Geomorphology

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Lecture 9
Weathering & Soil Formation (Types of Weathering)

So friends, good morning and welcome to this lecture series of geomorphology. And in this class will talk about the weathering and its type and its products and its utility. So what exactly it means that in the last class, we were talking something about the weathering and erosion and finally, we concluded weathering is the simply breaking down of rocks. And erosion once we say that means here considerable distance of transportation is associated.

Until unless the rock is transported from its place of weathering then there is no question of shape change landscape development because once the material is broken down from this original position and it remains there that means there is no mass moment. So until unless there is mass movement there is no question of landscape evolution. Whatever the landscapes we now a days see in the earth crust, like the Himalayas, like the Alps, like the Plains, like this plateaus like this oceans all these are related to weathering and erosion.

And if you remember we we re talking something about this paleogeographic history, paleogeographical changes generally the paleogeographical changes that also involved in the mass movement. So, whenever there is a change in geography, change in geography there has to be mass movement. Otherwise there will be no question of changing Geography. But the medium maybe river, it may be snow, it may be something like wind, irrespective of their mode of transport, the material has to be transported.

Even if the gravity so that is why weathering alone cannot change the topography, erosion must has to be involved so that the topographic changes can take place. Today, we are going to discuss about the types of weathering. Weathering generally it is in broad sense, it can be divided into three parts.

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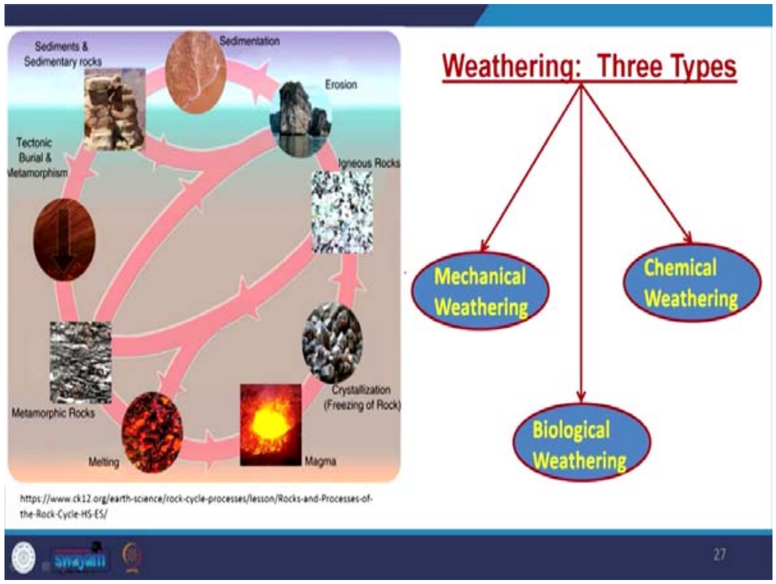

One is Mechanical weathering, second is Chemical weathering and third is Biological weathering. It does not mean once we say Mechanical weathering that means other two are not working at that particular geological environment. So that means I want to say, to reduce a rock to form the topography, to change the topographic perception there may be three types of weathering, they all together work.

And there are certain geological conditions, certain environmental conditions where one type of weathering dominates over others. So that does not mean other 2 types of weathering are not working and if you remember, we are talking something about Rock cycle. Rock cycle, three types of Rock form and finally due to weathering and erosion, one type of rock is converted to other types.

Mostly in weathering erosion, the sedimentary rocks are the product igneous, Metamorphic as well as the earlier Sedimentary rock, they get eroded, they get transported, they get deposited and finally these sedimentary rocks are formed. So mostly so we can say this sedimentary rock are the product of weathering and erosion. And soil formation, soil formation is prominently by weathering product until unless there will be no weathering there will be no soil formation, no food grain productions.

So Weathering has direct and indirect effect in our daily life. So lets elaborate what is this Mechanical weathering? What is this Chemical weathering? And what is Biological weathering,

