Geomorphology
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Lecture-04
Landform Development – Equilibrium and Evolution

Ok friends, today we will discuss about this landform development, equilibrium and evolution. So far we have discussed that the process and material and energy management. So, now taking this energy and material together with some geomorphic process involvement, we are going to create some landforms. Here, the internal energy is involved, the external energy is involved and some energy which is from extra terrestrial that means the another form of external energy, it is also involved.

So, finally, we are creating landforms and then we have to see whether it attains the equilibrium or it still in the evolving states. So, once the landforms it attains the equilibrium, then there will be less change or very little change occurs there. But if it is in evolving stage that means, you will notice positively change with time. So, that means the equilibrium the landforms which is attain the equilibrium, there is less chance that again it will evolved until unless some internal energy is used energy involved.

So, now if you see here to discuss these, to elaborate this, we have a geomorphic cycle which was proposed by Davis in 1989, that is called Davisian model of geomorphic cycle, it the first ever geomorphic cycle that was proposed. So, what this geomorphic Davis geomorphic cycle says.

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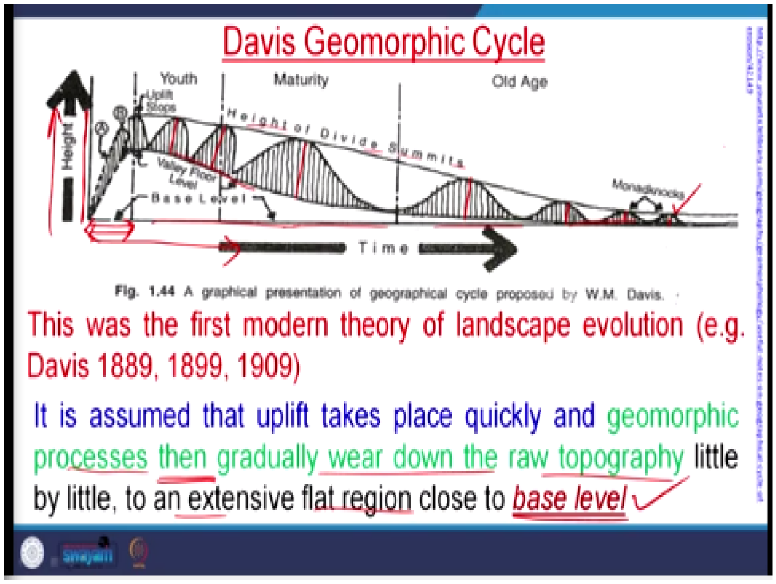

That he assumed, that the uplift takes place quickly and geomorphic processes then gradually wear down the new topography and little by little, to an extensive flat region close to base level. Here 3 things to be understood, one is that upliftment takes place very quickly. For example, if you see this figure here, we have the height that means the scale of upliftment, this side we have the scale of time.

So, now, you see here in this segment, we have very less time involved and now you see it attains this much height. So within less time, if your system is at attaining to much height that means here the rate of upliftment is very high. So that Davis geomorphic cycle says, in evolutionary system is involved in a geomorphic system, when we are creating a landform we are creating it very quickly.

That means if you remember your last class, we are talking some of the catastrophic approach and gradual approach. So that means Davis says many of this landforms, they are occur quickly, that means through catastrophic process. And another thing he says that geomorphic processes then gradually wear down to raw topography. So that mean he say, during upliftment there will be no wearing or tearing down, there will be no erosion.

And finally, to an extensive flat region close to base level, what is base level, if you see here this figure this is called base level. Base level that means, it is the general sea level, base level means, below that there will be no erosion. The agents either it is this rivers or the glaciers they cannot erode the topography, the land surface below that base level. So, base level is known for depositional zero contour or topographic zero contour, that here the land and sea that meet.

So, if you say so, where we have already discussed in our earlier classes, there are many times the geographic changes has been occurred. So, that means the base level has sometimes it is raised up, sometimes it is gone down. So, there will be change up base level in the geological past. So, once there is a change of base level occurred. Similarly, this corresponding geomorphic system they have shifted their place, so that is why there is a reason for paleogeographic changes.

