**Earthquake Geology: A tool for Seismic Hazard Assessment**
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**Lecture – 11**
**Plate Tectonics (Part IV)**

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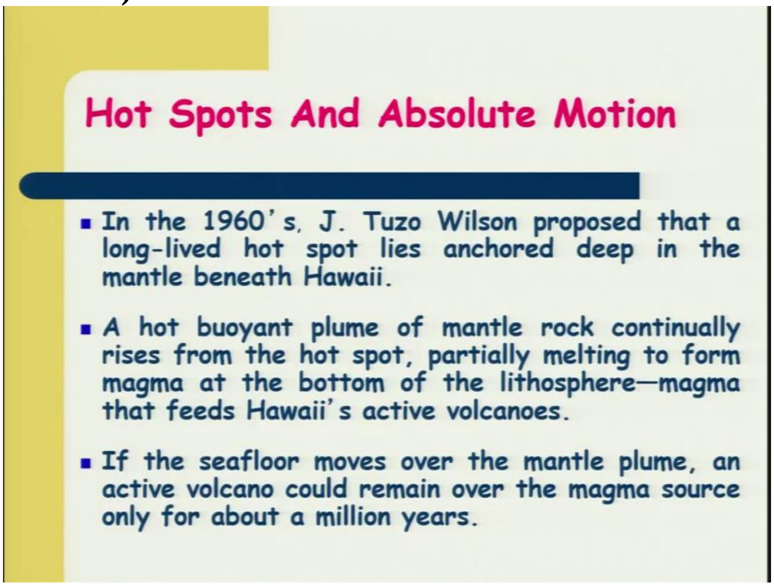


Welcome back. So, in previous lecture we discussed about the hot spot and how the hot spots can be taken into consideration to help us in understanding the absolute motion of different plates.

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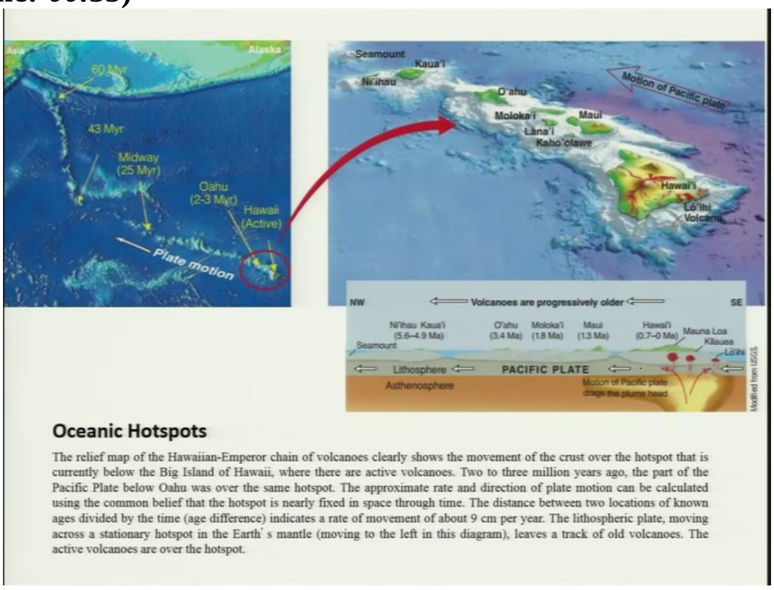


And so, if you look at this figure, this model explains that, how this volcanic chain now, this Hawaii Island chain was formed and still the process is ongoing. So, the part of the plate is moving on the top of this that is the Pacific plate and at some point or at a particular point there exist a plume that is an magma body, which is supplying continuously in the magma to the surface.

And since the plate is in an absolute motion at a particular velocity, this keeps moving on the top of this and so, until it remains on above this plume, then it will keep getting the magma on the surface and this is what they are talking about that this is an active Island. So, this island at present is an active which is having this source of magma coming out from the hotspot lying underneath.

And as the plate moves away from this hotspot, then this the volcanoes became extinct. And also what they found is that the age of this volcano which is sitting far away are older for example, this one is 5.6 to 4.9 million years and 3.4 million years 1.8 and so on and at present there is a sense lost  as 0.7 million years till present, this is now at this location. Now another important part which they understood.

That the plate can change its direction that is the movement direction of the movement and this is what this was well identified by the change in the direction. So, they say that around 43 million years the plate change a direction from its present direction what we have see now at present.

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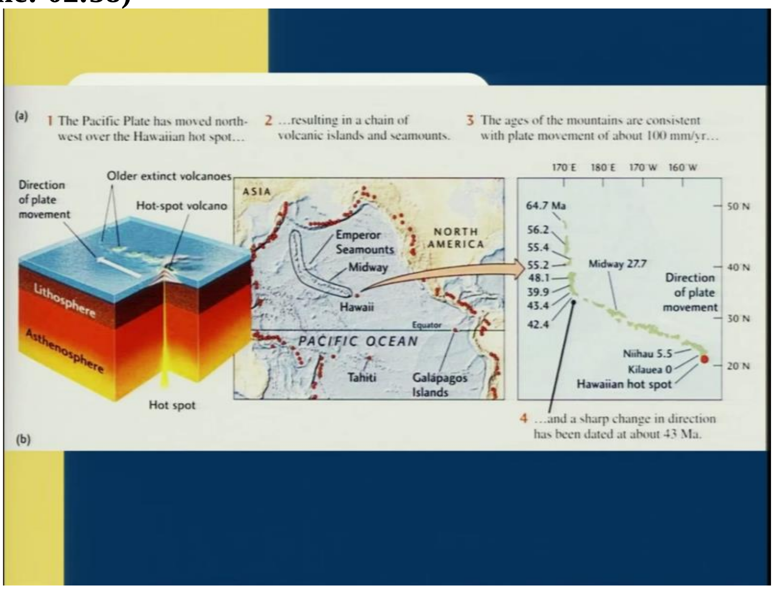


So, the Pacific plate has moved Northwest over the Hawaiian hotspot and the older one.

