Earth Sciences for Civil Engineering
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Module 1
Lecture No 4
Plate Tectonics and Continental Drift (Part-3)

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Welcome back. So last lecture we were talking about the Continental drift and theory which was been suggested by Alfred Wegener talking about how these continents were together.

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Figure 20.1 A

So quickly moving ahead. We talked about this that the southern part of the equator, the continents were being which were together were being termed as Gondwanaland and the continents on the northern side of the equator were termed as the Eurasian.

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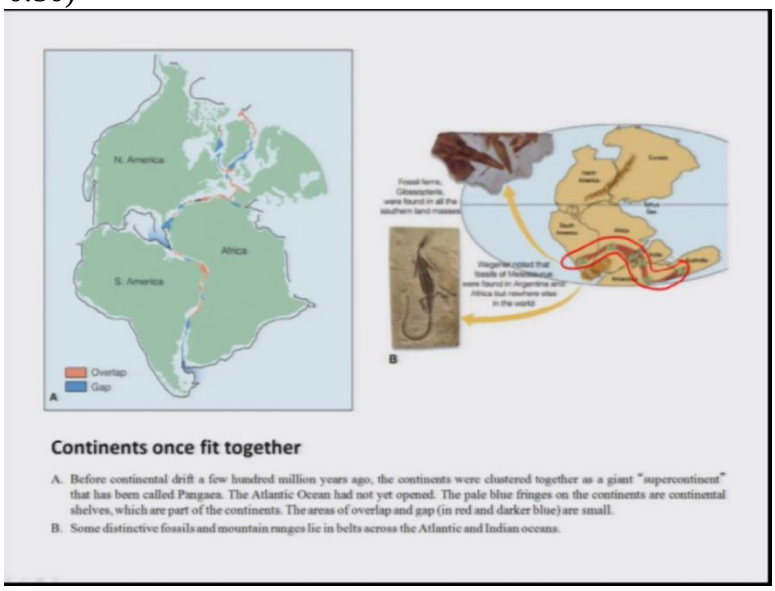

Continents once fit together

A. Before continental drift a few hundred million years ago, the continents were clustered together as a giant "supercontinent" that has been called Pangaea. The Atlantic Ocean had not yet opened. The pale blue fringes on the continents are continental shelves, which are part of the continents. The areas of overlap and gap (in red and darker blue) are small.

B. Some distinctive fossils and mountain ranges lie in belts across the Atlantic and Indian oceans.

Now as I told that they tried to look at, the geologists tried to look at the different rock types and also they thought of that if suppose these continents were together then they should have experienced similar climatic conditions and the floras and faunas which flourished in that period must be almost similar in this continent. And as shown here that they found a very similar floras and faunas in different continents like South America Africa, Antarctica, India, and Australia which are not at the same position now. They are very much apart.

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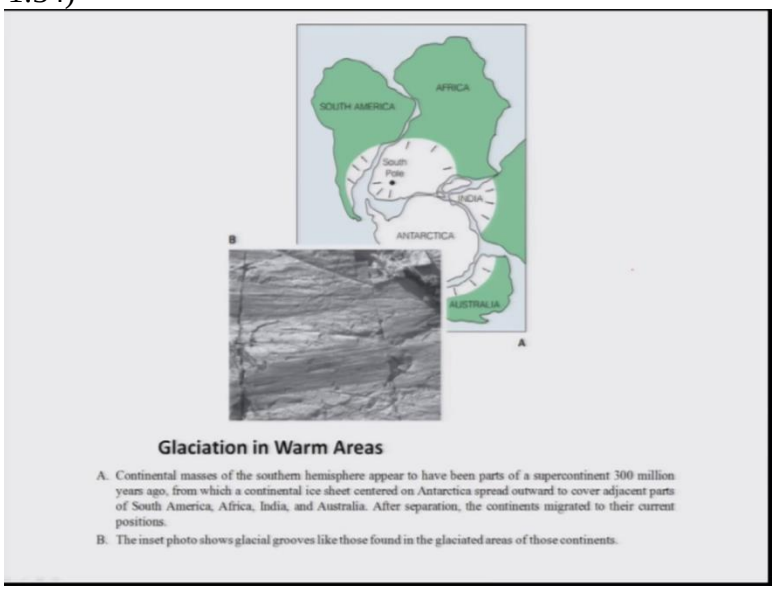

Now since they were closer to Antarctica they experienced the glaciation and they found the rocks and the indicators or the signatures of the glaciation during that period. Those evidence were also been collected and it helped in proving that these continents were together.

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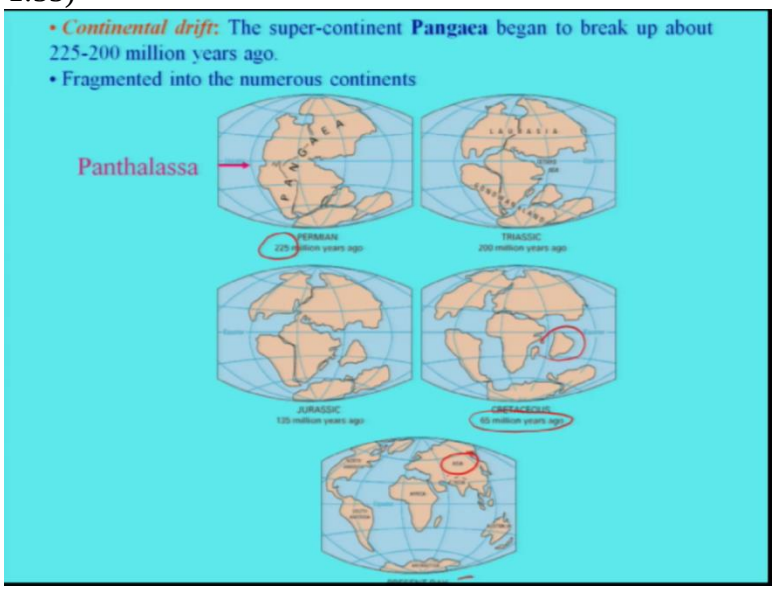

Now if you look at theory of the continental drift, it says that it was like the Pangaea began to break at around 225 to 200 million years ago, fragmented into numerous continents. So if you look at this chart here or the sketch it shows that it started, the movement started or the drifting started after 225 million years back. So it started moving and different stages if you see, it has been shown that how it moved.

So a few examples if we take at around 65 million years back, India was just close to the equator. And now what we are having, the present-day, we are having India collided with the Eurasian plate or what we call the Asian plate. So if you look at now if that that India which was very much in the southern side here, south of the equator had a different climate but now when it moved here, it is having a different climate.

And because of the collision or the subduction that we will talk in the coming few slides, this resulted into the formation of the Himalaya and we are having different seasons what we see. So this is what they say that ok fine this this this was being termed as Panthalasa.

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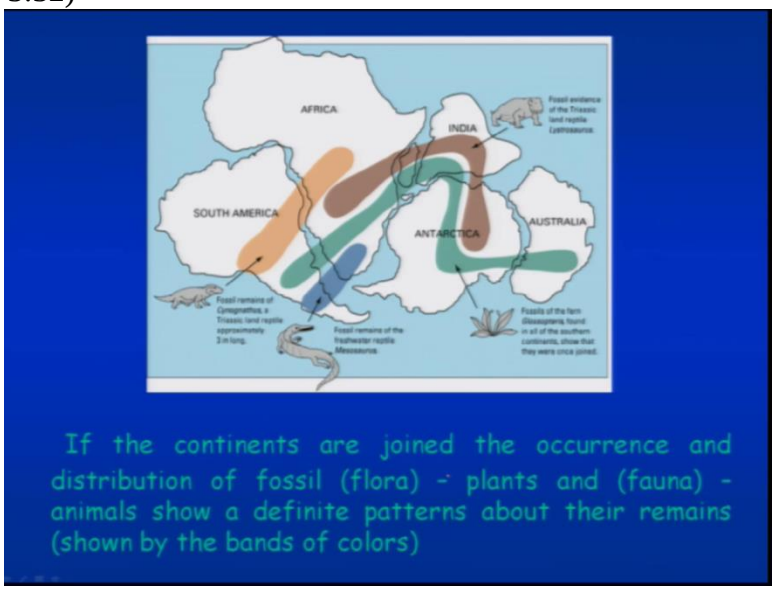

So as we talked that it was not only enough to look at the fossils or the floras and faunas which were seen in different continents but along with that they also looked at the rock types.

