

1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 01 (Class XI, Semester - 1)
Module Name/Title	Mass Movements – Part 2
Module Id	kegy_10602
Pre-requisites	Basic concepts of weathering, erosion and deposition
Objectives	<p>After going through this Module, the learners will be able to :</p> <ul style="list-style-type: none"> • Understand mass movements • Differentiate between mass movements and erosion • Categorise types of mass movements • Describe processes of soil formation • Explain soil forming factors and soil profile through diagrams
Keywords	Mass movement, creep, solifluction, earth flow, mud flow, debris, avalanche, landslide, erosion, deposition, pedology, humification, soil profile

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1. General Introduction

The downhill movement of masses of rock debris and other materials under the direct influence of gravity is termed as ***mass movement, for example*** rockslides, mudflows and slumps, e.. Mass movements are aided by gravity and geomorphic agents like running water, glaciers, wind, waves and currents do not participate in the process of mass movements.

Moreover, ***erosion*** is the dislodging of sediments by agents such as wind, water, glaciers, etc. Mass movement is perhaps the most important among agencies that sculpture and reduce the land surface. The movements of mass may range from slow to rapid, affecting shallow to deep columns of materials and include creep, flow, slide and fall. Gravity exerts its force on all matter, both bedrock and the products of weathering. So, weathering is not always a pre-requisite for mass movement though it aids mass movements. Mass movements are very active over weathered slopes rather than over unweathered materials.

Therefore mass movements do not come under erosion though they involve a shift of material aided by gravity. Materials resting over slopes have their own resistance to disturbing forces and will yield only when the driving force is greater than the shearing resistance of the materials. Weak unconsolidated materials, thinly bedded rocks, faults, steeply dipping beds, vertical cliffs or steep slopes, abundant precipitation and torrential rains and scarcity of vegetation etc. favour mass movements.



Fig No. 1 Rockslide at Oddicombe

https://upload.wikimedia.org/wikipedia/commons/1/15/Rockslide_at_Oddicombe.jpg

To understand mass movement in a better way we should understand the following terms, which are the three *forms of movements*:

- (a) **HEAVE**: It is the movement of material due to the expansion and contraction as a result of change in temperature.)Largely due to freeze and thaw)
- (b) **SLIDE**: Includes movement of cohesive material in which failure occurs because weight of overburden exceeds the strength of material.
- (c) **FLOW**: Includes non-cohesive material, which flow like fluids.

2. Factors Favouring Mass Movement

- i. Removal of support from natural or artificial means
- ii. Increase in gradient and height of slopes
- iii. Overloading through addition of materials naturally or by artificial fill in
- iv. Overloading due to heavy rainfall, saturation and lubrication of slope materials
- v. Removal of material or load from over the original slope surfaces
- vi. Occurrence of earthquakes, explosions or disturbances due to operation of machinery
- vii. Excessive natural seepage
- viii. Heavy drawdown of water from lakes, reservoirs and rivers leading to slow outflow of water from under the slopes or river banks
- ix. Indiscriminate removal of natural vegetation.

3. Classification of Mass Movement

Mass movements can be grouped under three major classes:

- i. Slow movements
- ii. Rapid movements
- iii. Landslides

Slow Movements

a) Creep: - In this slow flow movement, the amount of water present in the debris is relatively small hence the movement of debris is slow. **Creep** is one type under this category, which can occur on moderately steep, soil covered slopes. Movement of materials is extremely slow and imperceptible except through extended observation. Materials involved can be soil or rock debris. Have you ever seen fence posts, telephone poles lean downslope from their vertical position and in their linear alignment? That is due to the creep effect.

Depending upon the type of material involved, several *types of creep e.g.*, soil creep, talus creep or rock creep, rock-glacier creep etc., can be identified.

i) Soil Creep: It is a very slow form of mass wasting which is very difficult to notice unless you see the effects. For example; a fence post shifted out of alignment or telephone poles tipping downslope are signs of soil creep.



Fig No. 2 Soil Creep

Source: https://upload.wikimedia.org/wikipedia/commons/0/0e/Soil_Creep%2C_Millennium_Hill_-_geograph.org.uk_-_518574.jpg

(ii) Talus Creep: When the rock fragments detached from the cliffs or mountain slopes by weathering are deposited and piled up at their bases it is called rock creep. It is a common geological feature in regions of high cliffs.

