Geomorphology
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Lecture – 23
Arid Zone Geomorphology

Okay friends, good morning and welcome to this lecture series of geomorphology and today, we are going to discuss about the arid zone geomorphology. So, if you remember in your initial classes when we were talking about the introduction to geomorphology, in that class we have divided the land surface into different geomorphic domains, geomorphic domains means the geomorphic agents, they are predominantly at this particular region they are predominantly active.

So, for example we have glacial domain or glacial geographic province mostly, the higher latitudes and higher altitudes similarly, the fluvial domain, it is not restricted in particular environment, it is spreading throughout the globe however, the intensity of this fluvial system, this work culture or this activity of this river processes, though they vary from place to place but the distribution is concerned.

As per distribution, the whole globe can be well distributed with this fluvial system but the arid region, the wind it is restricted either in the deserts or in the coastal part or deserts means when I say, desert it may be cold desert or hot desert, so arid zone geomorphology when we talk, we talk about those part of this earth which is containing with arid climate, okay. So, let us discuss it elaborately what does it mean, what are this geomorphological characteristics of this arid zone.

And what type of geomorphic agents they are working in the arid zone to make the surface peneplain, so before moving to this arid zone geomorphology, we must first define what an arid zone means to you.

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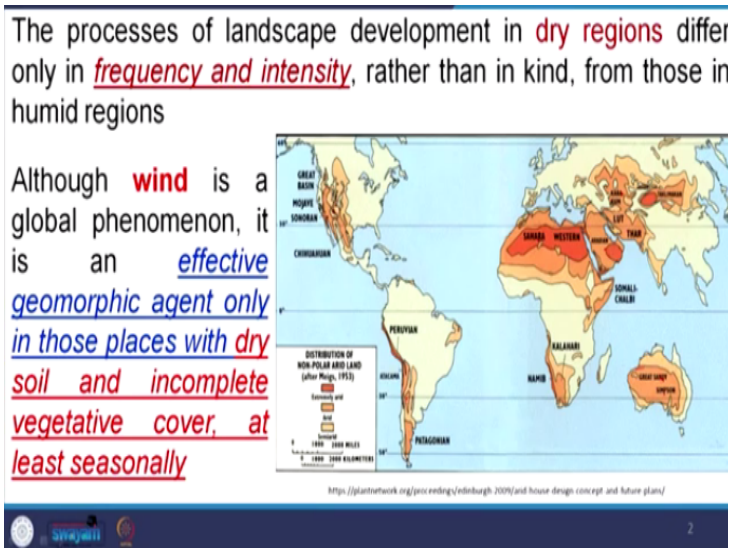

The process of landform development in a dry region differs only in frequency and intensity than the humid region, so it is very important to understand here, once we say the landform formation and its modification in arid region, the frequency and intensity is more as compared to humid region for example, in arid region it is mostly dry, lose sediment, lack of any vegetation cover.

So, this geomorphic agents; the erosional agent which is mostly by the dominated by wind, it plays major role in modifying and transporting this loose material from one place to another and that is why it modifies the land form very frequently. Similarly, the intensity is also more but as compared to this humid region, it is dominated by a river though there is land form development but here the frequency of land form modification is less as compared to the arid region.

Although wind is a global phenomenon, it is an effective geomorphic agent only in those parts, those places with dry soil and incomplete vegetable cover or vegetative cover at least seasonally, so here wind action plays major role why because it is a dry region, lack of vegetation and mostly, these regions are the arid regions, they are characterized by loose sediments.

So, once there is a loose sediment, it is easy for the wind to transport, to erode, to transport and to deposit somewhere else, so during changes of wind direction either diurnal changes or annual changes, so once a sediment which is eroded from this place and it is transported and deposited from that place in the evening time or in the either in the diurnal changes or in the

annual changes, when there will be a reverse of wind, again that land form will be modified from there to here.

And it will transported and it will new land probably, formed somewhere, so that is why in wind region or in wind dominated region or the arid region, this frequency of change, the landscape change is predominantly more than this frequency of change in the humid regions. So, if you see here the world map here, the arid regions they are occupying or restricted or given this red colour or the orange colour.

