Geomorphic Processes: Landforms and Landscapes
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Module No # 02
Lecture No # 10
Interior of the Earth &Plate Tectonics (Part I)

Welcome back so today we are going to start a new topic and that is interior of earth and along with that we are going to talk the plate tectonics. So this topic is important because what we see the landscape the morphology of the surface earth surface is basically because of the ongoing deformation. See if say this so it can be justified based on the mega structure which are present on the surface.

So on a large scale if you see this type of features or the a landscape then for example in India we have Himalayas. So Himalaya was formed because of the plate moments so it is important for us to understand the plate motion and how the land scape related to plate motions are formed. So in this topic basically we will see a different types of plates and the relationship between the 2 plates or the plates with respect to one another whether they are pulling apart from one another or they are subtracting or that is one is going beneath another one or they are collating with each other.

So that we will talk and we will also discuss about the isostasy so let us start with the isostasy part and talk about tectonic plate tectonics.

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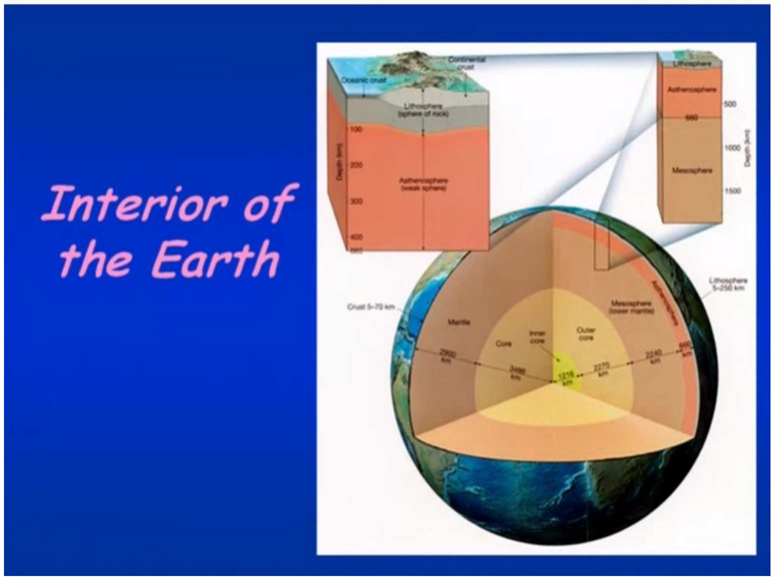

So the interior of earth is basically an important topic to understand the plate motion so very briefly we will see the interior of earth at the different layers or the units but we are not going go into the detail of the seismic waves and all that in this course. So as we all understand and know that the interior of course this was been identified based on the seismic waves transmission from the surface of the earth in and the interior and based on the velocity variation and also to some extent the geo chemical composition was been identified in based on that the different units are the layer where we defined and this different layer as different density as well as different chemical composition.

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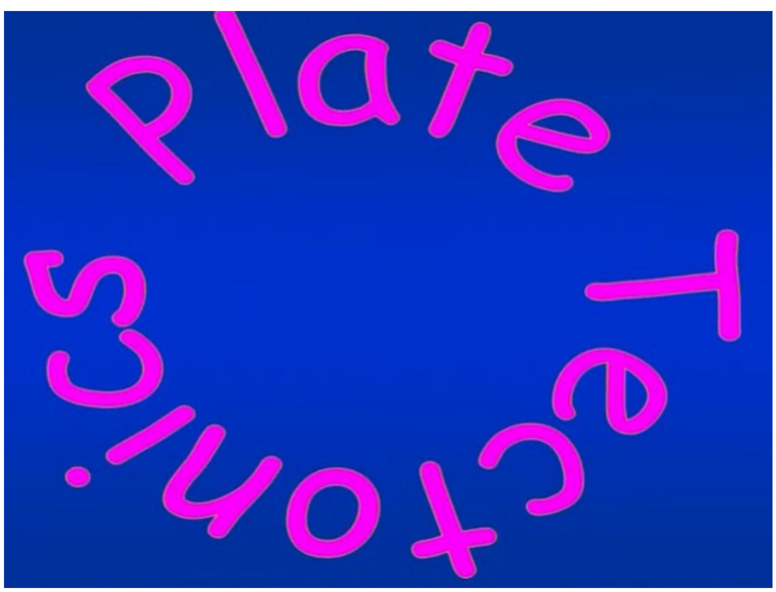

So will see in coming few slides the interior of earth in detail but if we start with the plate tectonics then the tectonics basically we say that it is an unifying theory.

