Geomorphology
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Lecture 10
Weathering and Soil Formation (Mechanical Weathering.,)

So friends welcome to this lecture series of Geomorphology and we will talk about this mechanical weathering in this class. So, if you remember the last class we are talking something about the prominent reasons for mechanical weathering. What does it mean and this mechanical weathering the sheeting joint or the pressure unloading was the prominent cause for this Sheeting joint and development and Hill slope evolution.

So in this class will elaborate what is this sheeting joints and how they are developed in the hilly terrains in hills and valleys how this sheeting joints look like and so on. So If you see here the mountainous terrains we have valleys and hills and we know the sheeting joints they occur near to the surface and parallel to the topography and expand upward. The rock surface expands upwards. Now you see here, there is an example of the Glaciated hilly terrains.

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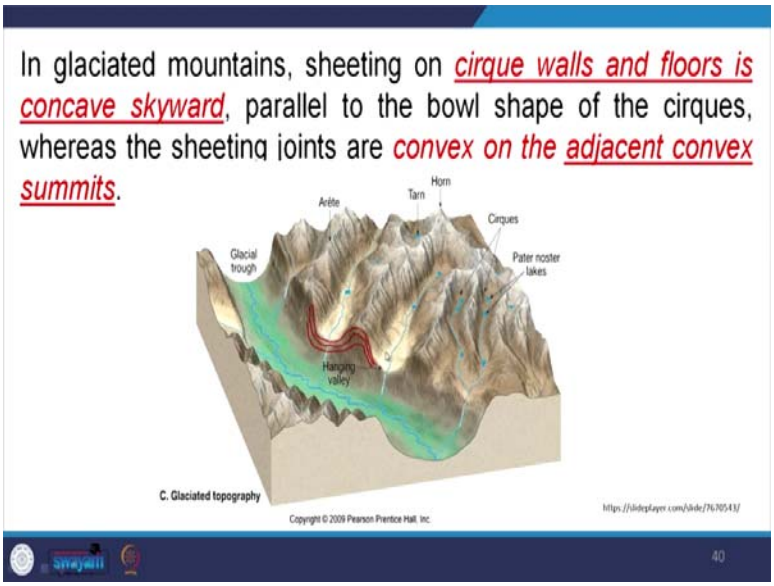

Here we have valley and here we have Hill. So in Hill and Valley what we are getting here the, at valleys these sheeting joints, they are concave upward. However, in the hills that is convex

upward. So the topography of this Hill terrain like this Hills and valleys Hills and Valleys similarly, the sheeting joints also follows topographic profile and occurs like convex upward and concave upward again convex upward. So that means I want to say this sheeting joints always follow the topographic profile locally.

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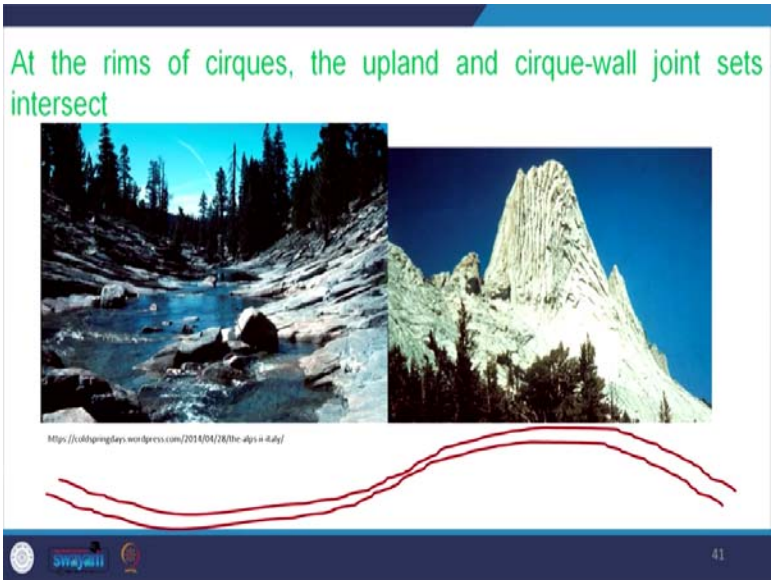

But if you consider yourself at this valley and the hill boundary, here these sheeting joints they mix with each other, they intersect with each other. So that is why now see one fracture is moving downward another fracture moving upward. So, at this valley and hill junction, they will intersect, once they intersect two fractures they are intersect so that means they will make the rock more fragile.

So at this Hill and Valley boundary, the rocks are more prone to mechanical weathering due to the intersections of these sheeting joints.

