Soil Science and Technology
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Lecture – 04
Weathering and Soil Formation (Contd.)

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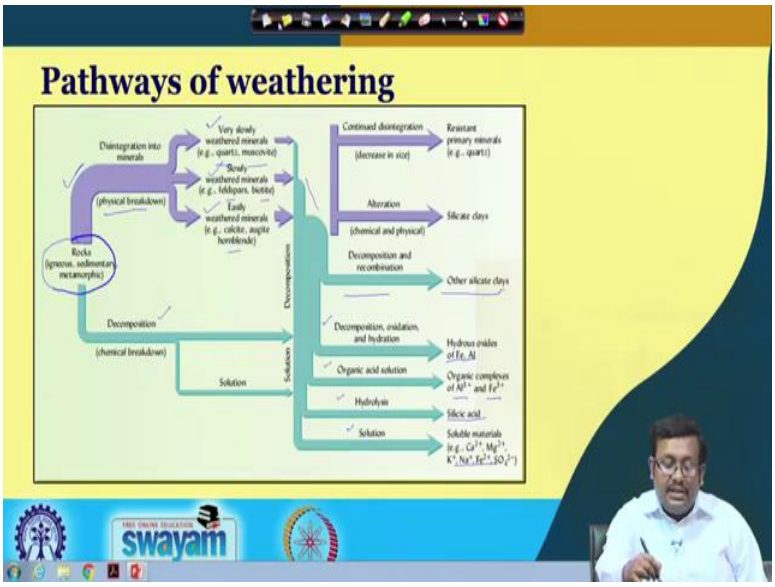

Hello, friends. Welcome to this lecture of Soil Science and Technology. Today, we will be discussing about different pathways of Weathering as well as different factors of Soil Formation. Now, in the last couple of lectures we talked about what is weathering and what are different types of weathering. So, you know that weathering is basically the disintegration and decomposition of rocks and minerals. And, weathering can be differentiated into three major types: one is physical weathering, another is chemical weathering, another is biological weathering.

Now, physical weathering the another name of physical weathering is disintegration and it is basically the you know in case of physical weathering, the rock size gets smaller and there is no chemical alteration in case of physical weathering. So, another name of physical weathering is mechanical weathering. However, in case of chemical weathering there will be a complete change of chemical characteristics or chemical composition that is why the other name of chemical weathering is decomposition and the third kind of

weathering is called the biological weathering and biological weathering is basically the combination of disintegration and decomposition. So, it is basically composed of both physical weathering and chemical weathering.

So, we have discussed about different factors of physical weathering what are the different factors or different process of chemical weathering and also biological weathering. So, today we will be discussing about different pathways of weathering in how the rocks and minerals weathered in different pathways to form ultimately soils. So, in this slide you can see that we have presented the different pathways of weathering. So, obviously, the starting point of weathering is rock as you already know. So, there are three types of rocks: igneous, sedimentary, metamorphic.

So, in this pathway you will see that chemical breakdown or decomposition or in other way it is chemical weathering and here we have listed the different process of chemical weathering like solutions, hydrolysis, organic acid solutions and then decomposition oxidation and hydration and these are the final outcome of this chemical weathering or final molecules or cations or anions of chemical weathering.

So, in terms of solution as you can see there are different types of soluble materials like different cations, calcium, magnesium, potassium, sodium, iron and sulfate in case of hydrolysis, obviously, the end product is silicic acid. In case of organic acid solutions different types of organic complexes of Al 3 plus and Fe 3 plus and you get some decomposition oxidation and hydration, obviously, there will be hydroxides of Fe and Al and these pathway shows the disintegration into minerals or physical breakdown or in other words it is physical weathering.

Now, physical weathering also depending on the clay mineral internal structure or crystal structure or depending on the crystal structure of minerals the mineral you know weather at different pace. For example, there are some various minerals which weather there very slowly, there are some minerals which weather slowly and which there are some minerals which weather very easily. For example, in case of in case of quartz and muscovite they weather very slowly because they are resistant to weathering and feldspars and biotite are slowly weatherable minerals and calcite, augite, hornblende all these are very easily weatherable minerals. As we have already discussed in the Bowen's series and Goldich series in the previous lecture.

And, all these weathered minerals will further undergo chemical decomposition to form other silicate clays or clay minerals. So, this is in a nutshell the pathways of weathering; obviously, these weathering processes occur simultaneously and ultimately results in different cations and different oxides of iron aluminium or different silicate clays. So, this is basically a nutshell about different pathways of weathering.

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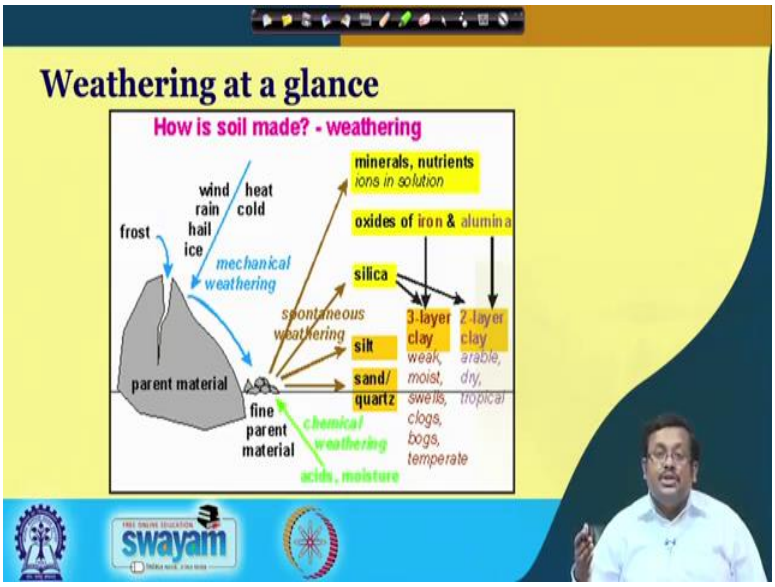

So, if we see weathering at a glance this slide shows weathering at a glance. Now, you see that the first the parent material and parent material is acted upon by different types of physical forces like frost, wind, rain, hail and ice and obviously, heat and cold. So, they would have different types of physical factors which are acting over this parent materials and these parent materials will undergo mechanical weathering to produce this fine parent materials as you can see and this fine parent materials will further undergo chemical weathering in the you know in you know while reacting with different types of acids and moisture present in the environment or in the soil.

