Earthquake Geology: A tool for Seismic Hazard Assessment
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Lecture – 10
Plate Tectonics (Part IV)

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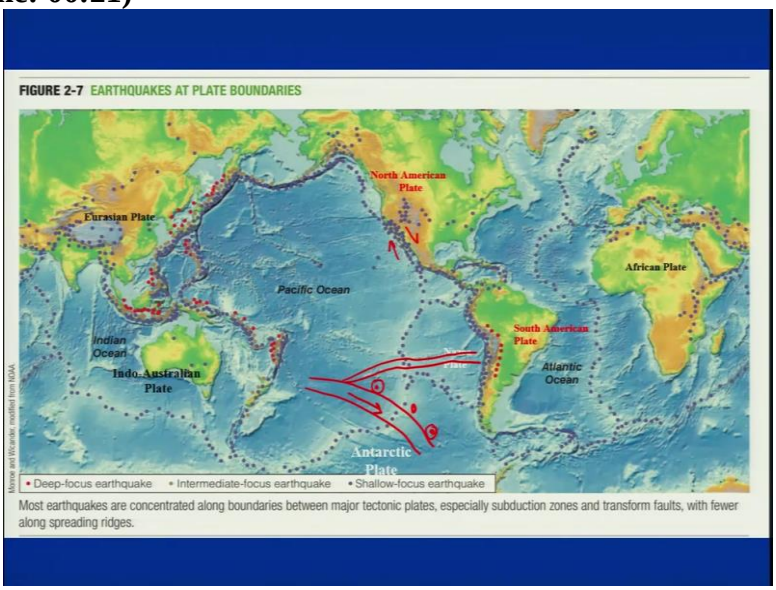

So, welcome back. So, in previous lecture, we discussed about the type of plate boundaries and what will be the earthquake occurrence of earthquakes with respect to the depth shallow, intermediate and deep earthquakes.

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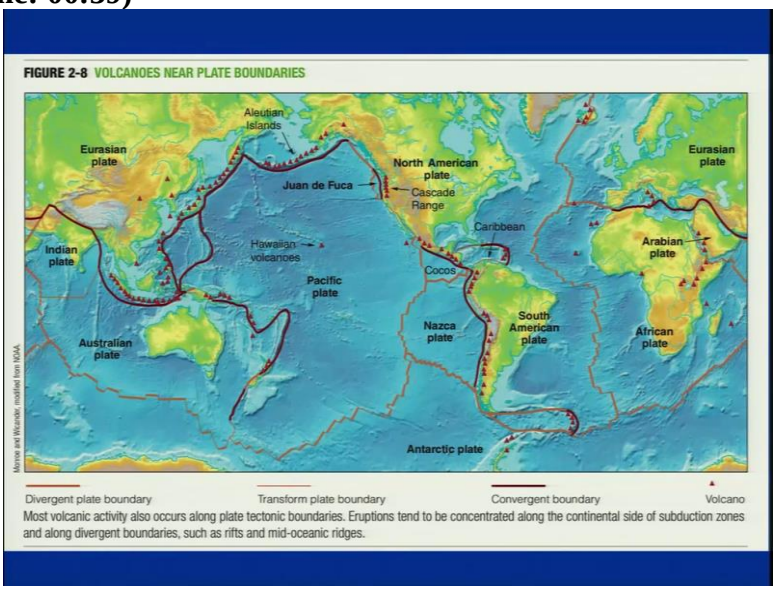

Now, along with the distribution of earthquake along the plate boundaries another feature which one will come across is the distribution of volcanoes. So, wherever you are having the subduction plate boundaries then mostly along that those plate boundaries you will be able to see the prefer overdone the alignment of the volcanic eruptions. So, mostly they will be seen between the plate boundaries where you are having the oceanic plate subjecting below the coast continental plates or the oceanic plate subducting below the oceanic plate.

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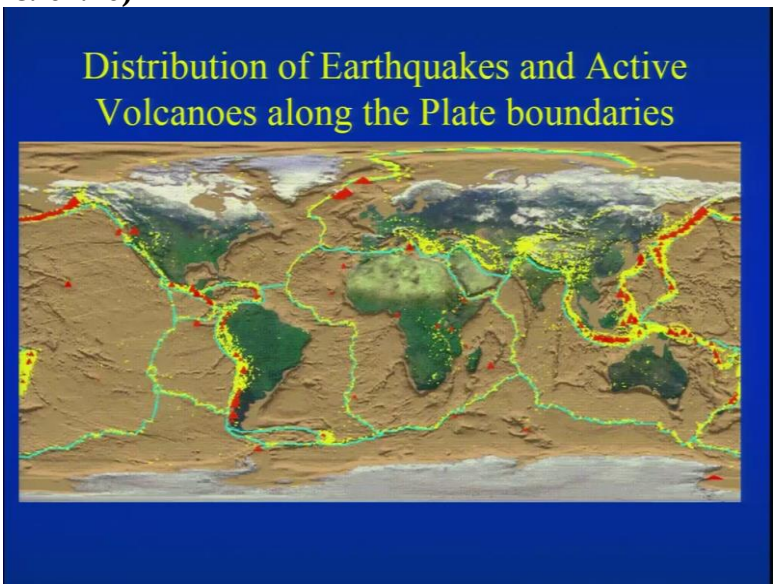

Now distribution of earthquakes and active volcanoes along the plate boundaries if you see in total then this is what we see the yellow dots are indicative of the distribution of earthquakes as well as the red triangles are indicative of the occurrence or the location of the volcanoes along the plate boundaries. So, as I told that we are having the oceanic plate subjecting below the continental plate or oceanic plates object in below the oceanic plate, you will be able to see the on the volcanoes.

But when you are having the collision, you would not be able to see the volcanoes only what we see is the earthquakes. So, particularly in India, what we will be able to see is the some locations at some location the volcanoes, as well as, but only one volcano we have a is an active volcano is the barren Island and along the Andaman arc and, and here in the northern side we do not see any volcano because no plate is subject in below the another plate.

