Earth Sciences for Civil Engineering
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Module 1
Lecture No 3
Plate Tectonics and Continental Drift (Part-2)

Okay. Hello everybody and welcome back. So in the last lecture, we talked about the interior of Earth. So I will just briefly try to cover a few points and then we will move ahead and talk about the plate tectonics today.

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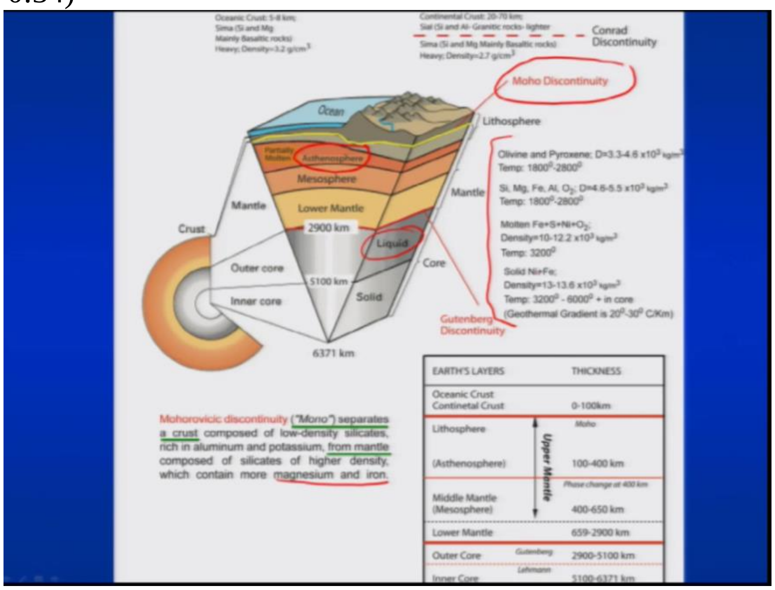

Yesterday, we spoke, we discussed about the different layers and we also talked about that the Earth is not homogenous. It has a different composition as well as the different layers have different compositions. In short, we can say that the Earth is not homogeneous and different layers have different properties. As well as what we see is that the composition is also different.

Now the most important thing which we were discussing yesterday was that the different discontinuities which exists between different layers and this discontinuities which we were talking yesterday about the Moho discontinuity or the Conrad discontinuity, they are marked with the help of seismic data. And of course ah, the seismic waves which behave differently while travelling through these layers or through the interior of Earth and their velocity change and all that. So based on that, they have marked these boundaries.

So the Moho discontinuity what it exists is again we can say that this exists between the crust and the mantle. The crust basically which is a low density, which is composed of silicates, rich in aluminium and potassium and the mineral which is composed of silicates and with high-density containing magnesium and iron okay. So this we discussed.

Now if we move further towards the interior of Earth, what we find is that we are having that the mantle which is comprised of the partially molten layer which is known as asthenosphere. Now there is no clear-cut discontinuity has been named between the lithosphere and the and the and the or the asthenosphere or we can say the crust and the part of the asthenosphere, there is not clear-cut but it has been marked as, this is a low velocity zone.

And this we will discuss or talk when we are talking about or discussing about the interior of Earth later on. So now the another important part here which I would like to emphasise is that the asthenosphere of course we will be talking as we move ahead in this lecture, the asthenosphere is responsible for the movement of the tectonic plates on this universe. And then another important part is the liquid core okay. Now this liquid core is responsible for generating the magnetic field.

And this is what we call as a geo-dynamo okay. This is one of the important part and why this has been termed as a geo-dynamo, I will talk in few minutes in the next slide. So moving ahead in this, so here the complete composition of the interior of Earth has been given which you can refer with and as we discussed in the previous lectures that the heavier material having the higher density segregated at the base and then we are having lighter material at the surface.

So that what we see is that the lighter ones are towards the surface which are forming the crust and all that. Whereas the heavier one like nickel and Iron are being seen in the core and core part.

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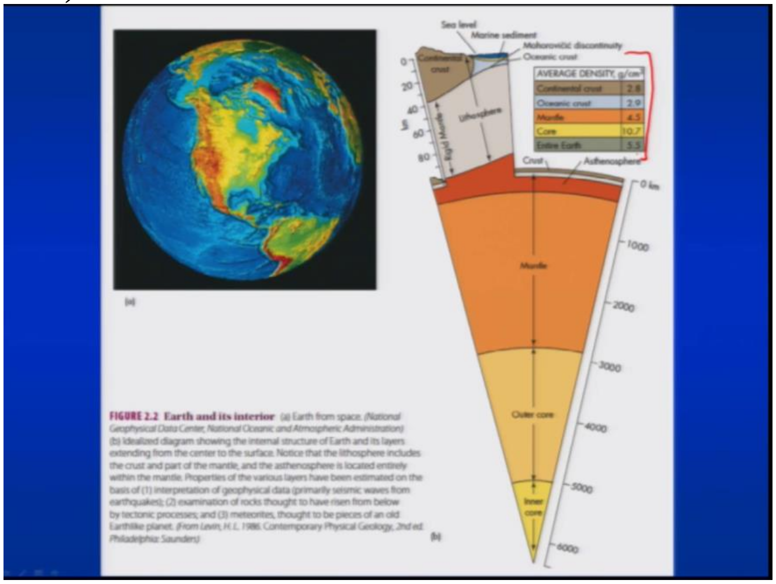

So this is again the very much similar which the section talks about the density part of the Earth's interior, right starting from the crust, including Continental and oceanic crust and then we are having mantle, core and entire earth okay. So entire earth average if we take, we are having the average density which is around 5.5 G.

