Geomorphology

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Lecture 8
Weathering & soil Formation Introduction-II

Ok friends welcome to again to weathering class and here we will discuss about how weathering is different from alteration because you know weathering either it is physically or chemically or it is biologically the alter the rocks. So, that means the product is alteration or the altered product. Similarly we have other mechanism also which alters the rock. For example if you see this is one the foremost agent is the hydrothermal alteration.

And we know the hydrothermal alteration it is hydrothermal fluid is involved. So hydro thermal fluid we know that the source is different from either it is from meteoric water, which is transporting through this fractures to the subsurface and getting heated up due to heating its convert to hydro thermal fluid and the hydro thermal fluid interacts with the rocks through the pore spaces through the fractured rocks and alters the rock.

Second thing is that magmatic water that means if there is a magmatic intrusion after the last phase hydrothermal water or hydrothermal solution, it comes out. So, these hydrothermal solutions interacts with the rock and finally make the rock alter, now the question arises if weathering alter the rock and hydrothermal system of hydrothermal activity is alters the rock how will you distinguish whether the alteration is due to hydro thermal activity or it is due to this water activity or weathering activity.

To differentiate between the two the best thing to study the degree of alteration from top to bottom the degree of alteration decreases due to in depth due to weathering because mostly the weathering is a surface phenomenon or near surface phenomena. If it is a subsurface phenomena so that will restrict with in few zone that means it will restrict within the fractures within the fractured rocks. But the alteration which is caused by hydrothermal fluid that increases with depth because hydro thermal fluid it will be reactive whenever it contains the heat.

And heat source is below either meteoric water going down. So that means below after reaching certain kilometer due to geothermal gradient or due to heat source from heat source is getting heated up and finally it its activity is restricted at the depth. Once it is coming to the surface. It cools down finally it behaves as normal water the alteration which is caused by weathering its gradually decreases with the depth that means degree of alteration is gradually decreases with depth.

However, the degree of alteration due to hydro thermal fluid it increases with depth. This is the difference between the alteration caused by weathering and caused by hydrothermal fluid.

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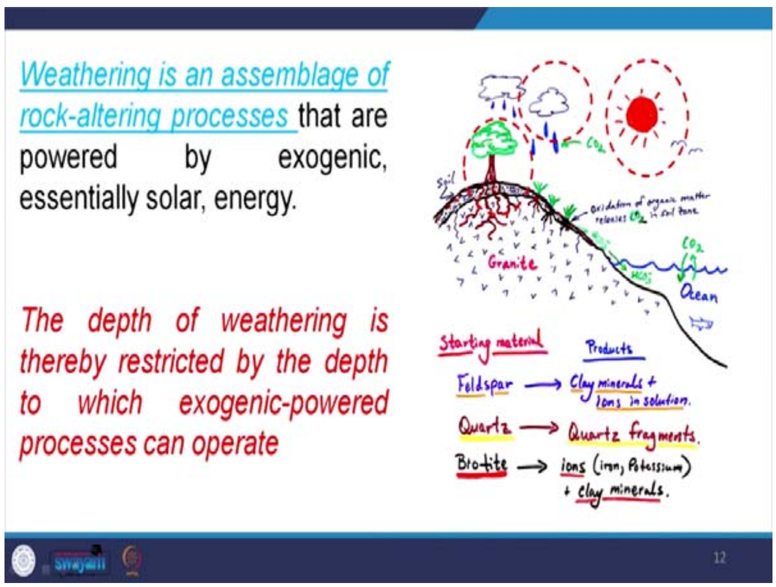

Weathering is the assimilation of rock altering processes that are power by exogenic essentially the solar energy. Now see here this solar energy mostly responsible for cloud formation for vegetation for raining those weathering at the surface or near surface. It is due to these activities so that means weathering is assemblage of rock altering process they are powered by exogenic mostly the solar energy essentially.

And the depth of weathering is there were restricted by the depth to which exogenic processes work. So that means if we are creating a fracture here and this water will circulate through the fracture and will come out this part will weather all other part remain as it is. So the depth of weathering is there by restricted by the depth to which exogenic processes can work. Because exogenic process the water coming out from the surface that will be to restricted in the fractured zone. Here it will be restricted within the fractured zone but in between the rocks remain unaltered.

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Rock weathering it must be studied in the light of a set of mineralogical and geochemical process it is very important to understand because in the last class we are talking something the scale of weathering it starts from very small particles and ends with huge erosion process of a mountain scale. Here if you see the rock weathering and mineral constituent of rock, it is very much that means very much related.

