Conservation Geography
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Module - 3
Lithosphere and landforms
Lecture - 8
Geomorphology and Processes

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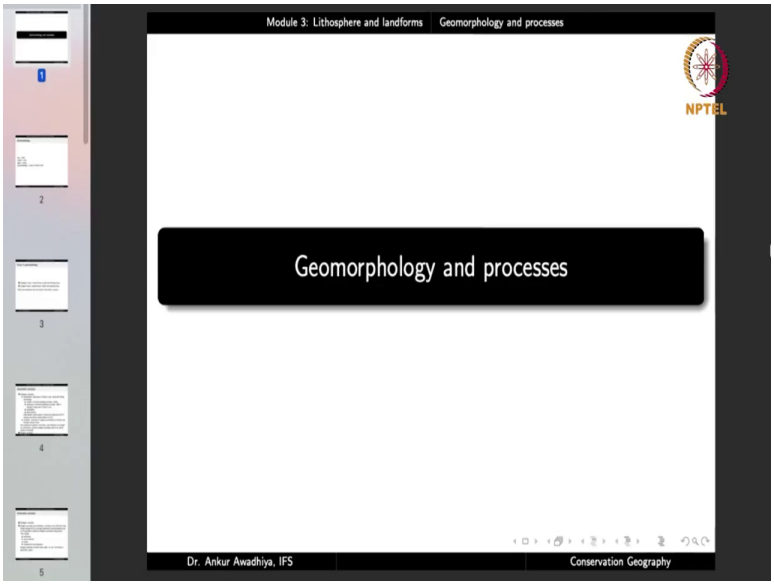

Namaste! We carry forward our discussion on lithosphere and landforms and in this lecture we shall have a look at geomorphology and processes.

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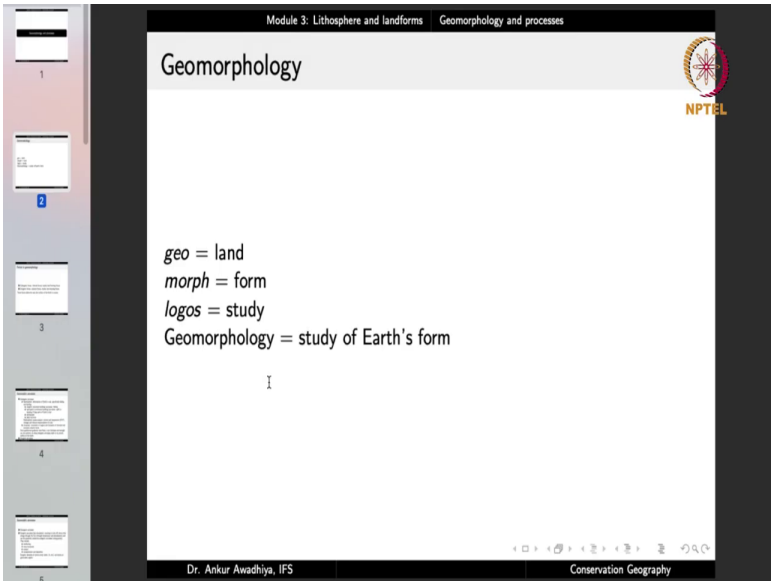

Now, the term geomorphology is derived from these word roots, geo meaning land on Earth, morph is form and logos is a study. So, essentially geomorphology is the study of Earth's form or the study of landforms. So, basically geomorphology asks the question, what are the different landforms that we have on Earth, where are they located and why are they located, where they are located?

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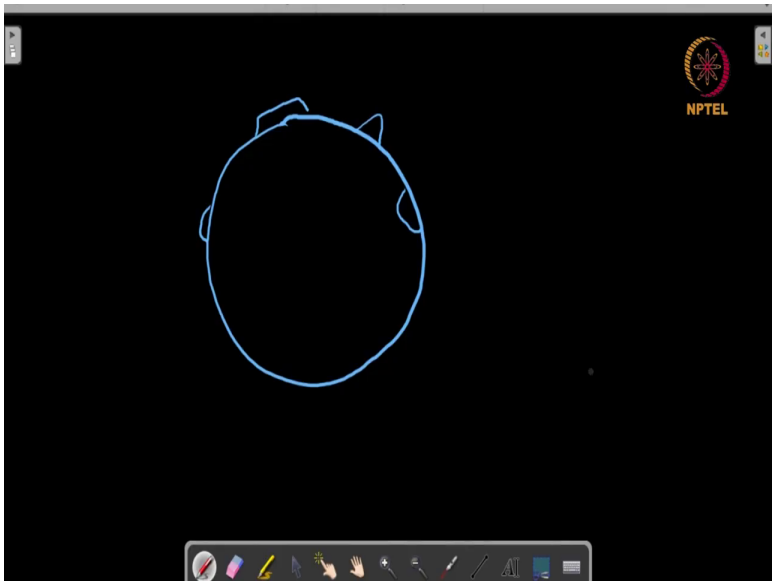

So, essentially in place of having an Earth that was just a sphere uniform everywhere, why do we have an Earth where we have mountains somewhere depression somewhere and maybe plateaus somewhere, hills somewhere, why do we have these different features and what are the forces and processes that lead to the generation of such different landforms.

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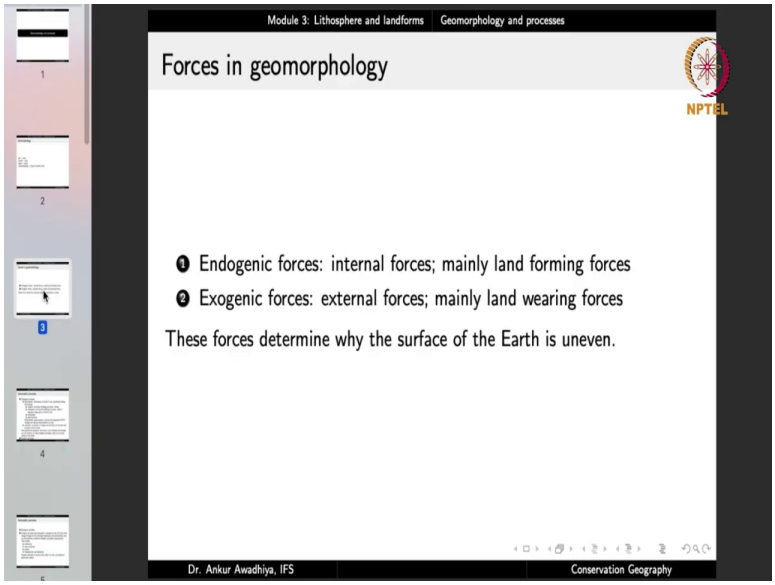

Now, in geomorphology, we recognize two different kinds of forces the first are Endogenic forces, which are internal forces mainly land forming forces and the second is Exogenic forces, which are external forces and are mainly land veering forces.

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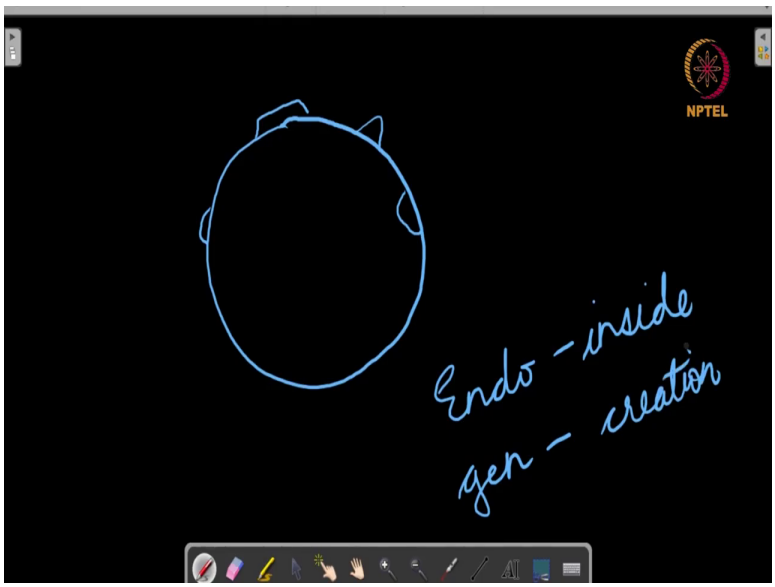

Now, the term endo it refers to inside and genesis is creation.

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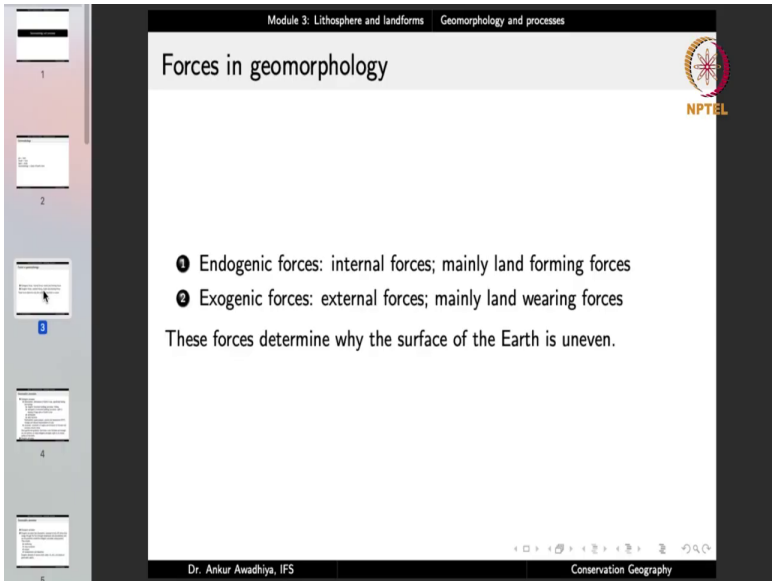

So, these are the forces that are created inside, which is why we call them as internal forces. Exo means outside; genic - again the term is related to genesis creation. So these are the forces that are created outside, so these are external forces. Now, when we say inside and outside inside and outside of what, so this is inside and outside of the Earth. So Endogenic forces are originated inside the Earth, whereas Exogenic forces originate outside the Earth.

Now, typically the Endogenic forces are land forming forces and the Exogenic forces are land varying forces. So essentially what we are saying here is that we have two different kinds of processes. One is the Endogenic processes that are done by Endogenic forces, which originate inside the Earth and they create land. On the other hand, there are Exogenic forces which originate outside the Earth and their main role is to veer down the land. So essentially when we talk about things such as erosion.

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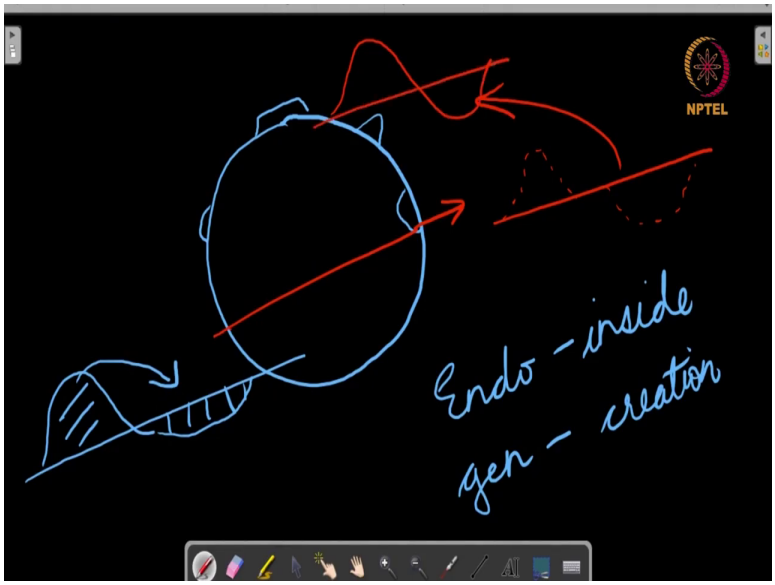

Now, in the case of erosion, what happens is that if you have, say, a mount here and here you have a depression. Now through the process of erosion the matter that is here, it will slowly be transported into this portion and from this stage, we will shift to a land that is more or less a flatland, because the matter that was here in the mount has been put into the depression.

So, the Exogenic forces such as the forces of erosion, they try to create a gradation that is they try to veer out the Earth they try to make the Earth into a level area, a uniform area. So they try to veer down the mountains they try to fill up the oceans or the depressions.

On the other hand, if we just have the Exogenic forces, then in that case over the billions of years, the Earth should have become completely uniform, we should not be having any mountains whatsoever, remaining today. Now the reason why we still have mountains and we still have different depressions has primarily got to do with the Endogenic forces, because Endogenic forces create the land. So, what the Endogenic forces do is that if there is a flatland they convert it into a land form that is up and down. So this is the role of the Endogenic forces.

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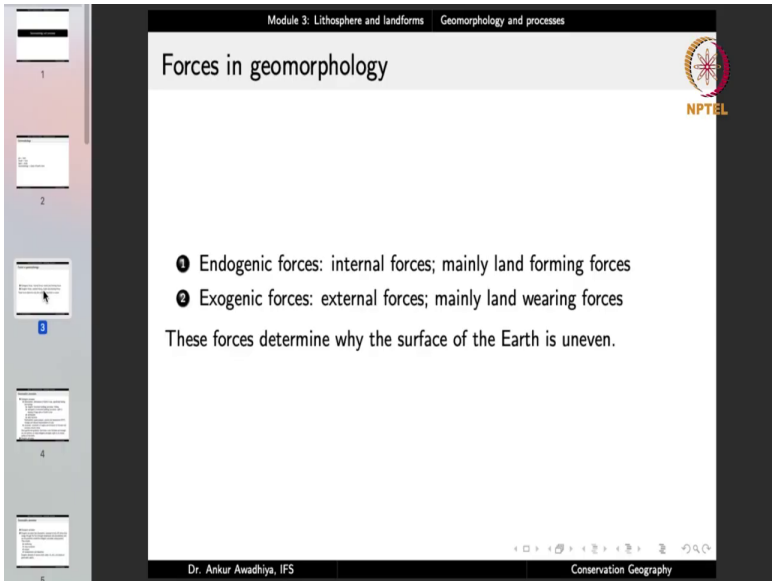

So there are two forces Endogenic and Exogenic. And these forces determine why the surface of the Earth is uneven.

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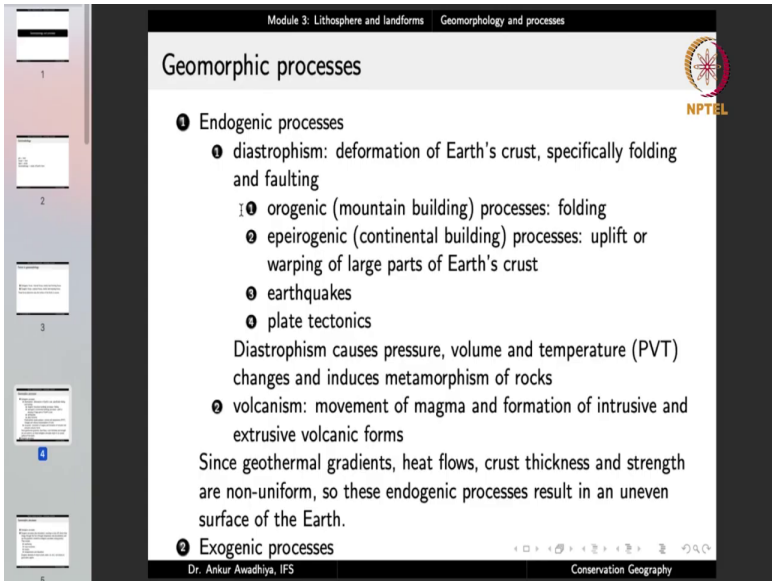

Now, we have had a look at certain Endogenic processes before. Now, we are going to summarize them in the context of geomorphology. The Endogenic processes are diastrophism and volcanism diastrophism refers to the deformation of Earth's crust, specifically folding and faulting deformation of the Earth's crust.

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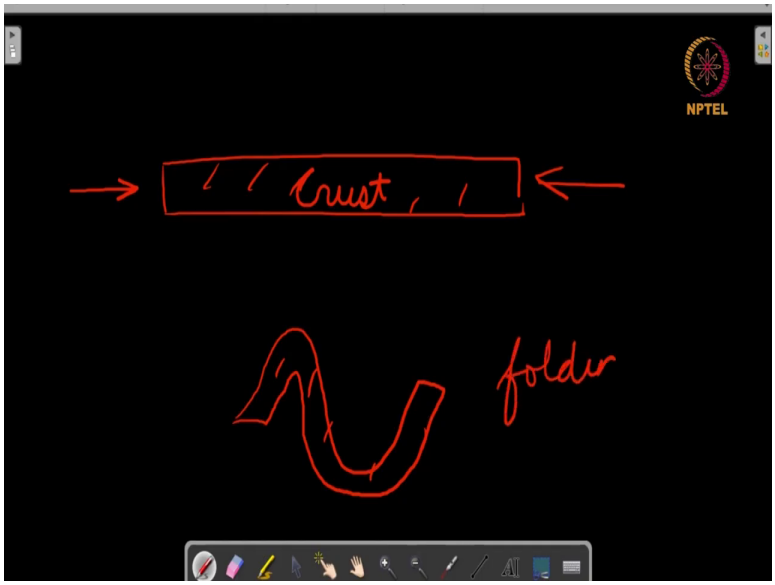

Now, what happens in the case of folding is that suppose you consider a sheet of material, let us say that this is the Earth's crust. Now, if a forces applied on the Earth's crust something like this, what will happen is that this crust, because you are applying pressure on both the sides, what will happen is that it will turn into certain folds, so it will become something like this.

Now, it is the same material that was here, the same material is now here, but the thing is in place of being a flat thing, it has now become up and down. Now, this is known as folding.

And folding is the process that results in the creation of fold mountains and also certain depressions. So the areas that have gone up, they become mountains, the areas that have gone down, they become depressions. Along with folding, we also have faulting. So as we have observed in a previous lecture, that in the process of faulting, we can have certain potions that go up and certain potions that go down.

