Earthquake Geology: A Tool for Seismic Hazard Assessment
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Lecture – 08
Plate Tectonics (Part I)

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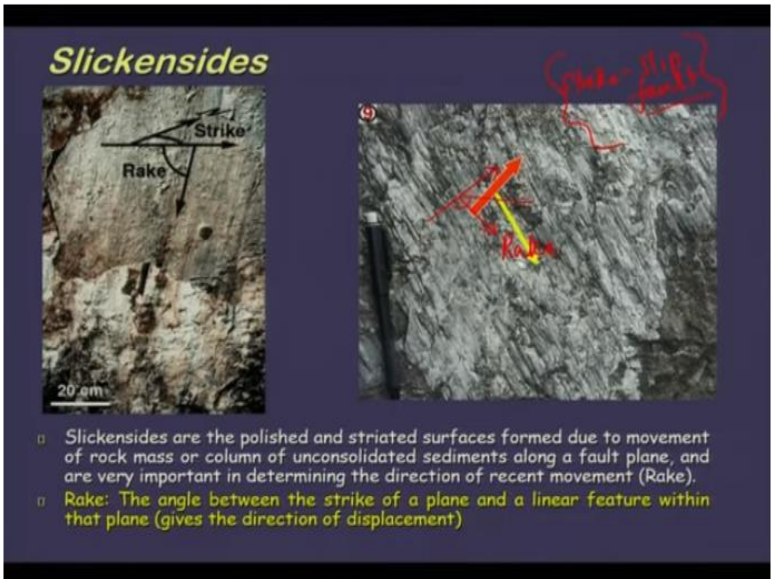

So welcome back so now we will we are towards the end of this part of primary and secondary features few more slides and then we will move to the topic on plate tectonics. This is also very commonly observed feature in tectonic deformation on a regional scale as well as on local scale and that what we term as and slickensides okay and slickensides to some extent are helpful in identifying the sense of movement.

So I hope you people are aware of what is strike and what is a dip and rake. So usually the rake is the direction which will help us and identifying that in which direction the displacement has occurred. Okay so the slickenside are the polished and stratified surfaces formed due to movement of rock masses or the unconsolidated sediment columns along the fault plane and a very important feature in determining the direction of recent moments.

And basically if you take there the definition of the rake, then the rake is the angle between the strike of a plane and a linear feature within the within that plane and this gives the direction of the displacement. So direction that is the in which direction it has moved for example you have these striations over here and this will be the strike and the amount of depth will be what we call as the exactly perpendicular.

So this will be the amount of depth here and this will be the and the moment of the indicating these based on the striations. So this will be your rake and mostly this type of features are been seen when we are able to look at the strike-slip faults. So this part will become more clear when we are talking about this strike-slip fault but as a part of the contacts or the features you can just remember this okay.

So this is the direction, and this is the rake or in the direction in which the defaulting has occurred or displacement has occurred.

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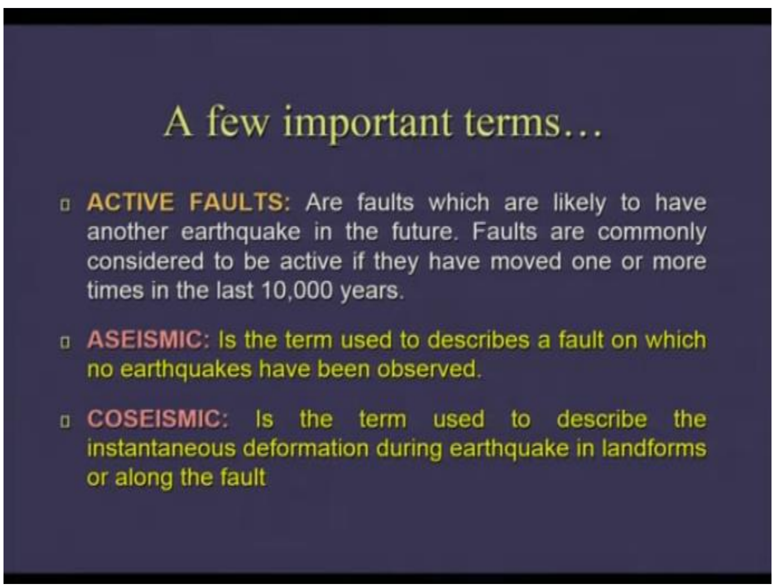

Few important terms before moving into the detail some details of the value seismology is the active faults of course we have an a major topic which we are going to talk about the active faults but the general definition if we take these are the faults which are likely to have another earthquake in future and faults are commonly considered to be inactive if they have moved one or more times in the last 10,000 years okay.