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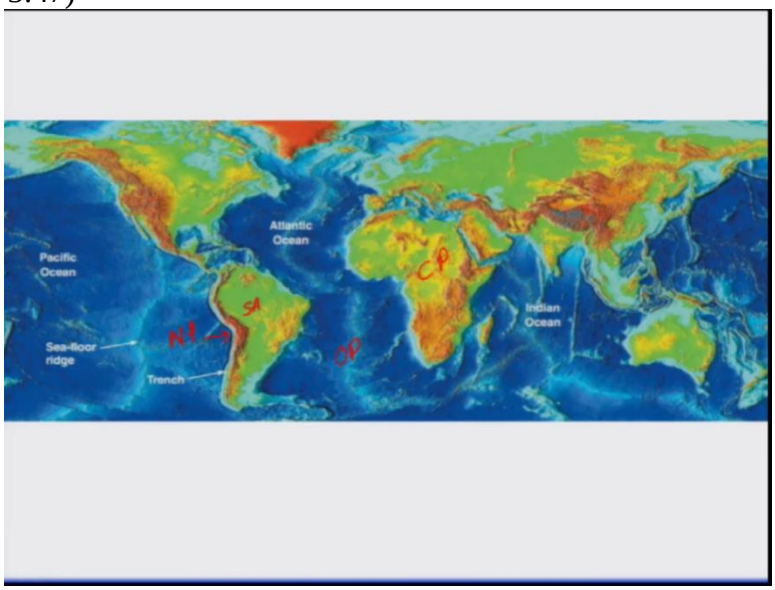

This is the present location the situation what we are having and since the plate moved from, the continents moved from its original position, on the way they underwent deformation, on the way they had the formation of valleys and all that and then after the collision, so we are having the oceanic plates. These are oceanic plates and these we are having Continental plates. So when they collided with each other, one of the plates which were heaviest, they subducted below the another one.

So for example if we take here, this this plate is a Naska plate which subjects below the South American plate here. And similarly here, these plates are also having the Pacific plate subject below the American plate and all that.

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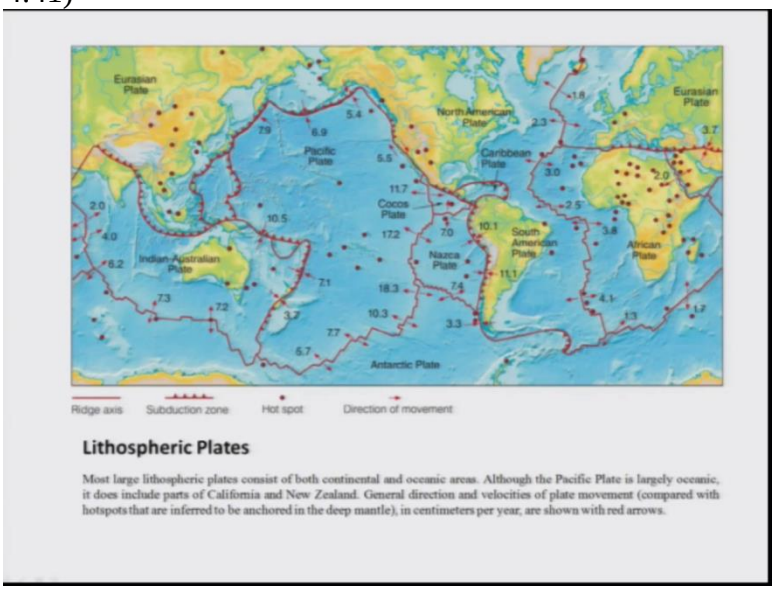

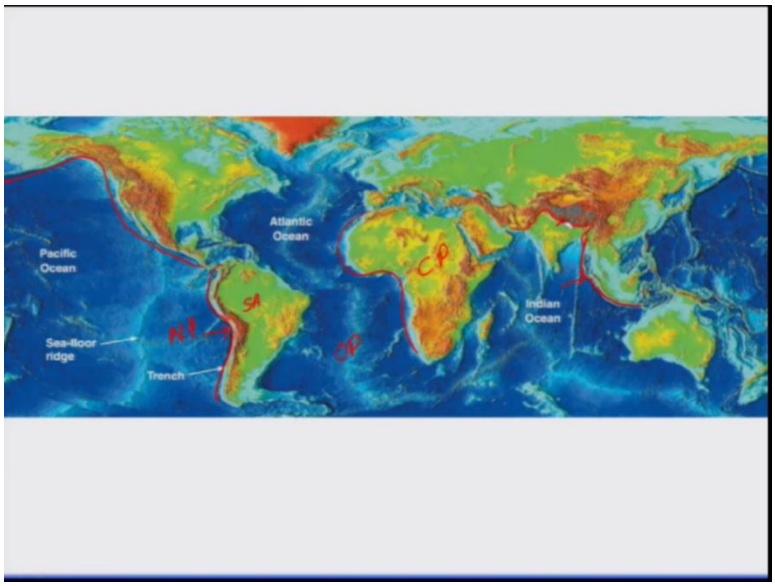

And if you look at what is the important one here is you look at the boundaries here, these are the plate boundaries what we call and this is another plate boundary here. This we are having another plate boundary here. Of these plate boundaries, some are having very similar characteristics but some are very different. And this is very important for us. This is another plate boundary here. And then we are having the plate boundary which goes like here, in this region.

So in Indian subcontinent, it is almost surrounded by a major plate tectonic boundary. And this plate boundary is different than this one in terms of the earthquake generations, in terms of the hazards we are having.

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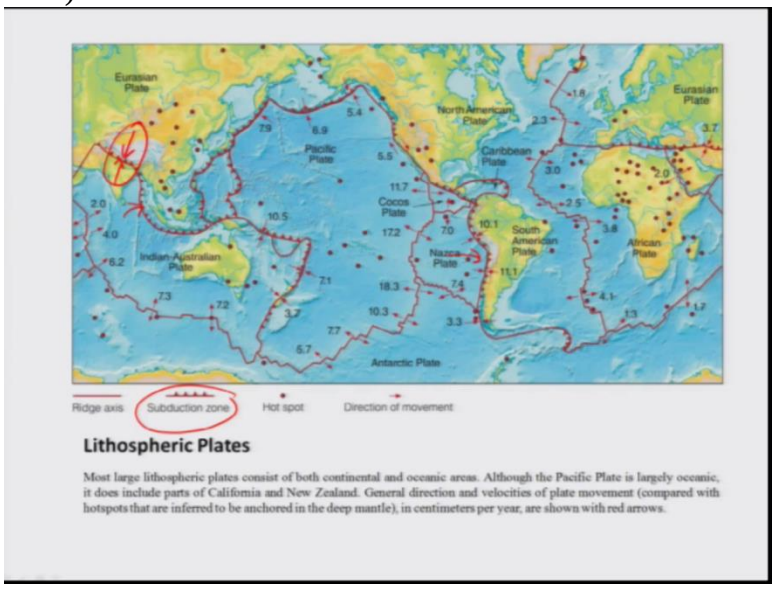

So if we look at the boundaries, we see that they are having like different patterns of either one plate is subducting below the another or in some places what we see is that one plate is colliding with one another. So here, we are having like head-on collision. Whereas here, we see a plate going below this one. So we will see what is important. So we are having a lot of dozens of tectonic plates which are around the globe and which are having different characteristics.

As I told that some are having very similar but some are having different than one another. As in India, we are having subducting boundary but one place we are having collision whereas another plate one plate is moving below the another one. This is what we call the subduction zone here. So we have this subduction and collision in the Indian region. That is the Indian subcontinent between Indian plate and the Eurasian plate.

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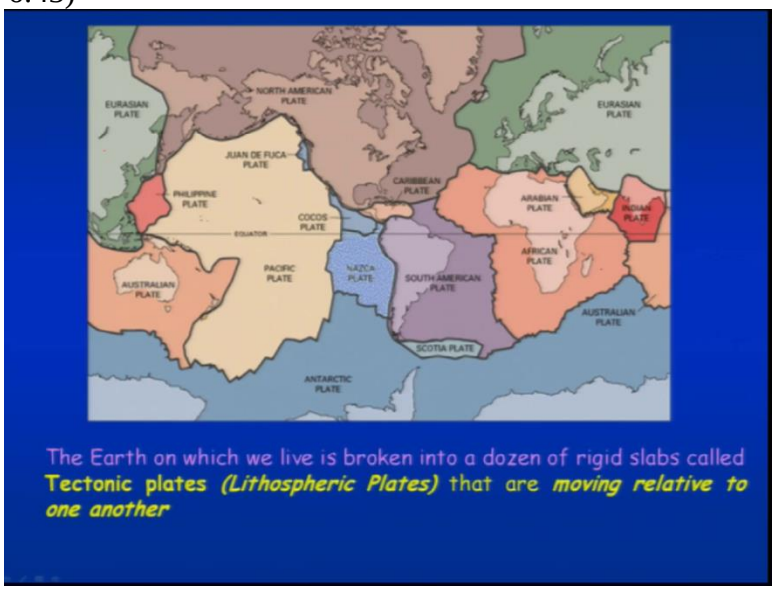

So these are the tectonic boundaries of different plates and what we call as a lithospheric plate that moves relative to one another.

