Geomorphology
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Lecture-01
Introduction to Geomorphology and Concept of Time Scale in a Geomorphic System

So friends today we will discuss about this geomorphology and its application in earth sciences and various aspects of day to day life. So, what does it mean, why geomorphology is important and what geomorphology tells about us. The geomorphology the term is derived from 2 Greek terms.

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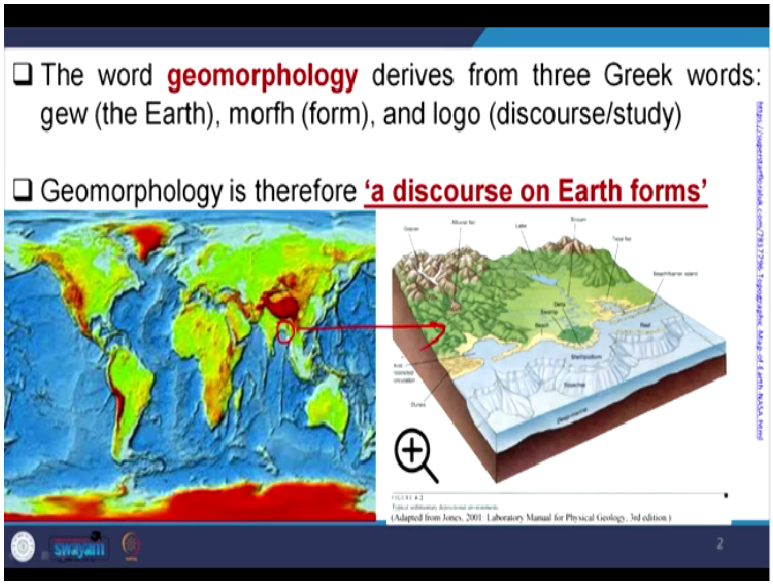

One is called "Gew" means "the Earth" and another is the "Morfh" Morfh means "the Form" and "logos" that means "the discourse" or "the study". So, that means, if you say this total meaning of geomorphology it says it is the discourse of the earth form, what does it mean, what is one is discourse, another is the earth form, discourse means if you see this first figure or the figure 1, it is mostly this is the world map, it is composed of the continents and the oceans.

So, that means within this continents if we divide it, so, if we zoom this continents then we will find somewhere there are rivers, somewhere there are mountains, somewhere there are this glaciers, somewhere there are deserts and somewhere if you move to this oceanic system,

somewhere we have the islands, the mid-oceanic ridges and some of the volcanoes like this. So, that means whatever the features I have discussed so far.

These features how they are arranged, how they are placed side by side and what is their internal relationships that is the discourse of this earth form. Similarly, suppose we are zooming it that means a particular place, suppose we are zooming from here and we are coming to this side. So, that means what we are getting, if you see here, this system the second figure, it is the zoomed version of this portion I have marked out.

You can see here we have the oceans or we have these continents within these continents what we are getting the upper part or the higher altitudes, it is occupied by the glaciers in the mountain front. Similarly, within this glaciers we are getting some glaciers valleys, some glacier erosion landforms, some glacier depositional landforms, and if we are coming to certain lower altitudes then we are getting here the lakes the glacial lakes.

And below that there is the fluvial system or the rivers they are originating from this glacier lakes, or the glaciers, and they are coming through these continents and merging to the ocean to the best level. So that means I want to say, if we are getting these types of landforms, side by side, then what is their interrelationship, how they are linked to each other, and how these things they influence our geomorphic studies and what is how they are influencing our day to day life, we will discuss in the present course.

Now, if we think so these are the earth forms and they are placed side by side they are interlinked. Now, the question arises, if this is the present form of the earth surface, does these form they are acting or they are present in the past, whether the same type of relationships they were existing in the geological past also. If they are then whether one discourse or one form they are dominating others, one process or dominating from the others. All other processes, they were equally dominating or equally affecting the earth form.