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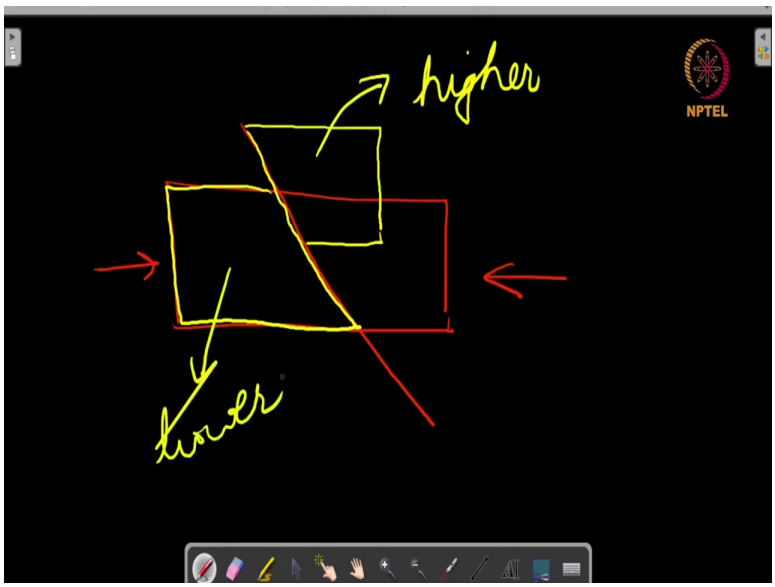

So, for instance, we can have a faulting in which case if there is this material, it so happens that when you apply force, there is a crack that develops like this and this portion now moves up and it becomes like this. So now the configuration is like this. Now here again, we have created an area that is higher and we have created an area that is lower.

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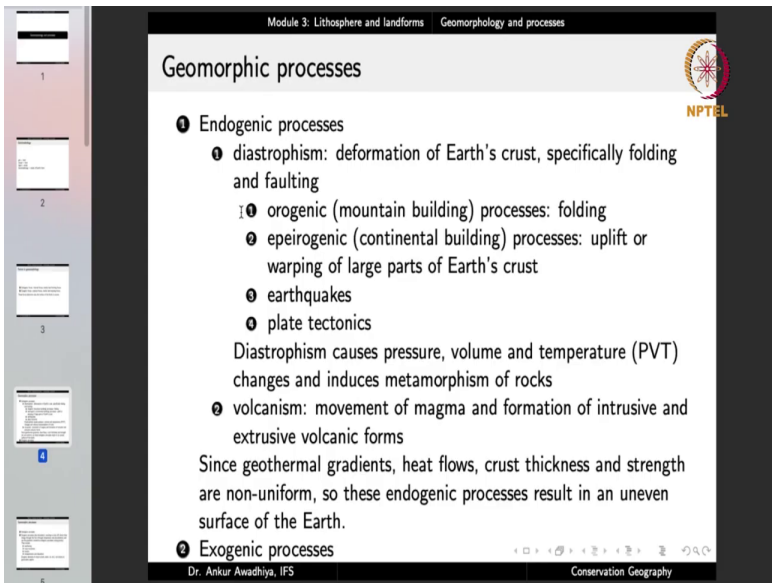

So, the process of folding and faulting, both of them lead to deformation of the Earth's crust, and this can lead to the creation of different landforms. Now in this context we differentiate between orogenic processes and epeirogenic processes orogenic means, mountain building or

orose is mountain, genesis is creation. So, these are mountain building processes such as folding.

So, when we talk about fold mountains such as the Himalayas, we have observed in one of the previous lectures that in the case of Himalayas, what happened was that we had two plates, they came together and after some time, because of the pressures one potion got up and up and up and ultimately we got the creation of a mountain. So, this is a process that leads to the creation of fold mountains, such as the Himalayas.

Epeirogenic processes are continental building processes, they occur on a much larger scale. So, they create continents, typically by uplifting or warping of large parts of the Earth's crust. So, orogenic processes occur on a smaller scale as compared to the apologetic processes and the main evolutionary processes are uplift or warping. Other diastrophic processes are earthquakes.

Now, earthquakes also result in the creation of different landforms, because there is a violent release of energy, there are waves that get propagated and typically the surface waves can result in changes to the landforms. So, earthquakes are also another important way in which diastrophism acts and plate tectonics.

Now, we have observed this before that in the case of plate movements also, when there is a convergence of plates, then we can have a situation in which one or both the plates move up, they may result in the creation of a fold mountain or they may result in the creation of faulting. Similarly, when the plates go away from each other, we can have the formation of ridges or in certain cases, we can even have the creation of drift valleys. So, these are the dystrophic forces, which result in deformation of the Earth's crust.

Now, in most of these cases, they result in PVT changes, that is changes in pressure, volume and temperature. And we have observed in the previous lecture, that the changes in pressure, volume and temperature are related to metamorphism of rocks.

So, whenever we have the working of dystrophic forces, we typically find metamorphic rocks. So, they will be folding, they will be faulting, but at the same time, we will also find certain metamorphic rocks. Another Endogenic process is volcanism, the movement of magma and the formation of intrusive and extrusive volcanic forms.

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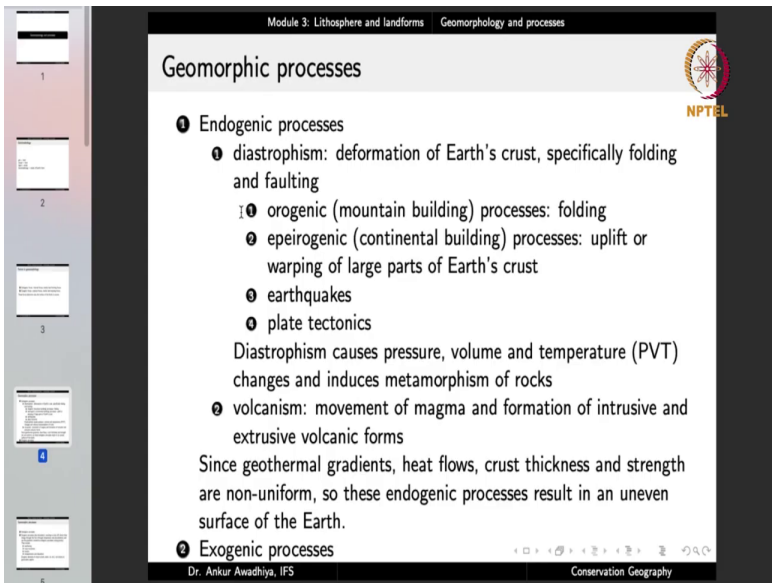

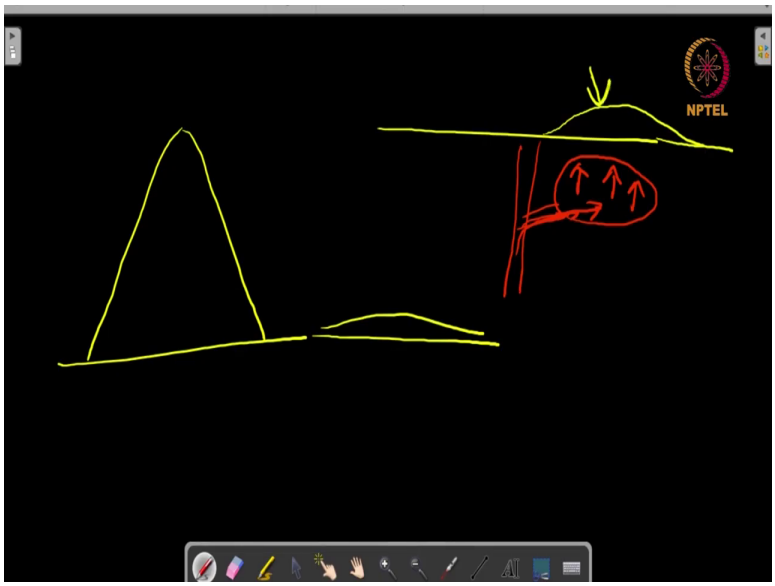

Now, these forms are not just the mountains, so we observed in an earlier lecture, that we have the creation of conical mountains or we can have the creation of shields. But together with this, we can also have the creation of other sorts of landforms. So, suppose the magma is moving up in a conduit, but then the magma finds a space here and it starts to accumulate in this portion.

Now, when the magma is accumulating here, then there will be an upward force, because the voids are getting filled with magma and there is even more pressure that is trying to fill up the voids. And so, what will happen is that the Earth's surface will also start to protrude. Now, we do not have an igneous rock here, it is just the Earth's crust that has gone up.

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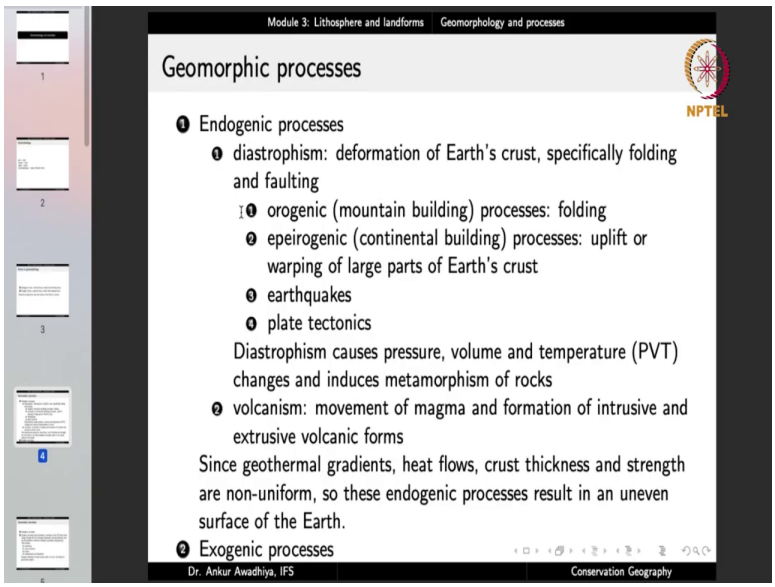

So, we can have different kinds of landforms that also are created because of volcanism, because of movement of magma and formation of intrusive and extrusive volcanic forms. Now, these processes do not occur at the same pace everywhere, because we do not find a volcano everywhere, we do not have earthquakes that are happening everywhere. We have observed in one of the earlier lectures, that the locations where earthquakes and volcanoes are frequent and large size volcanism and earthquakes occur, they have been mapped and they are only in a few locations.

Now, it means that the forces the endogenic forces that are due to these activities, earthquakes, volcanoes and other forces, they are localized they are not acting everywhere at the same time. Now if they are localized, if they are non uniform, then it is possible that in certain areas there will be an uplift and in certain other areas, there will not be an uplift.

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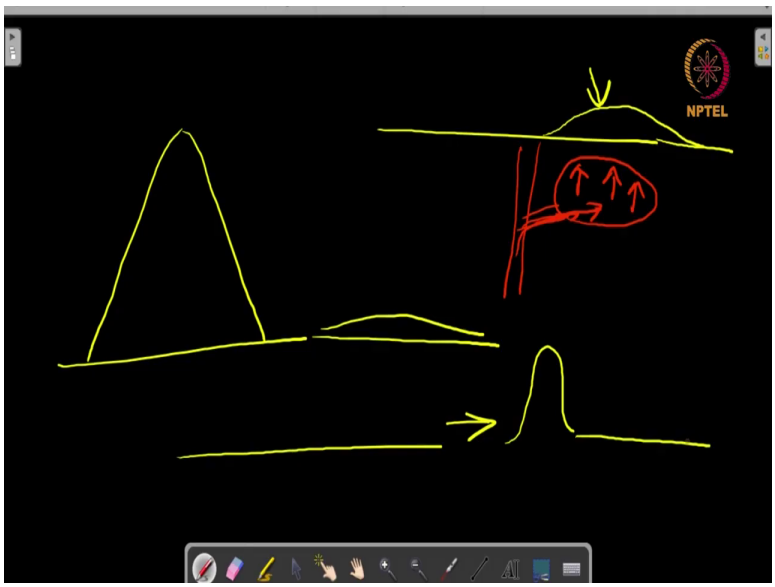

So, what happens in these cases is that you have the flat surface of Earth that is getting converted into an uplift somewhere, but elsewhere it is a level land. So, in this way, these Endogenic forces create the landforms.

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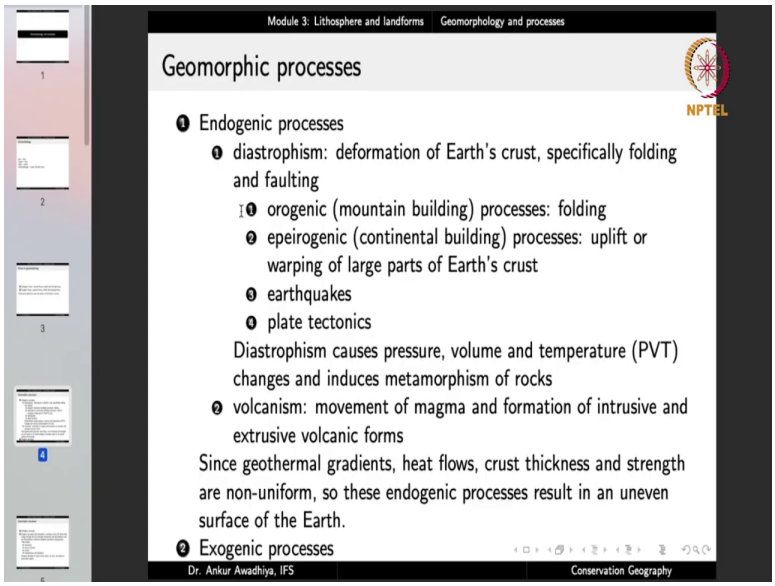

So, since geothermal gradients, heat flows, crust thickness and strength are non uniform, so these Endogenic processes result in an uneven surface of the Earth it is not just these forces that they are acting in localized manners, but at the same time, the thickness of the crust and the strength of the crust they are also non uniform.

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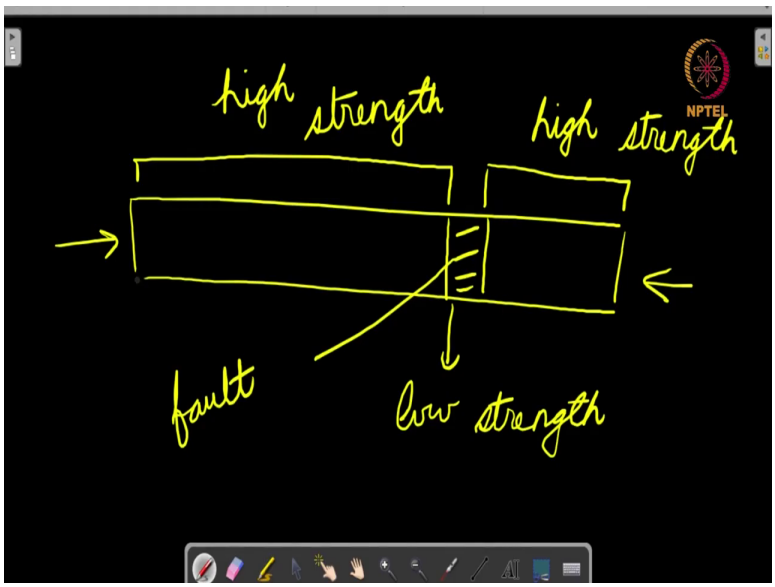

So, for instance if we have the crust like this, and there is the force that is acting on both the sides, then it is not that everywhere you will get a fold or everywhere you will get a fault, because it is possible that this region is having a high strength. Similarly, this region also has a high strength, but probably this region is having a low strength.

Now, when it has a low strength, then the chances are more that we will get a fault in this location. So, this portion will remain more or less level or this will move like a block the right portion will also move like a block but will get a fault in between. So, the properties of the cross because they are also non-uniform they also result in a differential action of these Endogenic processes and forces. And so these result in the creation of a non-uniform Earth.

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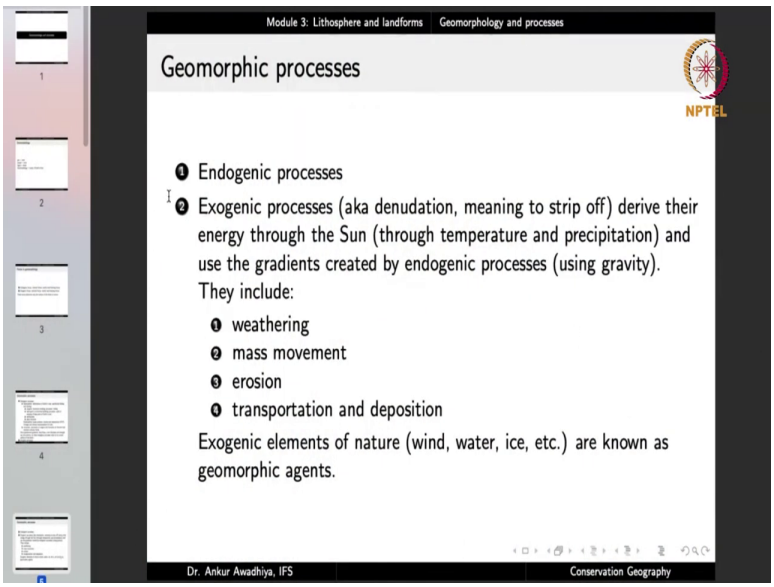

The forces are Exogenic forces, which are the processes of denudation which means stripping off.

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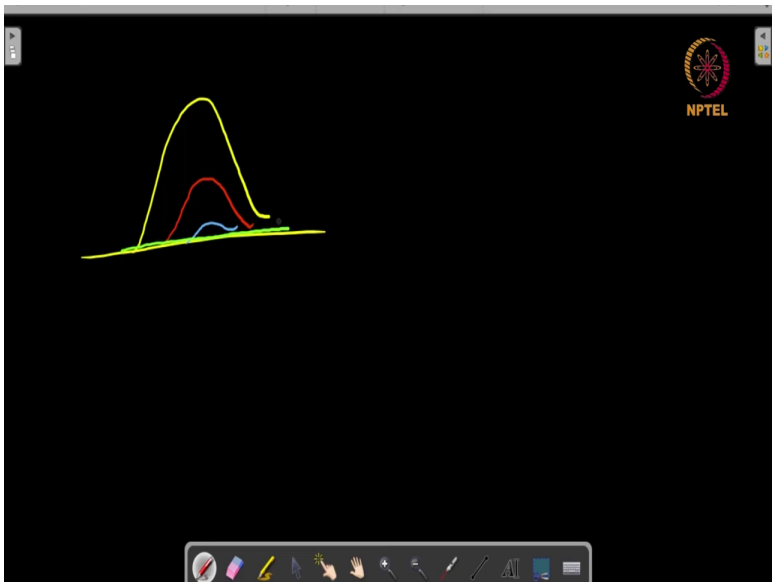

So, what the Exogenic forces do is that they take a landform and they denude it, which means that they veer it down, so from this, it will convert to this and then later on to this and ultimately you will only have a plain level surface.