B) Solifluction: Solifluction involves slow downslope flow of soil mass or fine-grained rock debris saturated or lubricated with water. This process is quite common in periglacial areas where surface melting of deeply frozen ground occurs annually. When the upper portions get saturated and when the lower parts are impervious to water percolation, flowing occurs in the upper part.



Fig No. 3 Solifluction

Source: https://c1.staticflickr.com/9/8327/8087893589_346a75529b_b.jpg

Rapid Movements

These movements are mostly prevalent in humid climatic regions and occur over slopes rising from gentle to steep some examples of the rapid movements are explained below:

A) Earthflow: The downward movement of water-saturated clayey or salty earth materials down low-angle terraces or hillsides is known as *earthflow*

Quite often, the materials slump making step like terraces and leaving arcuate scarps at their heads and an accumulation bulge at the toe. When slopes are steeper, even the bedrock, especially of soft sedimentary rocks like shale or deeply weathered igneous rock, may slide downslope.



Fig No. 4 Earthflow at the base of the cliffs

Source : http://s0.geograph.org.uk/geophotos/02/17/59/2175928_8aa35715.jpg

B) Mudflow: In the absence of vegetation cover and with heavy rainfall, thick layers of weathered material get saturated with water and either slowly or rapidly flows down along definite channels. It looks like a stream of mud within a valley. When mudflows emerge out of channels onto the piedmont or plains, they can be very destructive engulfing roads, bridges and houses. Mudflows occur frequently on the slopes of erupting or recently erupted volcanoes. Volcanic ash, dust and other fragments turn into mud due to heavy rains and flow down as tongues or streams of mud causing great destruction to human habitations.



Fig No. 5 Mudflow

Fig No, Source: https://c1.staticflickr.com/9/8872/28662615916_24126a15d6_b.jpg

C) DEBRIS AVALANCHE: - It is more common in humid regions with or without vegetation cover and occurs in narrow tracks on steep slopes. This debris avalanche can be much faster than the mudflow. Debris avalanche is similar to snow avalanche except materials that includes debris instead of snow.



Fig No. 6 Debris flow

Source :https://upload.wikimedia.org/wikipedia/commons/f/f1/Debris_flow_lawina_4.jpg

In Andes Mountains of South America and the Rockies mountains of North America, there are a few volcanoes which erupted during the last decade and very devastating mudflows occurred down their slopes during eruption as well as after eruption.

Landslides

These are relatively rapid and perceptible movements. The materials involved are relatively dry. The size and shape of the detached mass depends on the nature of discontinuities in the rock, the degree of weathering and the steepness of the slope. Depending upon the type of movement of materials these may be categorised into followings:

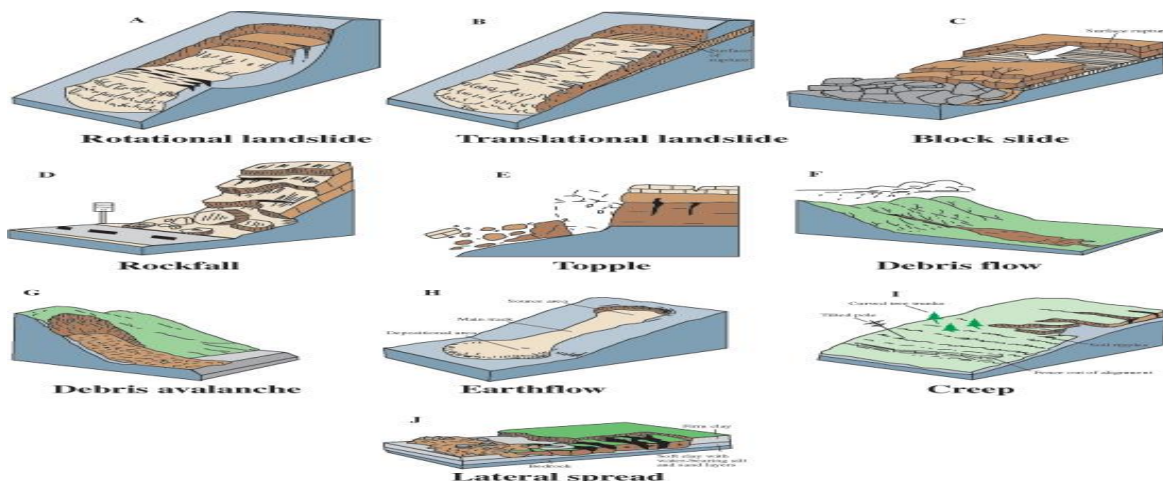


Fig No. 7 Types of landslides

Source ;<https://pubs.usgs.gov/fs/2004/3072/images/Fig3grouping-2LG.jpg>

a) Slump: It is slipping of one or several units of rock debris with a backward rotation with respect to the slope over which the movement takes place.

