Plate Tectonics
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Week - 12
Lecture – 59
Seafloor Spreading

Okay friends, welcome to this class of plate tectonics. And in today's class we will talk about sea floor spreading. If you remember the last class we were talking about this continental drift. So, that means the continents once upon a time they were together and with rifting subsequently drifting they separated from each other and now they are thousands of kilometer apart and separated by ocean floor. So, this is seafloor spreading. So, this is an integral part of plate tectonics and it says about this ocean floor and its characterstics and how this ocean floor is recycled and what is this magnetic strips or this magnetic properties of this basalt carpet that changes with time and its longitudinal change and lateral change that has been discussed.

So, once we know that this continents are drifting so whether these oceans are spreading or they are constant that has been discussed in this class. So, like this continental drift it was proposed by Alfred Wegener. This gentleman Harry Hess, he was an officer of US Navy. He proposed this sea floor spreading theory and during World War II he proposed this and that says he says that yes the sea floors are spreading and there are huge mountain chains that is submerged under this oceanic water. So, after this World War II this first this Atlantic Ocean was studied about its subsurface or about its surface you can say below the water and we found that huge mountain chain it is existing which is submerged under water and later on the ocean floor were studied and similar result was found yes there was mountain chains or long range mountain chains they are below this water and sea floor spreading is occurring along this mountain chains or you can say this mountain chains are the product of sea floor spreading.

And this theory it supported this continental drift theory of Wegener. So, though Wegener's hypothesis was rejected that time but once the sea floor spreading was established with evidences it also an add to this Wegener's continental drift theory. So, this question which Harry Hess was asked why there is little sediment deposited on the ocean floor and we believe this earth was formed around 4.6 billion years back and these continents was formed there later on these oceans were developed or you can say the oceans were developed around 4 billion years back. So, if a basin which was formed

around 4 billion years back and compared to this present day sedimentation rate if we think about its sedimentary thickness it is much much much below than expected.

So , now the question arises why so much less sediment is deposited on the ocean floor and another question that why are fossils found on the ocean floor no more than 180 to 200 million years or old. So, marine fossils in sedimentary rocks on land that is may be somewhere in the Himalayas or any higher mountain chains that is more than that 200 million years, but if you see this ocean floor this fossils are found not more than 200 million years. So, that means this 200 million years or 180 million years become this key time frame why beyond that there is no ocean floor existing there is no fossils found there is no sediment within that. So, this was the big question that Harry Hess was asked.

And Hess' reasoning was that sediment has been accumulating for the last 200 to 180 million years at most and this time frame it is matching perfectly or from this formation of this ocean floor at the mid-ocean ridge to this trench that means travel time from ridge to trench that travel time is also matching around 200 million years. So, that means it says this ocean floor which was formed beyond 200 million years it is not existing nowadays and had been subducted down. And magma which is continuously rising along this mid oceanic ridge it is recycling the crustal material by creating new ocean floor system because we know that this mid oceanic ridge it is the constructive plate boundary where this magma is generated and creating this ocean floor and the trench which is representing the destructive plate boundary where this ocean floor which is created at the mid oceanic ridge it is subducting down. So, that means you can say a carpet of basalt which is moving from the mid oceanic ridge and simply it is going down. So, this is a recycling process again it is rising here.

So, this is the conveyor belt type which is recycling this ocean floor system and recycling of this oceanic floor it explains why the oldest fossil found on the sea floor are not more than 180 to 200 million years. So, this is the key point to understand this is the time frame beyond that no ocean floor existing live at present day. So, that is why even if the sediments are deposited 400 billion years back but if the basin is not existing how can we expect this sediment should be preserved. So, some fact about this mid oceanic ridge system and this ocean floor huge cracks discovered at the mid-Atlantic ocean and there is a chain of submerged mountains running through this center of this Atlantic ocean that is called the mid Atlantic ridge and this chain is called the mid Atlantic ridge system and it is runs parallel at the middle of this Atlantic ocean and these are the digital elevation model and this is the underwater photograph how this mid ocean crease looks like the rocks you can see this pillow basalt these are the different pillows they are stacked on one another. So, this is the region where this new ocean floor is being created and the

ridge is a part of the system of the ocean ridge and this mid oceanic ridge are underwater mountain chains that run through earth ocean basin.

In Iceland the mid Atlantic ridge is exposed at Krafla island. So, if you want to see this mid oceanic ridge it is totally submerged under water and you can say submerged under deep water. However at the only place that is the Krafla island. So, here the mid ocean ridge is exposed you can go for geotourism and the sea floor spreading it is the process by which new ocean lithosphere is created and the older material are pushed away. So, here you can say this is the ocean floor and you see if you zoom this ocean floor and particularly the mid oceanic part if I am zooming this region.

