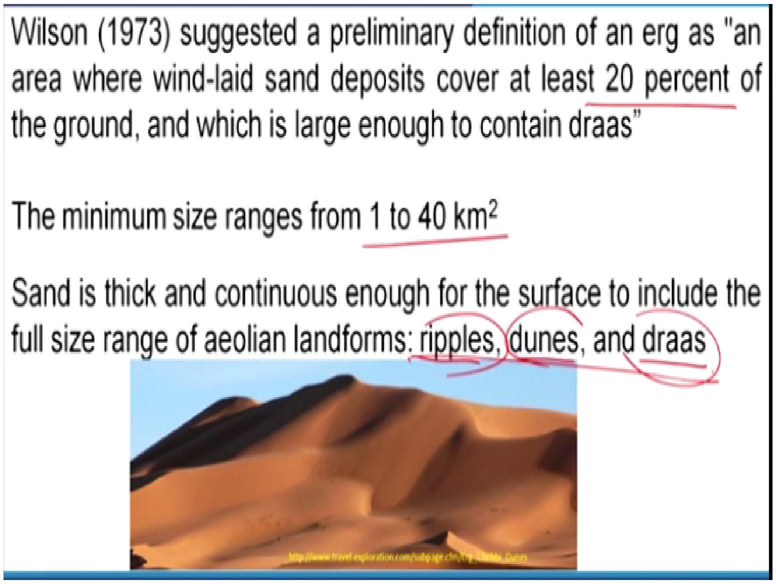

Now, Wilson 1973 suggested a preliminary definition of an erg that in an area where wind laid sand deposit, cover at least 20% of this ground and which is large enough to contain draas; draas we know it is a huge sand body, it is sand dunes type, a minimum size range from 1 to 40 square kilometre area. Sand is a thick and continuous enough to the surface to include the full size range of Aeolian landforms like ripples, dunes and draas.

So, that means, a sand sea that means, a huge area having sand, then that can accommodate ripples, dunes and draas that means all kind of Aeolian landforms, all kind of movement structures of the sand, that can be accommodate here, so this is the characteristics of the draas that means, all type of Aeolian structure will be available.

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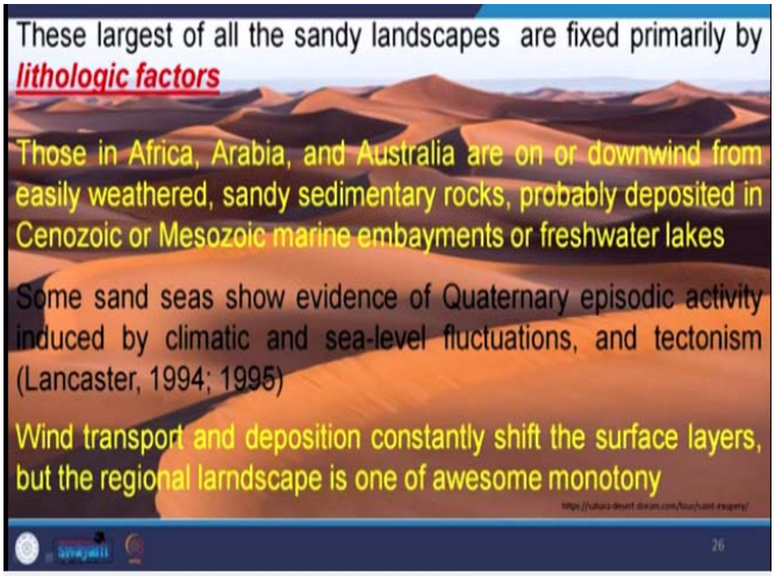

These largest of all sandy landscapes are fixed primarily by lithologic factor here; we are talking about the lithology plays a major role in accumulation of a sand in a particular area and creating a sand sea, how? If you compare here those in Africa, Arabia, and Australia are on the downwind form easily weathered sandy sedimentary rocks probably deposited in Cenozoic or Mesozoic marine embayments and fresh water lakes.

So that means, if you would discuss these; if you analyse the terrains of these different surroundings and compare with this sand sea, you will find the source area which surrounds in the opposite direction which is mostly, the sedimentary rocks either Quaternary or in the Mesozoic form and they are unconsolidated to semi consolidated, so that means, if this wind is allowed to blow on sedimentary rock which is unconsolidated or semi consolidated sedimentary rock or weathered sedimentary rock.