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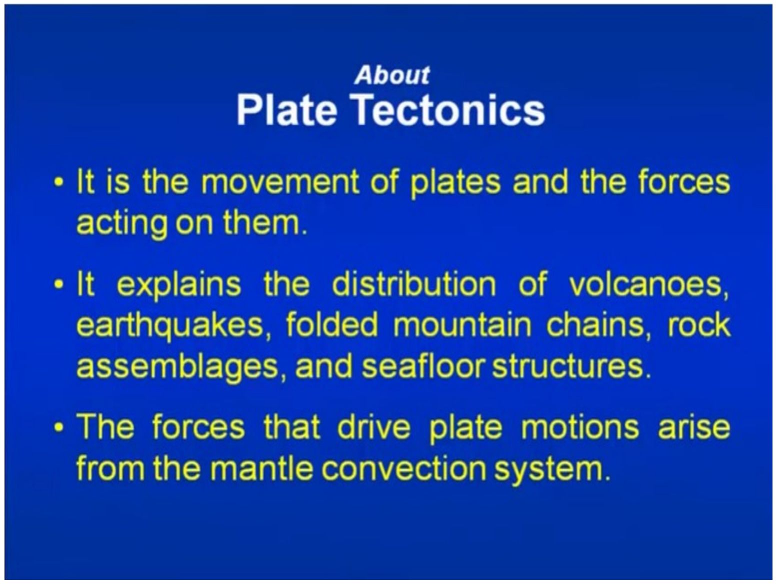

And that is here plate tectonics or it talks about is that it is moment of plate and the forces acting on them. So the plates which are floating on asthenosphere fear so you will see in coming slide what do you mean by this asthenosphere or we can just quickly look at this slide which talks about. So if you look at interior of earth here so we have the thin crust away just the hard ocean on the earth surface.

So we have oceanic crust and the continental crust and then we have the asthenosphere which is partially molten this unit that is the asthenosphere which is partially molten is responsible for the moment of the or the motions which are gained by the continental plate or the oceanic plate or oceanic crust or continental crust. So about plate tectonics it is moment of plates and the forces acting on them.

Now this is important because it explains the distribution of land forms mainly or the what we were talking about the mega landscape. So it explains the distribution of volcanoes it explains the distribution of mountain chains, rock assemblages and seafloor structures. So this is basically we are right now we are talking about the mostly the surface morphology of the continental region and not the seafloor structures that is oceanic morphology we are not going to talk about ocean geo morphology.

But of course the land scape is present submarine also have an and one of the example which we talking about the deepest path on the earth surface that is here Mariana trench. So the features or the landscape exist submarine also the forces that drive plate motion arises from the mantle convection. The mantle convection that is the asthenosphere that is the part of the interior of earth which is responsible for the moment of plates or the motion which is been added to the plates difference plates means your oceanic plate and continental plate.

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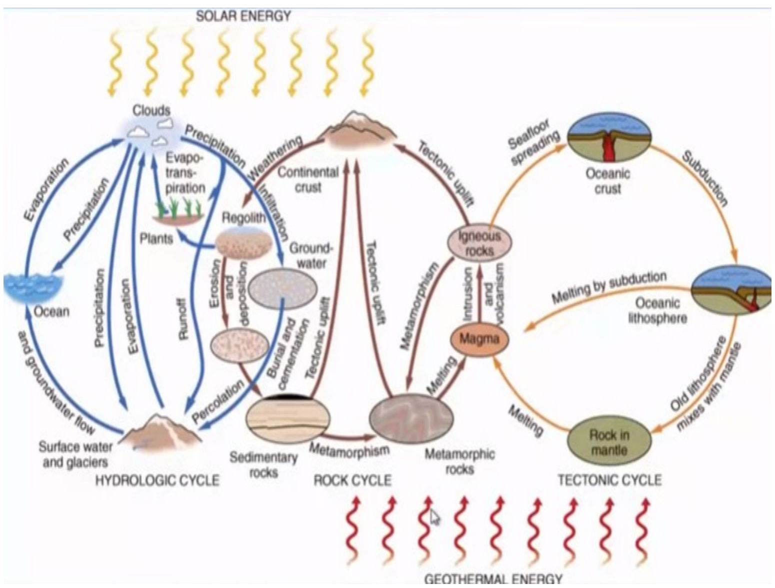

