Introduction to Engineering Seismology
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Lecture - 06
Plate Tectonics

Vanakkam. So we will start the today lectures. So last class I told you to check that there is a possibility of earthquake at particular location or there is a place where there is a free from earthquake. So I hope most of you might have come with answer yes or no. So according to my understanding of the earthquake and then elastic rebound theory, okay. So none of the place in the world is free from earthquake, okay.

So that means, throughout the world you can expect a earthquake. Only thing some places it may be frequent, some places it may be infrequent, that is all. It may take short time to occur at some place, long time to occur at different place. In some place if you see that in the historically there is no record, which means that, that earthquake was not noticed by the human being or not recorded by the equipment.

This is the only reason, not because of the nature okay. So that means throughout the world, each and every inch of the place is expected to have a earthquake, okay. So that means you have to understand the earthquake and try to predict that hazard so that you can minimize a human loss as well as the economical loss. Somebody says last 100 years, 200 years they do not have earthquake in the particular region.

It does not mean that there is no earthquake going to occur. This earthquake might have occurred before that. That was the scenario. So we told in the elastic rebound theory that the plates okay so the rock will undergo a strain storing due to the bending action and then it releases and then that breaks and releases that causes a earthquake. So we will see today class okay so where and all the major earthquakes are occurring?

What is meant by the plate tectonics? How they come to conclusion that these earthquakes are occurring and causing a plate breakage okay by locating the continent, okay. So that is what we are going to do in the today class.

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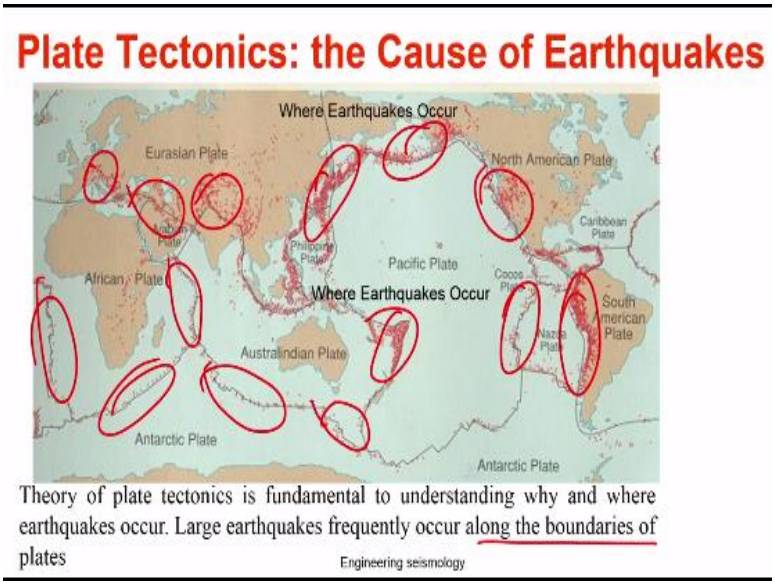

So if you look at this map, okay. So if you look at this map so all of you might have been studied in your schools the tectonic plates, okay. The major tectonic plates, a seven tectonic plates, you can superimpose the earthquake data collected by the human being. I am telling that the earthquake data collected means there may be earthquake which may not be collected by the human being, which is we are not concerned right now.

We only take the earthquake data which collected by the human being and superimpose on the tectonic, okay seven tectonic plates in the globe just to superimpose those earthquake and try to see. So you can notice that majority of the earthquakes are occurred on the boundaries, you can see here. You can see the majority of the earthquakes are occurring on the plate boundaries.

So as we have seen that the breakage and release happens on the weaker zone faster than the stronger zone. So generally if there is a plate okay, so the edges will be the more fragile and more weaker than the middle of the plate. So if you take a small metal piece, if you want to break a metal piece or if you take a biscuit, if you want to break it will be very easy to break a edge part than the middle part.

The same thing. So because it is a very fragile, the frequent release and breakage happens at joints of the plate, okay joints of the plate. That is why you will get a more earthquake in the joints. This joint may be below the ocean or in the surface it does not matter. As a earth this is the crust connected by the different plate. So that the

theory of plate tectonic is fundamental to understand why and where earthquakes are occurring.

The large earthquakes are frequently occurred along the boundaries of the plates, that is what we have seen.

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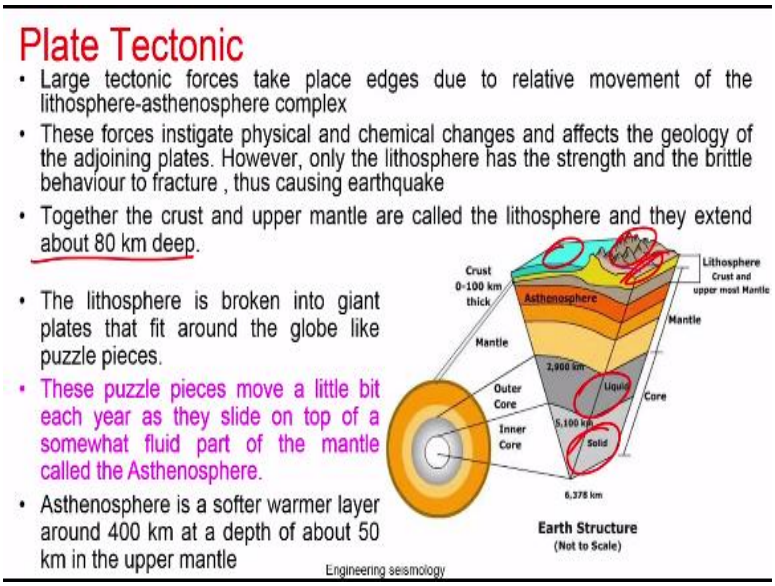

So the plate tectonics so if you see the plates and then cut a cake as a earth as a piece and try to understand the entire section up to the interior of the earth, you can see that the top portion we told that is a earth crust which is like lithosphere and then upper mantle also combination is called as earth crust, which consists of the sea, mountain and land is called as a earth crust.

So the followed by this earth crust basically varies thickness from 0 to 100 kilometer, okay. So where generally this called as a earth crust. Some of the places it is very thick, some of the places it is very thin. So the another one is the asthenosphere which is below the earth crust and within the mantle. You can see that mantle is divided as a three segments. Then followed by the outer core, which is classified as a liquid.

Then the inner core which is classified as a solid. How they classified we will discuss in the wave propagation. After wave propagation we will see how these people become come up with idea which is liquid, which is solid based on the seismic records of the different places. So the large tectonic force take place edges due to the relative movement of the lithosphere and asthenosphere complex.

These forces are instigate physical and chemical changes and affect geological and adjoining place. However only the lithosphere has strength the brittle behavior to fracture causing a earthquake. Together the crust and upper mantle are called as a lithosphere. They expand up to a depth of 80 kilometer, okay. The lithosphere broken into giant puzzle that fit around the globe like a puzzle pieces.

These plates are connected as a puzzle piece in the globe. These puzzle pieces move a little bit each year as they slide on top of somewhat fluid part of the mantle and called as a asthenosphere. So these puzzle pieces are sitting at the fluid part of the earth. That is why it is keep moving and each direction depends upon the position and this one.

Asthenosphere is softer warmer layer around 400 kilometer at a depth about 50 kilometer in the upper mantle. So basically the plates are sitting on the asthenosphere. So okay, so asthenosphere is about 400 kilometer a liquid form of material okay so when compared to the surface material.