So that means, mostly that will bring the sand, that will remove the sand from this system and will accumulate somewhere here, so had it been basalt, covered with basalt, had it been covered with granite probably such huge sand sea might have been occurred, so that means, the surrounding lithology plays also an important role whether what will be the area and what should be the spread of this sand cover.

Some sand seas show evidence of a Quaternary episodes activity induced by climatic and sea level fluctuation and tectonism, so that is also important, tectonism we know that tectonism is playing major role in producing sediments, it is more fractures, more up liftment will be there, more fractures will be there, more sediment degradation will be there and finally, it will be more; similarly sea level changes.

Sea level; if it is sea level is decreasing, then it is creating sediments, if the sea level is increasing, it is creating another kind of sediment, similarly climatic change, arid region it will create more sediment, so that is why, tectonism, sea level change, climatic change and the surrounding lithology, all those they play their respective roles in producing sediments and finally, those sediments were transferred and deposited and forming the ocean of sand or sand seas.

Wind transport and deposition constantly shift this surface layers, but the regional landscape is one of awesome monotony, so that is why by shifting the sands, by transporting the sands from the surrounding area, we are creating a sandy dominated area; sand dominated area and through this wind movement, we are deforming the sands, we are creating one type of topography, again we are migrating this dunes, so we are migrating the ripples, creating another type of topography.

And finally, this area is mostly dominated by wind driven sediments and its deformation and its rearrangement. So, what is we are talking so far, we are talking about the dunes, the ripples like that, the start dunes x, y, z, something, something, so that means, in all those structures, we were involving the sudden sea sand but what about the fine products because whenever that is weathering, when there is erosion, when there is sediment production, not only sand particles are created.

Silt, clay that means, finer size particles are also created, so it is the part of this work of this wind, which transport all those materials and deposit it at a place and if you remember, when we are talking about this sorting, due to this saltation, due to the suspension, due to the traction or this creep, different size fractions we separate out and in desert mostly, the coarser fraction remains and once the wind velocity or wind speed decreases at the periphery of this desert system or a grid system, this sand is not able to be transported out of the system.

It will remain inside, it will migrate here and there, it will create a different land form however, the finer particles; this silt and clay size particle, they once they come to suspension, they remain in the suspended for a longer time, it is very difficult to pick out a silt or clay size particles from this intact surface but once it comes out, once a system is steered that means, it will remain in suspension form for long time and it can migrate 1000's of kilometres, okay.

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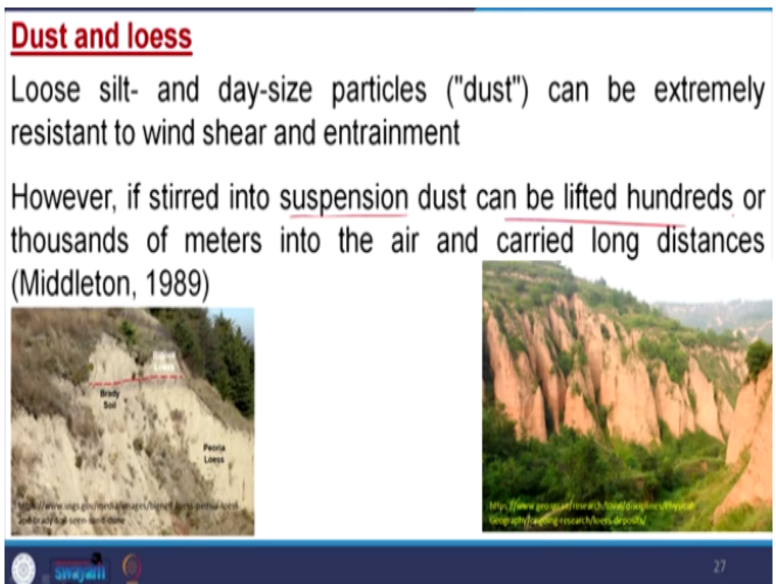

So, however if the stirred into suspense, dust can lift 100's of 1000's of metres into the air and carried long distances, so as we have discussed in our earlier classes, these volcanic ash deposit in Narmada valley, it is related to Toba volcanics that means, it is 1000 kilometres apart similarly, this erosions that can travel 1000's of kilometres through this blow, so that is why this silt and clay sized particle, once it is peaks up to the air system, it will continue travelling for long distance.