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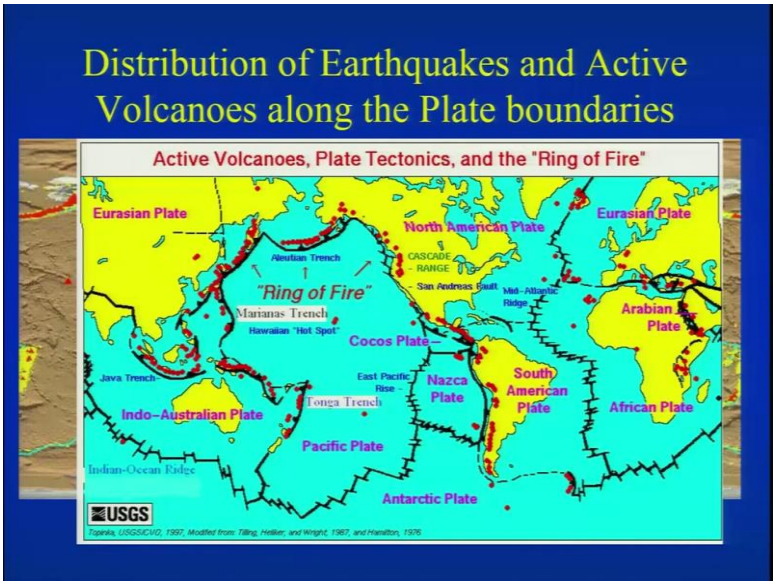

So, most prominent the distribution of the volcanoes if you see as along the Pacific region and this region has been termed us Pacific Ring of Fire or just the Ring of Fire. So, we have the one of the most active volcanoes along this one, this is termed as the Ring of Fire.

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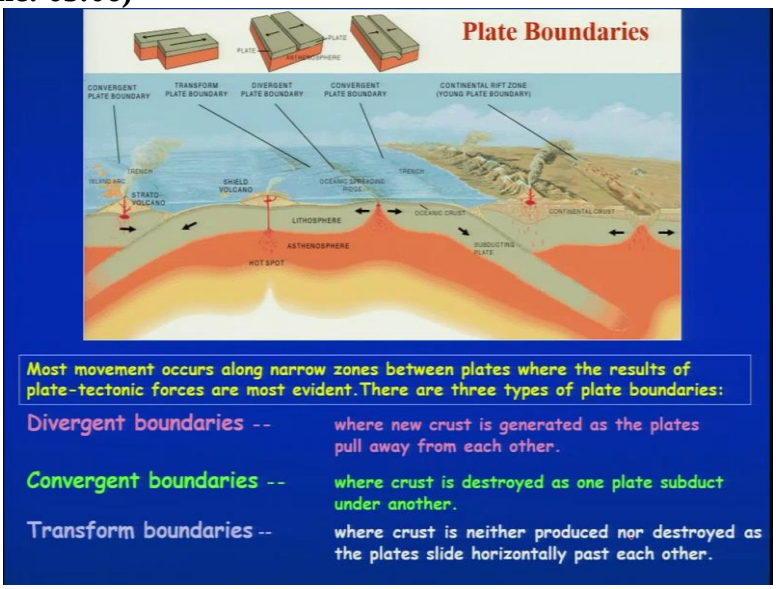

So, in terms of the plate boundaries if we take and generally we have 3 major play boundaries one is convergent plate boundary transform plate boundary and divergent plate boundary. So, most moment occurs along the narrow zone between the plates where the results of plate - tectonic forces are most evident. There are 3 time major types of plate boundaries one is your divergent plate boundary, which has been shown here. So, mainly the oceanic ridges or the spreading centers.

So, we say that we are new crust is generated as plates pull away from each other. So, the magma has been poured on the surface and every time you have the addition of the, the crust here, so, new formation of the has been taking place along the divergent plate boundary and this is also been termed as constructive plate boundary. Whereas, we have the convergent plate boundary as this one we have with one plate is subjecting below.

So, this has been shown with respect to your having the oceanic crust or oceanic plates subjecting below or the continent plate. And as I was talking about that, if you have the split going deeper into the Asthenol sphere, then you will have the deeper earthquakes, intermediate and shallow earthquakes and on further inland side you will have the volcanic eruptions.

So, you will find the formation of the mounting chains as well as the volcanic car. And similar case remains in the divergent plate boundaries where we have the oceanic crust subjecting below the oceanic crust and at the deeper part you will have the formation of Highland Park. And then finally, third one is your transform plate boundary, where the 2 plates just slip past each other that those are the transform plate boundary.

So, we have divergent, convergent and convergent where crust is destroyed because this crust is going down and getting melted and consumed. So, we do not have the addition of the crust here. So, these boundaries or such boundaries are also termed as destructive plate boundaries. Whereas in the transform plate boundaries, the crust is neither produced nor destroyed as the plates slide horizontally past each other.

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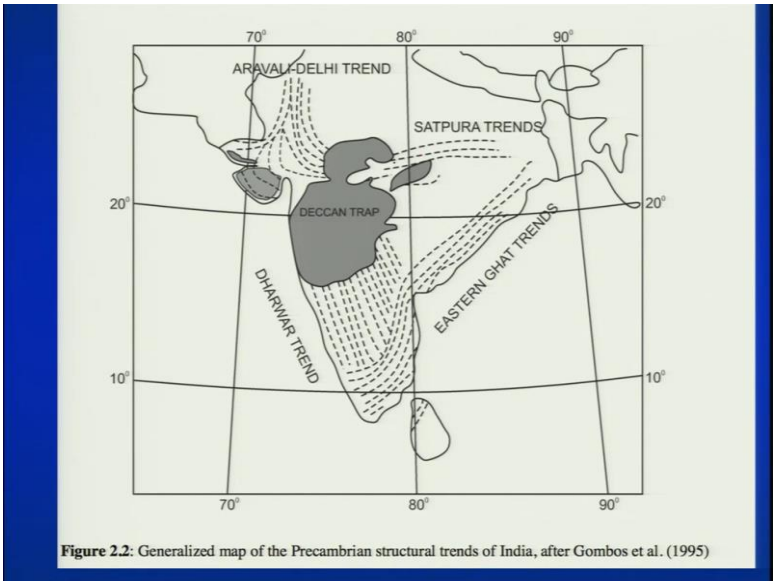

Figure 2.2: Generalized map of the Precambrian structural trends of India, after Gombos et al. (1995)

So in India there is this research have suggested that we have several boundaries between these smaller continents, but still we need more research to be done.