And if you see here most part of this arid region they are lying between here similarly, even if it is close to very; very close to coast, we are getting arid regions here similarly, here even if very close to this water source but we have arid regions but here these arid regions they are confined interior of this continent, so here also interior of the continent and this side it is close to this water source.

So, now the question arises; if arid region is the lack of water, lack of rain, then why a region which is close to this water source, very close to this oceans they are experiencing arid climate, so that means we have to first unravel the reasons behind it, what are the reasons for which the arid climate prevails in a particular area. So, dry climate; dry climate means the largest single identifiable climatic region in the earth is the dry climate, where either seasonal or annual precipitation is insufficient to maintain the vegetation cover and permit perennial streams.

So, perennial streams will not be found in the dry climatic region, so in fact we will get some ephemeral streams, seasonal streams during region, during rainy season they will contain water however, if we compare these ephemeral streams with the between this dry climate and the humid region or the arid region and the humid region, we will find the difference in the terms of that in humid region, though there is ephemeral stream which is flowing from this mountain front towards the plain, the water content increases with length.

The more and more downstream it goes, the more and more water will be added to it but in contrast to arid region; in arid region, though ephemeral streams they move so, they percolate water; water will be percolate from the riverbed, as a result from downstream; from upstream

to downstream, this water content of this ephemeral stream decreases. As a result, they try to vanish within this plane.

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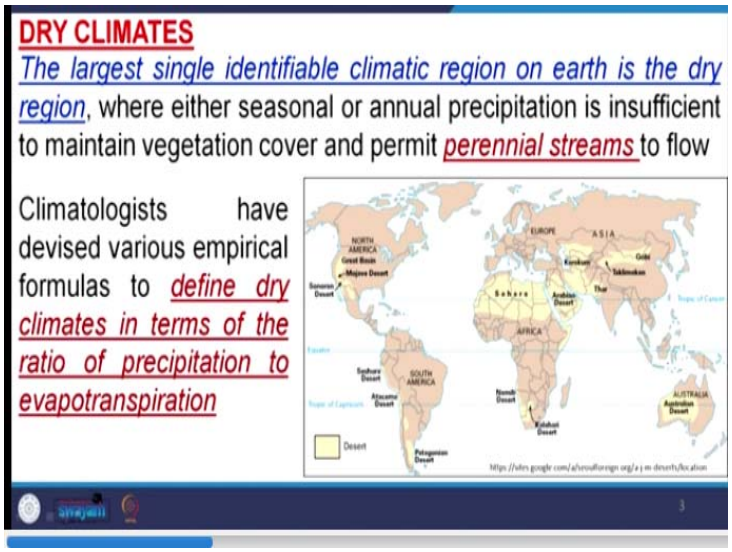

So, the climatologists have devised various empirical formula to define the dry climate. According to them, the dry climate in terms of ratio of precipitation and evapotranspiration, so that means 2 terminology; one is precipitation, another is evapotranspiration. So, if precipitation is more, then evapotranspiration it is humid region and if reverse is true, these regions are termed as arid region.

So, evapotranspiration and precipitation; this, the ratio of these 2, define whether we will say it is a dry climate or arid region or it is a humid region.

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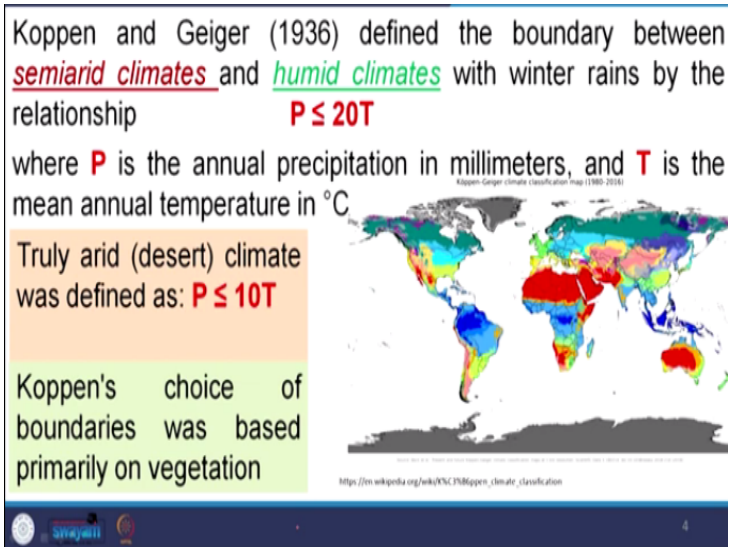