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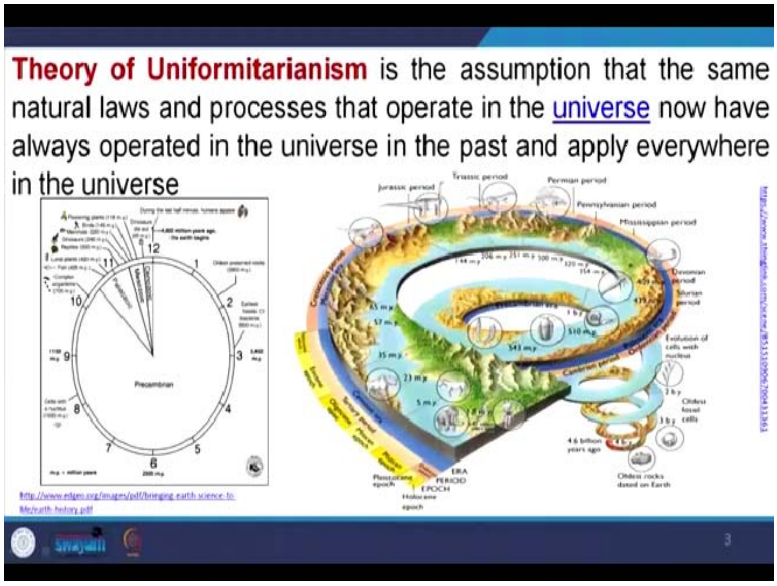

So, if you see here, the first figure, we have the earth clock, within this earth clock, if you see, this time is total divided into 12 hours during the last half minute, the human appears, we want to analyze the 460 million years of earth's history. And within that history, we are analyzing how the geomorphological changes occurred. That means those processes which are acting in present day that may not be acting in the past.

If they are acting, that means this same rate may or may not they were acting that is why, we have to analyze it within this earth processes within the earth's timescale, whether those processes are acting at the same rate, they are acting today or they are acting at a different rate and if they are different rate, how the discourse of geomorphology was existing and what changes occurred, if the rate changes slightly.

So if you see the second figure here, the earth this formed at 4.6 billion years ago, and now we are present here. So, that means, from here to here, if you analyze this figure at the oldest rocks of the earth, if you date it back, only there are one type of rock existing, that is the igneous rocks and with time the sedimentary rock come to existence and with new course of time, all those sedimentary rocks and igneous rocks they were metamorphosed and converted to metamorphic rock.

And within time, the atmospheric changes occur and within time this living organisms came to existence. So that means volcanoes they appear. So that means, these duration of this time, starting from the beginning and present day of this earth system, there are many times the earth surfaces had changed, and that surfacial changes that occured that is recorded within the geomorphological history.

That means, if we are starting from the beginning, and we analyze from this present day, if you see many times the earth has found this geomorphological changes, palaeogeographical changes process changes within this course of time, and all those changes they have been recorded within this earth history. And where they are recorded, they are record within this rock body, mostly in the sedimentary rock body.

So, that is why these sedimentary rock bodies they are more and more important as compared to other type of rocks to study the geomorphological history. So that means geomorphological history if we want to study from the beginning to now, we must target the sedimentary rock, these records may or may not present entirely through the rock body. For example, suppose there are some changes occurred.

And some changes they are locally occurred that means those sedimentary rocks which are found at that time, they may witness that changes, but they adjacent area they may not witness that things. So, that is why all those records that are found here, they may or may not present in their adjacent area depending upon their the area of influence. Similarly, there are geomorphical changes one change is called global changes.

Another change is that is the regional changes and third changes with the local changes, global changes. That means those changes which are affecting globally, for example, you might have heard about the eustatic sea level changes, eustatic sea level changes means it is the sea level changes that is measured from the center of the earth. So, if the eustatic sea level changes occur that means the sea level either increase or decreases that means affecting globally.

So, now imagine suppose a globally a sea level changes occur that means suppose imagine it is increasing. So, that means, more and more landmass area that is submerging under the sea. So, that means, respecting fluvial changes suppose the river which was acting here which are debouching here, if sea levels changes occur, these sea level increases, so, river will sit from one place to other. So, that means a global change, which is eustatic sea level changes, it is affecting the regional changes which is affecting the locals changes also.