For example suppose we have a rock for example it is Basalt, Basalt its essential mineral is plagioclase and pyroxene and basalt is extrusive igneous rock, which forms at the surface but if you consider its temperature of formation, the olivine the pyroxene it forms about 1100 to 1200 to 1300 degree Celsius the plagioclase also form simultaneously. So that means those minerals which are formed at 1300 degree 1200 degree Celsius when those minerals are kept in the surface temperature and pressure condition that becomes unstable.

So as a result they try to change themselves to a durable product which is stable at this present geological temperature and pressure conditions. So that is why mineralogical assemblage of a rock it place very essential role very prominent role to define the rock stability. For a example here a rock example is granite is composed of feldspar it is composed of quartz composed of biotite and some other minerals for example. Now you see quartz is the most stable mineral in the earth crust and the most stable mineral.

So that means weather a quartz it will take millions of years and compare to that feldspar relatively weather fast, biotite again relatively faster. So if you have a Granite block and we allow it to weathering chemically or physically or biologically. So, first the most unstable mineral like this biotite that weather first followed by felspar followed by quartz. So that means I want to say it is the mineralogical assemblers which is responsible for degree of weathering of rock.

In other hand if you take Quartzite, it is totally 99% quartz so it will be more stable so comparing this granite and quartzite together the granite will weather fast as compare to quartzite. And it in the physical and chemical response to near-surface environment because near-surface environment it is a less temperature and pressure environment but this rocks that are formed in a high pressure and temperature environment.

That is why this near surface environment to exist to survive in your near surface environment the mineralogy has to be changed accordingly.

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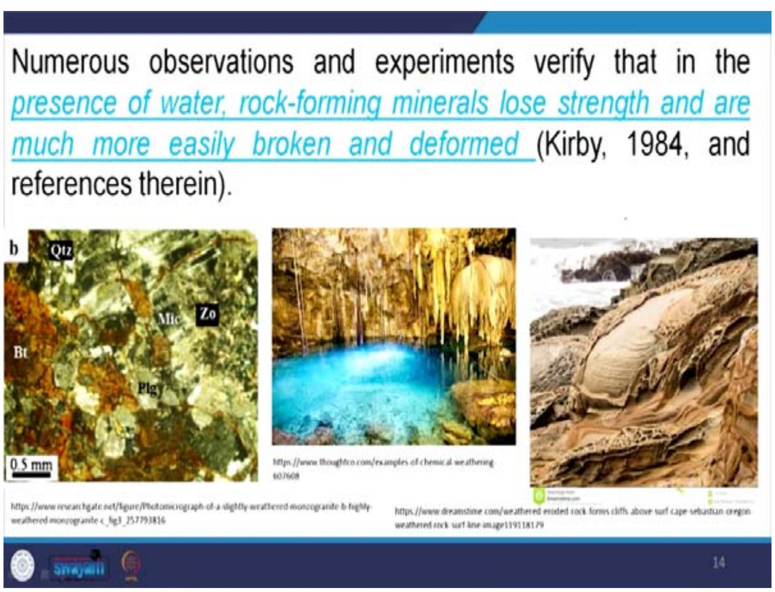

Numerous observation and experiment verify that in the presence of water Rock forming minerals lose their strength. That is very important see water is the main culprit for weathering of rock forming minerals because if we keep the rock forming minerals in water contact with water, there are certain minerals very much reactive. Either there is hydration occurs or hydrolysis occurs. They react fast and converted to another mineral.

So that is why water plays major role in weathering of rocks, for example. If you see here in this photograph this is ocean water. And this is rock. And if you see there are the circular patches. This is due to weathering. Due to weathering of this volatile material, weathering due to this water vapour reacting with the water vapour, similarly these are the stalactites in the limestone terrain they are the stalactites hanging from the wall.

Had water not been there this limestone would not have been eroded like this. So, that means water plays a major role in weathering approx. Similarly in this photomicrograph if you see there are certain minerals which are hydrous minerals. Because those minerals react with water and convert to Hydrous phase. So that means though mineralogy plays a major role. Similarly external agent either it is external water or the internal water that means the water which is in the crystal formal lattice, crystal lattice.

If water is there that means the rock is very much susceptible to weathering. The rock weather first which contains water in their crystal lattice or which weather water in fractures or in the pore spaces that means I want to say water plays a major role. It behaves as the accelerator to whether the rock surface.