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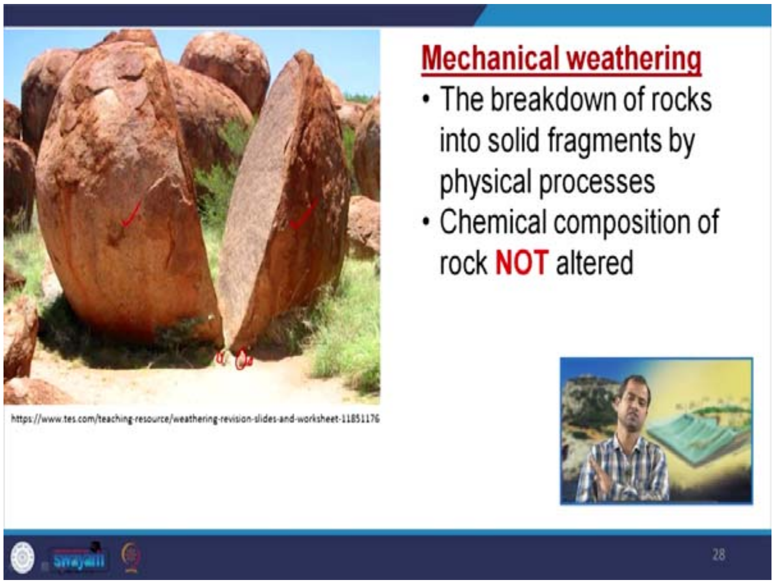

Mechanical weathering if you see here, is The breakdown of rocks into solid fragments by physical process. Chemical composition of the rock not altered. It has to be understood here. It is simply breaking down of rocks, physical. Either it is manmade physical that means man what suppose we hammer these rocks into fragments. Suppose For example, we take limestone for example the limestone if we hammer it from larger pieces, to smaller piece again smaller piece, again smaller piece again smaller piece.

So if you take the last piece of this rock, it will again it will be called limestone. That means here this chemical composition of this rock, it is not getting changed. So that is why physical weathering means simply breaking down of Rock from larger size particle to smaller size particle without changing its chemical composition. For example, mass movement from hill. Hill is a large body of rocks. From here one fragment one slice one slide one mountain fall, it comes down.

It is simply physically breaking down physically coming out. There is no chemical compositional changes occur within the rock. So that is called Physical weathering, or it is called mechanical weathering. In this figure if you see here, this is granite body. Within the granite body, it is converted into 2 parts. So that means here this party is also representing granite, this part is also representing granite. Similarly, if you see this smaller particle, smaller fragments again, even or, even small fragment, they are also representing the granites.

So that means here I want to say simply it is mechanically breaking down of earlier rocks into smaller and smaller fragments. This is called physical or mechanical weathering. Then, next comes the Chemical weathering.

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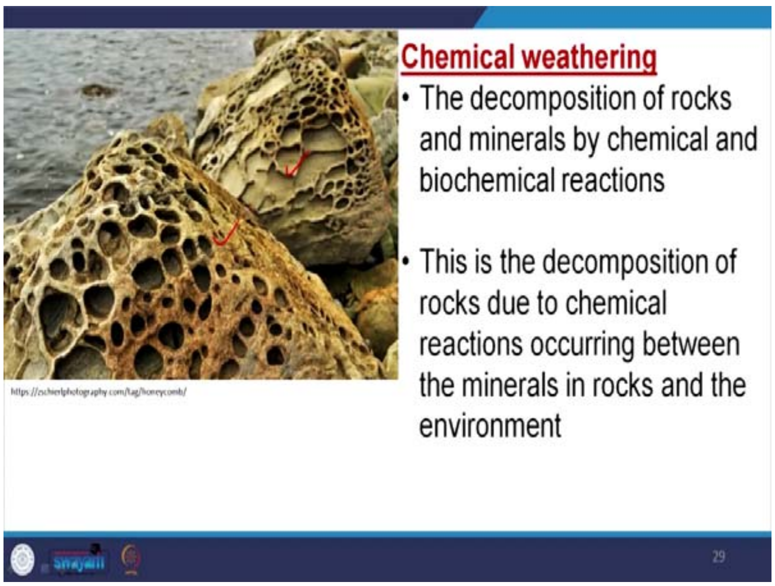

Chemical weathering means it is the chemical decomposition of minerals and rocks, chemically decomposition. Here the composition changes. Composition changes means for example suppose we take limestone. Again Limestone is calcium carbonate. Here Calcium will be separated and carbonate will be separated. That means here chemically, the rocks are getting separated. The chemical constituents are getting separated. This is called chemical weathering.

So, Chemical weathering and physical weathering the may work together they may work differently. Depending upon this atmospheric condition, depending upon this environment in which it is occurring, depending upon the process involved, the physical and chemical weathering are distinguished. For example, if you see this rocks, this. This fragment, this fragment, they are removed from this rock. So, this is chemical weathering. It is not fragments.