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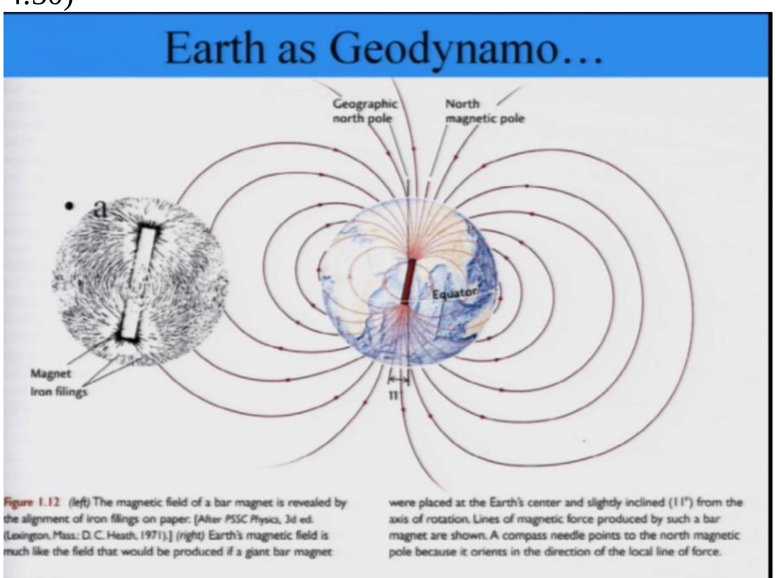

Now moving ahead, this is the important part. Now this magnetic field statistically is like if you take Earth, it acts as a giant magnetic bar okay. Now one very important part which I would like to mention here is that this magnetic field it goes far into the outer space. And this is one of the reasons why we are having the shielding of our biomass from the harmful radiations coming in. So this is also a very important part why we are having the shielding.

So this is because of the interior of the Earth and this has been given by the outer core. The outer core is responsible for generating the strong magnetic field in the Earth. And then another part which is important of this aspect is the question comes that ok fine, if we are having the magnet okay, so if you and any magnet if you put at a very high temperature, it will melt or it will be magnetised. But why again and again we are having like the strong magnetic field which keeps continuing. It is not destroyed completely.

So the scientists, they talked about this and they have discussed and what they found was that for example, I will just look, to explain in this one that the question is, why is the magnet, the field created by convection? This is because again, it is the heat flow and the heat flow keeps on producing the convections okay. Now in laboratory if you take, laboratory experiments demonstrate that the field of permanent magnet is destroyed at around 500 degree centigrade.

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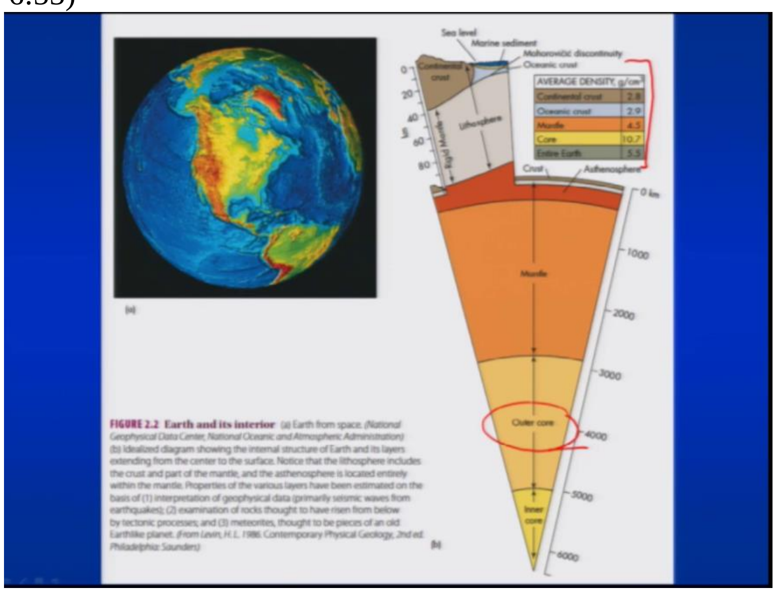

And the interior of the Earth if you look, we have, the temperatures are very very high. If you move beyond, maybe more than 1000 degrees or so. So interior of the Earth or the, the part is the outer core is having very high temperature. And even though it is capable of holding this property of the magnet okay, so what it was suggested that we know that the temperature in

Earth in the deep interior are much higher than that. And then 1000s of degrees in the centre. It is very high.

So unless and until the magnet is not constantly generated, it will not have, it cannot maintain the magnetic field of the Earth. So it needs to keep on generating the magnet again and again. So this is one of the reasons for generating and of course, it has been suggested that the convection currents which are being developed in the, if you compare because we have a partially molten layer that is asthenosphere which is also partially molten.

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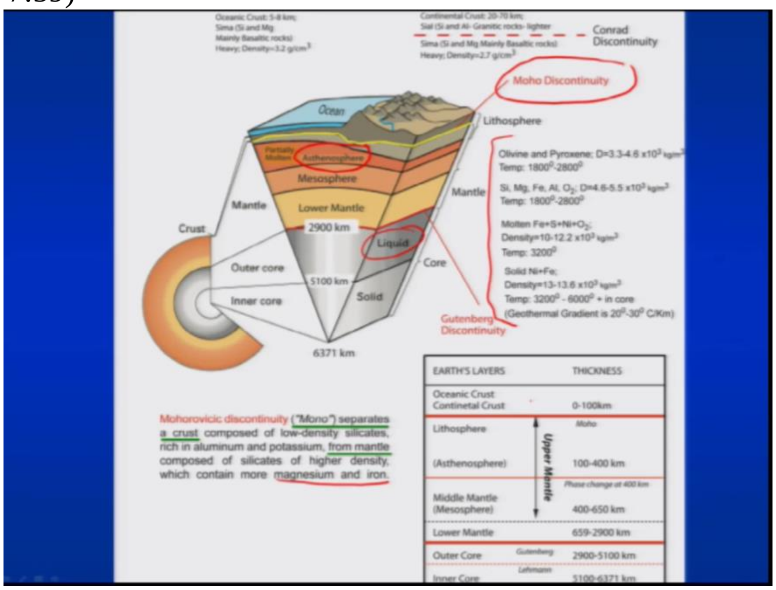

So why the magnet has not been generated there? Why only in the core? The reason that has been given is that we have the silicate rocks in the upper part of the interior of Earth. Whereas we are having iron and nickel which are good conductors of electricity which sets in the interior of Earth, that is in the core. Whereas in the asthenosphere, we do not have, we have the silicate rocks. Hence it is, they are poor conductors of electricity. So they do not help in generating the magnetic field and all that. And then 2nd reason which has been given is that this liquid core, the convection currents are much much higher. So the motion is very rapid as compared to what we see in asthenosphere.

