Plate Tectonics

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Lecture - 52
Himalayan Tectonics- I

Okay friends, welcome to this class of plate tectonics. And today we are going to discuss about the Himalayan tectonics. It is quite interesting because the Himalaya is the youngest mountain chain in the world and if you see this recent or research papers, you see many part that means many part of the world the people who are working in geoscience. So, they are working in the Himalayas and different aspects starting from the structural domain to metamorphic to geomorphology any domain you say. So, most geologically fascinating mountain system in the world is the Himalaya. And Himalayan tectonics probably you can remember when we are talking about this a continent-continent collision during the mountain building activities orogeny and apiorigeny classes.

We have discussed to substantial extent and in this class we will talk about this lithological domains or tectonal lithologic domain of the Himalayas, its extension, and its characteristics and how they evolved with time. And to continue that some fact about the Himalayan system it is around 2500 kilometer long and it is East-West trending the Himalayan fold-thrust belt. Here you see it is a fold-thrust belt different type of fold very eye catching fold you can see in the exposure sites. And additionally different types of fault starting from normal to reverse strike-slip in the mega-scale faults and thrust you can find in the Himalayas.

And as a consequence of this continent-continent collision we know this the Indian plate and Eurasian plate they collided together around 55 million years ago and which the Himalayan system was evolved. So, this is the geological map by Yin, 2005 and you see the different lithotectonic domain of the Himalayas are exposed. So, this blue color that is indicating the Indus-Tsangpo melange zone and this pink color this is the Tethyan Himalayan sequence. Then we have greater Himalayan crystalline or higher Himalayan crystalline, then we have lesser Himalayan sequence and we have sub-Himalayan sequence. So, mostly the Siwaliks and below that is the Indo-Gangetic foreland basin.

So, this is the broad tectonic domain of this Himalayan system and around 55 Ma this journey started this collision started. We know the structure related to this tectonics and that is collisional tectonics it depends upon the prior tectonic rheology of this continents associated. And we know this Indian plate it is more rigid and robust. However, the southern part of this Asian plate as it was on the subduction zone. So, many times it has been punctured by magmatic activities and that is why it is weak and mostly sedimentary rocks are there and whatever this metamorphic and igneous rocks are there they are weak due to many magmatic activities.

And in contrast the Indian plate it is most robust and rigid that's why during this collision the Indian plate could affect deep into the Asian plate. So, you see the deformation is very far reaching into this Asian plate or you can say up to the middle of this Asian plate or Eurasian plate. However, the Indian plates the deformation is only confined at the northern end. And this is the diagrammatic representation how the Neo-Tethys was formed around more than 130 million years. And with time subduction zone developed and this size of the Neo-Tethys gradually decreased and with total consumption of this Neo-Tethys lithosphere this India and Eurasian plate they are colliding and finally, giving rise to the Himalayan mountain chain.

And if you see this Indian plate journey it is earlier it was 15 to 16 centimeter per year and present it is around 5 centimeter per year. So, due to this collision the absolute motion of this Indian plate it drastically changed. And some facts about the Himalayas that is 13 peaks is are more than 8000 meter elevation and the highest one is the Everest. And upliftment rate it varies from 0.5 to 21 millimeter per year.

So, why this variation is there we were talking while you are talking about this continent-continent collisional system the convergent system because it is segmented. And different parts of this mountain system the locking behavior at the subsurface is different. So, that is why the upliftment rate is varying from 0.5 to 21 millimeter per annum. And it is bounded both side by strike-slip belts.

So, now, you see two prominent strike-slip faults they are bounding the Himalayas at its western and eastern end. For example, this Quetta-Chaman fault at the west it is in Afghanistan and the Sittang Zone it is in Burma it is in east. So, if you see this tectonic map of India you see this is a pure arcuate-shape this is a simple arc shape. And here this is the Quetta-Chaman fault at Afghanistan and now you can say here this is Quetta and this is Chaman. So, this is the fault which is restricting the Himalayas at the western end and the eastern this is the Sittang zone or Sittang fault zone this is and here so, this is also another strike-slip fault.

So, now, you see this is the global scale strike-slip fault it is separating the Himalayas from this other domains. And it is purely arcuate shape and within we have MFT, MBT, MCT like prominent thrust similarly STD this is normal fault. So, now, we have a number of faults of different nature strike-slip, normal, reverse of crustal scale faults are there. And this is the upliftment rate at a different places people have studies from different proxies. And here this upliftment has been studied from this terraces river terraces.

So, different river terraces people have used in different regions particularly at the Himalayan front in Haridwar and inside this Himalayas the rivers which are coming out it is forming tectonic terraces. And those tectonic terraces that can be dated and with comparison to their present day height we can say what was the rate of upliftment at different geological times. So, different rate of upliftment it is due to this different locking behavior and the segmented nature of the Himalayas. So, it says then it is terminate at both and nearly transverse syntaxes. Here we have a eastern syntaxis that is at Namche Barwa and at the western syntaxis that is in Nanga parbat.