That is those are the extinct volcanoes are sitting away from the active ones and as I was talking about in the in the previous slides that those are the in this area are receiving the or experiencing the earthquakes whereas the islands which are sitting or the volcanoes which are sitting away from this hotspot also does not experience any volcano seismic activity.

So, second part that this plate is moving and in northwest direction over the Hawaiian hotspot resulting in a chain of volcanic island and seamounts. So, this was the sharp change in the direction which has been dated around 43 million years. So, based on this evidence or the signatures on the Earth's surface, or we can see on this earth, one can easily make out that when exactly the plate changed its direction.

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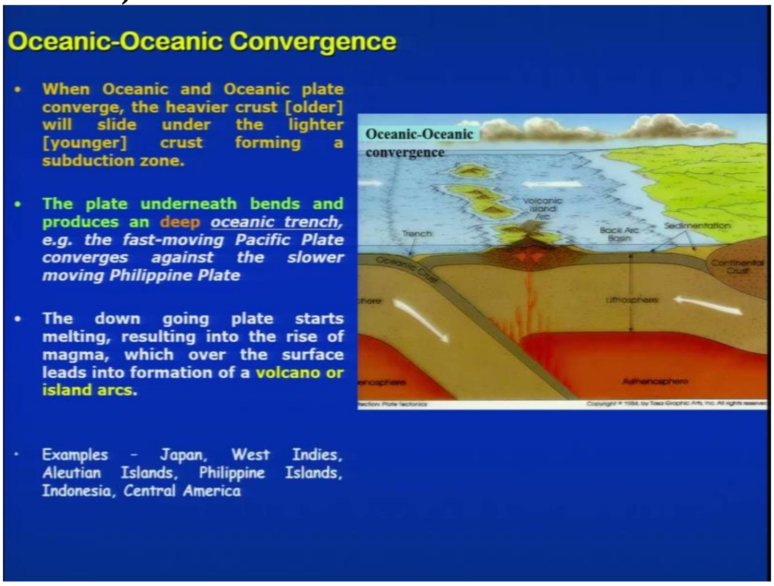


Now, coming to the other part of the convergence plate boundary as we will discuss that it can be between the oceanic continental and this example is from oceanic and oceanic plate itself. So, you have the oceanic plate as we discussed in the beginning that they are heavier as compared to the continental plates, but the older oceanic plates will be relatively heavier than the younger oceanic plate.

And the older oceanic plate will subject below the younger ones. And similar features like we will have volcanic arcs on the overriding plate and the formation of the trench along the boundary between the 2 plates will remain the same for input the configurations.

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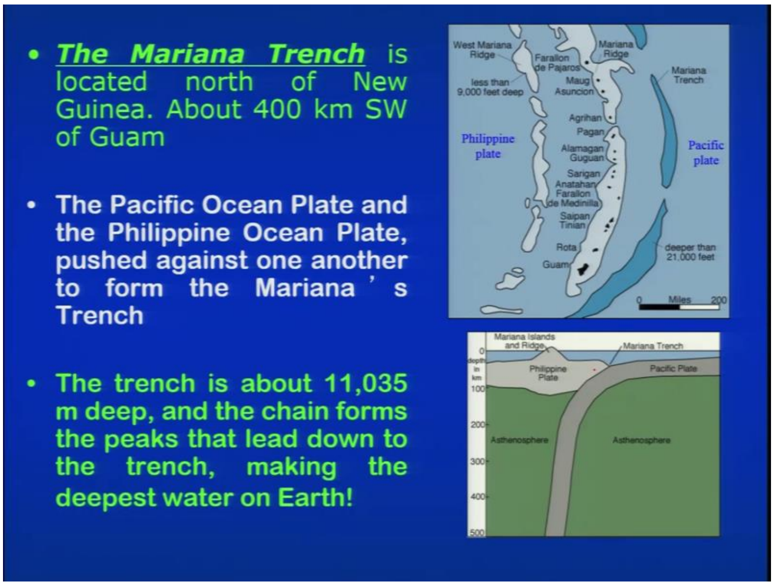


So the best example which exist on the Earth's surface, which indicates the deepest part on the earth, that is the Mariana Trench, which is between the Philippine plate and the Pacific plate, it is located almost like 400 kilometers southwest of Guam. And this is responsible again for triggering last magnitude or mega thrust earthquakes. At the end of this lecture, we will discuss about different type of trenches.

Because this is one trench which is different than the and the Chilean trench, so, we will discuss at the end, but in short, what we would like to emphasize here is that this mean the contact between the 2 plates at mark the trench landform exist and that exists between this 2 plates as the deepest one. It is around 11,035 meters and that exists between the Philippine plate and the Pacific plate. So, the Pacific plate is sub ducting below the Philippine plate.

