Natural Hazards
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Lecture – 11
Plate tectonics and related hazards Part I

Welcome, back. So, today, we are going to talk briefly about Plate Tectonics. Now, why I am saying briefly because this part is already covered in great detail and one of the course which we have given earlier now the earth sciences for civil engineering. So, I would like that you this the students who are going to take this course should refer to those slides and nevertheless for the new students who are totally fresh for this course I have tried my best to put some important slides and have discussion on that part. So, but if you want to go into greater details you can look at or browse through those slides or those lectures which will be helpful.

Now, basically this is a very important topic because when we are talking about the hazard part and the previous lecture we have we discussed about the Gorkha earthquake and all that. So, this is this part this topic is extremely important for us to understand the basics that where different type of earthquakes will occur, what are the different tectonic boundaries, where we expect the earthquakes and what are the, what will be the magnitude of the earthquake at particular point along the plate boundary. Along with that we are also interested that what the secondary hazard will be associated with such plate boundaries.

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So, plate tectonic theory is very important and this was being given long back which was been proposed as an earth as a jigsaw puzzle by Alfred Wegener in 1912. So, German a meteorologist, he proposed that the continents were all together like one piece named as and he named that as in Pangaea. So, he believed that this was this whole all continents were together and as one single landmass.

Now, how he got this idea I will quickly discuss that and then what he said that at present what we are looking at are all drifted plates. Earlier it was totally being together. So, then they drifted up the plates drifted apart and reached their present locations that theory who was named as continental drift theory. Initially people did not agree as usual everything also, but of course, still a lot of research has been done and finally, we all believe that this the phenomena definitely happened in the past.

So, jigsaw puzzle if you if you take then what was the basic idea to connect this whole understanding was that the boundary between the South Africa and the South America, if you look at they literally match each other the outer boundary. This was one very basic understanding which he came up with.

So, this is the picture which shows that long back initially all the continents were together.

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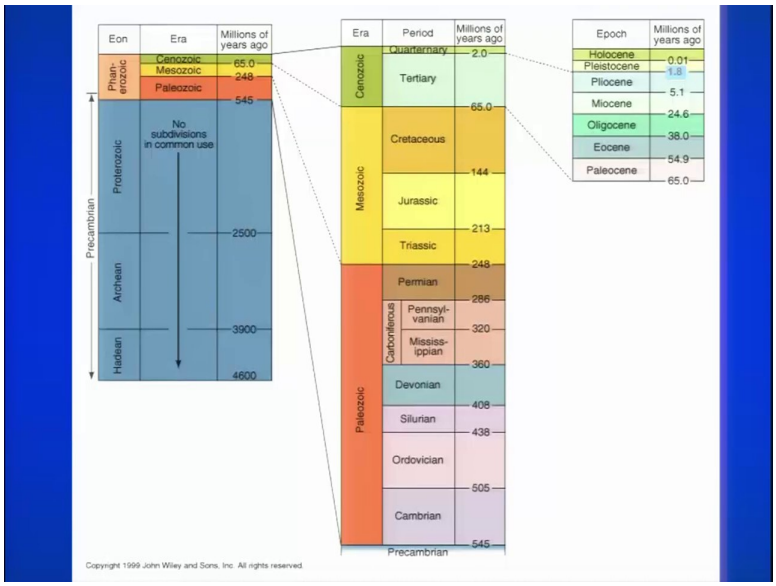

Now, I will not get into the detail of this, but just to make you people aware of that when we talk about that the slowly things moved and the move the continental drifted apart. So, there we will talk about something like the eon, maybe probably the eras,. We will talk that in what era and how many million years back things happened. So, this is the timescale which you see is the era and period and in the many years ago from present.

So, you have like period so this was this is the young more youngest period, we have quaternary and within quaternary we have two epochs Holocene and Pleistocene, but the activity start is long back if you consider the geological timescale and if you consider the continental drift theory.

