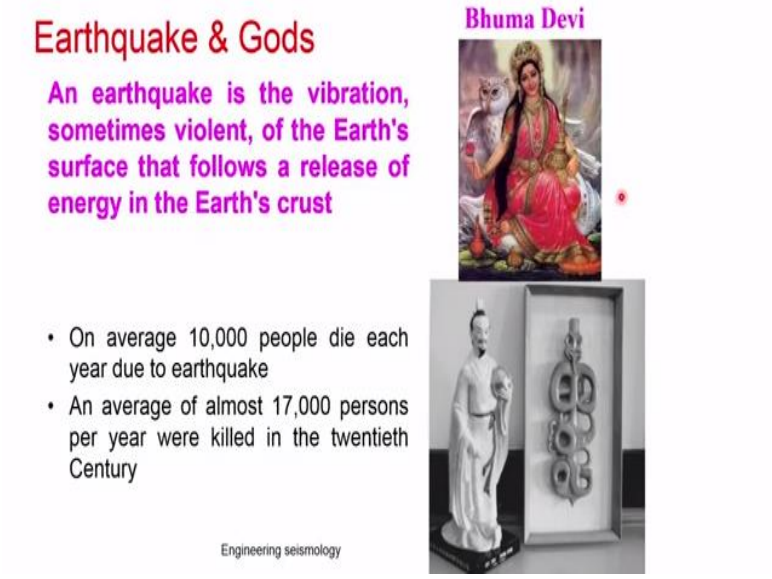
Introduction to Engineering Seismology
Prof. Dr. Anbazhagan P
Department of Civil Engineering
Indian Institute of Science Bangalore

Lecture No-30
Recapitulation - 2

So Vanakkam we will continue our lecture on engineering seismology So we have been recapping what we have done so far try to understand how the earthquakes are occurred, the basics what we learned as I told you that. So after a couple of hours classes, we will be going for the application side. So the understanding of the basics and recapping is very important because we will be recalling so many things. So, some of the points which may be missed during the regular lecture will be highlighted during this recapping of the lectures.

So today we are talking about, so the basically the earthquake mechanism the fault source so all those things as we have seen in the last class. So the earthquake hazard, the consequences, number of people die all those things. So since the development stage or the human settlement stage from the historic time people are trying to fight against earthquake. So they believed that the earthquake is act of God.

(Refer Slide Time: 01:21)



So that is why say **t**hey even add a so the myth and the relationship with respect to the God. So, this is basically a God which is responsible people believed that the worshipping of this God can

reduce the earthquake. So it is a true or not scientifically, we cannot comment. So I am not here also to comment about that but the people who worship so the God for the earthquake basically, this is predominant in India only India as well as in the Asia. So the down one basically is a God responsible or the person so they believed that will prevent from the earthquake damages actually this one.

So which is called as a Chinese or Japanese or whatever. So this is the God they believe. So the India people believe that is so the human, the so woman God so Bhuma Devi, so which is like a mother of earth is basically so worshipping of her and can reduce a sometime the violent vibration caused by the earthquake people will escape from the earthquake that is what is happens. So apart from that there is a, the myths are unscientific believe among the people also.

(Refer Slide Time: 02:36)

Fishmongers selling flesh from a *namazu* (catfish), whose excessive movement they believe caused the large Edo (Tokyo) earthquake and killed it. The people complain of the profiteering from their tragedy.

So particularly this Japanese so they, believed that a kind of fish called Namazu, which is a like a catfish. So the movement of this excessive movement of this fish basically causes a earthquake. So that is what they try to believe olden days. So this may be that you see generally when earthquakes are occurring there is a sensation to the all the living system in the earth where it can expect that something going to happen.

So it behave irregularly. So even sometime human also has that kind of tendency but since we in the name of technology we so much detach from the natural this one. So now we may not feel

those kind of feelings but the animals are still going for the that kind of feeling and preventing their generation death or the damage due to those kind of things by escaping from that. So, I even told one example that during the Dasavatharam movie.

So during the climax time when the Kamal Hassan so was talking about the before talking about the tsunami so where you might have seen that there is shown lot of birds are moved from the seashore area to the other area, which is not only that even a people after 2004 tsunami people have reported that the animals which is even tied like a cow goat and then dog. So those are all the animals try to escape from its original position to new position or move away from the coast.

So that is what we can precisely say that these animal move away from this is actually this has a some kind of sense which can detect what is going to happen in the nature, what is going to happen in the nature? So they try to move to, so prevent themselves die victim of that particular nature. So that may be the reason that during the earthquake or before the earthquake these fishes might have some kind of sense which is capable of basically sensing that.

So then it becomes a restless. So try to move to the fault rupture area to the non rupture area which may be ideally the seashore or close to the sea shore area kind of things. So this might have been noticed by the human being and misunderstood that moving of this fishes caused earthquake. So then that is a places where they start killing this kind of big fishes so in this region and try to hunt and eat as a part of food.