Aseismic with the term which has been used to describe a fault on which no earthquakes have occurred or been observed. Coseismic is the term used to describe the instantaneous deformation during earthquake and landforms or along the fault. So these are a few terms which we should keep in mind because we will be talking mostly about the active faults Coseismic ruptures and Aseismic deformation.

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So this part will lend a hand will start with the new one new topic and that is on the plate tectonics.

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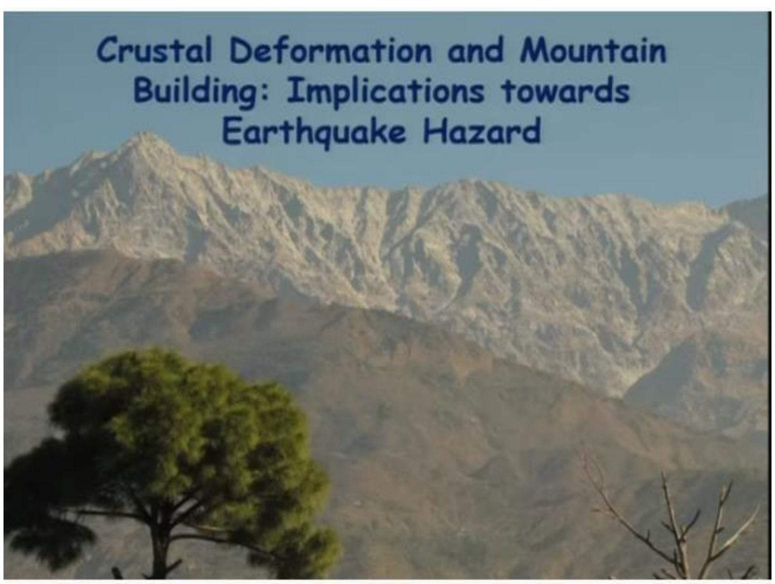

Now coming to this part I will be slightly quick because this basically we are talking why we have considered this and why we are talking about the plate tectonics because we need to understand the deformation on global scale and as we have discussed in couple of previous lectures that that we need to understand the deformation or the tectonics on the global scale then regional scale and then coming down to the local scale okay.

So a global scale is important because that will tell us that what is the; that other deformation pattern we can expect and in tectonically active or seismically active region okay. So for example I will just tell you few points in the beginning that we have, or we very well know about there is an collision zone between the Indian plate in the Eurasian Plate and the result what we see is the mighty Himalayas and those are all folded mountain chain.

So we are coming down from the global scale a to regional scale and then further site-specific if we come or the local one local scale then we are talking about the force and faults. So, crustal deformation and mountain building activity if we take is on the global scale and its implication towards earthquake hazard. So of course the picture which you see here is from the higher of the higher Himalayas taken from Kangra valley beautiful landscape.

But along with the beauty we also experience, or we know that we should know that the reason hazard associated with this and those that hazardous mainly the most common is the earthquake.

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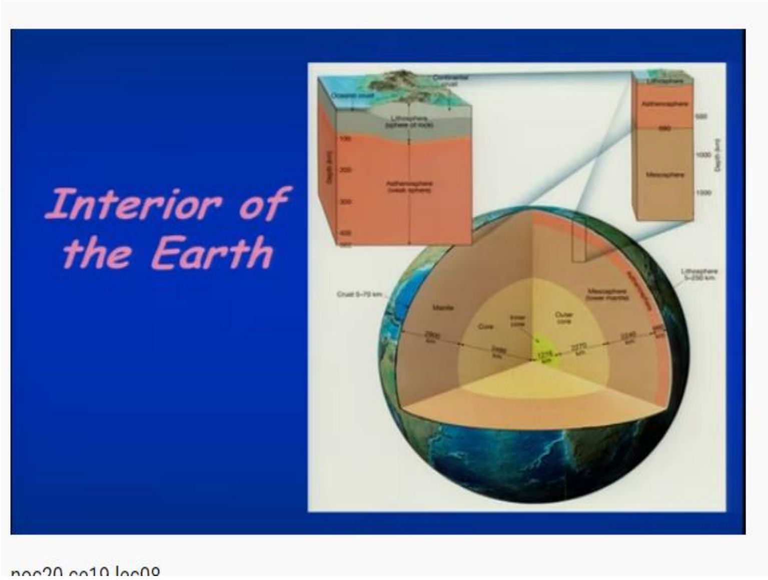

So before getting into the plate tectonic parts some of you might be aware of this but I will quickly move so that the new students who have taken this course should also understand the overall process. Earth to some extent is very important for us to understand because the plate moment what we see and plate movements from its original location millions and millions back and what is the present configuration in terms of with respect to one another in with respect to their plate boundaries between that exists between this plates is extremely important.