So this is just to show the relationship between the 3 cycles so one is the tectonics cycles so we are right now talking about the tectonics cycle and the tectonic cycle basically it takes about that the formation and destruction of the rocks or the plates because the plates are consist or comprised of made up of different rocks. So they will be finally like if you are talking about the oceanic crust at this location new crust is been added but this crust will be subtracted below and destroyed and then older lithosphere mixes with the mantle and then rock in mantle it start melting it comes through a surface in the form of maxima and then igneous rocks are formed and then so on.

So this is 1 cycle whereas the rock cycle it explains that you have the magma which is coming in then the igneous rock is formed and they are uplifted weathering will take place and then soil or loose material will be formed and erosion deposition then sedimentary rocks will be formed and then metamorphic rocks and further the metamorphic rocks burial will take place in the deeper part of the earth then will be folded and the melting will take place again and will result into the formation of magma.

So this is what is been suggested as an interlinking between or the relationship between the tectonic cycle and the rock cycle and then during the process of the burial and the formation of this sedimentary rocks or segmentation of the sedimentary rocks tectonic uplift which is what we are talking about because this process is because of the plate motion can also had here and results into the erosion. So the mountains which have been formed due to the deformation and are comprise of sedimentary metamorphic and ignitions rocks.

And then the relationship between the hydraulics hydrological cycle and rock cycle is the erosion mainly the erosion part. So they will contribute in terms of the erosion part and which will help in the formation of this sediments that is loose sediments and also to some extents this in cementations and burial and cementation and the formation of sedimentary rocks. So this again is been linked and the precipitation is also to some extent associated or have the relationship between the mountain building activity.

And then on from the atmosphere you have this solar energy coming to this earth surface and from geo thermal energy which is from interior of earth so this is the complete relationship between the 3 cycles that is your tectonic cycle, rock cycle and hydrological cycle.

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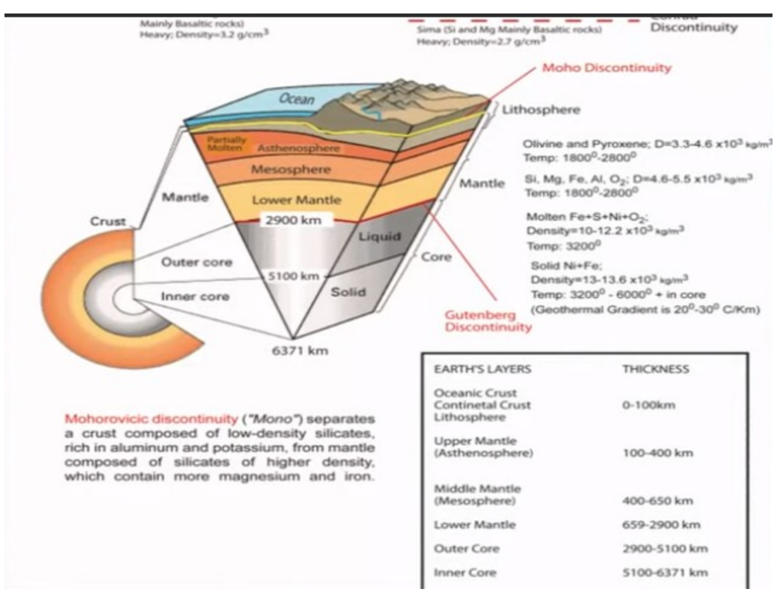

Now coming to the interior of earth this is diagram which shows the different layers from the surface up to the interior of earth. And the interior of the earth the radius if you take is almost 6370 kilometers and this is not homogenous it is it as different layers which have been listed her. So we have like earth's layer thickness 0 to 100 kilometers we have oceanic crust, continental crust and Lithosphere this is been the top portion here that is lithosphere then comes the upper mantle which is 100 to 400 kilometers which also comprises or the asthenosphere then middle mantle we say mesosphere and the lower mantle.