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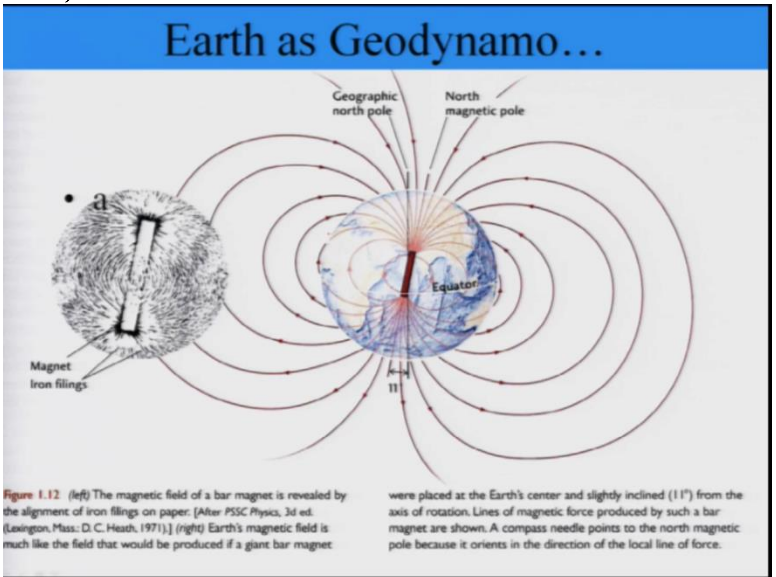

So these are some facts of to be understood for the, by be called Earth as geo-dynamo.

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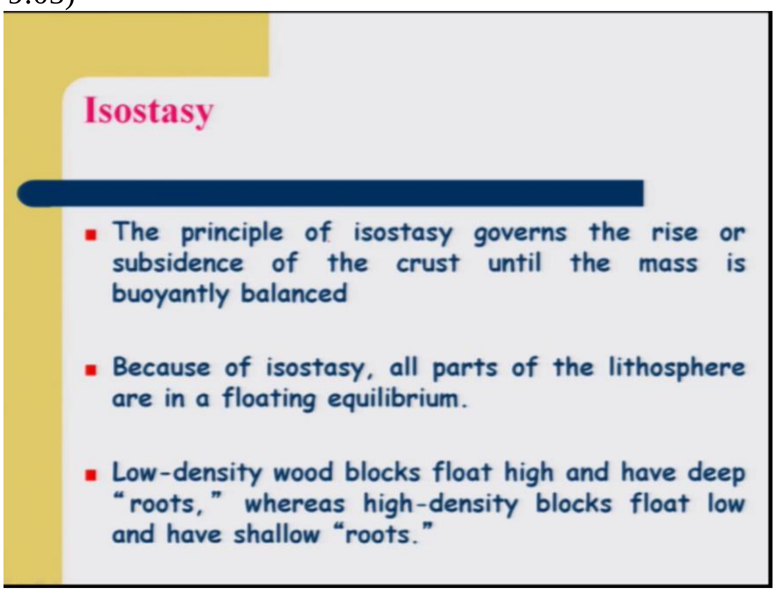

Moving ahead, there is another important part before we get into the plate tectonics. It is the Isostasy and this principal, it says that the principle of Isostasy governance the rise or subsidence of the crust until the mass is buoyantly balanced. So whatever you have or you see below the surface, you may have lesser on the surface. That has to be equally balanced. So because of Isostasy all parts of lithosphere are floating in equilibrium okay.

So if suppose we are having, you erode something from the surface, that will result into the uplift and that is what we see, a very good example in the Himalayan region. So we keep on eroding, the Himalaya keep on rising. Now the other point is, the low-density, for example, there is a example given, there is a low-density wood blocks float high and have deep roots whereas the high-density blocks float low and have shallow roots okay.

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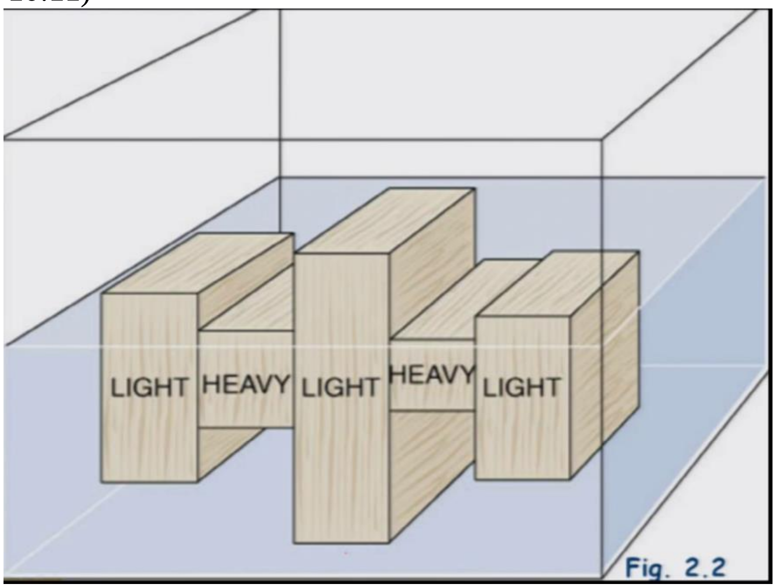

And this is what has been explained is that this one is the low-density blocks float higher and have deep roots whereas the lighter ones will have, you can have the high-density blocks float low and have shallow roots okay. So they will be shallowly.