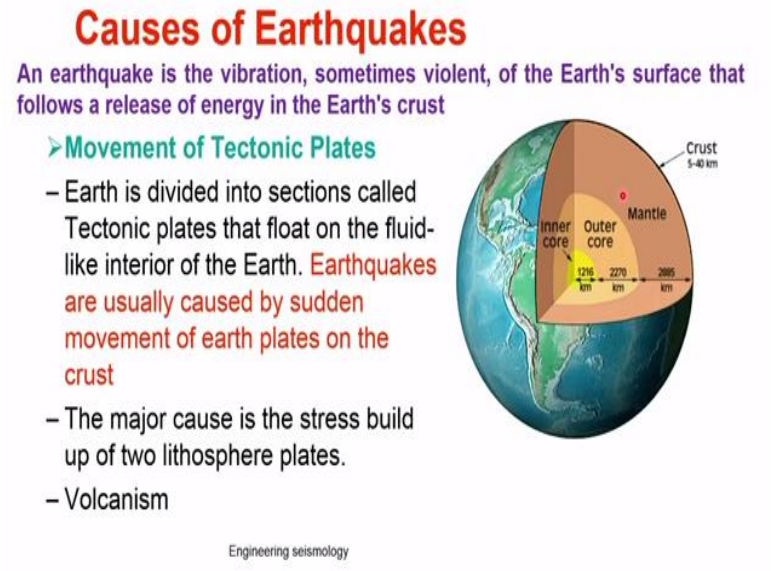
So that practice even today continuous maybe as I told you that Japan is only country where they either they kill a bigger size fishes and eat. So none other country will do for example most of the south coast people they do not eat a bigger fish, the bigger fish means fish which is like a 100kg, 1000kg fish and all we never catch we never eat. So maximum people will eat is like a 5kg or maximum 10kg kind of fish.

There is a relatively telling the kg because to relate a size but the Japan people catch even a dolphin. So the whale which is a several tones of weight, then kill them and eat. So that tradition may be started due to the misunderstanding of the fish movement with the earthquake relating.

So they believed that the Namazu movement caused the earthquake. So the killing of Namazu movement is one of the priority in the; those kind of the local settlement people kind of things.

So this is a typical the excessive this one where the people complained the so the profiteering the from the tragedy by killing this this one, so this is the typical Japanese literature evidence for the same. So as we have seen that the God and the moment mythology and belief are actually nowhere related to scientifically the earthquake what is happening. The earthquake so what is happening we try to understand in the form of so the plate tectonics.

(Refer Slide Time: 06:52)

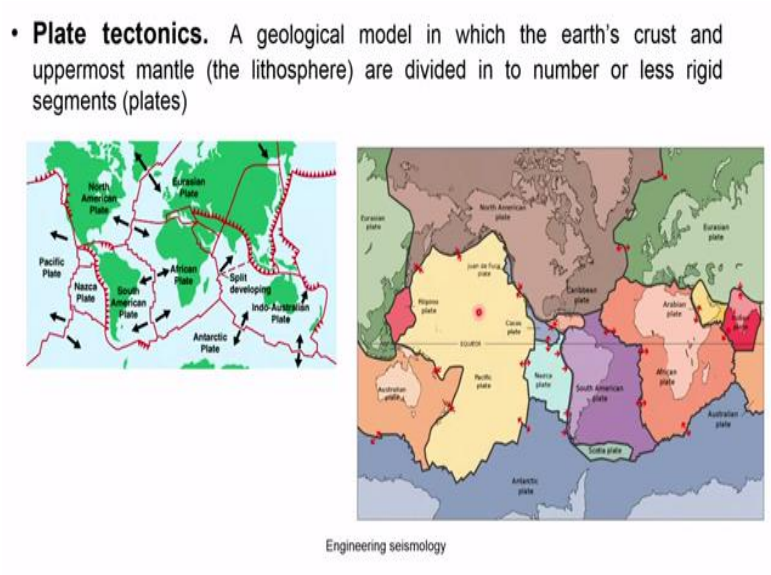


So, where the earthquakes actually occurs due to the movement of plate tectonic plates, so as we have seen that the earth has actually the four major sections like crust, mantle, inner core and outer core so, the crust actually the mantle and crust is the top most layer so where which has been broken as a different puzzle pieces this puzzle pieces are actually made the sphere so that is what you can see.

So this movement of this puzzle pieces basically causes a tectonic force this puzzle pieces called as a tectonic plate movement of this puzzle piece causes a tectonic force that tectonic force causes a earthquake, that is what scientifically people understand how the earthquakes are occurring so the why this occurring? As we all know that earth is spinning so there it is always rotating its own axis as well as the around the sun.

This rotation causes a stress and strain in the so the earth top most layer. As you have seen that anything ruptures the top portion get stressed and then immediately it goes decreasing with that so this stresses are start occurring at those plates of different places.