So the lower mantle goes up to from regulate up to 2900 kilometers and then we have outer core and the inner core. The outer core is liquid where is the inner core is solid this we will discuss towards the end that void is so that the temperature if we look at is the gradient it increases so it in the deeper part and the surface close to the upper portion. If you see the temperature is around 1800 degrees to 2800 degrees reduce go deeper and the temperature increases more than 3200 and it goes up to 6000 in core.

So the temperature increases but even then this portion is solid of course the pressure also increases. So the interior of earth if you look at then we have a asthenosphere we have so this is an upper mantle part and then we have mesosphere in middle mantle and the lower mantle. So asthenosphere is partially molten and in this the outer core is liquid. So this we will talk later about this asthenosphere right now it is important for us that we are going to about the plate tectonics.

Asthenosphere as in capability to generate the convection currents and this convection currents are is responsible for the moments of the plates which are oceanic and the continental plates floating on the on the Asthenosphere. So composition wise it is not the same so in the initial lectures we talked about that the composition of the crust mainly the lighter minerals or the lighter elements which is floated over the surface where is the heavier they moved towards the interior of earth.

So mostly the interior of earth in the deeper part that is the core ocean if we take and it is comprise of nickel and iron. It is when you move towards the surface then you start getting the silicon hydrogen oxy and oxygen along with the iron and silicon, magnesia, iron, aluminum and all that towards the surface. So mostly if you look at the oceanic crust and continental crust again in terms of the density the oceanic crust is heavier whereas the continental crust is lighter.

Because it comprises in comparison to the oceanic crust more of the lighter rocks or the rocks which are made up of mostly the competition is silicon alumina. So mainly what we talk about the kinetic rocks or the ignitious rocks they are lighter along with the sedimentary rocks and metamorphic rocks but they are lighter as compared to what you see in the oceanic crust. Oceanic crust the density is around 3.2 grams per centimeter cube whereas the density of the continental crust is 2.7.

And it also comprise the Sima that is what we call the silicon, magnesia mainly the basaltic rocks to some extent but the lighter rocks are much higher in concentration hence the continental crust is compared to the lighter. The thickness of the continental crust weighs from 20 to 70 kilometer but if you look at the oceanic crust which is thinner maximum up to 8 kilometers then also it is heavier because it comprises Sima that is silicon magnesium rocks comprising sili rocks comprising silicon magnesium.

So mainly it is heavier and this is going to be an important point which when we are going to talk about the isostasy.

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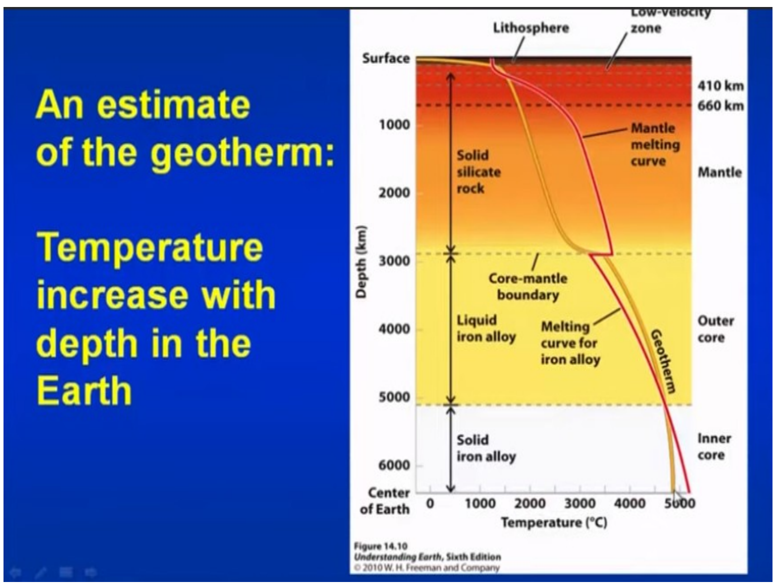

So and estimate of geotherm if you take as we have talking both the temperature increases with depth and as well as if you look at the temperature goes beyond 6000 degree centigrade. If you go deeper so this is the geotherm which is been shown here which indicates that close to the surface the temperature is quite low and then it starts from 0 and as it is enter into the asthenosphere over the mantle then it increases should its suits up from 1000 to almost like 3000 degree centigrade and reaches up to like more than 5000 degree centigrade or 6000 degree centigrade at the greater depth.