Similarly, one area it is volcanic eruption, volcanic eruption occur in a particular area. So, that means here some material is added to the system, some temperature increases there, new formation was there. So, this is a regional changes that means, a particular reasonable area is affected there, that is the regional changes and some of them are called local geomorphic changes that means, it is restricted to a particular area only not the adjacent area is affected.

For example, suppose there is a subsidence, subsidence either one village will be affected, one town will have affected or simply some square meters, some square kilometer area will be affected. So, these are called local changes. So, that means, I want to say both regional changes and this global changes, they affect the global geomorphology but the locals changes they change this they affect the local geomorphology.

So, that means those records those sedimentary records which are present there globally, they will record the global geomorphic changes, that is called suppose for example, if you say this one is called the PT boundary, Permian-Triassic boundary a KT boundary. So those boundaries, they are global record. So, that boundary means at that geological time frame these boundaries they affect those changes who just influencing globally.

So, that means all the geomorphic features that were formed there. So, there might have been affected by this global changes okay. So, that is the theory of uniformitarianism says. So, those processes which are acting nowadays, the same process are acting in the past also, but the rate of acting of this process, that is was may or may not be same. So that means these process is same earlier in geological past, the marine system was there.

The fluvial system was there, the aeolian system was there, the erosional processes was there, and present also the aeolian system, the glacial system, the marine system and fluvial system was acting. But in the past, whatever the rate of activity was there of these processes, this may not be same at the present activities. So that is why though the process theory of uniformitarianism says the process which is acting in the past is acting today or processes which are acting today is acting in the past.

But the rate of activity have been carried from time to time and that has been record within the earth system. So a geomorphologist, it must find out the geomorphic history of an area to reconstruct the paleogeography. So geomorphic history means to read the rock record within the rock record, whatever the changes are there geomorphic changes are there. Those geomorphic changes has to be correlated with the rock records.

So rock record will correlate the geomorphic changes and adjacent geomorphic processes that have been unraveled. And finally a geomorphologic history within the rock record within time has to be established. So, it is the fundamental principle of geology that the earth crust by means of natural process of geological time that means paleogeographic reconstruct that we have discussed here. Paleogeography reconstruction that means, simply it is the geomorphological history or raveling the geomorphological history.

Paleogeography for example, suppose a marine which are exiting here near to the marine there is a river which are debouching its sediments, near to the river and towards the continent side there was a lake and then there is a mountain front within the mountain front, there are glaciers. So, like that one process another process, third process, fourth process, they are interlinked.

So, now, if you suppose we change the marine sea levels we increase this level that means the river has to sit further continent one, similarly, the lake system that will be affected, the glacial system that will be affected. So, that means now in paleogeography reconstruction that means, where the geomorphic processes are acting here, and whether this same process or the same place the geomorphic processes acting or not acting.

If it is acting there from the beginning to present that means, the paleogeography has not been changed, whatever is the past it is in the present, what it has if it is changed that means, one system shifted to another system, it is occupied by another system. So, that means, within the rock record, we are getting the geomorphological history, they are recorded. So these geomorphological history that will available or the geomorphic processes where the acting and finally the paleogeography has been changed.

So, geomorphology it is study of earth physical lands surface features that means, we are restricting ourself within the land surface, which is not true, because if you see this submarine landforms, submarine landforms means within the marine, we have some channels, some mid-oceanic ridges, they were coming under this geomorphology. So, that means not only we are restricting ourselves within this continental, we are also going to this marine environment.

So, those processes which are acting from here to this marine level, all those processes are included within this geomorphological domain.