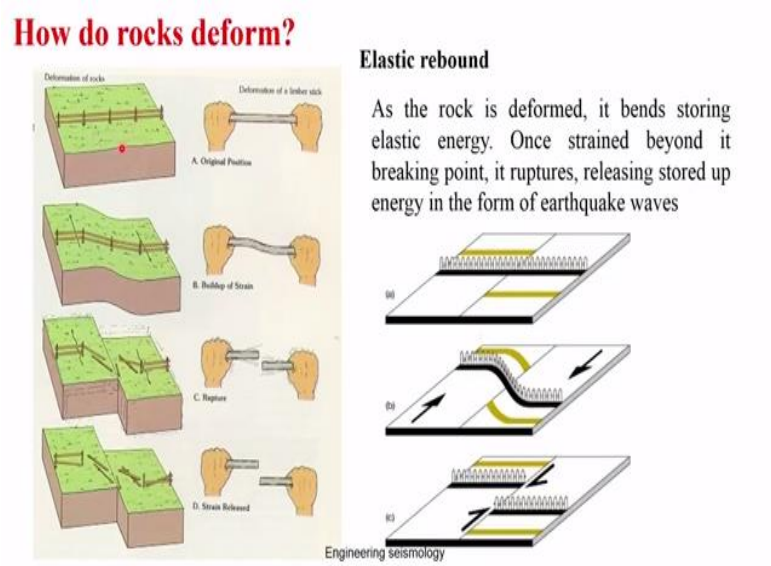
(Refer Slide Time: 08:12)



So, this try to accumulate in the material, the material has some kind of resistance which try to accumulating that, so when the material has its own property the stress applied is actually keep storing at one point of time the stress accumulated due to the rotation exceeding the strength of the material it breaks and releases the energy stored so far that energy is basically earthquake.

So this has been well explained in the engineering seismology. In the form of elastic rebound theory so this is basically a different plates what we can see and these plates are even though we I mean made it a different color and all so this plates are keep to rotation this moves it own direction and try to store a energy that stored energy basically accumulated.

(Refer Slide Time: 09:05)



For example if you take individual plate as a piece of rod or a the rectangular section, so you try to move the edge of the plate because, as I told that it is spinning and the different plates are there each plate is moving its own direction, you can see the movement actually marked here you can see its not moving on the same direction, it depends upon the position and all those things. So then this movement basically induce a stress which is actually stored in this part.

So initially it is stored in this part, so this material has some kind of strength so until reaches strength of this, this energy stored by the this one is resisted, so on one point of time the energy, the stress induced by this rotation exceed the strength of this material that breaks and become a regular 2 pieces. So this is how the plates are keep forming with the geological range. So this confirms the elastical rebound theory of the earthquake.

So the due to rotation of the earth; due to the geological forces or the rotation of the earth its own and as well as sun causes a stress in the earth surface which is keep accumulated in the plate, the plate is basically the topper portion of the earth which is consist of the soil and rock predominantly a rock structure. So, that stress keep on accumulating as the rock as it own strength at one point of time.

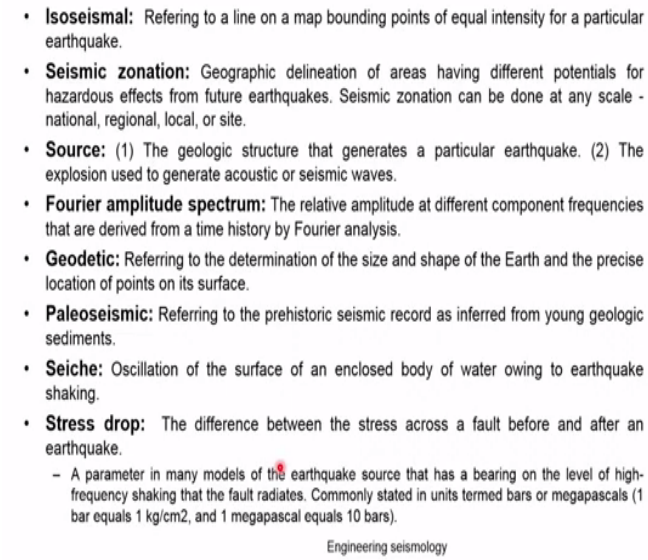
So this stress accumulating due to this force of rotation exceed the strength of the rock then it breaks as a two pieces that breaking releases a vibration and the seismic waves. So the vibration

in the form of seismic waves that is earthquake basically, so that is how people are try to understand. So when we try to understand this basically, this is called as a elastic rebound theory. We can also expect that since the earth is keep on rotating the occurrence of earthquake throughout the globe is possible.

Only thing some places it may occur frequently depends upon the; your thickness of the your rock. The thinner rock will break frequently a thicker rock we will break very late. The frequency of the earthquake will be depends upon the place to place but none of the place in the earth is free from earthquake. So that is what you can get from the elastic rebound theory understanding.

So this is the basically gives the scientific evidence and reason why how the earthquakes are occurring.

(Refer Slide Time: 11:44)

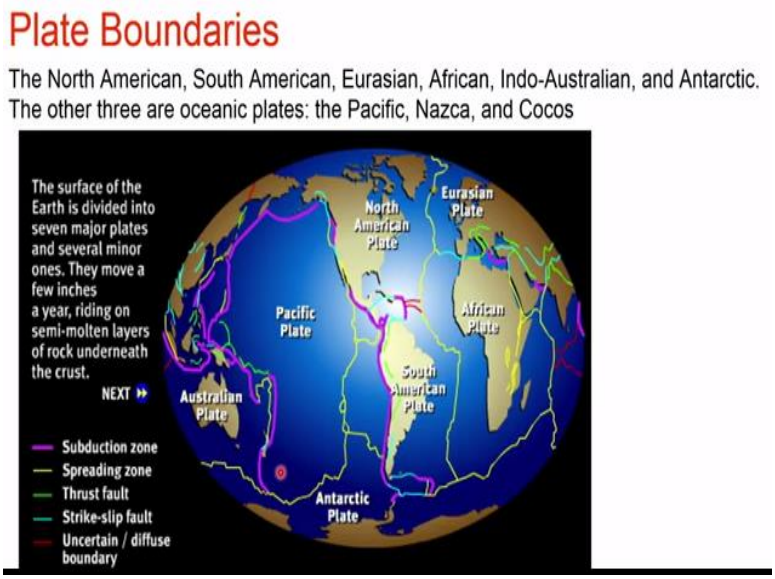


So with that we also discussed a different terms which will be used frequently in our course. So starting from the isoseismal map, source, Fourier amplitude spectrum, geodetic, paleoseismic, seiche, stress drop all of them, we discussed except the seismic zonation, which will be discussing in the future classes. So there we have seen several definitions just I give you the brief the slide.