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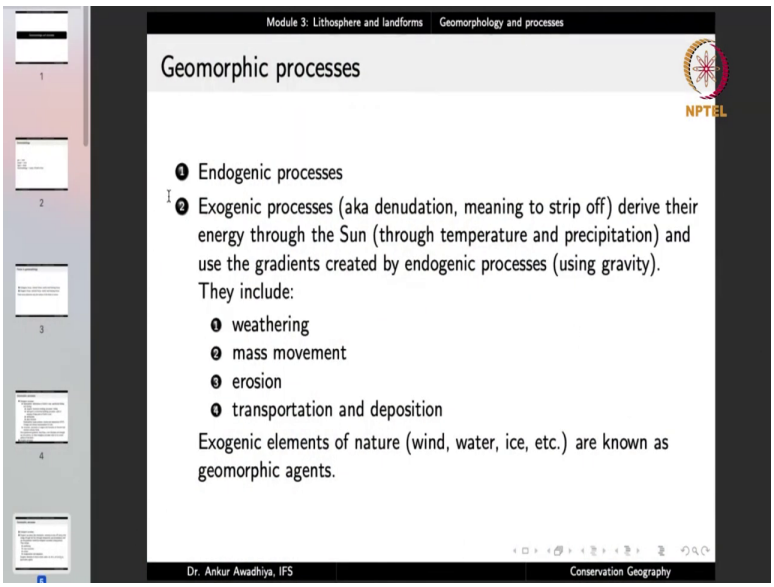

So, these are the forces of denudation the processes of stripping off, mostly they derive their energy through the Sun, which is why they are Exogenic, Exo is outside. So, they are getting their creation or they are getting their energy from the Sun, mostly through temperature and and precipitation also winds. And they use the gradients that are created by the Endogenic processes using gravity.

They include things like weathering, mass movement, erosion, transportation and deposition and the Exogenic elements of nature like wind, water, ice etc., they are also known as geomorphic agents. So what is happening in the case of Exogenic processes?

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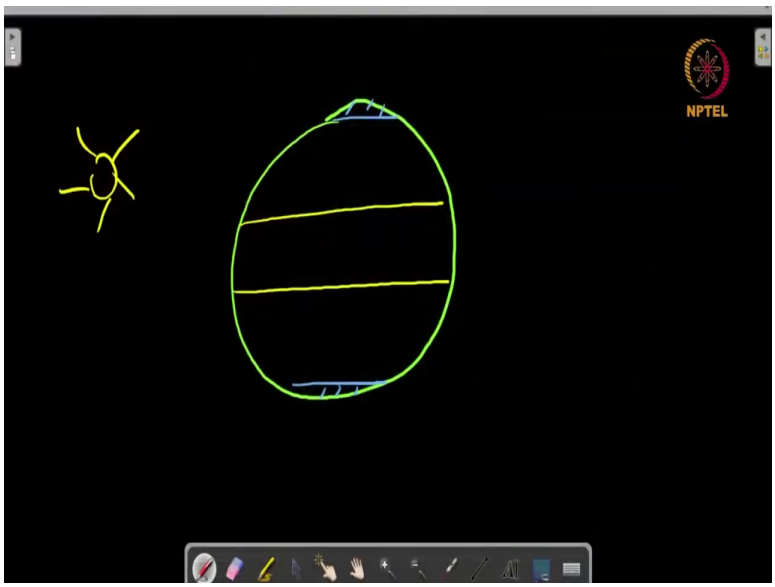

The agents are using the energy of the Sun, because the Sun is creating a temperature difference when we talk about the Earth. So when we have the Sun here, the areas near the equator they get heated up much more, the areas near the poles they have a very less amount of heat. So, there is a temperature gradient that gets created.

Similarly, if you consider two areas one is land, the other is water, then typically the land areas will get heated up much more as compared to the water bodies and when there is a difference in temperatures, it results in the creation of a wind.

Now, when you have a wind, the wind is an agent of denudation, the wind can carry things like dust particles or even sand particles.

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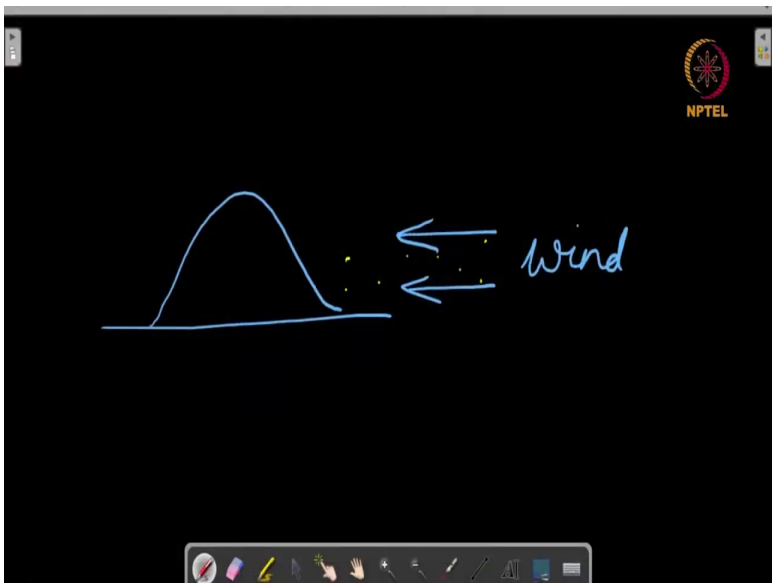

And so if you have a landform and you have winds that are blowing and these winds also have the sand particles. So, these winds create a condition, which is very similar to the action of a sandpaper. And through the sanding off process the landform will get denuded down, it will get worn down. So, these are Exogenic processes, because they are getting their energy from the Sun and they are working to degrade the landforms, similarly we have water.

Now, when you consider a river, a river is a very good geomorphic agent, it is a very good process that is an Exogenic process and what is happening in the case of rivers is that, because of the energy of the Sun, the water in the water bodies, it gets evaporated, it becomes water vapour it moves into the air, then it moves with the air, then it forms clouds and then it comes down as precipitation or rain.

Now, when you have rainfall, then the water that moves it will make use of the gradients that have been created by the Endogenic processes.

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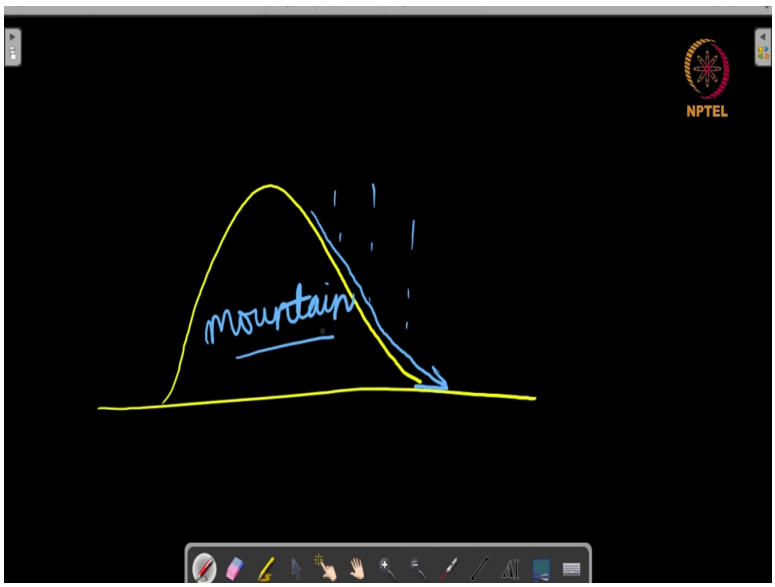

Meaning that, if you consider a mountain like this, so if there is rain fall on this side, then the rain is going to move from this top portion to the down portion, because of gravity. Now it is taking this direction because this mountain already exists and this mountain was created by an Endogenic process.

Now, this mountain creates a gradient along which the water will move. Now, when the water moves, it is also able to erode the land it is also able to transport materials in the form of sediments, in the form of small pebbles, in the form of sand. And so water also becomes a very good agent of your morphology it is a very good Exogenic process because again here also it is getting created outside the Earth, it is getting created using the energy from the Sun.

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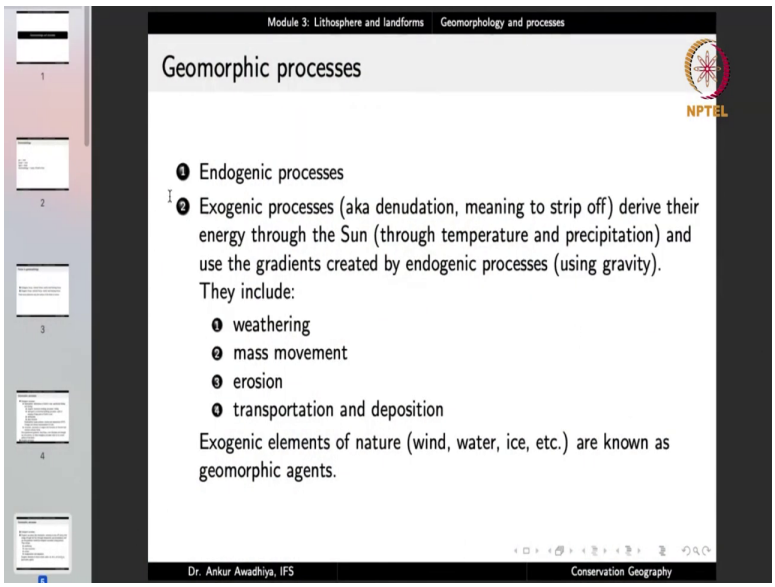

So, these are the Exogenic processes they lead to denudation which is stripping off they derive their energy from the Sun use the gradients created by Endogenic processes and gravity. And they include things like weathering, mass movement, erosion, transportation and deposition. So, we will also look at all of these.

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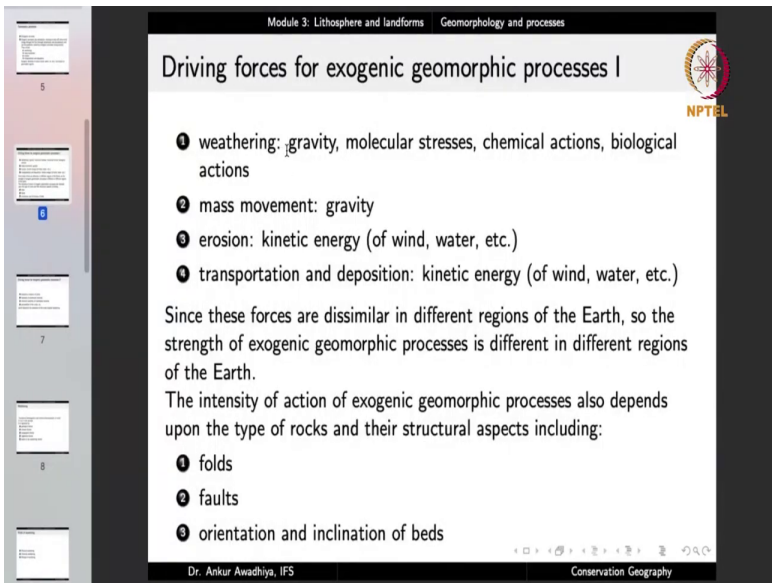

Now, when we talk about the Exogenic geomorphic processes, what are the forces that drive them? Now, when we talk about weathering, now in the process of weathering, a rock gets broken down into smaller particles because of physical agents because of chemical agents.

Now, when a rock is breaking down into smaller fragments, it is breaking down because of the action of a number of things one is gravity.

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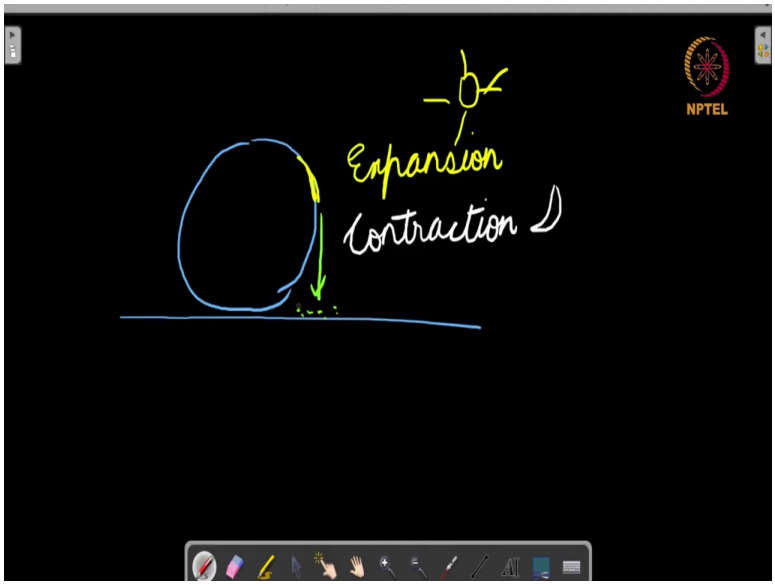

Now, gravity acts because if you consider a rock like this and it is getting heated up by the Sun, because of this heat this portion is getting heated up in the daytime in the night time it gets cold. So, in the daytime there is expansion, in the night time there is contraction. So, there is contraction during the night time. Now, because of regular expansion and contraction, it is possible that this fragment will slowly break off. Now, when it breaks off, it will move down because of gravity and it will probably accumulate here.

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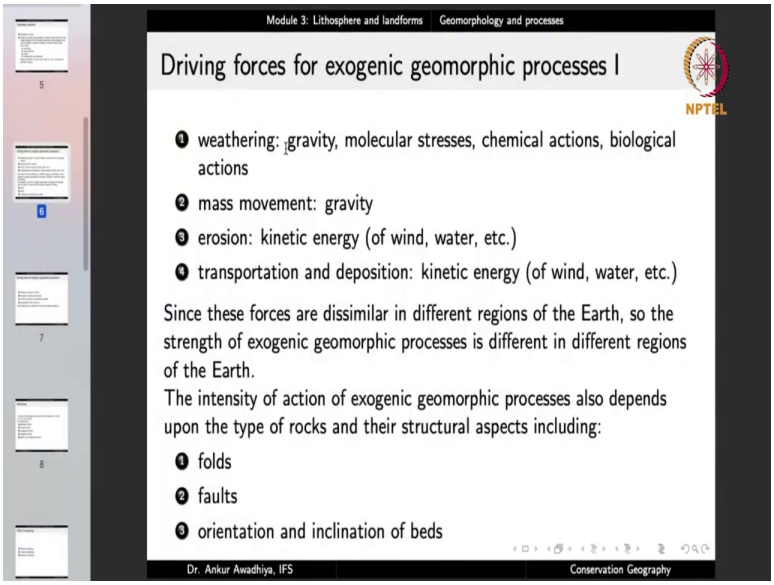

So, gravity plays a role in weathering, molecules stresses play a role.

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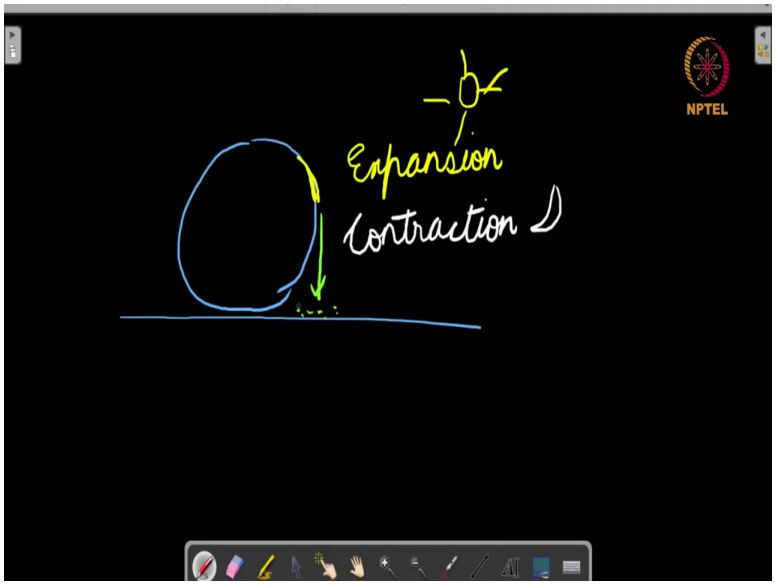

So, it was the stress at the molecular levels because of the agent of heat in this particular case that led to weathering. Now, suppose the material was very strong, suppose the material was very resilient in that case it would not weather easily. But if the material is a softer material that shows a very great amount of expansion and contraction in that case it will weather much more easily.

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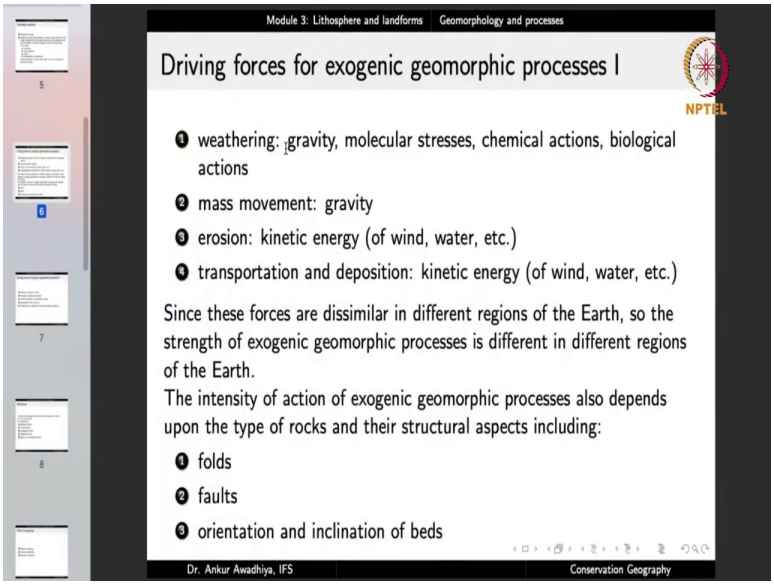

So, the molecules stresses are also a driving force in weathering. Chemical actions, so it is possible that in the case of this rock there is certain portion that has say calcium carbonate. Now, calcium carbonate can react with the carbonic acid that is present in the rainfall and it will then get dissolved.

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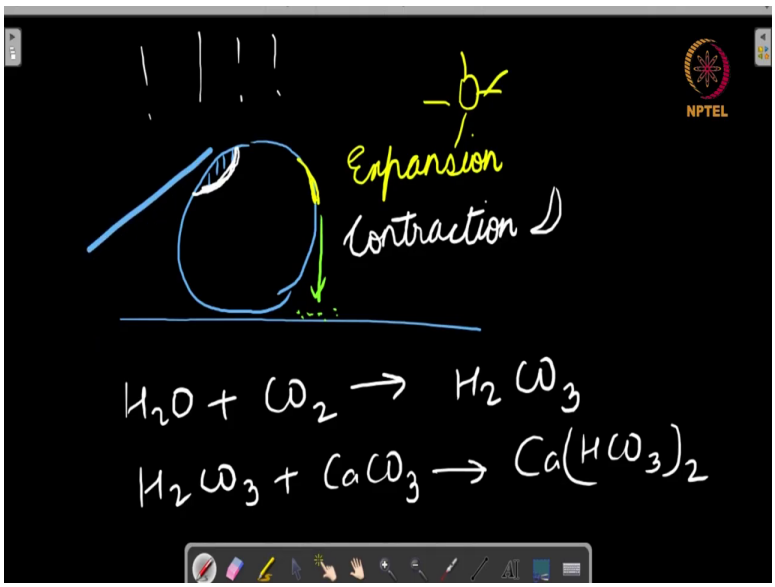

Now, because dissolution can also lead to a situation where you have, suppose in this piece of rock you have this portion that is high in calcium carbonates. Now, when it rains you have water that absorbs the carbon dioxide in the air and it forms the carbonic acid. Now, this carbonic acid can react with calcium carbonate and this will lead to dissolution, why, because

it will lead to the formation of calcium bicarbonate and calcium bicarbonate is soluble in water.