b) Debris Slide: Rapid rolling or sliding of earth debris without backward rotation of mass is known as debris slide. Debris fall is nearly a free fall of earth debris from a vertical or over hanging face.

c) Rock Slide: Sliding of individual rock masses down bedding, joint or fault surfaces is rockslide. Over steep slopes, rock sliding is very fast and destructive. Slides occur as planar failures along discontinuities like bedding planes that dip steeply.

d) Rock Fall: Rock fall is free falling of rock blocks over any steep slope keeping itself away from the slope. Rock falls occur from the superficial layers of the rock face, an occurrence that distinguishes it from rockslide, which affects materials up to a substantial depth.



Fig No. 8 Rock fall

Source: http://s0.geograph.org.uk/geophotos/05/08/36/5083698_b54610cc.jpg

In our country, debris avalanches and landslides occur very frequently in the Himalayas. There are many reasons for this. One, the Himalayas are tectonically active. They are mostly made up of sedimentary rocks and unconsolidated and semi-consolidated deposits. The slopes are very steep. Compared to the Himalayas, the Nilgiris bordering Tamilnadu, Karnataka, Kerala and the Western Ghats along the west coast are relatively tectonically stable and are mostly made up of very hard rocks; however debris avalanches and landslides occur here too, though not as frequently as in the Himalayas. This is because many slopes are steeper with almost vertical cliffs and escarpments in the Western Ghats and Nilgiris. Mechanical weathering (due to temperature changes and ranges) is pronounced. They receive heavy amounts of rainfall over short periods. So, there is almost direct rock fall quite frequently in these places along with landslides and debris avalanches.

4. Erosion and Deposition

Erosion involves acquisition and transportation of rock debris. When massive rocks break into smaller fragments through weathering and other processes, erosional agents like running water, groundwater, glaciers, wind and waves remove and transport it to other places depending upon the dynamics of each of these agents. . Abrasion by rock debris carried by these geomorphic agents also aids greatly in erosion. By erosion, relief degrades, i.e., the landscape is worn down. That means, though weathering aids erosion it is not a pre-condition for erosion to take place. Weathering, mass wasting and erosion are degradational processes.



Fig No. 9 Erosion

Source: https://c1.staticflickr.com/5/4149/5097649628_038da8176d_b.jpg

It is erosion that is largely responsible for continuous changes that the earth's surface is undergoing. Denudation processes like erosion and transportation are controlled by kinetic energy. The erosion and transportation of earth materials is brought about by wind, running water, glaciers, waves and ground water. Of these, the first three agents are controlled by climatic conditions. They represent three states of matter —gaseous (wind), liquid (running water) and solid glacier respectively. The work of the other two agents of erosion waves and ground water is not controlled by climate. In case of waves, it is the location along the interface of the lithosphere and hydrosphere in coastal regions that determines the work of waves. The work of ground water is determined more by the lithological character of the region. Karst topography develops only if the rocks are permeable and soluble and water is available.

- i. Deposition is a consequence of erosion. The erosional agents lose their velocity and hence energy on gentler slopes and the materials carried by them start to settle themselves. In other words, deposition is not actually the work of any agent.
- ii. The coarser materials get deposited first and finer ones later. As a result of deposition, depressions get filled up. The same erosional agents' viz., running water, glaciers, wind, waves and groundwater act as aggradational or depositional agents. Many landforms are created as a result of erosion and deposition by each agent.



Fig No. 10 Deposition

SOURCE : http://s0.geograph.org.uk/geophotos/01/91/34/1913412_801a7f8b.jpg

There is a shift of materials in mass movements as well as in erosion from one place to the other. So, why can't both be treated as one and the same? Can there be appreciable erosion without rocks undergoing weathering?

5. Soil

Pedology is a scientific study of soil. A **pedologist** is a soil-scientist. A pedologist *defines* soil as a collection of natural bodies on the earth's surface containing living and/or dead matter and supporting or capable of supporting plants.

Soil is a dynamic medium in which many chemical, physical and biological activities go on constantly. Soil is a result of decay; it is also the medium for growth of plants. It is a changing and developing body. It has many characteristics that fluctuate with seasons. It may be alternatively cold and warm or dry and moist. Biological activity is slowed or stopped if the soil becomes too cold or too dry. Organic matter increases when leaves fall or grasses die.