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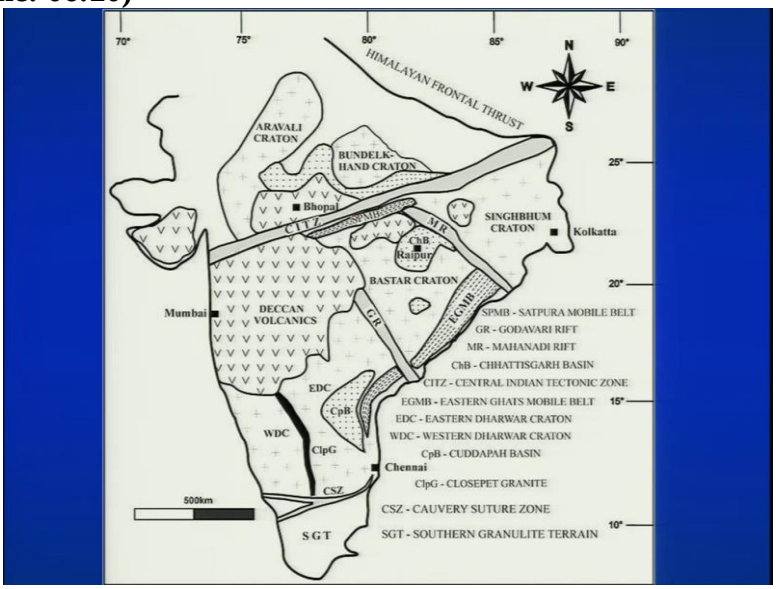

and what we call the lead the suture zones okay. So we have one along the Himalaya and then we have few suture zones which exist in between and the different smaller plates.

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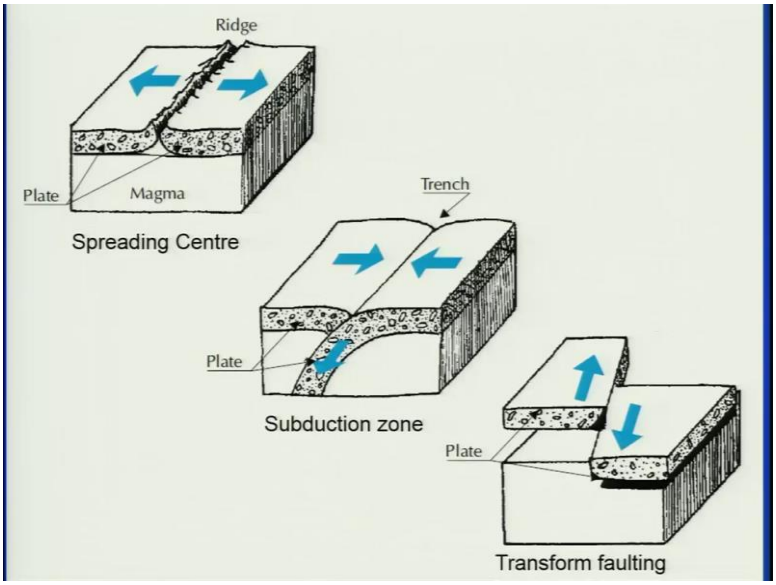

So in total what we see as the spreading centers we are having subduction zones and we are having transparent faulting or transform plate boundaries. So, in terms of the table, now, divergent plate boundaries, how it was been concluded that this is on the plate boundary where every time the new crust has been added up, and we have the addition of crust in this region that is mainly the spreading center.

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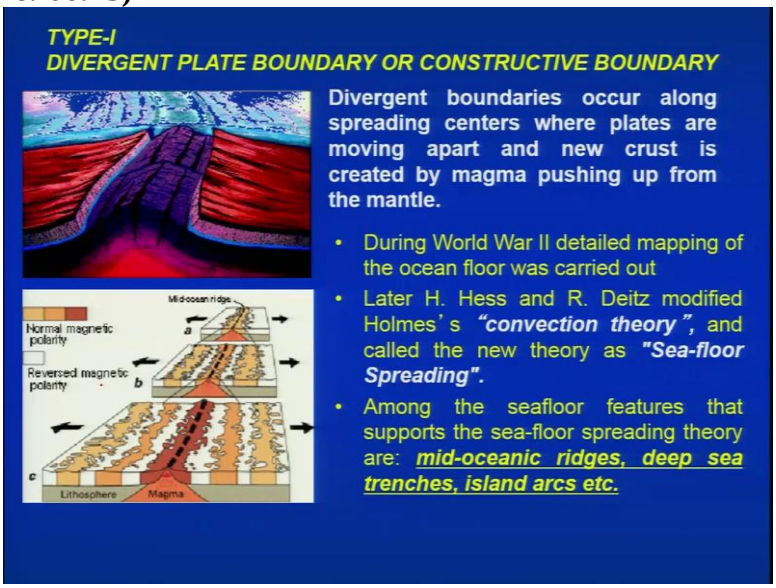

So divergent plate boundaries occur along spreading centers where plates are moving apart and new crust is been created added by magma pushing up from the mantle. Now, this came up during World War II, when the detail mapping was been carried out and they came to know that there are the older as well as the younger crust which have been which are forming along the spreading center and Later Hess and Deitz are they mostly modified the Holmes theory.

Which was been given as in conviction theory and they call that his new theory as an sea-floor spreading. So, mostly what has been shown here is that you have the, the older one are sitting away from the spreading centers and the younger ones are the close to the to the spreading center. And not only this, this the spreading center or the magma which has been seen here also indicated the reversal in the magnetic field.

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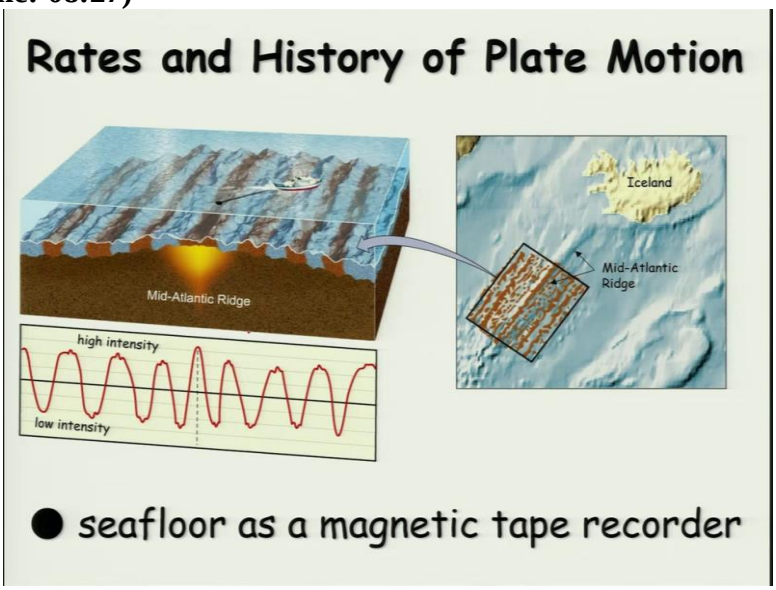

And this was been confirmed later on also and that we do not have the orientation of the magnet mental in the same direction as what we see we have at present. So sometime in some locations what we have is the, the positive and the negative anomalies. That is you having the, the shifting of the poles and there is also been termed as the magnetic tape. The sea floor is a typical what we call the magnetic tape recorder. So it also indicate that the North Pole and the South Pole never remains same it kept on changing.