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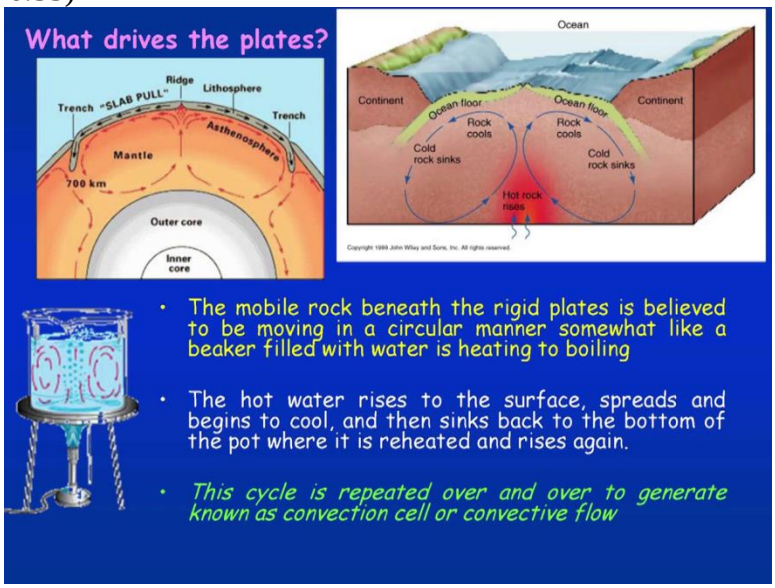

And now as I told, I will talk about that the GPS measurements have helped us in identifying that which plate is moving at what speed and what is the velocity of the or we can say velocity of the individual plates. Now as I was talking about the asthenosphere, it is partially molten and the heat flow basically results into the generation of convections. And this is very much similar to

what we have tried to explain that if you take a beaker and put some water and the soap solution or you can say and then you keep start heating it.

So what will happen? Soap solution, the hotter particles will come up on the top and then they will go down. So they will cool down and then they go again back. So this cycle keep on developing and that is what we call the convection which is developed within the asthenosphere. And this convection, the movement is responsible for the movement of the lithospheric plates. So the mobile rocks beneath the rigid plate is believed to be moving in a circular manner.

Somewhat like a beaker filled with water is heated to a boiling point. So this is very much similar to what I have explained. So this keeps on like moving the tectonic plates on the surface. So both the plates will ah moving, like continental plate as well as the oceanic plates. And this cycle repeats over and over and generates what we call the convection cell. Ok this is like a convection cell or a convection flow.

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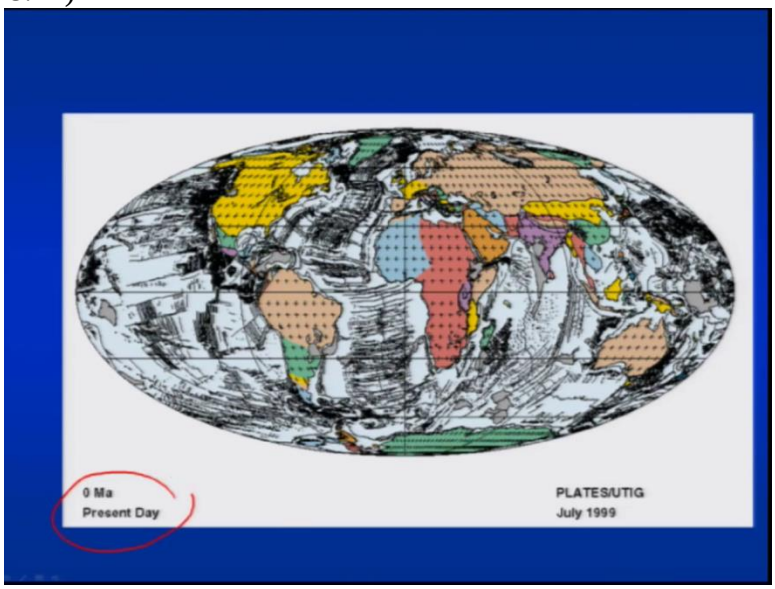

Now if you look at, this is an I do not know whether it will be plate now if you see, I will just go back again. So this side it is having like the time what we are having many years back.

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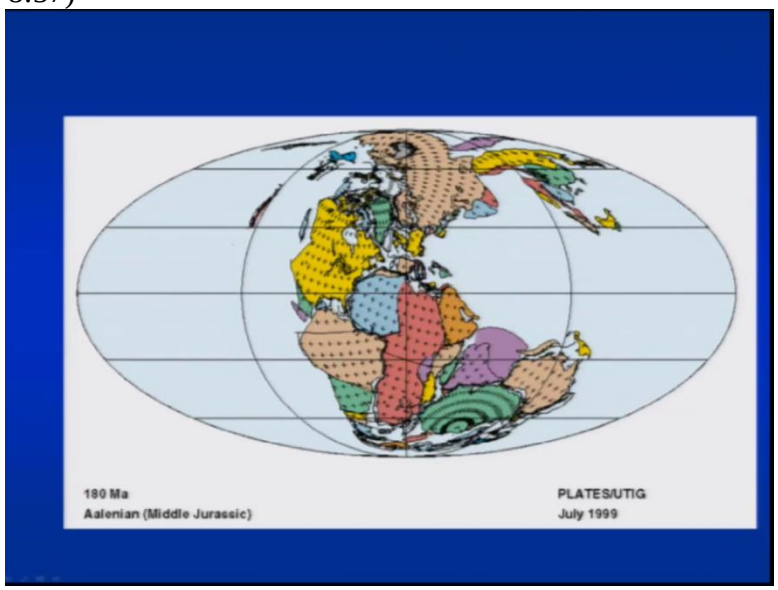
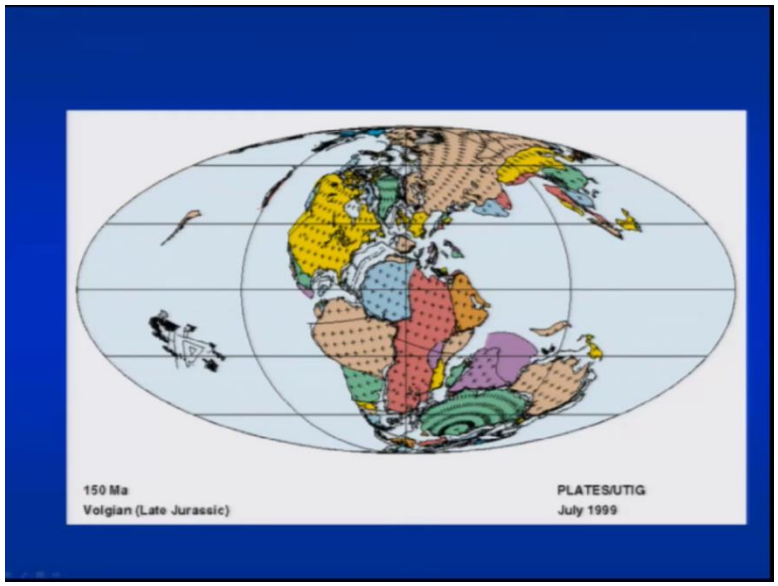
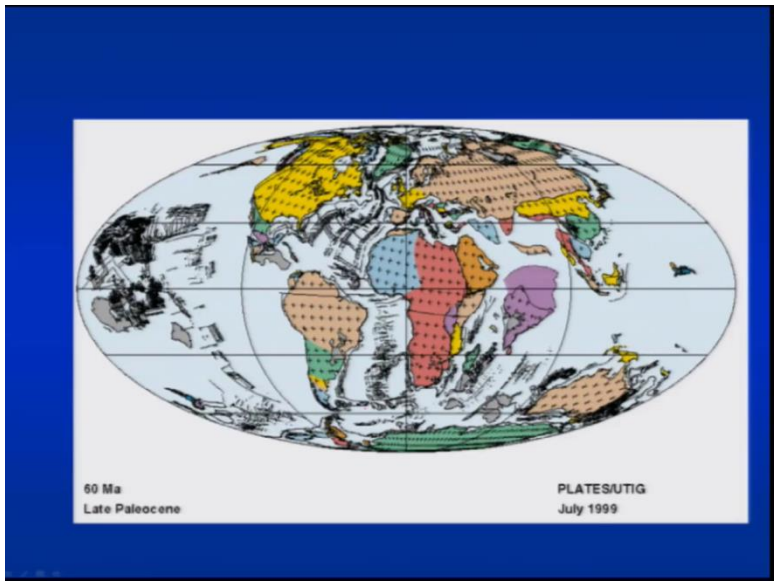
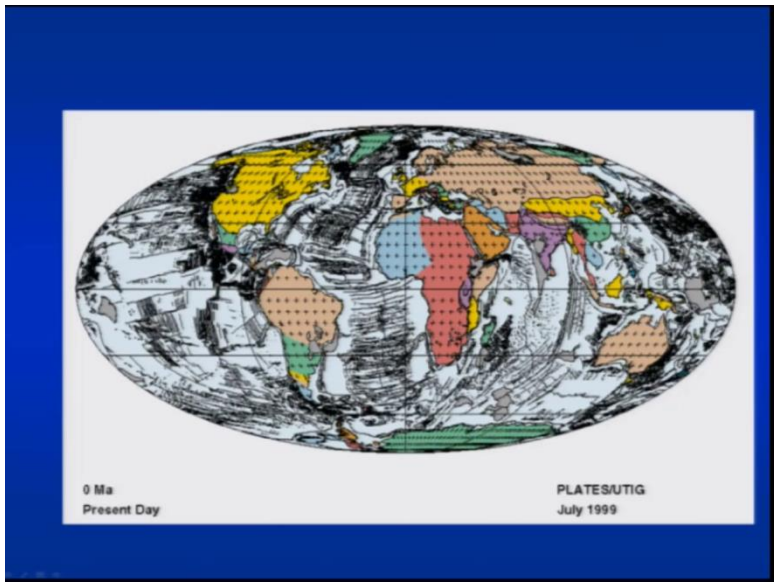