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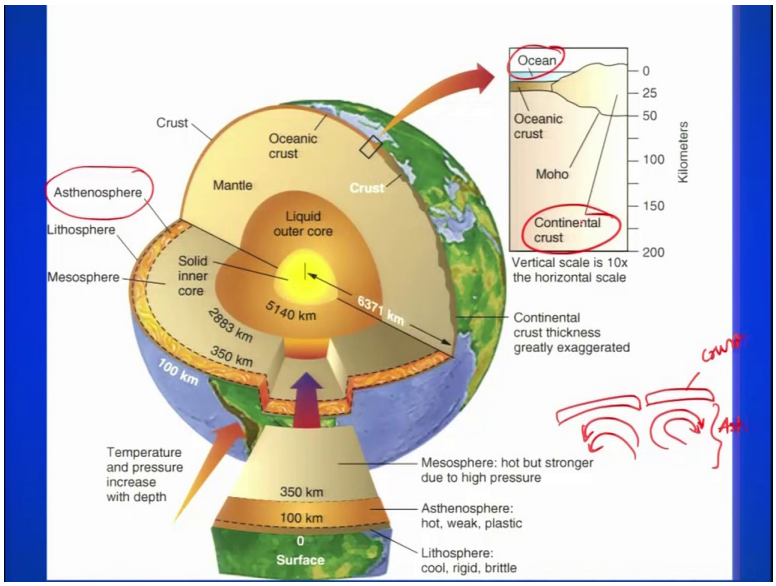

Now, a few more details which I would like you to remember that the earth interior is not homogeneous and what we see is the moment of the plates is just on the top of the earth, that is the lithospheric plates which are moving because of the convection current which is developed within the asthenosphere should this unit is playing an important role which is partially molten to drift the or move the plates.

So, if you draw a crust here like we are having so, these are the two plates which are moving up away from one another and there is a convection currents which are moving like that. So, as I told that you can go into the detail of this. So, this unit is your asthenosphere and this is your crust. So, we have two types of crust here we will have we have oceanic crust and we have continental crust and both have different density and that is an important part which has been taken in into consideration when we talk about the one of the plate tectonics and the and the different type of plate boundaries.

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So, once it was completely all the continents were together and slowly it drifted away.

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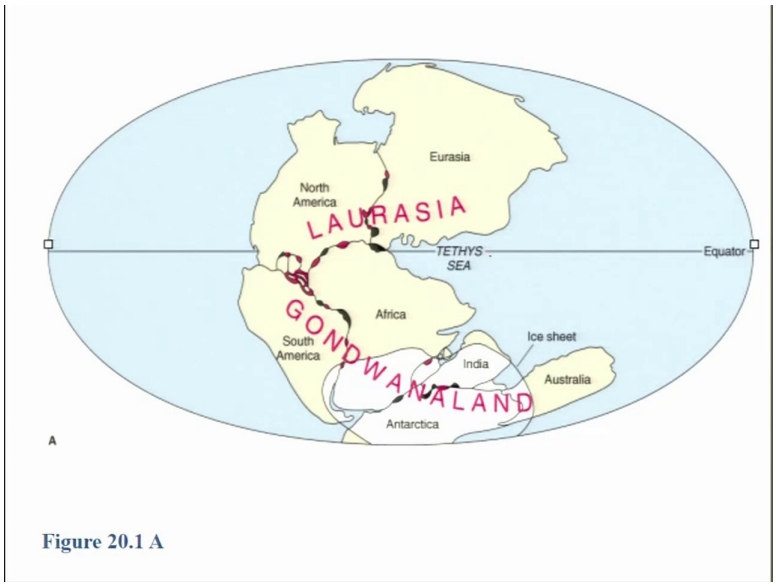

Figure 20.1 A

So, the area below the equator has been named as Gondwanaland and in the area the continents which were together and which is above the equator that is to the north of the towards the northern side has been termed as Laurasia and this sea or the ocean which engulfed or encircled this whole region was Tethys sea.