So, when this happens, this portion, the white portion, it will get dissolved in when it gets dissolved the portion that is on the top of it, it now becomes free. So this is a fragment that has been created by a chemical process.

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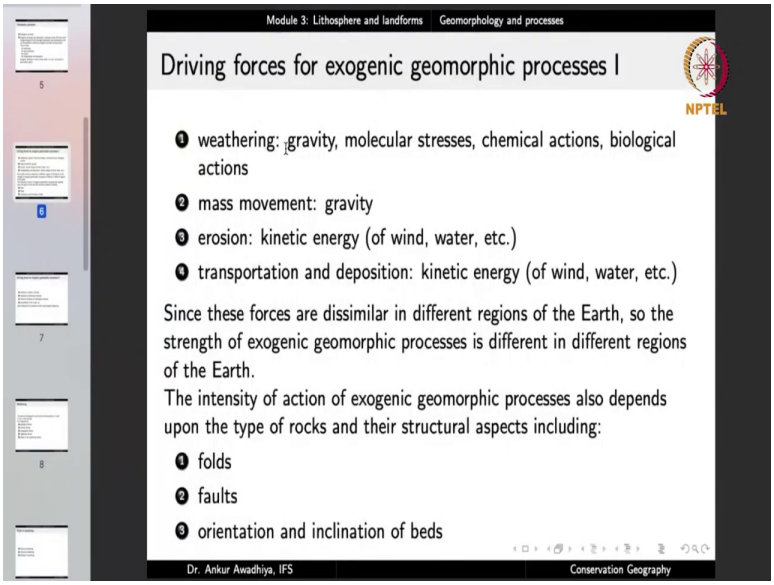

So, chemical agents actions also play a role in weathering similarly, biological actions.

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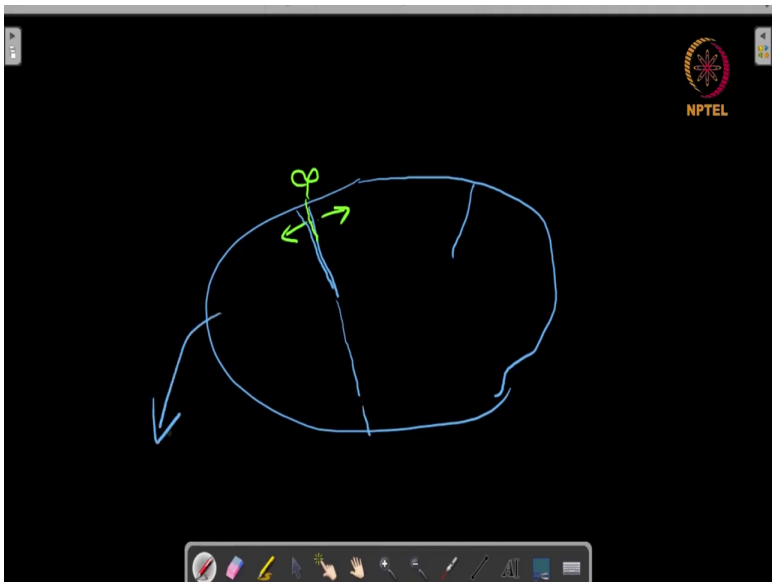

Suppose, you have a rock and in this rock there are certain cracks and suppose a plant comes up. So there is a plant that is now growing here the roots have entered inside. Now, the roots when they are growing they exert a force in the outward direction. In that case, the cracks will increase in size, because there is a force that is acting because of the role of these roots and this force or this pressure that is getting created it will lead to an expansion of this crack, it will lead to the creation of a larger sized crack and when this crack reaches to this point, this portion will topple off.

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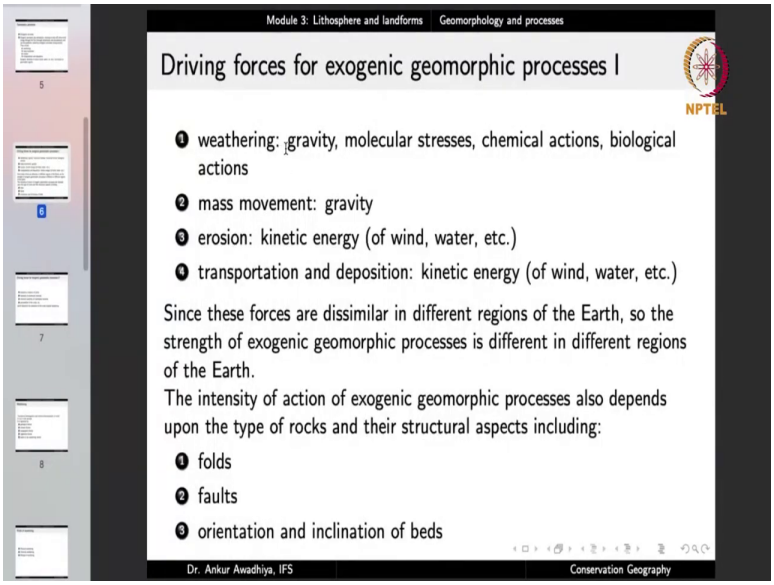

So, in this way we can have the action of biological beings such as plants that help in weathering. Now not only through physical processes such as pressure, but there are also certain chemical reactions that are aided by the biological processes.

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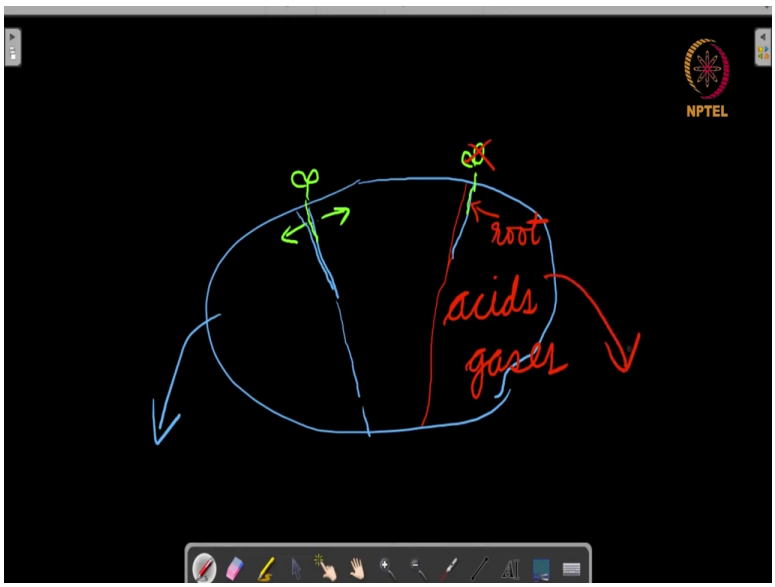

So, for instance you have this crack and suppose a plant came up the route came up here it was not able to exert a great amount of pressure on this rock, but later on this plant dies. Now, with this plant dies, you have this portion of route that is inside. Now, when the plant dies, then microbes will start to act on this route and they will degrade this route. Once this route gets degraded, it will lead to the generation of acids.

The acids will act chemically to probably further the weathering of this rock. It can also lead to the creation of gases, which will then exert a tremendous amount of force on this small portion of the rock and through the action of these acids and gases as well you can have a situation where the crack increases in size and then this portion gets toppled down. So, this is another driving force for weathering.

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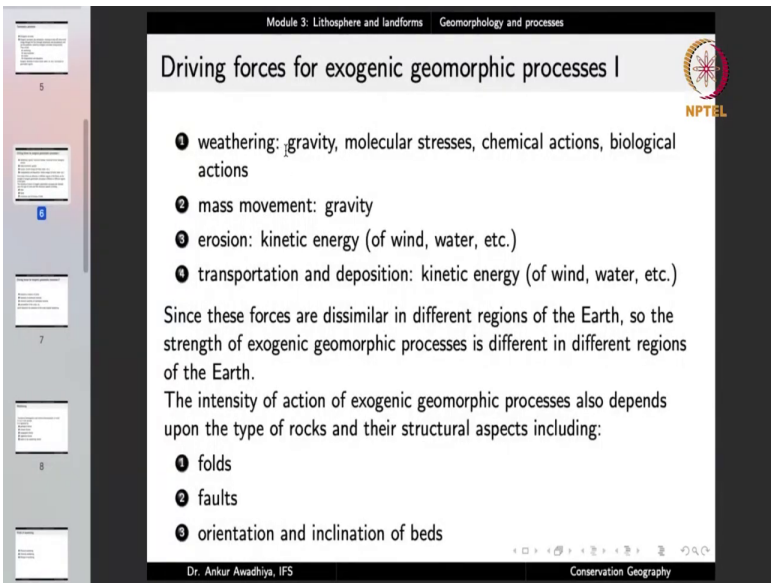

In the case of mass movement, it is the movement of large size masses, primarily because of gravity. So, gravity is a is a driving force for mass movements. For erosion, the driving forces kinetic energy of wind, water and other such geo-morphological agents.

So, if the wind is moving at a faster speed or if the water is moving at a faster speed, then you will have more and more amount of erosion. So the kinetic energy in this case is playing the role of a driving force. In the case of transportation and deposition as well, the kinetic energy plays the role of a driving force.

Now, since these forces, the gravity molecular stresses, chemical actions, biological actions, kinetic energy, because these forces are dissimilar in different regions of the Earth. So, the strength of the Exogenic geomorphic processes is also different in different regions of the Earth.

Now, here again, what we are observing is that the impact of these Exogenic forces is different in different areas. Not only that, the intensity of action of the Exogenic geomorphic processes also depends upon the type of rocks and their structural aspects. So, when you have the same water that is acting on different rocks, it is possible that one rock degrades faster, the other rock degrades at a slower speed.

And so, the action of these Exogenic forces is different everywhere on the Earth. So, we will have certain areas where the action is more, and so the amount of denudation will be more, in

certain other areas, the action will be less, and so the amount of denudation will be less. Now, this also leads to the creation of differential landforms on the planet.

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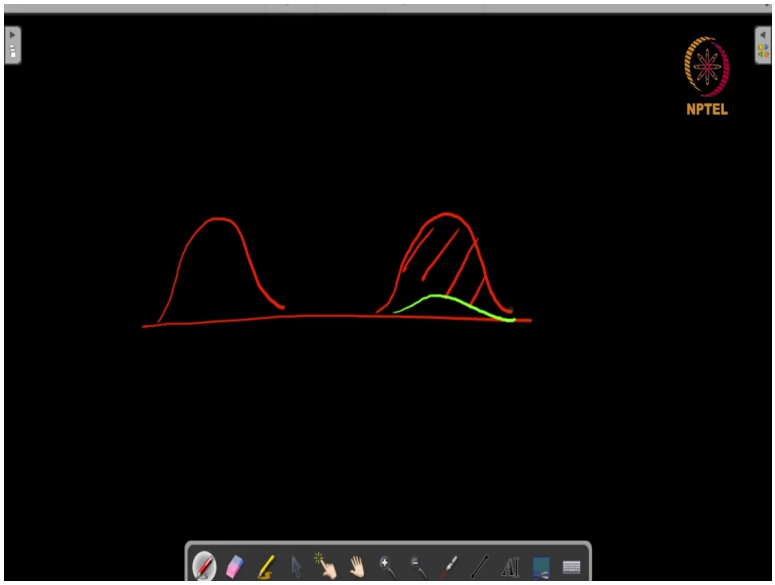

So, for instance, suppose we began with two hills that are probably of the same size, but one is getting denuded faster. So after a while, you will find that you have a large sized hill and probably a smaller sized hill.

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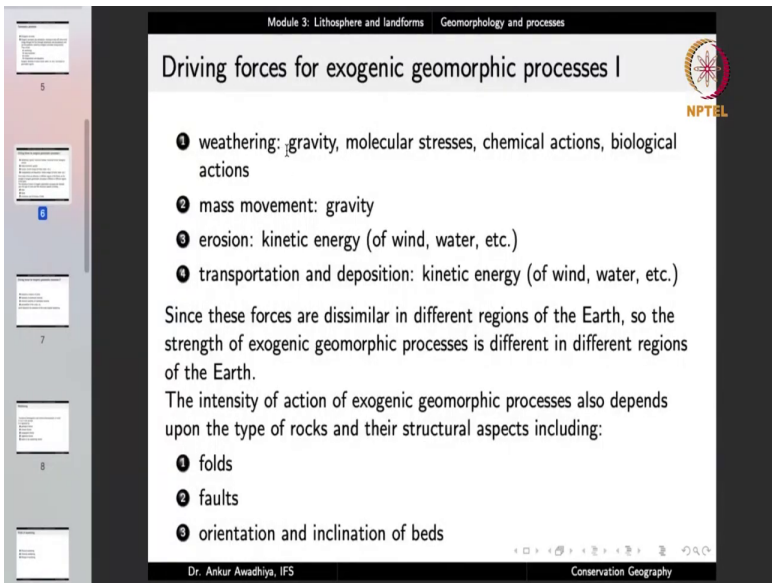

And so the Exogenic forces also lead to the creation of differential landforms on the planet. Now, the intensity of action depends on the type of rocks and the structural aspects, including things like folds.

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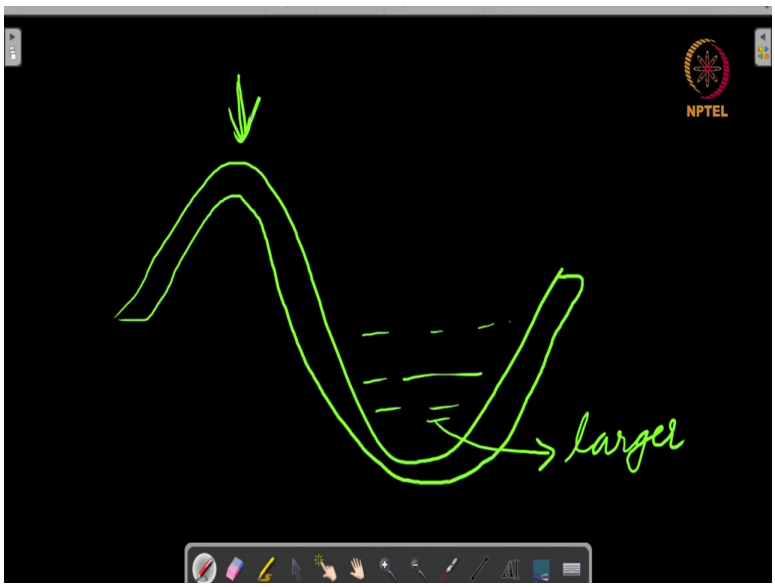

Now, if a rock has a fold, if the rock is like this, then probably some amount of water will get accumulated in this region, but water will not get accumulated in this region. And so, if there are certain chemicals that are acting to denude these rocks, then the amount of action in this area will be much larger as compared to the amount of action in this region.

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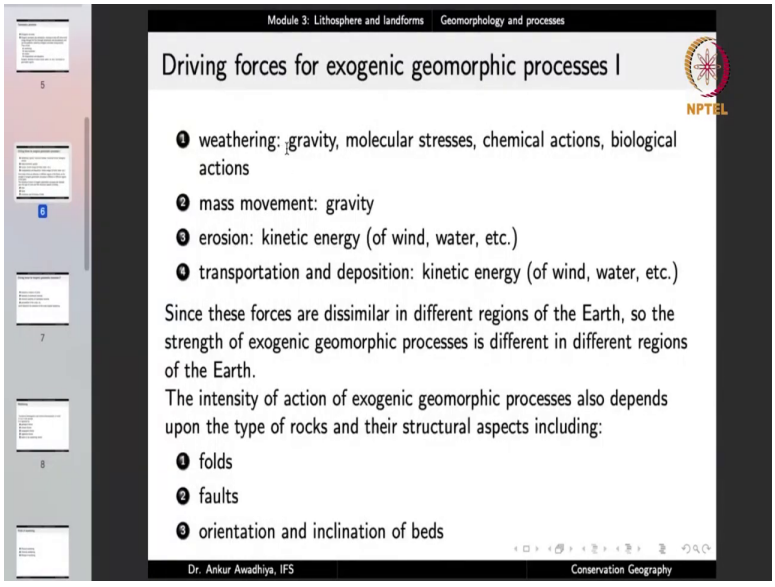

So, folds can affect the intensity of action of the Exogenic forces.

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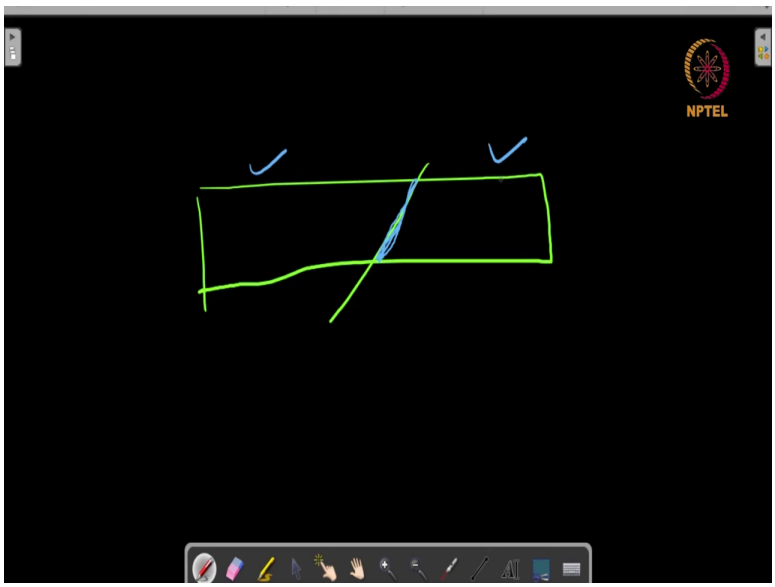

Similarly, false, if you have a rock and this rock already has a break hits somewhere suppose there is a break here. Now, in that case, water will be able to seep into this region and the weathering in this region will be greater as compared to, say, weathering in this region, a weathering in this region.