And, ultimately they will form different types of mineral nutrients which will comes into the soil solution and in the forms of different cations and anions and also they will form silica, silt, sand and quartz. And this silica will further undergo different types of chemical reactions with oxides of iron alumina to form three-layer clay or two-layer clay we will discuss these details in details later on while we will be discussing about the clay mineral structure.

But, remember that this chemical weathering is one of the major factor for production of different types of clay minerals. And, remember that this physical weathering prepares the ground for chemical weathering or in other words as a result of physical weathering the total surface area increases for more reaction and this more reaction will undergo, will these more chemical reactions will ultimately produce these clay minerals.

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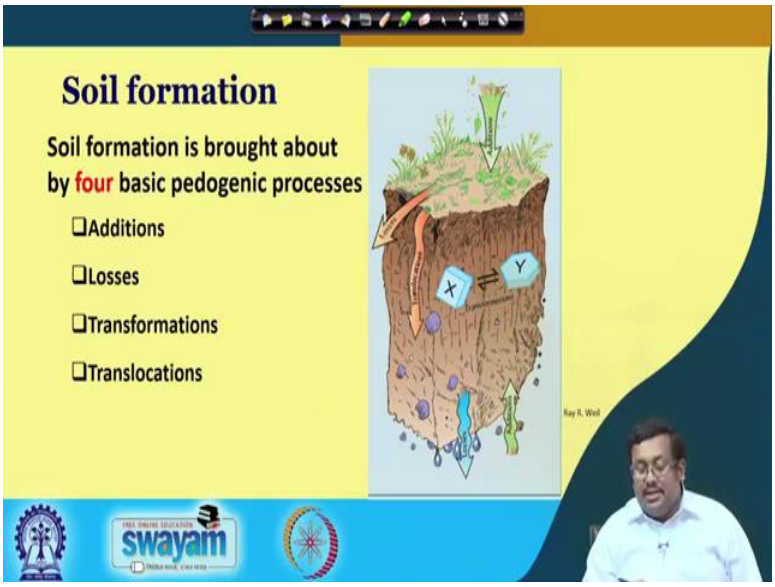

So, we have covered the soil weathering and we know how different weathering process occurs, physical weathering, chemical weathering and biological weathering, let us see what is soil formation. If you remember the soil formation is basically composed of two major steps: one is weathering, another is pedogenisis. Now, pedogenesis of soil formation is brought about by four major processes we call them pedogenic processes. These four processes are addition, losses, transformations and translocations.

Now, as you can see here there is a 3-dimensional you know 3-dimensional representation of a soil where you can see all these four pedogenic processes. Addition losses transformation and translocation, we will discuss them in details one by one.

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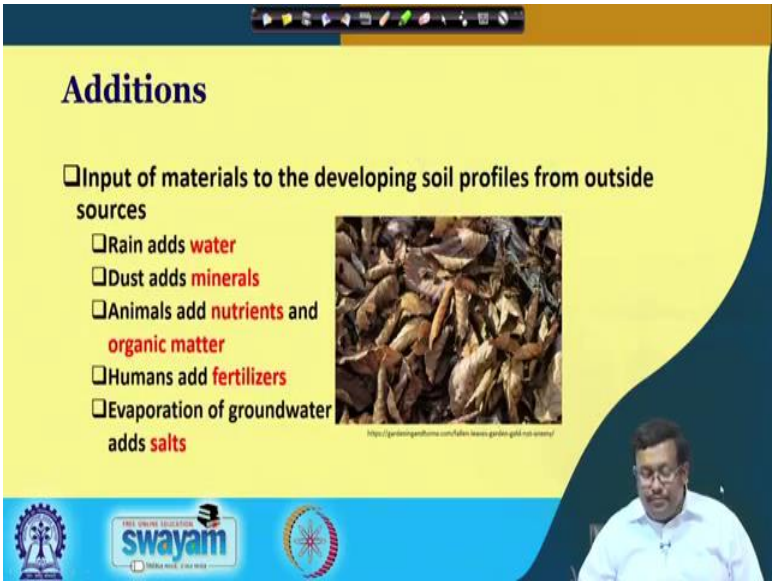

So, what are additions? Addition is basically input of mineral or input of materials to the developing soil profile from outside sources. When we are adding some materials or compounds from outside sources into the soil, that is called addition. For example, in case of rain that adds water into the soil, dust adds minerals into the soil, animals and nutrients adds organic matter into the soil and human add fertilizers into the soil and evaporation of groundwater adds salts to the soil. So, all these are adding something into the soil and that is one of the major pedogenic processes.

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What are the losses? Well, evaporation carries away water as you know this one form of loss from soil. Another erosion which carries away soil particles. Organic matter decomposition is another type of loss where we are losing organic matter and it is converting into carbon dioxide and other forms of organic matter. And, nutrients and minerals leach from the soil and that is another type of loss. So, all these losses are also important pedogenic processes which help in for proper soil formation.