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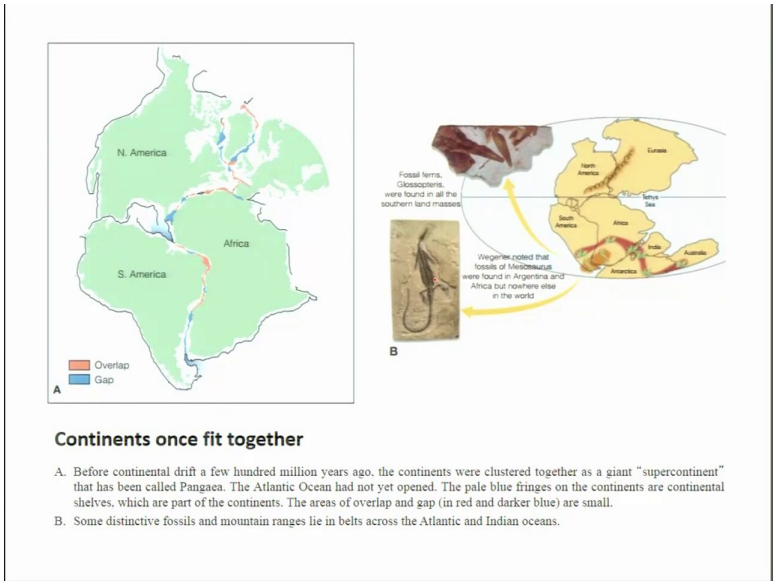

Now, as I was now telling that that was not enough to just say that this boundary meshed with each other and just based on the jigsaw puzzle or the matching of two boundaries and this was been confirmed. But, later more studies were been done in terms of the floras and fauna distributions and that also suggested that yes of course, this continents remained together in past because it had some short of an connectivity of or maybe the signatures were similar environment prevailed with supported the flora and fauna at that point of time.

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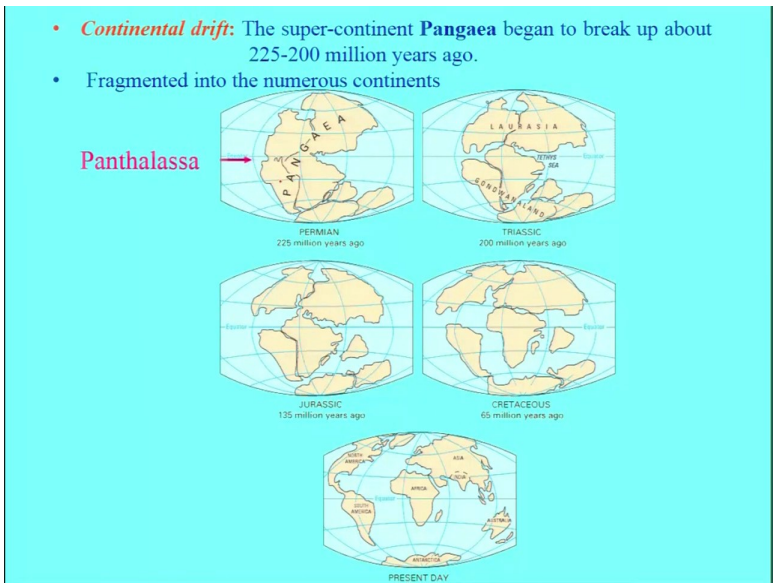

So, continental drift the supercontinent Pangaea began to break at about 225 to 200 million years ago. So, this you can try to look at the geological time scale and understand exactly when it started with. So, it was a round Permian when this were together, but slowly it started breaking up. And, what we see through that period or the journey finally, we see in the present day that these are all continents have occupied their own locations in the place.

There are like again people have postulated their thoughts and the hypothesis based on to some extent definitely the scientific signatures and the proofs that initially the plates were having very high velocity. So, they moved within higher velocity, but later on they slowed down and that one of the one of such example has been presented for India also that initially when the India started because the India if you look at is here, that is south of down south of equator. So, initially the speed or the velocity was very high, but when it crossed the equator and collided with the Eurasian plate or Laurasia then the speed slowed down and that probably is the point when it collided with the Eurasian or Laurasian play one of the Eurasia.

So, this is again the, an important point and that was been considered as in the period when the Himalaya start started growing. So, area also was being the move like termed as Panthalassa.