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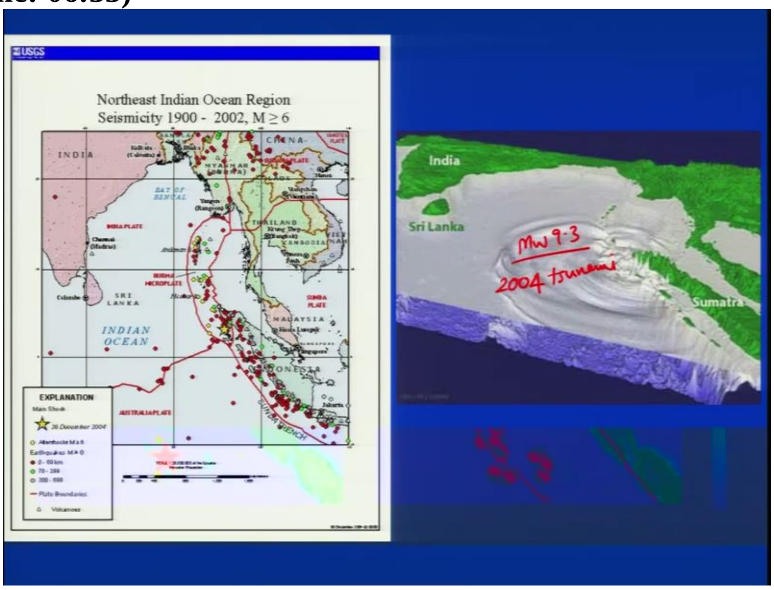

So, this you should remember and such trenches are the regions which exist, the subduction zones are responsible for triggering tsunami also and there is another example, which is one of the active region  on the globe and that is Sumatra Andaman trench, which was responsible for triggering 2004 tsunami and the magnitude of earthquake was around 9.3.

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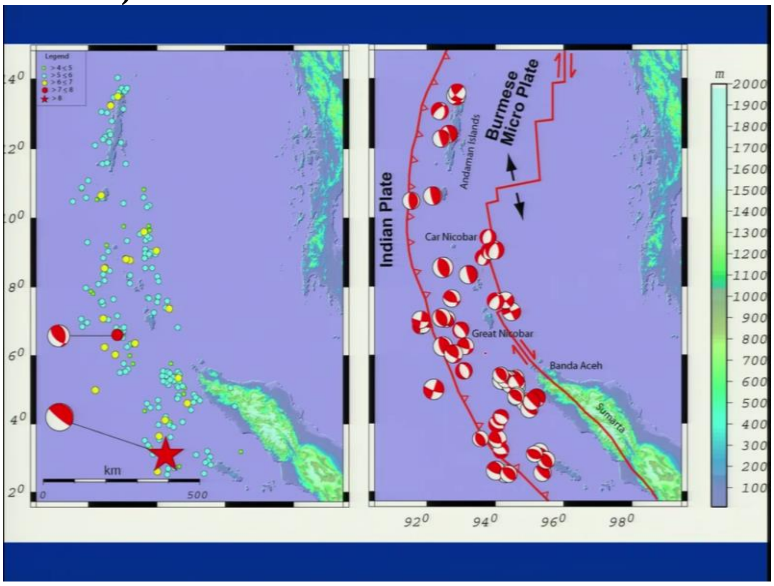


So, this is part of the Indian side what we see here that is here the Sumatra Andaman trench. So, for us, we are concerned about that what is going to happen like in the in the sense of the tsunami effect on this region, because this area of course, will experience ground shaking as well as this region to some extent it may if you are having a very large earthquake then this region also will experience ground shaking.

But this region will have an effect of land level change as well as the tsunami which is will affect the overall areas at joining the Indian Ocean. Just to show you the alignment or maybe the orientation of all the seismic events which are oriented or aligned along the trench areas and we are having another falls to me just sitting in the backyard region. So, this part we will talk when we are discussing more on the tsunami part.

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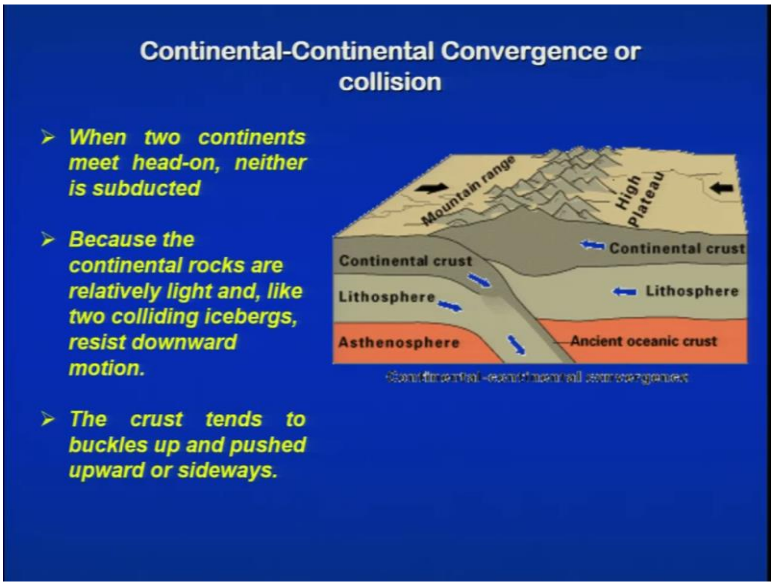


Now, coming to the continental-continental convergence and collision. So, as I have been emphasizing data from the beginning that on that we are concerned about the Indian part of course, we should understand what is happening in the rest of the world, but are on the globe, but for us it is important because the hazard which we are talking about in terms of the earthquakes or the secondary effects, that is the tsunamis or the ground shaking.