So, this base level plays major role in modifying the geomorphic system, because all the depositional topography, all these erosional topography, they are remain always and always about this base level position. So now, you see we have Davis geomorphic cycle says this is the best level and this is the valley floor level at the height of the divide up the summit, this means this water divides.

It says the upliftment takes place very fast within a small time we are uplifting the system and then gradually we are eroding down. If you see this height of this hills gradually the height is decreasing, and decreasing. And finally, these are called the monadnocks, monadnocks they are isolated hills, isolated erosional hills within the flat area, this is called monadnocks.

So that means at the initial time the hill has attended maximum height and now we have uplifted the system we keep at this level and gradually allowing the geomorphic agents to erode them. And finally with time, they are eroding and decreasing the level and finally they are mixing it with the base level. So that means I want to say erosion takes place only up to the base level. So this is the assumption of the Davis that there will be no erosion until unless upliftment is over, do we believe so, no.

Because we cannot say erosion to stop because upliftment is going on, at many places erosion and upliftment they go side by side, hand in hand, whenever will there will be upliftment, there will be erosion. So, the reduction process that means, the height reduction process creates a time sequence of landforms that progress though youth stage, mature stage and old stage. So, that means, if we take erosion as a package, landform development as a package, this process takes in 3 different stages.

In youth stage that means at early stage of development of the landform this rate of erosion is more. So, here, whatever the topography is form they will be very blunt and then if come to the mature stage. In the mature stage what happens, this the rate of erosion will be less, so that is why whatever these landforms are formed, they are corresponding to this rate of erosion and that will be less blunt.

And the old stage mostly the erosion is not dominant it is the depositional it is dominant, very little erosion if possible because it is close to the base level. And we know close to the base level there will be no erosion or very little. And youth stage we will get the topography, we will get this landforms which are erosional landforms. In mature stage mix erosional and depositional landforms, in old stage mostly it is the depositional landforms.

So, according to the Davisian model, upliftment and planation takes place alternatively. That means Davis geomorphic cycle says there will be no **or** erosion until unless there will be upliftment and upliftment stops then erosion starts, which is not possible. Here it says many landforms uplift and denudation occurs at the same time.

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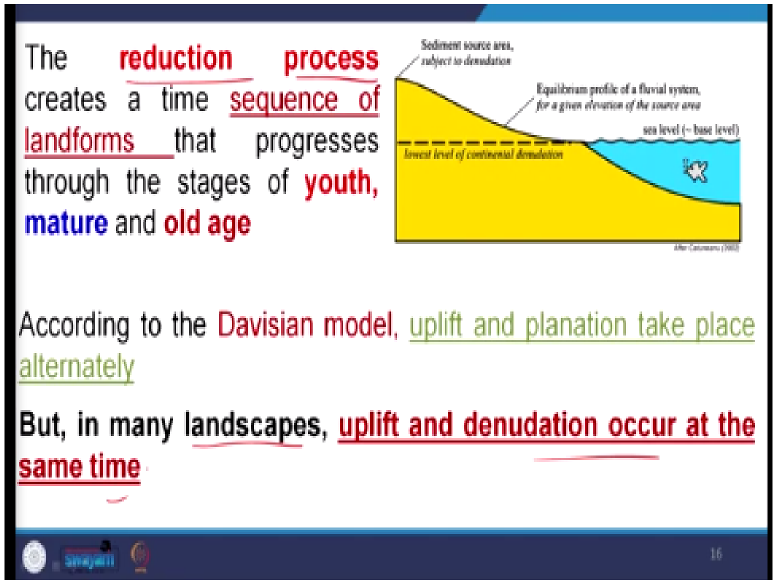

So, this was the flaw of a Davisian geomorphic model, though it was the first geomorphic model proposed and it is a prototype geomorphic model proposed. But it was the major flaw that Davis said that the erosion and upliftment they occur one after another. They cannot occur simultaneously, which was wrong, which was not supported and it is modern days also it is not supported.