So, I am creating this type of image in my mind that here is a huge crack existing and through this crack the magma is erupting continuously and the erupted magma once it is reaching to this subaqueous environment it is creating some pillows that means pillow basalt is developed . And this pillow basalt it is forming a carpet and from here this plot is moving in this direction and this other part is moving to other direction and finally it becomes a part of this solid oceanic crust. So, as the tectonic plates moves away from each other the sea floor spreads apart and magma rises to fill the gap. So, hot and less dense material below the earth's crust rises towards the surface at the mid-oceanic system. As the sea floor spreads apart magma moves up and flow from this cracks and cools and forms new ocean floor.

So, this ocean floor basalt or the ocean floor pillow basalt it is a product from the mid oceanic system. Now, whatever the fact we are discussing about we must have some evidences yes, seafloor spreading because if you remember when we were talking about this continental drift we had to provide number of evidences to prove yes, the continental drift is occurring. Similarly, to provide this evidence about the sea floor spreading number of experiments and number of field observations was carried out number of studies was carried out and one of this foremost study is the magnetic strips. Magnetic strips that means if you see when we are creating this mid-oceanic ridge basaltic system at the mid-oceanic ridge this basalt having some minerals ferromagnesian minerals and those ferromagnesian minerals they are aligning themselves and with the existing magnetic field. And we know this earth has a magnetic field which is reversing and with geological time and the rate of reversal is not same throughout.

For example here this is the geographic north pole and this is the magnetic north pole. If the geographic north pole and magnetic north pole they are on the same hemisphere we say it is normal magnetism, but if the reverse is true that means, we have geographic

north pole and magnetic south pole in the same hemisphere that is called reverse magnetization. So that means, these reverse and normal magnetization it happens in earth's history and in geological past in stratigraphic record you will see number of times the earth has recorded the normal magnetization and reverse magnetization and the duration is not constant you cannot say there is a continuous duration is there. So that means, it may be millions of years there will be prominent normal magnetization that is prevailing and reverse magnetization also prevailing for millions of years and it may have changed in thousands of years. So that means, there is no constant way and it is not properly understood that why it is happening so.

So that means, if you see this magnetic survey in this ocean floor reveals that the oceanic crust shows alternate arrangement of normal as well as reverse magnetism. So you see when this basalt is forming here and is two plates are moving away from each other whenever suppose for example, here this black color. So here that means, this black color is forming that means, suppose for example, it is normal magnetization and here that means, at this stage this earth magnetism is normal stage. So that means, the geographic north pole and this magnetic north pole they are in the same hemisphere. So, if it is happening so whenever these rocks are forming, so their magnetic minerals they are aligning with respect to that and after suppose for thousands of years it changes that means reverse magnetization occurs.

So the rock which will form at that time that will record that reverse magnetization within their magnetic minerals. So that means, that is why with the change of magnetic reversal and normal system the rocks which are forming from the mid-oceanic ridge they are aligning and they are forming the strips which is corresponding to this existing normal and reverse magnetization duration. And the width of the strip that depends upon two factor one factor is the rate of motion and another factor is the duration of the normal and reverse magnetization. If for a longer geological time normal or reverse magnetization occur so this strip width will be more. Similarly, if the rate of spreading is more a strip width will be more.

So, depending upon this strip width you can say whether this rate of spreading was more or this duration of this normal and reverse magnetization work for a more time. So, now we have alternative strips of normal and reverse magnetization that is occurring from this mid-oceanic ridge system and it is embedded within the basaltic rocks within that magnetic minerals. And the alternate normal and reverse magnetized strips represent positive and negative respectively that already we have discussed. Now the question arises when we are having this magnetometer it is attached with the strip you see, this

strip is moving and this is the magnetometer. So, this magnetometer once it is moving and it is recording this normal and reverse magnetization as a strips.

So, this rock magnetism which is recorded by this magnetometer it is affected by two factors. one is the internal factor that means, that is the convection current at the outer core and we know in your initial classes when we are talking about this earth's internal structure. When we are talking about this outer core configuration we are talking that this outer core due to this movement of this magnetic materials there will it is working as a dynamo and a electric field and subsequent the magnetic field is generated and that magnetic field it is affecting to the surface magnetization process. So, that is called the internal system. So, one contribution to the rock it is by this earth's internal field generated from this earth core.