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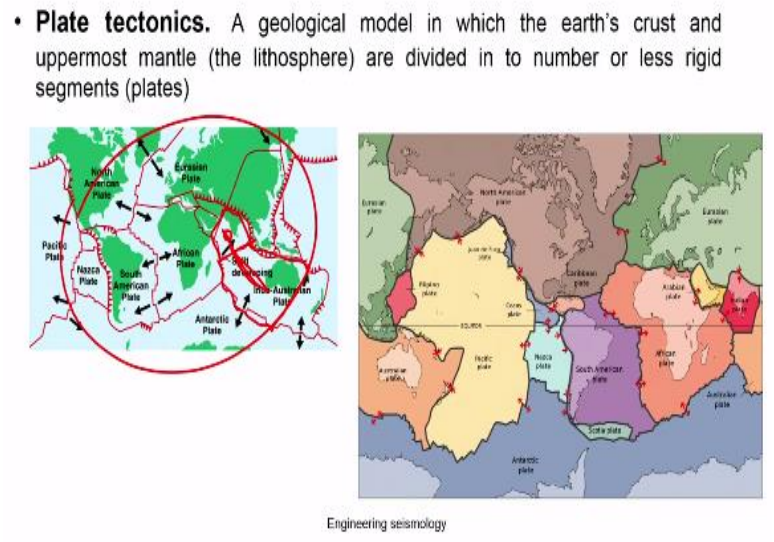

So the plate tectonics a geological model in which the earth crust and upper mantle are divided into number of and less rigid segments is called as a plates. So these are all the understanding of this part is called as a plate tectonics and see how the joints of the plates are there. So how the each plate interior. So here you can see that one is the

any place you will have the boundary of the plate and then you will have the interior of the plate.

So these are all the boundary of the plate, okay. So this is a major tectonic seven plates. So if you go to the smaller minor level, if you superimpose each plate with respect to the country you can see which are the countries where it is located. You can see where is India. So India is basically here. Okay, this is the smaller division of the plate. Basically these two are called as a single plate okay.

This is a small division. So this is the Australia. So this is the entire plate and this is actually the South America, North America that plate. This is the African plate where the Africa major part of the Africa is located. So the names respective names and all. So anyway these things you might have studied during your school days.

But still you can recall so that whenever we talk about some earthquake, you should know that this earthquakes are plate occurred on plate boundary or interior of the earthquake, interior of the plate.

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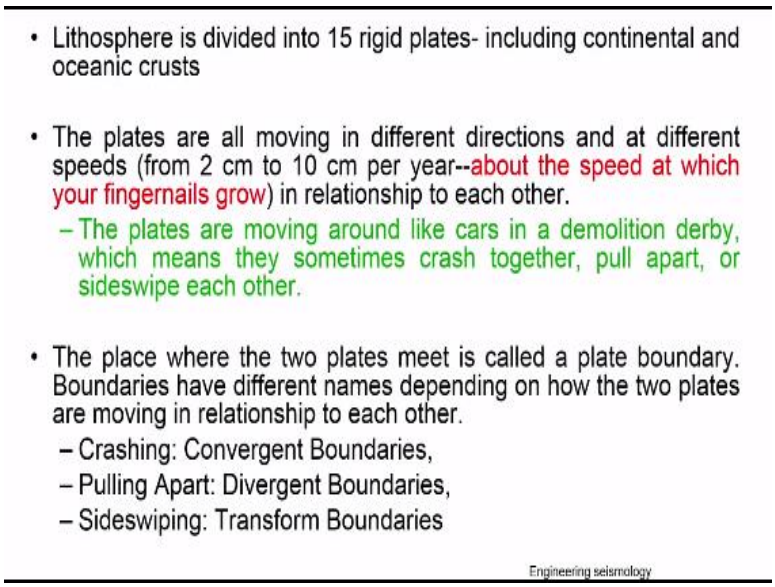

Lithosphere divided into five rigid plates including the continental and oceanic crust which we have seen as a smaller size on the right side image. This is basically a 15 plates. So then the plate that are moving different direction at different speed, okay, about speed at which your fingernails. So the plates are moving at a speed at which your finger nail grows, okay.

So your fingernails basically if you cut without I mean if you leave the fingernail without cutting you can see that it can grow up to 10 centimeter per year okay. The similar speed the plates are moving. So because of that only you could not able to see how the movement, feel the moment by yourself. But if you have the very sensitive equipment it will record how much it is moving.

So I do not know how many of you know that there is a global setup to know the plates movement in the world. That means they identify the crust rock not a soil, crust rock projected in the ground. And then they place a instrument there and communicate with the satellite and measure a position of that particular instrument every minute. And based on that they can estimate how that particular plate is moving, okay.

So you might have come across that the Indian plate is moving 5 centimeter per year something like that. So that was measured by installing this kind of equipment. For your information such kind of instrument plate moving, detecting a plate moment is installed at one at IISc close to swimming pool, okay. So in IISc campus, there is a rock outcrop okay which is from the crust that rock, so where this instrument is installed.

So where this is keep on monitoring the movement of the plates in the particular this one. The plates are moving around like a car in the demolished debris. So if you have the demolished debris if you put several car there, okay and start and leave it without driver this car will move its own direction depends upon the speed of the car and base of the wheel where it is located.

So it may sometime hit each other and pull apart and slide like that. So that kind of things are happening with respect to the movement of the plate. That means the movement are not in the one direction, okay. The movements are in opposite direction or it is parallel direction or it is together or hitting together that. So if you want to see that really you can start a car 5, 6 car and put it on the debris.

Debris means it is like the demolished waste dumped place. Then you can leave it and then you can see how the cars are moving. You visualize that. That is the way how our plates are moving. So that movement is basically causing a stress to the material in the plate. That stress is keep on accumulating. When it exceed the strength of the material, it breaks and releases the energy that is causing a earthquake, okay.

So now from this movement of the plates, we can make this as a three major category. So the plates where the two plates are meet is called as a plate boundary. The boundaries that different name depending upon the how the two plates are moving in relation to each other. So we can divide this as a three major category. One is that crushing and pulling apart and side away.

So like we said that the car hit each other or go each other and slide each other. So that respectively we call it as a convergent boundary, divergent boundary and transform boundary. The plates are hitting each other that is called as a convergent boundary and pulling each other apart that is called as a divergent boundary. The sliding each other is called as a transform boundaries.

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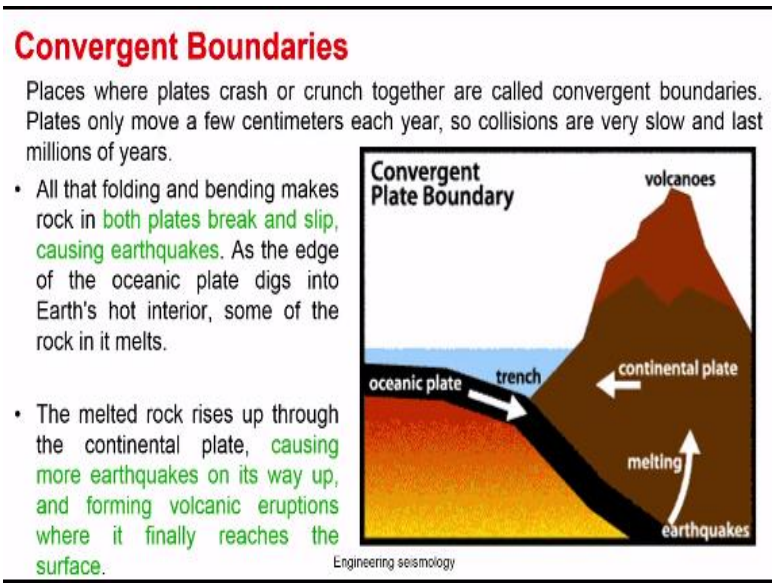

So this is very important to know how the earth surface is formed and how the plates are moving. The convergent boundary means basically a one plate. So one plate goes below the other plate or the both of them hit and grow okay. So those kind of plates are called as a convergent boundary. So the convergent boundary basically the one

plate goes below the other plate and that may be a oceanic plate or the continental plate.

So some time the oceanic plate will go below the continental plate. Sometime the continental plate goes oceanic plate. So because of that there is a consumption of plate. Like because the one plate goes on other plate there is a loss of land, okay. There is a loss of land. So and then if there is a this or very thin and it has a cracks where you can also expect a volcanic activity on those joints.

So wherever the volcano is there basically those places this plates are basically so hitting together and joining together. That is why the magma is coming which is below the crust, okay. So all the folding, bending rocks in both plate breaks and slips and causing a earthquake. As the edge of the oceanic plate reaches the earth hot interior some of rock is melt.

The melted rock rises up to the continental plate causing a more earthquake on its way and forming a volcanic eruption where it is finally reaches a surface.