They are soluble material earlier existing within rock. Due to reaction with water, you see water is existing here or even the water vapour, it interacts with the rock. So due to interaction with the water due to interaction with the water vapour, chemically the rock is altered. Finally soluble products they come to solution and remain in the solution form within that water for certain geological time until unless a favorable condition arrives, when the EH pH condition when the oxidation conditions comes this Rock precipitate like our limestone precipitation.

Limestone precipitate from sea water during this EH pH conditions within the water. So, this calcium carbonate earlier it was a part of a rock it came to a solution and remain in water due to changes in EH pH condition, this calcium carbonate precipitate in Rock and finally limestone formed. Again once the limestone is formed within the sea water, it remains there. Due to removal of the sea, due to drying up of the sea or due to tectonic upliftment it comes to the surface again it reacts with the atmospheric condition, finally, this calcium carbonate again, go to the solution.

So This is chemical weathering process. So chemical weathering, it is the chemical change, chemical constituents change of this rock. This is called chemical weathering. Reaction occurring between minerals in rock and the environment, it is important mineral constituents of the rock and environment. Chemical weatherings will occur or not occur that will depend upon the chemical composition of this rock as well as the chemical behaviour of the existing environment.

For example, that we are discussing here limestone. They are very prone, very much prone for chemical weathering if during acid rain. Suppose during raining, we have carbon dioxide, it is mixed with water it reacts with the limestone terrain. That is why the limestone getting easily dissolved. That is why most of this limestone terrain, most of this limestone terrain go for dissolution due to chemical weathering. Ok.

So it is the mineral and environment and the reaction between the 2. So, finally the chemical weathering product that will again come in the solid form when the existing EH pH condition changes when the favourable environment again re-occurs. Then third type of weathering that is called biological weathering.

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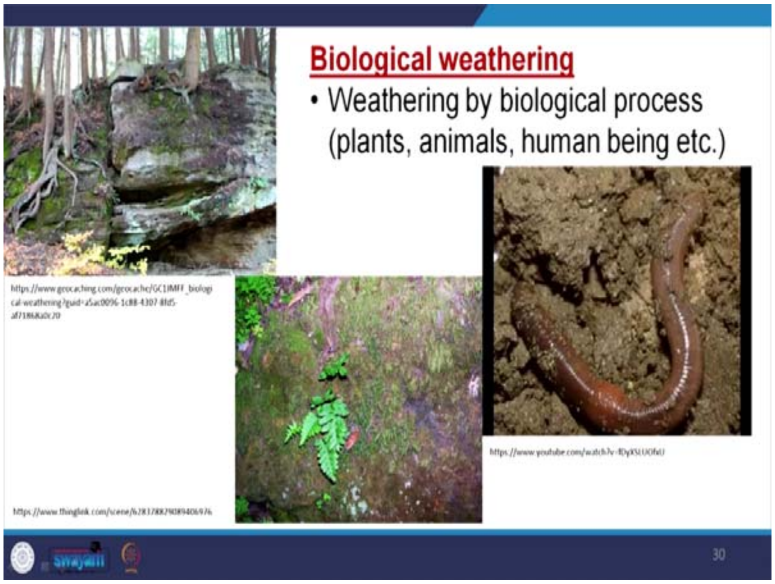

Here Biological elements, biological ingredients that are involved in rock fragmentation. Like plants, like animals, like human all this biological activity. If you see here this earth worm, it is very, very much responsible for biological weathering. So that means it remains within the soil profile and this create soil profile more porous and more permeable. Similarly, plants this type of rooted plants, if you see here due to plant growth the rock is getting fragmented they get fractured. That is biological weathering.

That means Biological agents are involved. So now question arises, if this biological materials or biological elements or agents they are involved in the rock fragmentation. So that does not mean the other type of weathering processes so that does not mean this rock is not reacting with this existing environment condition. That does not mean that the rock is not expanding during daytime and contracting during night time due to cooling and thermal expansion.

So, that means I want to say though biological agents are involved in rock fragmentation that does not mean other types of weathering agents, they remain calm and quiet. So, all those three types of weathering they may work together to fragment a rock. Ok. So that is why physical weathering, or mechanical weathering, chemical weathering and biological weathering both may work simultaneously, to fragment a rock to peneplain the earth surface.

but this dominance of one type of weathering over other that depends upon the Latitude, depending upon the altitude, depending upon this rock composition, depending upon the environmental condition so, all the factors they together work and finally define what type of weathering will dominant at what type of environmental condition. Similarly geological past, if you review the geological history of this earth, many times we have noticed climate change.