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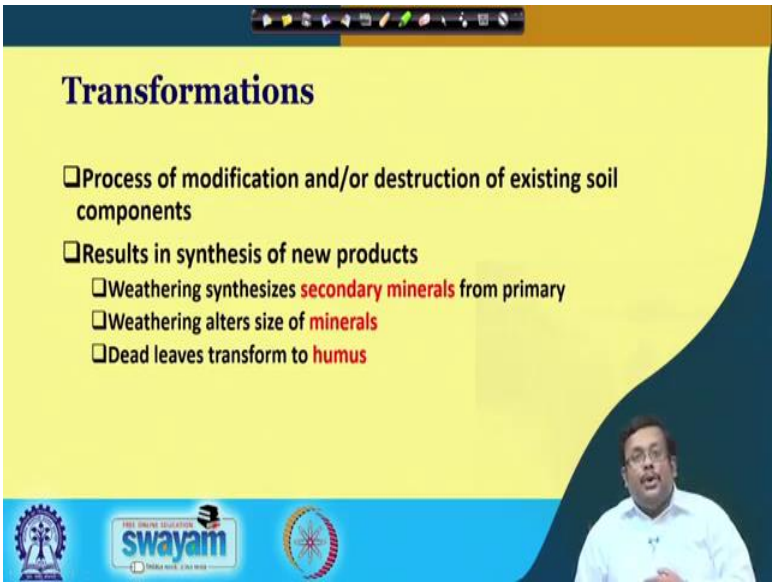

Now, what is transformation? Transformation is basically process of modification and a destruction of existing soil components, and remember that it always results in synthesis of new products. For example, weathering synthesis synthesizes secondary minerals from primary minerals and also weathering alters the size of the minerals especially the physical weathering and also dead leaves transformed to humus. So, all these are important transformation processes which are responsible for soil formation.

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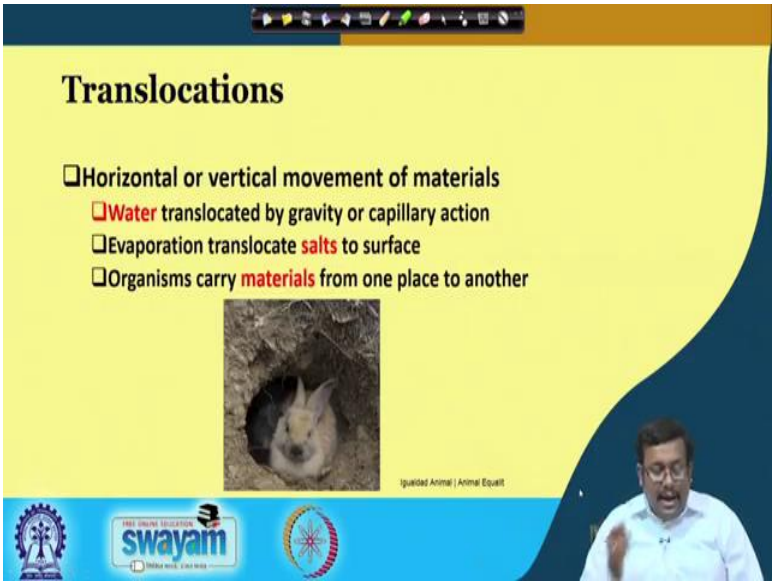

And finally, translocation. So, translocation is basically a horizontal or vertical movement of materials. For example, in case of water the translocation of water from by gravity or capillary forces in the soil. This is one form of translocation and evaporation; when evaporation translocate salts to surface that is another type of translocation and when organism carry materials from one place to another inside the soil, that is another form of translocation. So, all these are important forms of translocations which are responsible for soil formation.

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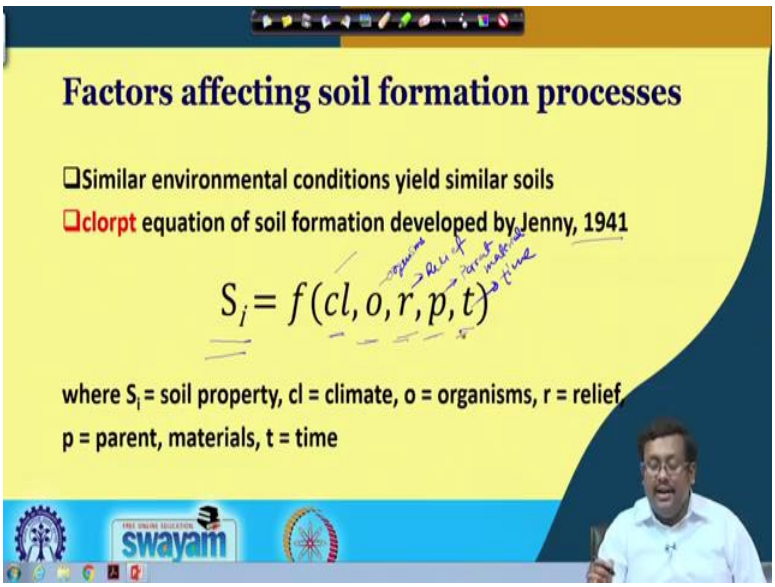

Now, let us see what are the important factors of soil formation. Now, Jenny in 1941 gave one equation which we call the soil forming factors equation for soil forming factors. Now, obviously, these soil forming factor equation is very much important for a proper understanding of how soil forms. So, as you can see we call it cl, o, r, p, t equation.

Now, this equation was again given by the scientist Jenny in 19 sorry 1941 and this equation shows that soil property of a given soil is a function of five different factors. So, five different factors first of all is climate, second is o that is organisms, r stands for relief, p stands for parent material and t stands for time.

So, this is the first important soil forming equation given by any scientist and obviously, there are some further modification the you know which have been proposed nowadays, I will discuss that later on while we will be discussing the digital soil mapping. So, again the soil any soil property is basically a function of climate, organism, relief, parent material and time. So, we will discuss them one by one.