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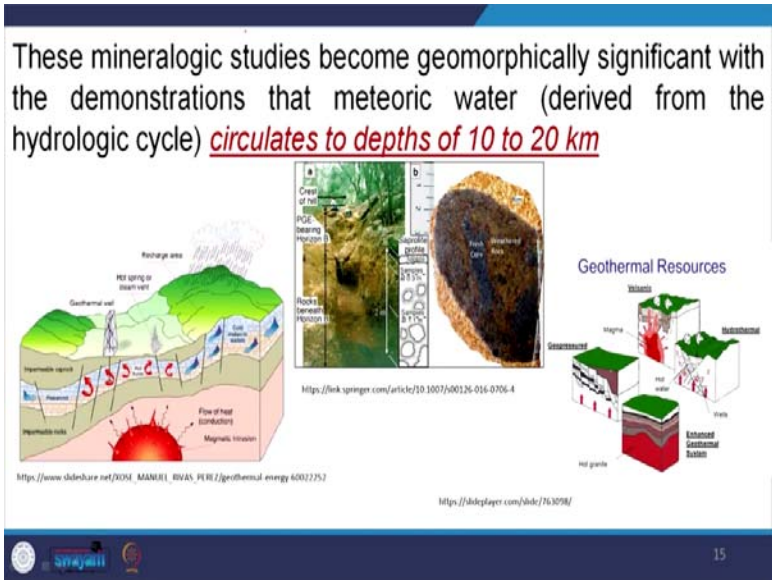

These mineralogical studies becomes geomorphologically significant and with the demonstration that meteoric water circulates a depth of 10 to 20 kilometre, this is very important the meteoric water it can penetrate up to 10 to 20 kilometre from the surface because you see we always talk about when weathering and erosion we talk it is a near surface phenomena, but 10 - 20 kilometre that means the whole crust the whole crustal system. So, that means we have the fractures so depth so, deep factures that it can circulate our water from the surface water to 10 to 20 kilometres depth.

So, that means before rock exposes to the surface, it getting reacted with this water and finally a weathered product is design. Second thing is that the nature of water also depends upon how intensely it will whether the rock. For example suppose there will be cold water in a frigid region where is cold water where penetrating where circulating cold water it will affect very less but once it is going down 10 to 20 kilometre.

If you are moving 1 kilometre the temperature increasing 25 degree Celsius that is geothermal gradient. So if you are moving 20 kilometre imagine how much temperature increase there so in that environment if you are putting water so that means water will be in volatile stage it will behave as a hydrothermal fluid and hydrothermal fluid it will alter the rocks so that means I want to say before the rock reaches to the surface due to tectonic upliftment or due to removal of this material many or this considerable part of the rock get eroded if it is a fractured rock and if the fractured deep penetrating.

So that is why mountainous regions in tectonically active mountainous region where deep seated fractures are there the rocks are more prone to weathering as compared to the stable part of the continent.

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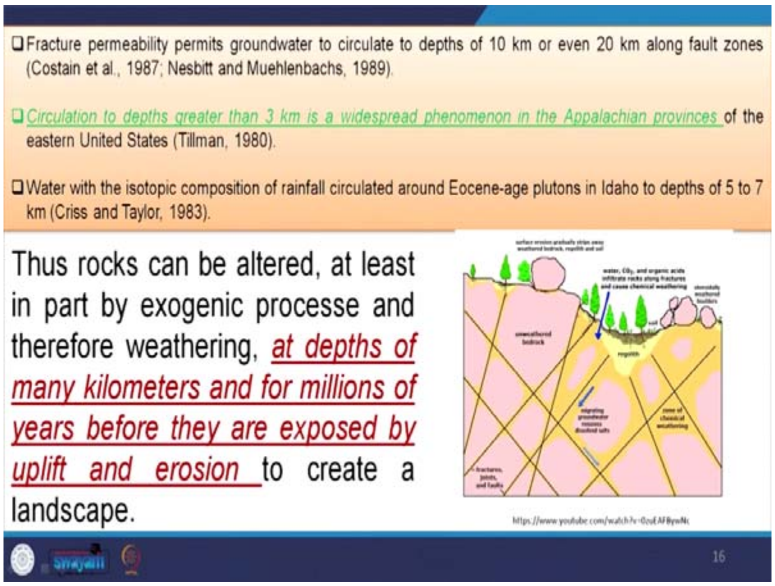

There are some examples written here. Fracture permeability permits groundwater to circulate depth up to 10 to 20 kilometre along the fault zones. Fault zone, we know faults are very deep seated, faults if is there fractured permeability increases the water circulation capacity. So that means the rock is fracture and it becomes permeable it allow water to freely pass through that. And once water going down it becomes it behaves as a hydro thermal fluid and those hydrothermal fluid that alters the surrounding rocks.