So we have seen the isoseismal line, the connecting up is equal intensity so values as a line is the isoseismal line the map which is source these isoseismal lines are isoseismal map. The stress drop we have seen the difference between the stress across the fault before and after the fault So we have been, you have been noticed that the stress drop, Fourier amplitude spectrum, the source so these are all interlinked with the generation of synthetic ground motion understanding the Fourier parameters of the earthquake.

All those things are very important which also we defined in the earlier kind of things which you can go through once again all the definitions.

(Refer Slide Time: 12:50)

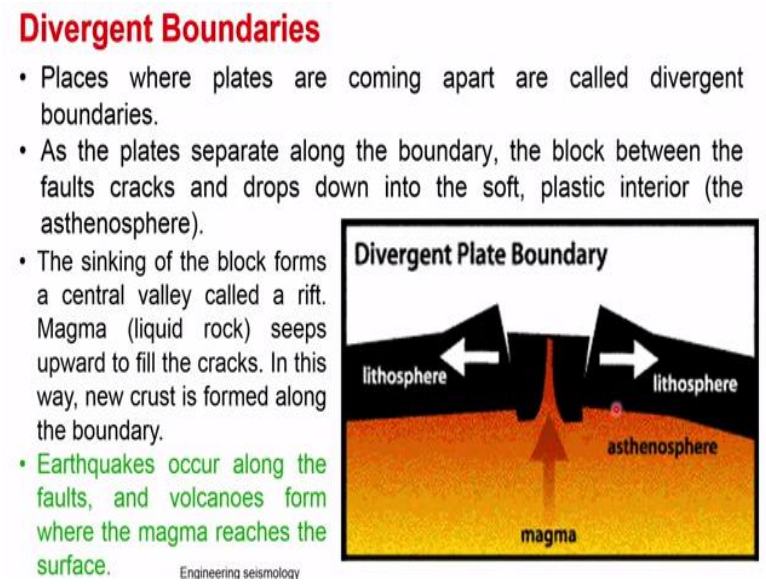


So we have seen that so even though we call it as say all these plates as a single component as a tectonic plate, but as I said that this tectonic place the joints are moving at a different direction from each one. So then it has been majorly categorized based on their tectonic plate activity or their interaction each plate how it interact, so based on that. So that is like a plate boundary interaction or plate boundary of the, so the tectonic plate.

You can see this is the boundaries of the different tectonic plate in the earth. So you can see that this boundary, the plate boundaries can be categorized the 3 major category. So one is that the subduction boundary, so then the spreading boundary and so divergent boundary and then the transform boundary, the subductions spreading and thrust fault and strike-slip and uncertain

diffuse binary, which is given this is major category as such so the subduction zone, so then the divergent zone and then the transform zone. So that subduction zone basically a plate.

(Refer Slide Time: 14:01)



The ozonic plate or earth plate 1 plate moves below the other plate. It may be occurs below the ocean or in the land it does not matter. 1 plate moves below the other plate which causes a kind of the stress built and releases the energy that kind of earthquake is called as a convergent boundary earthquake. So these convergent boundary earthquakes are responsible for building the mountain.

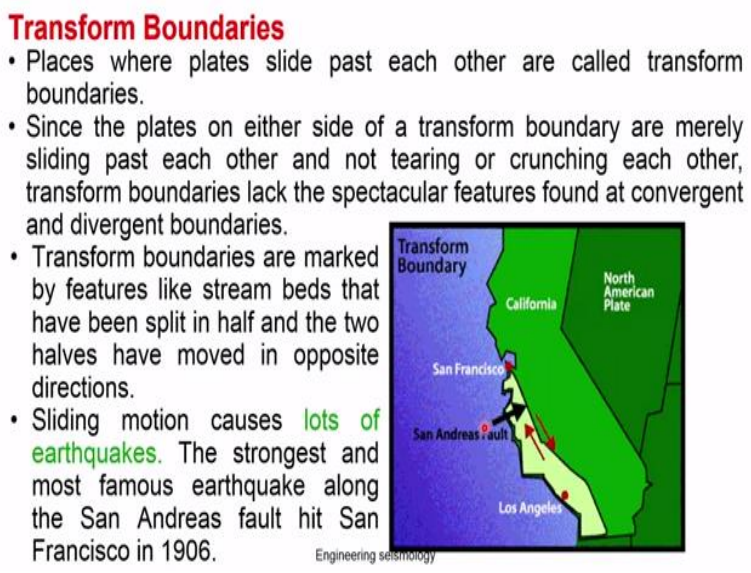
So because the two plates are hitting each other and one going other this place is generally the land is consumed, so the land reduces its size. So I do not know how many of you aware that as the India moving towards the Eurasian plate. So every year, we are losing few centimetres of land. You can find out what is the size of land we are losing. If we consider the entire length, okay of the India from the Kanyakumari to the so the Himalayan.