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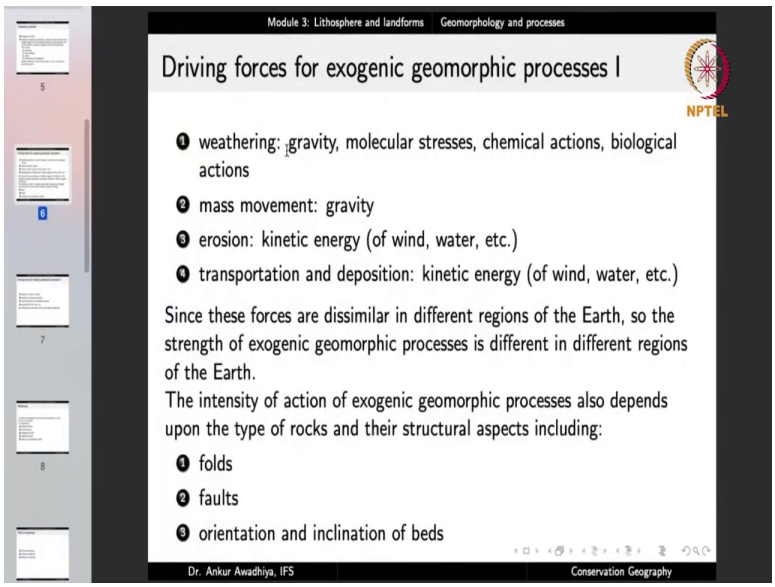

So, the existing faults can also change the intensity of action of the Exogenic agents. Orientation and inclination of the beds, are the beds oriented towards the geomorphic agent or are they oriented away from the geomorphic agent, such as the wind. Are they inclined in a way that they create a huge gradient or are they inclined in a way that the amount of gradient

is very less, because things like water will move faster when the gradient is more. And so the water will have more kinetic energy.

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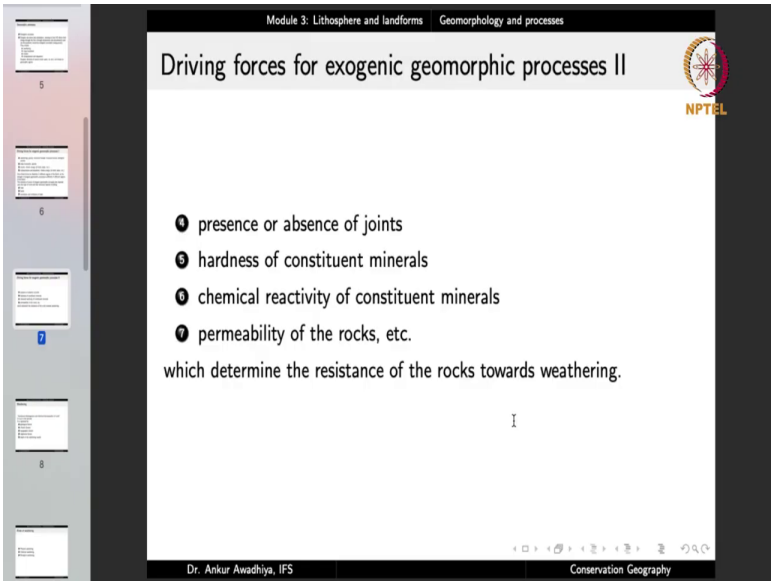

Similarly, the presence or absence of joints in the rock, if there are joints present then the amount of weathering will be more. The hardness of the constituent minerals, if the constituent minerals are harder in that case the weathering will be much more delayed as compared to cases where the constituent minerals are softer, because softer things are degraded faster.

Similarly, the chemical reactivity of the constituent minerals, do we have things like calcium carbonate in the rock, because calcium carbonate is very highly reactive. If there is a small amount of acid it will denude this rock. So the chemical reactivity of the constituents. Similarly, the permeability of the rocks if the rocks are permeable, meaning that they permit water to get inside them. So together with water, we can also have acids that go inside if we have water that seeps inside, then probably if it becomes very cold the water will freeze and it will begin to expand.

Now, water when it is able to enter into a rock because it is permeable, it will be able to create a great amount of force to break up the rock. But, if water is unable to enter, then in that case, the forces will not be there. So, permeability of the rocks also play a role. So all of these factors determine the resistance of the rocks towards weathering, and if a rock is more resistant towards weathering, then it will not be degraded that fast if the rock is less resistant to weathering, then it will degrade very quickly.

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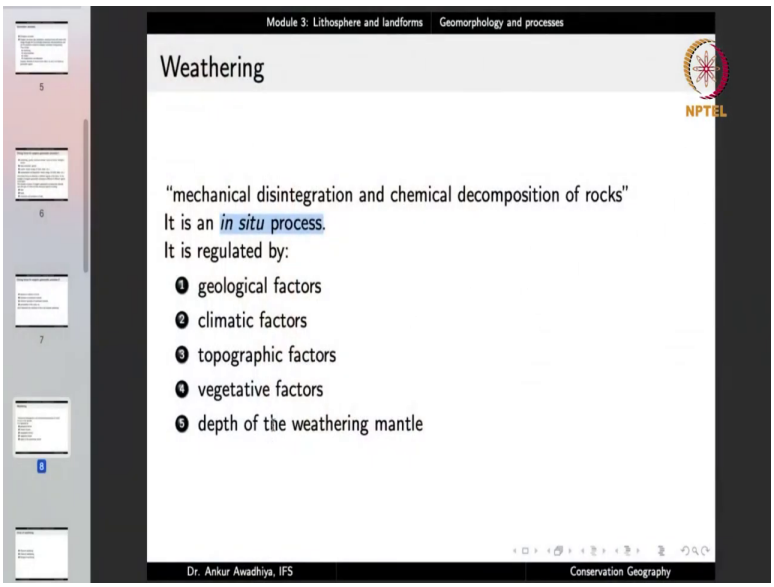

Now, let us look at these processes in more detail, what is weathering? Weathering is defined as mechanical disintegration and chemical decomposition of rocks. In this process the rocks are getting mechanically disintegrated, that is they are breaking up in a mechanical fashion and they are getting chemically decomposed meaning that chemicals are acting on these rocks and they are decomposing this rock through a chemical process.

And this process happens in situ, which means that this process occurs on the site of the rock. We are not talking about transportation of the rock to any other area. The process of weathering will occur wherever the rock is and it is regulated by a number of things such as geological factors, climatic factors, topographic factors, vegetative factors, depth of the weathering mantle and so on.

So geologically, if you have an area that suffers from a great variety of earthquakes, in that case, probably the rocks will be having a large number of defects, a large number of faults, a large number of joints, and in such cases, the amount of weathering will be greater.

It also depends on the climatic factors, if you have rocks in an area where you have plenty of rainfall, if you have rocks in an area that has a very abundant amount of sunshine or rocks in an area where you have the thawing action of snow. So, essentially ice gets formed there and then ice gets melted. So, the creation of ice and the melting of ice, if you have a situation like this, it is a very cold climate, then to the amount of weathering will be much greater, as compared to areas that have a much more equitable climate.

So, there is little amount of rainfall, there is little amount of sunshine, it does not get very cold in those areas, the rocks will not get weathered quickly, but in areas where the climatic factors are not supportive, the rocks will get weathered very quickly.

It also depends on topographic factors, things like whether these areas are on a height or whether they are in a depression. If you have things at a height, then probably those areas will typically have less amount of rainfall or the rain will not be able to stand in that area it will quickly get washed away.

Whereas, in the depressions the rain will get accumulated, there will be an accumulation of water and so the action of water will be greater. In those areas in such topography is where the slope is greater the water will be having a larger speed. In that case, when the water is moving faster, then it will have more kinetic energy and the amount of weathering that it can cause will be much greater, it also depends on vegetative factors.

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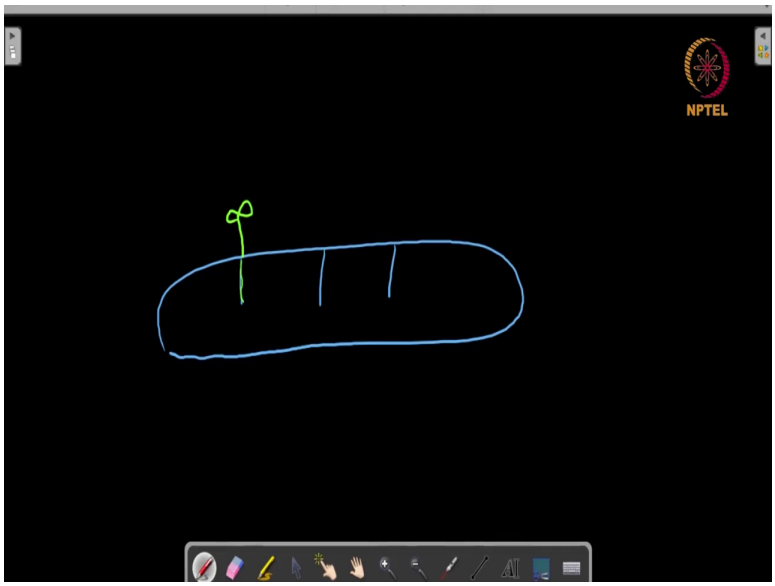

So, suppose, you have a rock and we have observed that if there are cracks and if there is vegetation then this vegetation can lead to the exacerbation of the cracks, but there is also another thing.

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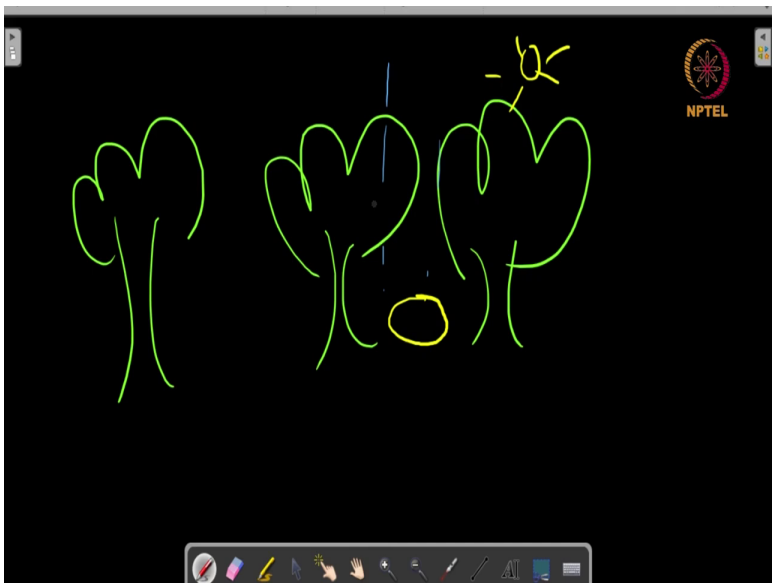

Suppose, you have a rock in a forest, so you have these trees and you have a rock here. Now, in this case the Sun is not able to heat up the rock directly because the rock is there in the shade of the trees. So the trees will act as a modifying agent.

Similarly, raindrops will not be able to directly impinge on the rock because they will get stopped by the canopy.

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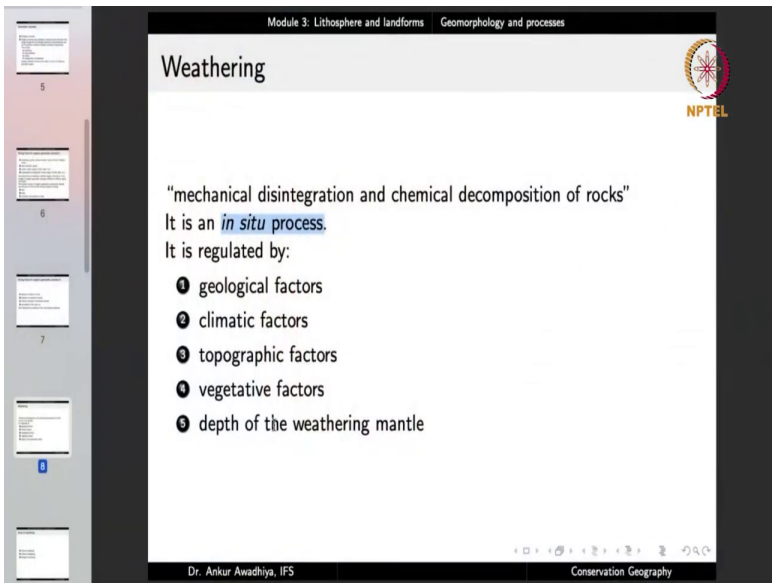

And so, the vegetative factors can play a role in increasing the amount of weathering or they can play a role in decreasing the amount of weathering, also the depth of the weathering mantle, what is the weathering mantle?

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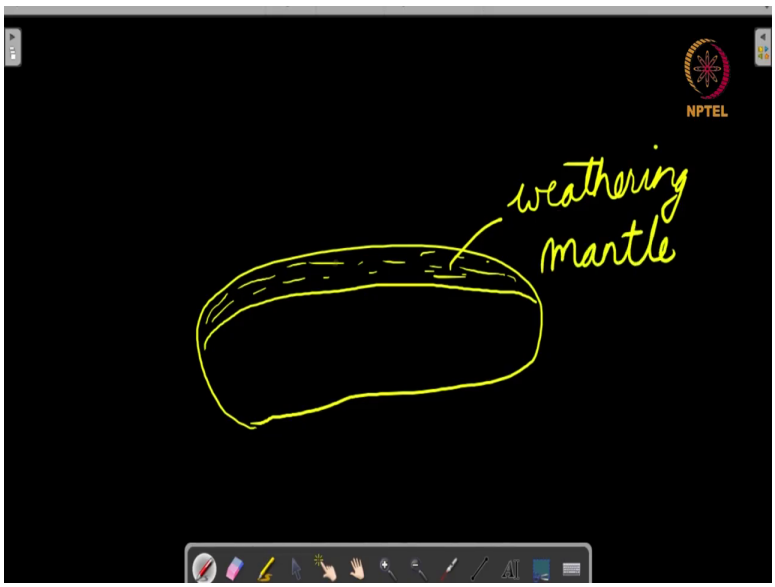

If you consider a rock and this rock is in the process of weathering. Now, suppose the top layer has already weathered, what happens to the bottom portion? If you have this thick a depth of the weathering mantle, so this is a weathering. Now, if the weathering mantle is not removed by the action of wind or water then it acts as a protective blanket over the rest of the rock. So, it prevents the weathering of the remaining portion of the rock.

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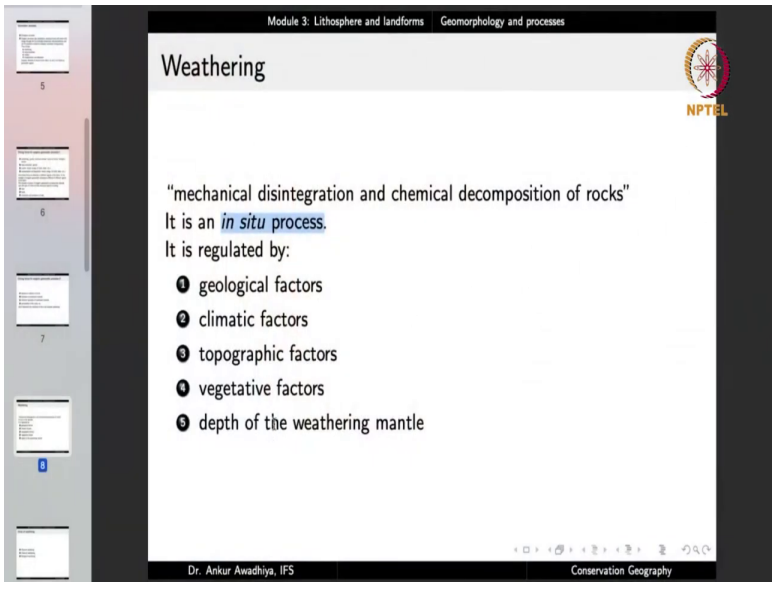

So, these are all different processes that regulate the amount of weathering.

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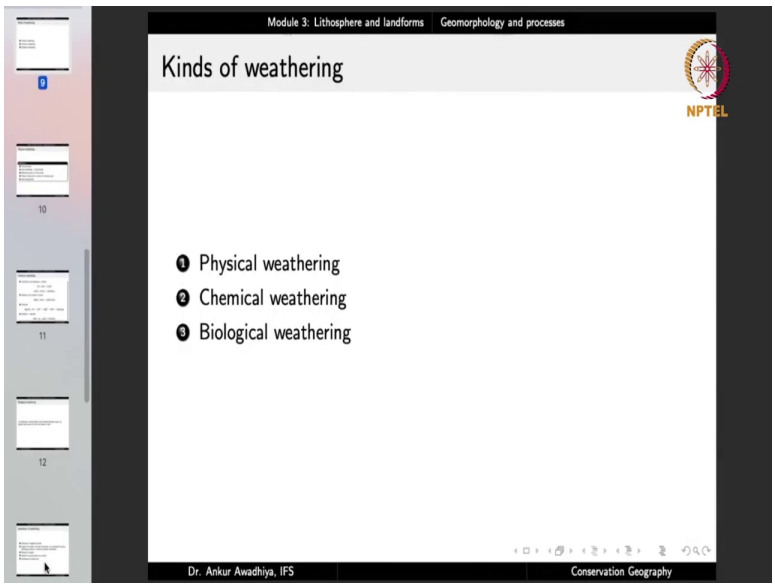

There are three different kinds of weathering we have physical weathering, chemical weathering and biological weathering.

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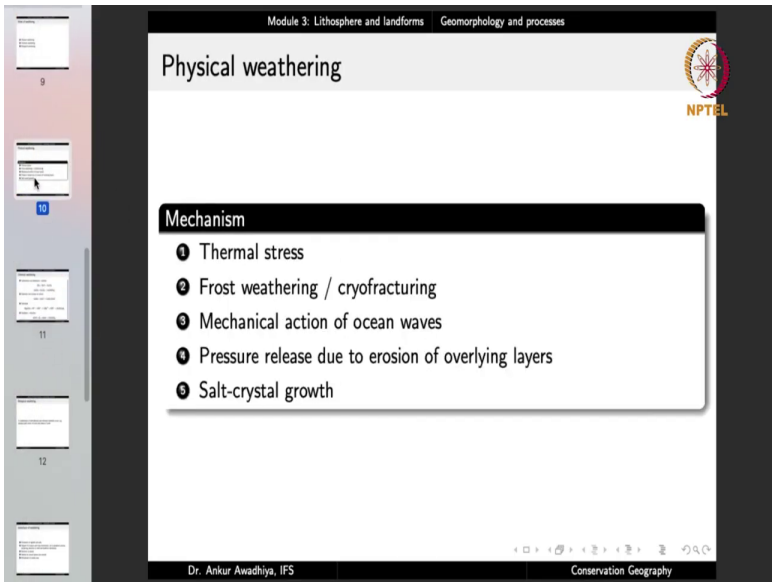

Physical weathering occurs through several mechanisms that act physically, meaning that there is no chemical reaction that goes on, it is just an action of changing temperature or pressure and so on.

So, we can have things like thermal stresses. Now, we have observed thermal stresses before in the case of a rock that is getting heated up in the daytime and it gets cooled in the night time. When there is heating, there will be expansion when there is cooling there will be

contraction and regular expansion and contraction, this will lead to a disintegration of the rock. So, this is a physical weathering due to thermal stresses.

