# Plate Tectonics

**Prof. Pitambar Pati**
**Department of Earth Sciences**
**Indian Institute of Technology, Roorkee**

**Week - 11**
**Lecture – 53**
**Himalayan Tectonics- II**

Ok friends, welcome to this plate tectonics class and we were talking about the Himalayan tectonics. So, if you remember the last class, we were talking this Himalayan formation. It was by this India and Eurasian collision and around 55 million years ago. And as a result, the Indian plate which was rigid and robust, it could penetrate into this weak Eurasian plate, up to this middle part of this Eurasian plate it was affected during this collisional system. And this Himalayan system when it was formed, it was not only deformed or it was affected around this orogenic area, but the global tectonics was also influenced during the Himalayan formation. If you remember when we were talking about the Ridge jump, particularly the Atlantic, there was Ridge jump was affected or it was recorded during that time.

And additionally, when we are talking about the volcanic islands at the specific, their orientation was also changed during the Himalayan tectonics. And the Himalayas, it is bounded by two strike-slip faults at the two end at the eastern end or the eastern syntaxes and the western syntaxes. And as a rigid block of the Indian plate, it is moving northward and it is converging with the Eurasian plate. And as a result, this Tibetan plateau, due to this ducking effect, it has raised and it is not taking part in the active deformation.

So, yesterday we are talking about all those Himalayan tectonics and the surrounding domains. And today, we are going to discuss about this lithotectonic domains of this Himalayas, how the Himalayas subdivided different lithotectonic domains, they are superimposed and their relationship with each other. So, now if you see this main lithotectonic zones of the Himalayas, here it is divided into two plots. One is your Asian plate system and here this is the Indo-Tsangpo suture zone, the trans-Himalayan granitoids that is batholith and the trans-Himalayan granitoids of Karakoram and Lhasa units. So, that means, if you see here, starting from this black region or this index here in the black region to northward, it is coming under this Asian plate.

And if you see this south of this black region that is coming under the Indian plate and this Indian plate, mostly you see the Tethyan Himalayan sequence, the Vaikrita group or the Greater Himalayan sequence, the Munsiari group, the Main Central Thrust region, then the Lesser Himalayan sequence, Outer Himalayan sequence and the Sub-Himalayan sequence. So, that means, you see this Himalayan system as it is a convergence between these two plates, two continental plates. So, both plates they are contributing to form this mountain system, this orogenesis. So, that can be divided and this Indo-Tsangpo suture zone is the boundary north of it, it comes under the Asian plate or Eurasian plate and south of that it is coming under the Indian plate. So, now this southward directed and propagating thrusting, so that means here this Himalayan system it is a compressional tectonic regime and in this compressional tectonic regime we know mostly the folds and this thrusts they are the characteristics features.

So, this southward verging thrust sheets like this MFT, MBT, MCT all those thrust sheets they are coming towards south originated from the north and this southward propagation has assembled this Tsangpo Suture Zone and the Himalayan from four main lithotectonic domains or lithotectonic zones and it is continuing all along the Himalayan range around 2500 kilometer. And starting from this north to south you see this lithotectonic domain can be divided into different segments and they are characteristics distinction is there and you can distinguish that this is the other domain and this is the other domains. So, that means different lithotectonic domains can be distinguished based on their field evidences and based on their analysis, based on the geochemistry, petrography and so on. So, the Eurasia paleoactive margin it is called also trans-himalayan batholith. So, this trans-himalayan batholith if you remember when we are talking about the convergent system this one plate was converging down and this igneous activity was there.

So, batholithic mass was evolved and this is the trans-himalayan batholithic system at the southern part of this Eurasian system or Eurasian plate. And the Tsangpo Suture zone that actually marks the site of a plate boundary along which the Tethys ocean lithosphere that separated India and Tibet was subducted beneath the Tibet. So, this Tsangpo Suture zone that is the welding point it separates two separate plates and the northern margin of this Indian continent it comprises four sub-units particularly the Tethyan Himalayan sequence which is mainly you can say it is undisturbed or relatively undisturbed sequence. So, that is called the geologic paradise you can say and the lesser Himalayan sequence the higher Himalayan sequence they are so deformed it is very difficult to establish the geological correlation and that is why it is called the geologic nightmare. However, the Tethyan sequence continuous sequence of the sedimentary rocks are exposed that is called geologic paradise.