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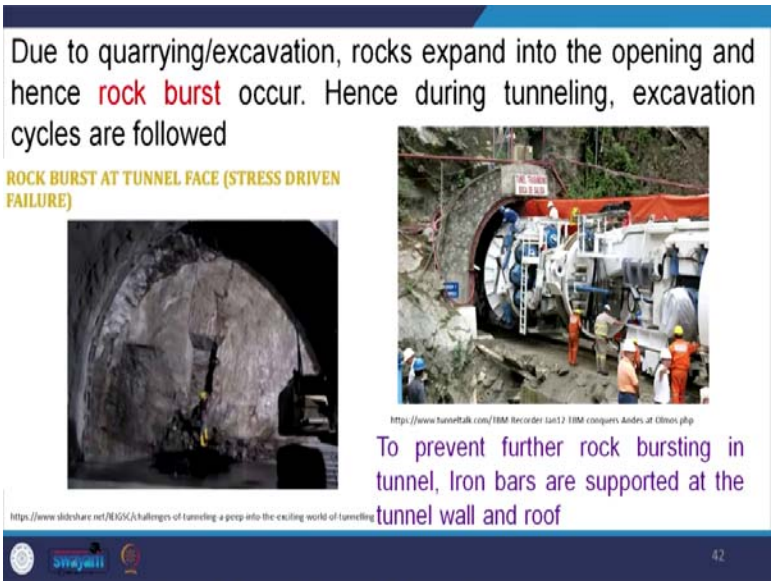

Now there is another example of pressure unloading is during Tunneling. If you see rock always wants to expand towards the free space, towards the free space because we know this sheeting at the case of sheeting joints the rock always expand upward. Because upward is the atmosphere at the free is the pressure unloading, the overburden is less, the removal of the overburden. So the rock will try to expand upward.

Similarly, suppose we are making a tunnel, here suppose we are making a tunnel that means we are creating an artificial free space within the rock body. So once we are creating an artificial free space the rocks of the surrounding they will try to expand downward. They will try to expand towards the free space. So that is why the rock due to rock expansion, whatever the diameter of the tunnel we decide in earlier times, or in during planning whatever this diameter of the tunnel, we decide due to expansion of these rocks to this free space is diameter gradually decreases.

So that is why during planning, during planning for this tunnel excavation, we have to take into consideration this factor also to prevent the rocks to expand towards the tunnel space. Sometimes we use this iron bars. Iron bars are intact with the system and finally it prevents further expansion. But in the initial time if we excavate some part of this tunnel and this as soon as we excavate we support by Iron bars, then it is also difficult to handle the situation.

So that is why during tunneling we do phasewise first phase of tunneling first phase of the rock excavation occurs we allow the rock to expand. So once we allow the rocks to expand some of this rock body that will expand within this system. So, again we start digging one again we start tunneling. So, by further removal of the rock then again, we allow to expand. So, during subsequent excavation and stopping of the excavation the rock will allow to expand within the tunneling system.

And further we remove the rock and finally we supported by Iron bars that is why during tunneling this work does not go on straight it will first it will expands will allow them to expand sometime then we remove this excess material. Then again will work for this tunneling like this phase wise we do this work.

So another type of rock expansion is called Anticlinal valley and synclinal hill. So what does it mean? Anticlinal valley and synclinal hill, Anticlinal valley and synclinal hill is due to formed in mature topography. Mature topographic means topographic, what is mature topography that means structurally it is already reached to the optimum time optimum size. So, that means what does it mean?

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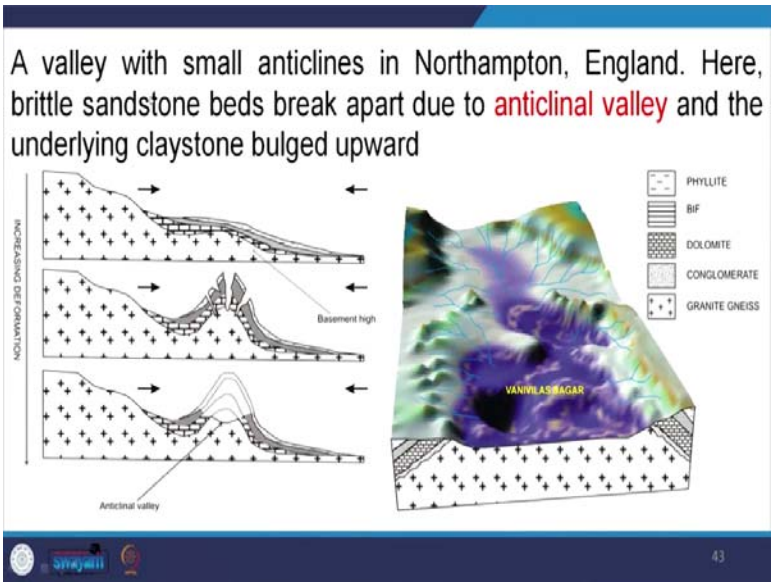