So about the isostasy I was talking about that this is important and what we have discussed in the previous slide about the density of the 2 plates and the oceanic plates and the continental plates. We will see that what is importance of that how a landscape varies what we see on the surface.

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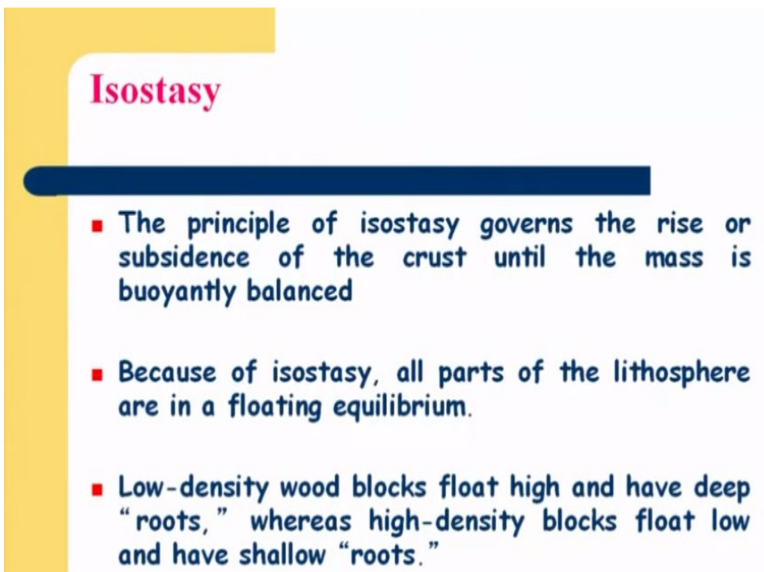

So isostasy basically is the principle of isostasy governs the rise or subsidence of the crust until the mass is buoyantly balanced. So on the if you are having the mean for example the lighters material which floats on because it is very much similar to the what is something it is floating on the surface of the ocean. So this is very much similar that the oceanic or the continental crust floating on the asthenosphere.

So asthenosphere of course as some density and an similar to what if you take in ocean so ocean water is also having the density and the material which will float will of course submerge little bit but remains at the surface if you take this ship then it submerge and if you to come extent but it remains on the surface of the ocean. Similarly the continents which are floating on the asthenosphere will remains so in the next slide we see so this is everything is of the points.

So if you suppose if you weight put the weight on the on ship or the any vessels then it will slightly shrink. Similarly if you put the load on the crust or the then it will shrink but if you remove then it will buoyant back. So this is what it takes about the principle of the iron isostasy. It governs the rise that is the uplift or subsidence of the crust until the mass is buoyantly balanced.

So it will remain in balance so if you suppose if you remove the material then it will buoyantly it will respond and it will come towards the surface. So this is because of the isostasy all parts of the lithosphere are in a floating equilibrium. So they will try to maintain the equilibrium. So the low density would blocks for example floats high and have deep roots. Whereas the high density blocks float low and have shallow roots.

Now this you can directly compare with the you can this you can compare directly with the oceanic crust and the continental crust. And this oceanic crust what we were talking about they are heavier and the continental crust are lighter. So the low density that is the lighter one's will float higher and will have deep roots. So for example straight away if we talk about a Himalayas so Himalayas is a continental crust so Himalaya is lighter the Himalayan crust then the Indian crust is lighter.

So the Himalaya is floating higher at the same time it as deeper roots whereas the oceanic crust is heavier will be flowing floating or will have will be shallower and will have low floating condition.