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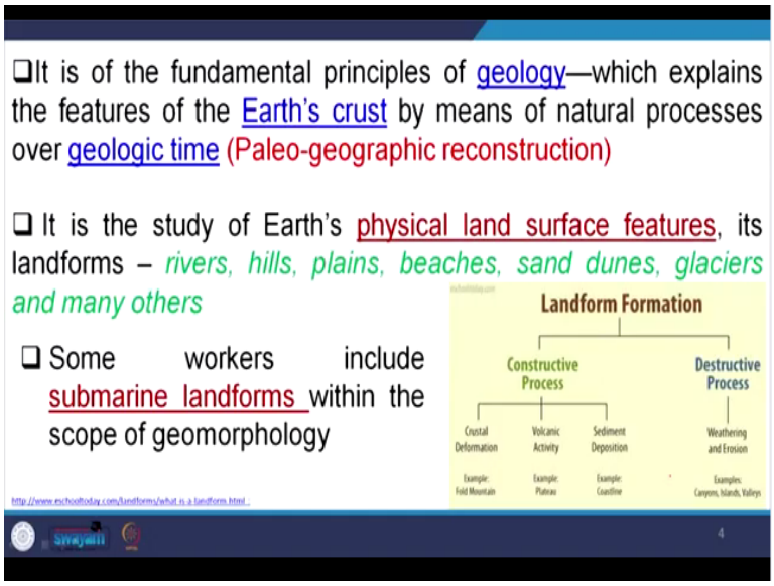

So, there are 2 types of processes if you see, one is called constructive process, constructive process means some material is added, material is added to the system and destructive process some material is wiped out. So, constructive process if you see here there is called crustal

deformation. That means we are deforming, we are creating a fold, once we are creating fold that means we are adding the material at present place.

Then volcanic activity, volcanic activity suppose a volcano is erupted that means it added some material here, a positive topography is formed. Similarly, sediment deposition, sediment deposition means which is eroding from some area somewhere from this higher lands and depositing at the mountain fronts. So, this is also creating positive topography. So, that means, those topographies which are created by addition of materials.

These geomorphological processes involved there, this is called the constructive processes and destructive processes that mostly it is weathering and erosion, this will be start in a separate class, but weathering and erosion that means, we are removing material either it is physically or it is chemically or it is biologically or the combination of both we are removing the material here. So, that means it is called destructive process, we are destroying the system here.

So, that means this constructive process and destructive to process both are responsible for change in the landforms. So this comes under the geomorphology. So, not only we are restricted our self to get this globe earlier, we are going beyond that we are going to the universe. So landforms or the territorial type planets and satellites.

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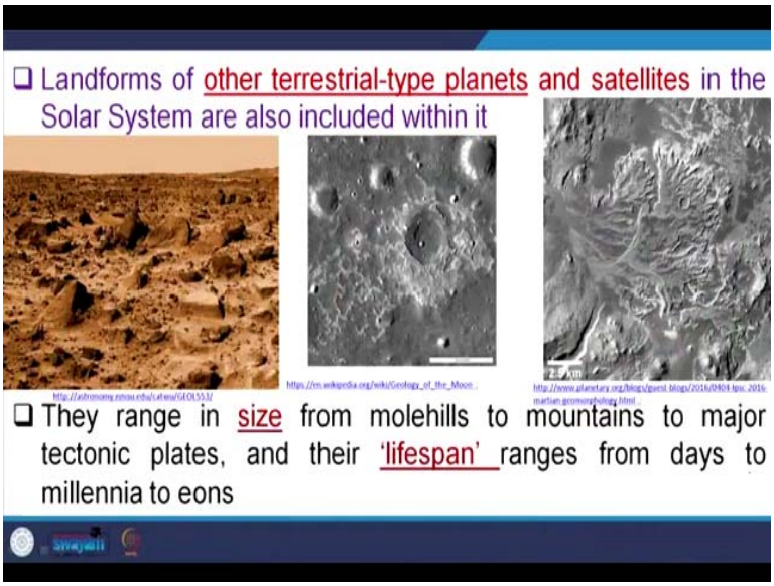

They also come under this geomorphology, the solar systems, all these planets for example, we have explored the moon, we explored the mars, we explored the Jupiter, we explored the venus. So, those processes which are acting there, they are also comes under the process of the geomorphology. Geomorphology if you say geomorphology means study in a earth forms, so geomorphology of mars that does not mean to study of earths in mars.

So, this is the processes that means mostly we are concentrating our self within the processes involve. So that means the same processes which are acting here, there may or may not acting in this terrestrial planet. For example, suppose if you see this past figure here, so, here this erosion topography that is it is from this mars. So, those erosion topography, how they are important there, because we know the erosion processes which are acting on the earth system, it is due to either the rivers due to this aeolian system or this wind or the glaciers or the other processes.