So, the pioneering work to define this climatic domain of the world, it was first of carried out by Koppen and Geiger in 1936, say define the boundary between semi-arid and humid climates with winter rains by relationship is P ≤20 T, where P is the annual precipitation in millimetre and T is the mean annual temperature in degree Celsius. So, truly arid deserts climate was defined as P ≤10 T.

So, this choice of boundaries which was adopted by Koppen which was based on primary vegetation, vegetation, as a parameters to define whether it will be arid region or it will be a humid region. So, according to him, truly desert climate will be precipitation P ≤10 T.

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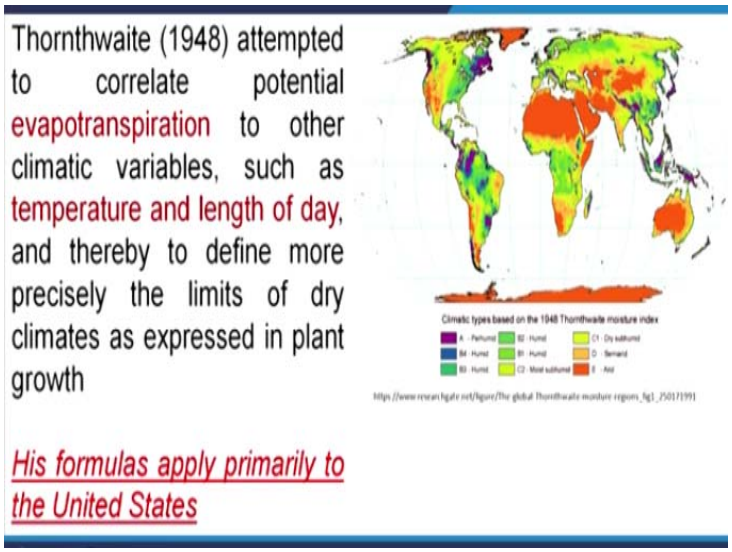

Then Thornthwaite in 1948, he attempted to correlate the potential evapotranspiration to other climatic variables such as temperature, length of the day and thereby to define more precisely, the limit of dry climate as expressed in the plant growth. So, his formula but it is restricted up to United State only but here 2 things to be marked; one is other parameters that also affecting the climatic condition.

One is the temperature and another is the length of the day, length of the day also plays a major role for example, suppose in our sense, in our case sometimes, we are getting 11 to 12 hour day and 12 hour night but if we are moving to higher latitudes, their day time will be more and night time will be less and from if you moving other part, the night time will be more the day time will be less.

So, that means the duration of day time, more the duration of daytime more will be the evaporation, more time Sun will looked this part of this earth, so that means the length of the day also decides what type of climate will prevail in a particular region.

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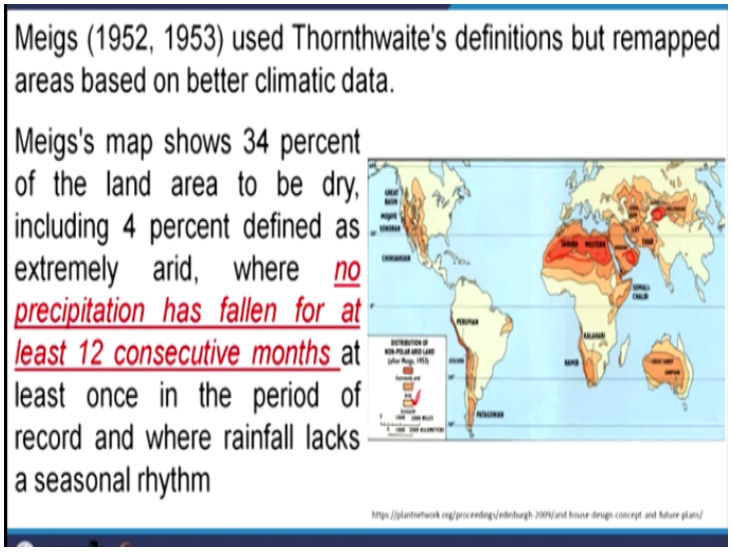

Meigs in 1952 and 53 used Thornthwaite classification or definition but remapped the area based on better climatic data. So, his map source 34% of this land area to be dry including 4% defined as the extremely arid, where no precipitation has fallen for at least 12 consequence months, at least once in a period of record, where rainfall lacks seasonal rhythm. So, this gentleman he again classified the Thornthwaite classification he reclassified.