Another system which is affecting the rock is from this external field that is from the sun. We have solar wind, we have different magnetic storms and due to this magnetic storm the solar wind it is also affecting our rock here. So, that means, a rock which is crystallizing on the surface of this earth it is affected by this external factor and also affected by the internal factor. Now, the question arises as a geologist our aim is to know about this internal system to restrict ourselves to this internal contribution of magnetization because we are interested to construct the magnetic poles. So, that is why we have to clean we have to rule out this external influence that is why we go for ignoring or cleaning of this external influence from this total one.

So, the remaining one is the internal influence that is from this convection system at the outer core system. And those magnetic strips finally, we are getting they are 10 to 20 kilometer width and run symmetrically parallel to the mid oceanic ridge system and their continuity it is just hindered by this transform fault. For example, here you see this is the mid-oceanic ridge system and these are the strips of normal and reverse magnetization and had it been not here that is the transform fault is not there that will be continuous. So, that means, this continuity it is broken by this transform fault here. Now, the question arises if we are having a magnetometer which is attached to the ship and it is moving on this ocean water and it is recording the magnetic field.

So, which layer of this oceanic crust or which layer of the oceanic lithosphere it is contributing to this magnetometer that means, the rock magnetization is contributed to the magnetometer. Because if you see this oceanic lithosphere when we are talking about the initial class about the oceanic lithospheric composition, we have layer 1 which is sediment mostly it is not ferromagnetism it is quartzo-feldspathic sediment. So, that

means, this layer 1 as it is not suitable composition that means, magnetically suitable composition. So, that is its contribution to this magnetometer is negligible.

So, we ruled out. Now come to this layer 2 which is a basaltic origin and it is enough magnetic mineral is there that can influence. And third is the layer 3 that is the gabbro and which is though it is containing magnetic mineral gabbro peridotite it is containing a magnetic mineral. But as their depth is too high their influence to this magnetometer which is near to the surface water surface is negligible. So, that means, layer 1 we ruled out because its composition. Layer 3 we ruled out because it is too deep.

So, the next one is the oceanic layer 2 that is the pillow basalt which is the main contributor. So, the source of anomalies must be therefore at least a part by the oceanic layer 2. So, that means, the pillow basaltic layer which is contributing to the magnetometer to study the magnetic strips. And layer 2 has been divided into a series of blocks running parallel to this ridge crest which have been assigned magnetization vector and which are either in the direction of ambient magnetic field or in reverse direction. So that means, this normal and reverse magnetization if you can see this animated image.

So, we have reverse and normal magnetization and you see how this with time when there is a normal period whatever the rocks are forming that is also recording the normal magnetization. When it is reverse period when this rocks are forming they are recording the reverse magnetization So, this normal reverse normal reverse that depends upon the earth's magnetic field existing that time. And the rate at which the geomagnetic reversal that is occurred in the geological time it is highly variable. So, no constant duration is there that this earth's magnetic field will change. And there has been a gradual increase in the rate of reversal during Cenozoic period.

Following a period of during cretaceous when the field was constant normal polarity about 35 million years. So, the cretaceous it was recording maximum normality and carboniferous and permian it is record prolonged reversal. So, carboniferous permian it is highly reversal period the duration was reversal period and this cretaceous period it was recording this high time it is normal period. Now, this is one evidence that yes sea floor is spreading. So, that is why we have a magnetic strips and that is recording the normal and reverse magnetization.

Another is the chain of volcanic island that we have already discussed during this continental drift when we are talking about. This chain of volcanic island if you see we

have a volcanic system that is this hotspot and this plate is moving we have different hotspot islands are there the older this side is the younger and we can calculate the rate of movement from here. And this method can only used up to early cretaceous because beyond that this earth's crust has already been destroyed. Then third is the drilling samples we have deep marine drilling projects. So, during drilling project if you are going away from this side that means, away from mid oceanic ridge we are drilling a system here and we are drilling a rock here and we are taking the rock we are dating it and finally, we will get we are getting the older side of rock here and we are getting younger side of this rock here.

So, that means, younger rocks near to the mid-ocean ridge, older rock away from the mid oceanic ridge and the oldest part of this live ocean floor we can get near to the trench of that basin. So, here if you are going to this Mariana trench in the Pacific you will find the oldest oceanic lithosphere live that is around 200 million years to early cretaceous. So, it means that newer rock is closest to the ridge and the older rock is further away and the oldest crust in the Atlantic Ocean is found at the edge of this continent and the oceanic lithosphere act as a conveyor belt. So, that means, we have a mid-oceanic system we are creating the basaltic system here we sending two opposite directions and finally, at this trench we are destroying it. So, again we are recycling this mid-oceanic ridge system.

So, that means, you see how the conveyor system is developed and due to this conveyor system this oceanic lithosphere it is recycled with time. So, thank you very much we will meet again.