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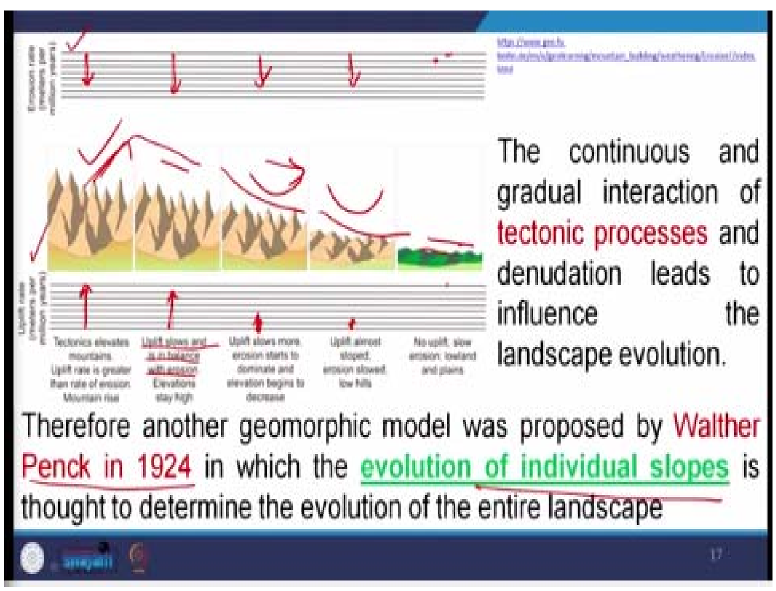

Now comes to this interaction of tectonic process and the denudation process. We know the tectonic process, it adds material, the denudation process that removes material. So now if you see here in the mountain systems, if we takes millions of years scale erosion also million of years scale and we are creating a mountain. Here if you see tectonic elevates mountains, uplift rate is greater than the erosional rise.

Now, you see here is the scale, here tectonic upliftment is more, here erosion if you compare these 2 scales upliftment is more as compared to erosion. So that means material added more than removed. So, if we are adding more material to a system, so, that means, we are elevating the system from the general level. So, that is why we are creating mountains. Now, with time, what happens if another segment, upliftment slows and it is balanced with erosion.

Now, you see, the scale of erosion and the scale of upliftment both are same. So, that means the amount of material we are adding to the system, the amount of material also we are removing to the system, so that means it is in steady state. We do not know, how the shape will change because material added is same, removal is same, so it is in equilibrium state. In third case if you see, erosion scale it is more however upliftment scale is less.

So, here we are removing more material and adding less material, so there will be negative topography, here there will be straight topography, here there will be positive topography, positive topography like this. So, that means, if we are removing more material, that means more material is going out of the system, less material is being added here, so there will be a material deficiency here.

And now, again if we are going down here, upliftment is very negligible, no upliftment and erosion is this much. That means again negative topography because material removes more and here if you see there is no upliftment at all similarly no erosion at all or very less erosion, so it is peneplain. So, that means within a system if you say we are moving with height, then coming straight, then with a negative then again negative, then we are coming very straight.

So, that means, this is the way how the landform evolution takes place, this is the way how the geomorphic system works. So, geomorphic system to sustain for a long time, it is simply a balance between the material and energy. So, upliftment energy adding material, erosion it is removing material. So this is the balance how this mountain will take shape, any mountain in the world, it is being shaped due to this function of these 2 material added and material removed.

So adding material, it is the tectonic forces, which is main responsible for adding the material here. And this erosional forces, they are removing the material here, but this erosional process if we see, again, it is either it is a gradual agent or due to catastrophic agent. Like landslides, like faulting there removes material very suddenly. Similarly, addition of material, tectonic forces, there will be thrusting it is adds material to the system, folding it adds material to the system, magmatism it adds material to the system.