So, this Tethyan sequence zone at the northern end and it is followed by the metamorphic higher Himalayan sequence and then to the south it is the lesser Himalayan sequence or the lower Himalayan sequence and this sub-Himalayan foredeep that is the south of this mountain belt sub-Himalayan sequence that is the Sivalik and south of that is the Indo-Gangetic foreland basin. And this Sivalik rocks are nothing it is the part of this Indo-Gangetic foreland basin which is uplifted due to this effect of this main frontal thrust. So, you can see the Sub-Himalayan sequence and this Indo-Gangetic plain sediment or the lithology wise both are same. However, one part is disturbed due to this propagation or due to this formation of the main frontal thrust it is uplifted up and this Indo-Gangetic plain it is lying down. And here this is the geological map it is the simplified geological map of this Himalayan sequence.

The trans-Himalayan this block one is trans-Himalayan followed by the Tethyan Himalayan sequence these are and this higher Himalayan sequence and this lesser Himalayan sequence and this sub-Himalayan sequence. So, these are falling under this Indian plate system except the trans-Himalayan. And in the cross section if you see here this Indo-Tsangpo suture zone it is the welding point between this Asian plate and this Indian plate. So, the northern part of this Indian margin that is been divided into different thrust sheets starting from the south to north we have main frontal thrust MFT which is separating the Indo-Gangetic undeformed sequence to deformed sequence. And then this MBT that is separating the Sivaliks from this lesser Himalayan sequence then this MCT main central thrust then it is these three are the thrusts are prominent thrust you can say and this is the south Tibetian detachment fault which is normal fault.

And then if you are moving further north we have different litho units they are totally deformed and coming to this Eurasian plate we have Calc-Alkaline magmatism then we have batholiths and there are some foredeep that means there are some newly developed rift basins they are filled by conglomerate and some other sedimentary rocks. So, this is the cross section starting from south to north of this Himalayan sequence and it is the most simplified that is shown here. Otherwise this Himalayan sequence is very complicated and each transect will give you different types of cross section and this is the simplified geological map of this Himalayas. And it is composed of three large imbricated thrust slices and related fold separated by four major fault systems. So, the first one it is the main frontal thrust at the south and if you see here this from south to northward gradually the age of the thrusts it increases.

So, that means the youngest thrust sheet it is at the south and this oldest at the north. So, this main frontal thrust it is the youngest and the most active fault in the Himalayan system that carries the Himalayas rock in the south in the flexural foredeep called the Ganga foreland basin and this is the Indo-Gangetic foreland basin and this main frontal thrust is taking this south that means the Himalayan or the outer Himalayan sequence on this Indo-Gangetic foreland basin. Then north of it is the main boundary thrust or it is called MBT. So, it lies above to the north of the MFT dipping gently to the north and active mostly during the Pleistocene and this fault carries the Precambrian, Mesozoic low grade schist and unmetamorphosed sedimentary rock on the lesser Himalayan southward to the Sub-Himalayan sequence. So, this separates the sub-Himalayan to the lesser Himalayan sequence that is the main boundary thrust.

Then further north it is the main central thrust or it is called the MCT. So, above the lesser Himalayas high-grade gneiss and Granitic rocks of higher Himalayas are carried southward along the main central thrust. If you see here the geological cross-section this is the main central thrust and we have this greater Himalayan sequence and it is coming or it is overriding on the lesser Himalayan sequence and the lesser Himalayan sequence as we have discussed it is mostly the sedimentary rocks some are it is less metamorphosed or unmetamorphosed and it is overriding on this siwaliks and then through the MCT this higher Himalayan rocks that is overriding on the lesser Himalayan rock. So, that means from south to north the age of the thrust sheet increases. Then all these thrust sheets that is MFT, MBT, MCT that we have discussed so far.

If you see these thrust sheets they are merging with one fault main fault it is called the main Himalayan thrust. So, the main Himalayan thrust or MHT it is the main thrust sheet and from which these MFT, MBT, MCTs they are acting as splays. So, these are the thrusts splays they are emerging or merging at the main Himalayan thrust sheet. So, at a depth each of the three main thrusts of the system merge downward into a common decollement that is called the main Himalayan thrust. Then further north we have south Tibetan detachment fault and the south Tibetan detachment fault it is a normal fault system.

So, now, see this is the Tethyan Himalayan sequence it is this STD is here. So, this STD or across the STD. So, here if you see this is the bounding at the top of the thrust stack at the surface that is the series of normal faults and that is called the south Tibetan detachment fault. This is the Tethyan Himalayan sequence it is going down with respect to this lesser Himalayan and higher Himalayan sequence and it is separated by this normal fault that is called south Tibetan detachment fault or STD and this is a normal fault. So, the basal detachment dips gently moderately to the north and separates the high grade gneiss of this greater Himalayan from the low grade Cambrian Eocene rock of the Tethyan sequence.