So, you can see that after 10 years 15 years, we will be loosed so much amount of the land. So after several million years there may not be India at all because all Indian plate will go inside the Eurasian plate. So, that is what the things are happening. So, these convergence are basically consuming a land. So in order to compensate us, you know that nature always balances the things.

So one place the consumption happens, another place the creation will happen. So that is what the nature always does. So since it is conversion happens in the convergent boundary. So the new plate created in the divergent boundary. So divergent boundary what happens, it pushes the plate apart and form a new land the new magma comes up and the cools and the form a land. So that happens in the ocean as well as the land where lot of volcanoes basically erupting and the forming a new land that kind of boundaries are called as a divergent boundaries.

So this is a divergent boundary example. So here you can also see that the convergent boundaries are more of compressible stress in nature, divergent boundaries more of the tensile stress where it pulls apart. You can see the arrow, so where you can see basically, your arrow of this one. So you can see the arrow. So where you can see the tensile force is responsible.

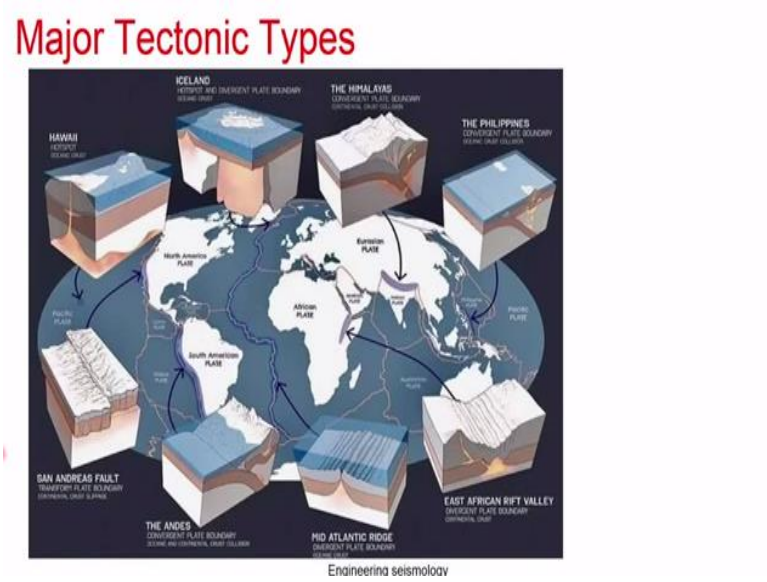
(Refer Slide Time: 16:28)



So the another one is the transform boundary as the land formation land consumption is happening there is nothing is happening but still you can get some kind of movement. So that kinds of boundaries are the transform boundary. So where the two plates are moving each other, it does not consume a land or does not create a land but this movement causes a vibration release or earthquake release that kind of boundaries called as a transform boundary.

So this transform boundary is actually the San Francisco earthquake. San Diego place that is a transform boundary in this. So if you go back to this map, so here it is mapped is a where is the transform boundary where is the convergent boundary where is the subduction zone. So those kinds of things basically marked here and even the spreading which are new form zonation all those things are mapped here.

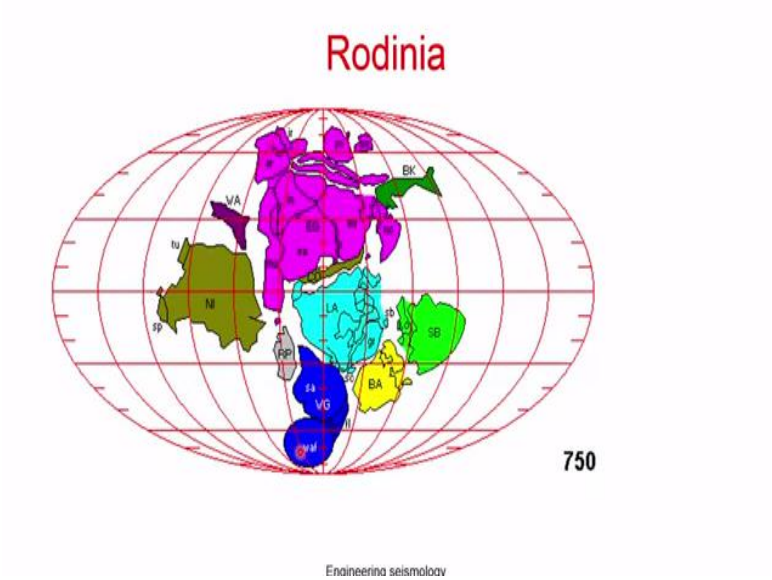
(Refer Slide Time: 17:24)



So which is very interesting the part of the seismology. So the overall global map you can look at the each boundary how it behaves you can see the Himalaya. So, subduction; where this particular belt goes inside and it hitting both of them creating a, the hill, so very high hill in the Himalayan. So there is a places where nothing is happening. So that is also you can see. So this is the place where you can see both of them basically moving each other no building up mountain or loss of land as happening.