For us it is important to know that what type of plate boundary exist around us. So one is the subduction zone as we have I was talking to the previous slide and this one is the zone which exist in the northern side is your continental-continental convergence or collision. So, this at the currently we what we see as the collision, but earlier there was not convergence because the ancient oceanic plate was sitting in front of the Indian continental plate with subducted.

So, at present what we see as that 2 continental plates of similar density, so, they will neither subject or with respect to one another so when the 2 continental meets head on neither is subducted. Because continental rocks are a little lighter and they or the time when the collide, we will just see and the emergence of or maybe we can say the crumbling of the material was of the overriding plate and the rising of the mountains for the building of the mountains.

So, the mighty Himalaya what we see is the result of the collision between the continental the Indian plate and the Eurasian plate and in the north.

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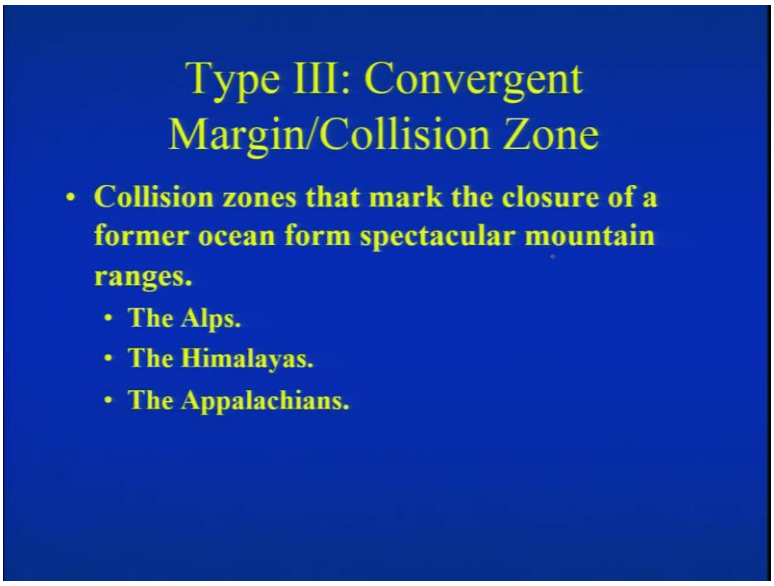


So type of converse in boundaries or collision zones if you take then we have at least 3 the Alps the Himalayas and Appalachians. So, they have resulted into the formation of spectacular mountain chain ranges.

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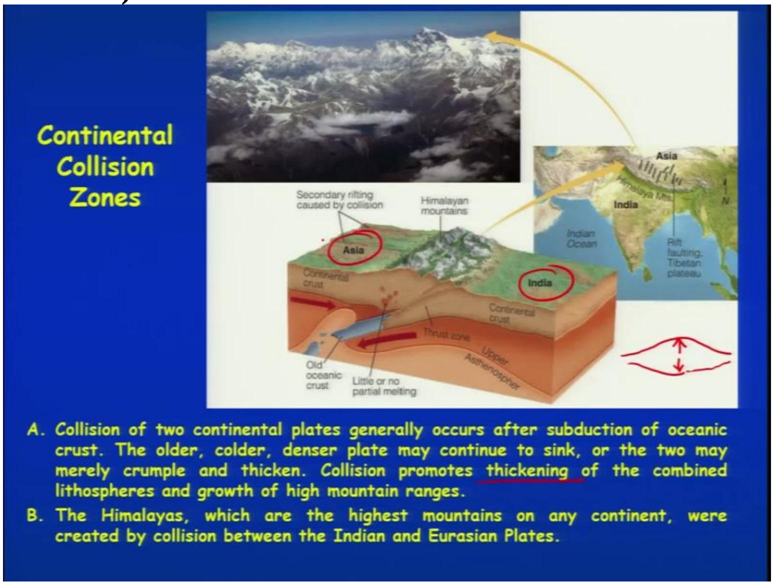


Now, looking further detail about the Indian plate or the and the Eurasian plate the collision between that those 2 so, initially there was an oceanic plate with subducted and that is one of the reason that we also see in Himalayas whatever the folded mountain are change we have in the rocks which got folded during this process comprises igneous rocks also. And we have some signatures of the volcanic activity as well.

So, this clearly indicates that initially we had oceanic plate and in front of the Indian continental plate we also had that that the oceanic plate was covered by the Tethys and this gigantic Himalayan belt which was produced was because of the collision between the 2 continental plates. So, collision of 2 continents generally occurs after subduction of oceanic trust.

The older or colder or denser plates may continue to sink. So, this definitely it continues to sink but there is no more plate which is available and no volcanic activity will be seen on the overriding plate. So, collision promotes thickening and so, this is important for us which we discussed in the beginning that the overriding plate continental plate will have will result into thickening of crust.