And found the 34% of the land area of the world to be dry including 4% defined it extremely arid, so extremely arid if you see here Meigs classification 1953, these colour, this deep orange colour this is defined extremely arid and if you see these extremely arid regions they are placed or situated in the interior of the continent, where this water vapour carrying winds they cannot reach, that is why he classified it is extremely arid.

And there is no raining for the last 12 consequence months, so that is why this area has been defined as extreme arid and according to his classification, this colour represents arid colour, this colour represent; this colour representing semi-arid, this is arid and this is extremely arid. So, here if you see in particularly in this larger continental part, this part is representing semi-arid, this part is representing arid and this is extremely arid and this is humid climate.

Similarly, here also even if these are the parts which are interior of the continent however, if you see this side close to coast, close to the Atlantic we have extremely arid, then it is arid, then it is semi-arid. So, now the question arises; what was the reason behind those places where, which are even close to this ocean body which plenty of water and water vapour is available, why these areas are falling under extremely arid climate.

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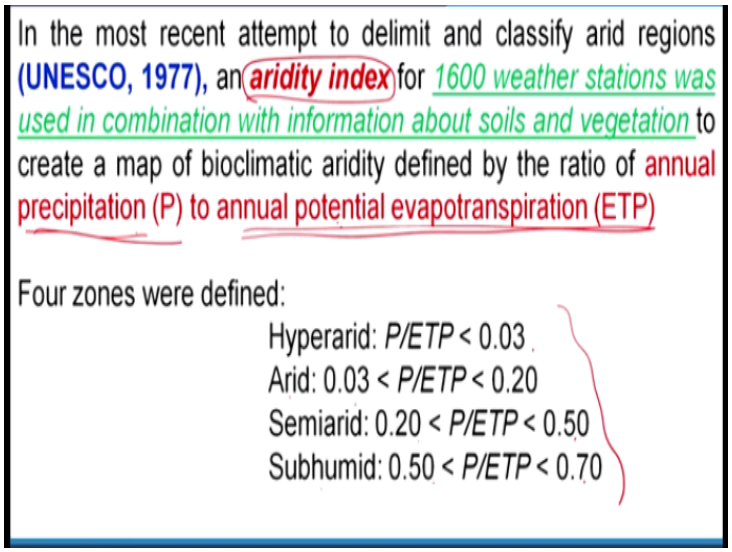

So, we have to search for the region, the most recent classification was carried out by UNESCO 1977 and is defined the aridity index; aridity index of 1600 weather stations were used in combination with information about soil and vegetation to create a map of bioclimatic aridity defined by a ratio of annual precipitation P to annual potential evapotranspiration ETP.

So, here the classification based on precipitation and annual potential evapotranspiration ETP, it is classified by UNESCO 1977 and it is defining the aridity index, so aridity index is a ratio; it is a ratio of precipitation and annual potential evapotranspiration. So, 4 zones has been defined according to UNESCO, one is hyper arid; hyper arid means P to ETP, ratio is 0.03, then arid 0.03 to 0.2, semi-arid 0.2 to 0.5 and sub humid 0.5 to 0.7.

So that means, based on this ratio of this precipitation to annual potential evapotranspiration, 4 arid zones to semi humid, including semi-humid, 4 zones has been divided.