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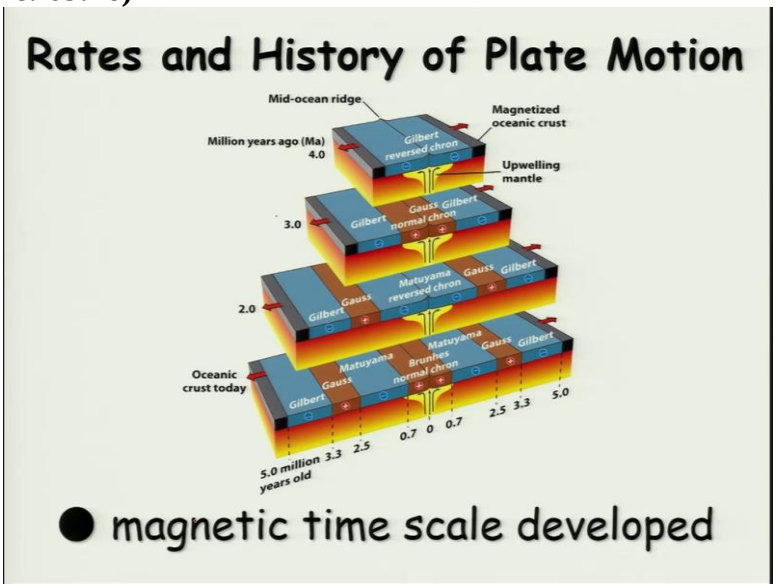

So this is what he has been shown here and you have on the positive negative that is a change in the magnetic field over the time.

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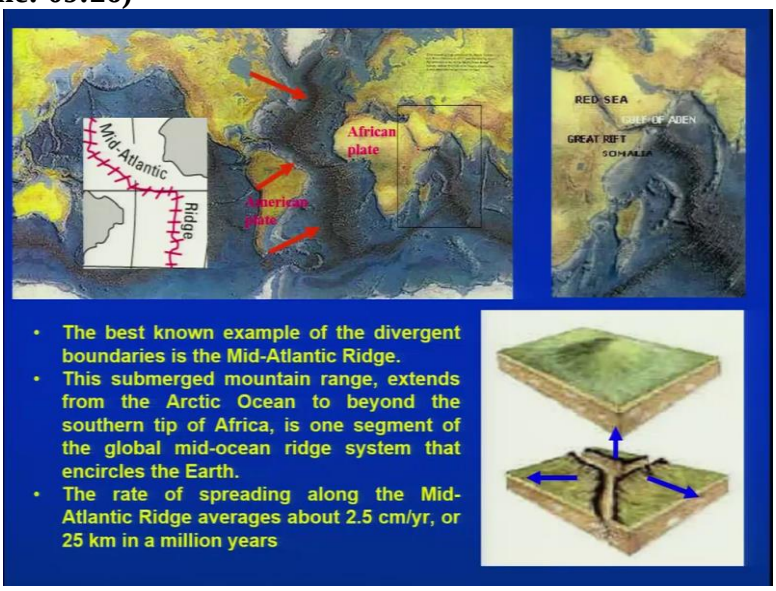

Now, looking at the Mid-Atlantic ridge, which is located between the African and the American plate, and along with that, so, these are the spreading center which has been seen between the 2 plates, but at some locations we also see what we call the triple junction, where 3 plates are moving away from one another. So, this you can see, west of India where we are having the 3 different plates are moving away from one another. That is between the African plate and then you are having the Arabian plate.

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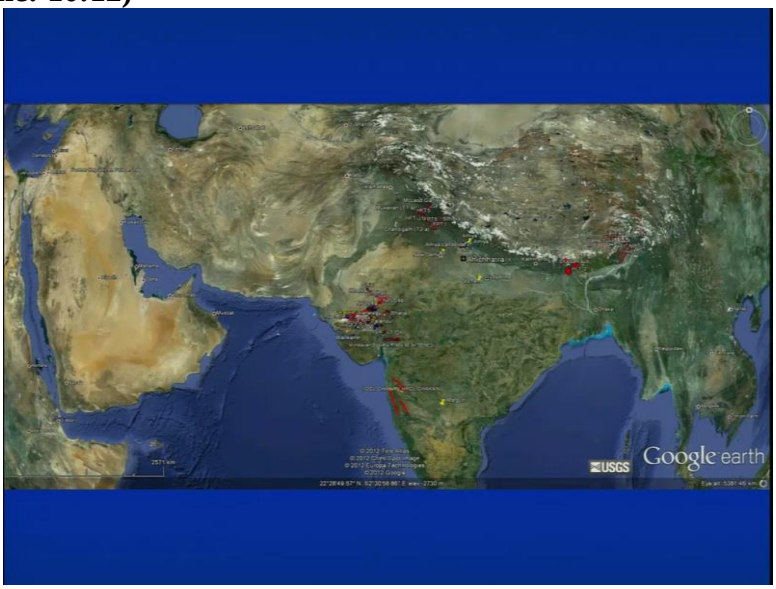

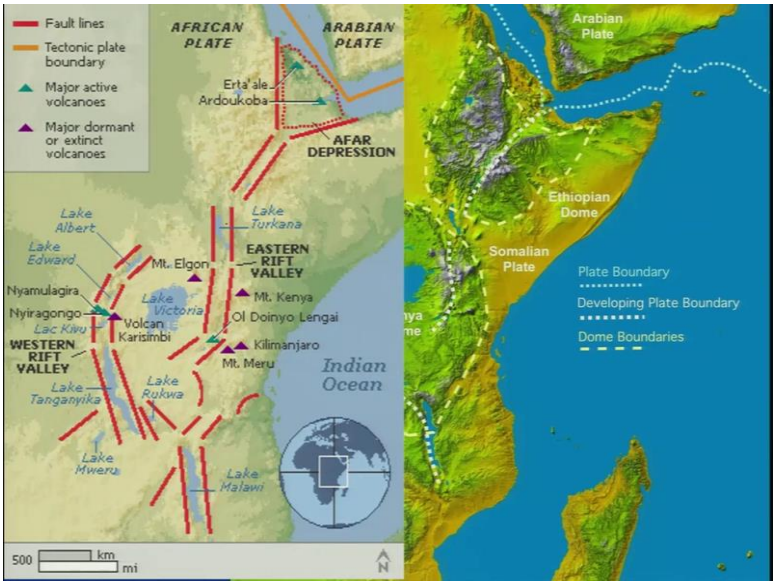

Now, getting into the detail further here, what we see as somewhere in this region. And then further moving to the divergent plate boundary, we have the most prominent one and the African plate, where the extension has already started.