If you see here in a valley with small anticlines in Northampton small anticline in Northampton, England, here the brittle sandstone beds break apart due to Anticlinal valley and underlying the

clay stone bulged upward. So, now you see clay stone, clay once it is react with water, we add water in the clay it will expand. So, once it expands that means in tunneling if you go back remember this few minutes back, we are talking something about tunneling. During tunneling we have to encounter different types of rocks.

So all those rocks do not behave similarly to the expansion coefficients so that is why those areas which are during tunneling which is encountered by granite that will expand differently, if it is clay bed that will expand differently, if it is limestone that will expand differently. So, the degree of expansion that will depends upon the rock properties. Now here we see in a valley or in a anticline we have sandstone body which is on the top below is the claystone. We remove the sandstone part. Once we are removing sandstone part the clay will interact with the atmosphere and observe water vapour.

It will try to expand, once it is try to expand here at the anticline part once the removal of sandstone occurs the clay will expand in and bulging out. So this is another example of rock expansion. But Anticlinal valley and synclinal hill that is different issue will discuss here, what is Anticlinal valley anticline if you see, Anticlinal means two sides of a or two limbs they are dipping away from each other.

Syncline two limbs of a fold dipping towards each other. So, in Anticline the rock is under tremendous stress, you are extending this system we are expanding the system it is stretched the rock is stretched. But in syncline the rocks are compressed, the rock are compressed. So, once the system is extended stretching the cracks developed. Once the cracks are developed, through this cracks physical weathering, mechanical weathering occurs.

Removal of the material occurs for example if you see here in this figure given it is an example from the Chitradurga schist belt and it is; there is a presently at reservoir is existing that is called Vanivilas Sagar. Now you see here earlier the granite was there at the basement on the granite we have sandstone claystone like here whatever is given sandstone, conglomerate, dolomite, Banded iron formation phyllite which are the constituent rocks.

Now if you see here this granitic basement is capped by limestone sandstone claystone like this. Now this whole system is folded so due to the folding of the whole system a geographical positive area occurs here geographically negative area is here. Now, once the system is folded now you see due to this stretching some cracks are developed. Due to development of this cracks rocks gets physical or mechanical weathering.

And due to removal of the material from this anti forms. Now you see due to removal of this material from this antiform here gradually, gradually geographically negative area occurs. So, that means due to removal of material once upon a time which was a geological or geographically positive topography due to removal of this material this become geographical negative topography and once it becomes negative topography.

So here this example is the Vanivilas Sagar dam. Vanivilas Sagar reservoir now it is occupied by water body it is behaving as a reservoir that means reservoir means it is a geographical negative topography. But if you go to the geological past here if you see here, this is the block diagram showing earlier this was the topography was like this, the topography was like this, but due to this removal of this material now becomes negative topography and finally it is site for the Vani Vilas Sagar reservoir.

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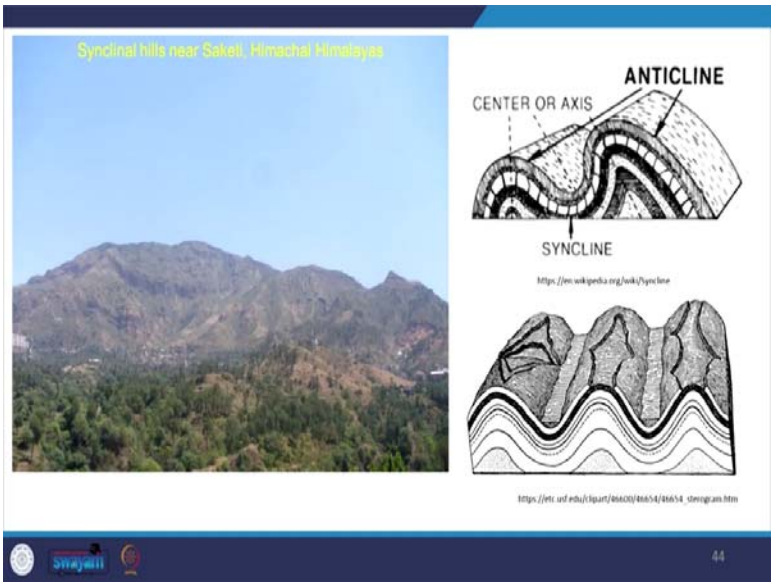