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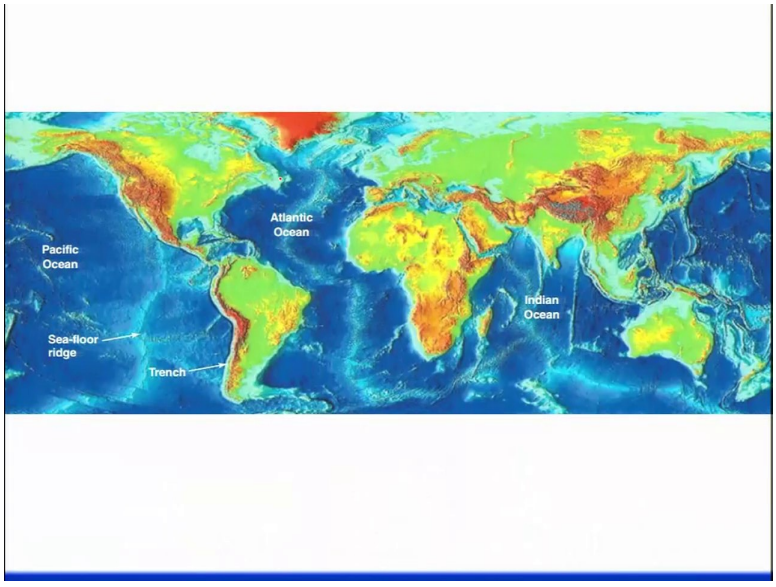

Now, for us the most important part is we all if we agree we can move ahead with that, but we know that all this plates were together, moved away everything is fine, but what is important at present that we are going to discuss in this couple of slides coming ahead.

Now, if you look at the elevation model which has been shown here where we see the greenish part and the reddish part is are all plates different plates over here. This is an in subcontinent and of course, the orange or the reddish part are marking some elevation or higher than these grounds take the green areas and blue are all ocean.

But, there are very prominent signatures which are like for example, which I have been seeing here which I have been seeing here these are all related to your plate tectonics or continental drift. So, when for example, this two continent moved apart this moved in this direction and this moved in this direction away from this then they created a mid oceanic spreading center in between. So, this is again very linear or not linear, but actually we can say that this is the one of the feature which is seen in the ocean on the oceanic plate which encircle most of the part of the globe.

So, the boundaries here what we look at very sharp boundaries here and then terms which have been used as a trench we will I will just explain in the coming slides and then we have the seafloor edges or the spreading centers where just the plates are moving apart from one another or they are sliding down, but they are not very dangerous in terms of the earthquakes which are which are occurring along this plate boundaries.

Now, the hazard if we in terms of the earthquakes and the other associated one if we look at here will be different than what we will experience here actually and similarly what we were going to experience here. Definitely one common hazard remains here is earthquake. I will come to that point again later.

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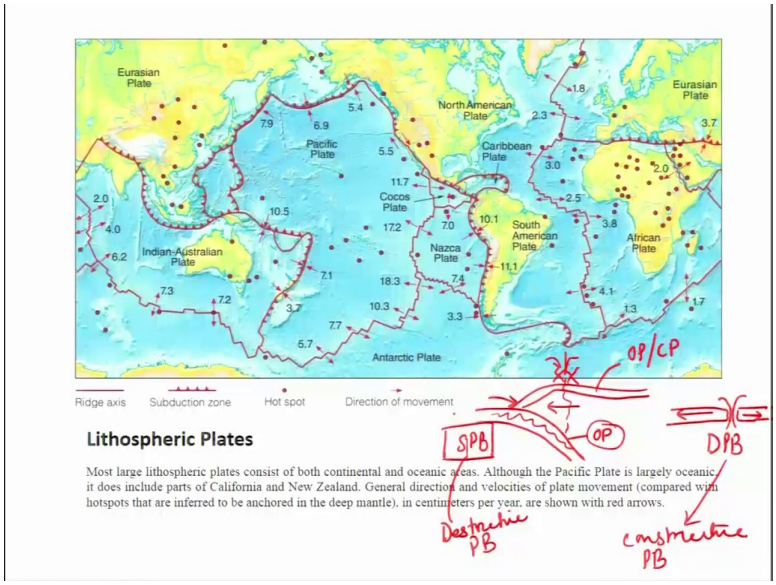

So, these are the plates which are have been marked and based on their nature of the plate boundary different plates have been marked. For example, say subduction zones.