So these Climatic changes that defined what type of weathering will be dominant at that time. At present scenario also, for example, if we take the Indian context in the upper reaches in the Himalayan system, in the upper part where the glacial system is dominating, that part is dominated by Glacial weathering similarly, in Central Indian part or the peninsular part, river erosion. In the Coastal part we have marine erosion. And in the Coastal, near Coast we have interaction of water as well as rocks for there will be chemical weathering will be there.

Similarly in hilly terrains where there are rooted plants are there is biological weathering. So, in arid region, there is physical weathering like the Thar desert. It is physical or mechanical weathering. So, different type of geological environment it creates different type of weathering environment, so together physical, chemical, biological weathering working 24 into 7 to make this surface peneplain. Now, we will discuss what is the reason behind the physical or mechanical weathering?

There are different points, different Rock properties, different environment properties are responsible for this type of physical and mechanical weathering. One of the prominent reasons for this mechanical weathering is pressure release or Unloading. What does it mean? Pressure release or unloading?

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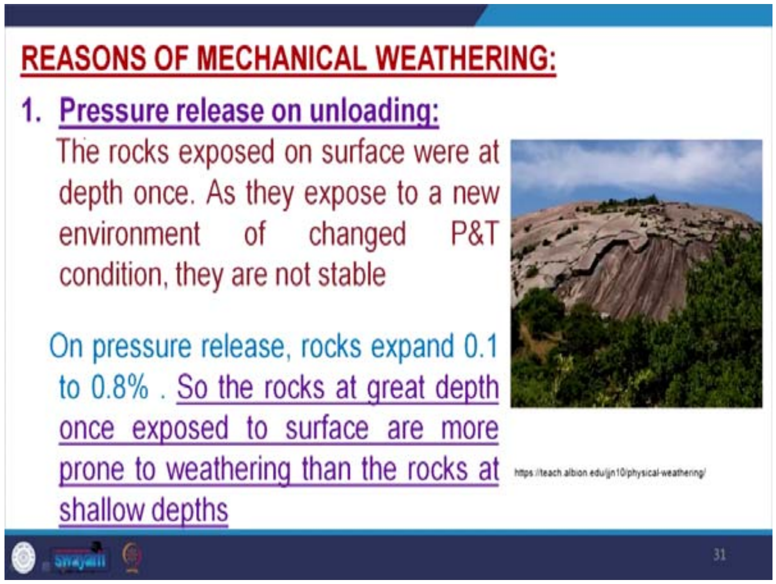

We see most of these rocks accept the sedimentary rocks. Most of these rocks like this igneous and metamorphic. They were formed much below the earth crust. So you take for example of Granite. Granite, it is a plutonic rock that means occur below subsurface. So, once this granite was formed in a geological environment which is high temperature and pressure environment. But contrast to Basalt, Basalt forms at the surface because it has a high temperature phenomena.

So now a question arises if a rock is forming at high pressure and temperature environment below the earth crust. So, once due to tectonic upliftment or due to removal of the overburden, this system comes to the surface. So that means it is not able to withstand the surficial pressure and temperature condition. That is why there is the weathering it tries to adjust. But weathering will be dominated. Why because the existing surficial temperature and pressure condition is not suitable for this rocks.

That is why if you see here, in this case, we have a granite body, a dome type of granite body and finally, we are getting some fragments are there. So this is physical weathering due to pressure unloading because we are unloading the system, we are removing the overboard, we are uplifting the system. This rocks which are earlier present at the subsurface once it is coming to the surface, in a low pressure condition this type of weathering occurs here.

On pressure release rock expands to 0.1 to 0.8%. So, the rock of great depth once exposed to surface, are more prone to weathering than the rocks at the shallow depth. Here a question arises, those rocks, which occur at greater depth like the granite, they are more prone to weathering as compared to basalt which is formed near to the surface. But exceptions are there. Basalt if you see has compositional differences?

But if you compare with this Rhyolite, Granite and Rhyolite, Granite occurs in great depth and Rhyolite occurs at the surface, compositionally, both are more or less same. So if you put granite and Rhyolite together, granite will weather fast as compared to Rhyolite because Rhyolite occurs at the surficial conditions. So its pressure and temperature is more or less same. But in Granite, it will weather fast.

Here, some of the, these figures that are illustrating how the pressure release, weathers the rock profiles. Now you see here unloading of the pressure.