Similarly Anticlinal valley and synclinal hills are well seen in the Himalayan terrain also. It is in classical example of Himachal Pradesh near to Sakethi if you see here from the distance you can even see this is the synclinal part this is the synclinal part and this synclinal part it was earlier it was a valley synclinal part now see here this is synclinal part this is behaving as a valley. The Anticlinal part is behaving as a ridge but due to this removal of this material from the Anticline this becomes a valley and the adjacent adjacent ridge become valley.

And the valley become ridge this type of topography they are called matured topography that means for long geological time that has been suffering this geological agents are continuously working together and finally the topographic inversion occurs. This type of topographic inversions mostly they are found in the mature topographic area which is large for the large geological and longest geological time there exposed to the surface.

Another type of weathering by expansion or removal of the overburden due to expansion from the subsurface is a classical example of salt dome. Evaporite, evaporite salt generally they are the indicator of arid climates. Salt dome they occurs in the subsurface and due to their low density, low density they try to expand, due to addition of more and more salt the salt dome try to expand because density is low the material is being added.

So that has to occupy large space, so in order to occupy large space expansion occurs. Due to expansion it uplift the region. The overlying material getting uplifted so once they uplifted they are more prone to weathering because higher altitude there are more prone to weathering as compared to a lower altitude counterpart. So that is why due to formation of evaporite or salt due to expansion this overburden now you see earlier this bed it was with the continuation with this one.

Similarly this bed it is continuation with this one is it not. So, now once uplifting the system from the subsurface, so it becomes Anticlinal form;

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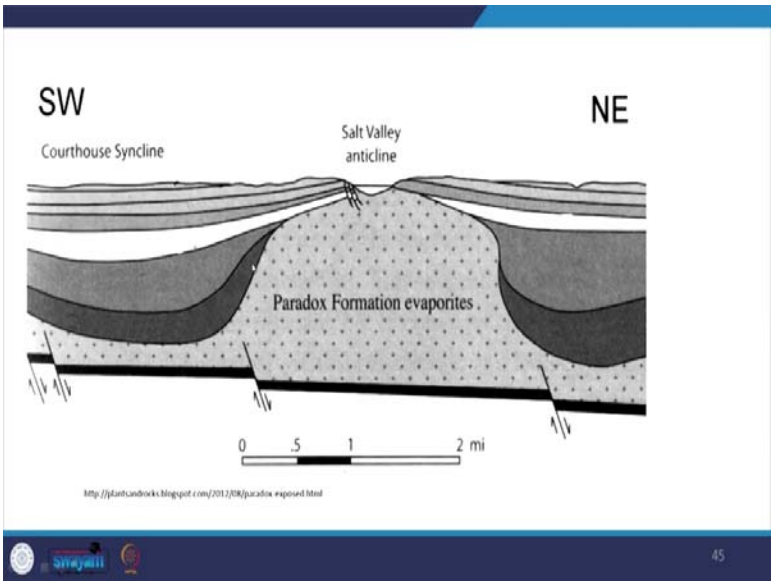

So, that is why it is cut-off this 2 beds now they are separated one bed they are separated from the other side counterpart. So, that is why, what happens this expansion occurs, due to expansion erosion occurs. Now you see salt valley antiline salt valley antiline due to expansion removal of the overburden occurs and due to removal overburden it becomes a valley. So, this is another kind of example of physical weathering by salt dome expansion.

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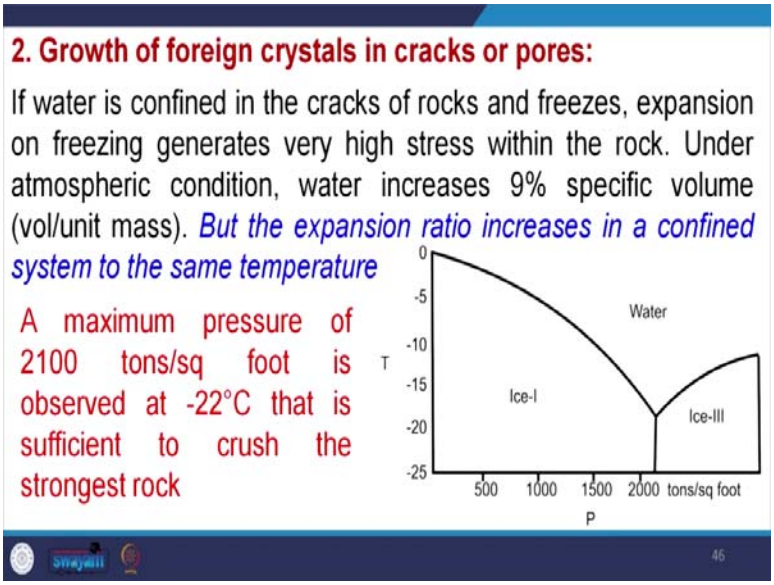