So, now, the question arises if the erosional processes they are erosional landforms are there that means, whether rivers the existing, whether these wind was existing, where the glacier are existing. Now, this is the question to answer in the future, because we are studying here, the more and more research is going on further the river was existing there, the wind was existing there or the glacier are existing there.

If the existing what is the region these all are wiped out because now that they are not present here. Similarly, if you see the moon surface, there are many impact craters. So, that means, there were impact, there are impact means there are these meteoritic impact, these are the depressions. So, now, the question arises if this impact was there and all the landforms are the planets were form in the same process, whether this type of impact is found in the earth form, then this type of infrastructure found in the earth crust, yes, it is found.

So, now, the question arises where are they, some of this impact structures they are present on this earth supposed for example lunar lake in Maharashtra, this is due to impact structures, there is a meteorite which will large meteorite impact and finally, a lake was formed. So, other part of this earth which is totally covered by vegetation. It has been removed by anthropological activity it is modified by anthropological activities.

Though the processes by this wind, this process is by river, these processes by glacier, they have modified the earth surface, that is why even if they were present in the geological past, but now they have been buried, they have been modified. So, impact structure is there, what it is buried, which is wiped out, some of them are they are remaining as evidences. So, that means, I want to say though we are not restricting ourselves within the marine body.

We are not restricting ourselves within the continental system that means, we are thinking beyond that in the solar system. So, all those geomorphic features, they are present in the universe, they can be categorized or can be included in the geomorphology. So, now, the question arises if their landforms which has present, what are their size, what are their lifespan, whether these size what type of what is this cut-off size that can be a categorized, that can be considered in a geomorphic form.

And what should be the lifespan if it is one day process would you be included in the geomorphology, it is a million year process can be included in the geomorphology. Yes, the size it starting from very small it is a grain size level, mineral level, micro level and similarly, it is varying from mountain scale, it varies from continental scale. Similarly, lifespan is considered it starting from 1 minute lifespan to millions of lifespan.

For example, suppose we have certain gestures like the Kedarnath tragedy like fault movement like volcanoes, it will one day movement a flood play, cloud burst it is one day process. So, that means one day process 1 minute process or 1 hour process that will completely change the earth surface, that will completely change the map. So this comes from the geomorphological process. Similarly, some processes they are very highly time durable.

That means, it starts from millions years back and is continuing nowadays. For example, weathering an erosion, weathering an erosion it was present in the geological past billion years back, it is also present it is going down. So, that means, the lifespan and size it is considered the geomorphic process, it may start, it may continue for a minute to millions of years. Similarly, size from micro level to continental level to mountain level up to the global level.

So, there is no boundary of lifespan or boundary of timescale and there is no boundary of the size.

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So, geomorphology it investigates landforms and processes that fashion them. So, all the landforms we have discussed that comes under geomorphology. Similarly all those processes, they are responsible to form this landform, either the constructive process or the destructive process, all those processes are comes under the geomorphic process. So, modern geomorphology study 3 aspects of landforms.

That is form, process and history, these 3 are important forms, that means, how it is looking like, how large the size is and processes that means which process is involved in formation, either it is a constructive process is involved or the destructive process is involved, then it is history, history means, how it was form, what is the time duration it has taken to form, either it is one day process, or it is a long time process.

That means, history that means in millions of years history is there. So, that means all those forms, processes in the history if you combine them together in a rock record, they will unravel the geomorphological history of a region. So, the means to unravel the geomorphological history, we have to go through the rock record within rock record different structures, different rock

properties, their recorded there, within that property we have the found out which property is diagnostic of which process.

So, that means one rock record, one type of structures, one type of process. So, similarly, within the rock record different processes involved, that process may or may not have same process, for example, at this beginning or at the base of the system suppose there is a tillite bed, tillite we know it is formed by the glacier. Then, here we have igneous seal that means from glacial system similarly, there was a after the glacial system there is igneous activity.

And there is a pool of lava and finally, this is igneous sealed has formed. Similarly, suppose after that there is sedimentary rock, suppose a cross-bedding sandstone was deposited. That means, we can say either it is a fluvial system or a marine system depending upon the what type of sediment rocks and what are the properties there. So that means, within the rock record different processes they have left their imprints.