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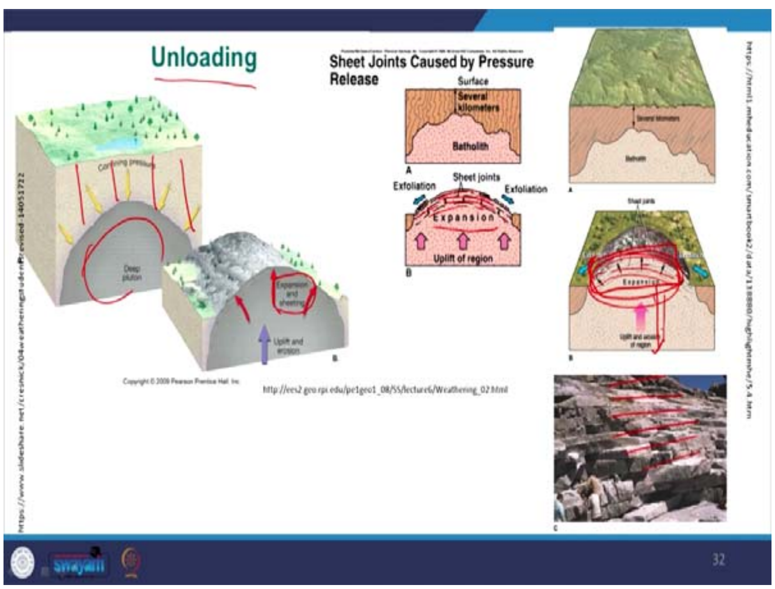

Earlier, this was the thickness of overburden when this deep Granite Pluton was formed here. Now with some reason we have removed the overburden. There is no overburden here. So this rock will expand this surface because once the rock was inside the overburden pressure was downward. Now, the overburden we removed finally rock will try to expand itself. Due to expansion, if you see here, due to expansion we have certain cracks, certain fractures which were generating parallel to the surface.

This is very important to note it here. These fractures, these weak planes of this rock that developed parallel to the surface, so once the Parallel to the surface the rocks occur you see These are parallel to the surface, these cracks are developed and finally once geological times goes on, this type of structures are dominated on this rock. These are called sheeting joints. Sheet joints sheet Sheet means planner surface sheeting joints.

And sheeting joints generally occurs near to the surface and parallel to the topography near to the surface and parallel to the topography. Now the question arises, if it is near to the surface, so do we find sheeting joints in the same rock body at the depth? The answer is no why? Because once are moving, for example here, once we are moving downward again this rock pressurizes at this rock which is lying below. So that is why it is in the same condition what it was in geological past.

That is why sheeting joints are very near surface phenomena about 200 metres from surface below or so. So, in the same rock if you are going down, we will not get any sheeting joints. Due to pressure release distinct set of joints develop on the rocks. That is called sheeting joints or exfoliation. Sheeting joints are parallel to the land surface and form concentric shell of layers up to a few feet thickness spacing in joint increases with depth that is very important to remember here spacing of joint is increase with depth.

That means I want to say in a same granitic body, near to the surface, if you see, this spacing of the joint will be very small that means thin sheet of rock fragments, thin sheet of granite that will form near to the surface. However, if you move down to depth, certain depth of this granitic body, gradually the thickness of the sheets increases. And finally if you are moving further downward you will not find those types of sheets.

They are rarely extend more than 200 feet of meters from the surface. And it is mostly seen 200 meters is the limit, arbitrary limit, it is not that after 200 meters you will not get anything. Above

200 meter will get everything. Everything we mean to say just sheeting joints. That is what I want to say. It is up to 200 meters from the surface, most of this sheeting joints are seen in the rocks. And sheetings are best seen in granite and massive quartzite.

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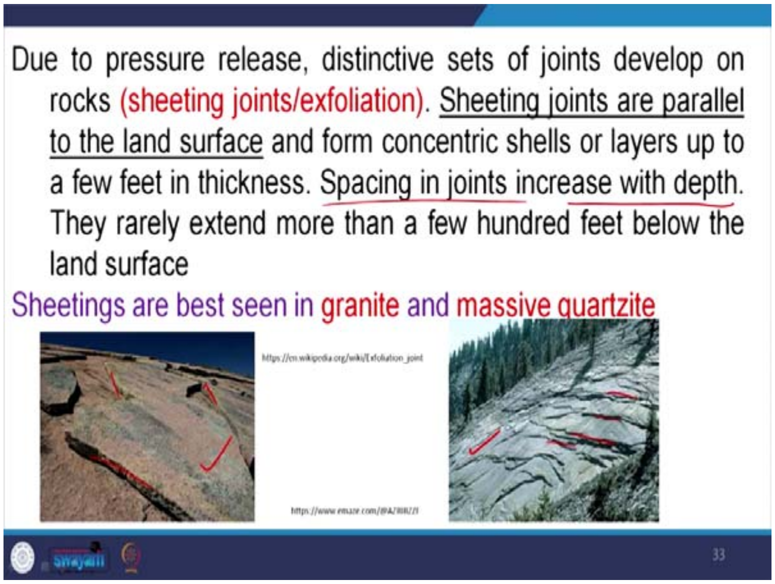