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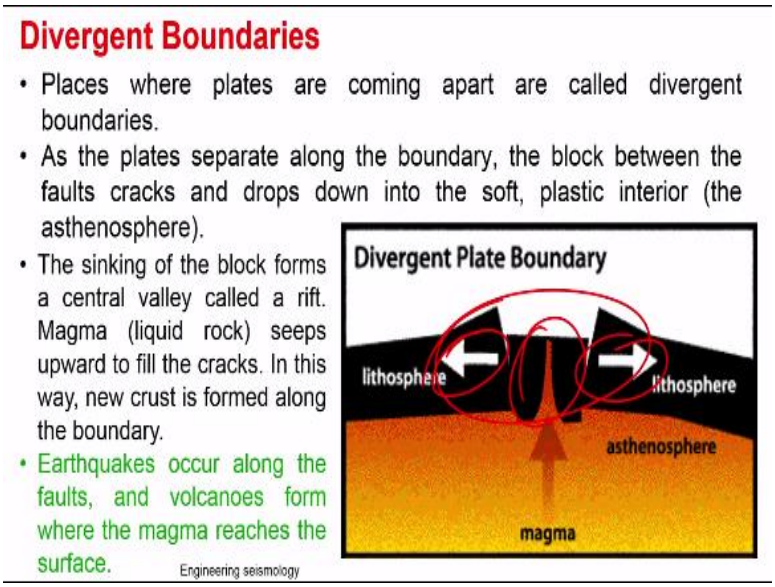

So the another one is divergent boundary. As we said that in the convergent boundary, there is a consumption of lab, consumption of space. One plate goes other plate. That means there is a consumption of the space with respect to the earth area. So then it has to be released at some place, correct? So that happens at divergent boundary. So divergent boundary what happens, the plates are getting separated, you can see.

So it get separated and then magma comes up and cooling down and forming a land. So in the convergent boundary the land is consumed, in divergent boundary new lands are formed. So where you can see the large new land formation and also the volcanoes in the divergent boundary. The earthquake occurring these two this kind of activity is called as a divergent boundary earthquakes, where the plates are get separated and new land is formed.

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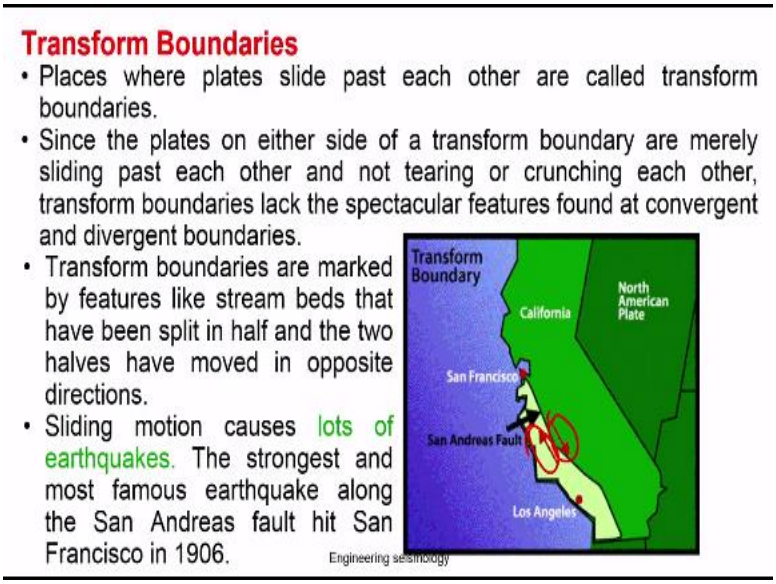

So once the formation and then the consumption is taking place the other one should have nothing. So that is called as a transform boundary. In the transform boundary plates only moves on each other with respect to horizontal and it does not consume a land or does not create a new land. That kind of boundary is called as a transformed boundary.

The San Francisco and San Andalusian fault is the one of the classical example of transformed boundaries. So in 1906 there was a big earthquake in the San Andreas fault, okay. So the many people died I told that fire was one of the major concern. So after that the San Francisco government San Francisco district they have taken lot of initiative to educate a people, even through movies.

So you might have seen that there is a movie called Quack and also the movie called San Andreas. So something like that there is a movie related to this particular earthquake hazard resulted on this region and related some stories. So those if you had

a chance, you can watch those English movies where you can see how the consequence of earthquakes. How different hazard are caused by the earthquake.

How people are suffering, okay. So I do not know how many of you experienced earthquake. So if you experienced some natural hazard is basically you will get a very good memory of life. You understand what is a life basically if you experience a natural hazard. But is very unfortunate because you will sometime die also. You get injuries, permanent injuries or loss of leg and hand.

One should not experience any earthquake or any natural hazard in their life on the larger scale particularly deadly one or disastrous one we should not experience. So to teach the people even those kind of movies are there. So as on now India there is no movie explicitly says about the Indian earthquake and its consequences except Dasavatharam movie by Kamal Hassan.

Where he shows tsunami basically rises to basically to kill some of the virus. He does not show the impact of that tsunami. But at least somewhere he brought that tsunami into the movie.

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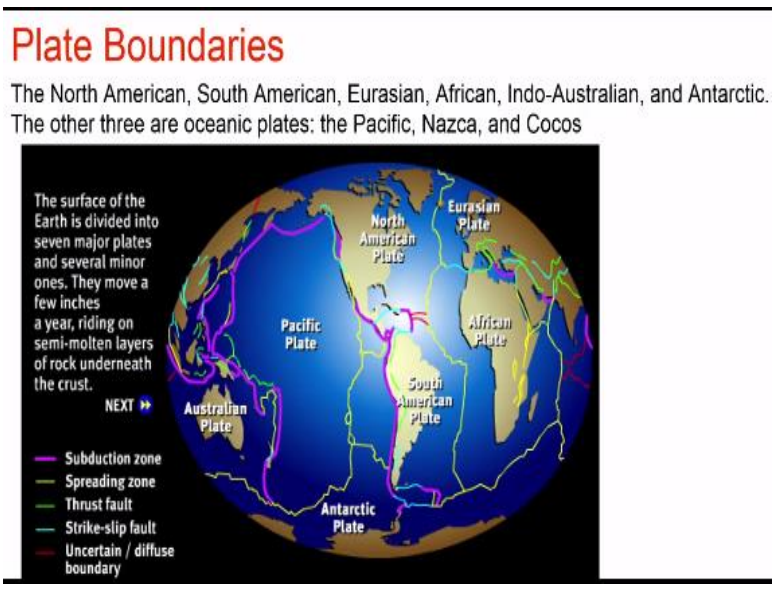

That was maybe the one of the movies as per my knowledge, maybe there may be. So if you look at the entire globe okay, how this earthquake boundaries are distributed. You can see the all the boundaries like subduction, spreading, okay. So the thrust and

strike-slip and underlying. The spreading is basically divergent boundary, okay. The convergent boundary is subduction, okay.

So the trust and strike-slip basically is the transformed boundary kind of thing. Sometime this subduction and convergent okay divergent and convergent also in the trust form region it will come okay.

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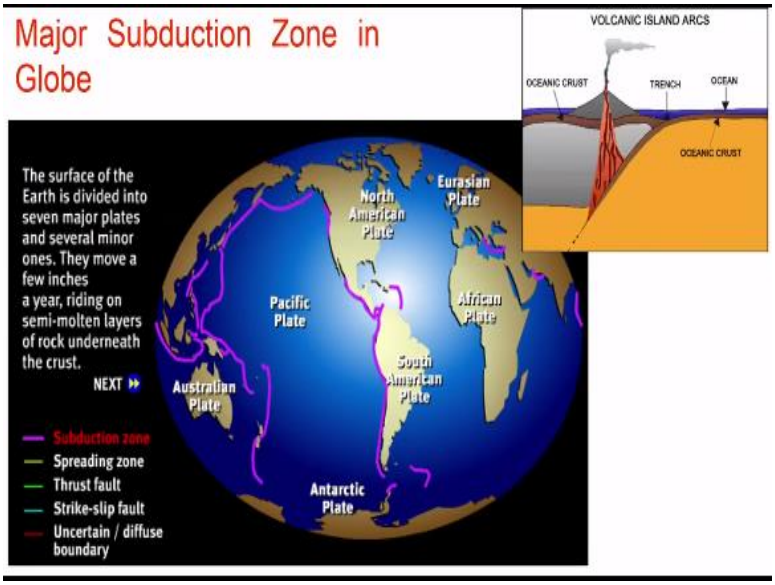

So we can see these things. You can see here the subduction zone of the world. You can see the subduction zone where and all it is there. So this kind of places where you can see the convergent boundaries, okay. So where the earthquakes are occurring on this kind of places are the subduction zone. The next is spreading zone. So this is how the volcano happens. One plate goes to the other plate in the your convergent boundaries.