So the interior of earth mainly the asthenosphere is the important unit which is responsible for the movement of all the plates okay.

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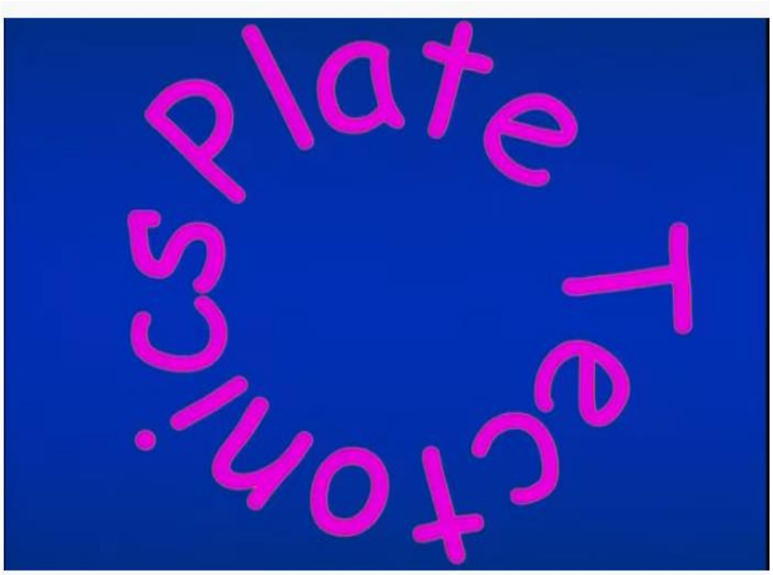

So plate tectonics.

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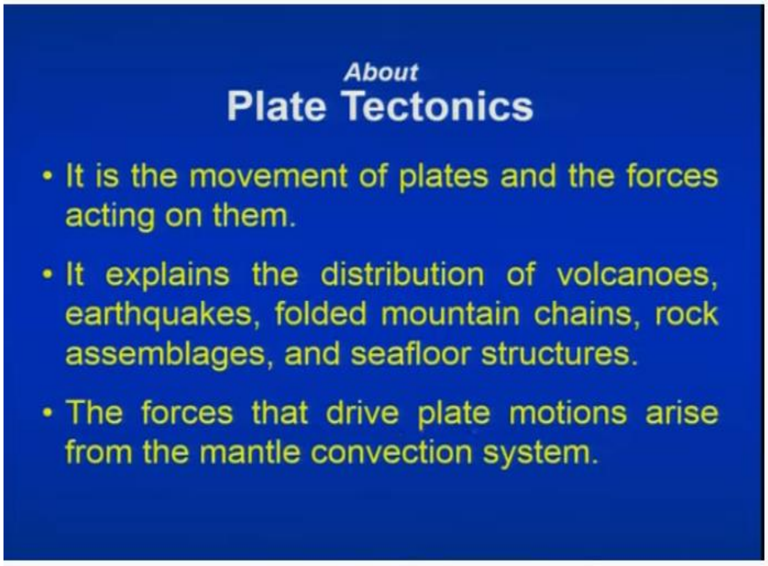

Mainly talks about the plate movement so it is the movement of plates and the forces acting on them. It explains the distribution of volcanoes earthquakes folded mountain chains rocks assemblages and sea floor structures. So this we are talking about the on the global scale. The forces that drive plate motions arises from the mantle convection system. So for this purpose we need to at least know that which layer or the portion of the interior of Earth is responsible for the for driving the plate the different tectonic plates or lithospheric plates we can talk about.

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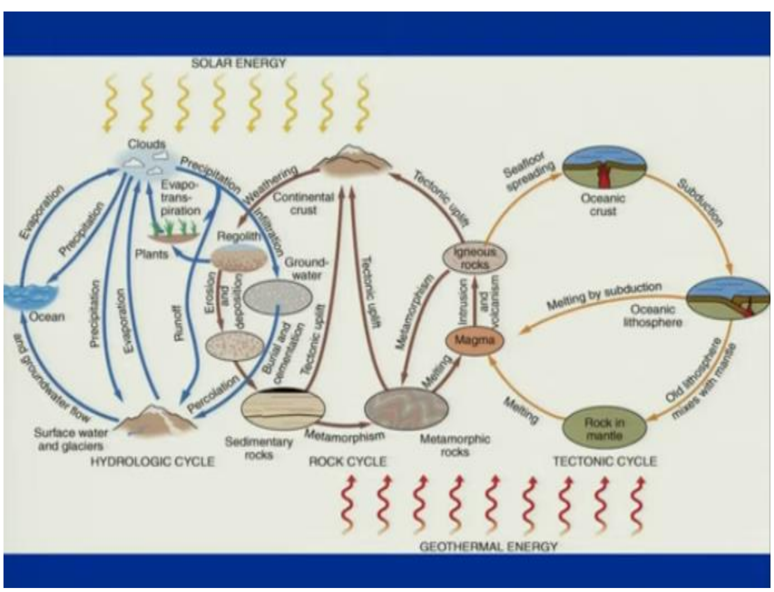