So, now, you see from this higher Himalayan crystalline both side it is bounded by the sedimentary rock, this side it is relatively undeformed and this side it is relatively highly deformed and this high deformation you due to this thrust movement and it is the sequence between this MCT and different segments of this different splays of this MCTs are there. So, that is why they are more deformed as compared to this. And the greater Himalaya it consists of this Precambrian gneiss overlain by Paleozoic and Mesozoic sedimentary rock of Tethyan origin and this unit includes migmatites and amphibolite grade of metamorphosed rock, intruded by light color granite bodies that is Miocene age called leucogranite and it is light color granite that is called leucogranite and you can see here the gneiss and migmatite rocks that is exposed along this road cut and this migmatite and leucogranite have originated by partial melting of the lower crust beneath the Tibet. If you remember when we are talking about this mountain building activities or this orogenic system when we are talking about the continent-continent collision, we are talking that beneath this Tibet we have a sequence which is higher that means, this temperature is high that is why it is a detached from this main colliding continents and that is why this is the melting due to the high-temperature melting takes place and this melting of this lower crust beneath the Tibet which is the generating the migmatite and the leucogranite and are absent in the north of this greater Himalayan sequence. Then we have a prominent gneissic dome that is called Kangmar dome here this is the geological map of this Kangmar dome itself.

So, what it says that this discontinuous series of metamorphic culminations throughout the tethyan zone it is called a gneissic dome or it is called the Kangmar gneissic dome which forms part of an antiform cored by Precambrian metamorphic basement surrounded by mantle of less metamorphosed carboniferous-Triassic rocks. So, now you see this dome it is exposed or it is surrounded both side by younger rocks and this is the gneissic or migmatitic dome is there. Then further north we are reaching at the Indo-Tsangpo suture zone which is the welding point between this India and Eurasian plates. So, at this Indo-Tsangpo suture zone at the northern end of this Tethyan zone it separates the rock that once formed a part of this Indian plate from this Paleozoic to Mesozoic rocks of the Lhasa terrain. And the suture is defined by a different mixture of components derived from both of these plates like this India and Eurasian plate as well as the tethyan ophiolite sequence which is the blueschists.

So, that means, this suture zone as it is the welding zone between these two plates it is different and it is representing the rock contribution from both of these plate systems. And these are these simplified geological maps of whatever we have discussed about these are the lithologic domain or lithotectonic domains and these are the cross sections and these are the tethyan Himalayan sequence relatively only formed then it is the higher Himalayan crystalline sequence then this is the lesser Himalayan sequence which are highly defined and further we will have this Indo-Tsangpo suture zone here. Then another is the Gangdese batholith of the trans-Himalayan zone. So, this Gangdese batholith of trans-Himalayan zone it is the cretaceous or Eocene age formed along an ocean-continent convergent. So, if you remember whatever Himalayan tectonics we are talking about this is the continent-continent collision and before that we had a Tethys ocean which was subducting you know the Eurasian system and once it was subducting and reaching at this asthenospheric system partial melting was taking place and this magmatism was there and this was the batholithic mass which was emplaced.

So, this is representing the Gangdese batholith. So, this batholith it is of cretaceous-eocene age and it is formed along this ocean-continent convergent plate margin in response to this northward underthrusting of the Tethyan oceanic lithosphere prior to this Indian-Eurasian collision. So, this batholithic mass it is older than this collisional system because that time this part of this oceanic lithosphere that of tethys it was existing and was subducting down and north of this Indus-Zangpo suture zone active normal faulting and east-west extension was there. Clearly you can see these are the newly formed rift basins and once it is a compressional zone because the Indian plate which is moving in this way and this is the Eurasian plate which is converging here. So, this is the compressional zone once there is a compression there will be extension perpendicular to it.

So, due to this extension related that means compressional related extension we are creating some rift basins and those rift basins they are filled with this conglomerate and other younger sediments. So, this is the north of this Indo-Tsangpo suture zone active normal faulting and east-west extension are dominant forming a series of young rift basins that tend to approximate north-south because it is orientation it is parallel to this compressional direction. So, most of them are filled with Pliocene and younger conglomerate and appears to have formed since the Miocene. So, these are the later formed rift basins are there and this is the geological representation how the rift basins are forming. So, here this is this Indian plate and the Himalayan system and this is the Eurasian plate which are compressing both are colliding with each other that is why there will be extension in the perpendicular direction to this compressional direction.

And finally, we are creating this rift basins and it is filled by this conglomerates and the younger sediments derived from this surroundings and from the Himalayas and gradually the size is increasing and it is occupied by this lakes and different alluvial fans mega alluvial fans or mega fans here depositing at the here and filling these basins. So, this is all about this Himalayan system how these different lithotectonic domains are distributed across the Himalayan and along the Himalayas and how these compressional related extension has been developed and in this extension rift basins are developed and the rift basins are receiving sediment from the surrounding. So, this is all about your Himalayan tectonics. Thank you very much.

We will meet in the next class.