Circulation depth greater than 3 kilometre is widespread phenomena in Appalachian provinces we have observations, scientific observations are there. The water with isotopic composition of rain water circulates around Eocene age plutons of depth of 5 to 7 kilometre depth. So, that means these are the observed places where deep seated fractures are existing and through this deep seated fractures water is playing major role in chemical or physical weathering in their respective places.

So, rocks can be alter at least in part by exogenic process and therefore weathering in depth of many kilometers and Millions of years before they are exposed uplift by erosion.

So, that means I say if we need a tectonic force to uplift the rock near to the surface and getting it eroded. Similarly If you remove the overburden to make this rock come to the surface and getting eroded it is partly truth. So, that means I want to say these rocks which are below the surface also there are certain zones which are deep seated fractures that are existing these rocks get eroded very fast before they come to the surface.

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Basic structure of the rock mass including bedding and other primary layer structures granularity and intrusive dikes and veins they are not obliterated until unless this weathering is intense so that means if the weathering in the initial stage it starts with small grains it start with a patch. So, in the initial stage weathering does not affect the primary structure, primary structure means those structures which forms at the formation time of Rock.

Like this bedding cleavage, so similarly suppose there is intrusive dikes intrusive sills that's mineralogy, mineral orientation mineral composition. In the initial stages of weathering these parameters they do not change but once the weathering becomes more and more intense more and more time of involvement of geological agents. The weathering becomes more intense. So, finally what happens due to this intense weathering the initial Rock parameters the rock structures like the granularity like the bedding like dike placement these things becomes very intensely affected. So finally in intense altered rock, it will be very difficult to distinguish whether there is a dike intruded or as it is the rock is there. So, that means I want say at the initial stage of the weather the effect very less to the rock but once the weathering become intense the whole rock looks like same.

Weathering and erosion it is distinguished based on this terminology. It is called in situ that we have already discussed in situ that means the rock material which is disintegrated from this Rock mass this remains as it is at the same place without considerable transportation.

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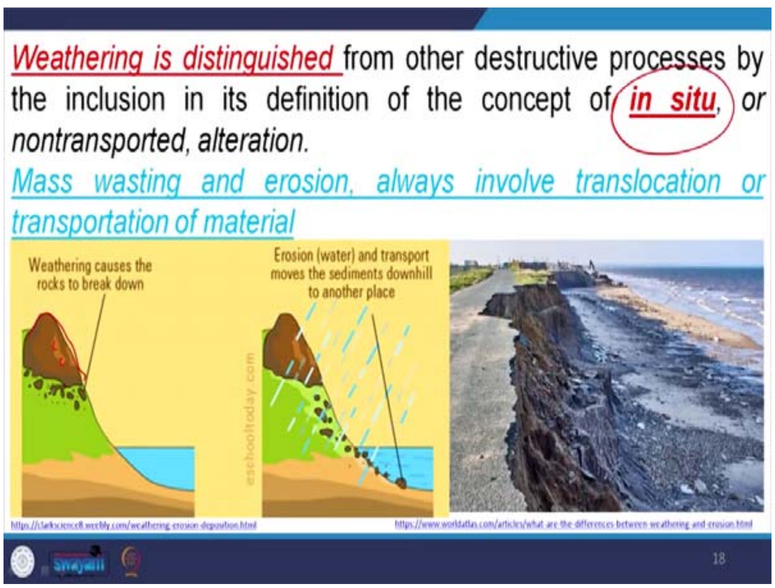

Considerable transportation that means for example suppose this is the tip of the hill. And these are the material which has removed they are laying just below this is weathering you can say it is transported from here to hear but it has to transport due to gravitational pull this rock has to fall down so that is weathering. Due to this external agent suppose due to raining there due to streams this materials are removed from this distance to this distance.

This is erosion that means here an external factor is involved from removing the material from their weather site to a deposition site. It is cut off from this parent rock. This is called erosion. So if you see this figure it is coastal erosion you might have not seen you might have not heard coastal weathering coastal erosion, river erosion glacial erosion why? Because those agents either that is sea water or it is river or it is glacier or wind the transport the particles that transport the products from one place to another that is why the term erosion is there.