60 Ma
Late Paleocene
PLATES/UTIG
July 1999


0 Ma
Present Day
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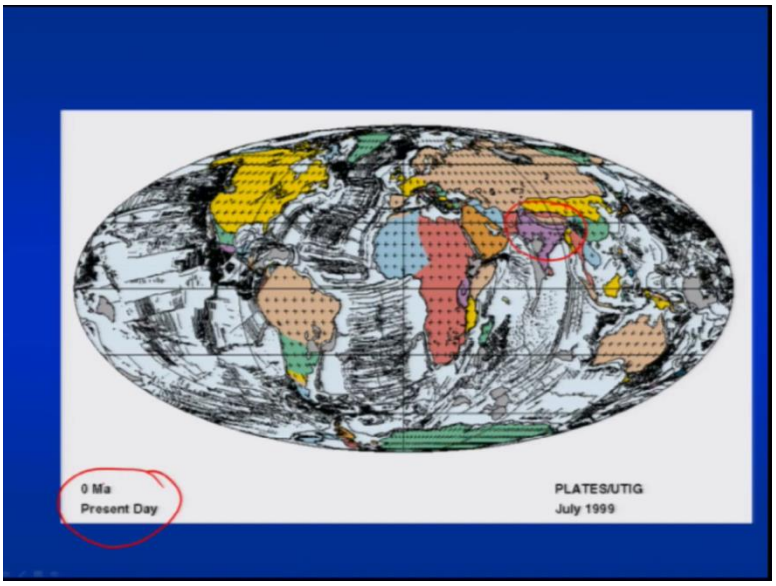

So it talks as 2 million years back what happened and how the different continents moved and what we started getting is if you see here, at the Centre what we started getting the spreading centre what we call the mid-oceanic ridges and all that. And then finally what you look at here that India has collided and this is the present day situation. So this is a schematic cartoon which talks about or which tries to explain that how different continents were together and how they moved.

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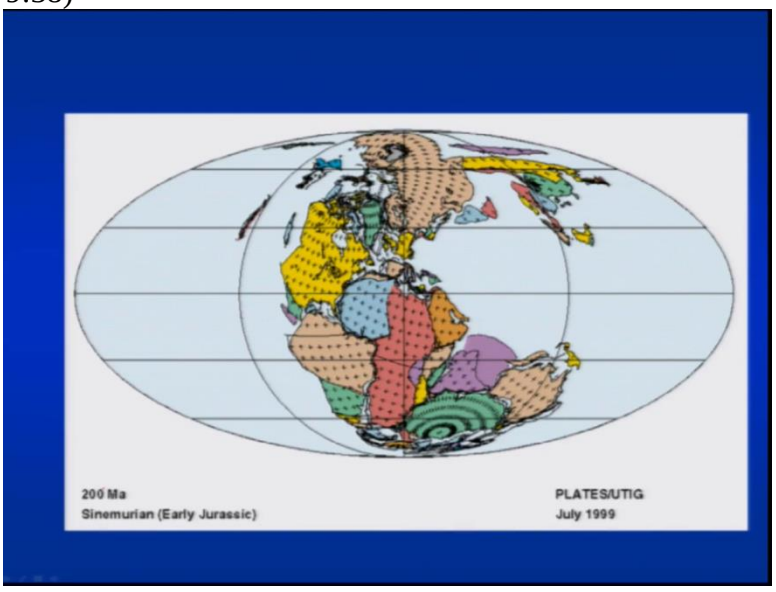
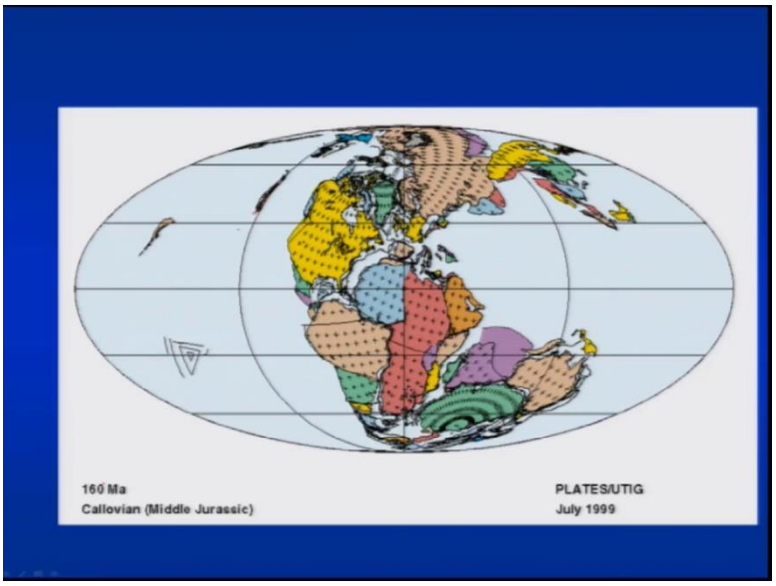
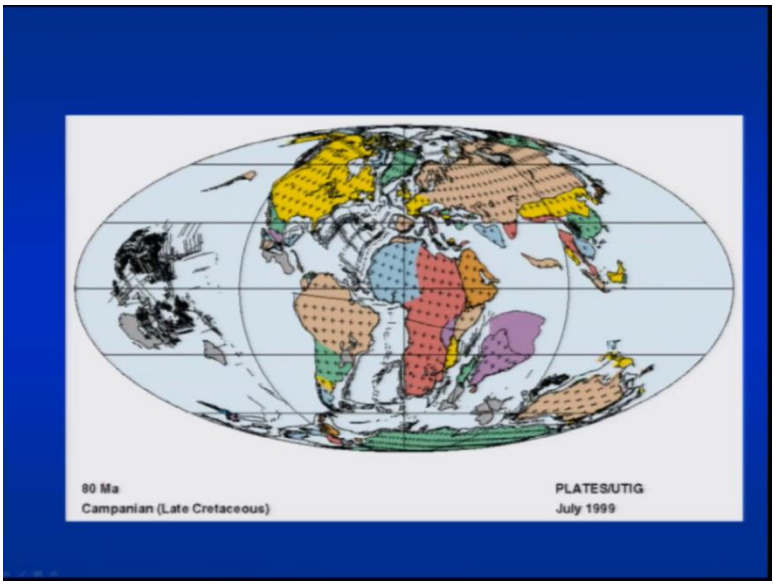
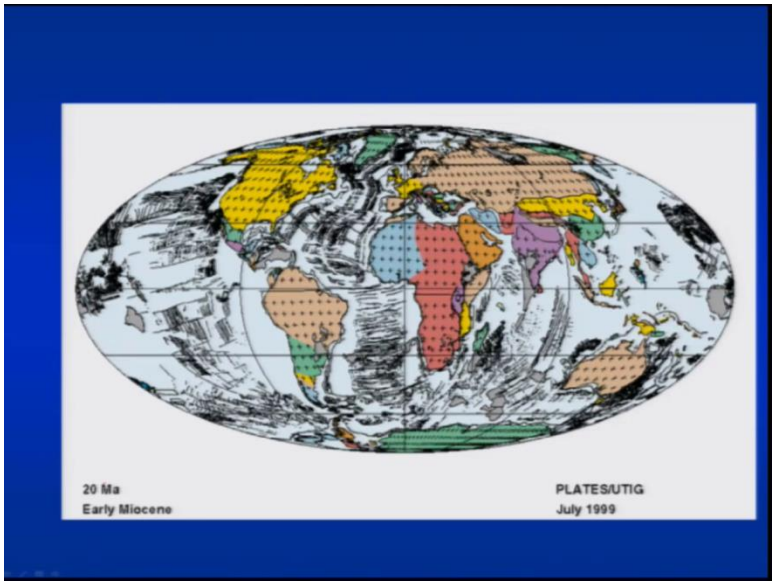



160 Ma
Callovian (Middle Jurassic)
PLATES/UTIG
July 1999


130 Ma
Hauterivian (Early Cretaceous)
PLATES/UTIG
July 1999





So I am just going back. So now we have reached up to 190. And this is 200 million years back what happened. So now 190. And then we are having 180, 170, 160. So it says around 50 to 70 million years back India was very close to the equator and now it has moved farther.