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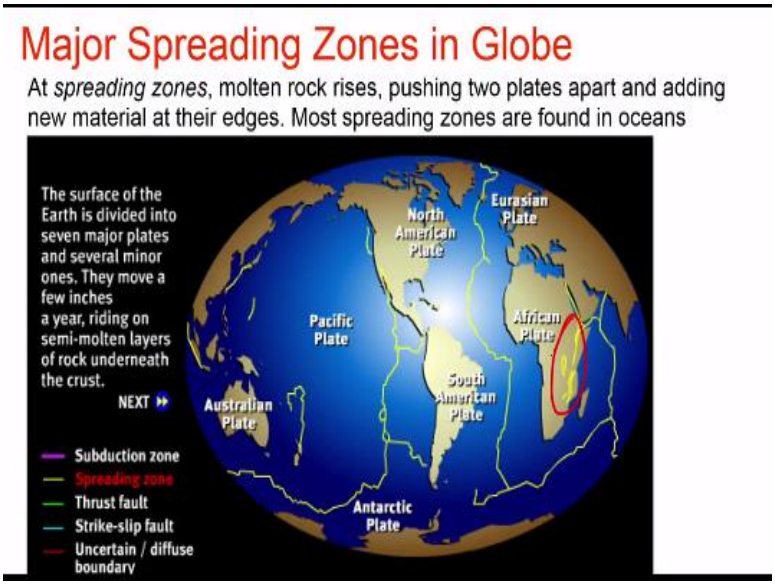

So this is actually spreading zone which is called as a divergent where the new land mass is formed. So most of the time this land mass formation occurs below the sea. You can see most of these boundaries are below the sea, not close to the land except a few places here, okay. So rest of the place it is below the sea.

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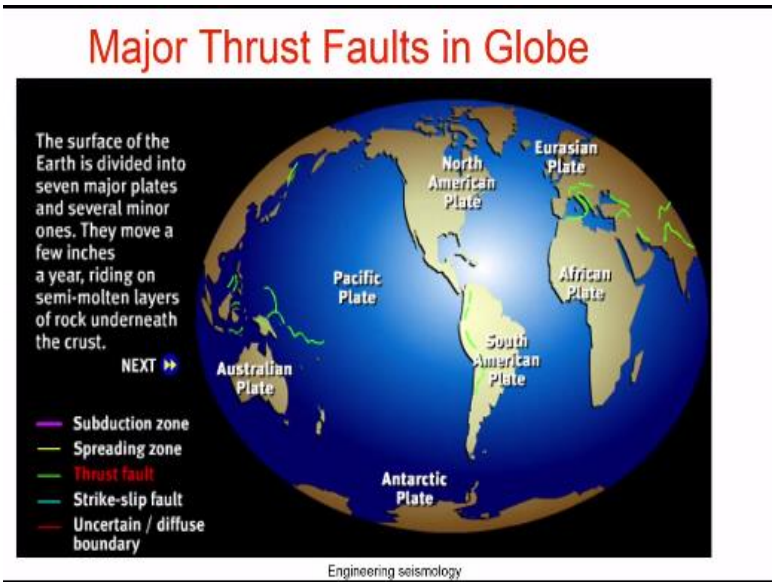

So the other one is the thrust fault. So the thrust faults basically it may be the convergent boundaries, okay which is happening at the land mass where you can see the thrust fault kind of things, where the fault is actually by the thrust action, okay.

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So then the next strike slip. So this is again maybe the interior of the plates, sometime the boundary of the plates. Depends upon the action. We will see what is the strike slip all those things are in the future classes we will discuss strike slip fault and all those things.

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So these are uncertain or diffused boundaries in the globe. So where these are all the uncertain. So it is not like characterized properly or diffuse kind of boundaries, you can call it. So these are all the location where you can locate this. This is mostly below the sea basically, okay.

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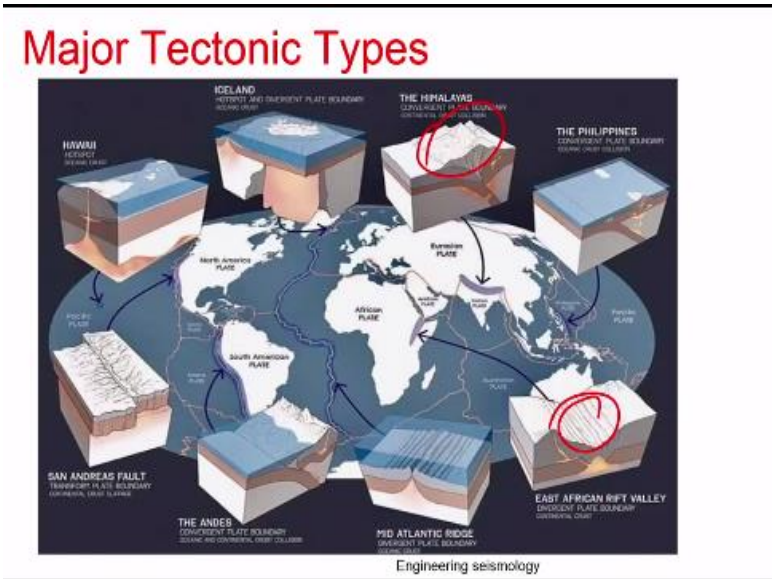

So all these boundaries if you put together in the global with major known location, so you can see that the Philippines okay you can see a the convergent boundary at Philippines. So the Himalayan also is a, so convergent boundary. And then the Iceland okay so where you get a new land formation. Then Hawaii where you getting a new land formation. These are all called as a divergent boundary.

So this is a San Francisco where you can get a transformed boundaries. Again these are convergent boundaries okay. So this is basically a transformed boundaries. Again the sorry this is a divergent boundaries. Again this is a divergent boundaries with valleys kind of things, okay. So these are all the different features where you can see. Here you can see that these are raising of two plates are happening.

Here consumption dipping of two plates are happening at this place okay. So this will indicate when you visit these places by chance next time you can see these things in the aerial view, if you travel in the flight or something you can see these kind of signatures which is basically reassembles a plate activities.

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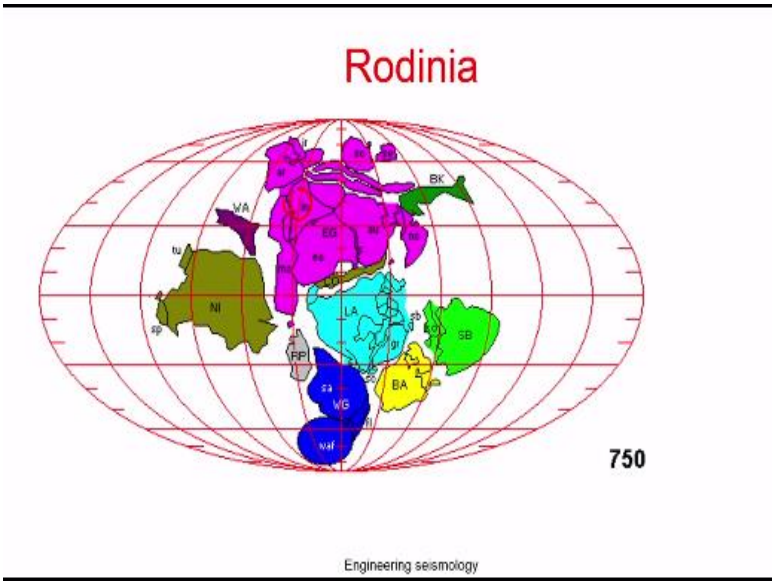

So how this plate activities are people try to understand. So people try to understand this by looking at a carbon dating and assembling of all this data into this one. So far that you should go back to your old the time how the plates was there. So as we all know that the earth was formed several million years. So if you look at the about a 1000 million years how the earth was then you can understand how these plates are moving each other.