Mass wasting and erosion always involved translocation or transportation of this material. So, once the transportation is involved considerable distances involved then term erosion become more prevalent. This is the basic difference between weathering and erosion weathering is in situ product only simply disintegration and erosion is the removal from this parent rock that is erosion.

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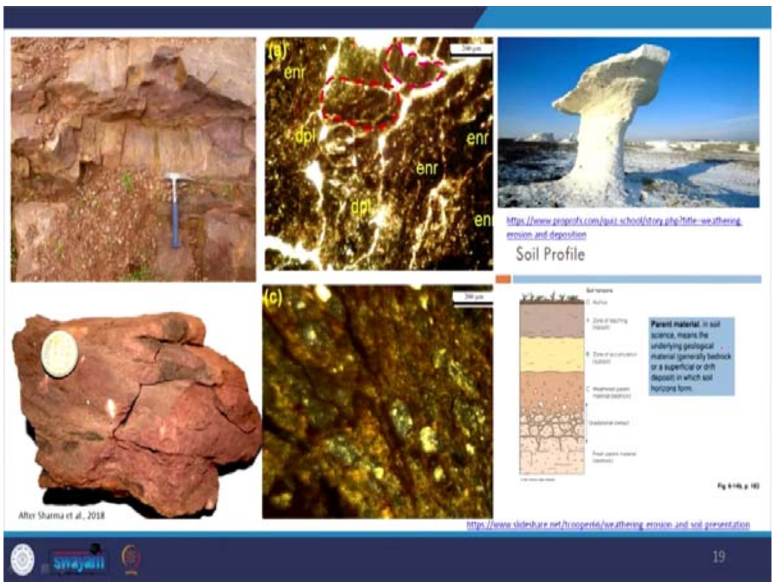

And if you see here the weathering occurs, it is not occur properly in simultaneously or uniformly, even weathering in a small place even in the microscopic scale also it is not uniformly distributed. For example, if you see here, this is sandstone body. This is sandstone body. Within this 2 sandstone body there is a rock layer there is a layer this is called paleosol. Paleosol means soil which is buried this is called paleosol.

Soil horizon which is buried and this is the weathered part of this paleosol and these are photomicrographs. In the photomicrograph if you see here if this DPL, DPL means depleted. ENR; ENR means enrichment enriched, so that means I want to say within microscopic scale also there will be depletion there will be removal of material and there will be enrichment of material that means deposition of material.

So we cannot say it is erosion it is weathering because within the same section within the microscopic scale so erosion only and only the terminology is used when this migration the transportation it is a considerable scale. You see here this is wind erosion this photograph wind erosion, it is removed the material from here, this become isolated, material which is removed. And similarly here if you see we have a soil profile within the soil profile.

This material they are removed from this horizons and finally it becomes transported downward and the B-horizon it is again enriched and we cannot say it is erosion and it is weathering. Because this transportation is not of considered scale it is a millimeter, it is centimetre. So, that is why this is the basic difference of weathering and erosion. Weathering is the precursor of mass wasting and erosion.

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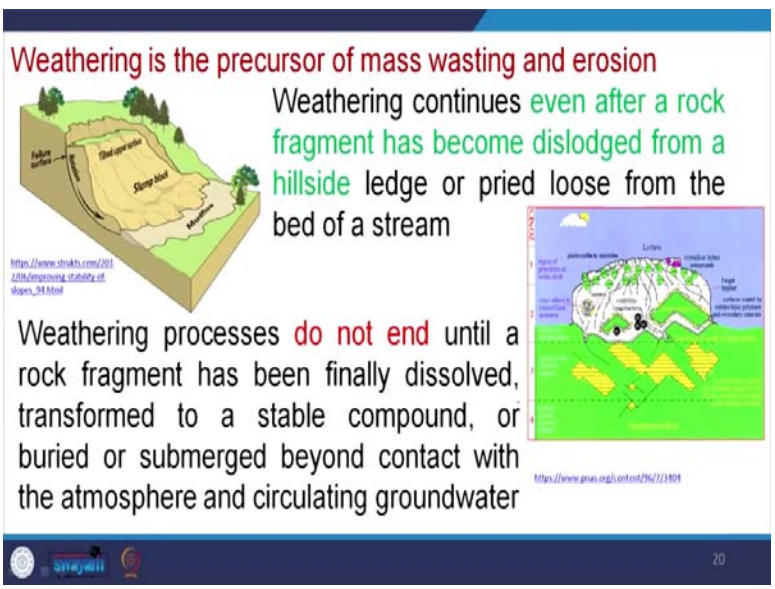

That means weathering it makes the rock more feasible to erosion it weaken the rock. The weakening product that weakening process is caused by weathering and once the rock become weaken it move out from this main body and different geological agents that transport the material from one place to another and this environment and this transportation it is called the erosional process and weathering does not end till the product becomes more stable. What does it mean?