Because, we one way we are rising so, this will also will be there. So, we will see the up as well as down we will see the rising as well as the thickening of the plate. So the Himalayas which are the highest mountain on any continent where they were created by collision between the Indian and the Eurasian plate so, this you should remember that this is between the collision between the Indian and the Eurasian plate.

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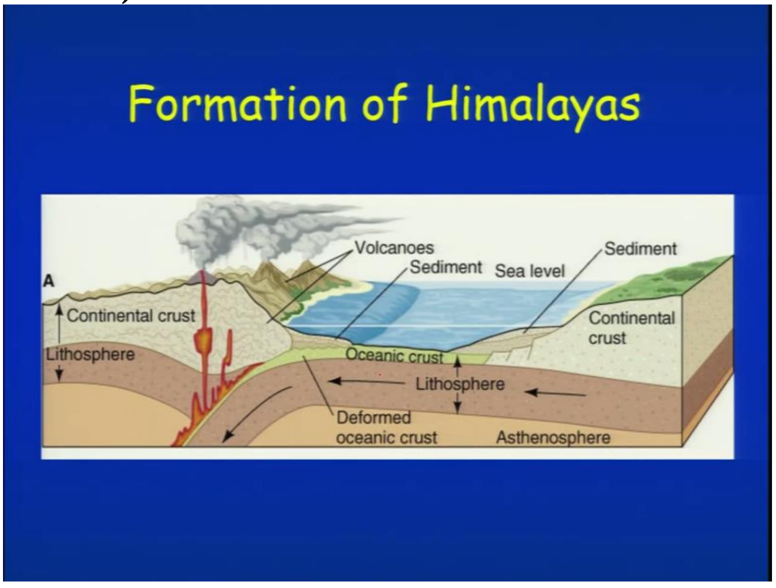


This cartoon also explains not initially what we had was the oceanic crust and if the oceanic crust is subducting below the continental crust or we are having the oceanic crust here, but in this case, what we are looking at the example of the Indian subcontinent we had oceanic crust before and subducting below the continental crust. So at that time, we experienced the process of volcanic activity. So formation of Himalaya basically there is the first stage when the 2 plates met each other, and one sub ducted below the another one.

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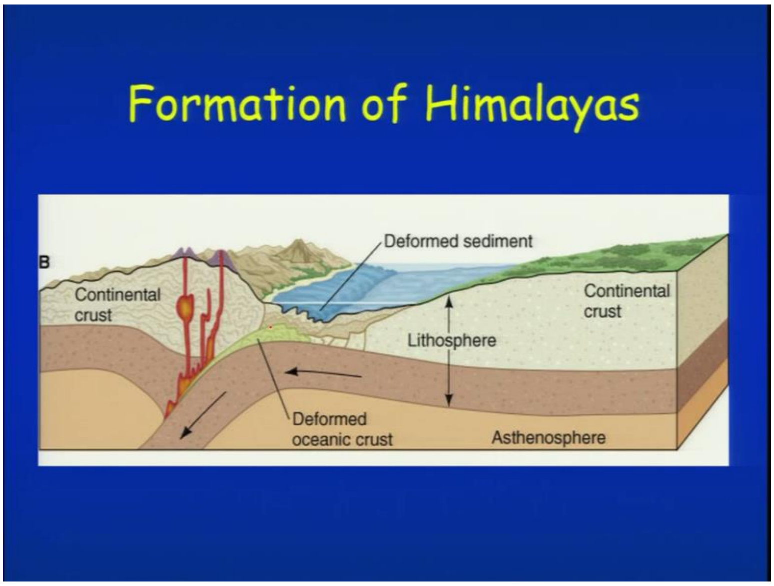


Then later as the movement remain this active, then there was an closure of the depth of sea and the overriding plate usually experience more of the formation.

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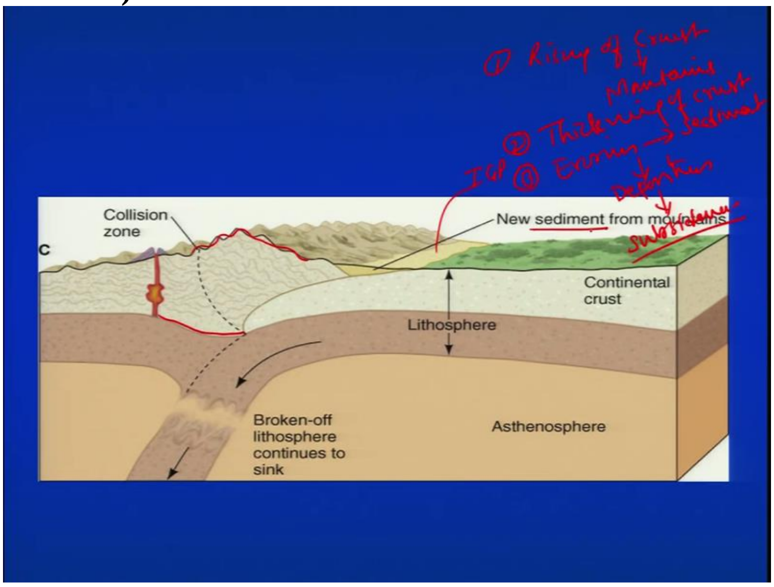


And finally, what we see is the closer of the ocean. So if you see this ocean, which is what we called depth Sea close down. And then we had the further rising of the Himalaya and the drainages are formed and for the new sediments from the mountain were deposited in the base and this is what we now see is the indo gangatic planes and in one of the slide, if you remember in the beginning. We talking about that one point is your; that rising of the crust.