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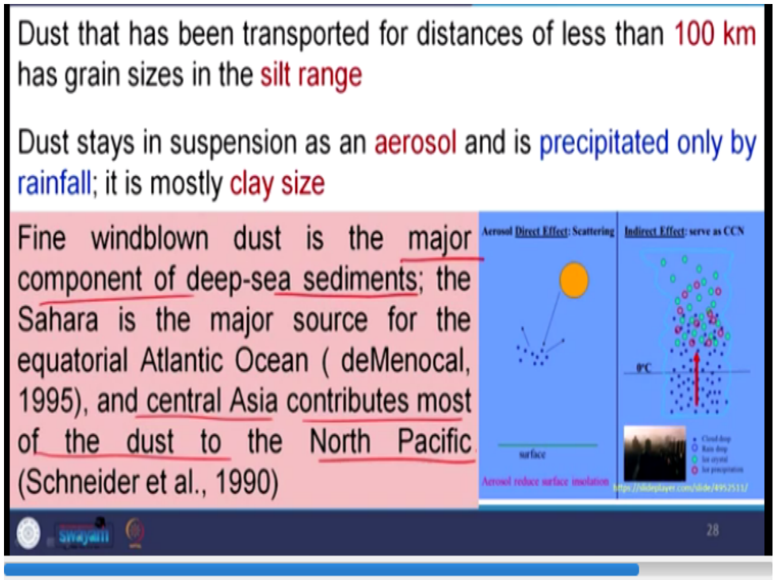

Dust that has been transported for distance of less than 100 kilometre has grain size of silt range, dust stays in suspension as an aerosol and is precipitated only by rainfall, it is mostly of clay size, so the aerosols mostly, of clay size particles and this silt mostly it is by loess deposits, so loess deposit mostly in our Indian context if you see, in Punjab, Haryana it is, if the periphery; UP, in the periphery of this Thar desert, we are getting lowest deposits.

Fine windblown dust is the major component of deep sea sediments also, deep sea sediments when we talking something about deep sea sediments, some of the sediments are biogenic origin, some of these origin are chemically precipitate and mostly, it is the major component of this deep sea sediment is of wind or Aeolian region, these are there also, this is the finer particles, they settle down there, due to moisture effect they become heavy and finally, they settle down.

So, this is major component of the deep sea sediments, this Sahara is the major source for the equatorial Atlantic Ocean, so if you see this, analyse the source of this Atlantic Ocean sediments, deeper ocean sediments which are Aeolian region and it is mostly, picked up from the Sahara's and Central Asia contributes most of the dust to the North Pacific, a Central Asia and Sahara, so that means, major arid systems, major arid regions, major desert regions, they are creating this silt and size particles and it travel to 1000's, to 100's of kilometres and they settle down in the ocean surface.

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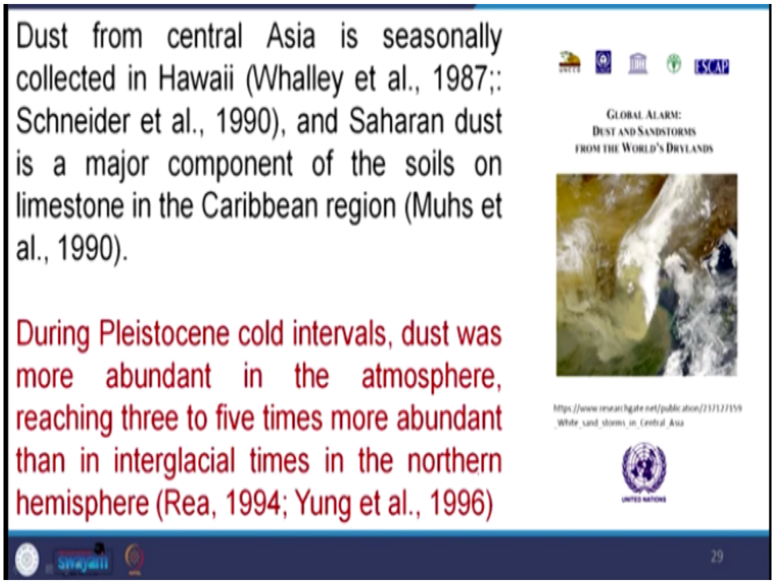

Dust from Central Asia is seasonality collected in Hawaii and Sahara dust is a major component of the soils on limestone in the Caribbean region, so if you see here this is not only contributing for this oceanic sediments, if you remember while we are talking about this weathering and erosion and we are talking something about calcrete formation, we can remember calcrete or this soils, the carbonate; calcium carbonate soil, maximum part, it is contributed from this windblown material.