Even if the rock mass it dislodged from the main body of rock that does not mean weathering become silent or erosion become silent. No. Because it moves up to the grain level it moves up to the mineralogical level. Though a whole mass it detaches from the hill that does not mean weathering remains stop there. It will transport again transport again transport again transport. Finally, it will disintegrate and decompose the rock minute particle.

Even it is minute particles if it convert to minute particle that does not mean again the weathering stops there. It will continue to work until unless it become dissolved and become stable with the existing environment then it stops. And from starting point to stopping point it involves physical weathering biological weathering chemical weathering all type of weathering processes they work together. So, there is no end of weathering process until or unless The Rock particles become desolved and become stable with the existing environment.

So that means I want to say either physically or chemically the nature always wants to make suitable at the existing situations, existing P and T condition or exiting geological conditions.

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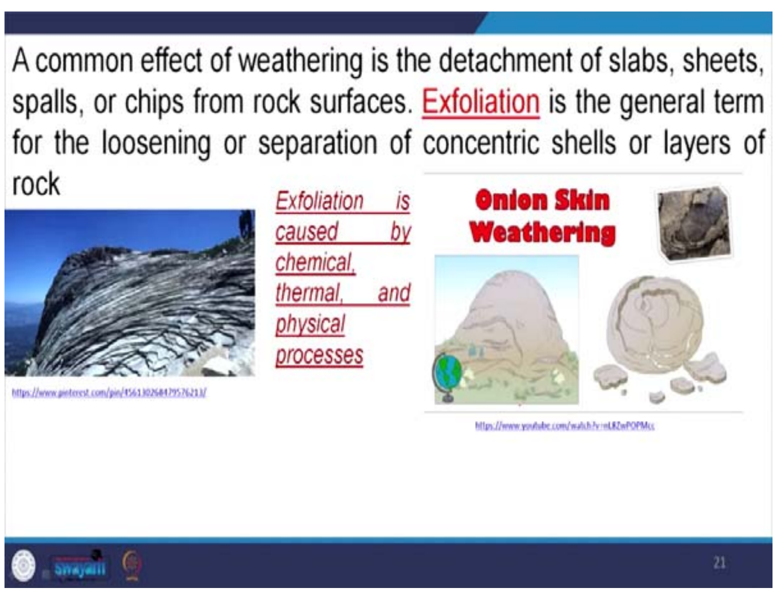

A common effect of weathering is the detachment of slabs, sheets, spalls, chips form the rock is called exfoliation. Exfoliation is a special kind of weathering which is like cabbage like appearance of rock of particles. If you see here this is a massif quartzite body, these are the layers these are not the primary layers which is existing like the bedding in a sandstone, no. This is the exfoliation layer. And this exfoliation mostly it is occurs by pressure unloading.

Pressure unloading means now you see to form sandstone to quartzite we need temperature and pressure that means in a high temperature and pressure and environment we converted sandstone to quartzite. Now due to weathering or to removal of overburden this quartzite will come to the surface near to the surface. Due to release of this overburden pressure, due to release of overburden pressure this layers that means surface parallel occurs this is exfoliation. This is onion skin weathering otherwise; it is called onion skin weathering.