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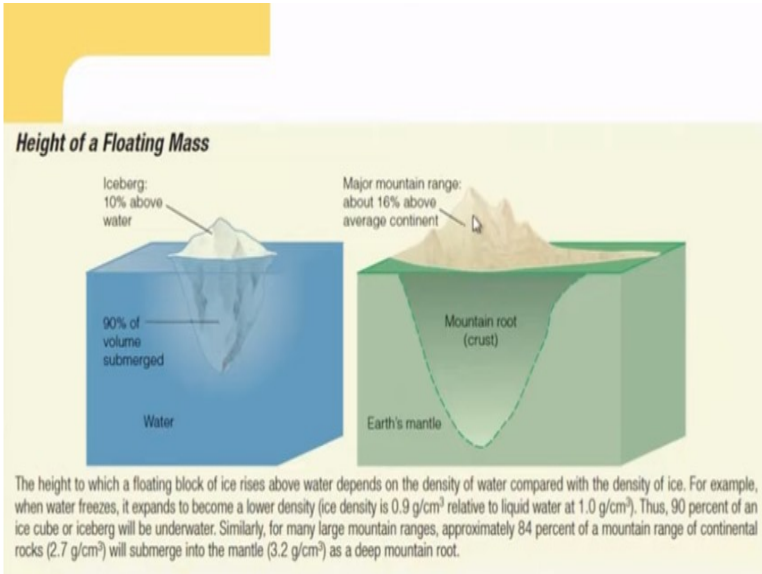

So this is an example which is been given there is a height of an floating mass so one is the ice berg and then you are talking about the this is an water and this is the part of the crust in the earth mantle. So the in terms of the ice berg what we see the 10% above the water where is the 90% of the ice berg is submerged in water so the height of which the floating blocks that is the ice rises above water depends on the density of the water compared with the density of the ice.

So for example when the water is flows freezing freeze or freezes it expands to become lower density. So the density of the ice is around 0.9 grams per centimeter cube and relative to the liquid water which is around 1.0 grams per centimeter thus 90% of the ice cube or iceberg will be under water. Similarly for many large mountain ranges so one of the example which we are talking about this Himalaya approximately 84% of the mountain range of continental rocks with density of 2.7 out of (()) (22:44) gram per cubic centimeter cube will submerge into the mantle that is the asthenosphere and the mantle and 3.2 gram per as deep mountain root.

So this will be seen at the whatever is the is on seen on the surface much more will be in the deeper part.

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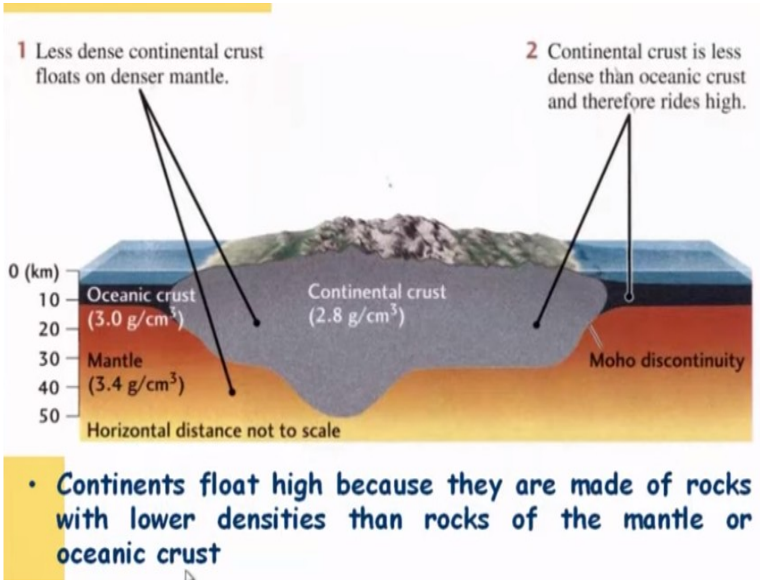

So this is an example which talks about that is the density of the mantle if we take is a 3.4 grams or 3.5 grams here and the oceanic crust is around 3.4 or 3.3 and this 2.7 or 2.8 so the continental crust is seen that it is rooted deeper as compared to the continental also oceanic crust in to the mantle. So less dense deeper root and if you are having denser then you are having the shallower root. So continents float high because they are made up of rocks with lower density then rocks of the mantle are oceanic crust.