So this usually we look into like try to connect and try to understand that what is the connectivity between the different cycles okay. So, on the larger scale or the global scale as we were talking about the plate tectonics so the tectonic cycle usually this keeps going on okay. So you have the building up of the oceanic crust and that oceanic and then the plates are moving away from one another getting subjected and then we have the volcanic eruptions and this plate will be consumed further.

So what we see when it goes down and we have rock melting or the crust is getting melted and the new crust has been formed or the new material is coming out in from of lava and then which forms the igneous rocks and all that and due to the formation we have the mountain building activity and that will be subjected to erosion weathering and all that and the sediments are been formed and then those sediments getting consolidated resulting into the formation of sedimentary rocks deformation and high temperature and pressure and then result into the foliated rocks and non-foliated.

Also what we can metamorphic rocks again they are melted in this process and then this cycle goes on. So there is an connectivity of this as well as the connections or the connectivity of the cycle what we saw always an erosion okay. So all the cycles hydrological cycle, rock cycle and tectonic cycle are been connected and the 3 cycles are basically been governed by the geothermal energy which is coming from the interior of earth and the solar energy which we receive from the Sun so just keep in mind go through it in detail so you will be able to understand that what we are looking at the connectivity.

So the deposition erosion because of the environment where the rocks are exposed, and the deformation will result into the folding of the material and then the erosion formation of rocks and all that and the plate tectonics will keep on adding new crust melting the old one or getting the old one beneath into the asthenosphere then coming out in the form of. So, this cycles keeps going on.

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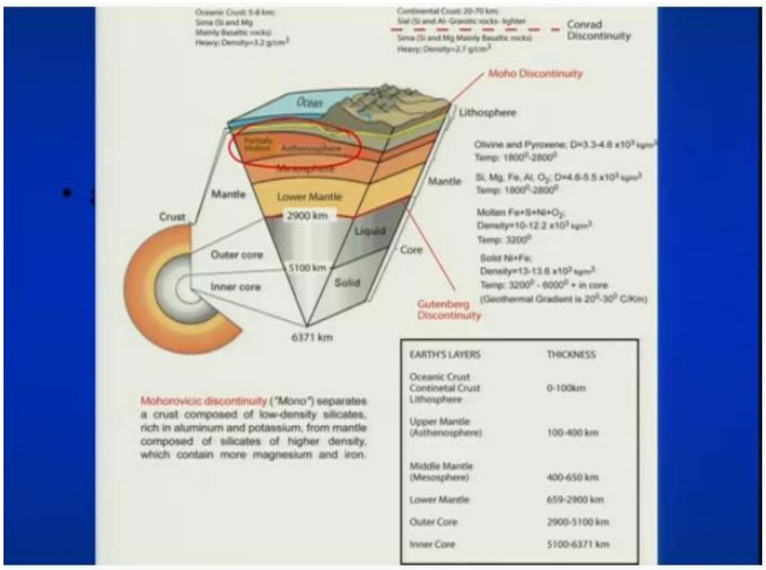

So if you look at the interior of Earth, I am not going to get into the details of this but for us the this unit now that is to know the this unit is important because this transfer is responsible for the movement of the tectonic plates that is oceanic plate and the lithospheric plate.