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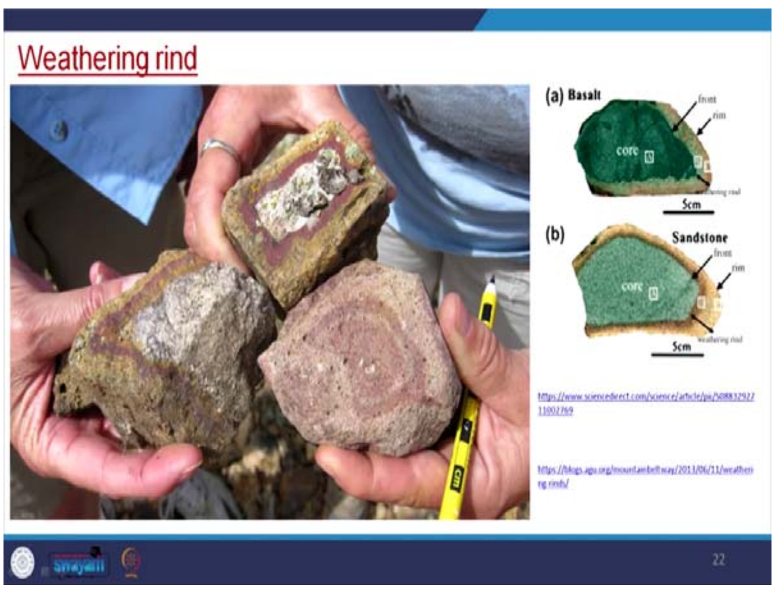

And here is one type of chemical weathering is there that is a form it is called weathering rind, rinds not ring weathering rind. Now you see these 3 boulders concentric layers of different composition. Similarly concentric layers of different composition it is called weathering rind and this is a typical chemical weathering. Now you see if we have weathering rind that means the stable minerals the stable constituents of this rock.

That will remain here the unstable constituents which are not stable to the existing geological condition of geochemical condition will be removed. So that is why if you move margin to the centre of this boulder gradually the stable minerals will be here and unstable minerals will be removed. So, this is called weathering rind. At the core we will get the fresh rock, the core either it is sandstone or it is Basalt.

The core is occupied by the fresh rocks and rim is occupied by the weathered rock mostly the stable minerals because unstable mineral already been removed. So weathering rind has a geological solution for climate indicators. Similarly age of the rock more the time rock will be exposed more thick rind will be formed is it not. So, that will define how much time the rock as spent on this official condition. What are the different climates rock as suffered during transportation? Or during its remain in the existing environment.

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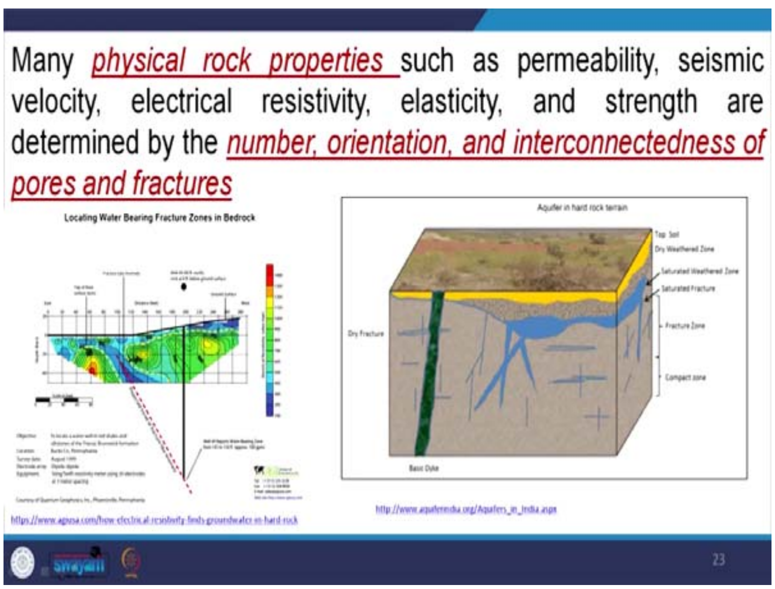

Many physical rock properties such as permeability seismic velocity, electrical resistivity elasticity and strength are determined by the number of orientation of interconnectedness of pores and fractures. So these are the product of weathering. So that means I want to say weathering affect the rock permeability, for example suppose we have Granite. Granite does not have its porosity it is not permeable or porous but once we superimpose the effect of weathering on it It becomes more feasible for weathering.

And different cracks are developed different set of joints are developed and secondary porosity superimposed on it. So, due to superimposition of secondary porosity, it aquifers natural aquifers are developed within that granite. Similarly the seismic velocity we know the seismic velocity of a rock it depends upon its compactness that means its specific gravity now due to weathering this seismic velocity decreases because the rocks become less compact.

Electrical resistivity, if you see here electrical resistivity that means it weathered zone where there will be a accumulation of water where passage of water there will be less resistance so by electrical resistivity we can say what is the depth of this weathered zone whether the fractures are deep seated to what depth this fracture is continuing like so. Similarly strength is determined by weathering a weathered rock is less strength or less strong as compared to the non-weathered fresh rock.