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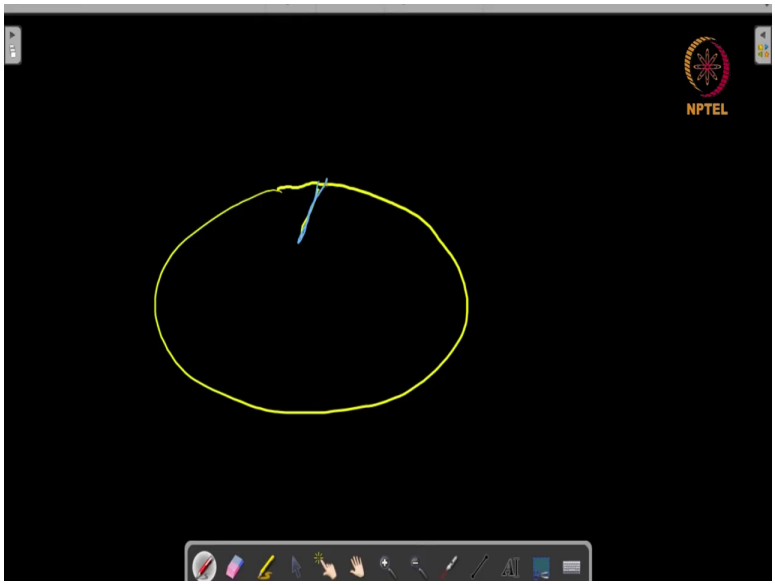

We can have frost reading or cryofracturing. In this case, if there is a rock let's say a small crack, water enters into this crack and at the night time this water freezes when the temperatures go down.

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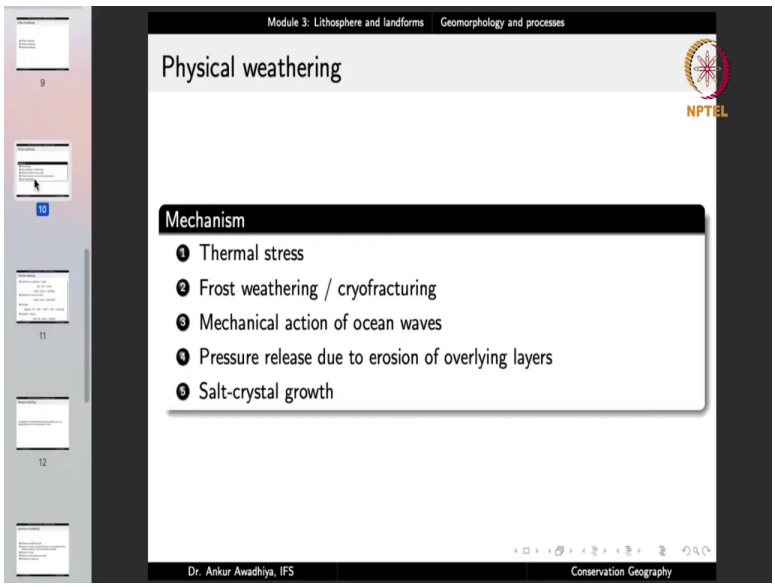

Now, if you talk about water that is freezing, we will find that the ice has a larger volume as compared to water, because ice is less dense than water. If you put an ice cube in water, the ice cube will float, now the ice cube floats because its density is less.

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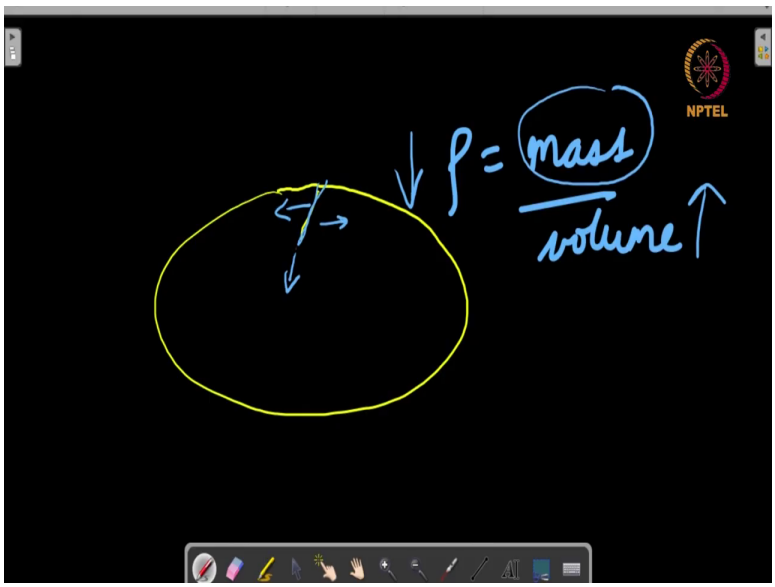

Density refers to mass per unit volume. Now, when we say that ice has a lesser density than water, it means that for the same mass, it has a greater volume than water. Now, greater volume means that the ice is going to take more space that is it will increase in size as compared to the size of the water. And so, this will exert a force that is on the outside and with this, the crack will increase in size.

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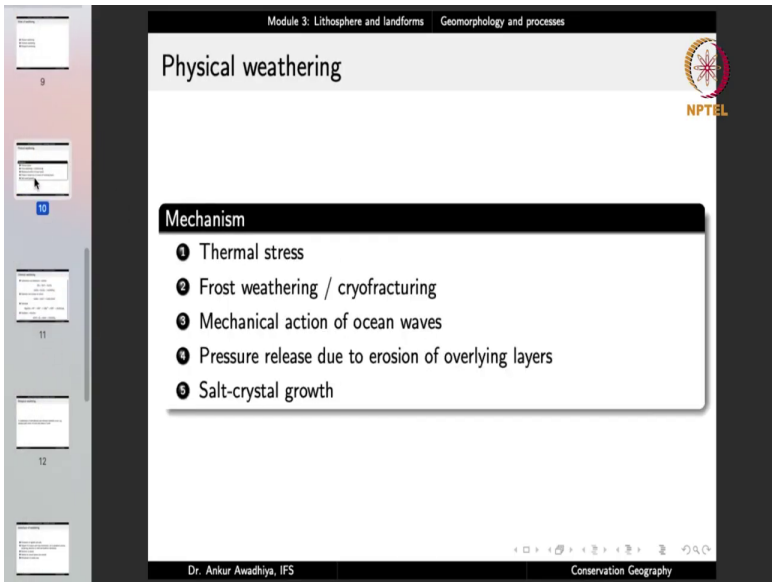

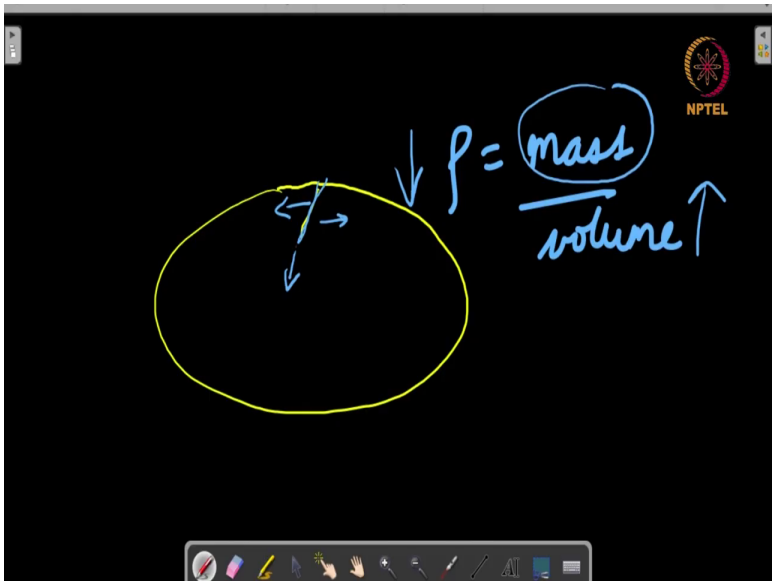

So, this is frost widening or cryofracturing, cryo is cold. And in this case, we are getting a fracture in a rock, because of cold conditions, because the water is getting frozen into ice.

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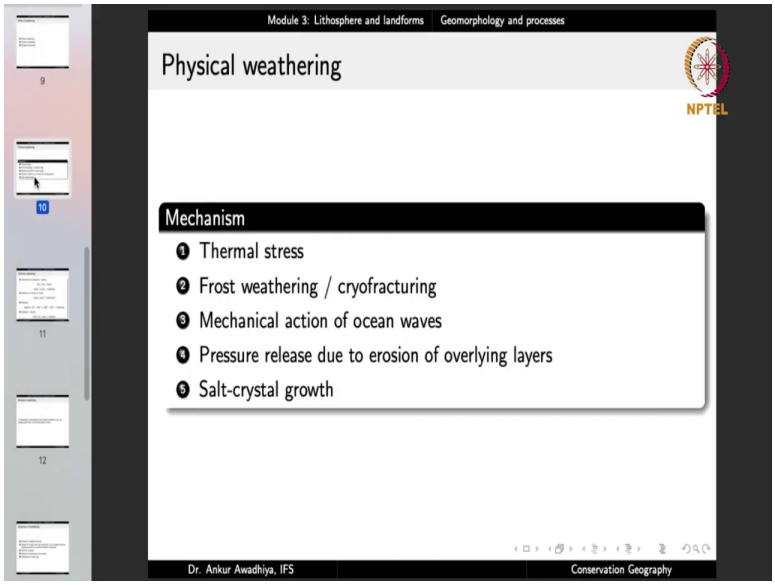

Another mechanism is the mechanical action of ocean waves. Now, ocean waves when they strike at a rock, they are exerting a physical force on the rock, they are pumping against the rock again and again. They will probably also be carrying some amount of sand, which will also act as a sandpaper to wear off the rocks. So, we have the physical bumping and we also have the sand because of the rock weather in a physical manner. We also have the pressure release due to erosion of overlying layers, what is that?

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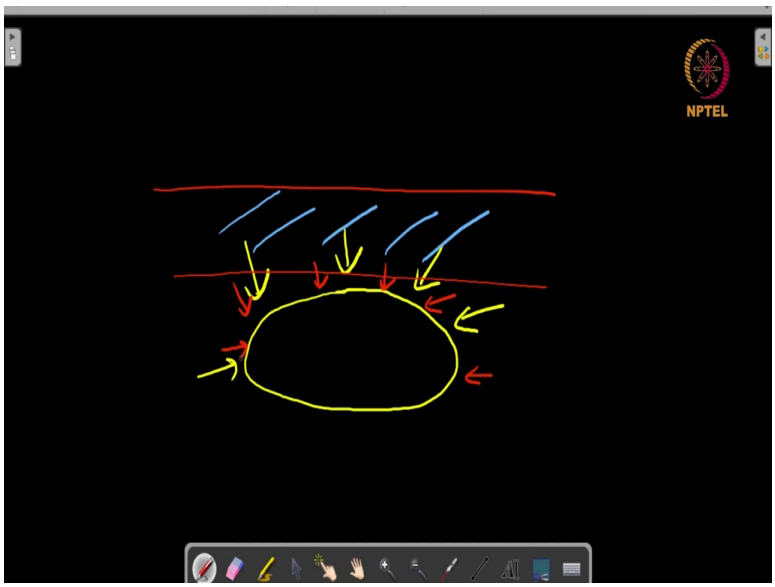

Suppose, we consider land and there is an intrusive igneous rock that gets formed here. Now, when the rock was getting formed, then there was a pressure that was being exerted by the Earth on this rock. And so, this rock got created under a condition of intense pressure.

Now, later on, if the top portion of the soil if it gets eroded. So, now this soil is removed and now only this much amount of soil remains. Now, in that case, the pressure that is now being exerted on the rock it will be lesser.

So, when the pressure is less in that case, the rock will tend to increase in size, its size was limited by the pressure. And so, when the pressure is released, that rock will try to increase in size and because of that, there will be fractures that are developed in the rock. This is another mechanism of physical weathering,

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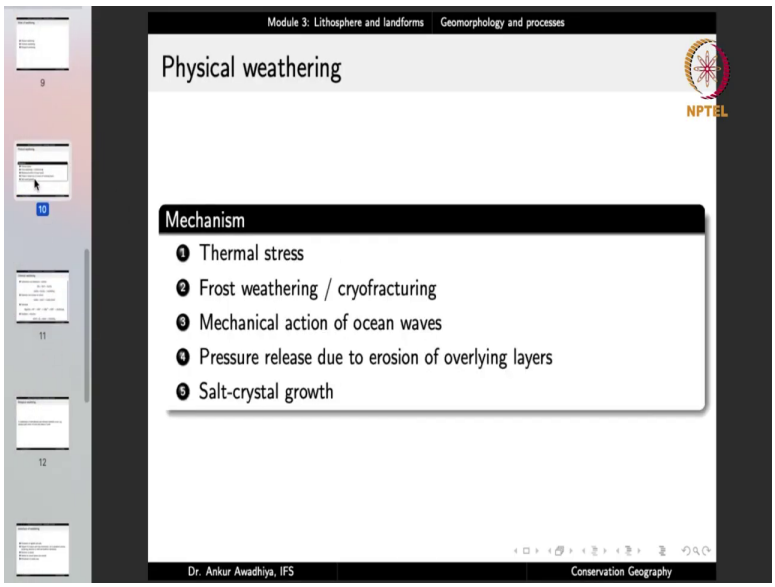

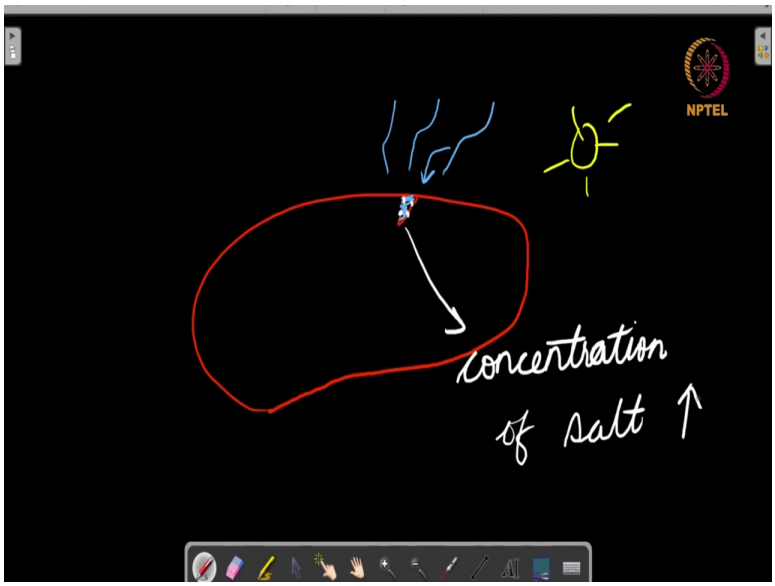

Yet another mechanism is the growth of salt crystals. Now, here what happens is that you have a rock and if there is a small crack and you have water, that also has salt, so that water gets filled inside. Now, in the daytime, when you have the Sun, the water gets evaporated as water vapour, but the salt that was inside it remains here. So, that leads to a concentration of salt to increase. Now, when this concentration of salt increases then we have the process of crystallization that is the smaller crystals of salt that get formed they tend to increase in size due to crystal growth.

Now, once you have a crystal inside here, then this crystal when it is growing this will again exert a force on the outside and because of this force also there will be a physical weathering. So, this is yet another mechanism of physically weathering.

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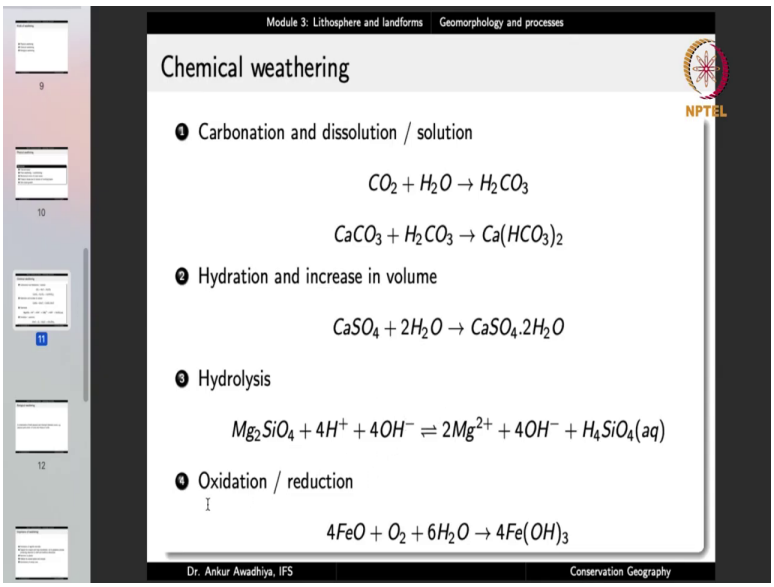

When we talk about chemical weathering, we can have chemical reactions such as carbonation and dissolution or solution. Now, we have seen this before, carbon dioxide in the air dissolves in water to form carbonic acid and carbonic acid can act on calcium carbonate in the rocks to form calcium bicarbonate and calcium bicarbonate being soluble in water it is removed from this area. Other reactions include hydration and increase in volume, as in the case of calcium sulphate. So, when it reacts with water it forms gypsum, which has a greater volume than the anhydrous calcium sulfate.

Now, an increase in volume will also result in greater operations then are exerted by this material. We also have hydrolysis, which is breakage because of the action of water and we also have redox reactions that is oxidation and reduction reactions.

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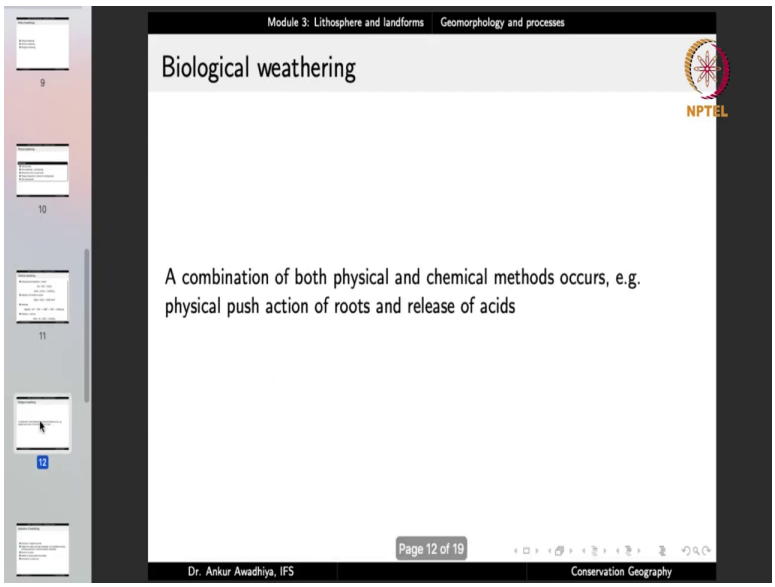

In the case of biological weathering, we have a combination of both physical and chemical methods example, physical push action of roots and the release of acids or the release of gases. So this is weathering and weathering is very important not just because it creates landforms, but also for the functioning of life on this planet.