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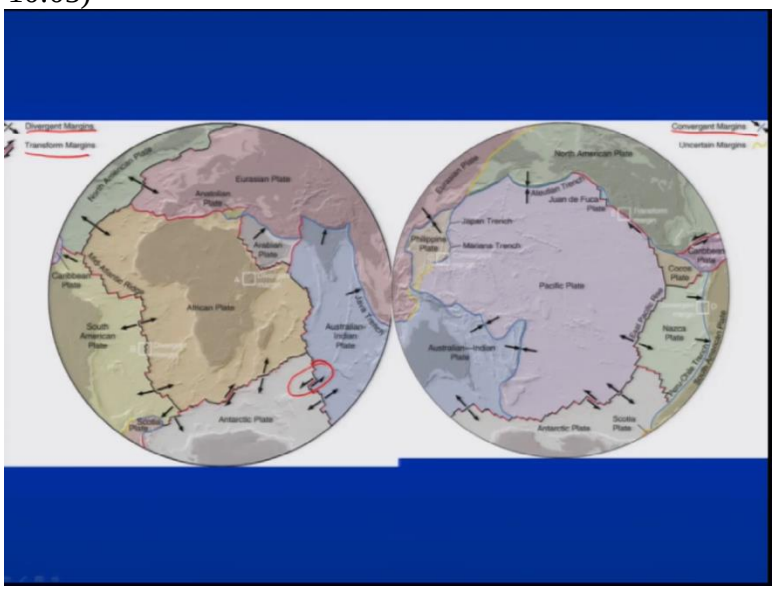

Now these are the 2 diagrams which shows the different type of plate boundaries. So we are having what it says the divergent plate boundary, we are having transform plate boundaries, we are having convergent plate boundaries and all that. And some places, it has not been answered that what type of boundary it is. It is not well studied. So as I told that this we are having, like some spaces we see these transforms. So that is one plate is moving past each other.

So we are having a slip along a particular direction and both the plates will slip past each other. That is what we call the transform plate boundaries. And some places what we are having, the typical collision. So both the plates are coming and colliding with each other. And some places, the heavier plates are subducting below. So we are having this type of configuration.

So when this plates goes down, there will be a formation of mountain ranges on the overriding plate. Of course there will be some sort of a compression which will be taken by the subducting plate but most of the compression will be taken up by the overriding plate. And that is what we see, the formation of Himalaya. 1st there was a subduction and then finally we are having collision between the 2 plates ok. So we will see what is the term which is known as the trenches.

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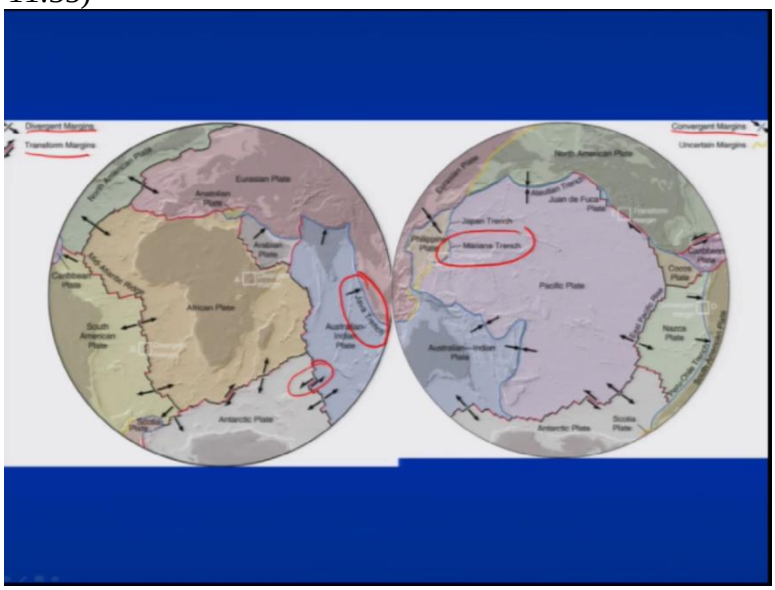

This is again a very much seen where we are having the oceanic plates subducting below the continental plates. And we have one of the famous location on the earths surface, that is the deepest part which we have, we talked in the previous lecture, the deepest part is the Mariana trench. So when we are having the same subducting plate going below the that is the oceanic plate subducting below the another, either it is continental plate that is the overriding is the continental or oceanic plates.

Then there is a deeper part which has been developed here and that has been termed as trench. So that you will find only where you are having the subducting plate boundaries. So we have a close like within the Indian part that is the Sumatra Andaman trench we have which resulted into the formation of tsunami and this is because the ocean is present in the along the boundary. So that resulted into the formation of tsunami and all that. We will talk about the tsunami later.

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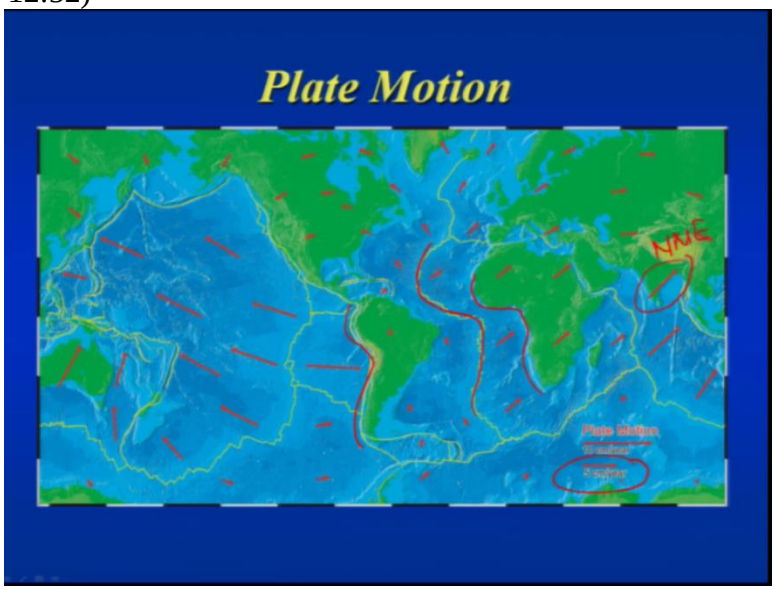

So then that is what I was talking about and the plate motions now. So with the help of GPS, we can make out that which plate is moving a which direction and what is the motion that is the speed? Like, what is the rate of the movement? Like if you look at here, India is having the rate at around maybe that is definitely more than 5 cm. So it is around 55 mm, 45 to 55 mm per year. And if you see the direction of the Indian plate, it is almost like North East.

It is moving in this direction and it is colliding with the Eurasian plate. Similarly, some vectors if you look at of the plate motion, they are very much much higher. So higher the motion, you may have more earthquakes along the plate boundaries. Like this is having more than 10 cm, around 10 cm or so okay.

So the another part which is very much important is that wherever these boundaries are. So if you look at these boundaries, this one, this is a midoceanic spreading centre and we are having the boundaries here. Then we are having the boundaries here.

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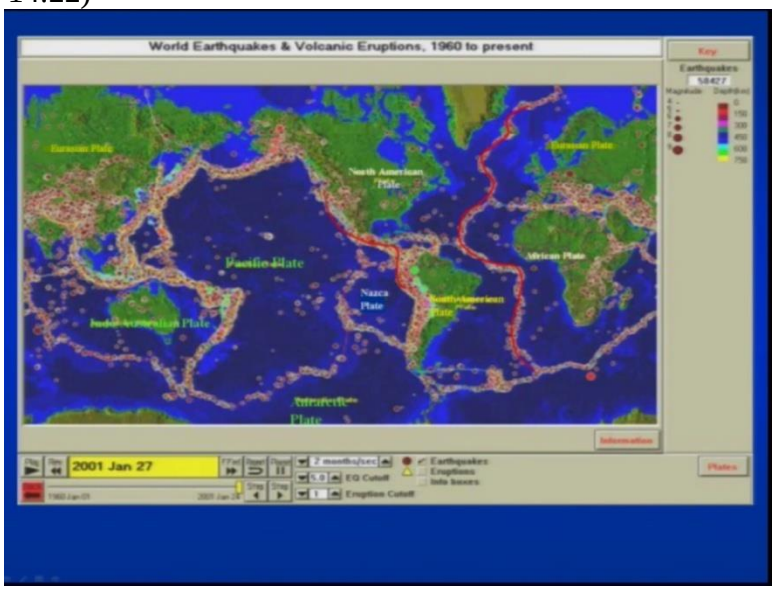

Now this all if you look at from the earthquake perspective view, what you will find is that the earthquakes are almost aligned along these plate boundaries. Or low magnitude earthquake, smaller magnitude earthquakes and the larger magnitude earthquakes are aligned along the plate boundaries. So you can easily mark the plate boundaries here. I am sorry, this is not the boundary here. But of course, there is some tectonic movement which has been seen between this plate and the African plate.