So this is actually the Rodinia about 750 million years ago how the plates are. You can see here, you can earmark a plate India. You can see where India. IN is Indian plate. So you can kept here. So you can see this. This is the before 750 years.

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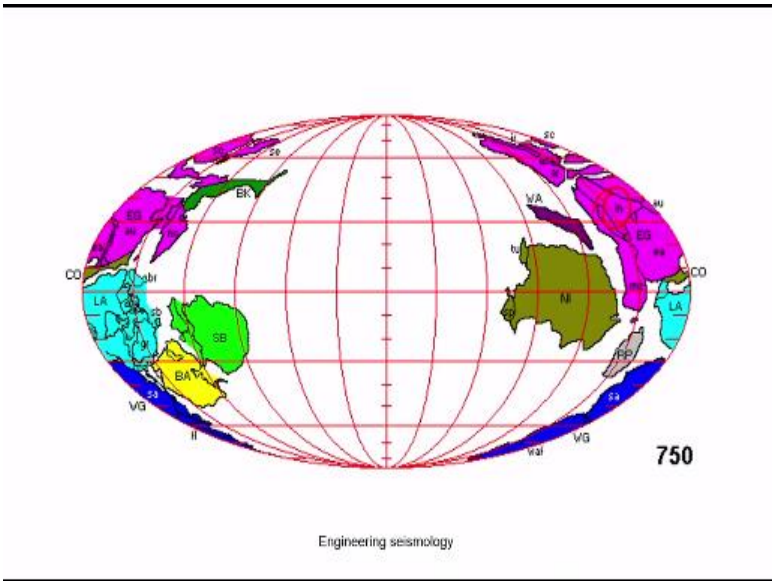

In the 750 years India basically here. 750 years million okay this is the one.

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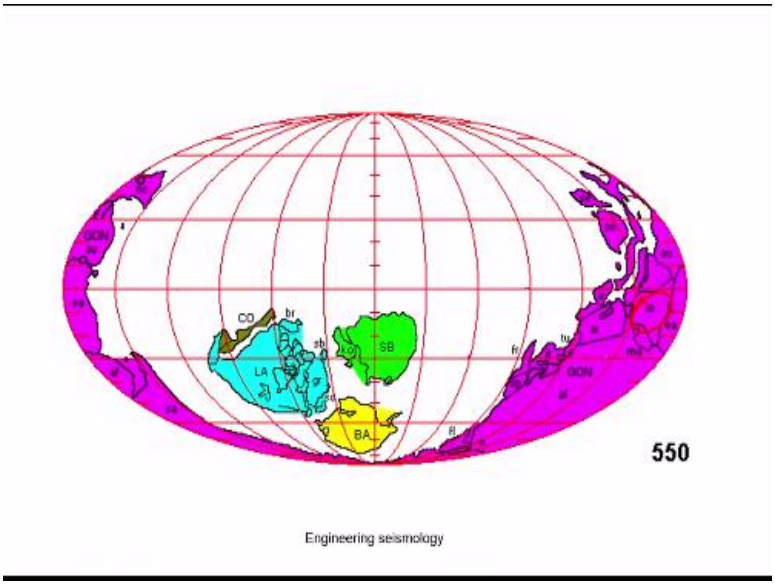

And then in the 550 million years the India come to this position.

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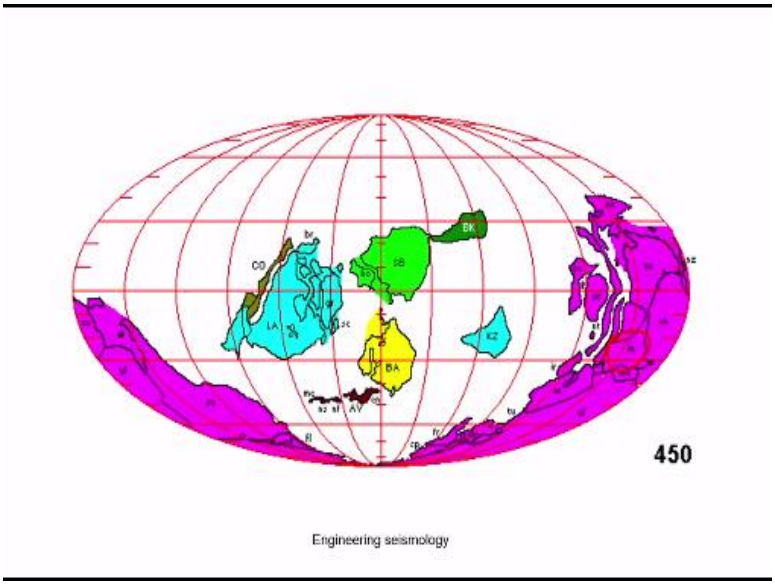

And followed by the India come to this position at 450 million years.

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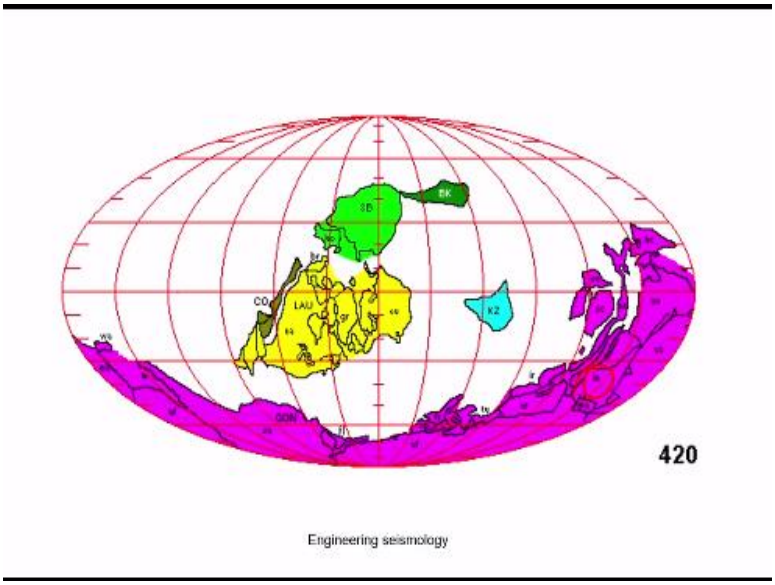

And 420 million years India is here.

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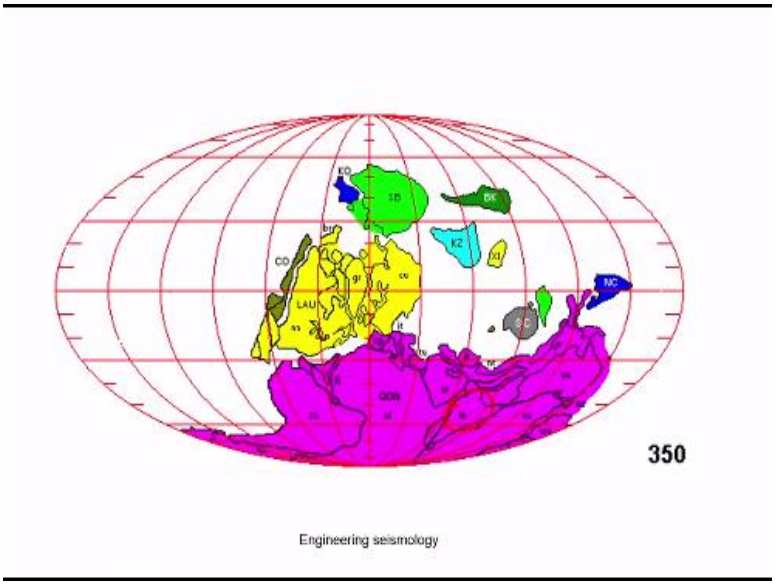

And then 350 million years India is here.