Now, one is that there is one plate which is sub ducting below the another one then. So, this is this is what we call the subduction plate boundary and this is overriding that is when this is sub ducting below. This is your subduction plate boundary which has been seen here. For example, this is your subduction plate boundary in India this is your subduction plane boundary.

Now, another one is that you are having just the plates which are drifting away from one another; one plate is moving like that another plate. This is your divergent plate boundary this is your subduction plate boundary. So, these are the two different plate boundaries and then we have spreading centers. Spreading centers are been seen here over here, these are all spreading centers.

So, this plate boundaries one is termed as a destructive plate boundary another is constructive plate boundary because here every time you will have an edition of the material and the new plate has been generated, but here we lose the plate which is moving down here. Now, if you are having the plate which is moving down could be an oceanic plate or mostly the oceanic plate only will go down what could be. So, oceanic plate here, but this portion which is overriding may be the oceanic plate or continental plate.

Now, until we have the supply of this plate moving down you will find that there is in volcanic eruptions as soon as this stops you will not see any volcanic. So, the case of India maybe I have this slide in I can show you that, but this you should remember that until then you have the supply of the plate which is going down when it the in within the asthenosphere and getting melted again and coming back in the form of your eruptions. So, until then you will have this phenomenon otherwise it will stop.

These are very well marked boundaries which one can see even on Google earth if you browse through the Google earth you will be able to see those boundaries. Now, what is been shown here is numbers are the numbers based on the GPS measurements and this shows the plate moment. They show the general directions and the velocity of the plate moment compared with the hot spots that are inferred near the anchored deep mantle in centimeter per year and these arrows I have been shown with the red here.

So, these are these are the direction of the moment and how fast they are moving away.

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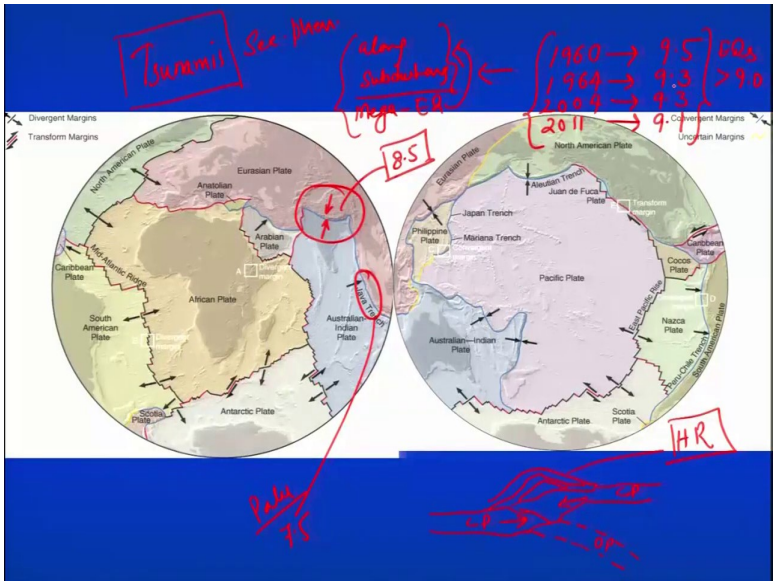

So, we have different type of plate boundaries that exist on this cloak and different plate boundaries are associated with different type of hazard one is that if you are having as I was talking about that subduction zones where one plate is sub ducting below the another one. This could be oceanic plate, this could be oceanic plate or continental plate and, then another one I was talking about the drifting divergent plate boundary third one is that initially you sub duct something not something, but we can say the oceanic plate and

that continental plate is riding on top of this. But, when if the core the oceanic plate, is the part of the oceanic plate is connected with your continental plate behind.

So, what happens when this plate moves down and then finally, we see this is coming in contact with this one. This is also continental plate, this is also continental plate. So, there will be no supply of the oceanic plate below. So, whatever else is gone down there is the old oceanic plate so, no supply. Hence this will keep on colliding with each other and form in collision zone and then it will be seen as in buckling up of two plates there is an example how the Himalayan range was formed.