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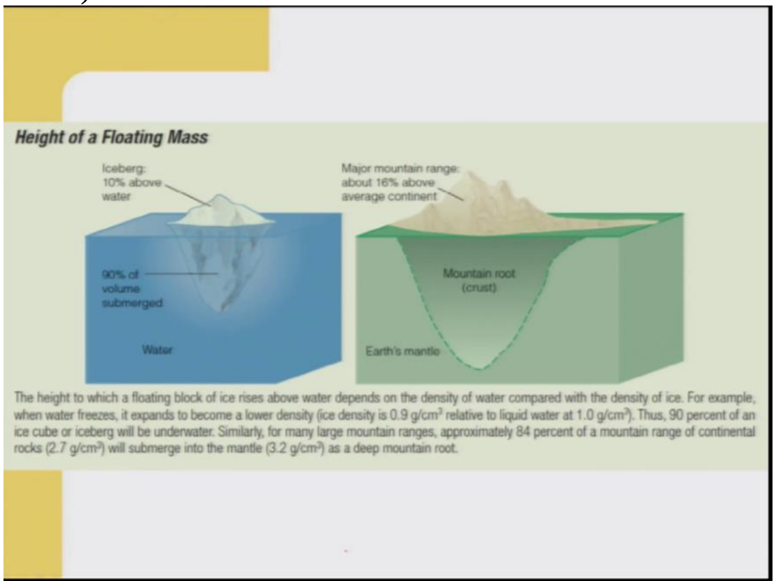

So similarly this is an example which has been given in compared to the iceberg which has been there and the major mountain ranges okay. So major mountain ranges, about 16% above the average continent remains.

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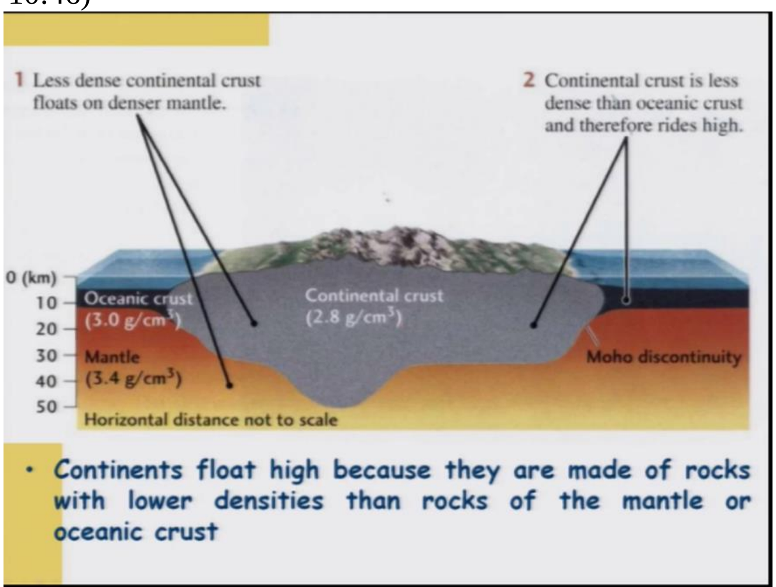

Now similarly what we see here if we take in terms of the oceanic crust and the Continental crust, the oceanic rests are heavier and not so deeply rooted but the Continental crust which are comparatively. So Continental crust is less denser than the oceanic crust. Therefore, they ride higher as compared to that. So Continental floats high because they are made up of rocks with lower densities okay. So they float higher as compared to the oceanic crust.

That is one of the reasons why we see the Himalayas are very high and the Alpine mountains, the Himalayan chain of mountains are sitting very high in terms of their height.

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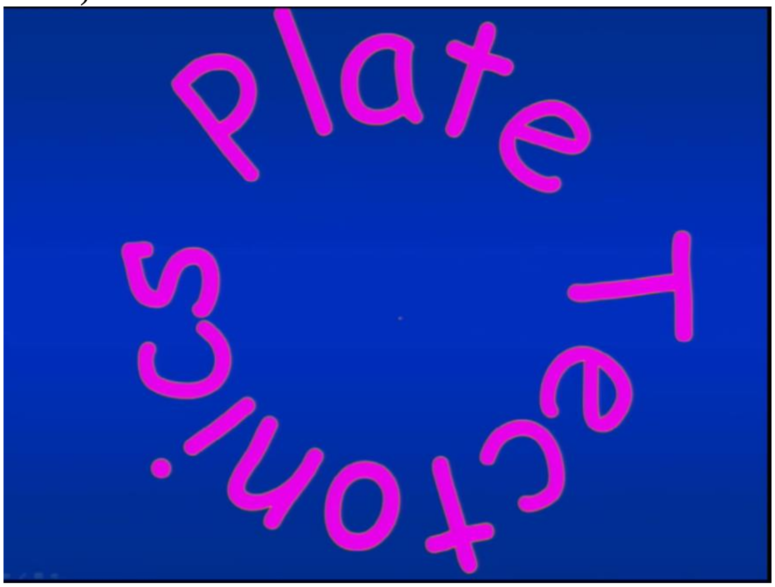

Now coming to the main topic what we were talking about, the plate tectonics. So whatever is like if we have a disturbance here, we will keep on having the rise every time.

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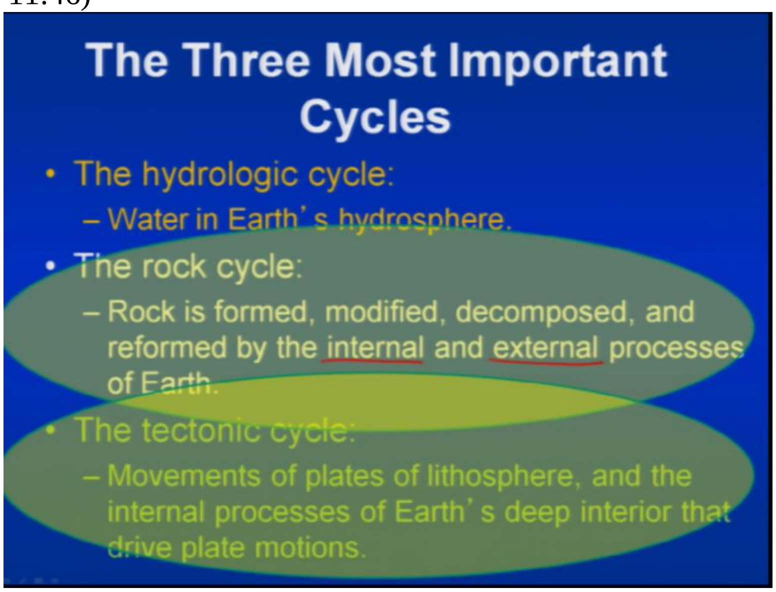

So plate tectonics, the three most important cycles if we look at, they are interlinked. We say that these, the one is the hydrological cycle. And these are also again again we can say that this is interlinked with the plate tectonics because if the plate movements are there and if plate moves from one place to another place, the climatic cycle and everything will change. For example, earlier we never had, like for example, for Indian subcontinent, we never had Himalayas.