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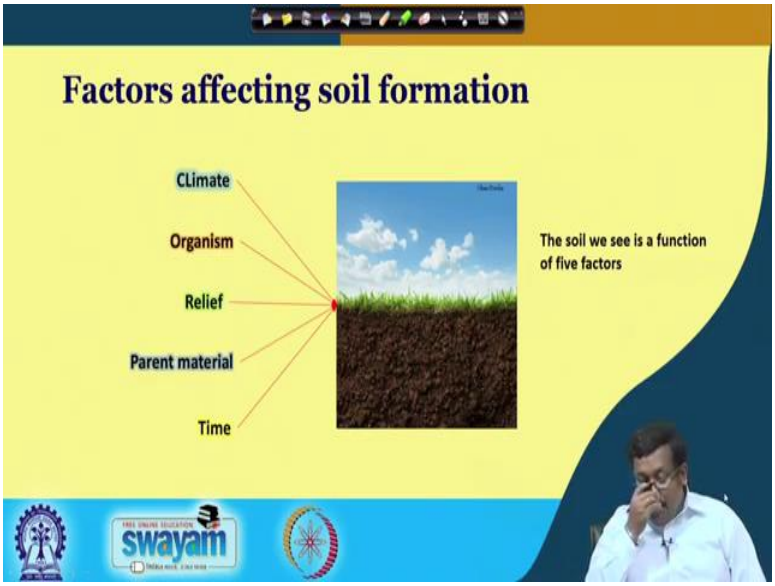

So, the soil we see is a basically function of all these five factors. Climate, organism, relief, parent material, time and all these factors acts simultaneously or interconnectingly to form soil and this is a very slow forming process and remember that for forming one inch of topsoil it requires almost million years.

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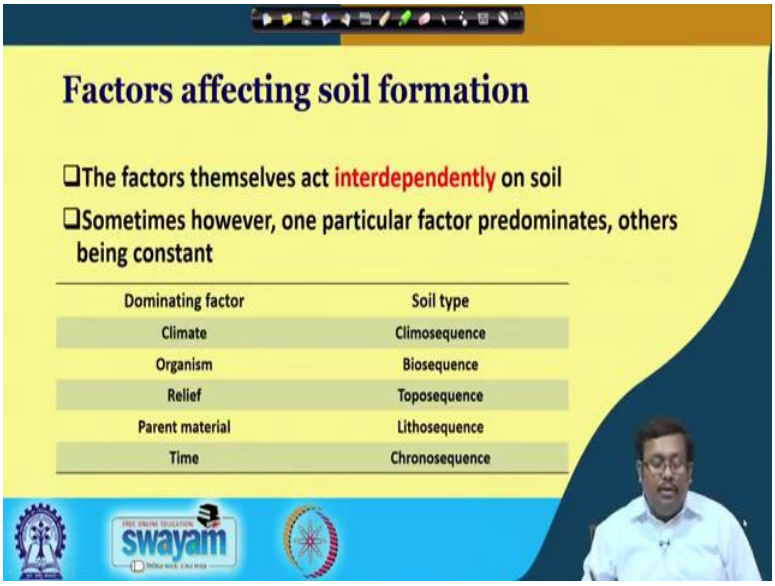

So, let us see their influence one by one. Obviously, the factors themselves act independently on soil we will see that later on and sometimes however, one particular factor predominates and other being constants. So, when the dominant factor is climate we call it climosequence, the soil type is known as climosequence, when the dominant factor is organism we call it biosequence. When the dominant factor is relief we call it toposequence. When the dominant factor is parent material we call is lithosequence and when the dominant factor is time we call it chronosequence.

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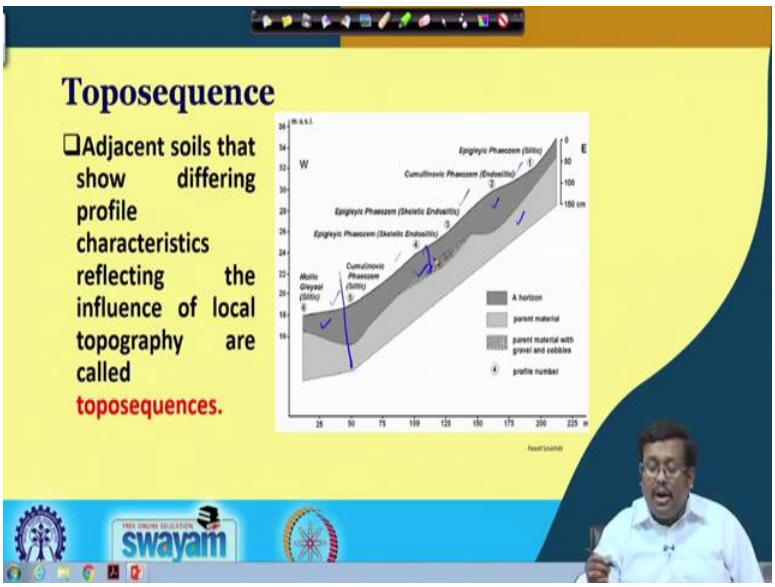

I have given one example here of toposequence. So, toposequence basically says the adjacent soil that showed different profile characteristics reflecting the influence of local topography are called toposequence. Again, soils that show different profile characteristics reflecting the influence of soil local topography are called toposequence. And, as you can see in this diagram the soil there are different types of soil which are formed in this place and obviously, there is difference in the steepness of the slope.

And, this is the parent material from which soil basically forms and A horizon is basically a mineral of the mixed organic horizon which is present in almost all the soils and parent materials with gravels and cobbles are shown by this dotted zone. So, as you can see the soil profile or the thickness of the soil varies from one place to another place based on their position on the slope. For example, this soil which is present at the plains or concave part of the slope is showing higher thickness of the soil or a horizon which is basically A soil horizon.