And finally, those imprints had been preserved. By looking those imprints from bottom to top, we have to unravel what type of a geomorphic process was involved in geological past. And very importantly, if we can date those rock records, we have different dating techniques. If we can date those record that means time limit, if we restrict from top to bottom, that means what process was acting at what geological time we can unravel.

So that means from time one point to another point, within the duration of the time, what type of different geological events that were involved in to form this type of geological record or the rock record, they can unravelled. So this is the geomorphological history of the geological history.

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Whenever I talk about the timescale of landform development, we must consider that what scale of the landscape we are looking at, it is very important, the timescale and rock record that is proportional to each other. If suppose for example, we are analyzing for a timescale of millions of years, millions of years that means more interaction with the process and the rock. So that means whatever the rock is form, that records the history of that time span.

Either the erosional or this depositional system is there or the constructive or destructive process is there. Landforms development is a function of time, process, mechanism or permission and supply energy and material especially depositional landforms. Here it is important to understand what is it is the function of time, more time small landform or small time more landform, it is also possible.

For example, suppose we take about we are considering about the same disastrous events. So, that means, within a minute, within an hour, huge amount of sediment will losses out and will spread in the entire area. So, that means the time span is very less within an hour but it is covering a regional scale, it is covering a regional system it is a region. Similarly, the process and mechanism of formation.

Process and mechanism of formation means which type of processes involved in what type of mechanism is involved. For example, suppose the rate of erosion is very small or the rate of

deposition is very small. So, that means to fill a basin it may take some millions of years. But if the rate of sedimentation is very high to fill a basin it may takes certain thousands of years. Similarly, supply of energy, which type of energy is involved.

Similarly material, whether the material is available and it is particularly this energy and material involvement that is restricted to depositional landform. Depositional landform is a construction landform. So, to constructional landform or constructional process we need to supply the energy and material. If the energy is there, but material is not there, then very small landform to be form within a large time.

But if the reverse is true material is there but energy is not there. So, the same process, the same system also occurs, so that means the supply of energy and material, it is only restricted for the depositional landform or the constructional landform of category, but other in the time process they are interlinked. So, here a table is given if you see approximate spatial scale in kilometer square.

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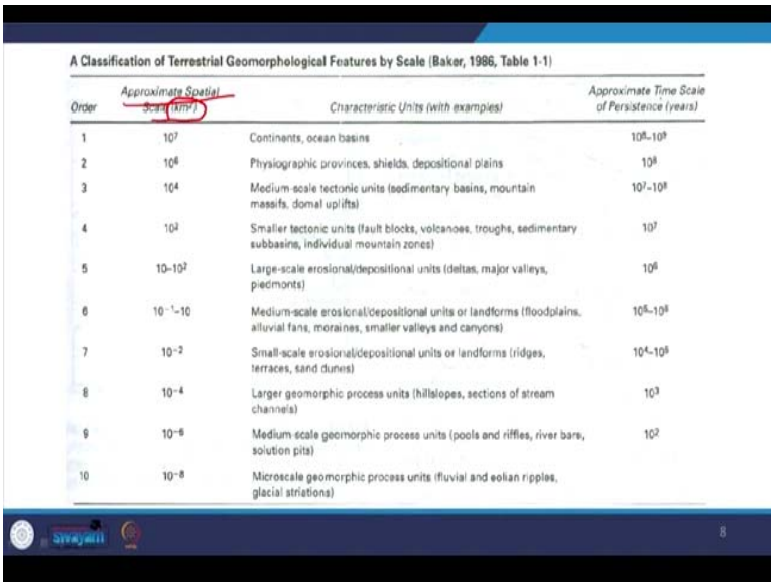

They landform size and approximate time scale i.e. years. So, if you see here continent and ocean basin a continent to form a ocean to form it takes this much time, if we consider the continent of ocean of this much size. So, similarly, if you take this continent and ocean development, it is part of plate tectonic process and we know the plate movement it is a very slow process some

millimeter per year to some centimeter per year to create a vast ocean to create a vast continent we need millions and billions of years okay.