So there are places where the new land is created. You can see these are the places. So it may be a valley or ridge depends upon the joints where its basically a divergent is I taking into action. So these are all the places those kind of divergent volcanoes, new formation this is the different tectonic this one which you recently published in the web you can basically understand how the different plate joints are behaving using this. So this is what we discussed in that.

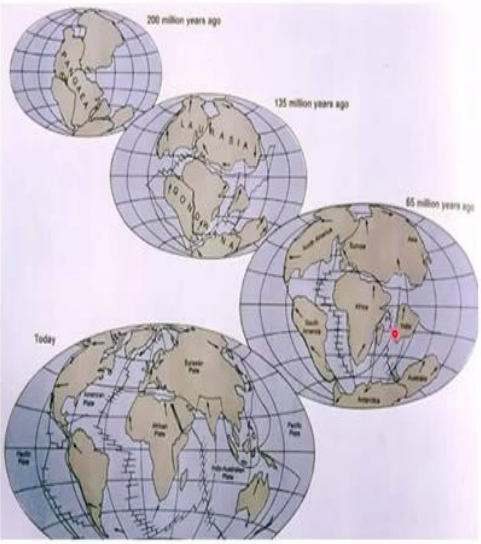
(Refer Slide Time: 18:29)



So we also understand that whatever the concept we are kept on talking about the place joint, the tectonic force which has been proved by the taking in the continental drift theory. So the continental drift theory what it says basically so this kind of movements are a keep occurring in the globe since several million years ago. So that is why the plates are not in the same position it keep moving here and there.

So, they proved this continent this movement by taking a some kind of evidence. So before going to the complete proof so, they say that before 750 million years ago, this is the position of the plate you can see. Where is the India? So this is a this one BA, SB, LA where is SA you can see this are different countries. You can see the plates are moving like this. So once it was all of them are together. So then;

(Refer Slide Time: 19:30)



Continental drift from 200 million years ago to Today

Due to the this moment and the earthquake this keep separating you can see this is a 200 million years how this plates are located then the 135 million years and 65 million years and as on today so you can see the very closely the India basically so where the India is basically you can see this is the India, so I am not very sure how many of you know, very well about the literature of the Indian landmass, since ancient time but the people who are, from southern side they are all exposed the place called Kumari Kandam.

So in the Kumari Kandam so it has been written in the Tamil literature, they say that the once the Kumarikandam was a island that was the you can see so about 65 million years ago, this is the India it is a island so now today its actually as a peninsular where the 3 side sea 1 side land peninsula but before that it was island, this is called as Kumari kandam in the Tamil literature this Kumari Kandam is actually written.

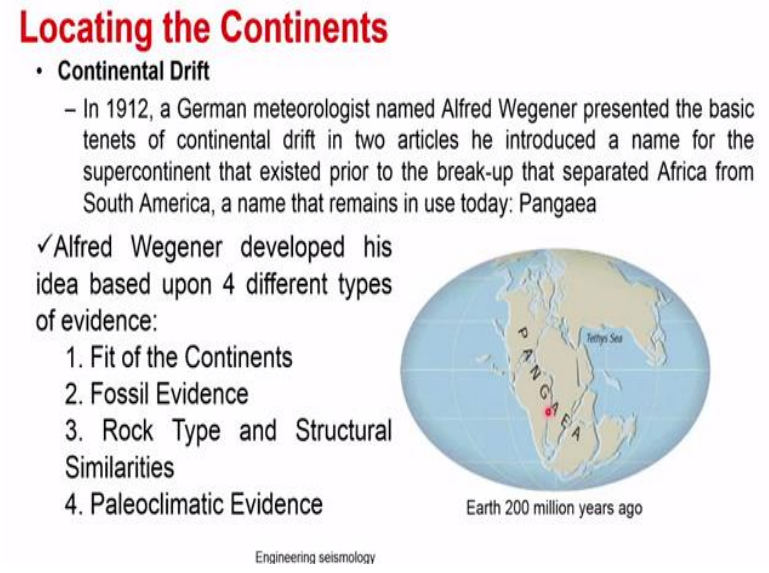
So the written about this island and the people lived there their kingdom all those things are there, so these are all the even the fossil evidence are proved that the once the India was a island so even the plate tectonic theory, so the continental drift theory also says that India once it was island so that may be the reason that the many fellow seismology studies in Himalaya they found the fossil, the animal fossil and fish fossil in the Himalaya.

Which is very highest level in the world. That means once upon a time Himalaya was under the sea so under the sea obviously it might be the island so that is the evidence where people can get and here can also stress that this not only the formation of the land evidence it also evidence that the Tamil is the oldest language because if the people have written about the Kumari Kandam in the 65 million years ago.

Where the people have read literature people have told that this is the literature was written in those days with the older so that is that is why the Tamil language is a oldest language and a classical language people are claiming and also it is a proof of where you can see the island India is the island where this was called as a Kumari kandam in the olden days where people there was having literature knowledge of writing, reading even they left some of the evidence which has been found very recently in the several places through a archaeological study.

So here we can understand that this was actually well proved by the continental drift theory how it was once together how it was separated by taking a few typical example one of them they used was actually fitting the continent as a puzzle.