So, two syntaxes that means, the Himalayas taking sudden bend in its trend. So, two prominent syntaxes are there. And its collisional history says this closure of this Mesozoic Tethys ocean resulted in the collision between the India and Asia. If you remember when we are talking about this collisional system this orogenic mountain building activities, we had the Neotethys ocean existing there it is the oceanic lithosphere and now the ocean body or this oceanic lithosphere it is totally subducted down. So, this India and Eurasia they are colliding and finally, this Himalayan system has developed.

And this intracratonic subduction and the collision between India and Asia occurred in the equatorial latitude that is very important to understand here because we know this plate tectonics these plates are moving and this collision was not occurring here at this present state. Now, it is in the northern latitude, how would the collision started at the equatorial latitude. So, that means, you can see how much distance the India and Eurasian plate has traveled from this 55 million years up to now. And it is with the progressive suturing from this Paleocene in the Northwest Himalayas that is around 67 to 60 million years until the early Eocene around 50 Ma in the Eastern Himalayas. So, this collisional history says both end of this Himalayas that is the eastern and the western boundary or you can say the northwestern and north-eastern boundary as not same.

The collision started first at the northwestern boundary around 67 to 60 Ma, but in the eastern boundary it is around 50 Ma. So, this collision it is from starting from the west and moving towards the east. And around 8000 kilometer of convergence which provide an indicative size of this consumed tethys lithosphere. So, the size around 8000 kilometer length this total system was consumed. Some of the places at the interior of this continent the remnant of the tethys ocean is existing like the Mediterranean or so, otherwise this total tethys ocean has been consumed.

And up to 50 Ma the displacement of the India was very rapid around 15 to 25 centimeter per annum. And from this 42 million years the displacement changed to 4 to 5 centimeter per year. So, that means, this is the time we can say and this collision was intense so, that this motion was slowed down. And it around this time span it is it was around 2 to 3 million years so, that this collision was intense so, that this drastic change in the plate velocity was recorded and the present day rate of convergence across the Himalayas is around 1.5 centimeter per annum.

And that also we have discussed that is not same throughout the Himalayas due to its locking behavior different places and due to its segmented nature of the different places. And if you see this collisional history from both side that is the north eastern tip and it is the north western tip here the rate is different. So, that is why this different side or different segment of the Himalayan system that is behaving tectonically differently. So, collision between this continental part of the Indian and a Eurasian system was placed in the Eocene at about 55 ma and when the northward motion of this India was slowed down rapidly that is 10 centimeter per annum to 5 centimeter per annum. So, this collision that means, someone is opposing you to move so, that is why your motion is decreasing.

What is the evidences of collision? You see the timing is consistent with that inferred from the age of the coesite-bearing eclogite in Ladakh. So, if you remember when we were talking about this a continent-continent collision we were talking about this intense deformation. This is the delamination mental delamination once we are colliding the system we are increasing its thickness and finally, at the lower side we are moving it into the asthenospheric domain. So, that due to high heat this phase change which is there it is forming the eclogite and due to eclogite formation as it is very heavy it is going down the crustal delamination occurs and this high pressure is forming the coesite. So, this coesite bearing eclogite in Ladakh it says there was collision otherwise this much pressure is not very common in normal plate tectonic domain.

Then the youngest age of the subduction related granitite about 50 Ma. So, this granitoid which is occurred due to collision. So, this youngest one it is the 50 Ma and the age of the youngest marine sediment along the suture zone around 50 Ma. So, due to collision it is thrusted up. So, this is also demarketing it is 50 Ma.

So, there are different evidences, their convergence of evidences says this collision of India and Eurasian was there around 50 or 55 Ma. So, these are the field photographs of eclogite lenses within that gneiss and this is the microscopic photograph of presence of coesite. Then this India and Eurasian collision it is not only affect only this Indian and Eurasian plate or its boundaries. There is global change or global effect of this collision was recorded. So, one of this global record it says the development of this Hawaiian emperor seamount chains and their change in their orientation.

For example, in Pacific a major plate reorganization at 43 Ma is recorded by the abrupt bend in the Hawaii emperor seamount chains. Now, you see earlier the older seamount chains their trend is like this but after 43 Ma this trend is like this. So, now, you see when we are talking about hotspot that means, this spot is fixed and we are putting this plate on the surface. So, earlier this plate was moving like this, but now this plate is moving like this. So, that means, this change of the orientation of the seamount chains it is coinciding with the India-Asia collisional system.

And in the North Atlantic at about the same time the ridge jump of this Labrador sea to the Reykjanes Ridge east of Greenland. So, that means, you see this ridge jump if you remember when we were talking about the divergent plate margin system we are talking about the ridge jump how the orientation of ridge is readjusted with the change of this Euler's pool or change of this plate motion so, this Reykjanes ridge in the Greenland that was ridge jump was recorded this change of orientation of this mid-Atlantic ridge was there during this India-Asia collision. So, thank you very much. We will meet in the next class. We will continue discussion about the Himalayan tectonics. Thank you.