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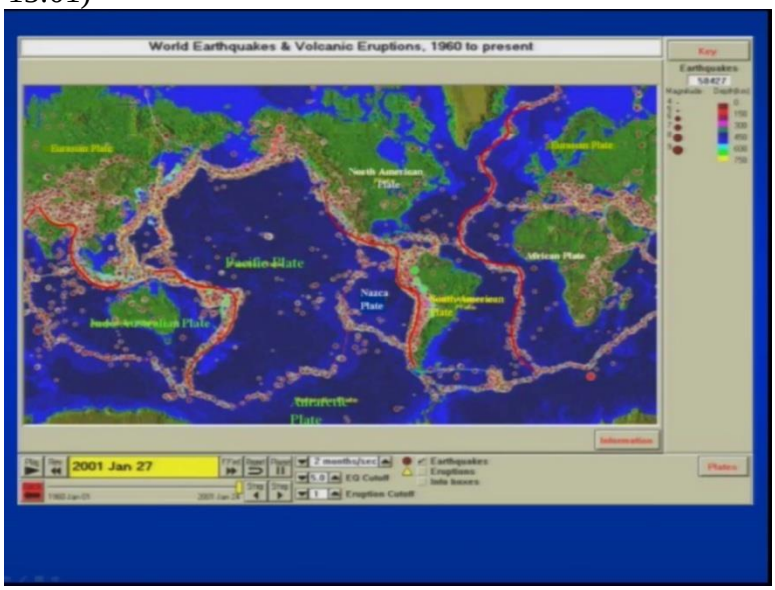

So if you look at the pattern it explains that there is some contact between the 2 plates and India is sitting somewhere here. So we have this plate boundary which is going like this over here.

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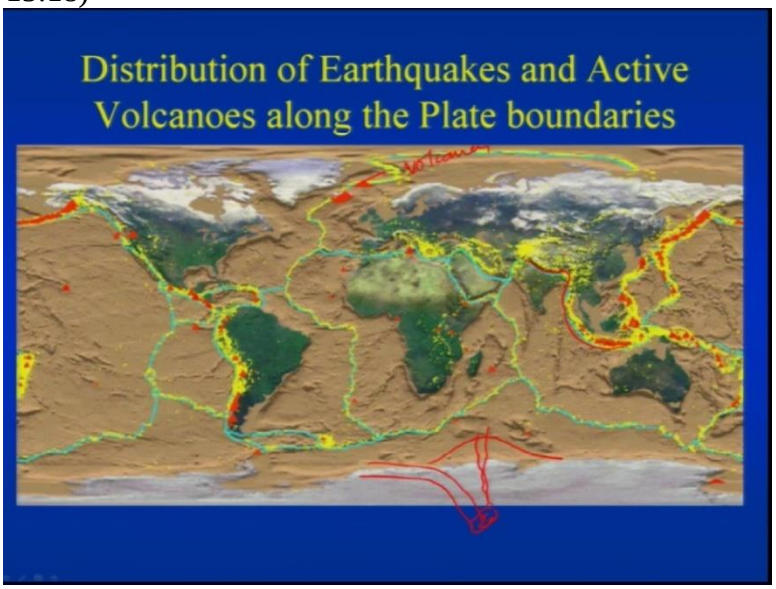

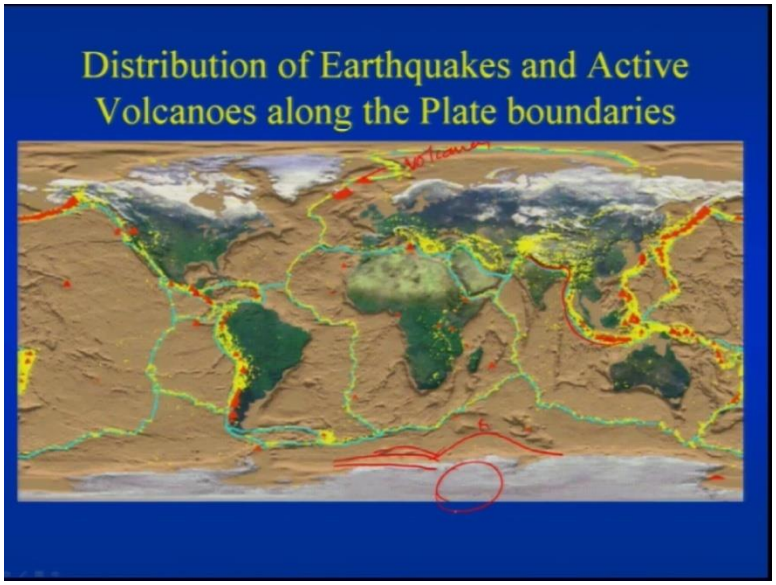

And along with this if you look at what we are able to locate is that what has been marked here is the yellow dots are all earthquakes which are aligned along t6he plate boundaries and the triangles, triangles are all the volcanoes. So we are having volcanoes which have been marked by the triangles. Now even though we defined this in subduction plate boundaries and many locations, like this has been termed as a subduction plate boundary.

But you soon only see the volcanic eruptions which are being confined here. You do not see the volcanoes here. No volcanoes have been seen here. So you only have volcanoes in the region where we are having the oceanic plate subducting below. Because volcano is the source or the material which comes out through volcano is your molten magma. So unless and until you will not put the plate below like for example, you are having the plate which is going down here and you are having the overriding plate here, so this will melt, the rocks will melt and then you will have a volcanic eruptions on the surface.

But if you are not having this plate below then you may not have. If your plate is not going down and it is just colliding here then there is no material which will be melted and no material will come up. So that is the one of the reason why you do not see volcanoes between the Indian plate and the Eurasian plate and many other places. Over here also, you do not see the volcanic eruptions.

But the volcanoes are only aligned along the plate boundaries where you are having the plates which are going down and then getting melted. So this is another important part which one should remember. And as we move ahead in this lecture, we will talk about that how this plate boundaries, which plate boundaries are more dangerous in terms of the hazard as compared to the another one.

So we have like so different like subduction zones and we are having the continental collision zones and all that. We will talk about that. So please remember this part that the volcanic eruptions or the location of the volcanoes are only confined along those plate boundaries where we are having the plate subducting, one plate subducting below the another one. Either it may be a continental continental, sorry oceanic continental or oceanic oceanic if we are having, that does not matter.

But if there is no supply of the plate which is going below into the deep interior of the Earth, no volcanic eruption will be found or seen there.

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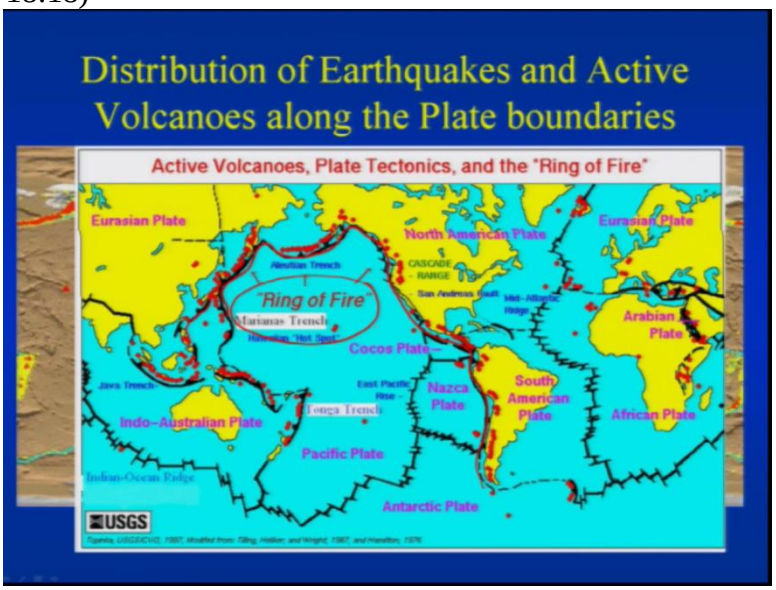

So this figure which shows about the concentration of volcanoes in this area , that is this is the Nazca plate and we are having South American. So we are having boundary here. So we are having the align, volcanoes which are aligned along this area. And then we are having this part also. And this region that is why has been termed as the ring of fire.