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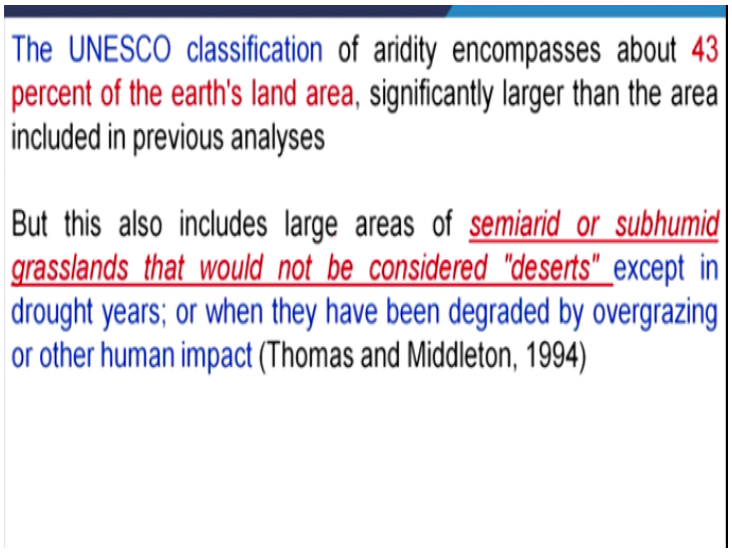

And if you see the UNESCO classification of aridity encompasses about 43% of this earth land area significantly, larger than the area included in the previous analysis, so that means this UNESCO classification, according to UNESCO parameters, 43% of the area is covered by arid climate but if you see this earlier classifications made by those gentleman's, 25 to 30% of this earth area was coming under arid climate.

So, now this is also includes large areas of sub humid glaciations that would be of consider as deserts, there are deserts, there are called cold deserts, there are hot deserts, so those deserts except in drought areas or where they have been degraded by over grazing or other human impact that also included here. So that means, I think personally this UNESCO classification has to be modified.

Nevertheless by any means of classification, either it is the UNESCO classification or those classification by earlier preferred by other 3 to 4 people or the group of people, other workers any classification if you take, then we find that between 25 to 40% of this earth land area is presently arid.

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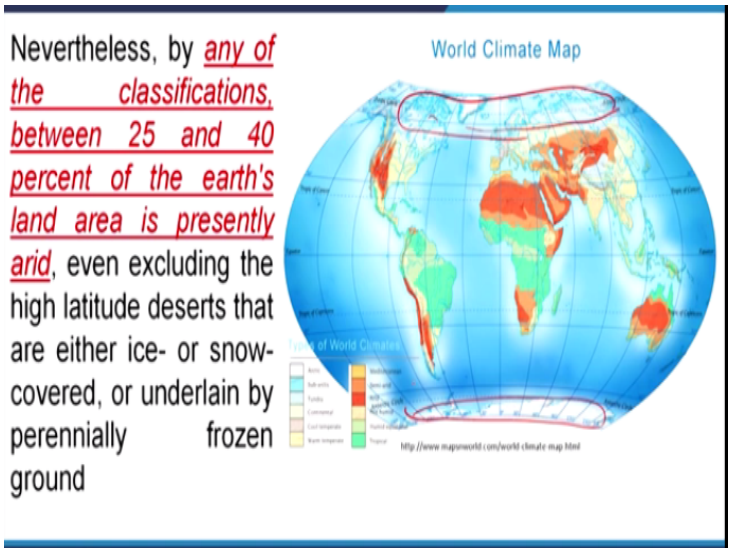

So, if you see here this world climatic map, this area Australia's most part is desert, Africa northern part, southern part in Asia, this Central Asia, then Western Europe, Western America, North America and South America, so that means including all those parts 25 to 40% of this earth land area is presently in arid condition even in this case, we have excluded those areas which are lying on the higher latitudes.

Higher latitudes that means, these are these permanent cold deserts are there, permanent cold desert it is totally covered with ice, so that means in this classification were in this 25 to 40% arid climates we have excluded the ice cover areas and those areas having permanently frozen ground. So, those areas has excluded here but only whenever talking about this classification of arid zone that means, we are here within that for 25 to 40 %, we have only included which is the arid region and it is excluding the ice cover areas.