That will result into the formation of mountings then second that we will have thickening of crust and third after thickening we can say that and the rising we will experience is the erosion. So, erosion will produce new sediments and they will be deposited on either side of the slope. So, the deposition of huge amount will result into your subsidence. So, we definitely will experience or we are still experiencing slight subsidence

And because of the overloading so, these are few points, which you should remember that is the rising of crust will result on the surface the formation of the mountains. So, that what you see here and then thickening of the crust erosion will result into the pollution of the sediments and subsidence. So, this part you should remember moving further what finally, we see is the present configuration between the 2 plates.

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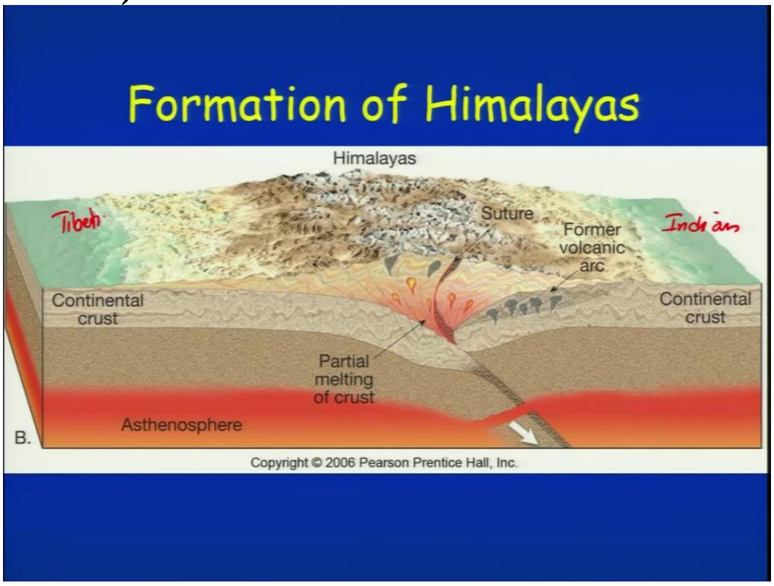


So, we see the thickening of the crust here, the crumbling of the material and the deformed material is also sliding over the continental plate. So, this side what we see as the Indian side this is your Tibetians side.

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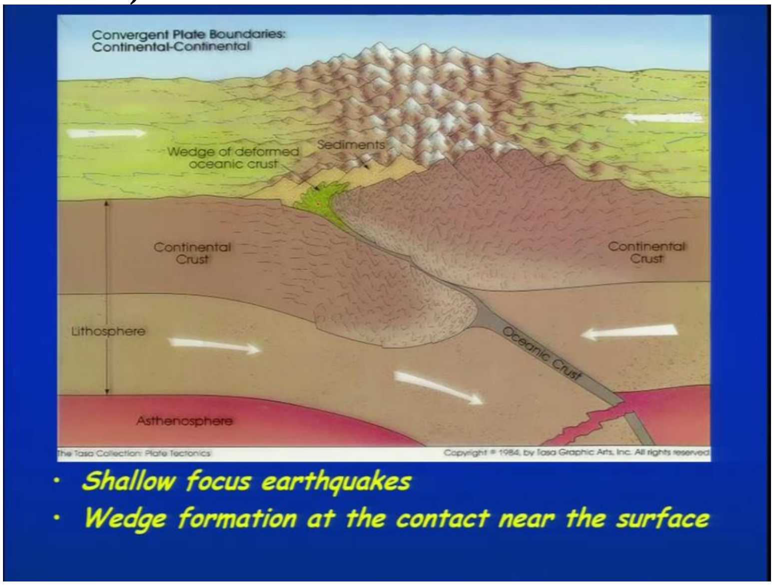

Now, in such situation, what type of earthquakes we will experience because one thing is that initially, as we talking about that we had an oceanic crust, which was subducting below. So this subduction would have resulted into taking the oceanic lithosphere in the deeper part. So, we must have experienced the deeper earthquake occurring at the deeper portion of the crust. But now, what we have is the only collision which has going on.

So mostly what we see is not we have the shallow earthquakes in this region and which more dangerous in terms of when the energy has been released along with that the formation of which in the frontal part is gain and the portion of like, which will trigger more earthquakes in the shallow ocean.

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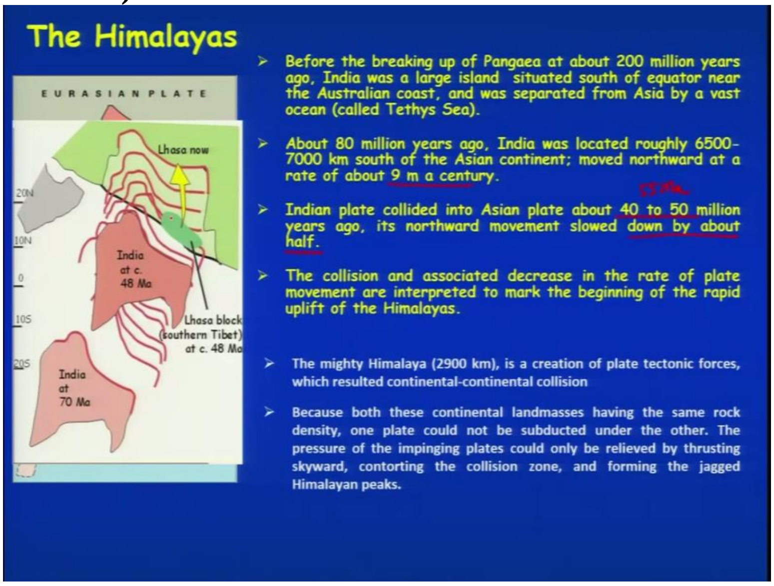