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And the best example what we see here is the splitting up of Africa and this is what has been concluded that as time will pass the portion of the unit is the eastern portion of the African plate will move away and slowly a new continent will come up so, that what they say that splitting up of the African plate so we have small movie here, which I would like you to look at, and which also highlights the recent crack or huge or mega crack which came upon came across the island here.

So basically, what we see here is that the splitting of the continent to plate into 2 and as it was shown in the movie from the African plate or the region where the splitting has occurred, that this will keep going on. So, this is not the, time when initially we have experience of the local people have experienced, but this is the continuous process of plate moment. And this will result eventually and to the breaking of the landmass.

And we will have we can, we will see if of course, not we will not be here on this earth, of course, in future after maybe almost like 50 million years or 5 million years he will be able to see that this has been split into the 2 islands.

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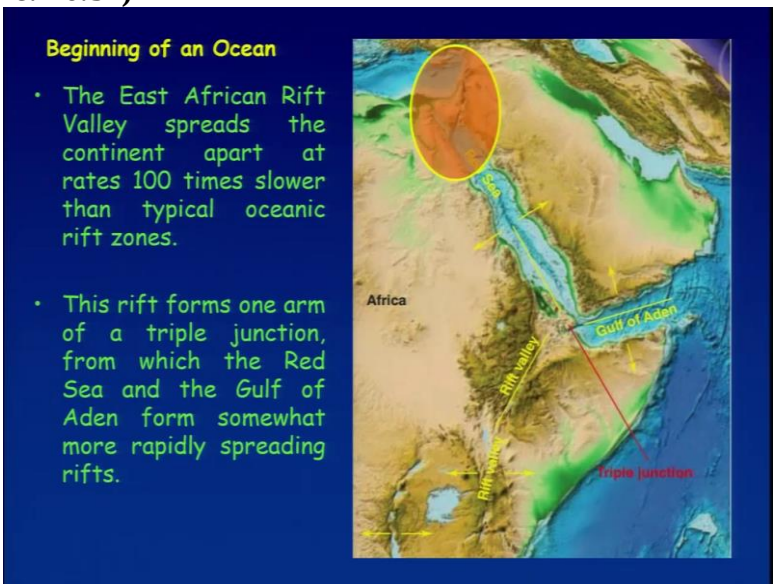

Now, coming to the part of the triple junction, we have to this what we were looking at that this the Rift Valley, which is moving away from one another, and the opening of the crack has been seen along the this line. So, the East African drift, this is the East African first, which we were showing you on the previous slide and the movie, it splits the continent apart at the rate of almost 100 times slower than the typical ocean reflects what we see. So, the drifting rate is very slow here.

And this sort of forms one arm of a triple junction. So, this is forming in one arm of the triple junction, what we see here, so, this is one plate here, another one, and this forms the, one arm of the triple junction, which the Red Sea and the Gulf of Aden forms somewhat more rapidly, they are more rapidly moving as compared to this one. So, coming to this part here, we have, like, transform plate by but let us see it somewhere.

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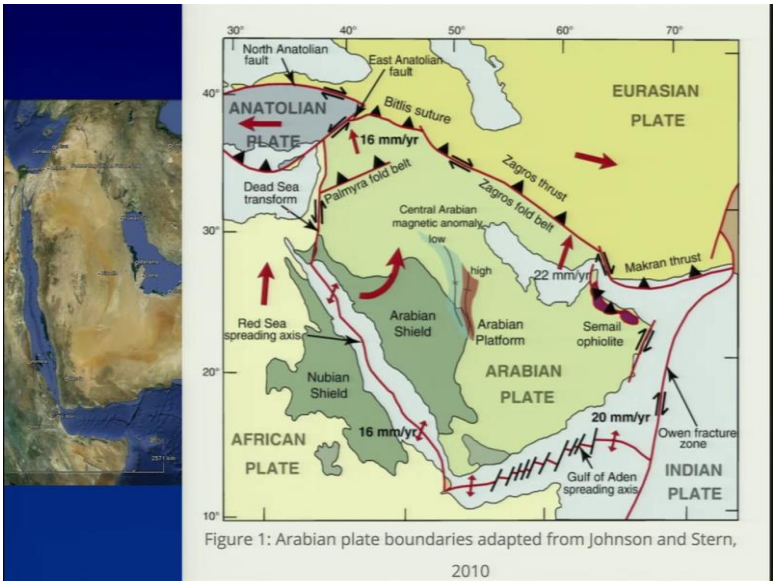

Figure 1: Arabian plate boundaries adapted from Johnson and Stern, 2010

So, close up of that if you see and we have the swan okay. So, we are having the Arabian plate, we are having the African plate and then we have the Indian plate over here and this portion is the transform plate boundary which is the Dead Sea transfer plated out the default here.

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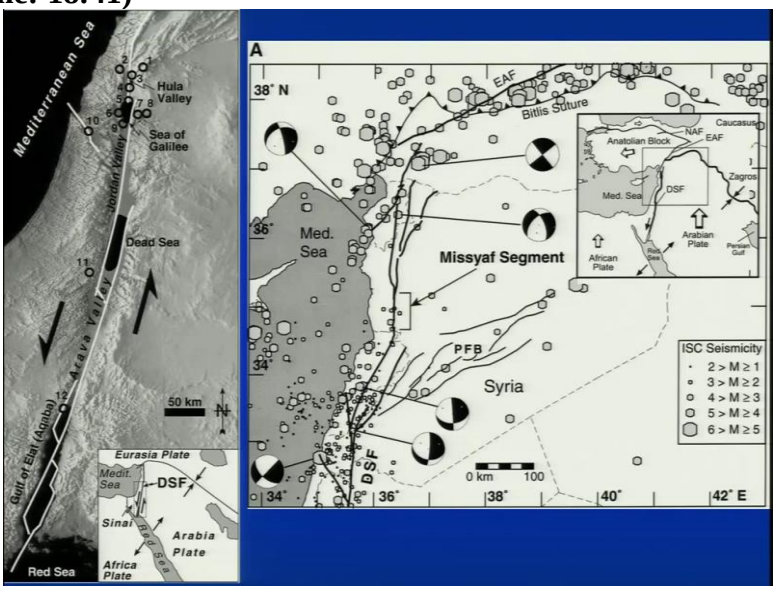

Now, as it was mentioned and the movie and which you saw that similar to what is experienced in the African plate, this valley particularly also experience somewhat similar the formation but here the moment is almost left lateral. So, this portion is moving or this part of the plate is moving in this direction and this is going in this direction. And a lot of archaeological sites sitting along this fault line is all has also revealed that the moment can is continuous and all the time.