If you see these 2 figures here, here this is a Granite body and this is a massive quartzite body and here if you see these are sheeting joints. So, Granite and massive quartzite they both are prone to weather, mechanical weathering is dominant, they are prone to weather, sheet wise this is called sheeting joints. Why because Granite it is a plutonic rock which is formed at the depth at greater depth.

Similarly, massive quartzite quartzite it is derived from sandstone. It is a metamorphic product and metamorphism occurs at great depth which converts sandstone to quartzite. So once these 2 rocks, once they occur below the surface at greater temperature and pressure condition, once they are exposed to the surface, they have to adjust themselves with the existence surface and pressure temperature conditions.

That is why the removal of this overburden, once they come to the surface, the removal of the overburden occurs. That is why they try to expand, get to expand themselves and once they try to expand themselves this type of joints; these types of cracks develop from the surface. That is why, granites and massive quartzite, they are more prone to develop sheeting joints. In contrast to this rocks which are formed near to the surface or on the surface, they do not show development of sheeting joints.

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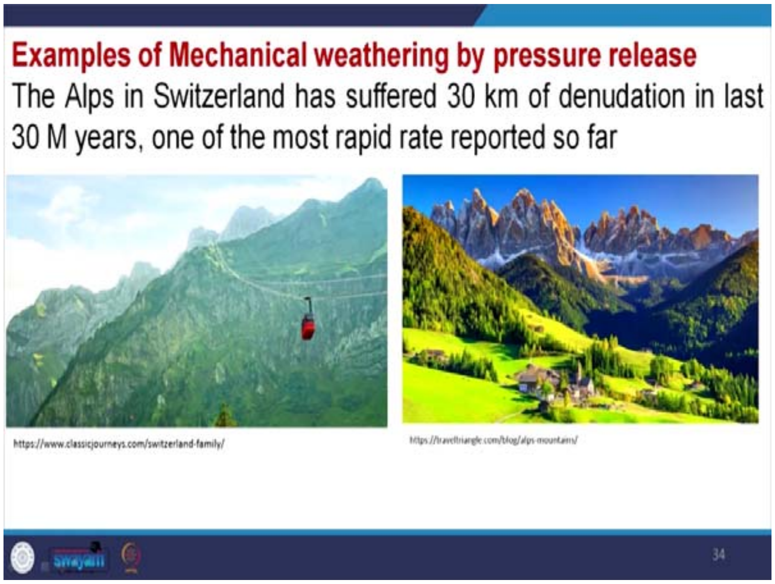

Very classical example of mechanical weathering by pressure release is the Alps in Switzerland If you see this data, Switzerland had suffered 30 kilometre denudation of Alps for last 30 million years, one of the most rapid rate of reported loss of Mountain found so far. So, that means the length of this Alps it has reduced 30 km in last 30 million years due to this pressure release or unloading pressure unloading.

Probably sheeting joints occur near to the land surface because geothermal gradient decreases to more less than the normal out of 200 metre and crossed the temperature of this rock becomes nearly constant. Geothermal gradient, you know, if you remember, the thermal gradient is the temperature increment per kilometre once we move from surface of the earth to subsurface. In general, 25 degree Celsius per kilometre is the geothermal gradient.

But this is not hold good in the plate boundaries. And plate boundaries exceptions are always there and you will find more than 25 degree per Celsius at the plate boundaries. So, now the geothermal gradient decreases much less in normal out of 200 meter. And the overburden pressure however, continues to decrease a rate proportional to the rate to which overlying rock is purely peeled out by erosion. So that means pressure, pressure release is more as compared to temperature changes. Pressure plays here a major role as compared to temperature.