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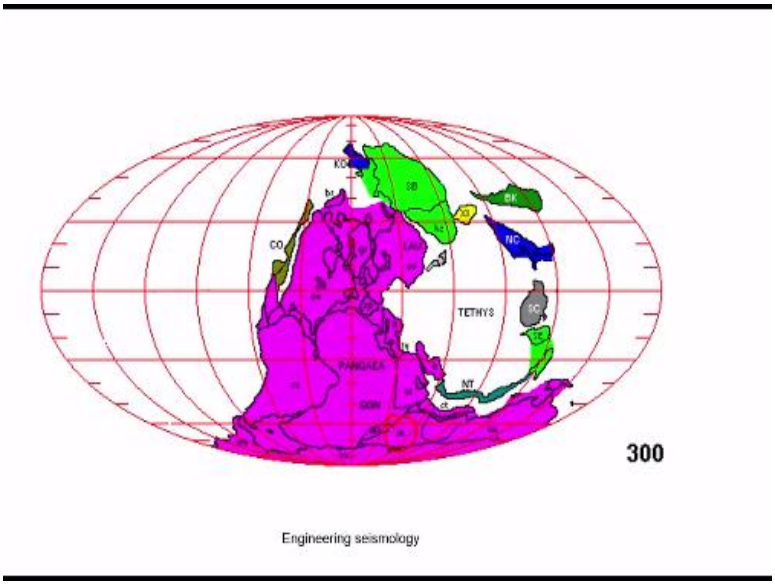

And then 300 million years, the India is somewhere here.

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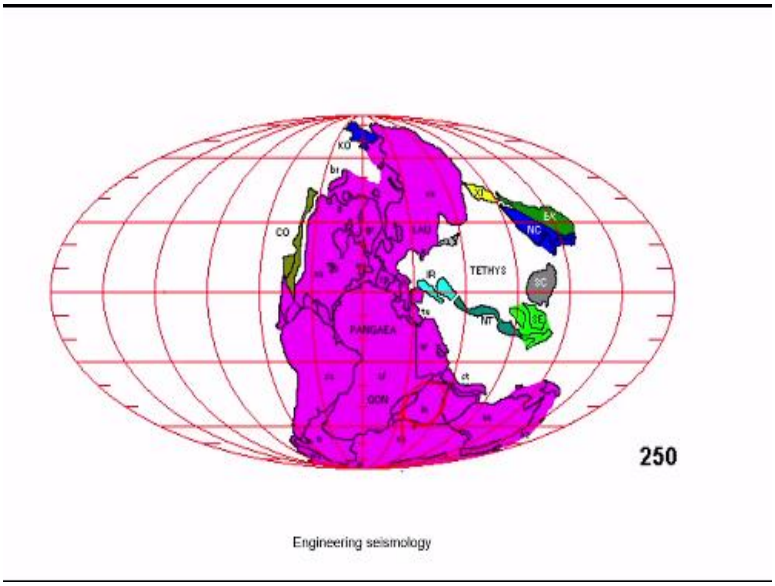

And then followed by 250 million years India is here.

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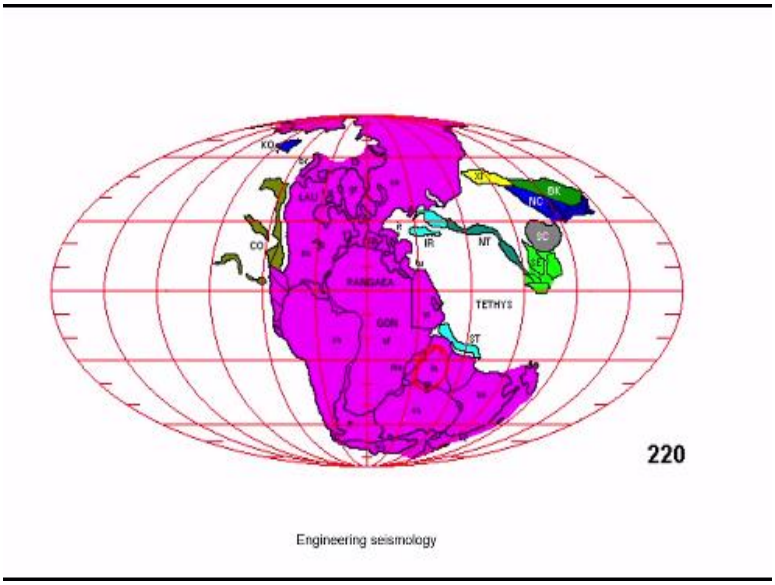

And followed by 220 million years India is here.

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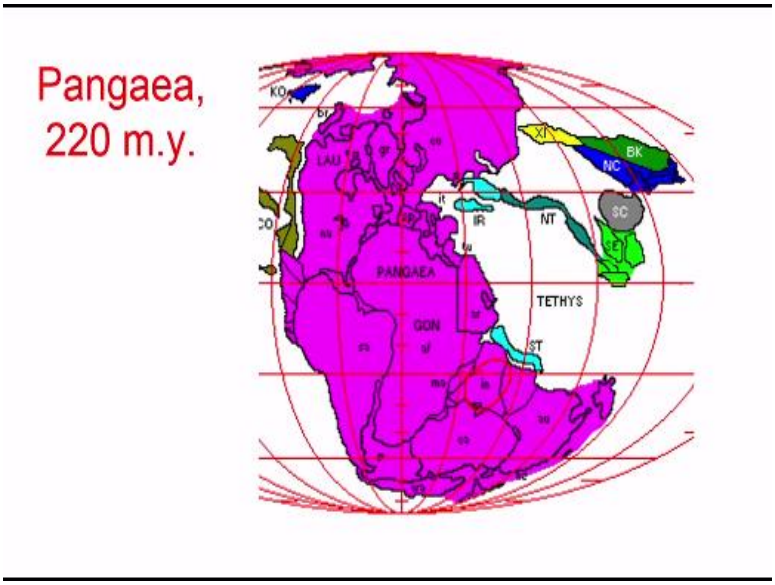

And then followed by so Pangaea which is 220 million years where India is the here.

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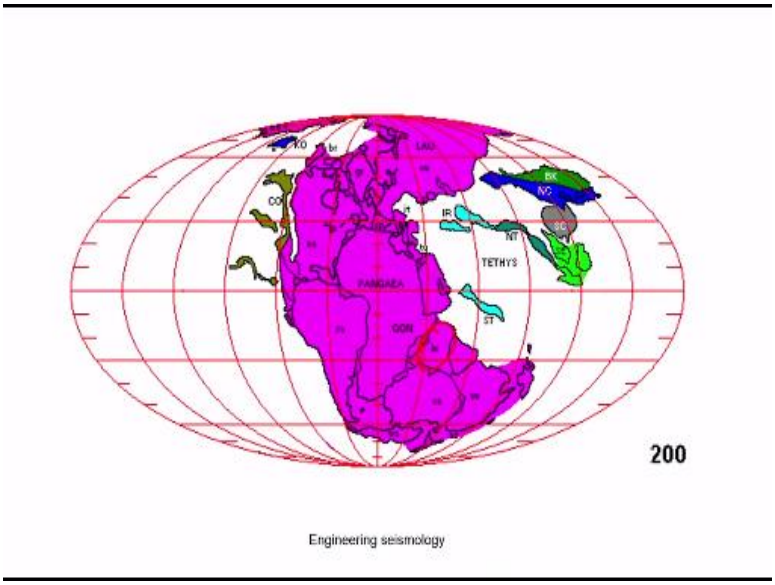

So then 200 million is this one India.

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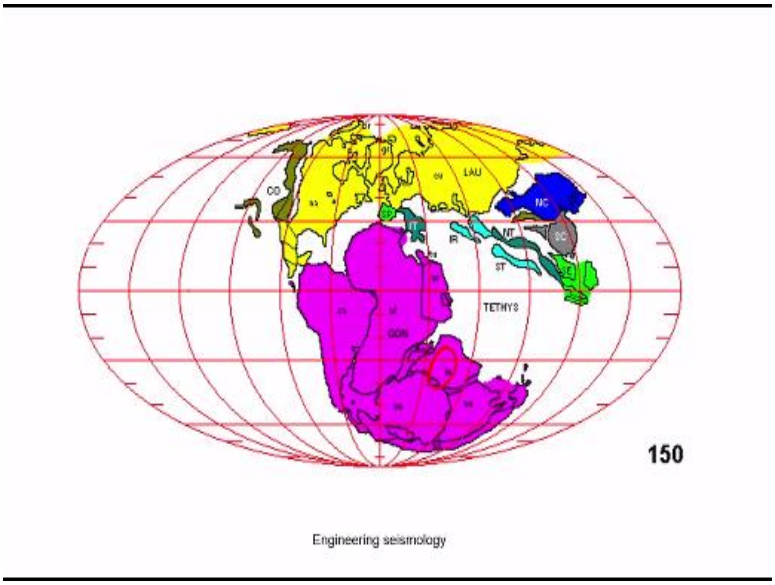

Then 150 million years, you can see. You can see that the position and the size of the plates are keep changing. That is also you can notice.