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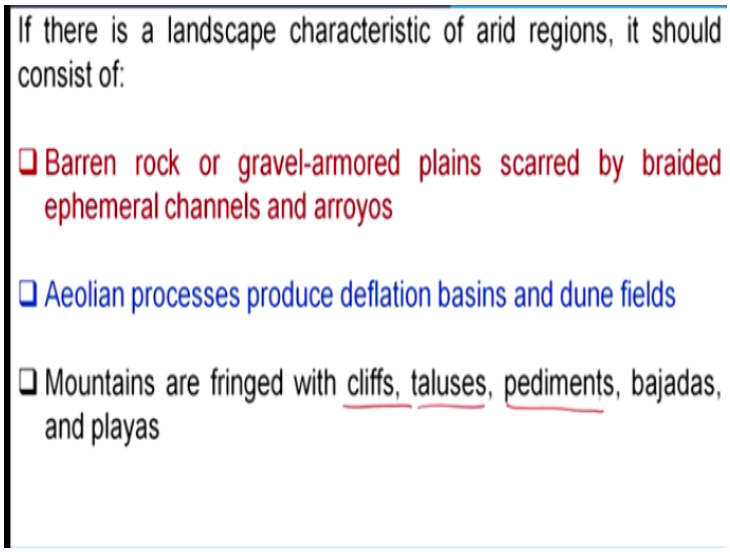

So, there is a landscape characteristics of arid region, it should consist of few of this element, what are those? First is; it should contain barren rock or gravel-armored plains scarred by braided ephemeral channels and arroyos, so this characteristics of arid region is defined here. First this region should contain barren rock or gravel-armored plains, the plains the soil it is covered by gravel, why?

Because due to the wind action, the finer particles have been removed, so these gravels they are the residue, the lags, lag deposit, so this lag gravel deposit will be there and braided ephemeral streams, the stream will be of braided characteristics and ephemeral. Second thing what is braided; braided means in the fluvial geomorphology, we will talk about in detail what is the braided characteristic of river, what is meandering characteristics of the river.

So, here just you remember that in braided characteristics of the streams will be there but in ephemeral nature that means, seasonal flow whenever there will be a flash flood, there will be raining, if it happens so, so this channels will contain water otherwise, throughout the year they remain dry. Then second characteristic said that Aeolian processes produce deflation basins and dune fields.

Aeolian; Aeolian means wind action, wind processes, Aeolian processes produce deflation basins, deflation basins means, suppose there is wind; due to wind action from a particular area due to wind blowing, finer particles are removed, so the area will be depressed because the material is removed, so these are called deflation hollows, so these are the deflation points.

So, places of deflation that means, it is getting depressed and dune fields, so that means this removal material that will be deposited somewhere due to either this some obstacle or due to change in wind velocity, so that means those material which was removed from a particular place that will be deposited somewhere, that is forming a dune. So, we have deflations, deflation points or deflation basins and we have dune fields.

Then mountains are fringed with cliffs, talus, pediment, bajadas, and playas, these are the different elements and they are very, very characteristics element of the arid region, what are those? First mountains are fringed with cliffs, cliffs we know, if they are very sharp slope near about vertical slope against which free fall occurs, then talus below this, it is talus, then pediment; pediment again, pediment in the erosional residual product of this country rock.

Then bajadas; bajada means a coalescence of alluvial fans that is called Bajada, then playas; playas means lakes, shallow level lakes and mostly, it is characterised by salt deposit, so that means mountains will show cliffs, talus slope, then at this base of this mountain, we will have pediments and we have bajadas, then near to this mountain front, we will have playas or within plains, we have playas.

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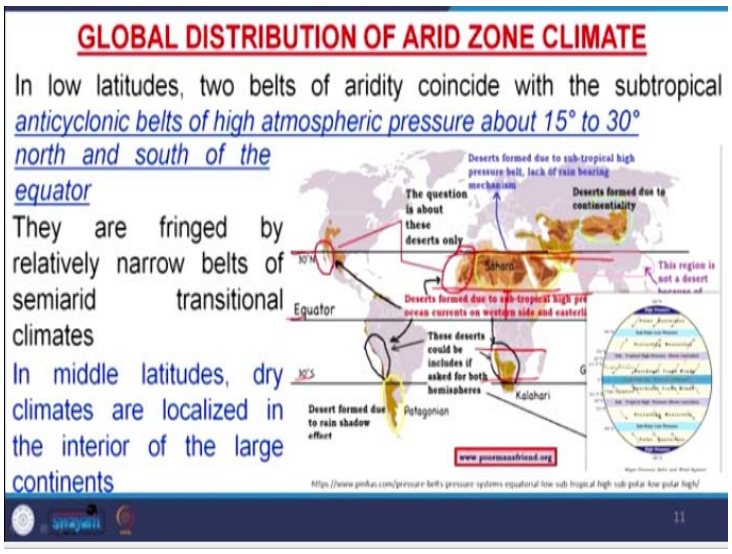