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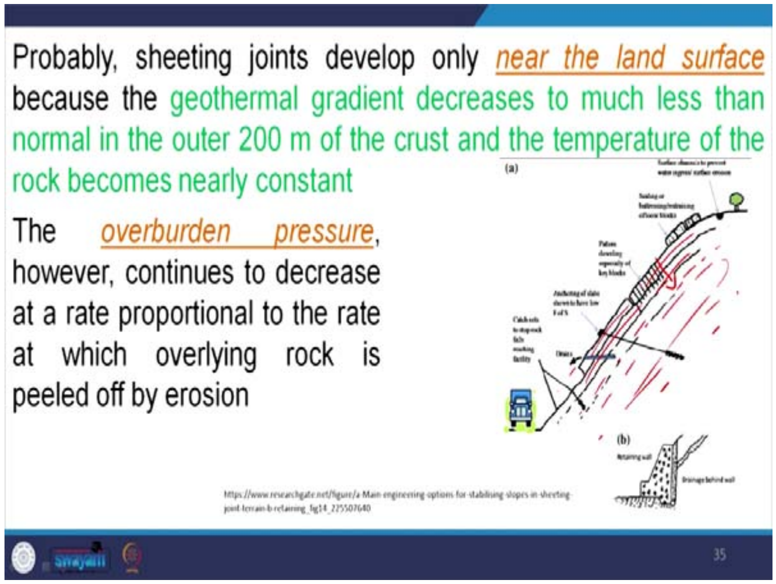

So, now if you see here, in this figure, here we have joints. And gradually if you see the joints become discontinuous become discontinuous. Finally there is no joint in this region, in this region there is no joint. That means once we are moving downward, the sheeting joints are gradually managing, but sheeting joints are very close to the surface they are more prominent. And most of this hilly terrains the steep sides, they are prone to slide due to sheeting joints.

When we will talk about the mass movement we will talk elaborately how this behaves as a medium or helps the rocks to slide down and formation of mass movement. And once the pressure is released the temperature more or less remains constant.

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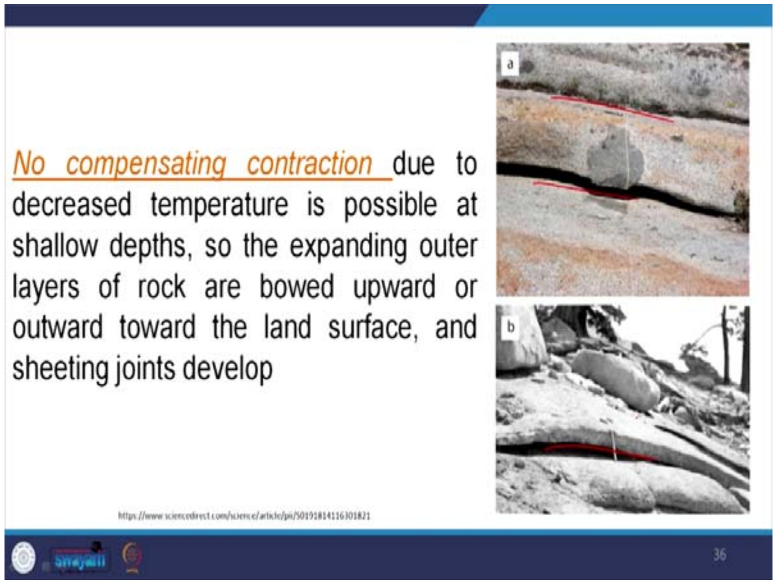

No compensating contraction occurs why due to decreased temperature. It is possible at shallow depth. So expansion is the dominant phenomena here. The rocks try to expand, it is depressurized and so temperature remains more or less constant. So due to depressurization, it tries to expand. That is why these Sheeting joints are developed. And once sheeting joints are developed, there should be sheet type of appearance there should be sheet type of erosion.

What the rocks are fragmented here? It is due to Physical weathering or other types of physical weathering. Once the sheet is formed then they are easy to fragment them. There is biological weathering there is physical or mechanical weathering, they are dominating on these sheets. So, finally, they are making into fragments. Suppose, a rock is irregularly fractured in the subsurface. Irregularly fractured means suppose there is a rock mass of this much size fragment and rock mass of this much size fragments, of different sizes.