So where we have the volcanoes which are surrounded along the plate boundary. This is the area. So the ring of fire is where the Pacific region, mainly the Pacific region we see the ring of fire.

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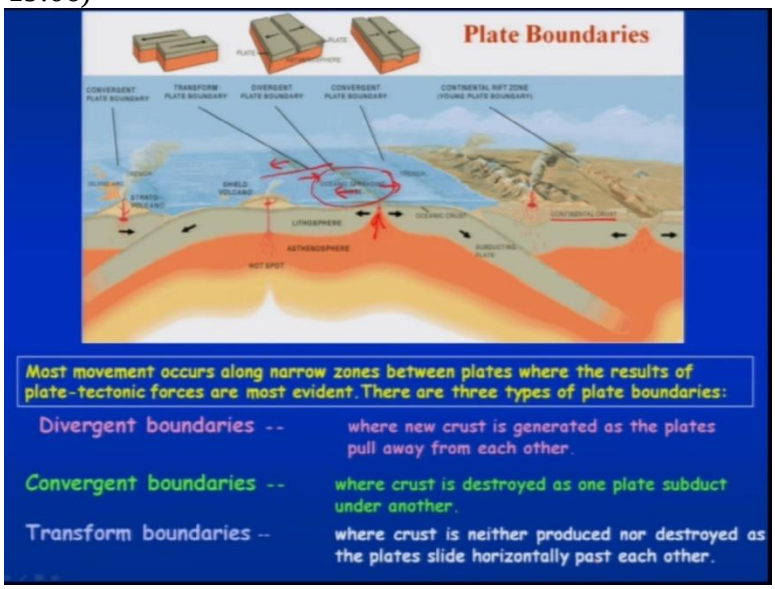

Now continental if we take the plate boundaries, we have in short 3 plate boundaries. We can have, we can say that 3 major plate boundaries are there. One is divergent plate boundary. Now the divergent plate boundaries are where new crust is generated. This is a divergent plate boundary. So where always a new crust has been generated because of the rising of magma.

So these are being termed as, also being termed as the constructive plate boundaries where we are having the new generation or the new formation of the plates the lithospheric plates. And then we are having, so here is both the plates will move part or away from one another and the magma keeps on rising on the surface, cools down, forms the crust and moves away from the spreading centre.

Then we are having convergent plate boundaries where the crust is destroyed as one plate subduct under below the another one. So these are the destructive plate boundaries or what we call the convergent plate boundary. So one plate is moving below. The another one is overriding. So as I told that this could be, the divergent plate boundary could be between the oceanic and continental crust or we are having both oceanic crust and oceanic crust here. So that depends on that.

And because of the subducting plate, as it moves below, melting will start and we will have volcanoes on the surface and here also similar what we see, the volcanic eruptions on the surface. So this is a very important part which we should remember. So we are having the 3rd one is the transform plate boundaries where the plate will just move, slip apart from one another. So this is with what we call the transform plate boundary. So these are not very dangerous ones.

So here where the crust is neither produced nor destroyed, nothing will happen much ok. Or just they will slide past each other. They will just move with respect to one another here. So not much will happen here in this region.

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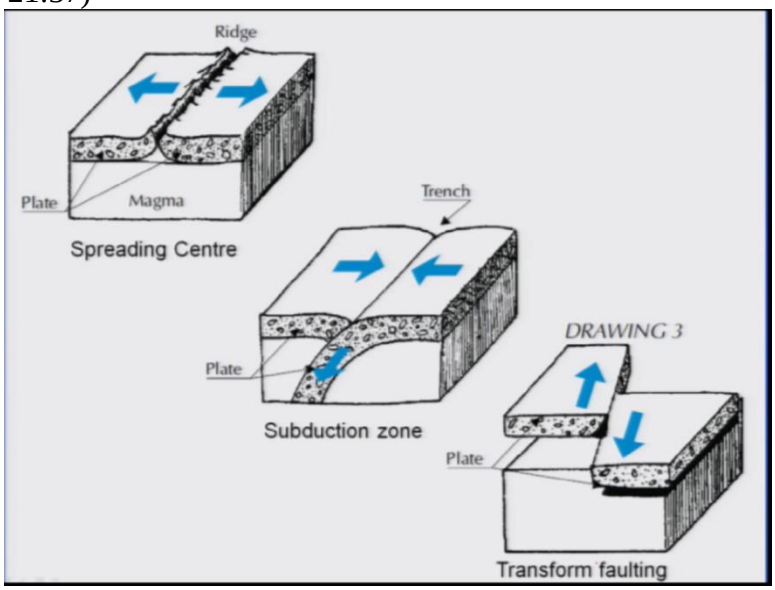

So in short if you look at what we see is the spreading centre. We have subduction zones and we have transfer zones in terms of the plate boundaries.

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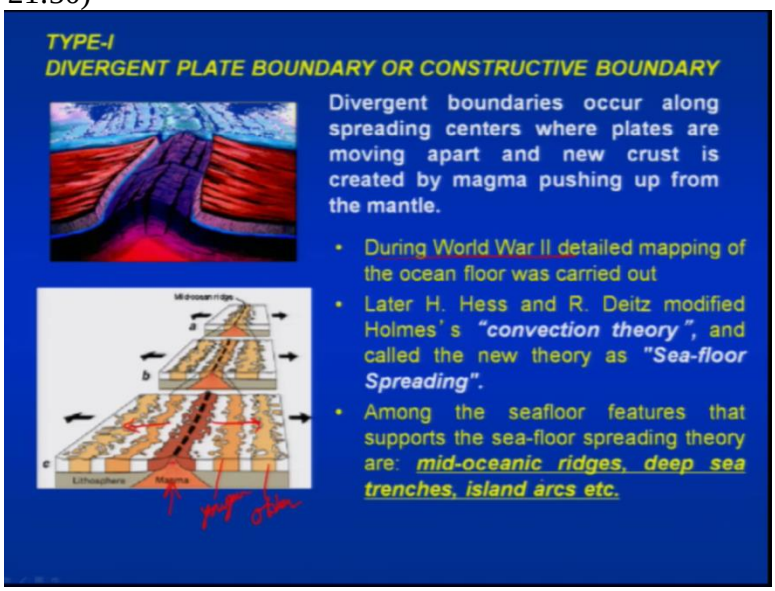

Now the divergent plate boundaries, this is what happened and then in this had been identified long back, almost during the Second World War. A detail mapping of oceanic floor was being carried out and they found that there are some plates which keep on having the different anomalies and if we move away from those, that spreading centre, we have different anomaly.

And what they found later on was that the lithospheric portion which is seen or which is found away from the spreading centre are older.

So these are older ones and these are the younger ones. So which are closer to the centre are the younger ones and which are away from the centre are the older ones. So that is how they tried to understand that whatever is being generated here is the new crust which is forming and slowly they are moving away from one another. And these are the regions where we call, we have termed as the mid-oceanic ridges.

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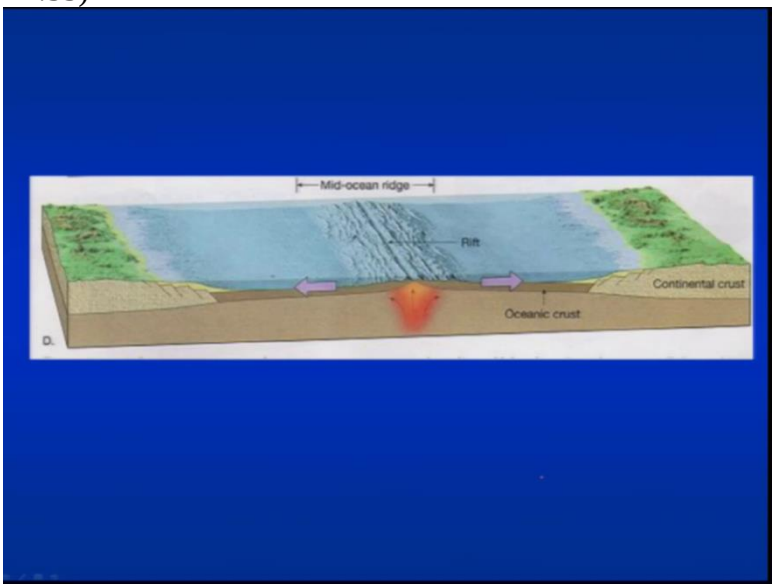