So to sustain the system geomorphologically for a long time, it has to be balanced between the energy and material. So this was the flaws of the Davis geomorphic cycle, that Davis says upliftment occurs and erosional occurs. But they do not occur simultaneously, erosion occurs after the upliftment. But to overcome this flaws Penck 1924, he proposed another geomorphic cycle, that is called Penck's geomorphic cycle.

Here the plus point was there, advantages was there, that in Davis geomorphic cycle, the whole system was involved. But Penck restrict himself within the slopes, evolution of individual slope rather than involvement of the whole landform. So, individual slopes, that means their integral part of the landforms. So, it does not mean that if one slope is acting or eroding, very fast that other slope will also erode very fast.

So taking the whole landforms at a time considering a whole landform at a time we may doing something wrong. So that is why Penck was very cautious and very precisely he is restricted himself within this slopes only, evolution of slopes only. So, there are 3 types of slopes, one is called convex slope.

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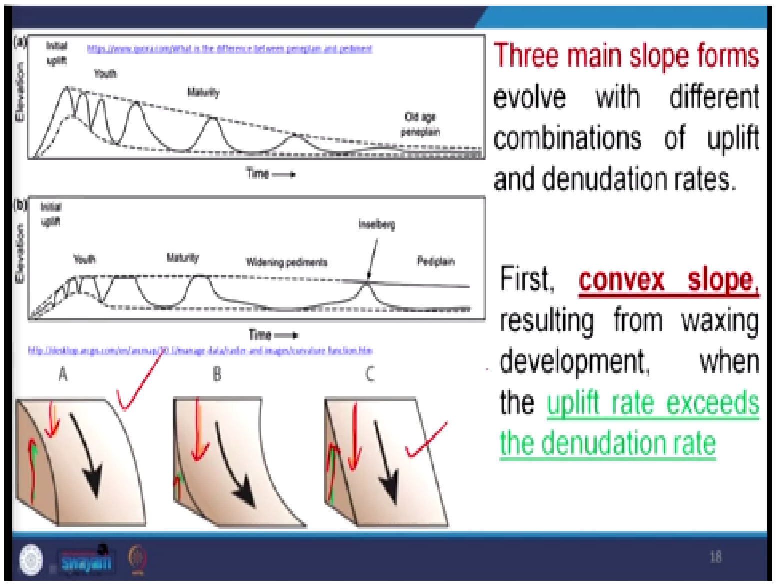

That means here if you see material added is more than removal is less. So if we are adding more material by tectonic forces and removing less, so that means we are getting a convex slope. So it is otherwise called waxing slope and suppose where removing more material and adding very less material, that means we are creating a concave slope. But here suppose we are adding material and removing material both are same, so here we will get a straight slope.

So hill slope can be straight slope, can be a concave slope, can be a convex slope, that depends upon which slope is responding to this geomorphic system in which way. And at which slope the tectonic process is adding material, in which slope the erosional process is removing material. So, this is all about this game, how these slope can be defined and which slope will be convex, concave and straight and how they will affect the geomorphic process they will study here.

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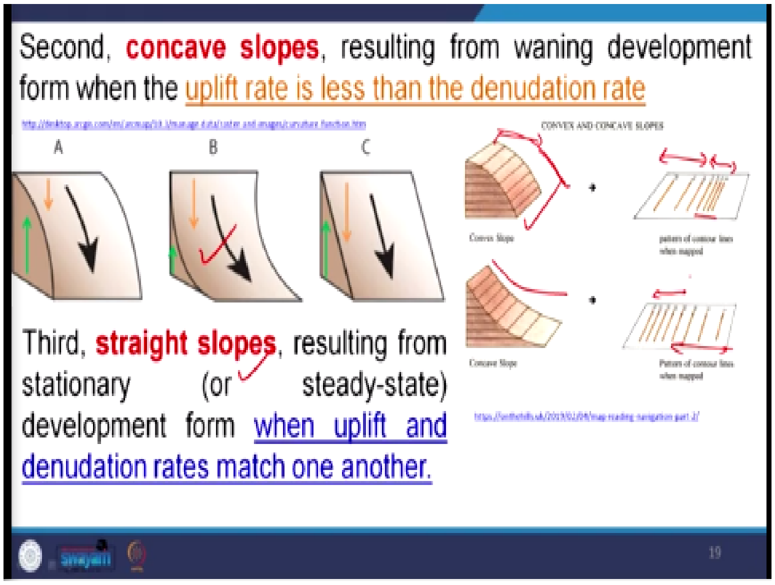