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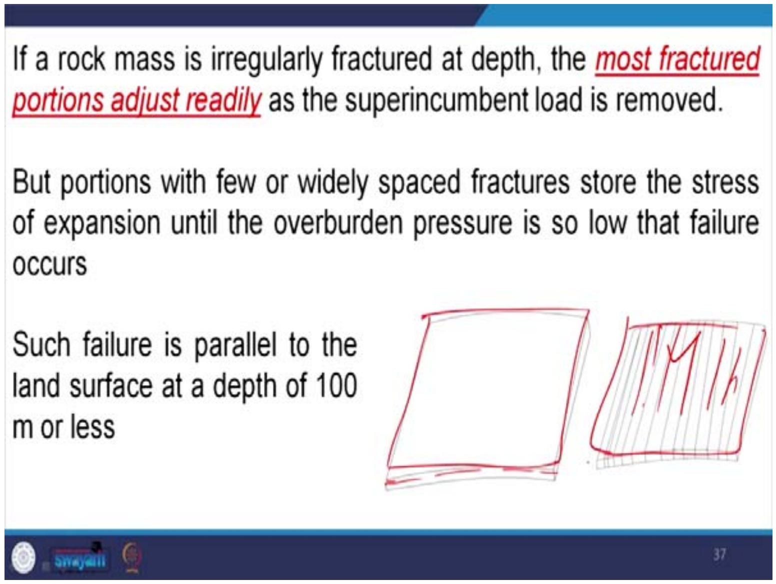

For example, here it is given once you see suppose once we are sheeting a rock, once its the surface area is this much another same sheet, same surface area but we are creating into different smaller fragments and we depressurize it. Once we depressurize it that means those small fragments they will re-adjust themselves, but the larger fragments it retains the strain within it. So, it will try to expand and once you try to expand this type of sheet will generate.

Because the smaller fragmented rock which is very small fragments they re-adjust themselves according to the release of pressure. However, the larger rock bodies, they are not able to adjust. That is why they want to release the strain, due to release of overburden and finally will try to expand upward. But portions with few wide or widely spaced fragment store this stress for extension until the overburden pressure is so low that failure occurs.

Such failure is parallel to the land surface at the depth of 100 metre or less very prominent example is given here, how the small fragments and large fragments on the subsurface they react with the overburden pressure release. so That is why those rocks which are very intact. Less fragment they are more prone to develop sheeting joints as compared to fractured rocks. So, this sheeting joints follow closely to local topography what does it mean?

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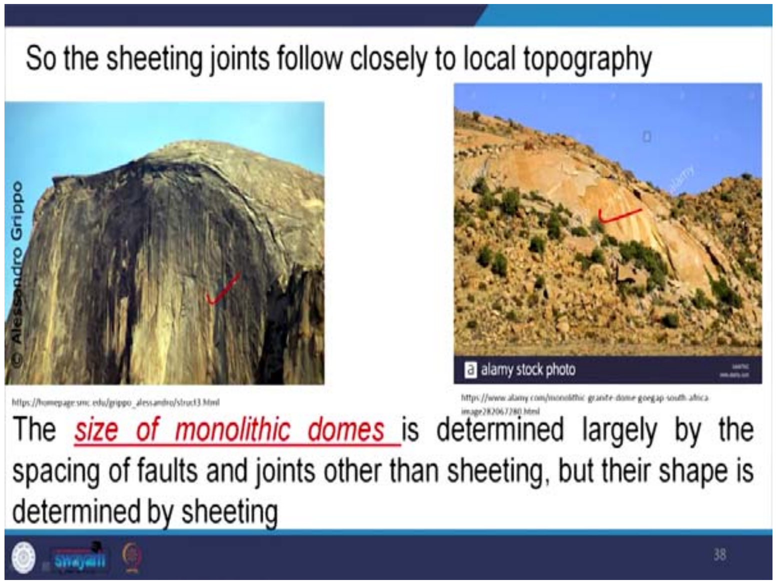

Close to local topography if you see these 2 figures, this is a granitic dome and this is also granitic dome. And here these are the sheeting joints local topography if you see this is a profile, if you to draw a profile, the profile will be like this and the sheeting joints if you see the sheeting joints the shape of the sheeting joints that will be same as the topography. Similarly here the profile will be like this here the sheeting joints they are also arranged like this.

So, it follows the topography the profile of the topography ok. So the size of the monolithic dome it determined largely by the spacing of faults joints and sheeting but the shape is determined by sheeting. So that is why the topography, the whole topography if you take this profile, once we release the overburden whatever the sheeting joints would develop those sheeting joints will follow this topographic profile.

So that is why I can say these sheeting joints developed due to pressure release. And this sheeting a joint they are very close to the surface and that follows the topographic boundary and those rocks which are formed at greater depth they are more prone to generate sheeting joints as compared to the rocks which are formed near to the surface and this is a prominent phenomena of mechanical or physical weathering. So Thank you we will meet in the class.