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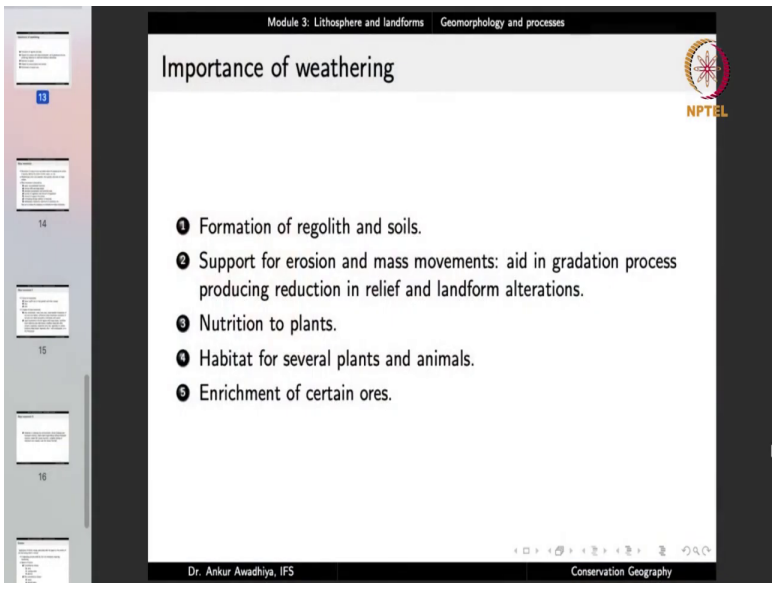

Weathering creates regolith, it creates soils, soil support plants and plants support all the other organisms. And so, weathering because it plays a role in the soil formation it is important for the sustenance of life on this planet.

Support for erosion and mass movements the aid in the gradation process producing reduction in relief and landform alterations. Now in the process of weathering, large size rocks are broken down into smaller fragments.

Now, it is easier for agents such as wind and water to transport smaller fragments because they are having a lesser mass they have a lesser weight as compared to larger fragments. And so, through the generation of smaller fragments, the process of weathering aids in the gradation processes, it aids erosion, it also aids mass wasting, which means movement of matter because of gravity. We will look at mass wasting in a short while.

Weathering also releases the minerals that are in the rocks, which provide nutrition to plants, weathering creates habitat for several plants and animals and it also leads to enrichment of certain ores, why?

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Because, suppose you have a rock and the rock has certain important minerals for you, say iron, or say gold. Now, when there is weathering, the rock will break down into smaller fragments and when there is erosion in transport, then the lighter portions will get removed from this place. So the rock has broken down, so you have these white portions that are lighter and you also have the yellow portions that are heavier.

Now, when you have the action of wind or water, the white portions will get removed and ultimately you will have a situation where your yellow portions remain in this area. So, this is leading to an enrichment of the ore.

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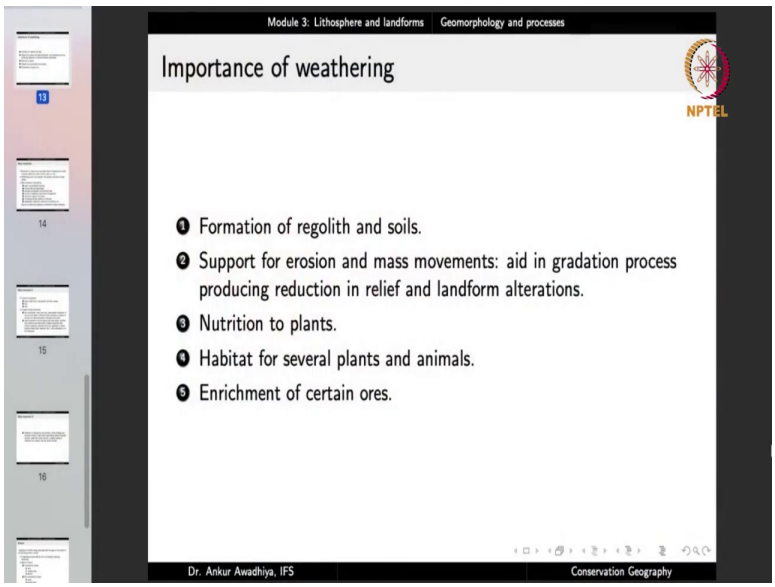

So, your ore is now having more and more amount of that mineral that you are interested in. So this plays a very important role in the mining for different materials. So this is an economic importance as well.

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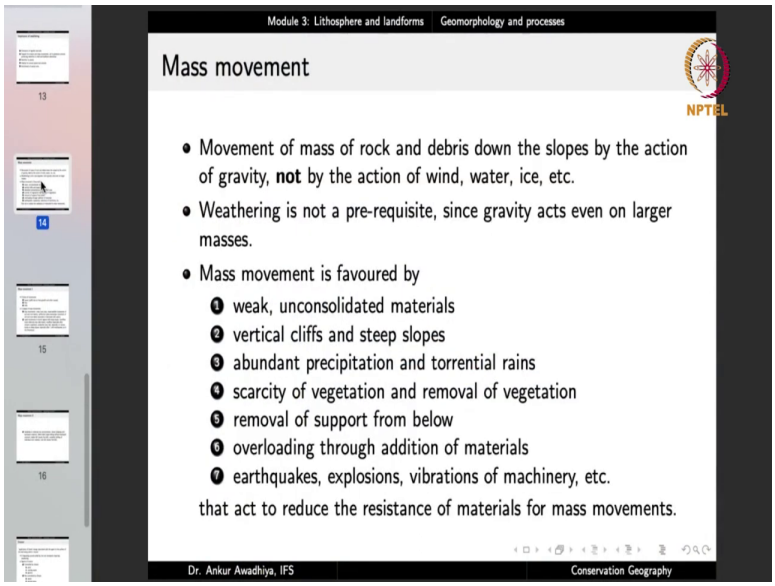

Next, let us have a look at mass movement, mass movement is movement of mass of rock and debris down the slopes by the action of gravity, not by the action of wind, water, ice, etc. So, it is primarily the moment of material down the slopes through the action of gravity that is mass movement.

Weathering is not a prerequisite since gravity acts even on larger masses, but weathering can play a role to facilitate mass movement, because typically the smaller fragments are easier to move.

Mass movement is favoured by weak and unconsolidated materials. If the materials are very much consolidated, they exist as a large size mass then probably in a smaller slope, it will be difficult to move it. But in the case of unconsolidated materials, they collapse very easily they tend to move very easily.

Vertical cliffs and steep slopes, now here because gravity is playing the majority of role. So if there is a vertical cliff or if the slope is steep, then gravity can move the material in a much easier manner.

Abundant precipitation and torrential rains, now in this case, when there is rain then the soil will get converted into a slush. So you will have a slush that has soil, it has rocks, it has water and this slush can move much more easily than say a very dry portion that has only soil and the rocks.

Now, remember that in this case, we are not talking about movements through water, we are not talking about the action say of a stream to carry the material, but water plays a role in supplementing this process of mass movement by creating a slush. So abundant precipitation and torrential rains also help.

Scarcity of vegetation and removal of vegetation, because vegetation tends to hold the soil it tends to hold the materials even it tends to hold the rocks.

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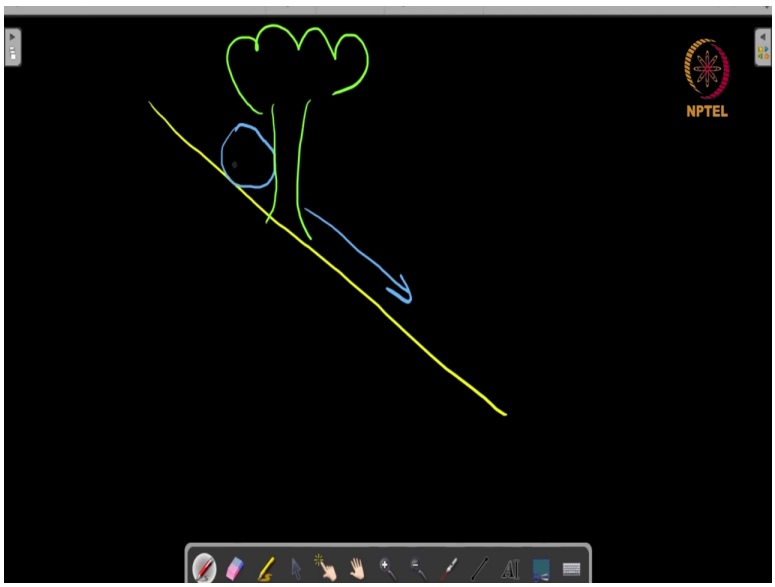

So, suppose you have a slope and you have a rock and if there is no vegetation, then probably this rock will very easily move down. But if there is say a big size tree here, then the rock will be stopped here at this location it will not be able to move.

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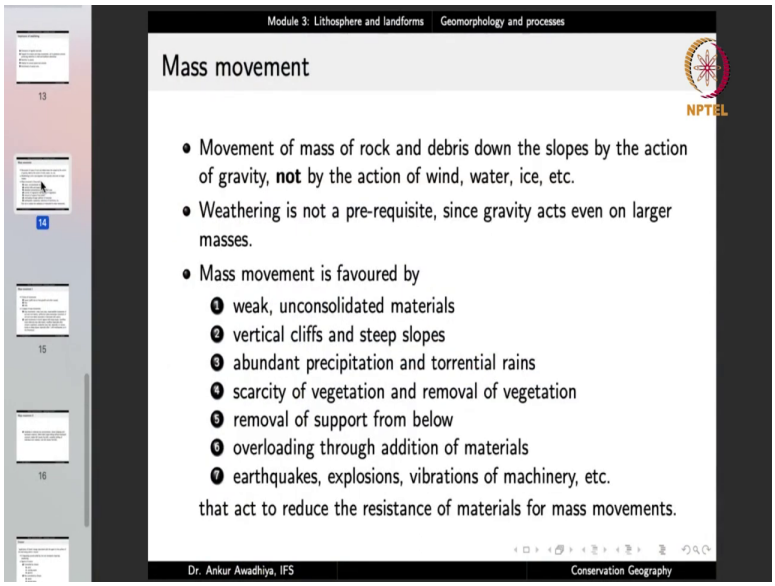

So, vegetation stops the mass movement. And so, removal of vegetation or scarcity of vegetation helps the mass movement.

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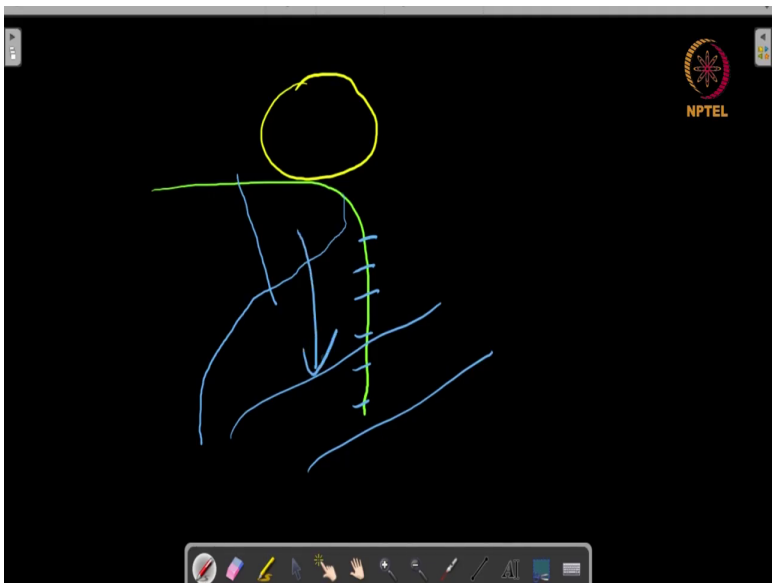

Removal of support from below. Suppose you consider a cliff that is like this and you have a rock on the top and through the process of erosion, now this portion has been eroded like this. So, this portion is now gone, because probably there is a river that is flowing here and it is eroding away the soil that is at the bottom.

So, in this case, now the support is gone and so, there will be a crack sort of a situation here and this whole material will come down.

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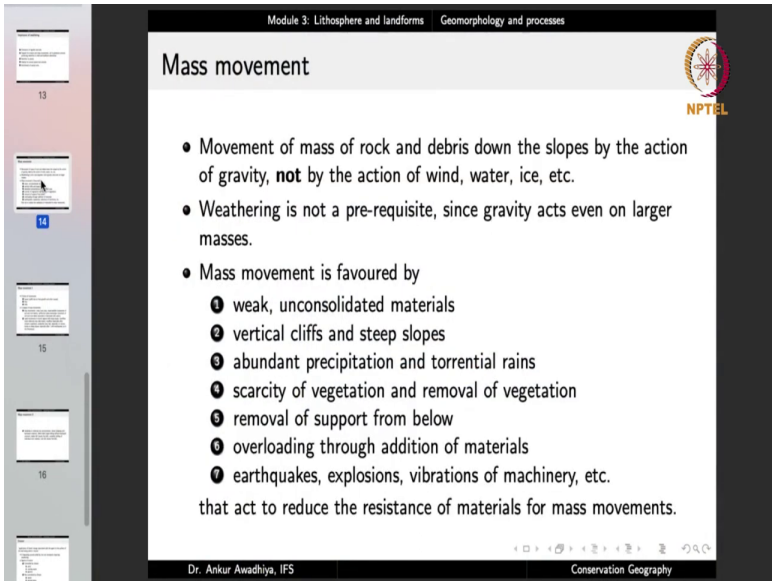

So, in this case, the removal of support from below is also aiding mass movement. Overloading through addition of materials.

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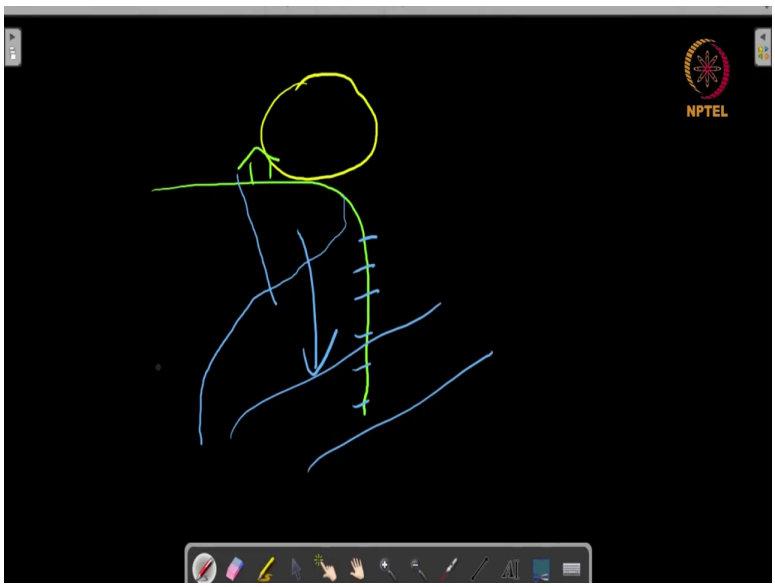

Suppose you have this situation and because there was a person who had this land, he tried to create a house here adding to the load. So that will also aid in the mass movement, because of an excessive load, this motion will fail much more easily.

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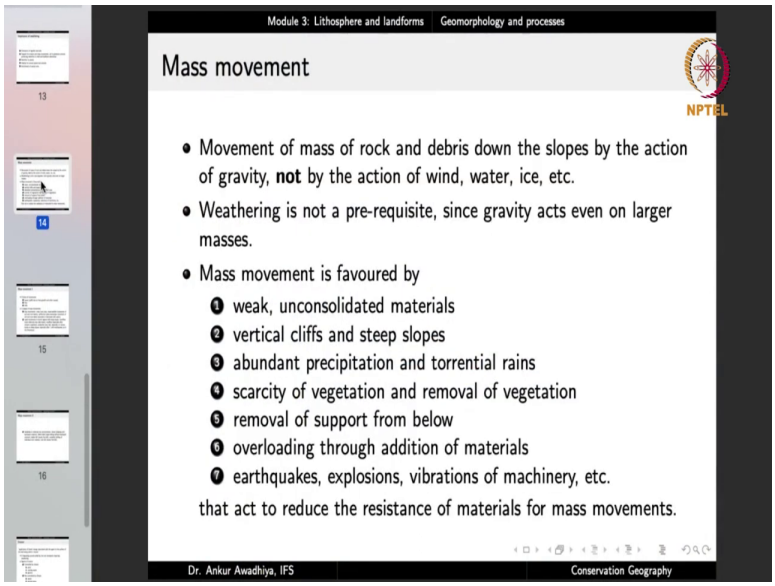

Earthquakes, explosions, vibration of machinery, etc., that also aids mass movement, it helps matter to move, because all of these act to reduce that resistance of materials for mass movements.

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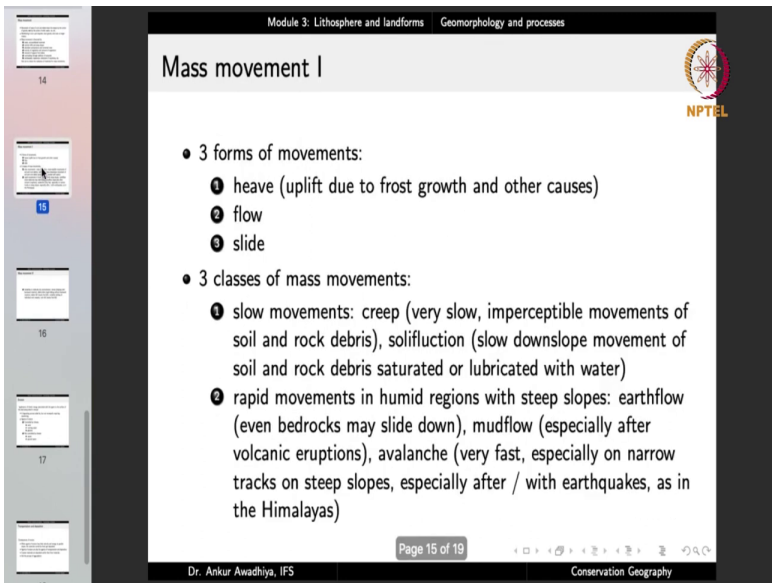

Now, there are three forms of mass movement, you have heave which is uplift due to frost growth and other causes.