However, the soil which forms here is showing somewhat smaller thickness. So, basically the thickness of the soil or soil characteristics is differing from one place to another place based on the local topography. So, that is why we can see the relief factor is more predominant here and that is why we call it topo sequence.

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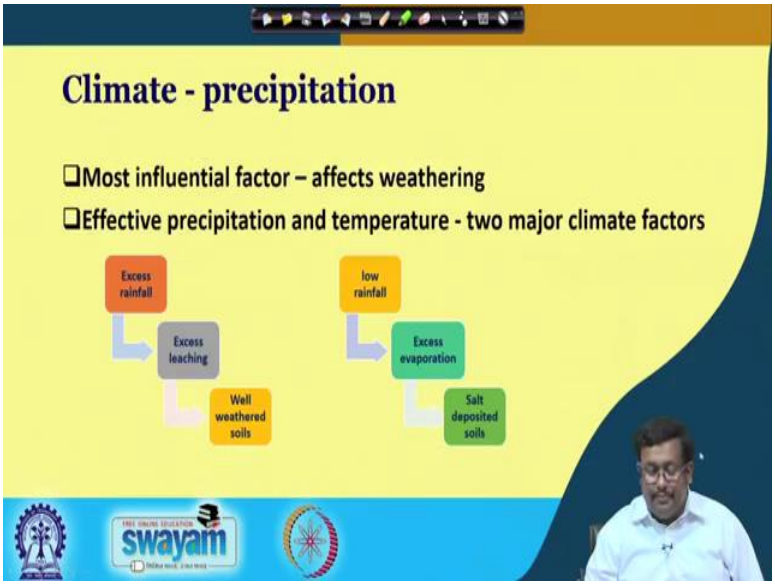

So, climate: climate is very much important because from the point of view of both precipitation as well as temperature we will discuss them later on. But, precipitation is

the most influential factors which affects weathering and effective precipitation and temperature are two major climatic factors. As you can see here when there is an excess rainfall; obviously, that will lead to excess leaching and this excess leaching will be, this excess leaching will ultimately form well weathered soil.

Now, leaching is basically the downward movement of salt in solution form. So, obviously, when there is an excess leaching there will be when there will be excess leaching there will be well weathering or chemical weathering. Now, when there is a low rainfall, obviously, there will be excess evaporation when there will be excess evaporation well there will be salt deposition at the surface. So, these are showing basically the impact of climate for soil formation.

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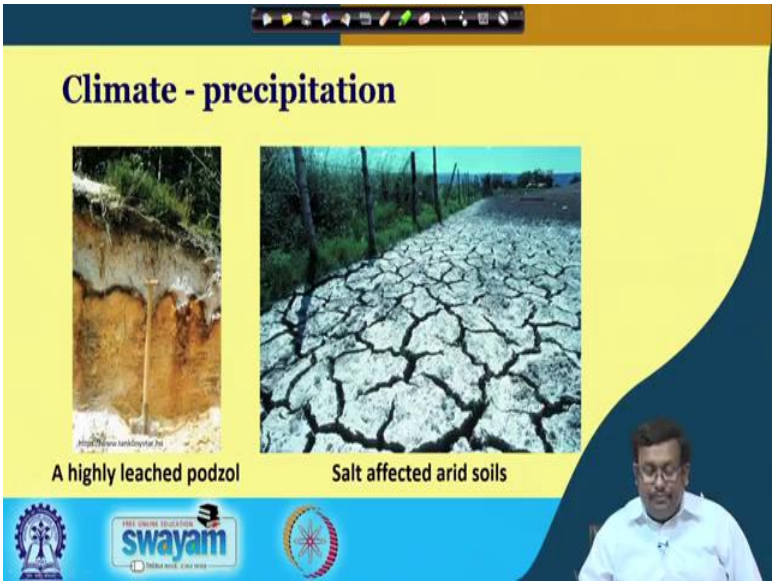

As you can see due to the climatic variation there are two different types of soil mean form one is highly leached which occurs due to high amount of leaching, due to high rainfall and another is salt affected arid soil where salts are being deposited at the surface due to high evaporation and crusting of the soil. So, these are basically showing the effect of climate for soil formation.

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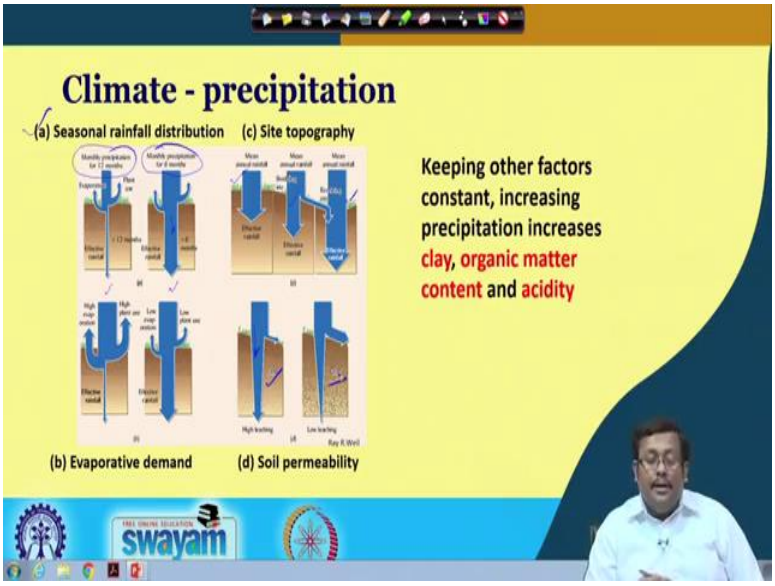

Now, another here you know in this slide you can see the impact of seasonal rainfall distribution, site topography, evaporative demand and soil permeability for you know soil development. Now, as you know that keeping other factors constant increasing precipitation we know increasing precipitation increases clay organic matter content and acidity. So, let us think that in this case for example, let us consider the seasonal rainfall distribution. Let us consider there is a 600 millimeter of rainfall and which is well distributed throughout the 12 month period and obviously, when there will be you know another condition those 600 millimeter of rainfall will be distributed throughout 6 months period.