So we never had the monsoon. But now we have monsoon. We never had the rivers. But now we have the rivers and all that. And that is the reason, the reason is for, is given that this is because of the plate tectonics. Movement of plate movements which resulted into the formation of Himalayas. And then we have the rock cycle which is also interlinked. So rock is formed again, this movement is the rocks are formed, modified, decomposed and reformed by the internal and external processes.

So here both the processes are involved. Whereas in plate tectonics and external is the ocean and solidification or weathering we can talk about that okay. Then we are having tectonics cycles. So movement of plates of lithosphere and their internal processes of Earth, Earth's deep interiors that drives the plate okay. So this also has been involved in this cycle. These are 3 cycles which are interlinked in a sense okay. Because they do not have like they are interlinked in a broader sense.

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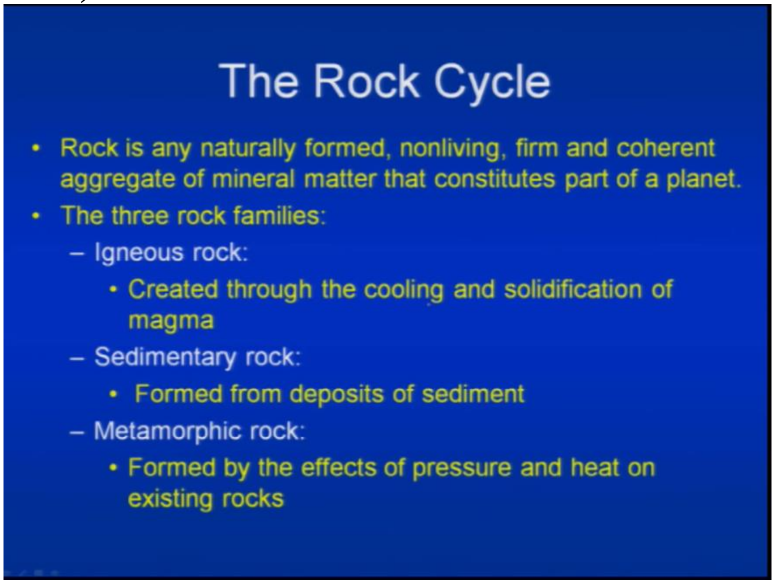

So rock cycle if we take, and we look at what it usually composed of, the rock is a naturally formed, nonliving, firm and coherent aggregate of minerals that matter that constitutes the part of the plates the planets. So we are having 3 types of rocks. Yesterday I was mentioning about this. We have igneous rocks which are created through the cooling and solidification of magma.

So this is again very much related to the plate tectonic because not all places you will find that the magma is coming up on the surface or there is a volcanic eruption okay. Because the source is through volcanic eruptions in particularly the magma coming up on the surface. So plate tectonic is an extremely important, it plays an important role when we are talking about the generation of magma. So the igneous rocks will form through the cooling and solidification of magma.

Then we are having the sedimentary rocks. When this material is coming up, the erosion will result in the formation of the sediments. Then different sedimentary rocks are formed in different environments. Then talking about the metamorphic rocks which are formed mainly because of the effect of the high temperature and pressure. So this again, when they are buried in the deeper part of the Earth, they will be subjected to metamorphism.

So one rock will be transformed to another type of rock okay. So for example, sedimentary rocks if we take, sandstone will get transformed into quartzites and all that okay. And if you are having the granite, maybe it will get transformed into the nice and all. So we have that sort of a transformation from one rock to another rock when it cools under the process of metamorphism.

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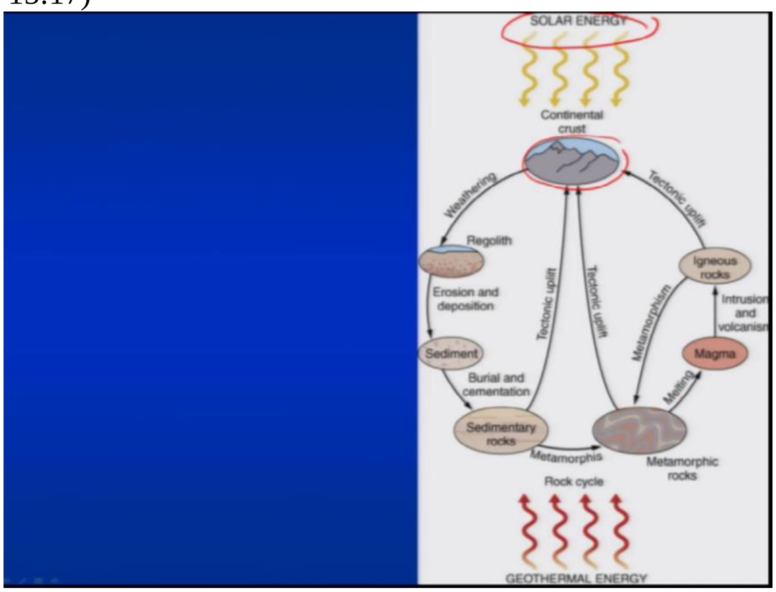

So this is the cycle which talks about how they are interlinked. So we are having like the Continental crust if we start from here or maybe we can say that the okay, we can start from this place. So we are having geothermal energy. So we are having the magma is getting heated up.

And then the rocks are melted and they are brought up to the surface through intrusion or volcanic eruption.