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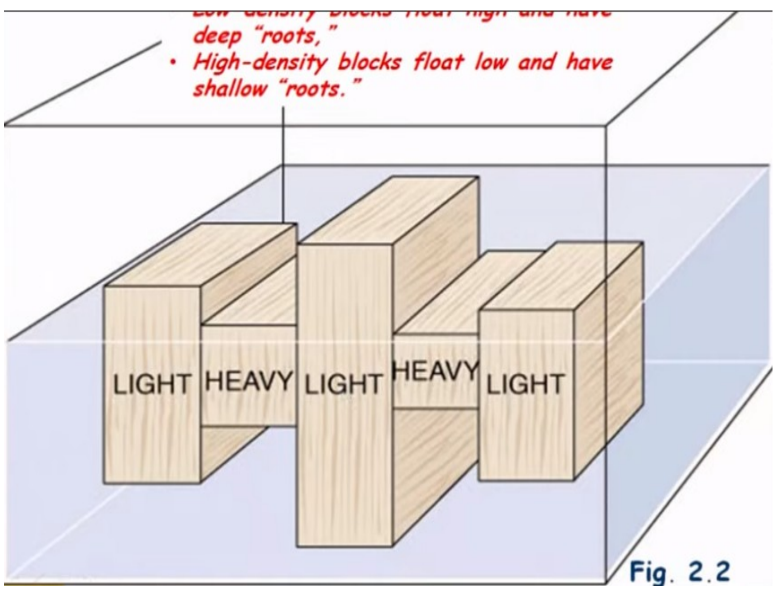

So low density blocks at which are lighter float high and have deep roots high density blocks which have been shown here this are heavier so will float low and have shallow roots. So this you can keep in mind so as you keep on because what is the most importance the next slide we will talk about. So if you keep on removing the weight from here it will keep coming up and that you will be able to do with the help of the hydrological cycle and the solar radiation.

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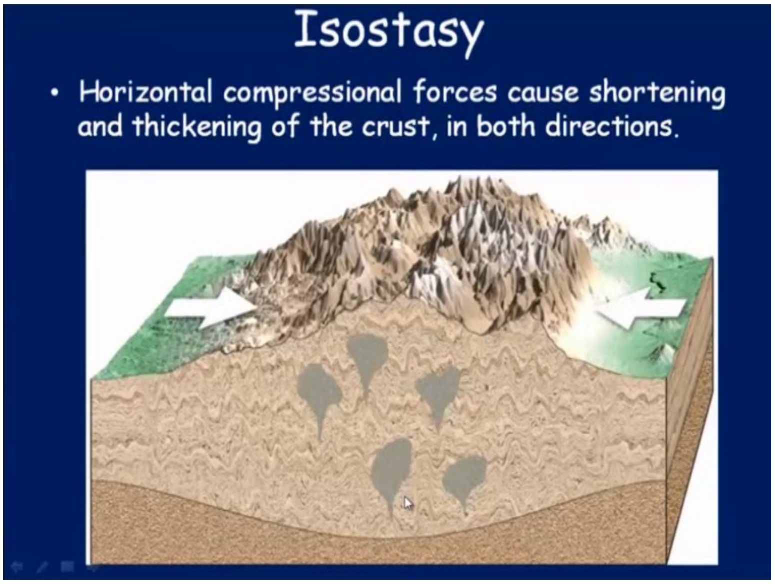

So isostasy horizontal compression or compression forces causes shortening and thickening of the crust in both direction. So this is what it explains that if you have compression or if you compress the continental crust then you are going to do the shortening one and as well as thickening of the crust so you are going doing in the both direction one side you are taking this up towards the surface or towards the sky and another you are also deepening or thickening the crust in the mantle.

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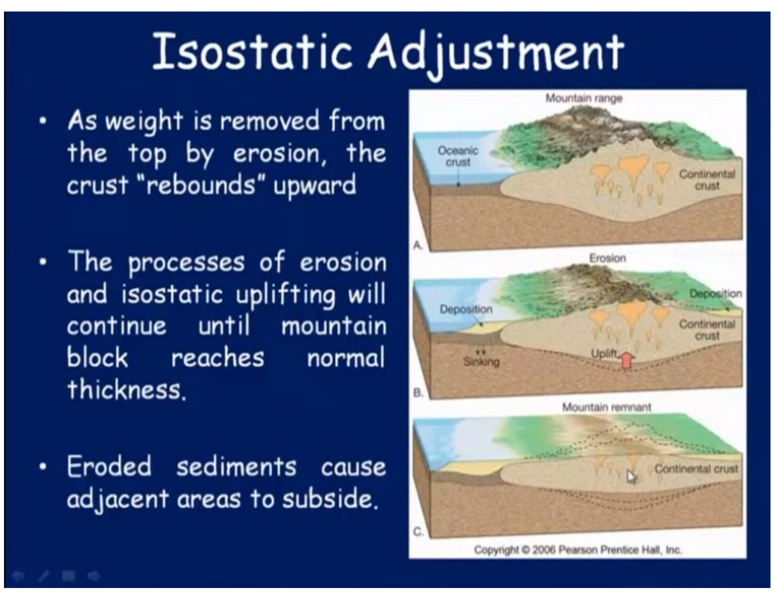