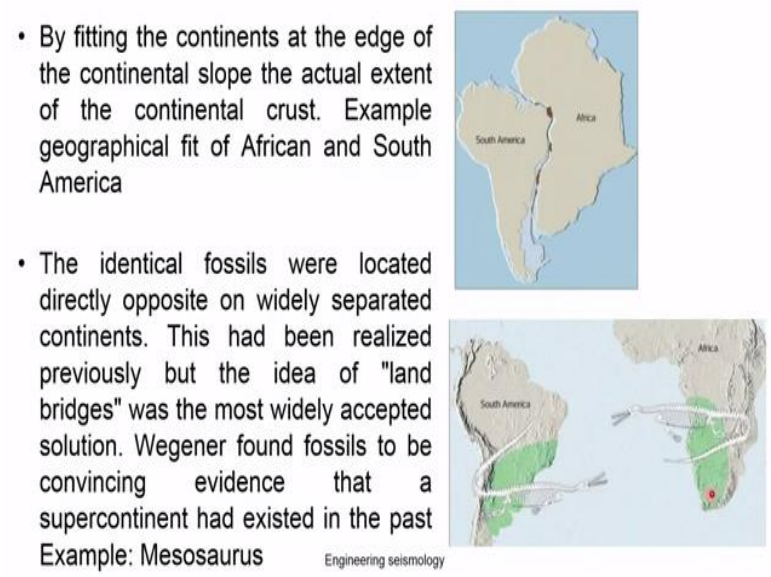
(Refer Slide Time: 22:28)



So you can see that these are all the different continent today what you are seeing but once it was here together so 200 million years this is a together so this is the one of the evidence fitting of

continent, so this is the basically a Africa this is South America so you can see exact matching of the puzzle, it is broken and the moved away then the fossil evidence

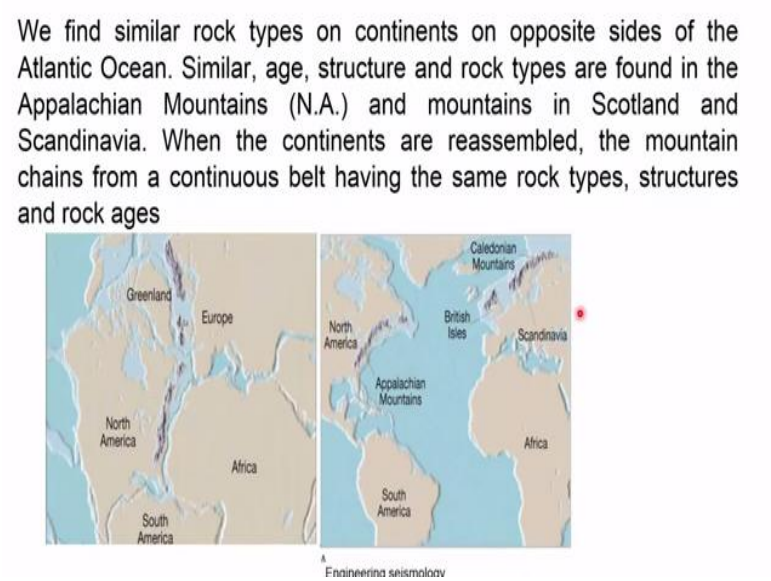
(Refer Slide Time: 22:51)



So the fossil evidence basically where the animals and these two places which is lived 200 million years or 100 million years are similar. The vegetations are similar so those are all the fossil evidence also they find in the matching, so which may be possible only if was together because I do not think any animal moved here will move so many kilometer and also stay here. Because once it was here together like this and then that time the all animals are moving here and there.

Then it was a broken due to the big earthquake and moved away due to the tsunami or whatever so then, this animals are separated here is separated here, but you can find those fossils now which you can relate and say that this was together once.

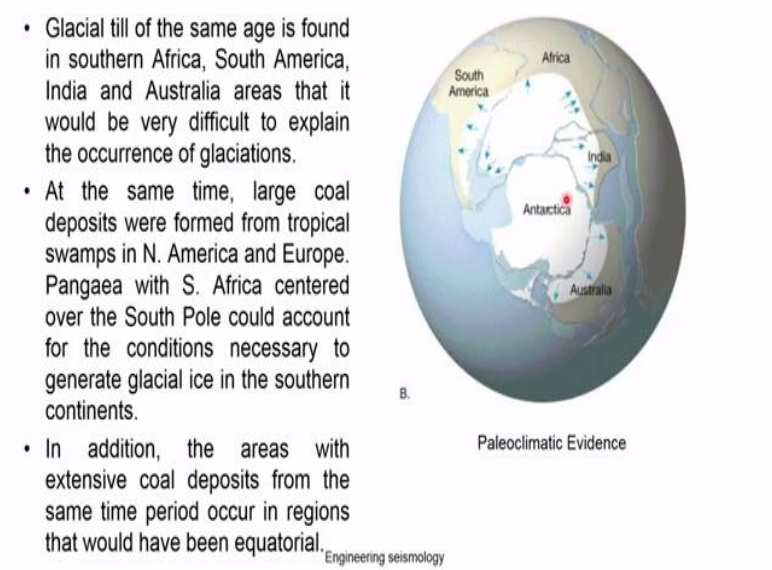
(Refer Slide Time: 23:38)



Then we can also see the rock type, as you know that so the islands are together or rocks may be in the area will be together, so this was the old image where the formation of the rock must be together, this is the new scenario, where even now if you drill a core then see a mountain you can see basically this is the mountain, this is the mountain when it was together when its broken it is moved like this and moved you can see the similar kind of mountains.