Now the second point is the growth of foreign crystal in the cracks of the rock. This is another prominent point of physical weathering. What is growth of foreign crystals? Foreign crystal means the crystal of these rocks which are formed outside that is foreign crystals. So, that means it is no relation to the rocks which is hosting it. Mostly in higher latitudes and higher altitudes

water plays a major role in forms of ice for expansion and cracking down of rocks that is very important to understand here in high latitudes and high altitudes.

Suppose we have cracks in the rocks and we fill it with water so during the winter or even if it the; it is in higher latitudes every time the water is converted to ice. So, once water is converted to ice its volume increases, so here if you see water increases 9% specific volume but the expansion ratio increases in a confined system to the same temperature. Once we convert water to ice its volume increases 9%. But the same case if water is confined within a system confined within the pore spaces confined within the cracks the ratio increases more.

So, that is why it will put pressure on both side of this crack wall or it will put pressure on the pores spaces and maximum pressure of 2100 tonnes per square feet is observed at -22 degree Celsius that is sufficient to crush the strongest Rock very important here to understand. Even if the strongest rock basalt, granite we create cracks, the crack is filled with water and allowed to freeze. So, whatever the ice will be created that will expand this cracks, and its pressure will be 2100 tonnes per square feet and that -22 degree Celsius that much pressure is sufficient to crush the granite the basalt even more strong most strongest rock.

So, that means the cracks are filled with ice or filled with water converted to ice that means ice is the foreign crystal for the rock. These are very much responsible for this expansion of this rock and a prominent reason for the physical or mechanical weathering. This is otherwise called frost wedging because it is wedge it is a wedge of frost. The wedge is filled with ice.

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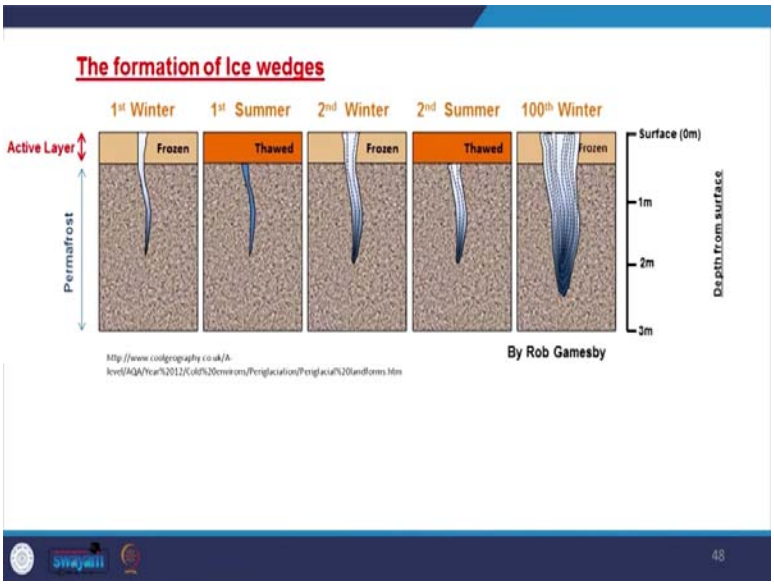

Here how this frigid ice growth occurs and how this volume of this ice occurs and how the thickness of this cracks increases with time is given in the figure. Now you see the formation of ice wedges. There are different stages is given the first winter this is the cracks filled with ice and this the first summer the ice getting melt, it is melting and finally this is filled of water. Now in the second winter again, there will be filled of ice. So there is a boundary between the first and the second ice. Similarly in the second summer part of the ice is converted to water and part remains as ice.

And 100s of winter that means 100s of years if it remains there, so finally the volume of ice getting increased year per year and that is why it is volume gradually increases. Finally the cracks are; earlier when these cracks are formed. This size was this much and after hundred years this cracks width is much not only this much if you see here earlier crack, this extension is up to here but now if you see due to volume increment.