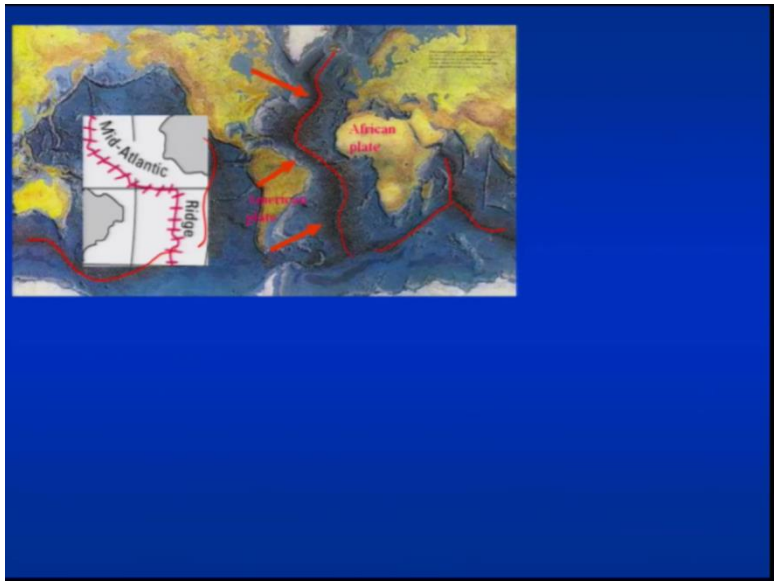

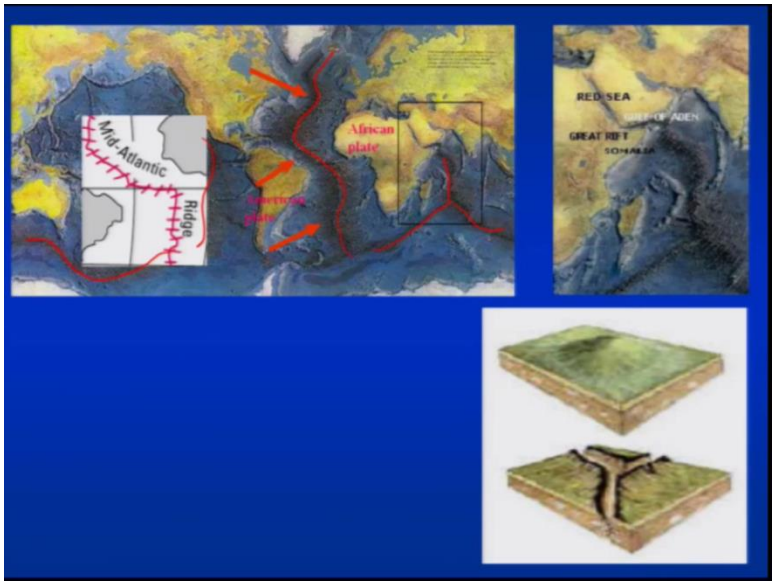

This is almost a similar one. So we are having the spreading centres which are being lined up here and very long which is almost like encircling the universe. We are having this one. So mid-Atlantic ridge. This has been termed as mid-Atlantic Ridge. Now looking to this part, I will see that how the few examples of the triple junction also.

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Now this is what is the triple junction. We are having the 3 plates which are moving apart from one another. And then we are having a very well-developed rift zone which is again what we call the areas which were which are drifting away or drifted away from one another resulting into the formation of valleys.

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So if you look at this part particularly in this region, then we will be able to see that what has happened?

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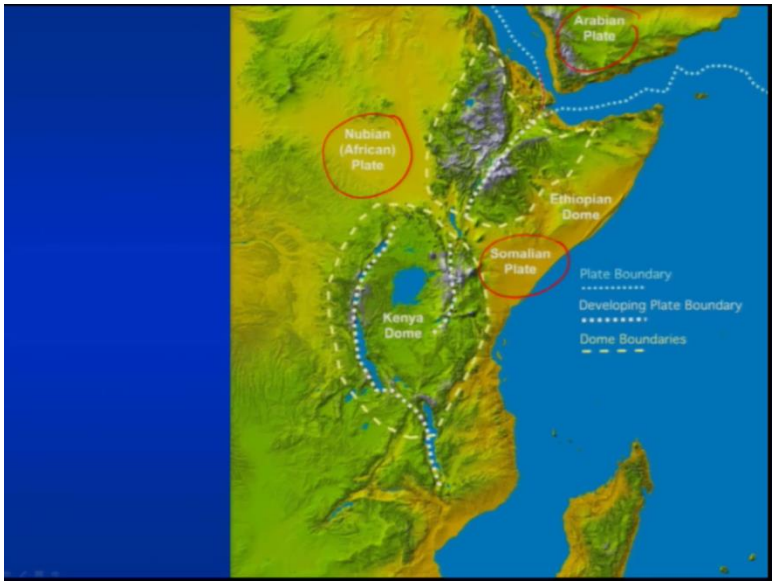

So this is the area of again the plate boundaries where we are having the Somalian plate and then we are having the African plate and then we are having the Arabian plate. And this location has been what we are having the triple junction.

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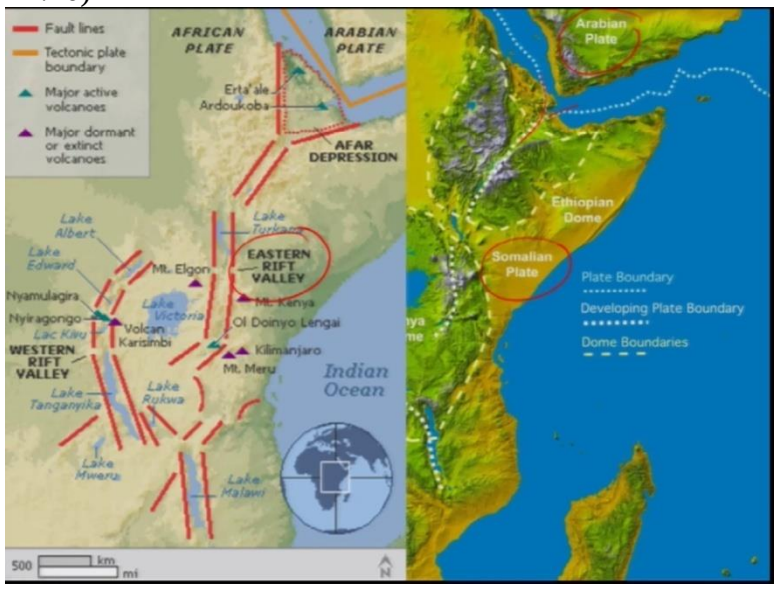

And the portion which has been seen here that is on the eastern side of the African plate is the rift Valley, Eastern rift Valley along the eastern side of the eastern side of the African plate.

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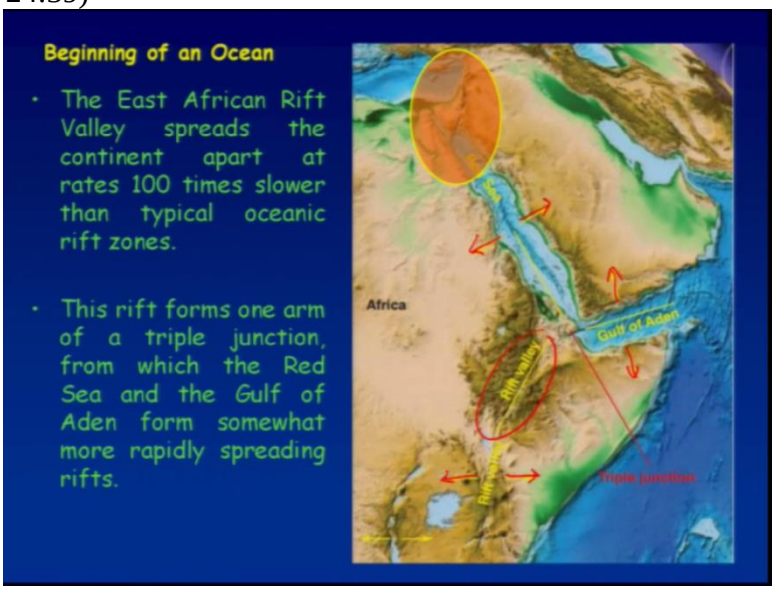

So this is what has been explained as a triple junction. So we are having the 3 plates which are seen like coming closer or or were near to each other and we are having the different like extensional areas. We are having this. If you see the rift Valley here, this rift Valley is, the land is moving apart from each other and here also, these plates are moving away from one another and we have opening which is developing.

So this region will keep on growing. Gulf of Aden or the Red Sea region are growing and widing up as the plates are moving away from each other. So East African Rift Valley spreads the continent apart at the rate of around hundred times slower than as compared to what typically what is seen in the oceanic rift zones.

That is oceanic rift zones of. So this rift forms one arm of the triple junction, that is this one. That is the Red Valley sea and the Gulf of Aden forms somewhat more rapid. So these are moving a bit comparatively more rapid as compared to this one. Now coming to this, because of the tectonic configuration over here so let us discuss this part in the next lecture. So I will stop here. Thank you so much.