So, obviously, in the second condition there will be more chance of leaching and more chance of more leaching will are more leaching will further accelerates the chemical weathering. So, you can say seasonal rainfall distribution is an important part for soil chemical weathering or soil formation. Second is site topography as you can see here obviously, the infiltration of water or effective rainfall is much higher in the relatively flat surfaces then that of the soil which is present in this steep slope. So, obviously, the soil development also differ in this places due to difference in the site topography.

When there will be a higher evaporative demand and another case there will low evaporative demand, in case of low evaporative demand water infiltration we will be more and as a result there will be more soil development. And, obviously, depending on

the difference in soil permeability also; depending on the soil permeability you know water movement also varies from one soil to another soil. For example, in case of sandy soil there will be high leaching as compared to the clay soil and obviously, as a result of that the in case of sandy soil the rate of soil formation is more as compared to clay soil.

So, this slide basically shows the impact of soil impact of different climatic factors for soil formation.

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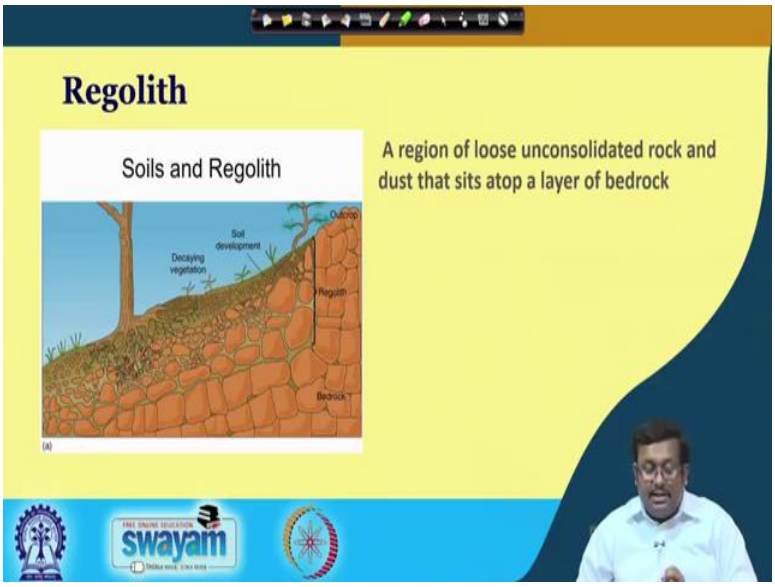

So, what is regolith? Will we will we will discuss this term later on in more frequently. So, let us discuss what is regolith. So, regolith is a region of loose unconsolidated rock and dust that sits atop a layer of bedrock. So, at the bottom you will see the bedrock if you dig down the soil vertically and ultimately you will see at the bottom there are bed rocks from which soil forms and above the bedrock they will see some unconsolidated rocks and dust and we call them regolith. And, these regolith contains both mineral matter organic matter and all these things.

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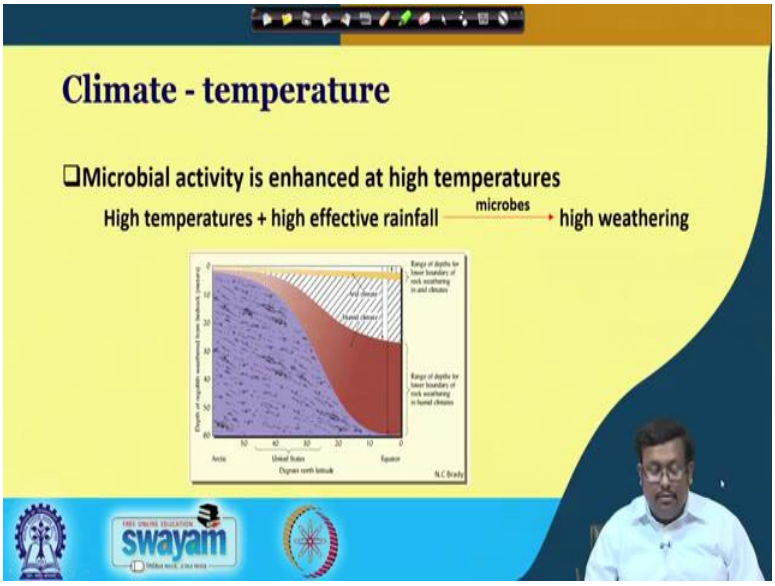

So, and also let us see what is the impact of climate and you know precipitation in temperature. So, this slide shows the joint impact of precipitation and temperature. Now, as you can see here in the arctic region the in both humid condition and in arid climate region in you know there are there are two different we are considering two different climates: one is arid climate, another is humid climate. So, in arctic region in both climatic situation, the soil formation the rate of soil formation will be almost same.

However, as we move from arctic region to equator region the rate of soil formation in humid climates or in other words the rate of weathering in humid climates you know will be more as compared to that of the arctic or arid climate. So, this slide basically shows the joint impact of rainfall as well as temperature for soil formation.