Now, this crack is moving downward also so lateral and downward increase of this cracks finally makes the rock fragmented into different small, small particles. So this is another example of growth of foreign crystals in the physical weathering.

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If it is permafrost now, you see if you go to this news and research papers due to climate change the permafrost regions are mostly affected like the Alaska in USA and the Siberian where the permafrost regions. So in the permafrost region what happens the lower part in the soil profile that is total frigid So, you know soil profile there are pore spaces the pores spaces we have water there in frigid condition and frigid condition that means there is expanded volume.

Ice, once it is there it is in the expansion form, now due to climate change once the temperature increases 1 degree 2 degree or so this permafrost region this ice sheet which in the pore spaces they are melting. Once this pore space was occupied by ice, it is filled with ice under expansion condition. So now if it is melting that means it is squeezing that 9% specific volume that is squeezing. Once squeezing that means the pore spaces is increasing.

The volume is pore space is more that is why the surface it is subsiding down. this is the most, most severely facing problem in the permafrost region nowadays. So, now you see in this figure this or this development of these cracks in the permafrost region due to melting of ice. So, in Alaska in Siberia these are the most severe facing problem nowadays. So, this is an example of ice sheet melting and growth of ice sheet in physical or mechanical weathering.

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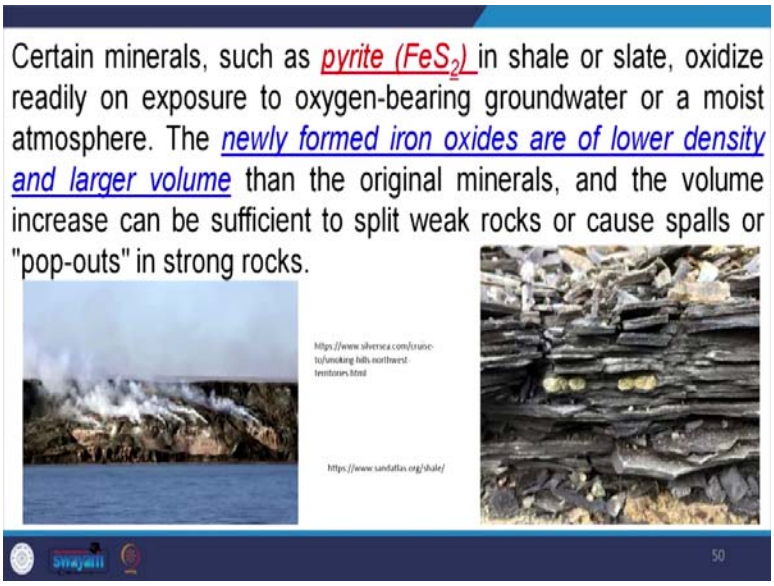

So, another example of foreign Crystal growth in physical weathering is the pyrite occurrence of pyrite. Pyrite we know iron sulphide (FeS_2), here you can see a pyrite generally found in shale, limestone if iron and sulphur are there. Now pyrite occurs in reducing environment because oxygen is not there that is why sulphide FeS2 it is occurring in anoxic environment. Now suppose this shale surface is exposed to the atmospheric condition up to the water.

So, here the iron is easily reacts with the water the oxygen, so removing the sulphur. So, once the reaction occurs it is in exothermic reaction. So, here newly formed iron oxide so that will form iron oxide rather than iron sulphide, sulphur will remove. So, this newly formed iron oxides are lower density and larger volume, so that means volume expansion occurs. Once the volume expansion occurs that means it will create some cracks

It will stress the rock outward so that means cracks expansion cracks will be developed. Suppose here a pyrite crystal is growing and here a pyrite Crystal is growing so here it is fracturing rocks here this also fracturing the rock, so 2 fractures here it is growing this way and here this is growing this way so this mixed together. And 2 facture mix means one fragmented the rock comes out. So, this is one type of mechanical or physical weathering.

Here what happens this pyrite oxidation if you not believe it will create this type of smokes. So that is why in many areas in the Earth due to this pyrite oxidation. The Hills are called smoking

Hills this type of vapours or this type of smokes they occur. So, these are named as smoking Hill, so smoking hills. That means there will be pyrite oxidation and this due to pyrite oxidation the volume expands due to expansion of this volume, it creates cracks and cracks migrate from one place to another and intermix with another cracks interact with another cracks finally rocks into rocks are getting fragmented.