This is the rock formation, rock structure, rock materials are same so these are all the evidence gives a idea that these continents was together once. So then it is separated with the geological age, geological age is basically million years, several million years back how it was. So apart from that

(Refer Slide Time: 24:34)



You can also see the climate, so the changes a paleoclimate changes so where you can see there are places even today so it is has a unique climate, so maybe you consider India is a like a small land but you might also see that we have a desert, in our some part of the country, snow in some part of the country so these are all the once maybe the in the region of snow in the olden days and this is called as a paleoclimatic evidence.

So they take some kind of paleoclimatic evidence and try to prove that this was a the climate which was once so even after it breaks some climate continues to be there, that is why they say there is a paleoclimate change. So these are all the evidence which proves beyond doubt that this plates in the plates which we are seeing now like South America and North America, Africa, India, Eurasian plates we are now far away as on now but it was once together the earthquake.

So the earthquake tectonic plate tectonic earthquakes are the responsible force which separated them and made them to move away that was a understanding which gives this kind of the plate tectonic theory and also the continental drift. So those who seen the Ice age movie, so the Ice age movie also you can see there is a continental drift happens the family separates then they find a way to come together which is only possible in the movie.

But reality it never happens, but you can see the some kind of evidence which you prove, for example. I told you that so the once the India was together with the several continent about 200

years back. Correct so the before the India was separating you can see that the India, the Indian plate actually connected with the Australia, so the Australian plate and also the African plate and South American plate.

These are all the connected together once so that may be the evidence that you can see that the people living in South India, will have similar kind of face color and appearance is in the people living in Africa and South America even, in the Australia so you can see there are some kind of similarity even a people proved that some part of these countries people speak a similar language, which is called as a Tamili.

So in Tamil language, what are we call it as a Tamil now it was a oldest language earlier so its called as a Tamili and other version so those people speak a similar kind of language, so that means the Tamil language spoken in India, southern part of the India state called Tamil Nadu is been spoken by also some part of the Africa some part of the South America and some part of the Australia.

Where it says that this people are once maybe together due to the separation so this has happened the more people moved but still they used to continue to speak their language, that is what it indicates so this kind of plate tectonics and continental drift theory, gives evidence that the earthquake causes a excessive movement and it makes the revolution so people will move away animals will move away.

Its spread across the animals and people which is sustained longer will have the evidence even today they are there are animals which is not sustained due to several reasons which is becoming a fossil. So those are all the evidence are used to prove that these are all plate tectonics and earthquake consequences which happens, so as from this we can take it message that so the plates are keep moving so due to the movement of the plate.

There is a stress built in the rock or crust of the plate so that stress exceeding the capacity of the rock so then it breaks and the releases that release is basically causes a vibration. That vibration propagate as a seismic waves so the elastic rebound theory, plate tectonics, continental drift are

interlinked together to show that today world so whatever you are seeing a beautiful scenes of the Himalaya as well as the several valleys and ridges.

Several natural formations of the earth mountain so everything happens because of the earthquake and plate tectonics. The earthquake caused land to move, cause the excessive deformation and displace so that causes your beautiful land formation, landscape, so which is a responsible so the earthquake occurring cannot be prevented at any cost because if the earthquakes are not occurring you may not have the earth itself.

So the earthquakes are keep on occurring only the way to for us to escape are avoid death due to earthquake is basically prepared our self for that. So that is what you see in the I told you that the earthquake 200 million years, there was a generation there once together but still they exist now on the different places where the earthquakes separated them, so there be now there may be slight changes but still they speak their own languages and their own practices they continue to be doing that.

So in that case occurrence of earthquake you cannot prevent only you can make yourself resilience to the earthquake, as I told you that the earth vibration happens in the earth is earthquake the similar kind of vibrations also noticed in the rest of the plate like a moonquake, mars quake, venus quake, so there is a vibration caused in the not only the earth planet it also happens in the different planets in the universe system.

Only thing right now, we have the technology to measure these earthquakes in the earth and try to ourselves resilience to resist this earthquake so that our generation sustain for the next several million years but other places where we have the technology to know the vibration but we are not able to understand how the earth was releasing the seismic energy similarly there is not much understanding has been done in the Mars and as well as the moon.

But there was a record which shows that the vibrations are created or vibrations are happening in the moon, which is called as a moonquake, so the vibrations are occurring or created in the Mars is a Mars quake, so then other planet too. So those who are interested to know about that you can

Google it find out what is the moonquake, mars quake and then the venus quake so you can see a typical record which is released by the NASA and other space organizations about the vibrations in different planet.

So the revolution happens because of the, this kind of changes are occurring in the planet so which cannot be minimized which cannot be controlled which cannot be deducted. Only the effect or hazard caused by this can be minimized reduced and deducted if you understand this theory properly and try to understand how these waves are behave. That is what we are doing in the engineering seismology.

So with this the recap 2 is over so we will go to the next recap to discuss continuation with this. So thank you very much for watching this video we look forward next class, so thank you.