This keep on the earthquakes keeps on occurring here and the moment is very much prominence. So, you can see the remnants or the signatures along this fault line and this is termed as the Dead Sea fault is a left lateral fault system transform fault system.

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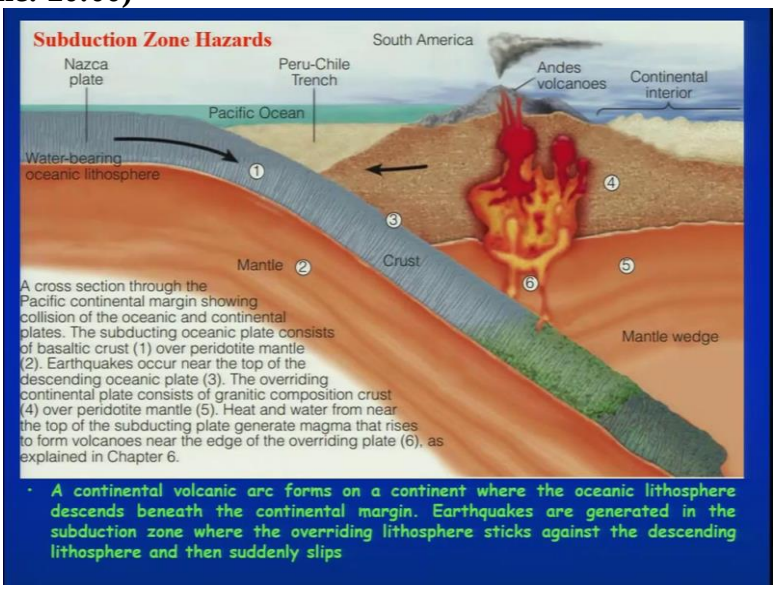

Now coming to the subduction zone what features and the other related hazard one will experiences the features we will see as the volcanoes either if you are having on the land that is the Continental area or you are having in the oceanic plates. So, you will have the volcanoes along with that you will also experience the earthquakes which are occurring along the subduction zone plate boundary as well as within the, plates which are either subjecting or over riding with respect to one another and one of the best example between the Nazca plate and the South American plate the beautiful volcanoes covered with snow.

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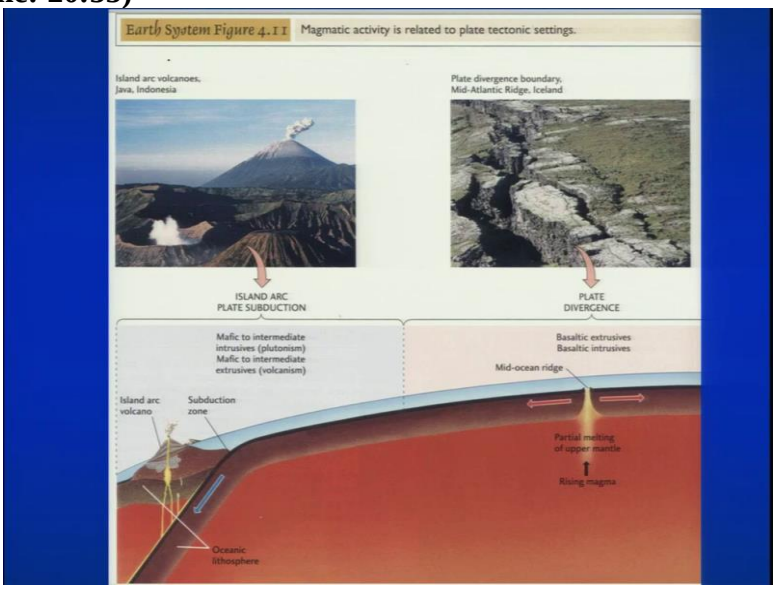

So, one like the, the location which you will see in that as the magnetic activity related to the plate-tectonics setting, it will come across on the surface or you will see along the way boundaries So, you have the volcanic art here and this is the spreading centers. And the example which has been shown here not usually we see the divergent plate boundary or the mixed portion of bridges in the ocean or the oceanic plate, but in one location displayed boundary has been seen on the surface in Iceland.

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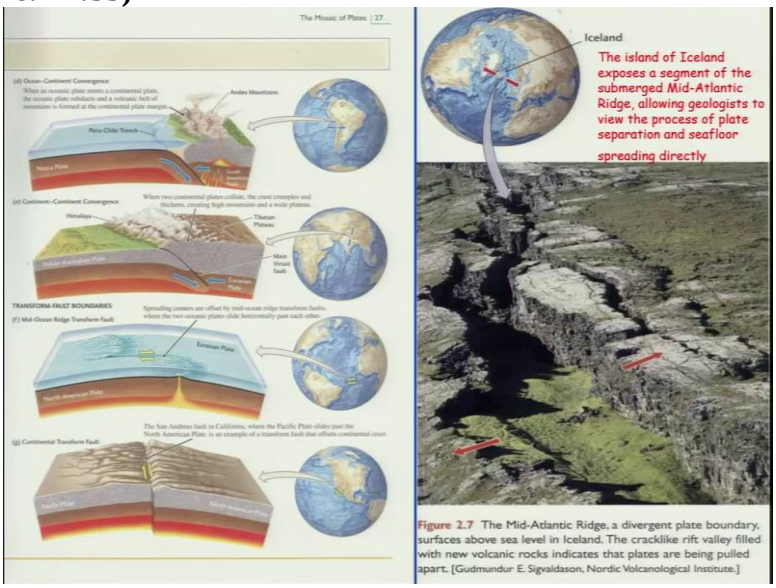

So, this is an example of that. So, where the plate boundary is just crossing the small island that is your Iceland and this example can be clearly seen on the on the surface. So, the island of Iceland exposes a segment of submerged Mid-Atlantic Ridge, allowing the geologists to view the process of plate separation and sea floor spreading directly. So, very much Similar is happening in the on the eastern East Rift Valley of Africa.