So, further quick details about the Himalayas. So, Himalaya was almost sitting way south from equator and it had like the oceanic plate as well as the Tethys Sea the front of the plate that is the continental plate so about 8 million years ago, India was located almost like 6500 to 7000 kilometers south of the Asian continent, and that is further towards south of the equator.

Move to northward at the rate of around 9 meters per century Indian plate collided with the Asian or Eurasian plate and about 40 to 50 million years are around 55 million years ago. It is northward moment slowed down by about half. So, scientists suggested that these marks are either you have saved in some literature you will find 40 to 50. And some literature you will find 55 also.

So, around this period, the moment which was around like 9 meters per century was reduced to half almost. And this reduction of the moment from 9 meters to half of that around 4.5 meter per year was been like is it related to your collision. So, the collision and associated decrease in the rate of plate moment are interpreted to mark the beginning of the rapid uplift of Himalayas.

So, this collision was responsible for the reduction of the velocity to half and at the same time the landform which was formed, what we see is the starting point of the formation of joint Himalayas. The Mighty Himalayas almost like covering the area of 2900 kilometers from east to west is a creation of plate tectonic forces, which resulted from continental -continental collision. So, this is again another cartoon which shows and there was not small in the like the plate which also was compressed in between these 2 plates is the Lhasa plate.

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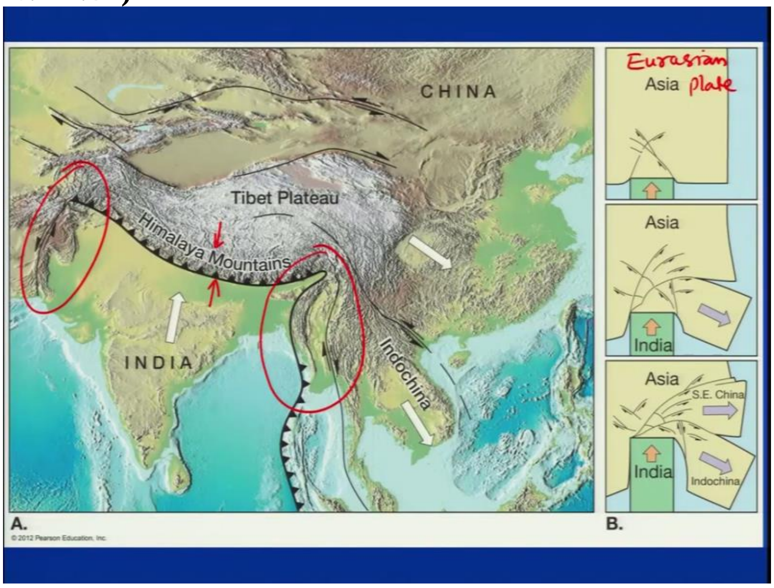


So, overall confirmation if you look at then we have the trench area in the east and further south here which goes on probably connects here and then we have the collision zone of Himalaya. And the most interesting part what we see here is not the eastern edge of the Himalaya and the western edge of the Himalaya are showing 2 different type of moment. So, one is where the other right hand side block.

Along this fault line or the line of contact between the 2 plates is moving towards right and this is moving towards left actually. So, this showing what we call the right lateral movement, whereas here it is opposite this is what we have the left lateral and along this zone where we see of course, this is also part of the Himalayas and this also part of Himalaya but here we see almost the collision that is we see crust moment.

So, here we have almost both the plates are colliding and the cartoon on the right explains that when the Indian plate collided with the Asian or you can say the Eurasian plate then there were many fractures are the weak zones which were formed and we are responsible for accommodating the formation and this is what we see at present that we have the Indochina part, this is the Indochina part.

Which is extruding towards east and southeast and the part of what we see in that is Pakistan area is moving in this direction. So, and the portion here that is the Tibetan part is getting extruded further in the eastern side or southeast side. So, this is a pattern of deformation we have and for us as I have been repeating again and again this whole zone is vulnerable to earthquakes.

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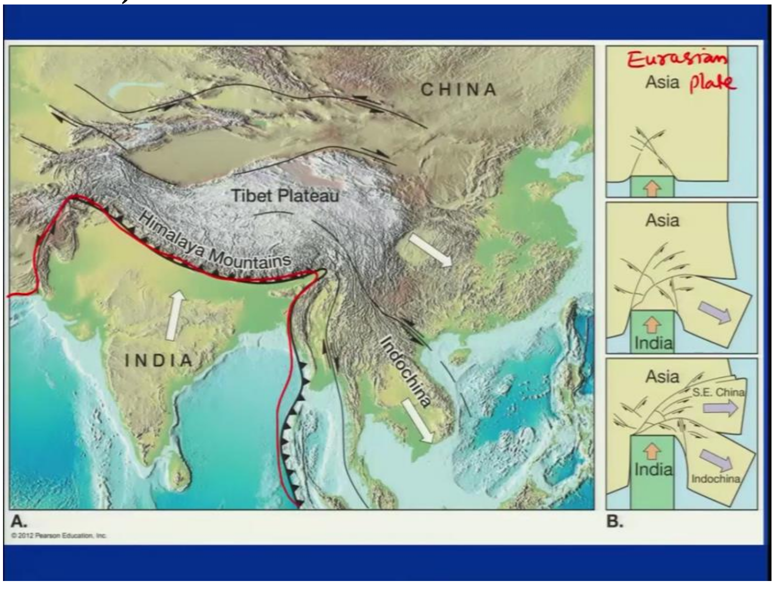


So, we have the subduction zone here collision zone and subduction zone here so, transfer fault margins as we are looking at very much similar to this one.