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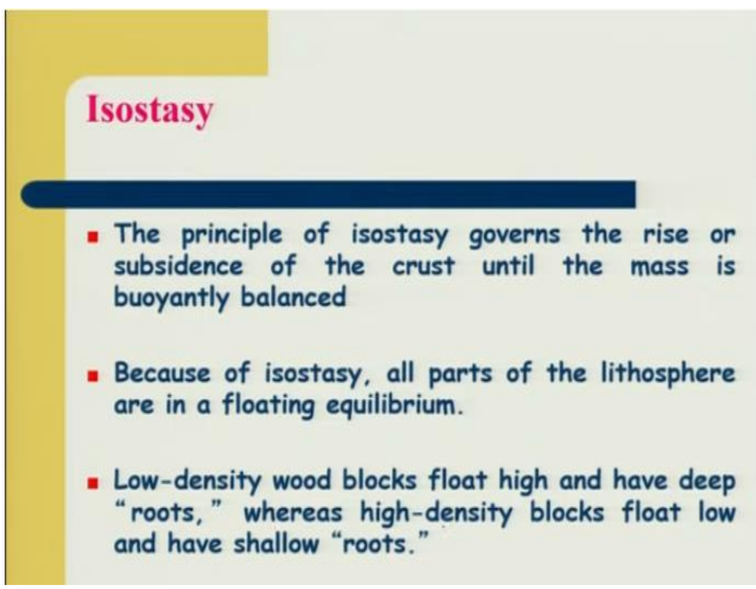

Now the isostasy basically we look at that oceanic plate and the continental plate has been shown here they are basically floating on the partially molten layer that is your asthenosphere and depending on the density of this plates because the oceanic plate if you take this is the oceanic plate here they are heavier whereas the continental plates are comparatively lighter in terms of the density.

So they will float on the partially molten layers at different elevation and it has been understood to some extent because this process takes like in geological timescale it will take long time but in overall it has been understood that this balance okay or the plates will try to keep themselves in in a balanced form okay. So the principle of isostasy governance the rise or subsidence of the crust until the mass is buoyantly balanced because they are floating on the on the partially molten units.

Because of isostasy all parts of the lithosphere are in a floating equilibrium. So if you erode the upper portion which is exposed of any plate then it will again rise up and try to balance itself okay. So the low density wood for example okay float high and the and will have a deep root. So here the low density if you consider in terms of the earth crust then what we are having the low density is here continental plates okay.

So the continental plates usually will float high and will have deep roots okay whereas the high density blocks. So in this case the high density block is having your oceanic plates which floats low and will have shallow roots.

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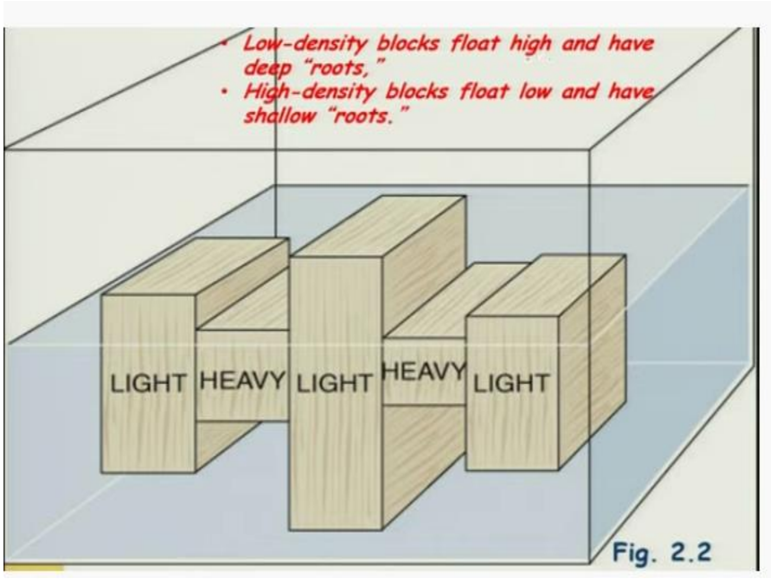

Fig. 2.2

So this is an example which has been given here is a low density block floats higher. So you have and will have deeper roots whereas the heavy blocks will have will float low and will have shallower roots okay. So they will not have the deeper roots but the lighter one will have deeper roots and they will also float higher and this is overall if we see is important in terms of the erosion and then what erosion will trigger. Because if there is an continuous erosion of this then it will keep coming up actually.

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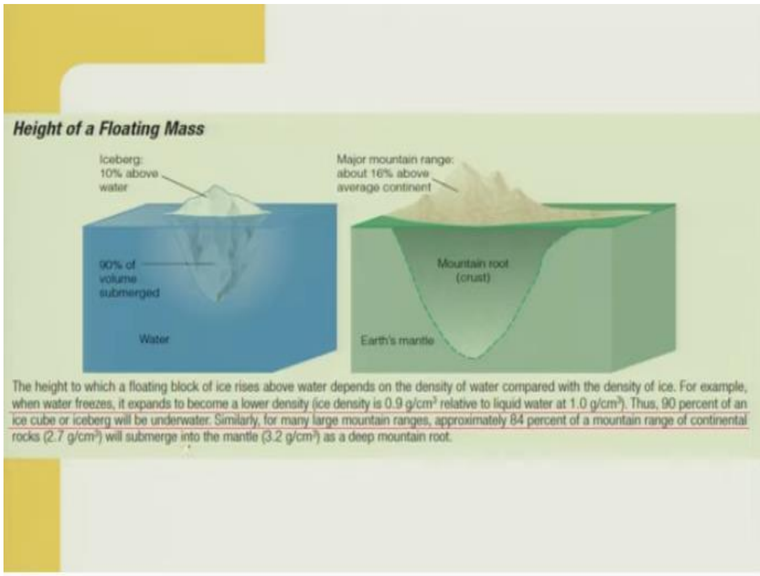