So the magma which is molten magma it will be intruded in the country rocks or it will be extruded on the surface through volcanic eruptions. So that will result into the formation of the igneous rocks and then those rocks are tectonically uplifted. So ongoing deformation will result into the uplift and result into the formation of mountains and all that we are having. And here what we have?

That there will be a weathering process because these sediments will be exposed to the solar radiation or maybe we can say that the rain or through snow or any mean of the different type of agents and they will be weathered and result into the formation of rego lith or the soil and then this process of weathering, and what we see, the erosion and deposition of sediments okay. And upon burial and solidification or cementation, they will result into the formation of sedimentary rocks.

And again, they are metamorphosed, they dipper, folded, deformed result into the formation of or causing formation of metamorphic rocks. So we have this cycle which goes on. So they are interlinked. So the formation of rocks, destruction of rocks and regeneration of rocks or reformation of rocks is completely linked with the plate motions or the plate tectonics okay. We will learn that part in shortly or how the rocks are being (())(17:15).

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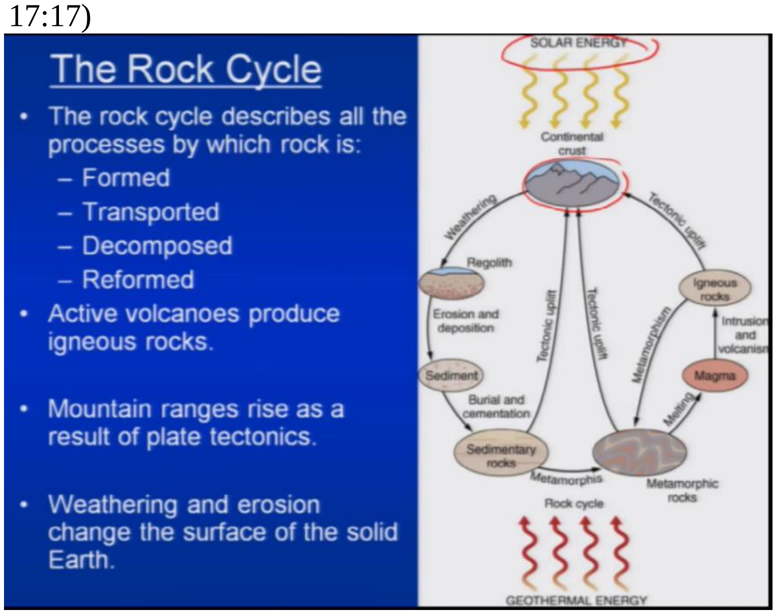

So rocks we have that what we discussed the rock cycle describes all processes by which the rock is formed, transported, decomposed and reformed. So decomposed means, they are eroded and then deposited and then reformed. Active volcanoes produce igneous rocks. Mountain ranges rises as a result of plate tectonics. So what we see?

The mountain ranges have been resulted from the plate motions and the formation of the crust. And then weathering and erosion changes the surface of the solid earth. So the erosion will result into the formation of sediments and then further sedimentary rocks and then deep burial will result into the metamorphic rocks okay.

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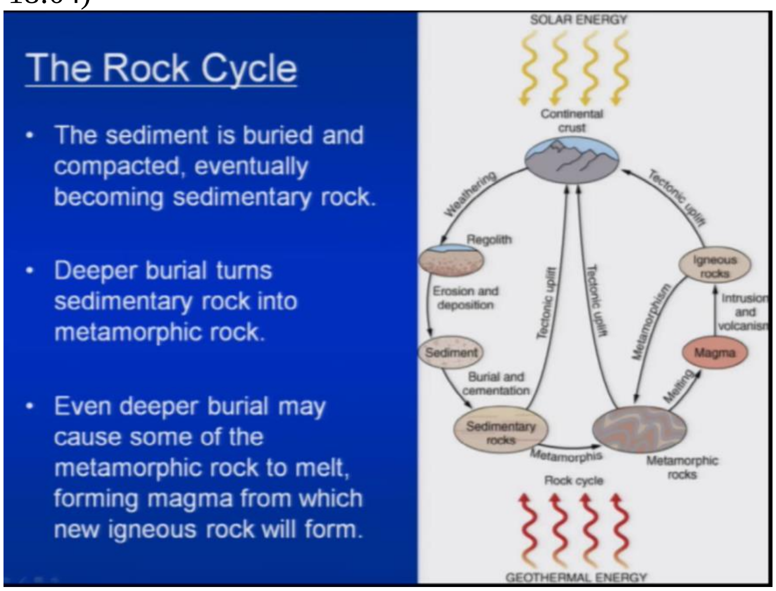

So sediments is buried and compacted, eventually become the sedimentary rocks. And the deeper burial turns the sedimentary rocks into metamorphic rocks okay. So even deeper burial may cause some metamorphic rocks to melt again and result into the formation of magma. So the cycle keeps on going and this never ends.

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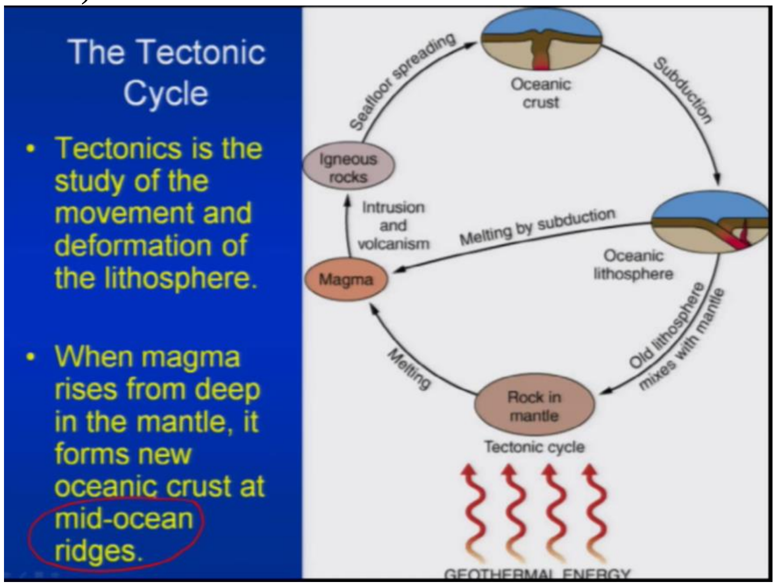

So tectonic cycle, tectonic again is a word which has been used to for the branch which studies the movement and deformation of lithosphere mainly. And then, when the magma rises from the deeper part from the mantle, it forms a new crust. So it keeps on, at some places, it keeps on adding and they result into the formation of new crust. And mainly, this has been formed in the area where we talk about the or we say the mid ocean ridges where we have the new formation of crust every time.