So, these are the characteristics elements of an arid region now, with those characteristics element with the distribution of those characteristics element, the global distribution of arid zones has been classified. So, how these arid zones have been distributed globally let us

discuss. In low latitudes, 2 belts of aridity coincide with the subtropical anti-cyclonic belt of high atmospheric pressure about 15 to 30 degree latitude north and south of this equator.

So, now you see we have equator, this is 30 degree, this 30 degree now, you move from here to here 15 degree, so now you see within 15 to 30 degree similarly, here within 15 to 30 degree, most of these arid zones are lined and those are representing the anti-cyclonic belt of atmospheric high pressure zone and if you see here from here, this is atmospheric high pressure zone, 15 to 30 degree.

Similarly, here 15 to 30 degree we have high pressure zone, so those regions 15 to 30 degree representing high atmospheric pressure zone, they are representing most of this arid region of the world both side from equator north and south, they are fringed by relatively narrow belts of semi-arid climate or transitional semi-arid climate. In middle latitudes, the climates are localized in the interior of the large continents.

Now, you come to beyond this 30 degree latitude, if you are coming to our, these middle latitudes now, you see the interior of this continent; the interior of the continent similarly, here this side, the interior of this continent we are getting the semi-arid climate or the arid climate, so that means a low latitudes we are getting in the high pressure belts, 15 to 30 degree region.

And in mid-latitudes we are getting arid climate in the interior of this main or an interior of the large continents.

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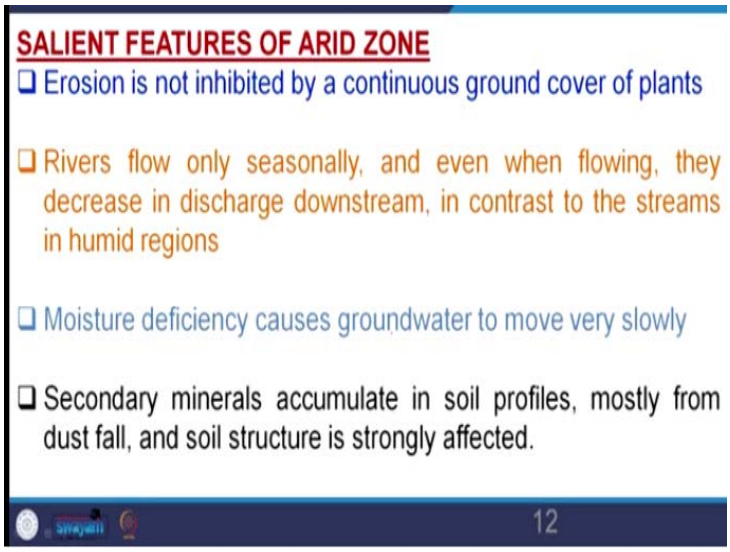

Now, salient features of the arid zone; first is erosion is not inhibited by continuous ground cover of plants, so that means erosion is a dominant phenomena why; because of the lack of vegetative cover, so in arid region there are lack of vegetation, total barren land, so that is why wind gets an opportunity to remove the material from one place to another easily, so that is why due to lack of vegetation; lack of vegetation is a characteristic feature of an arid region as well as this wind action is dominant process.

Second thing that rivers flow only seasonally, there is no perennial rivers, seasonal flows and those seasonal rivers that will be of a braided characteristics or even when flowing that decrease in discharge downstream in contrast to the streams of the humid region, as we have discussed those rivers though it is ephemeral, even if during rainy seasons, when they start flow the water content decreases downstream.

Because as this area is very dry, the soil absorbs the water, percolation is there, so once the percolation that means, most of this water is percolated downward and it is, the river becomes dry. Moisture deficiency causes groundwater to move very slow because there will be no capillary pressure, so moisture deficiency is there, groundwater or whatever is there inside they move very slowly.