So if we look at these two examples which have been given on the right hand side, we have with respect to the earth mantle and the continental lithosphere and on the left hand side what we see is the ocean water and the iceberg. So basically as well as soon as the density of the material varies it will show a different elevation or a different like the deeper roots and all that okay. So for example if you are having the frozen and when water freezes it basically changes a density and which becomes lower as compared to the water okay.

So it will float on the surface of the water and will have almost like whatever you see on the surface that is an iceberg which is hardly 10% but will have the deeper root behind below the reserved water surface okay. So you having 90% of the volume is submerged and similar is in case of the continental crust okay.

So you have like similar to the iceberg many large mountains mountain ranges approximately 80 % 84 % of the mountain ranges range of the continent rocks are around 2.7 that is a density and will submerge in the mantle, mantle density is higher and will have the deeper root okay so if you if what we see as an mountains on the only surface must be having a very deeper root below okay.

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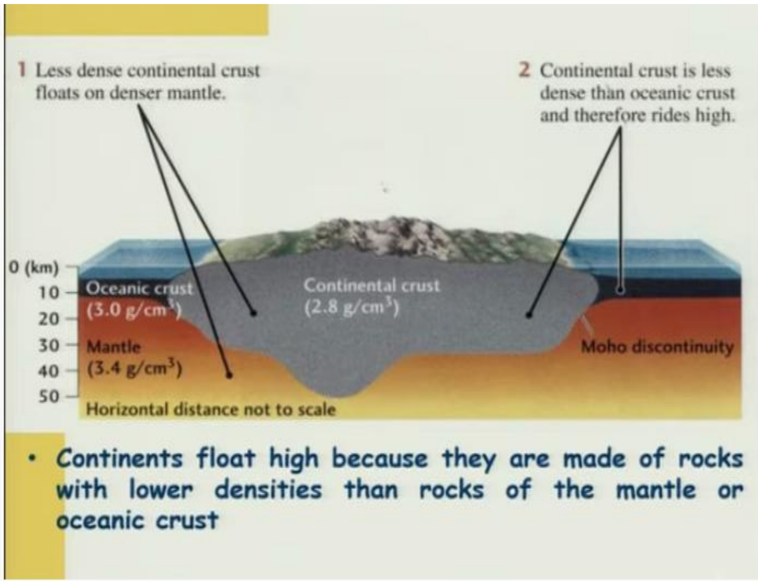

And this is what has been shown here that you have an average of 2.7 or 2.8 is the density of the continental plates and the this the density of the mantle is around 3.2 or 3.4 and the oceanic is comparatively higher on 3 to 3.2 or more but this this makes the changes which we see on the surface as well as the deeper part. So overall this understanding is important because the erosion will keep changing this configuration of and the portion which is which is deep-rooted.

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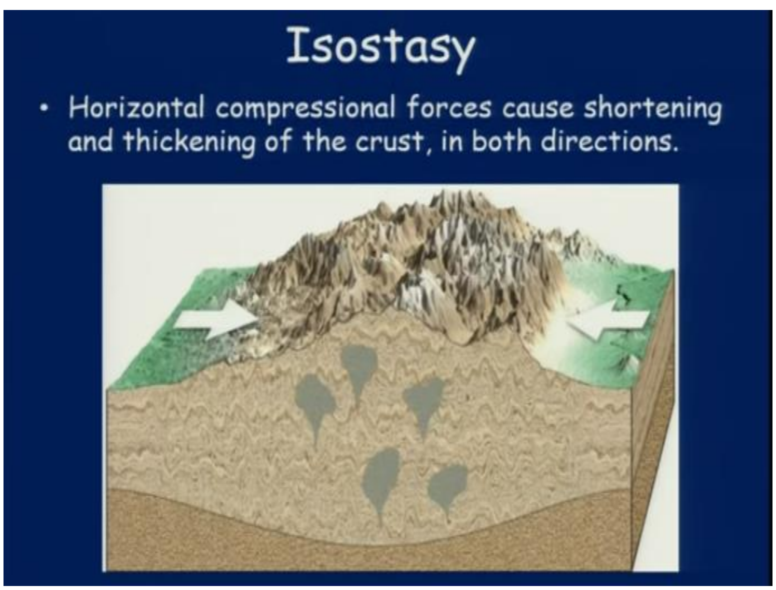

So if you look at the this part basically then what we are able to see yes that the horizontally when we keep compressing the material horizontally then the forces cause a shortening okay and at the same time we have that what we see the shortening on the surface but at the same time the deform material will keep acquiring and thickening of the crust will take place okay. So you have the growth of the crust will be on both the direction.