So isostatic adjustments as I was talking if you keep removing the material then this will happen actually so this is an example which is given which shows that as you remove the material that is as the way it removed from the top a erosion. So erosion here the hydrological cycle will play an important role and the solar radiation which is coming to the surface of course this is the relationship between what we were talking about hydrological cycle, rock cycle and tectonics.

So all 3 cycles are linked but here what we were talking about is the rebounds system which will results the upwards movement of the mountain chains because of the erosion there will be an uplift and this is happening in Himalayas. So the process of erosion and isostatic uplifting will continue until the mountain blocks reaches normal thickness. That means the whatever the root as root which is available it is emptied then it will stop.

So this is very much important in change in the landscape what we are talking about it so the time will come when we will not be able to see the Himalayas the Himalayas is but it will take long time. So the eroded sediment causes adjacent bay areas to subside. So what it talks about us that you uplift that is you erode you uplift and the sediments which have been supplied from the from or eroded sediments which are generated from the mountains will be deposited and this deposition will overload the adjacent areas and this will result into the subsidence of this region.

So once side we have eroding, uplifting and another on the side ways we are subsiding so you can understand the landscape keep on evolving or changing in different time. So the time will come when you will not be able to see the Himalayas but as we have discussed that Himalaya is part of the continental crust and then the continental crust lighter as compared to the oceanic crust. So the lighter once will float high and will have deeper root. So the roots of Himalayas or the continental crust what we have in India is thicker and we will take lot of time to get eroded.

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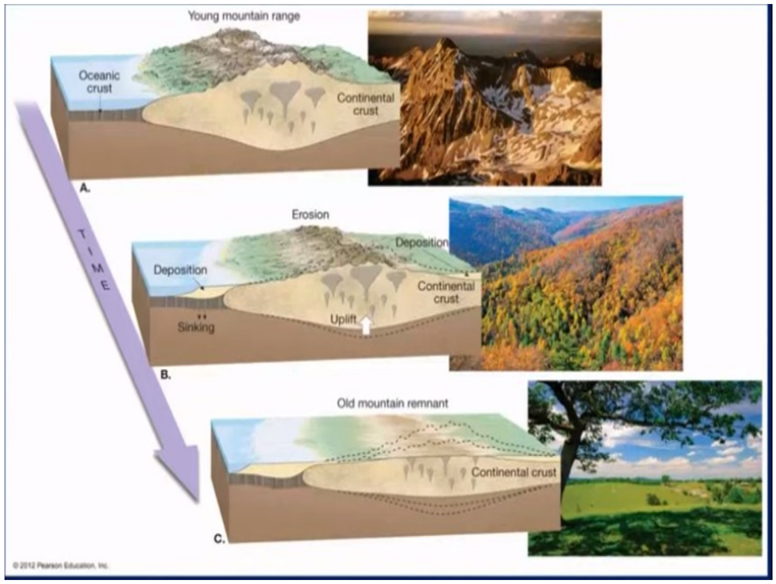

So this is how the landscape will change so this is been shown here that we have the young mountain ranges like Himalayas and then you are having the erosion which is going on and the erosion will results into the uplift. So over the time this phenomena will take place and then a later when this whole root material which is available or the continental crust which is available in the deeper part or the in the deep roots will exhaust and will result into the (()) (29:14) planes.

So the remnants of the whole mountain which where have the towering heights now what you see is the flat areas. So this also will affect the climate because if you talk about the Himalayas governs the monsoon area and if you are not having the Himalayas then we will have different climate. So will also result not only the in the change in the climate but also the landscape in the region. So this portion is extremely important and we can learn based on the isostasy so we will stop here and we will continue in the next lecture.