Now another reason of physical and mechanical weathering is called salt crystallization. We know in water, there are many salts that are in soluble form. So, due to drying of water due to this EH-pH changes the salt has to crystallized. Suppose rock body which is saturated with water and this water containing salt and the salts removal from this rock body itself or the salt it is removed from somewhere else transported to the soluble transported to the water and remains in the pore space.

Suppose due to the change of EH-pH condition salt crystallization take place within that water body within the pore spaces. So, once this salt crystallization occurs it will expand the system.

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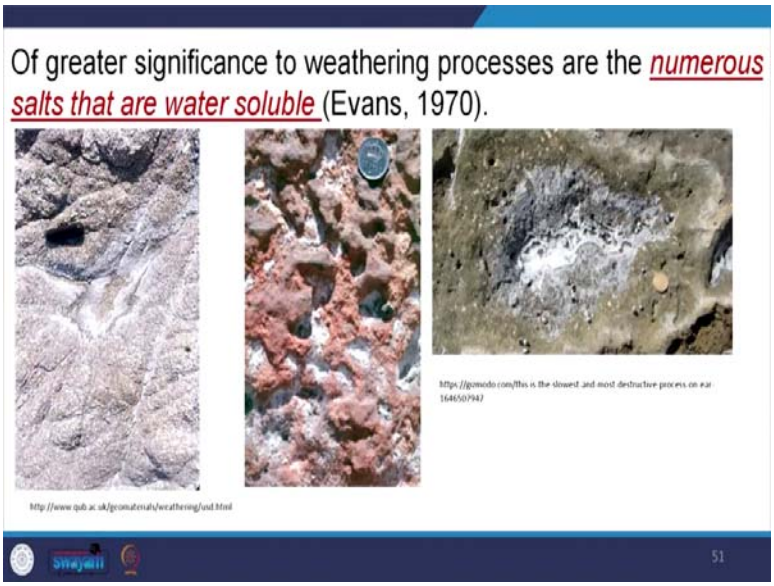

So, once this expands the system again crack are developed there.

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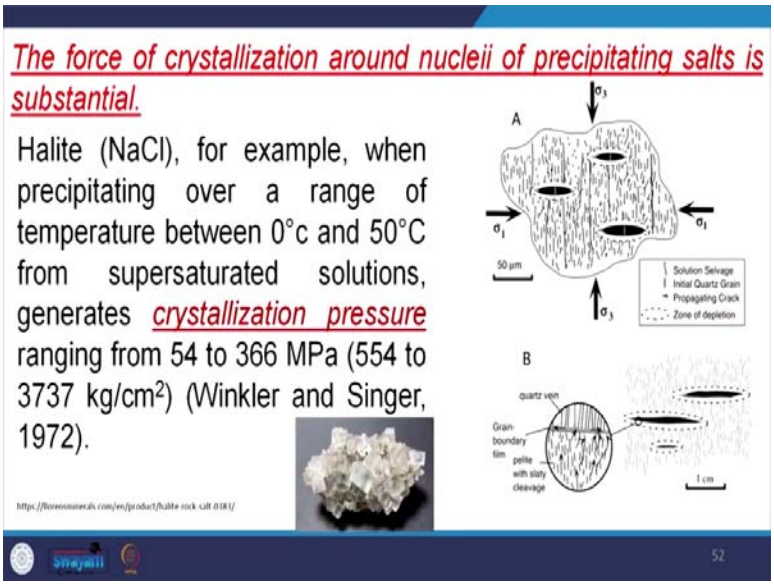

Here the force of crystallization around the nucleus of precipitation salt is substantial very, very important to understand here. The force of crystallization once the salt crystal salt crystallization takes place within pore space. This force of crystallization it is very much as compared to the strength of the rock is concerned for example 1 example is given here halite. Halite crystal; when precipitating over a range of temperature between 0 to 50 degree Celsius from supersaturated solution generate crystallization pressure ranging from 54 to 366 megapascal which is sufficient to crush a rock.

So that means salt crystallization within the pores space of the rock. It is also playing significant role in expanding or in cracking the rock which it is been hosted. Such pressures exceed the strength and almost all rocks and cracks are developed. Super saturation is the necessary condition for the growth of salt crystal but it is easily achieved either by cooling or saturated solution or by evaporation.

Suppose we have this playas in the deserts so here this super saturation of water occurs. Similarly water is isolated in basin or in a small basin small hole type small hole small ditches so due to evaporation salt precipitation occurs even in the walls once the bricks are saturated during rainy time and during summer this water is evaporated finally the salt are precipitate on the brick wall. So those salt that precipitated salt that means this force of crystallization.