So you have the growth on the surface as well as you have the thickening of that will keep growing within the earth crust okay. So you have the roots keep on extending down as well as the elevation which has been picking up over here.

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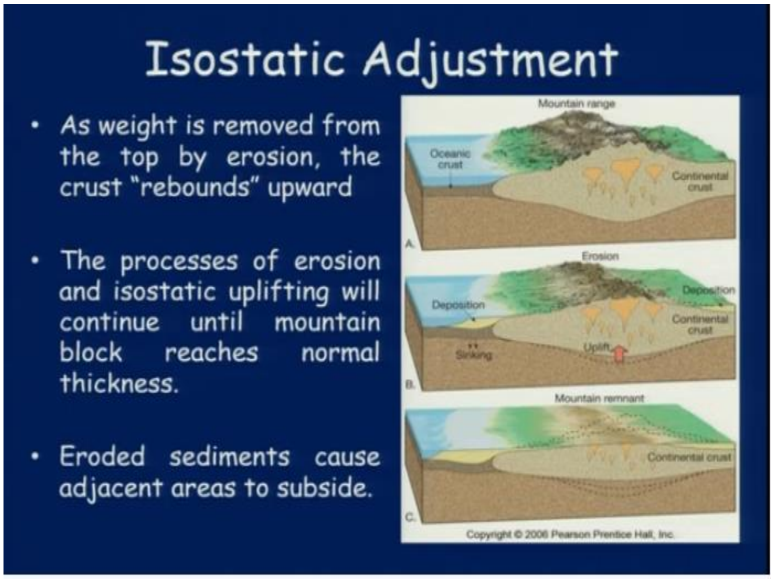

But this never remains the same because there is an isostatic adjustments and this cartoon it explains that when you are having the initial stages you have like you have the mountain building activity and the crust has been the continental crust is also thickened and having deeper roots but this portion okay which is exposed to the environment will keep on having the erosion okay.

So they will be eroded so erosion and then deposition on either side, but this is reducing the elevation. So as I was talking about that the isostatic balance of the adjustment will keep occurring over the time. So this portion will be again raised up because need to may be in the equilibrium state. So there is an uplift and this pore process can also trigger earthquakes okay and similarly the time will come when you have all flat areas and no more thicker part has been left out okay but again this will keep will be in balance okay.

So as weight is removed from the top by erosion or the crust rebounds upward the process of erosion and isostatic uplifting will continue until mountain block reaches normal thickening erosion eroded sediments causes adjacent areas to subside. So what will happen that you are removing the material from here and at the same time because you are depositing also. So those areas on the either side will start sinking or subsiding because this also is because of the loading, unloading phenomena process okay.

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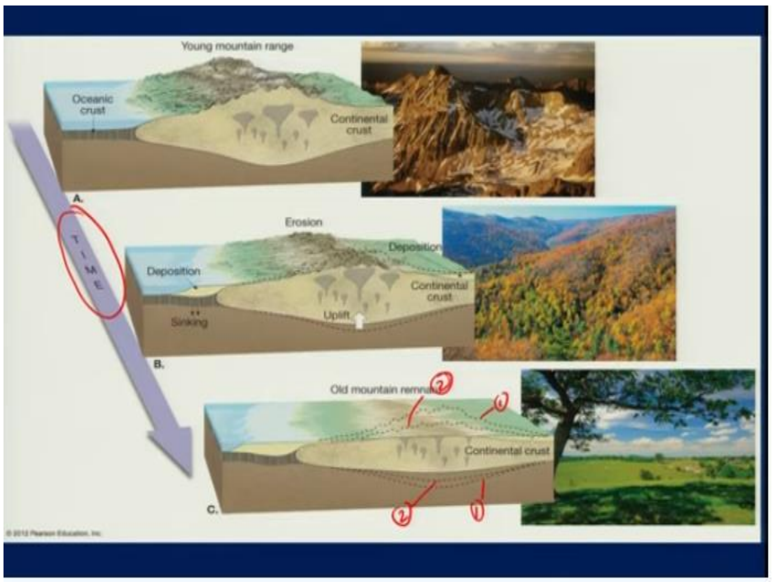

So any mountains if you look at the time will come but this time is very large because this will not take place in couple of years but millions of years it will take. But usually the landscape will keep changing so you are having the young mountain ranges with and deeper roots in the mantle and the erosion is there and you have deposition on the either side this portion will sink or subside, but this will keep uplifting.