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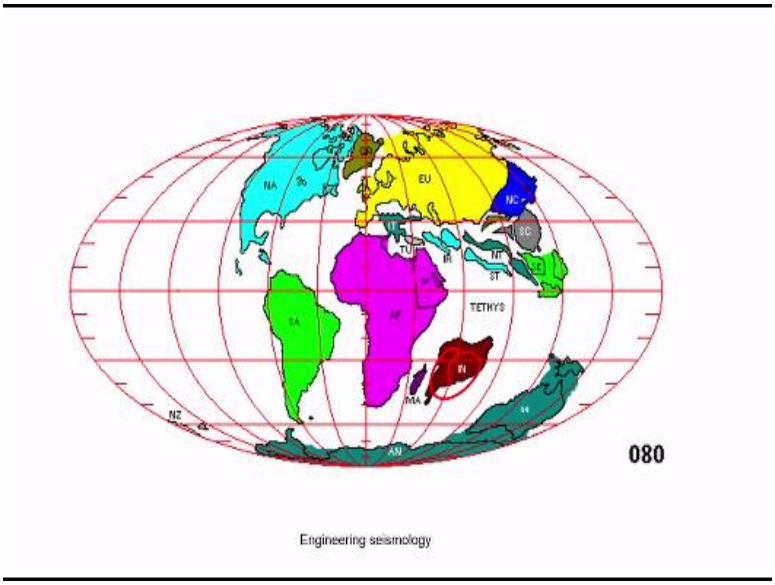

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And then in 80 million years, the India is basically island, you can see now. So this is a reason those who are from South India, they may well understood that there was a story of Kumari kandam, okay, so there was a history okay. So in the literature saying that the Tamil speaking people okay who lived in the Kumari kandam was several thousand years old.

So where you can see that India basically the southern part of India, basically is a island where that language still exists, okay. So you can see this is the Indian plate about 80 million years.

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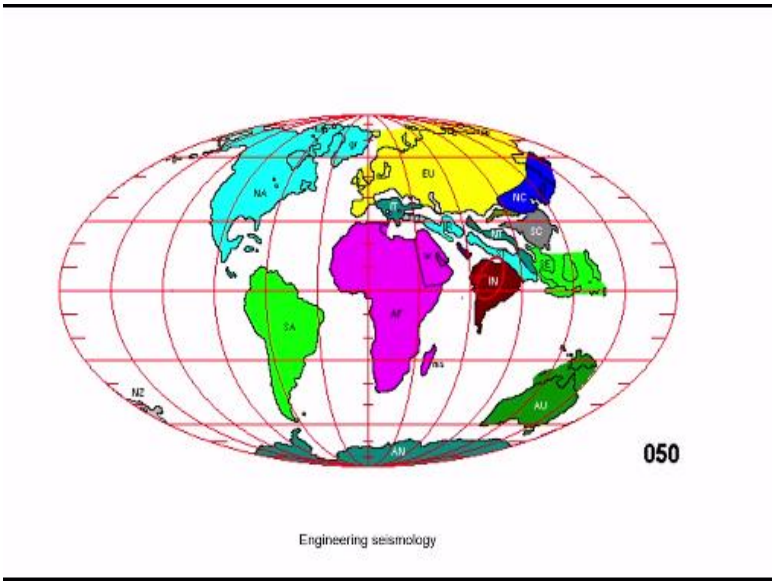

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So then 50 million it has come to here.

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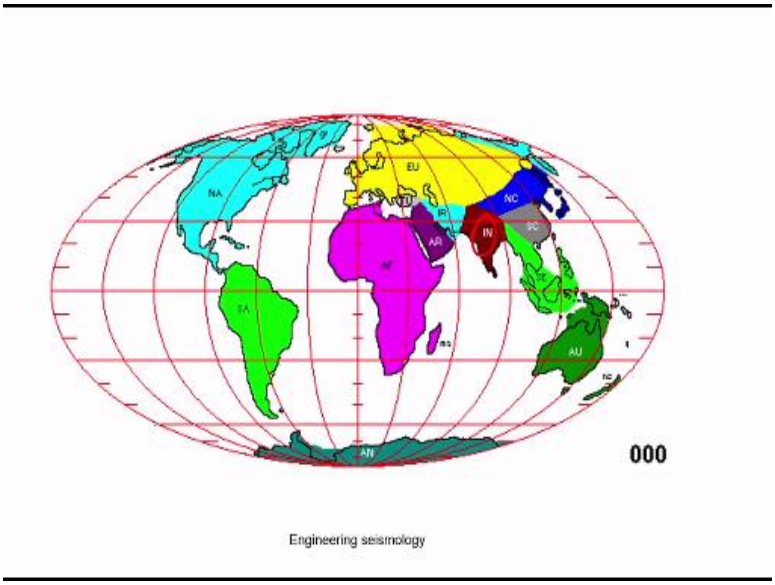

And then today, so okay. So the island became a land mass connected and became a peninsula where three side there is a water okay. So this is the today scenario which gives this one. How the people say that these are all the stories are true? What is the scientific evidence, okay.

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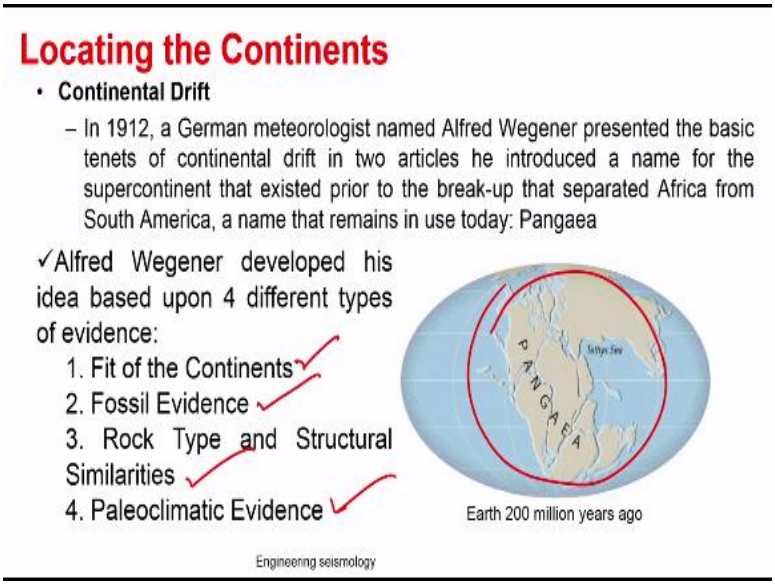

So if you want to understand that you have to go back to the continental drift theory. So the continental drift theory was developed by the 1912 by the German meteorologist named Albert Wegener presented a basic tenets of the continental drift in a two article he introduced name of the supercontinent that existed prior to the breakup of the separate Africa and South America and name remains used as a Pangaea, okay.

So this as I told you that before 200 million years this was the all the plates are together, okay. So what we are seeing now the separate seven plates distributed throughout the globe was together once 700 years. So he explains that theory okay by giving a proper evidence. So the Alfred Wegener developed his idea based on the four type of evidence. One is that fit of continents, fossil evidence, rock type and structural similarity and paeloclimatic evidence.

So how so if you take the present plates whatever exist now the land mass and try to join together, you can see that basically it will join as a puzzle piece.