The force of nucleation it is very much fast and very high so that it can crack micro level of cracks in the walls in the houses or even the rock surface. So once the micro cracks are developed so that means it creates a passage for the other agent. The passage to the air, passage to the water in the rock body so that means further this rock getting fragmented due to this type of agents. This is another example of mechanical weathering.

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Dendritic crystals you might have seen in some walls some rock fragments their dendrites here with example of dendrite is there. Dendritic crystals are even crushed maybe forming cracks along rock joints and buildings on which grain boundaries which permeability permeable of otherwise coherent rocks. Here due to this salt growth due to Salt crystal growth. Due to dendritic growth of salts the cracks getting expanded.

Once it is getting expanded so that means it is promoting physical weathering. So, this hydration pressure; hydration and dehydration, hydration means addition of water absorbance of water, water is absorbed by rocks mostly the clays they absorb water and expand themselves. So this is hydration. Dehydration that means they release water and getting contracted. So, generally the clays the muds due to hydration and dehydration repeatedly create cracks.

And those cracks once the hydration and dehydration cracks are developed that means it creates Passage to percolate water to percolate air passage of air to the rock body. So, once air water

passes through so that means physical biological and chemical weathering both from they are promoted. So that is why dehydration and hydration reaction they are also responsible for physical and mechanical weathering. Here it is a example given the hydration pressure of common salt range from 10 megapascal to more than 200 megapascal.

Common salt which by absorbing and by releasing water and this hydration and dehydration pressure it is vary from 10 megapascal to 200 megapascal. Which is much, much more than breaking of rock or as per the rock strength is concerned. Compared to the rock strength this much pressure is much larger to break this rock into fragments. Then tafoni it is a special kind of weathering mostly found near to this is shore and it is the reaction between this water vapour, the salt, saturated water vapours as well as salts in the rocks.

So water vapours and salts in the rock they react together and finally this type of honeycomb structure there are formed. Common feature of deserts and semi-arid regions especially near to coast or whether salt can precipitate from the dew or fog. Once salt precipitate here on the rock surface we know crystallization pressure is high. So, once salt precipitate on the rock body so it creates micro cracks and those micro cracks are responsible for weathering.

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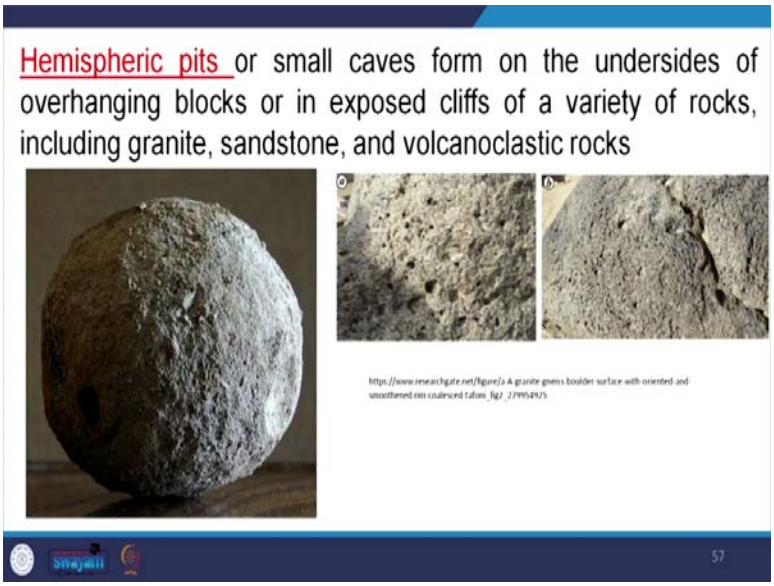

Then hemispherical pits are also found if we have granitic body, we have sandstone body on the base of this sandstone body hemispherical pits are generally found. Small caves from the

underside of the overriding blocks in exposed cliff variety of rocks, including granite sandstone and volcanic rocks. Here you will get the hemispherical pits below that, at that hemispherical pit are nothing but salt precipitation and this salt precipitation once that occurs, again same thing the micro cracks are there developed.

So those micro cracks either it is salt precipitation or it is by foreign crystal growth or by pyrite oxidation or by any means once the cracks are developed this creates a passage way for the other agent like air like water to move inside the rocks and once this system moves down. This cracks are again expanded with time and finally one cracks interact with other cracks and the rock body fragmented in two different fragments.

So, this is the process of physical weathering and in the next class we will discuss more about physical and chemical and biological weathering for this today's class this much is here. Thank you very much will meet in the next class.