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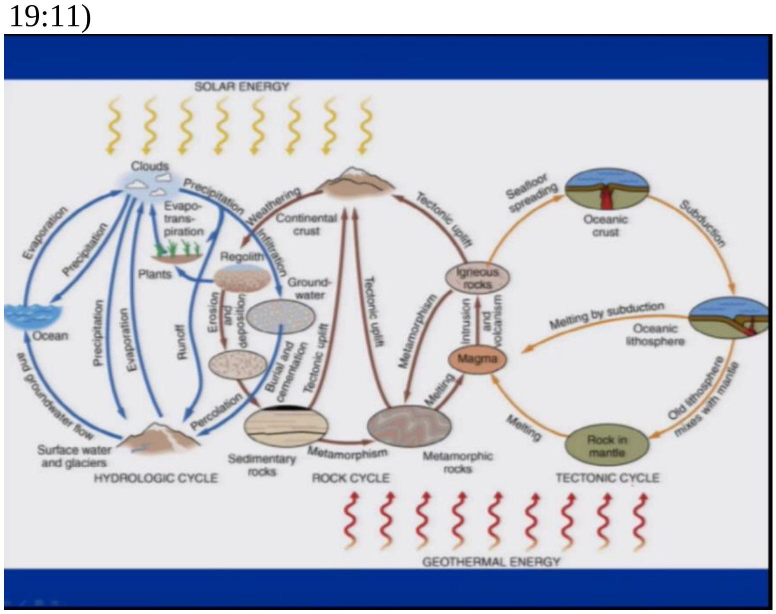

So this is how it has been shown that things are been interlinked. So these all cycles are interlinked. That is the hydrological cycle, rock cycle and tectonic cycle, they are interlinked with each other.

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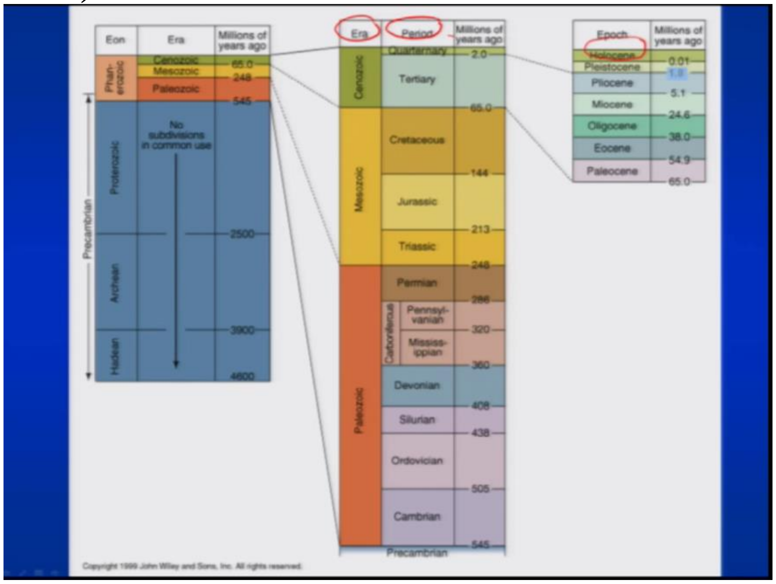

Now before we move to the part which we are talking about that and the plate tectonics and all that okay, this in the last lecture we talked about the geological timescale. We have era, we have period and then we have the epoch okay. We are having this one. And right now what we are looking at? We are in the Holocene epoch.

And the most recent one, the period in the geological timescale if we have to take is the quarternary. So this is the most recent period we are having. And then further they are divided into 2 where we have the Pleistocene and we are having the Holocene epoch.

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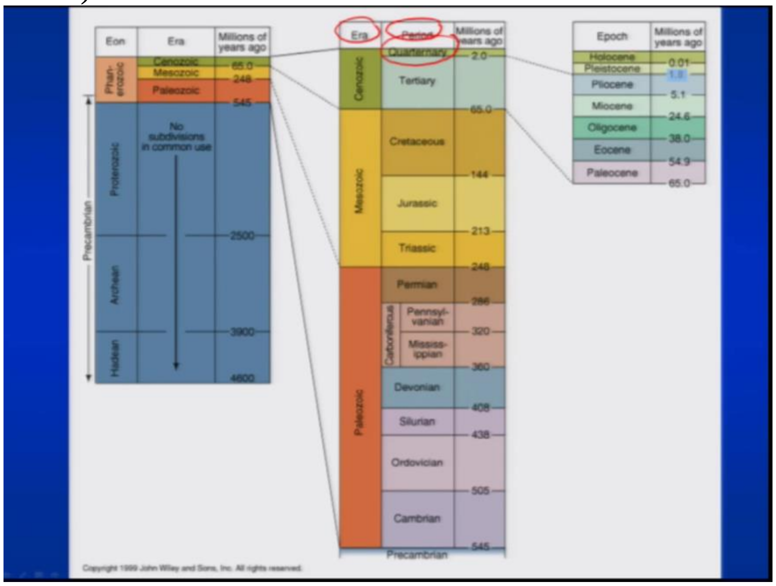

So let us see what what, we look at this, I have already discussed. So just I will move ahead.

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And this is the time, the person who introduced or gave the theory and tried to explain that the plates or the continents which we see today were not at the same place in the past. But they were, they moved. They were together long back but they moved from one place to another and then what we and that is what he said about the Continental drift okay. So they drifted from one place to another due to the convection currents which are generated within the asthenosphere.