So, these are the fine grain particles of calcium carbonates, the sand particles; or sorry, the silt and clay size particles, they are deposited there and forming a calcrete layer, so it not only contributes to the ocean sediment or deep ocean sediment, it contributes to the soil forming process also, soil formation, soil thickness, soil horizon thicknesses also. During Pleistocene cold interval, dust was more abundant in the atmosphere reaching 3 to 5 times more abundant than interglacial times in the northern hemisphere.

It is estimated that, that means, during interglacial period and this glacial period, these cold period; cold arid period, they are producing more dust as compared to this interglacial period because interglacial period, mostly it moist environment, there will fluvial sedimentation was more but in glacial period, this is totally dry, so there is more chances of wind activity and this dust productions, so that is why comparing the interglacial and glacial period is more prone to develop dust or the silt and clay size particle as compared to this inter glacial period.

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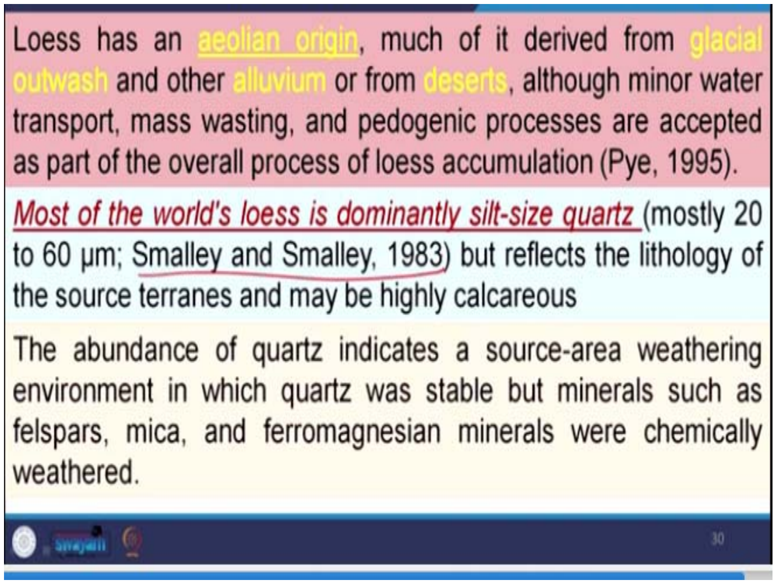

Loess it is mostly, this loess terminology comes from the loose, unconsolidated, so loess has an Aeolian origin, much of the derived from glacial out wash and other alluvium or from desert although, minor water transport mass twisting and pedogenic processes are accepted as part of the overall process of loess accumulation. Loess; it is a loose material, loose, unconsolidated material mostly, it is of a silt and clay, mostly it is silt and less is clay.

So, these are this product of either glacial out wash that in deserts and alluvial sediments, so due to reworking by wind, this finer dust particles they removed and very less contribution is from fluvial sediments and it is forming loess. So, nowadays, whatever the loess reaches you can see in the Punjab, Haryana, Uttar Pradesh and somewhere else, so mostly they are representing these silt size particles derived from this wind; derived by the wind activity from the surrounding arid region.

And for an Indian context, it is from Thar and from the Ganga plain during this climate change, most of the world loess is dominantly silt size quartz to that is mostly 20 to 60 micro meter but reflected the lithology of the source terrane and maybe highly calcaneus. The abundance of quartz indicates a source area weathering, that weathering process should have removed this ferromagnesian minerals, the mica's, this other type of minerals or the feldspars.

And such type of erosion that means a particular type of erosion, which is responsible for enrichment of quartz in the source area, so here you can say, this the silt or the clay that the final material is blowing out of this desert periphery and deposited where there is a decrease in wind speed and finally, it forming the Loess and mostly, the world loess, it is composed of silt size particle and it is responsible for the deposition during this climatic change. So, I think we should stop here and then in the next class, we will discuss with the different topics. Thank you.