Now, second is the concave slope already we have discussed, then straight slope we have discussed as a geomorphologist, you will always and always deal with the topographic map. So, if you as a geologist or a geomorphologist if you handle with a topographic map, how it will determine which type of slope you are dealing with. So, that is by looking the topographic contours the height contours.

So, as far as survey of India is concerned the toposheet is prepared, these contour difference on 1:50,000 scale is 20 meter. That means, if you are moving from one contour to another contour either you are going down 20 meter or going up 20 meter and 1:25,000 meter scale this contour difference is 10 meter. So, by looking the contour pattern, by looking this contour arrangement, by looking the spacing of these contours, you can say what type of slopes you are dealing with.

For example, if you see here this is a convex slope and you come here, this is the topographic map, the contours are arranged. At these slopes, these contours, they are very closely spaced and if we are moving relatively to flat region. Now you see, this is the system this is relatively flat and this is sloping surface. In the sloping surface, the contours they are very closely spaced and relatively flat versions the contours, they are widely spaced.

Similarly, here in concave slopes, this side this is the concave the slope is more than this the slope is less. So in the less slope we have spacing contours but in higher slopes we have close contours, very closely space contours. So, that means by looking this arrangement of this contours, you can say what type of slopes you are dealing with in a topographic map.

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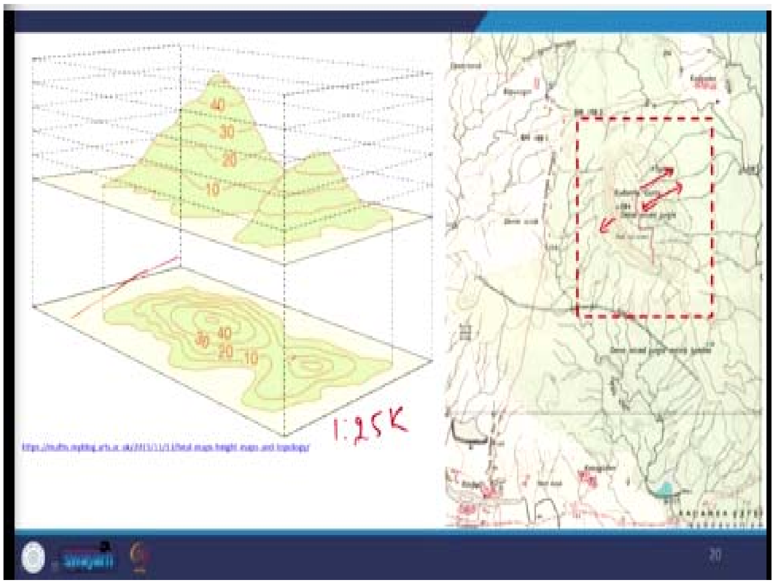

This is a live example of this slope, now you see, these are the 2 mountain systems, 2 mountains having some contour values is given. And now, this topographic map is prepared for this mountain systems. Now, you see these are the closed contours and 10 meter contour interval as per of survey of India topographies is concerned, this can be of 1:25,000 map, is not it. Now, here in the mountain system, you see this side from this side these contours they are very widely spaced.

But this side of this hill this contours they are very closely spaced, so we can say this is a gentle sloping mountain front, and this is a steep sloping mountain front. So, understanding this contour is very much important for geomorphologist to work for tunnel development for planning purpose, for defense purpose and for water management purpose. So, whatever maybe these developmental project is concerned, so, understanding is contour is very much important.