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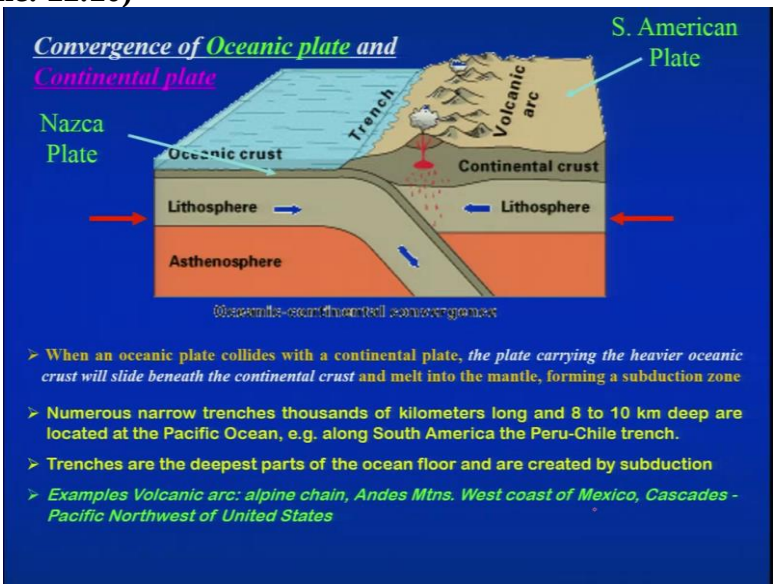

Coming to the convergence or convergent plate boundary, which is between the oceanic plate and the continental plate. So, you are having the Continental plate overriding the oceanic plate and these contact between these 2 plate will result into the formation of the deeper portion aligned along the plate boundary is been termed as trench. So, when an oceanic plate collides with the Continental plates, the plate carries the heavier one.

So this name here what we discussed in the beginning, the density was the heavier one is the oceanic plate will subduct beneath or below the Continental plate with his comparatively knighted Numerous narrow trenches thousands of kilometers long and thousands hundreds of kilometers deep are located at Pacific Ocean that is along the south American, the Peru-Chile trench or you can see along the Pacific plate and mother plate where you are having the Mariana Trench.

So the trench are the deepest portion of the ocean floor created by subduction one and you have for example, the volcanic arcs along with that, you will be able to see is the Andes Mountains West Mexico cascades and so on.

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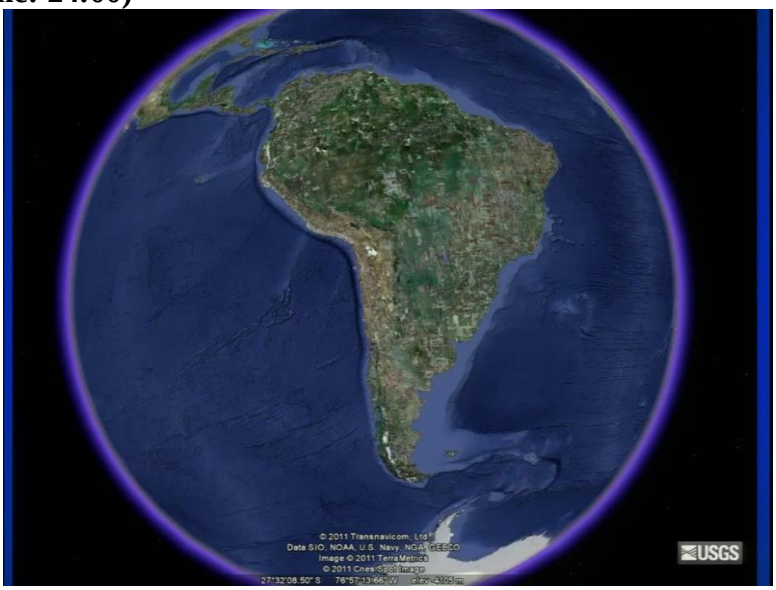

So, the trench portion has been the shown global the Google Earth image which shows the very prominent, deeper part here which marks the plate boundary between the Nazca plate and the South American plate, this portion is the contact which indicates the trench portion and this is the deeper part as compared to this and this one.

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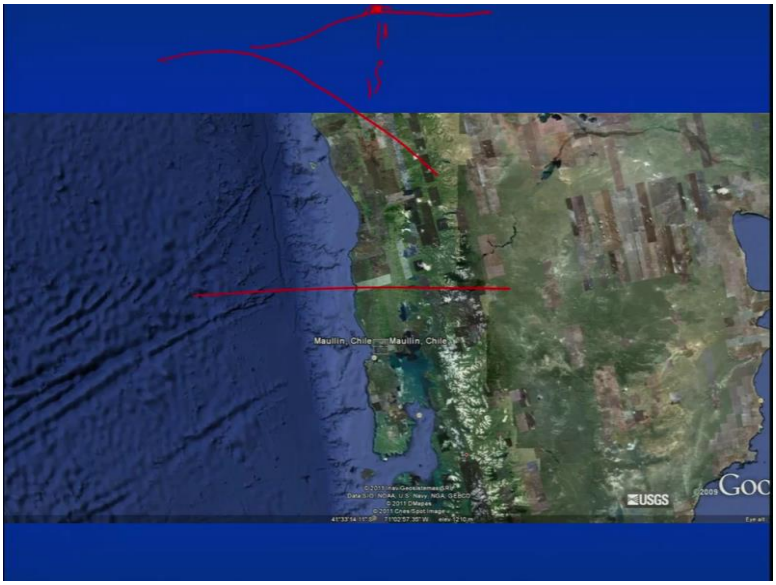

Now, the volcanic distribution so, this is the trench area as the plate is subjecting below this one and at the further deeper part. So, if you take this section here, then what you will be able to see as this is the trench area and then this is going deeper on here. So, you have the volcanic eruption sitting over here.

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So, these are the area of the volcanoes which are aligned along the boundary, the close up of that and the most beautiful volcano in Chile which has also been compared with the Mount Fuji in Japan. And this is termed as Osorno resembles the Mount Fuji of Japan.

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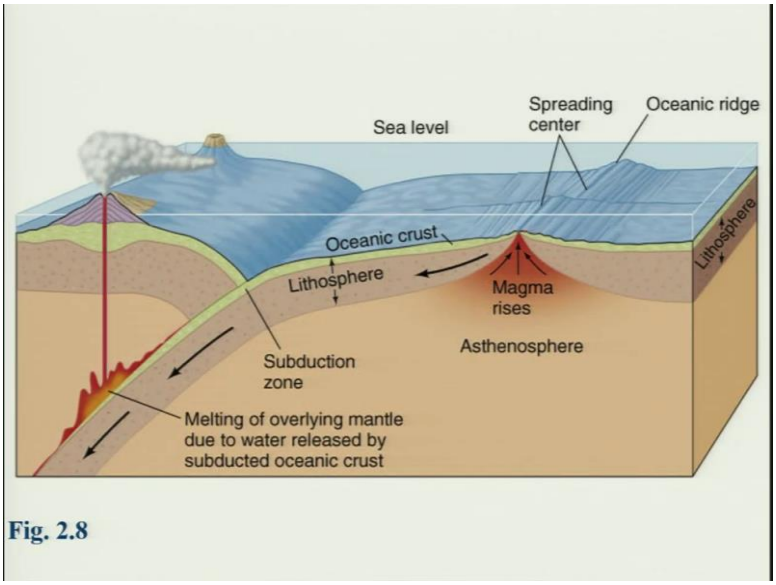

Fig. 2.8

So, this cartoon shows the spreading center transform fold subduction oceanic crust and the formation of the volcanoes.