Because it has to balance the isostatic balance has to be there and then finally it will die out okay. So those dotted lines are indicating the previous topography which has been shown here. So this is the first one the original one with this line here, so you have this one here and this is one here this is second one and this is second one okay and then finally what you see is this one. So this is your third stage and the landscape what you see on this on the surface will be somewhat like this.

So finally what we see is the very flat areas where no mountains have been seen all are completely eroded.

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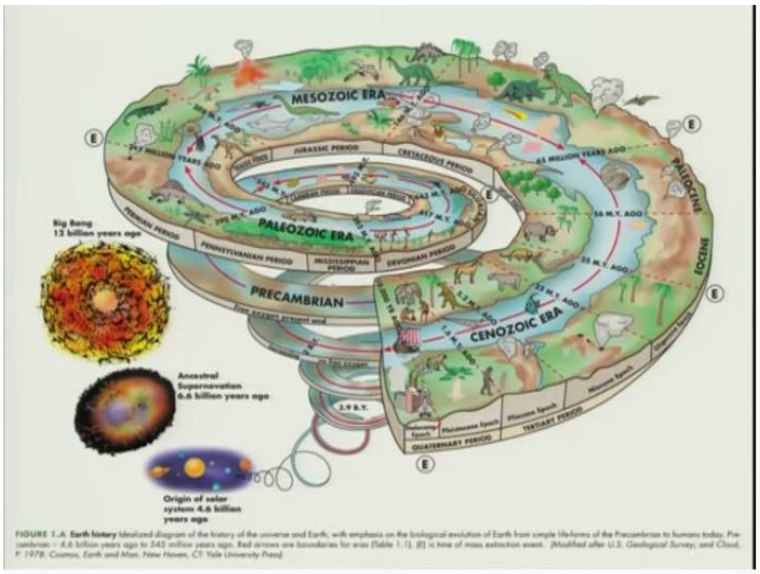

So as we discussed in the beginning not since the formation of since the birth of the earth almost like 4.6 billion years ago and we have number of events which have occurred in terms of the tectonic deformation in terms of the only global scale and on the regional scale and the local scale okay. But for us as we have talked about that we are interested in the quaternary period and this is the period and the epochs which have been listed here Holocene and Pleistocene an important for us because it is the time and there was an evolution of the man and then in this epoch that is a Holocene epoch basically we have the onset of the urbanization.

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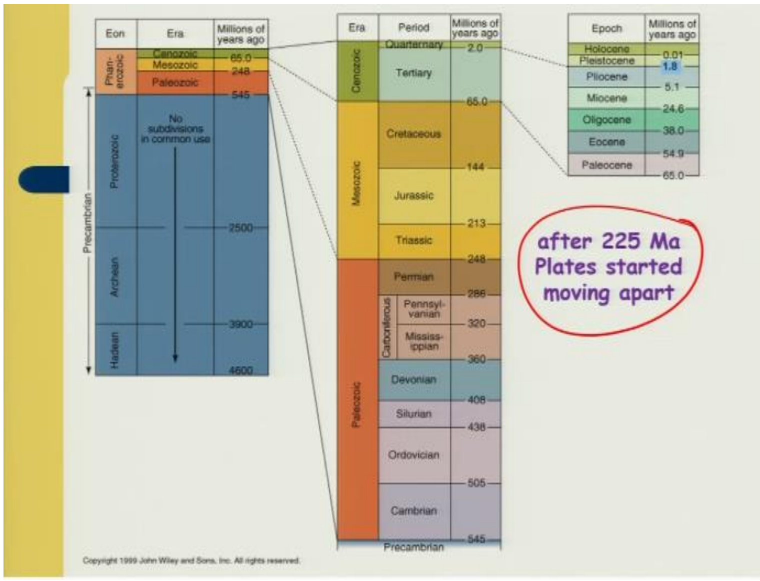

So quaternary period mainly we will be talking about that. But if you go on the on the global scale then we are talking and getting into the details of the plate tectonics that is after 225 million years that it started moving okay. So this part I will start in the next lecture and I hope you enjoyed and will try to cover this one move ahead into the main topic of value seismology. Thank you so much.