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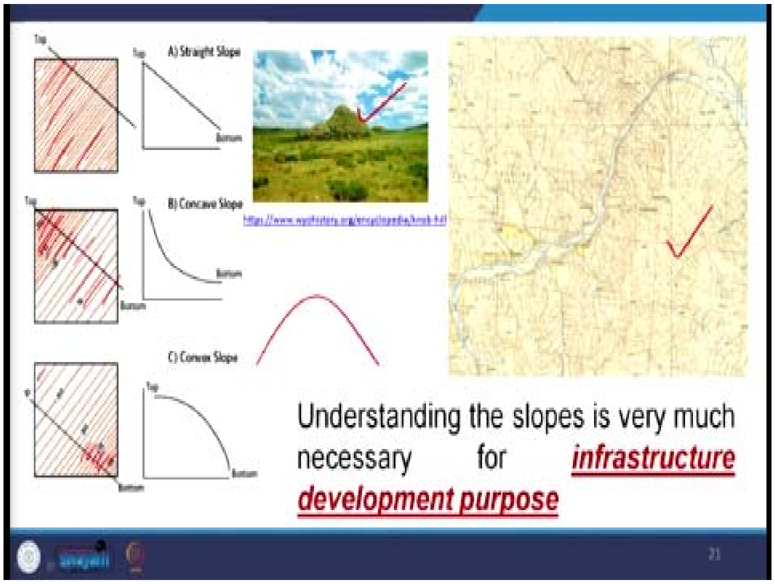

Now, these are this topographic map, in a topographic map a straight slope you see straight slope equally spaced. There is no spacing or either it is closed spacing or it widely spacing, it hardly matters because this slope is straight. So, you see equal contour distance but in case of concave slope you see this side these contours are very closed space and this side they are very widely spaced.

Similarly the convex slopes this side very closely spaced, they side very widely spaced and if you see this toposheet of 1:50000 scale somewhere from Himachal Pradesh the Pin valley. This Himalayan system, the Himalayan mountain system is very, very closely spaced contour. That means, it is indicating that this Himalayan system the slopes are very steep however if you consider this Eastern ghat here this will it will be look like this.

That means contours are widely spaced but in steep slopes like the Himalayas, the contours are very closely spaced. So that is why understanding the slopes is very much necessary for infrastructure development purpose. Until unless you slope geometry you do not understand you cannot go for developmental program, you cannot go for reservoir development, you cannot go for dam development, you cannot go for tunneling, you can go for watershed management.

So, slope surface management and its understanding, it is very much important for geomorphologist.

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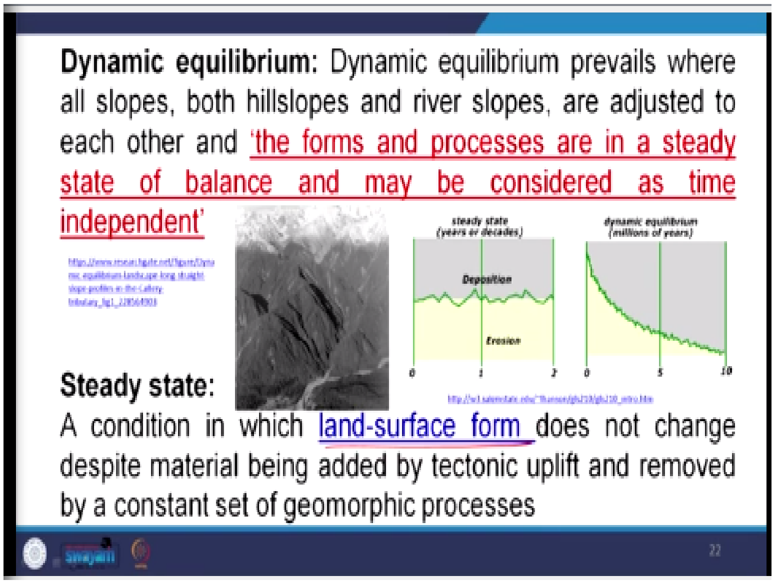

Now, another terminology comes here, it is called dynamic equilibrium, that means we have a evolving surface, the geomorphic systems they peneplain the system, they peneplain the slopes the erode the slope. Then what is dynamic equilibrium, dynamic equilibrium in the prevails where all slope both hill slope and river slopes they are adjust to each other. In the form and the process are in the steady state of balance and maybe consider at the time independent, what does it mean.