So, we are having now continental-continental collision, but earlier the front part of the Indian plate had the oceanic plate which subducted below the continental plate, but now we do not see that. So, the subduction zones which are wherever we see we which are marked here for example, over here we have an oceanic plate subducting below the oceanic plate in some places we are having continental plate. So, this is one example.

Another example is we are having over here in the oceanic plate is subducting below the continental plate. Now, these are the areas which are prone to or make earthquakes make an earthquakes in subduction zone. So, if you recall 1960, Chilean earthquake was of 9.5 magnitude; then 1964 when Alaskan 9.3, but at the same time we also say 2004, Sumatra-Andaman was 9.3; then we had 2011, Tohoku earthquake 9.1. All earthquakes greater than 9 magnitudes.

Now, if you ask that where all these earthquakes occurred the answer is along subduction zone hence we say these are as mega earthquakes along subduction zone and if such earthquakes are triggered then for sure we will have tsunamis. So, we have this as a secondary phenomena, but in collision zone which was initially a subduction still the plate is subducting below because it is not completely because if the contact which was been formed still exist. So, still we have some continental plate tracked down, but not as much as what happened in the past. This cannot trigger tsunami, but this can host an earthquake up to magnitude 8.5 or so.

But, if an earthquake is occurring along this not only just the he does not a subduction zone earthquake or because of the earthquakes in. So, along subduction zone definitely they will trigger tsunami. Even with magnitude around 7.5 a recent Sulawesi earthquake

or Palu earthquake triggered a massive tsunami, but this all events where along the subduction zone.

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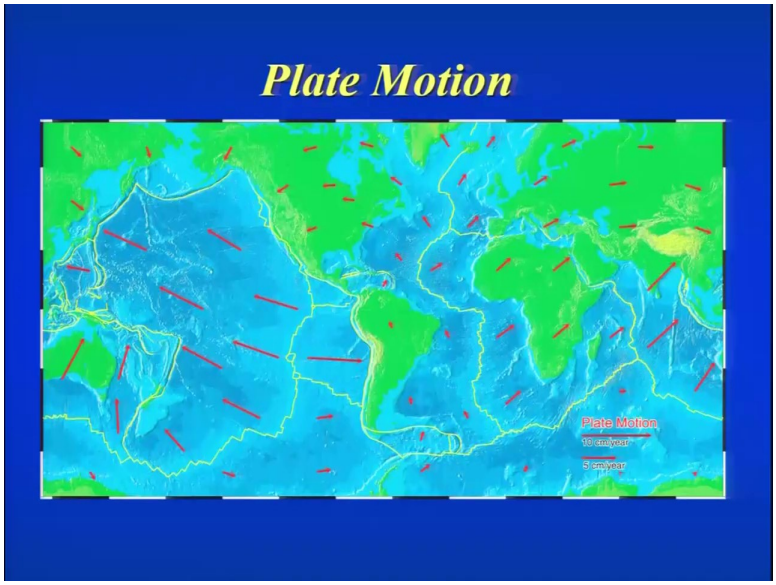

So, the most important point which I would like to emphasize here is that all this plate boundaries will have one thing common as earthquakes, but associated hazard will vary from place to place depending on what is the configuration or the relation between the two plates. If it is subducting below the plate then we will have volcanic arc, volcanic eruptions. Now, this is the case where the oceanic plate is subducting below the continental plate we have volcanic arranged here. So, volcanoes are there active volcanoes this is South American plate. We have volcanoes here, we have volcanoes over here also.

So, if we go to this area again we have volcanoes in this Sumatra area. We have one of the best example of Hawaii Island chain where we have that is in hotspot. So, we have volcanic eruptions. So, the volcanic eruption is also possessing hazard to the nearby environment or the ecosystem, but of course, it will not be seen everywhere or it will not be experienced everywhere.

So, I will come back again on this topic in the next lecture and very quickly we will cover this part. Meanwhile, as I told that those who want to get into more detail of plate tectonics can refer our previous lectures.

Thank you so much.