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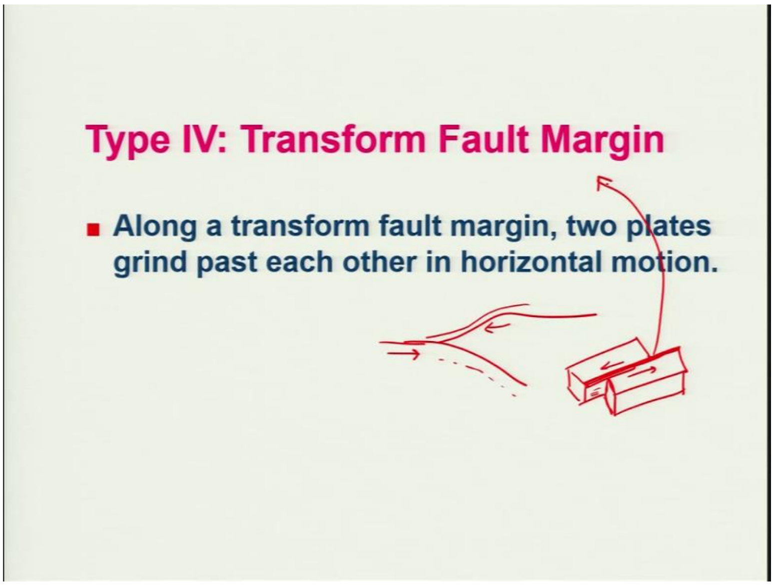


So, these are the transform fault we are having. So, such fault margins are those along which as are between the 2 plates which trying to pass each other. So, in a horizontal direction. So, one is what we see as there is an overriding one. So, this plate is overriding the, the other one that is this moving in this direction this is moving in this direction too. So, this close down and this keeps on all writing this one.

So, this is one type of boundary in which we have in and another one will have just the for example if I draw 2 blocks and you have so you have the moment like this. So, along this one so this is another type of boundaries which we have and this is termed as your transform fault plate boundary. So, direction may be different also in the sense the right lateral left lateral as we were talking about in the form of the eastern part. We are having that is what our swing here is not the eastern part we are having right lateral and the western part we are having a left lateral moment. So, the way this direction can vary from place to place.

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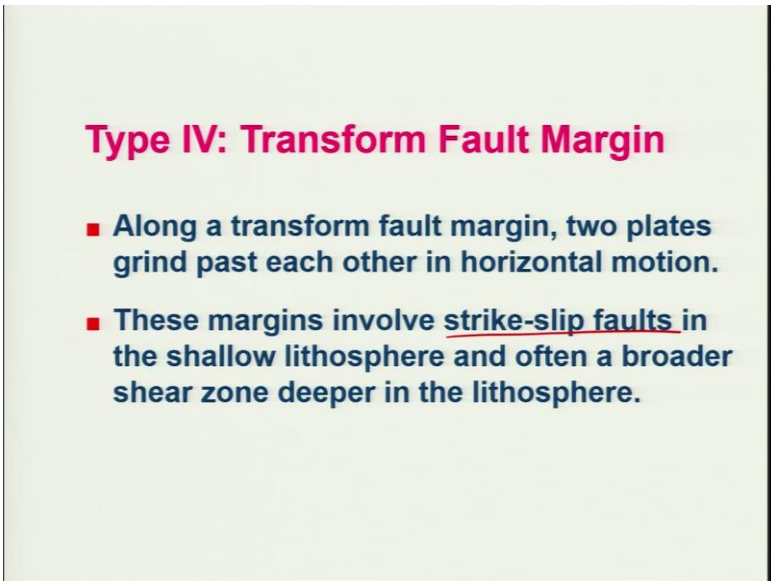


Now, this margins involves strikes slip faulting this we will come into like we will talk in detail when we are talking about the different type of force, but, they are basically the this term as strikes default and they are mostly in the shallow lithosphere and often a borders, shear zone deeper in the lithosphere. So, most transform fault occurs underwater between oceanic plate and one of the best examples. If we look at about this one is along the mid oceanic ridges we have most of the transform faults which are sitting.

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Nevertheless, we have also had very good example of between the Pacific plate North American plate again we have the transform boundary. But along with the transform fault margin, we also see our experienced there, the trust moment and that is the subduction. So 2 of Earth's most notorious and dangerous transform falls are on land. So, one is the northern Anatolian fault in Turkey.

And then second one is the San Andreas Fault in California. These are most dangerous fault on the earth. And those faults are your transform faults or you can also say the strikes default. So I will end here and then we will continue in the next lecture.