So, if you see here the extreme end 10^{-8} kilometer square, micro scale geomorphic process units fluvial and eolian ripples, glacial striations, ripples this much size. So, it will take a minute or a second to form. So, that means, the geomorphological bodies of size if you consider from here to here. Similarly, the time also varies from here to here and sometimes the exception is there.

That means we are talking from the about the disaster processes, within a minute you can change the topography, you change the geomorphology, now landforms they are divided into constructive and destructive.

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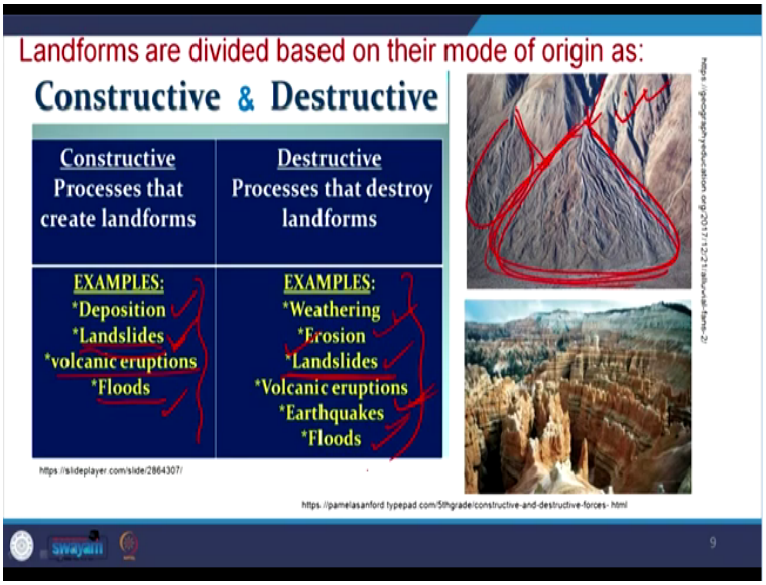

Mostly the constructive processes, if you see here, this is an alluvial fan, it is constructive landform and now the material and energy involved here, whatever the energy, this is the rivers, which are creating this landforms, it is the fluvial energy, the river energy, it is involved and material where from this material get, it is from the adjacent area from the nearby higher altitudes.

So, now, we see, whatever the material involved the formation of this alluvial fan the material is being supplied from the adjacent mountains. So, if the material is removed from this mountain,

now, 2 processes are there, one is here constructional process and the adjacent to it is the destruction process. So, material is eroded from here that means destruction is going on there and adjacent to it the construction is going on here.

Similarly, another example here it is erosional landforms. If you see this erosion, there are topography rugged topography, this erosion is due to removal of material, this is the destruction process. This is weathering, erosion landslides, volcanic eruption, earthquakes, floods, these are this example of the destructive process, on constructive process that the deposition landslides both here if you see it landslide is here, landslide is here.

Why both sides it is intersection is there, because landslide it creates some landforms, it added material at places at the same time it eroded material from other places. So, that is why this process one place it is acting as a destructional process. In another time another places it is acting as a constructional process. Similarly, volcanic eruption it material is added constructive process material is added what is destroyed the system another system it destroyed, then floods similarly, it deposits material at one place but erodes the material from other places. So that is why in the either domain constructive and destructive domain, some are common and that is less specific at one places they are acting as constructional process and another place it is acting and destructional process.

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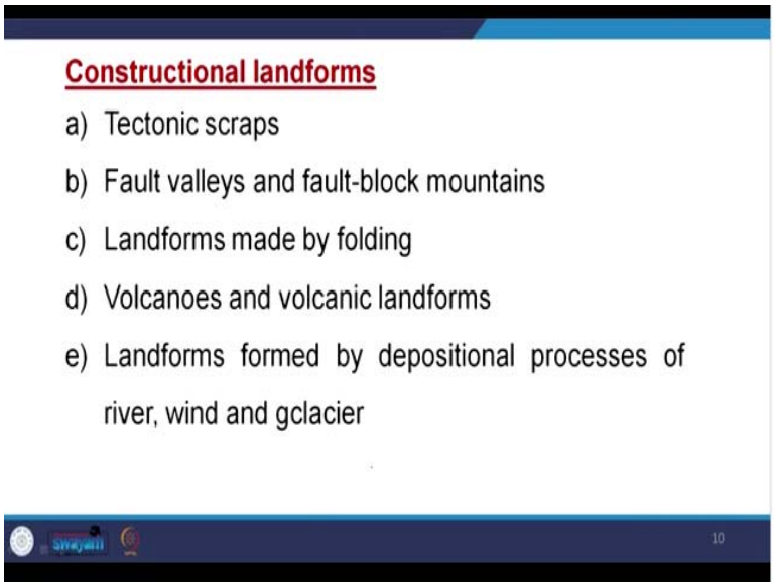