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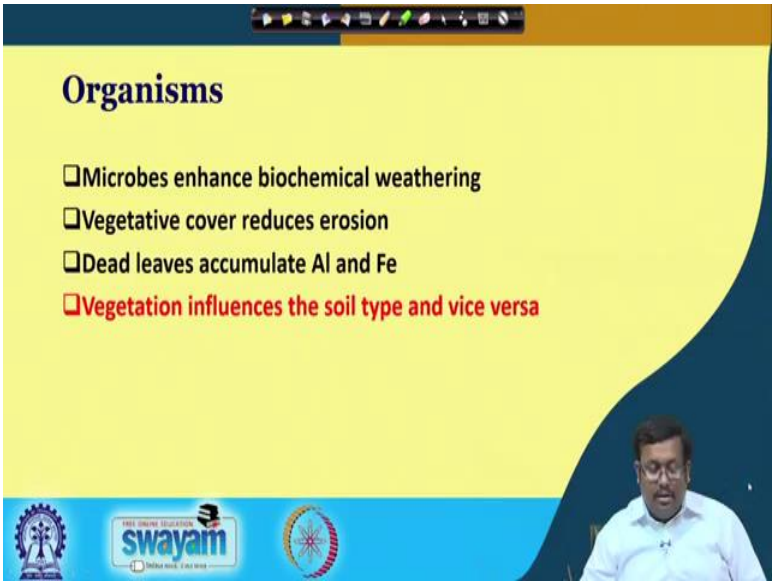

Another important factor for soil formation are organisms. Remember that microbes enhances biochemical weathering and vegetative cover reduces solutions. Sometimes dead leaves accumulates aluminum and iron, and vegetation in differences the soil type and vice versa. So, let us focus on the last one how vegetation influences the soil types.

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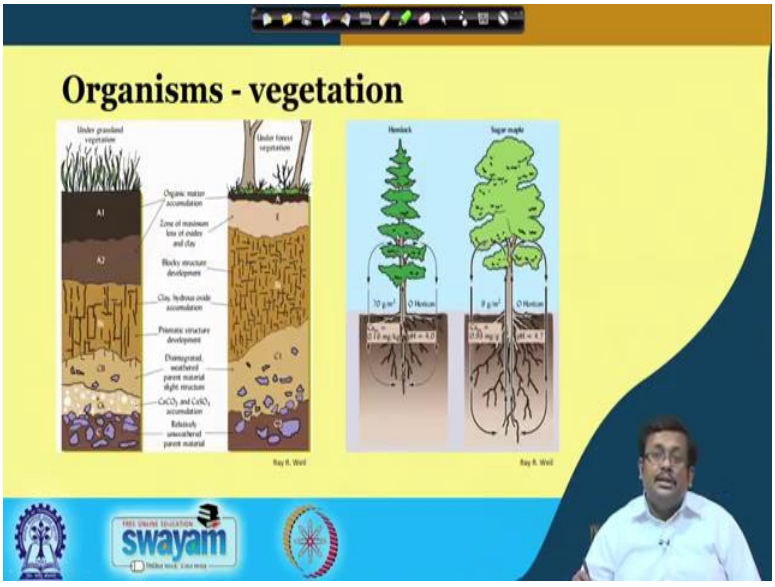

So, as you can see here two different conditions are given. In the first condition you are seeing that grassland vegetation and here you are seeing forest vegetation. So, in case of

grassland vegetation you are seeing that there are different types of soil horizon A 1, A 2 Bt, CB, Ck and all these form.

However, in case of forest vegetation the A horizon is very thin followed by an alluvial horizon, we will discuss this horizon later on and also the Bt horizon and C 1 and C 2 horizon. So, the soil characteristic differs as a result of different types of vegetations and also here in the second picture you will see we have you know I have given here two different example one is hemlock which is a coniferous plant, another is sugar maple which is a deciduous plant and obviously, in case of sugar maple its roots are very effective for uptaking the calcium irons from the soil from the deeper layers of the soils. So, and also the leaves of the sugar maple are highly rich in calcium. So, when the leaves decompose over the soil surface they you know there will be high amount of calcium at the soil surface. So, obviously, there will be comparatively higher ph at the soil surface due to the decomposition of calcium rich leaves of sugar maple and there will be obviously, lower pH in the bottom layer of the soil due to efficient uptake of calcium.

However, in case of hemlock, the hemlock leaves do not have calcium in them. So, when they decompose over the soil surface the soil pH remains somewhat near 4. So, as you can see it is very clear that depending on an another practical implication for this difference in nutrient cycling is increase of sugar maple the soil weathering will be more prevalent as compared to the hemlock. So, you can see so, the depending on differences in vegetation obviously, the type of soil varies from one place to another place. Obviously, when there will be grassland vegetation there will be high accumulation of organic matter as compared to forest vegetation. And depending on the nature of cations uptake and nature and chemical composition of the leaves the adjacent soil characteristics also varies. So, this basically shows the impact of climate sorry, organisms.

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Another important factor is organism you know in case of organism is animals. And, obviously, when the animals there are several macro fauna which are you know which are present in to the soil and when they move from one place to another place they also churn the soil materials within. They are also churning you know the helps in churning the soil materials and these churning of the soil materials as a result of these organism is called pedoturbation and as a result of pedoturbation the physical and chemical weathering increases.

So, obviously, the organism plays an important role for increasing the rate of soil formation.

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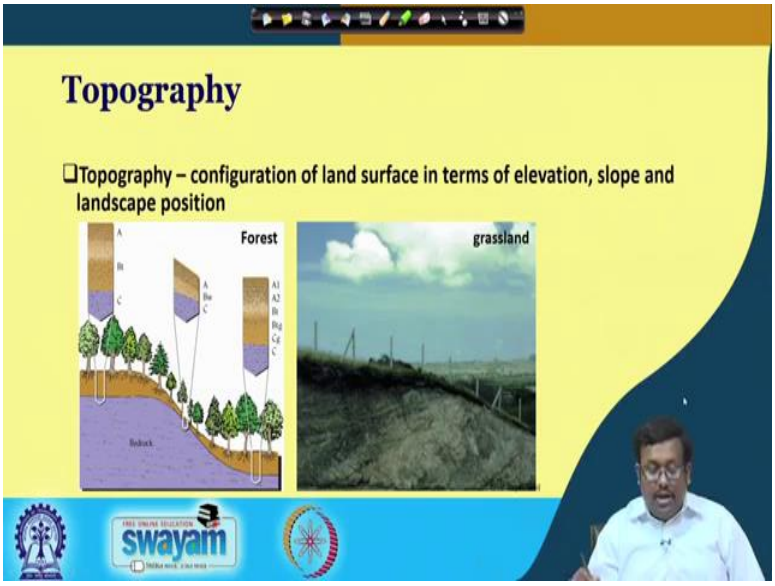

Topography as we have already discussed. Topography is basically the configuration of the land surface in terms of elevation slope and landscape positions and depending on the topography the characteristics of the soil you know varies from one place to another place. As you can see the number of horizon develops differing from one soil to another soil based on their local topography.