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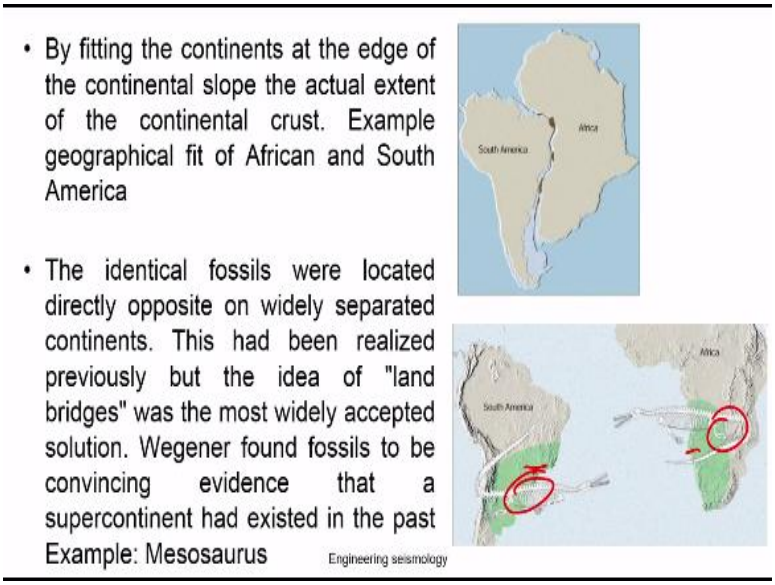

So for example, you can South America and Africa you can join like this, okay. So that is the evidence that it was broken at one point. Before that, it may be different. How you say it is evidence, because you can see the vegetation similarities, the plants in these regions are similar. The animal lived on these places, which is obtained from the fossil are similar. As you know that this right now these two continents are very far.

No animal and plants can move just like that and may migrate and live there. So maybe the animals are living when it was together and when it was separated, these animals are went far away. Those fossils are proving that it was together at once.

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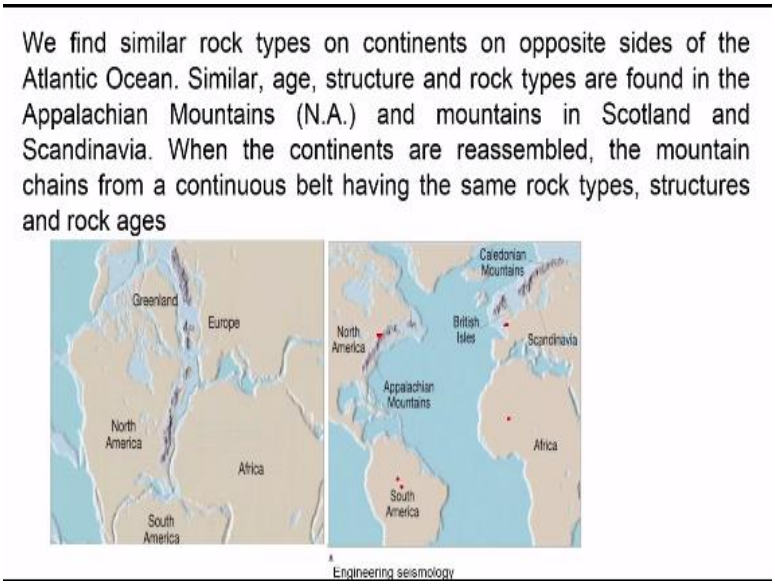

So that was his theory. Then next is basically so the rock type, the rock minerals, rock type is the same in this region. Why because once it was formed like this, the crust rock below 10 kilometer, 15 kilometer depth, whatever you can see is should be same. Even if it is after breaking and when separate. So now the rock formation of this place and this place and this place also similar.

Not only the rock type even you can match the people in this region. Those who are living in the South India or the DNA test confirmed ancient Indian people. In South India they almost look like similar to Africa and South America people. So these are all indicates that once they are all together.

Even there was a article which is written in Australia that there are people in Australia that speak oldest, ancient language of Tamil okay in Africa sorry Australia. So they speak those languages. So that means these are all ones together and it may be separated. People living there still they practice their one.

So those who are in the old Australian people, okay the origin Australian people they speak language similar to the Tamil language spoken in southern part of the country, which indicates that they are all people separated by nature by means of this kind of actions.

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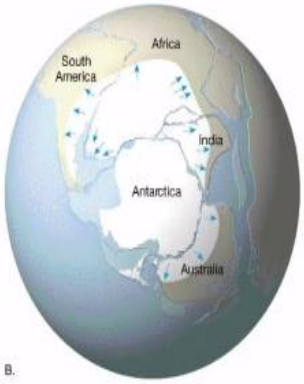
- Glacial till of the same age is found in southern Africa, South America, India and Australia areas that it would be very difficult to explain the occurrence of glaciations.
- At the same time, large coal deposits were formed from tropical swamps in N. America and Europe. Pangaea with S. Africa centered over the South Pole could account for the conditions necessary to generate glacial ice in the southern continents.
- In addition, the areas with extensive coal deposits from the same time period occur in regions that would have been equatorial.



Paleoclimatic Evidence

And then the paleoclimate. Paleoclimate means is the sum of the area where you can see the climate exist on that particular part, okay in the historic time. So these are all the where you can see that the olden climate study shows that these are all the region is actually Antarctica kind of things where you can see the peculiar similar climate. So as you know that in some part of the India still we have the snow, okay.

So some part of the India we do not even get a snow. So this was because once these regions are in the similar kind of climate.

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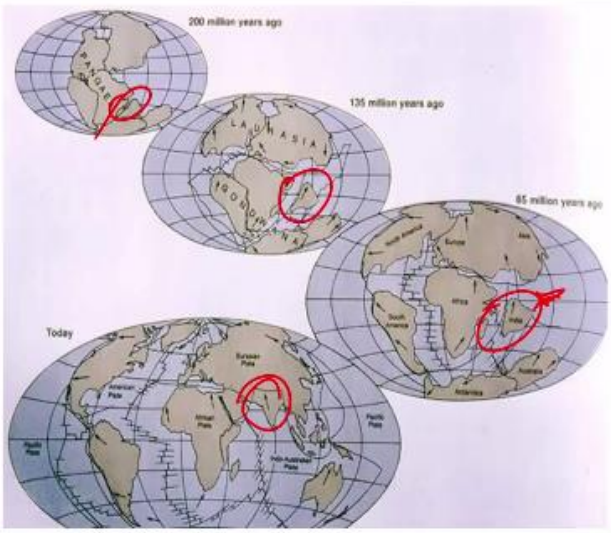

Continental drift from 200 million years ago to Today

So these are all the evidence where which can confirm that these plates are together once and separated due to the plate tectonic movement or by the major earthquakes. So you can trace from here this is basically 200 million years ago how this was. Then

135 million years how this was. 65 million years how this was. And today now how it is. You can see the India how it was, okay. So the India was once a island, okay.

Today it has become a land mass with peninsula. Peninsula means three side covered by the water, one side covered by the land is called as a peninsula, okay. So this evidence very clearly shows that there is existence of a old India as a island which they used to call as a Kumari kandam in Tamil literature.

Those who are keen on studying that you can basically look at this and it may be written in the literature of the oldest language of the world Tamil, okay. So with that, so we can finish the today class. So today we tried to understand what is meant by the plate tectonic okay. So how the plates was together once. How the continental drift theory was used to prove that the plates are together. We have seen the India was the different position and different shape.

So what we are seeing today was not true before 80 million years. 80 million years before India was a island. So which has been proved by the matching of animals, matching of vegetable, rocks and paleoclimate and all those things. So understanding of plate basically will help you where you are located.

So you are, if you are located very close to the plate boundaries, you should be take more cautious to estimate a seismic force expected in the region and design your structures. If you leave middle of the plate accordingly you can take the steps to know the earthquake in the this one. For example, India comes on both category. Part of the India is in plate boundary where you can see that entire northern part or northeast part actually located on the plate boundary.

So the place like this Uttarakhand, Himachal, Jammu and Kashmir and then followed by the Sikkim and Tripura and Bangladesh okay those are the place close to the plate boundary. And after that there is a region which is close to the plate boundary. This also expected a high seismicity because as we have seen that the plate boundaries are more frequently breaking and releasing the energy.

The other part of the India where it is comes in the middle of the plate, where the frequency of the earthquakes are less when compared to plate boundary and the size of the earthquakes also less when compared to that. That we will be discussing in detail in the future classes. So as on now we can understand that none of the place in the world is free from earthquake.

More frequent earthquakes are expected in the plate boundaries and less frequent earthquakes are expected in the middle of the plate. So these plates are once together and separated and which was proved by the continental drift theory. So where the matching of the people, animal, and land and climate material type and all they have been shown this. So with this we will close the today class.

I thank you. So we will see in the next class about more about the earthquake understanding and things like that, okay. So thank you very much.