So, some example of construction landform are, one is tectonic scarps. Tectonic scarps means fault scarps, fault scarps you might have heard about fault scarps. That means if there is a fault, suppose this is a fault, and finally, this is the scarp, this is a constructional process. So that means it is adding material it is looking at this material to the systems. Fault valleys and fault block mountains.

It is a positive topography is a construction process, landforms made by folding we are folding the system that means we are creating positive topography, volcanic landforms it is creating positive topography, landform formed by depositional process river, wind, and glaciers, they are the constructional process.

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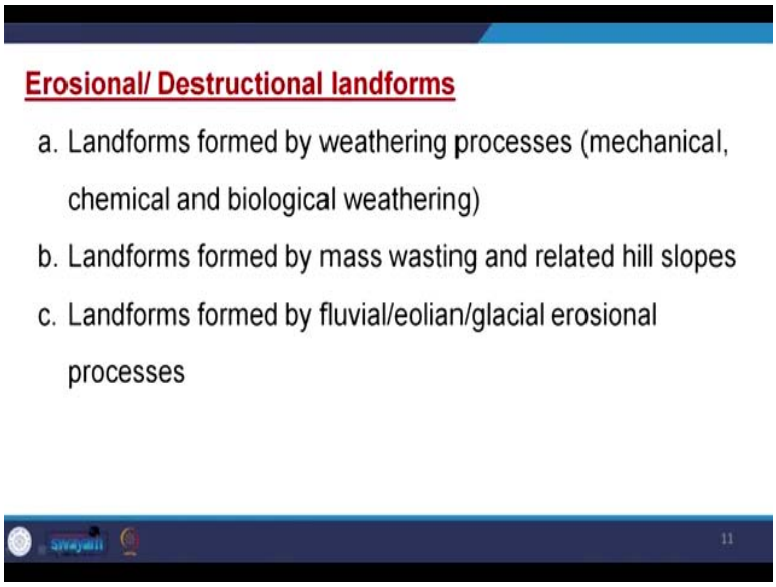

And destructional or erosional topographic landform formed by weathering process, we have already discussed either it is mechanical weathering, chemical weathering or biological weathering. Irrespective of the form this material is being removed that is destruction process, landforms form by mass wasting, mass wasting, it is the process into one type of erosional process.

And mostly it is involved for hill slope modifications. Hill slope modification huge amount of material being removed and the same material is deposited somewhere in the down here. Mostly it is related to hill slope evolution. Landforms formed by fluvial, eolian, and glacial erosional

process. The 3 different domains they will take separate classes, fluvial system in the vast process, eolian system it is restricted to coastal environment as well as arid zone environment.

Glacier higher latitude and higher altitudes, but is compared to the 3 the fluvial process is more dominant everywhere you will find the fluvial process but eolian and the glacier process they are restricted to particular places. So, irrespective of their restriction, irrespective of their time domain that they form landforms, either they are constructive landform and destructive landform. So, these 3 domains have to separately discussed.

So, in this class what we discussed that means this geomorphological processes, they are present everywhere that means in the earth, in the moon or the any extraterrestrial body. Similar these processes form this typography, either it is a constructional topography or the destructional topography and they are related to each other. That means time, process and material.

If they are properly arranged the geomorphic processes work 24 into 7 to modify them at forming a constructional topography or the destructional topography. And the time span that varies from very few minutes to millions of years that depending upon the rate of working. So, this is the conclusion of this class. Thank you very much and we will meet in the next class.