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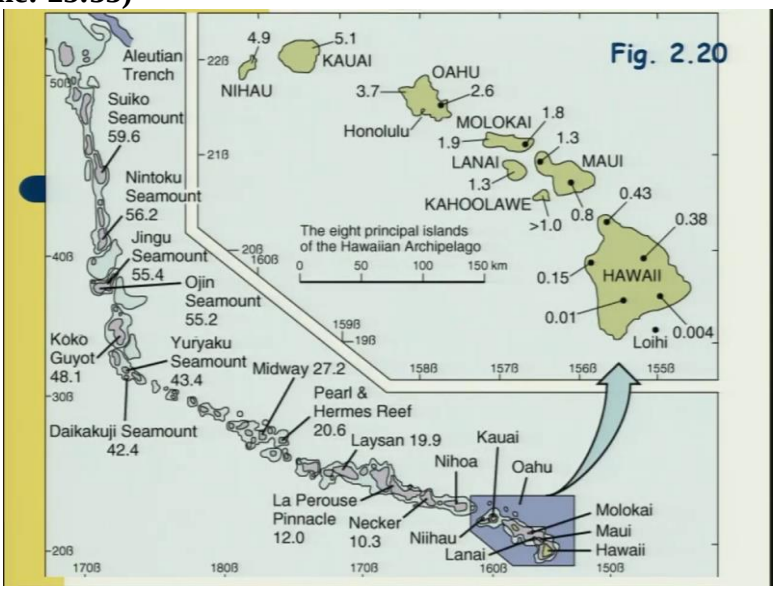

Now, this was also confirmed further that with the help of the formation of the island chain or the volcanic arc, you can say and this was also been proved that if the over the time the plates may change its direction of all the way in which direction they are presently moving, but they may change their direction and this is what was been observed and confirmed from the Hawaiian chain of islands.

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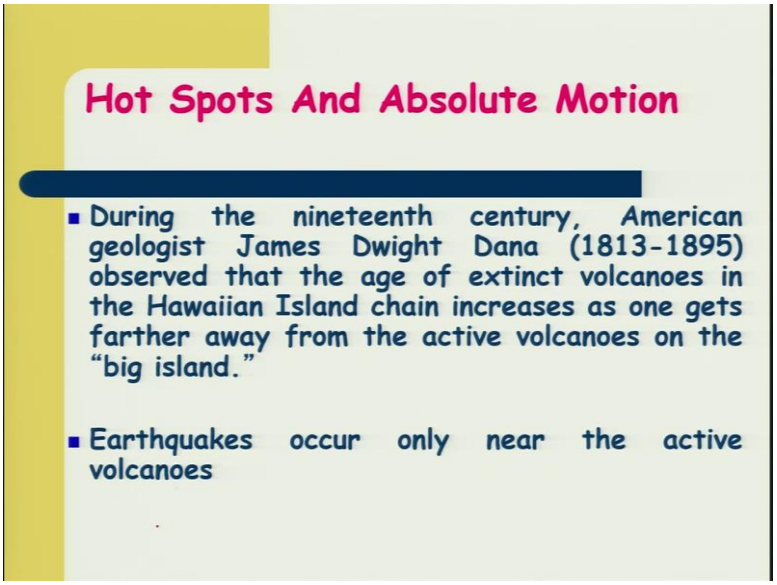

So, hotspots have been taken into concentration as an absolute motion theory. So during the 19th century, the James dana observed that the age of the extinct volcanoes and Hawaiian Island chain increases as one gets further away from the active volcanoes on the Big Island. So, this one is the big island, what you have okay. And if you move away from it, then you will keep getting the older rocks.

And this is what was been observed and, suggested that the, volcanoes the land which has been on the top of, the hotspot keeps getting or the having the source of magma here, which keeps getting the magma on the surface and allows the landforms to form but since the plate is moving, it will defunding the islands which are sitting away dormant, but this will remain active. So this the next portion of this will be somewhere here and the new island will start forming.

So this was observed that the age of the extinct well know that the volcano in the Hawaiian volcano increases as one gets farther away from the active volcanoes on the Picard earthquake occurs only near the active volcano so no earthquakes were been observed along the older islands.

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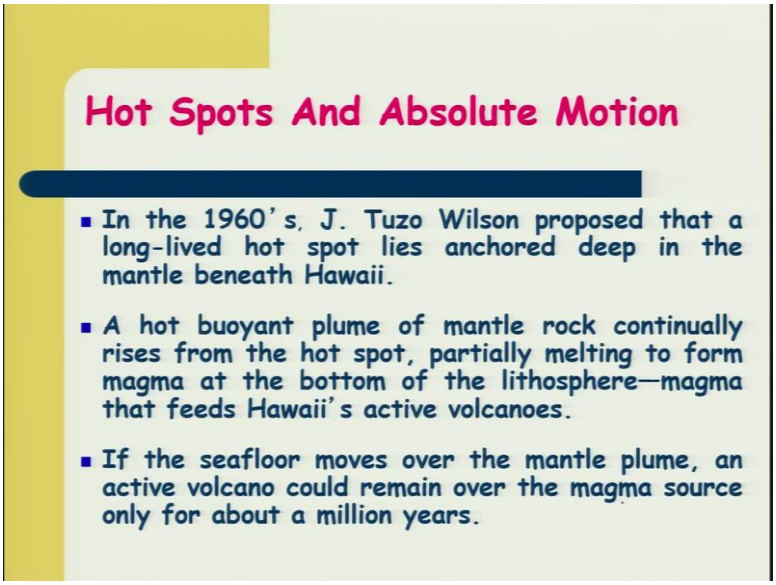

So, in 1960 further the Wilson propose that a long-lived hotspot lies anchored deep in the mantle beneath, the Hawaii Islands and a hot buoyant plume of the mantle rocks continuously rises from the hotspots partially melting from magma at the bottom. So, this is basically we are talking about that they had the they having a source of which, that is an hotspot, which is pouring out the magma on the surface.

So, if sea floor moves over the mantle plume on active volcano, an active volcano could remain over the magma source only for about a million years. So, after this, because this plate is moving. So, the new world the area will be on the top of the hot spot and the new island will keep forming. So, you will have an addition of, the landform which has been continuously poured by the magma chamber. So, I will stop here. So, we will continue in the next lecture.