We have rivers, we have hills, so that means a hill and the river slope they are in straight line, that is called dynamic equilibrium. That means, material being added from this hill, they are removed by these river. So, in that case, straight slope remain straight, concave slope remains concave, convex slope remain convex. So, material being added and removed, it hardly affect the slope geometry, that is called dynamic equilibrium.

That means, it is in a dynamic state, material being added and it is also being removed, so that is called dynamic equilibrium. Though it is in a dynamic form but, it is in equilibrium, so that is called dynamic equilibrium. Then steady state, it is condition in which land surface form does not change despite material being added by tectonic uplifted and removed from the geomorphic process.

The other word the steady state and dynamic equilibrium both can be similar way understood. So, a condition which land surface form does not change, that means a hill a rocked hill remains a rocked hill, a straight slope remains a straight slope. So, land surface form remains as it is either a material being added and removed it does not matter, so it is in steady state.

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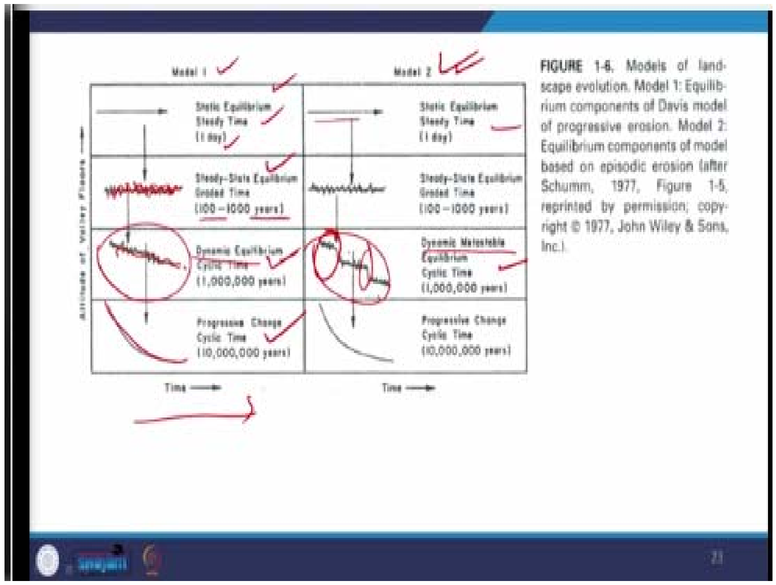

So, here 2 models are proposed, one is model 1, model 2. Here altitude of a valley floor altitude is more and here. Here this scale is time scale, you see here in static equilibrium steady time suppose 1 day it is hardly matters. Steady state in equilibrium 100 to thousands of years, here if you see there is small changes. But dynamic equilibrium here you see some changes is there and gradually this side earlier if you see here, earlier notice you here

This in the steady state it is in straight line, but gradually it is sloping down and in progressive change in cyclic time if you see this is a concave slope formed or if you say it is a valley slope that means it is in steady state. Now, here model 2 static equilibrium, it is straight same as it is, it is 1 day. Now, if you see here the basic change is here, here the dynamic equilibrium, here also dynamic equilibrium, cyclic time.

But here it is periodic change that means, material is being added here. So, these are the intermittent tectonic forces, they are adding material and it is removing material by these geomorphic processes finally this ultimate product is same in both case. So, this is in static what this is in dynamic. So, I can conclude here this material and energy management in this geomorphic system is very much important.

Rather, we should not consider the whole geomorphic system at a time rather we should concentrate ourselves within the slopes. So if we are able to understand individual slopes, we can predict how the whole geomorphic system will behave in future to the geomorphic processes, this is all about the today's class, thank you very much.