Secondary minerals accumulation in soil profile mostly from dust form and soil structure is strongly affected now, we see here, these mineral accumulation we have already discussed when we are talking about this soil formation process, there is calcite development and there

will be other salt accumulations and if you remember those salts within that rock, they are very less, they are generated from the rock by evapotranspiration.

Most of them they are dust falls, so that means secondary mineral accumulation, moisture deficiency in soil, the seasonal flow of ephemeral streams, erosion by winds and gravel cover on the top surface, so these are the characteristics feature on basis; on the basis of which we can define this arid climate from the sub arid climate.

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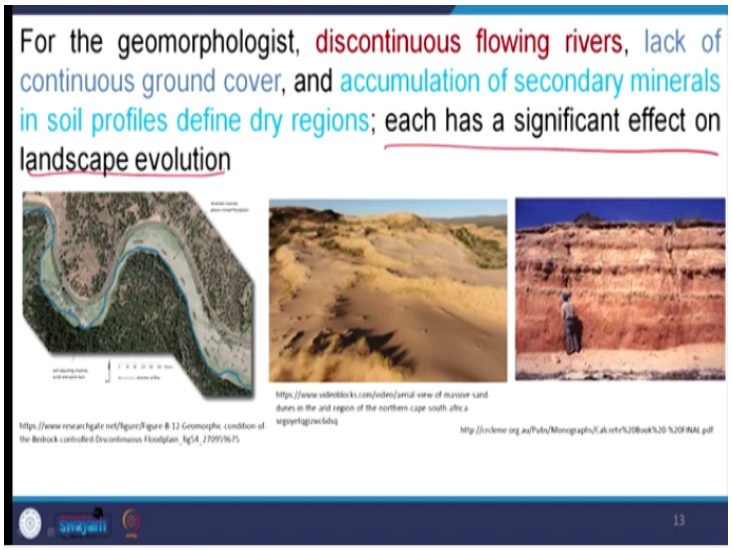

For the geomorphologist, discontinuous flowing rivers, lack of continuous ground cover, accumulation of secondary minerals in soil profile define dry region, each has a significant effect on landscape evolution, this is very important to understand here because as a geomorphologists, our major work is always confined for land form development and each of the parameters discussed here.

That means, discontinuous flow of river, lack of continuous ground cover, accumulation of secondary minerals all those parameters, they influence the landform evolution, so that is why land form evolution in arid region has to be seen on the basis of these parameters only, so this change of these parameters or intensity and either magnitude or frequency of a change of these parameters that define how frequently the land form will evolve in arid region.

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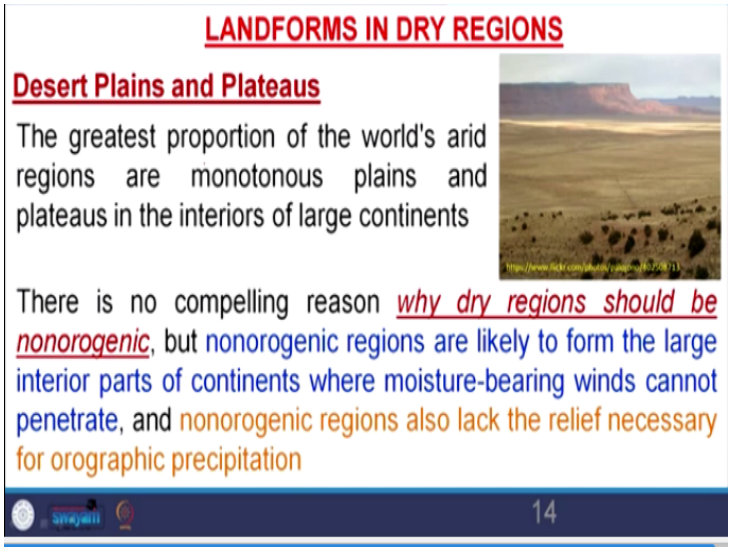

So, let us discuss about landforms in dry region but I think we will meet in the next class to discuss about these landforms in the dry region, so till then I can see you, thank you very much for your attention.