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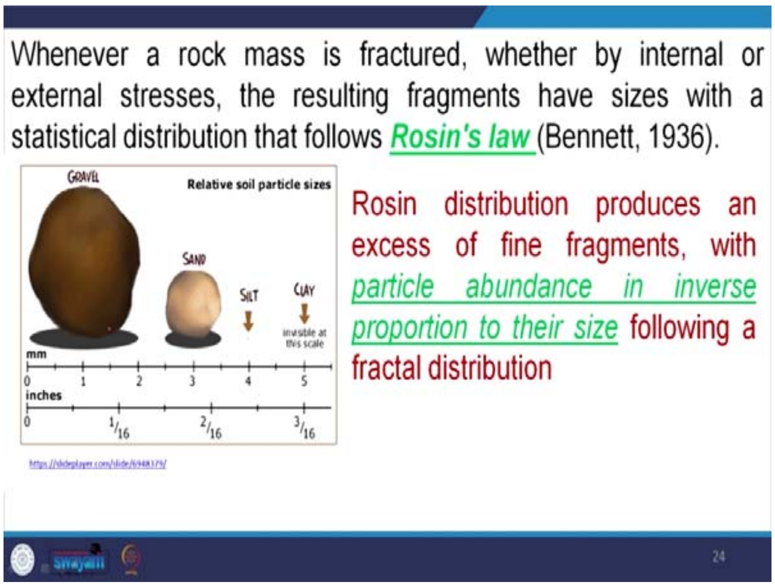

So, this product of weathering it follows the Rosin's law. What is Rosin's law? Rosin's law says this number of particles is inversely proportional to the size of particles in terms of physical weathering. And this Rosin's law holds good only for physical weathering. So, now you see here that means Rosin's law says the clay particle that will produce more and compared to the gravel particle. So, that means in a physical weathering small particles are more produced as compared to large particles. This is called Rosin's law.

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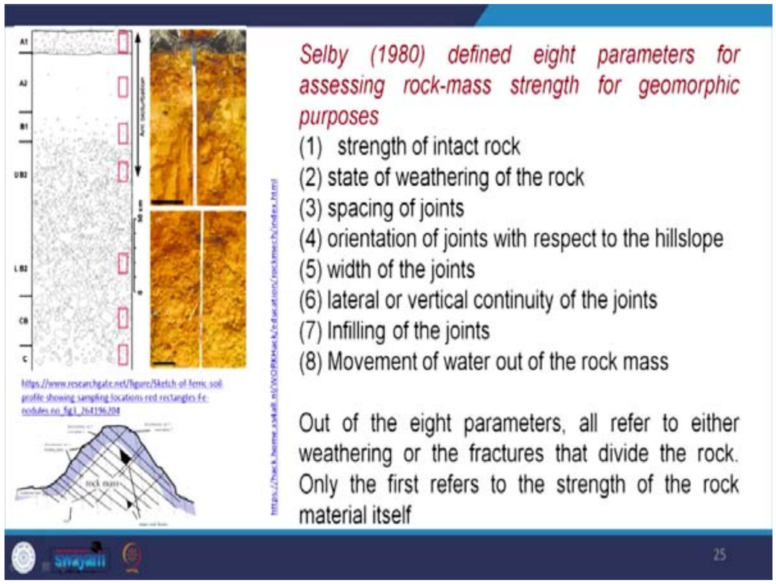

Same happens in a soil profile also if you see the soil profile here there particles this are the larger particles there is comparatively smaller particle and comparatively smaller particle. So, in Soil profile also will get less number of boulders, more number of sand again more number of clay. So, that means Rosin's law says It will hold good only for physical weathering. And there are different Rock parameters. If you see these rock parameters you will see mostly rock parameters are governed by weathering only except the first one.

The strength of the rock strength of the rock intact rock it is rock's inherent strength when it was formed the rock strength was there. But after all state of weathering of rock spacing of joints orientation of joint with respect to hill slope, width of joint, lateral for vertical continuity of joints, in-fillling of joints, movement of water in the rock mass all those that the product of weathering. So, those weathering products that defined how strong the rock will be so that means weathering play a major role in our infrastructure development also.

So, we cannot build heavier infrastructure on weathered rocks. That means for that purpose we have to remove overburden and go up to the fresh rock table and then where foundations to be laid down there.

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So, thank you very much will meet in the next class.