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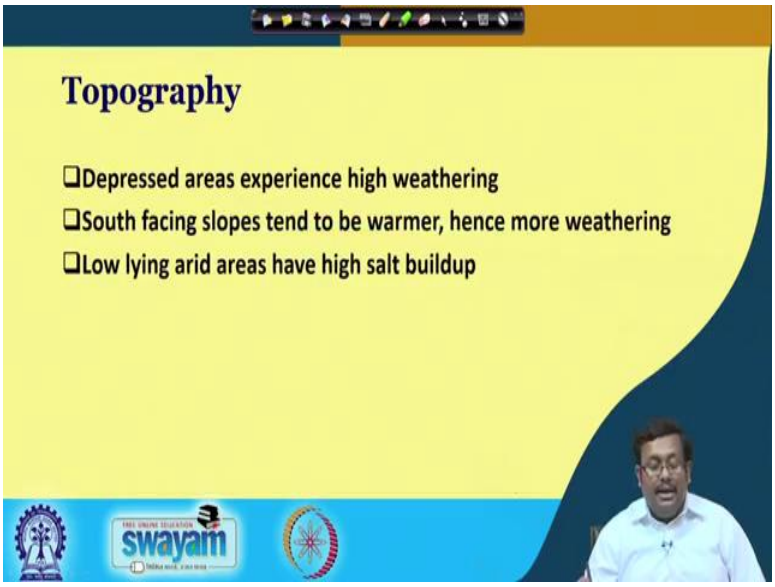

And, remember the couple of point that depressed areas experience higher rate of weathering and south facing slopes tends to be warmer hence more weathering and low lying and arid areas always show high salt build up.

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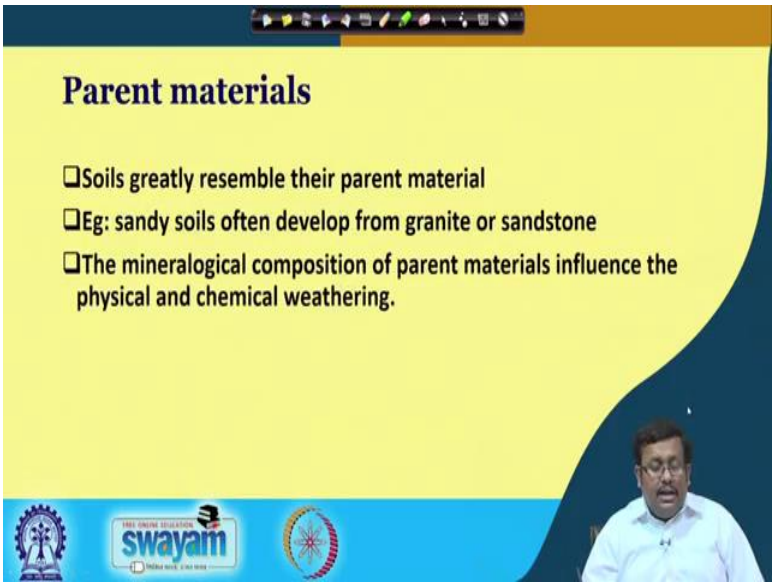

So, finally, what is parent material? Now, parent material is the material from which soil develops. So, soil greatly resembles their parent meeting for example, sandy soil often develop from granite and sandstone and the mineralogical composition of parent material influence is the physical and chemical weathering which is quite obvious.

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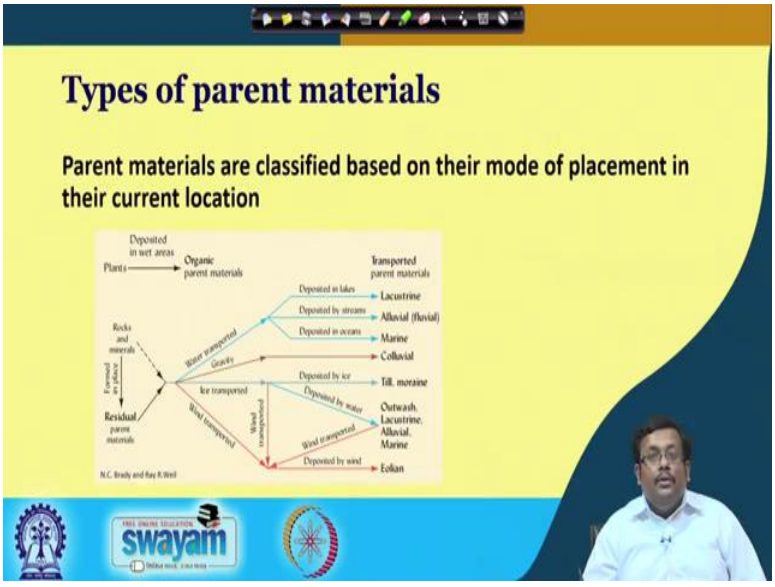

So, depending on the types of parent materials also we have differentiate different types of soil and let us wrap up here and from the next lecture we will start from here.

Thank you.