So he said that Earth, he looked at Earth as a jigsaw puzzle okay. So in 1912, Alfred Wegener, a German meteorologist suppose that the continents were all together like one piece and that was named as one land or all lands that this Pangaea. Then they drifted apart and reached their present location. And that theory was being termed as the Continental drift theory. So this was been given by Alfred Wegener.

Initially not many people believed him but now we can even measure the movement of the continents at millimetre accuracy by differential GPS.

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So this is called as an that Earth has a jigsaw puzzle. So if you look at the boundaries of the African West side and the American, South American plate on the eastern, they match or they fit each other very much. So this is like a puzzle which he talked about. So earlier, what he suggested that the Pangaea, that all continents were together. So if you match the boundaries of each continent, they will almost fit very with each other. And that is what he termed as a Pangaea. This was long back.

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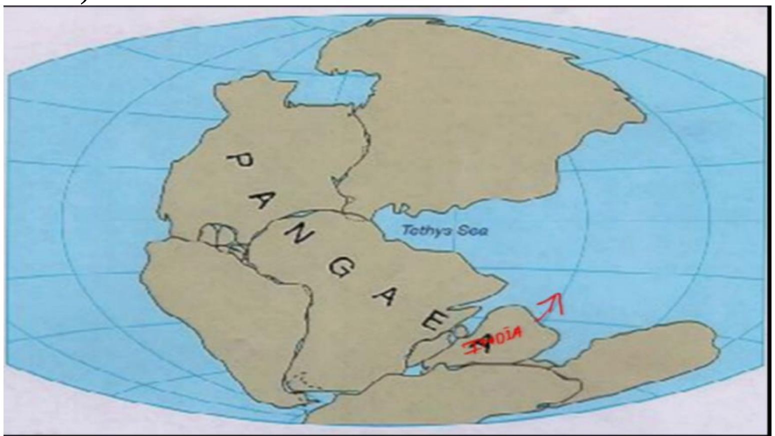

So now if you look at the landmass special the theory which has been which has been given that we had all the continents were together. And it was been engulfed by ocean which was being termed as the sea and here it is the India. This was your Indian subcontinent which was almost like 1000s of kilometres south of equator and it moved towards north and then finally it collided with the Eurasian plate. Ok this is Eurasian plate here.

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Figure 20.1 A

So this what has been termed as and then the northern side, the continents on the northern side of the equator were being termed as Laurasia and the clients which were on the southern side were being termed as the Gondwanaland. And India lied very much south of the equator but now if we look at, it has almost travelled a lot many kilometres to reach its present position.

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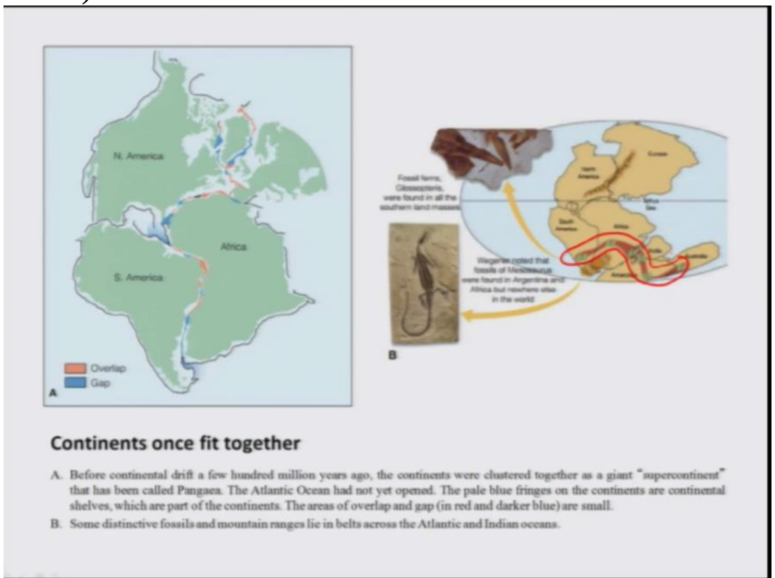

Now that was not, what what they studied was that they tried to look at and then the geologists and the palaeontologists they tried to look at if these continents were together then they must have almost similar climate. Hence the floras and faunas should be almost similar. So that is what they tried to look at and they found ok fine the areas which showed the floras and faunas were very much similar in this subcontinent okay.

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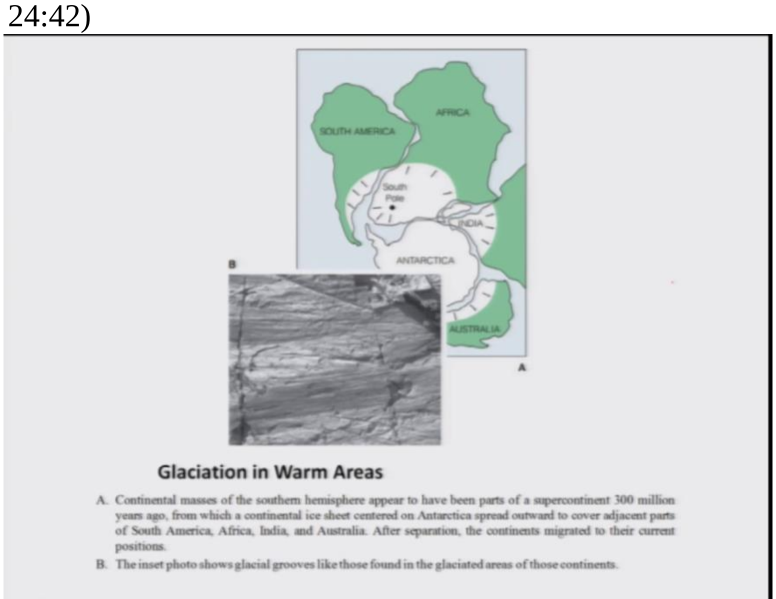

And then another one what they look at that ok fine these regions might have experienced a particular climate. So yes, I will continue in the next lecture. Thank you very much.