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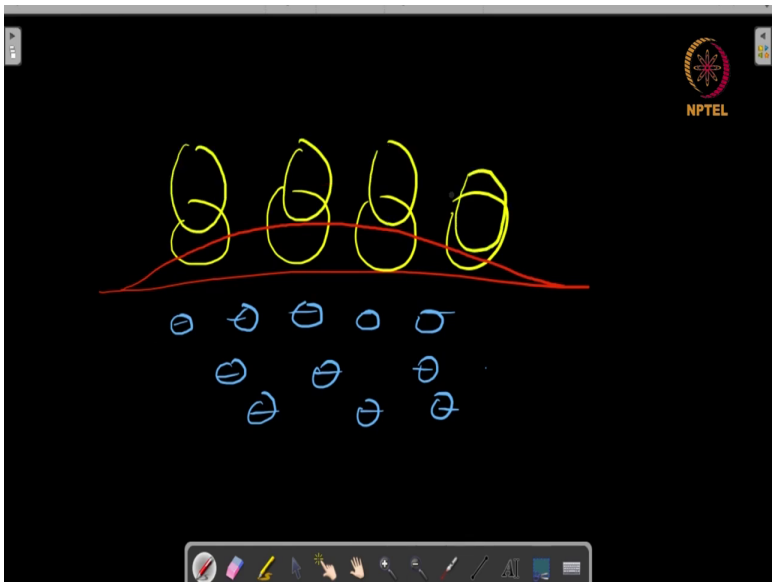

So, in the case of heave, what happens is you have the soil and the soil has certain masses on top of it, this soil is wet, it is saturated with water. Now in the colder climates, this water freezes, so it turns into ice and as we have seen before ice has a greater volume as compared to water. So in this case, when the water is getting converted into ice, then the total volume increases and the land will move up like this and with the land, all of these matters will also arise.

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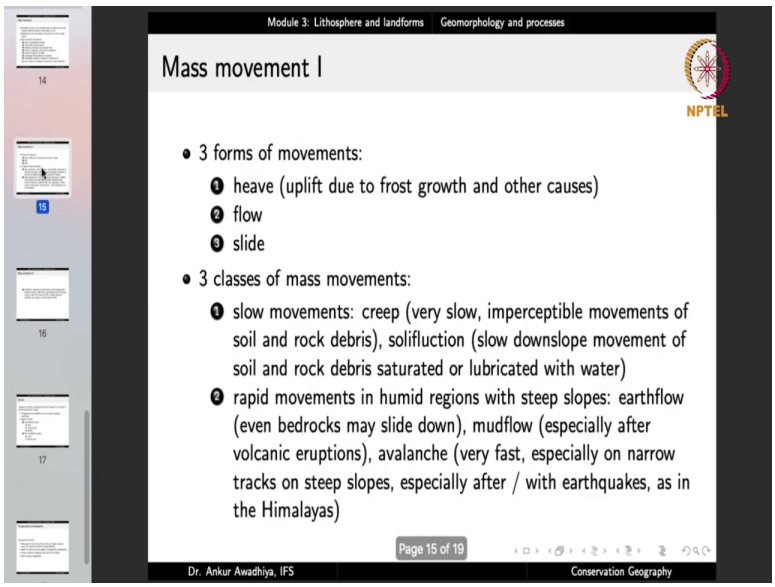

So, this uplifting due to frost growth and other causes is known as heave. We also have flow. Now in the case of flow, there is a movement of material together with water. And we can also have slide.

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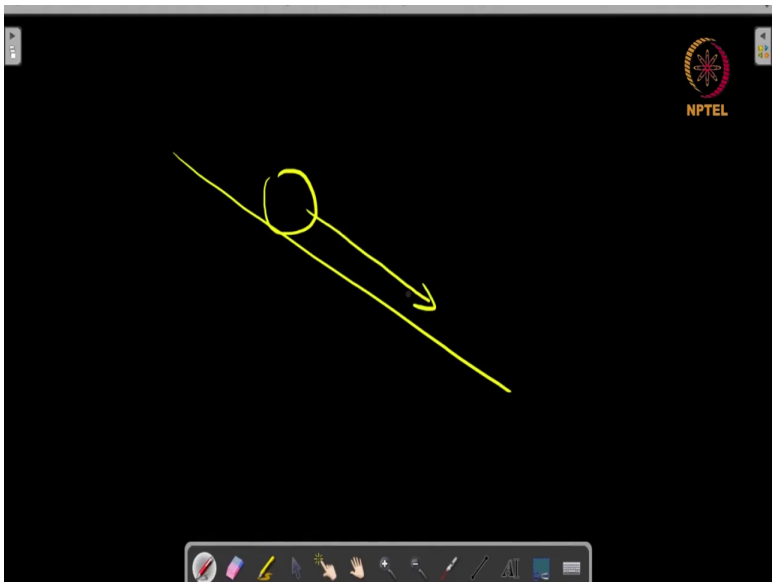

Now, in the case of a slide you just have a slope there is a material and this material slides down with rolling or without rolling.

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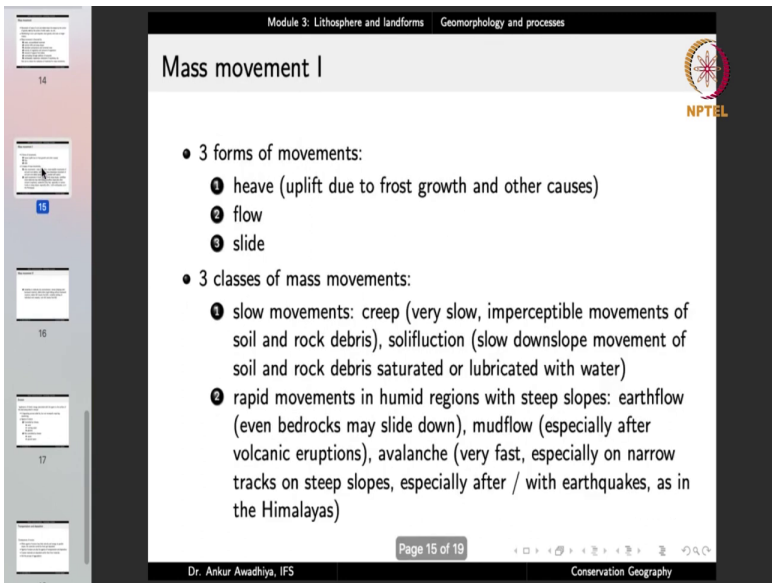

So, we have three different forms of movement. We also classify the movements in three classes, we have slow movements, such as creep, a creep is a very slow imperceptible movement of soil and rock debris, you will not find the soil and the rocks moving, but you can find an indication of creep say by looking at electric poles. So, if there is a movement of soil, the electric pole that was earlier straight it might turn. So this is an indication that the soil has moved.

So, creep is a very slow movement. You also have solifluction, which is slow downslope movement of soil and rock debris that is saturated or lubricated with water. Then we also have rapid movements typically in humid areas with steep slopes. We have things like Earth flow, in which even bedrocks may slide down, mud flow especially after volcanic eruptions.

So, when we talk about flow, what happens is that if we look at this model. So here we have a land and in this area, there is flow that is happening, now when there is a flow, the flow occurs like this. So you can see that there is a movement that is coming out here, so this is back and here now the flow is coming out.

Now, in the case of flow because the material is having lots of water, so it will typically move right next to the ground. We also have avalanches, which are very fast movements, especially on narrow tracks on steep slopes, especially after in with earthquakes as in the Himalayas. And we also have landslides,

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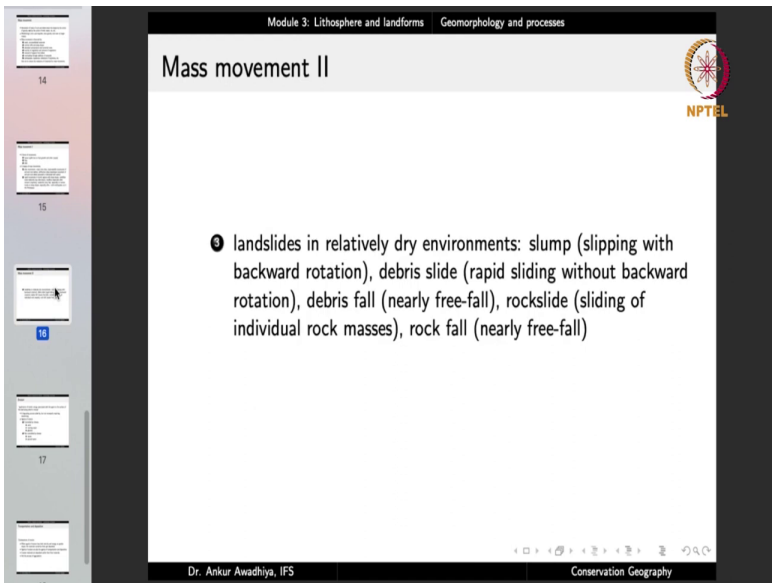

Now landslides typically occur in drier areas. And we have things like slump, slump is slipping with a backward rotation. So, what happens in the case of a slump is that here you have a land which is a flat land. Now, in the case of slump this movement, this material goes down with a rotation. And so, now this portion has come down, but it has also come down at an angle. So this is the angle that is created.

So, this is slump which is slipping with a backward rotation. We also have slide: a slide is a rapid sliding without backward rotation. Meaning that if you begin with a situation like this, so here you have a flat land, in the case of slide this portion goes down like this. So the matter has gone down, but we still have this flat area on the top, there is no rotating moment it does not rotate like this, it just remains a flat portion. So that is slide and we can have debris slide, which is movement of debris.

We can also have fall. Fall is a nearly free fall of material, such as debris or we can also have rock falls, which is falling of rocks. We also have rock slides, which is the sliding of individual rock masses.

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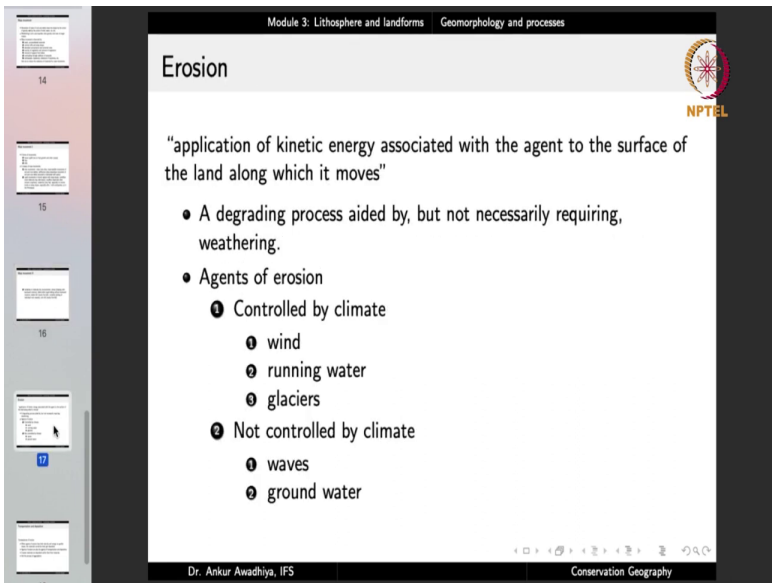

Now, typically weathering is also followed by erosion, erosion is defined as the application of kinetic energy associated with the agent to the surface of the land along which it moves. So erosion is again a degrading process which is aided by but does not necessarily require weathering, it is aided by weathering, because if you have smaller fragments to move, then you can move the fragments easily. So, it is aided by weathering, but weathering is not a prerequisite, because in the process of erosion, even larger sized rocks can be moved.

But, the important thing here is the application of kinetic energy it is occurring because the erosional agent is having kinetic energy, good erosional agents are things like wind and water. So, if they are moving with a speed, they can also carry material with them.

The agents of erosion that are controlled by climate include things like wind, running water and glaciers. The agents of erosion that are not controlled by climate include things like waves and groundwater.

Now, all of these because they have kinetic energy, because they have movement, so they can carry materials along with them. So they are agents of erosion, they are agents of erosion that are controlled by climate and they are also agents of the region that are not controlled by the climate.

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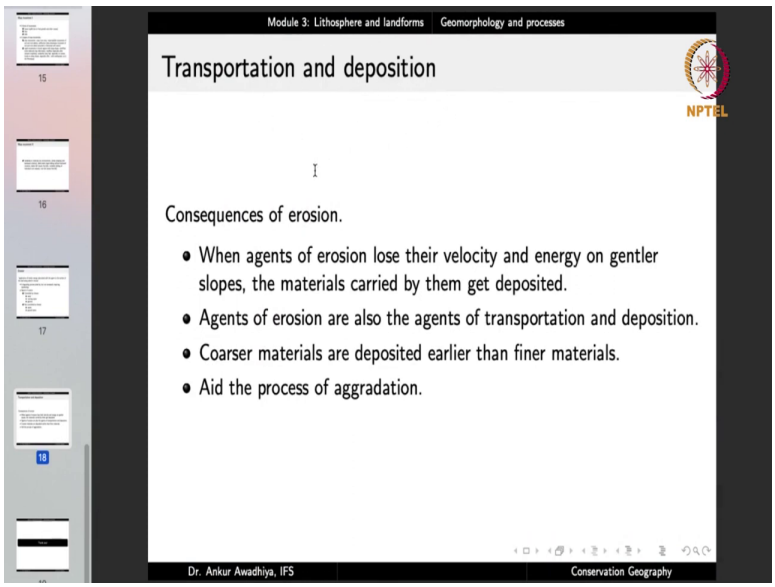

But, then once the material is moved, what happens to the material? Well later on this material will be deposited somewhere. So the material is moved, it is transported and later on it is deposited. So, transportation and deposition are also consequences of erosion, when the agents of erosion lose their velocity and energy on gentler slopes, the materials that are carried by them get deposited.

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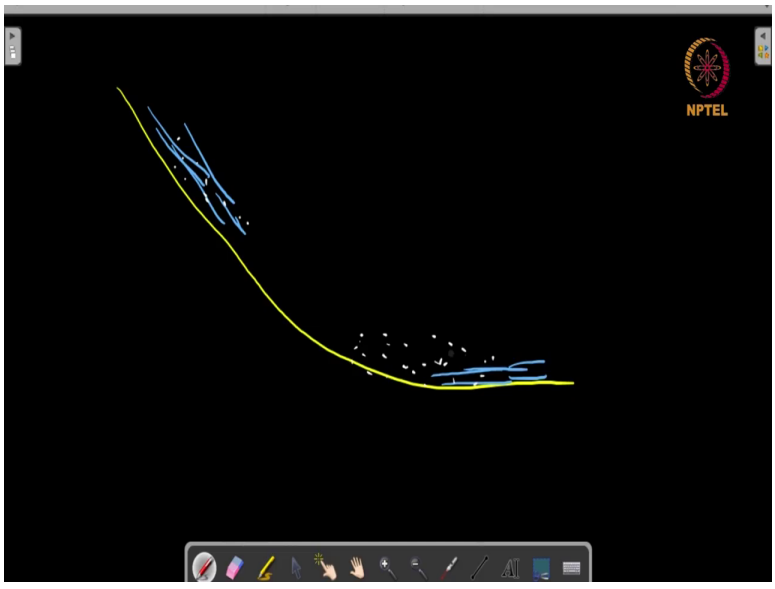

So, suppose you consider hilly region. So in this portion, the water is moving with a greater speed in this portion the water is moving at a slower speed. So the fragments or the sediments

that are carried by water, they will be deposited in this area, because the water speed is going down.

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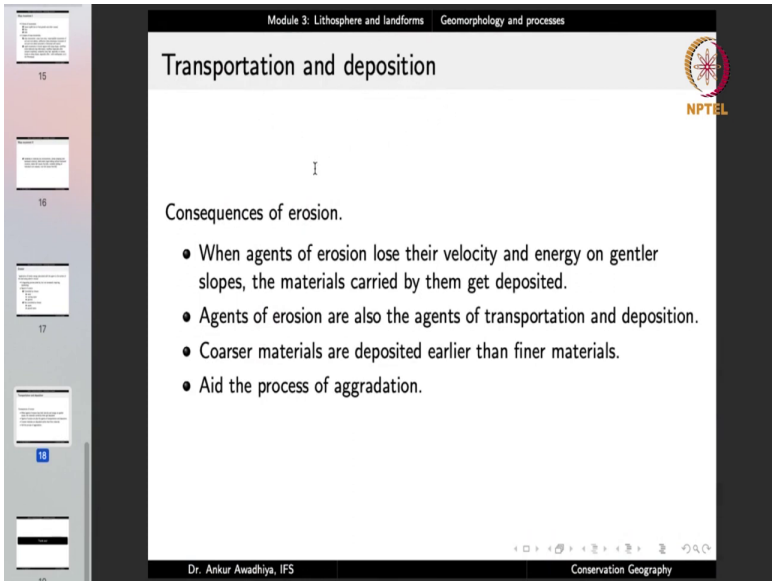

So, agents of transportation or agents of erosion are also agents of deposition. Coarser materials are deposited earlier than final materials, because it is difficult to move the coarser materials and so they are deposited earlier, as soon as the speed reduces a bit, the coarser materials will start to get deposited. Whereas, the finer materials can be carried even at lower speeds and so they will be carried to a much greater distance. And transportation and deposition aid the process of aggradation.

Now, we are not talking about degradation, which is wearing off of surfaces, but we are talking about aggradation, which is the addition of things.

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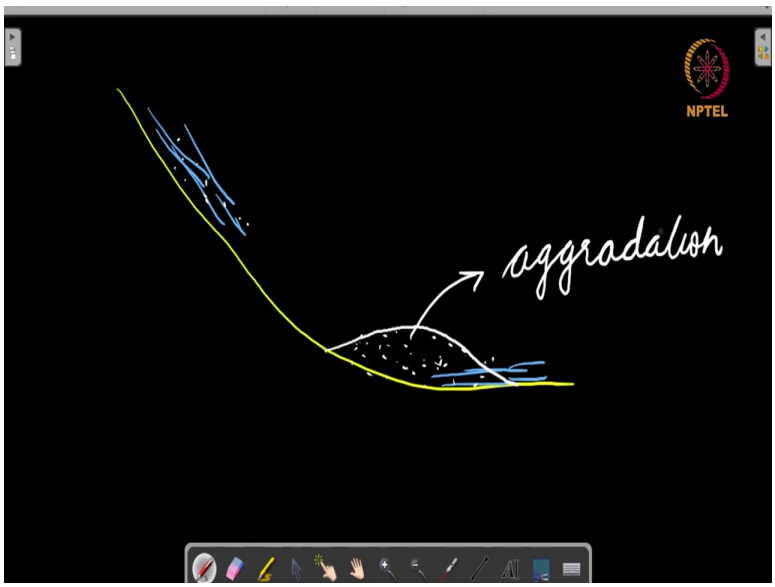

So, in this case when material is being added to this area, then we are getting a land form that is getting created like this. So this is a land form that is being created through the process of aggradation. So, the agents of erosion are also the agents of transportation and they are also the agents of deposition.

So that is all for today. Thank you for your attention. Jai Hind!