Process of Soil Formation

Soil formation or **pedogenesis** depends first on weathering. It is this weathering mantle (depth layers of weathered material) which is the basic input for soil to form. First, the weathered material or transported deposits are colonised by bacteria and other inferior plant bodies like mosses and lichens. In addition, several minor organisms may take shelter within the mantle and deposits. The dead remains of organisms and plants help in humus accumulation. Minor grasses and ferns may grow; later, bushes and trees will start growing from seeds brought in by birds and wind. As plant roots penetrate into the soil, burrowing animals bring up particles, the mass of material becomes porous and sponge like, with a capacity to retain water and to permit the passage of air and finally a mature soil, a complex mixture of mineral and organic products, forms.

Soil-forming factors

There are five basic factors that control the formation of soils:

- parent material
- topography
- climate
- biological activity
- time

In fact, soil-forming factors act in union and affect the action of one another.

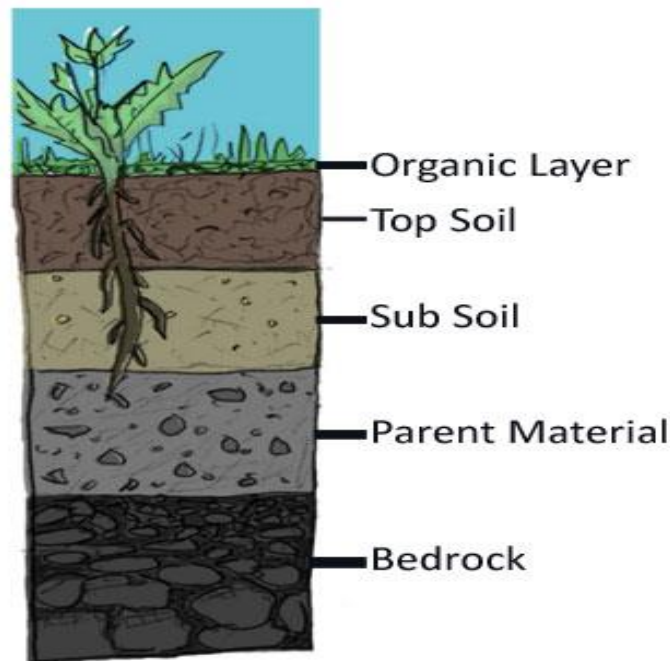


Fig. No. 11 Soil-forming factors

Source : https://upload.wikimedia.org/wikipedia/commons/9/92/Soil_Layers.jpg

Parent Material

Parent material is a passive control factor in soil formation. Parent materials can be any insitu or on-site weathered rock debris. This gives leads to the formation of residual soils. material transported and deposited from elsewhere leads to the formation of transported soils. Soil formation depends upon the texture sizes of debris and structure disposition of individual grains/particles of debris as well as the mineral and chemical composition of the rock debris/deposits.

The type and rate of weathering and the depth of weathering mantle are important factors influencing soil formation. Different soils may be formed from the same parent material while dissimilar bed rocks may have similar soils above them. But when soils are very

young and have not matured these show strong links with the type of parent rock. Also, in the case of some parent material (like limestone) the weathering processes are specific and peculiar, and soils show a clear relation with the parent rock.

Topography

Topography like parent materials is another passive control factor. Topography influences through the exposure of parent material to sunlight and also the amount of surface and sub-surface drainage over and through parent material. Soils will be thin on steep slopes and thicker over flat upland areas. Gentle slopes, where erosion is slow and percolation of water is good, favour soil formation. In flat areas soil may develop a thick layer of clay with a good accumulation of organic matter giving the soil a dark colour. In middle latitudes, south and north facing slopes have difference of vegetation and soils as their exposure to sunlight is different.

Climate

Climate is an important active factor in soil formation. The climatic elements involved in soil development are:

- i. Moisture in terms of the intensity, frequency and duration of precipitation, evaporation and humidity.
- ii. Temperature in terms of seasonal and diurnal variations.

Precipitation gives soil its moisture content, which makes chemical and biological activities possible. Excess water may transport some soil components from the upper layers of the soil to the lower layers. The process of removal of material from the top layers is known as *eluviation* and its deposition is known as *illuviation*. Elements like calcium, sodium, magnesium and potassium are commonly removed by elutriation but where rainfall is very high, even silica may be removed in a process known as desilication.

In dry climates, where evaporation exceeds precipitation ground water is brought up to the surface by capillary action. The water contains dissolved salts. When water evaporates it leaves behind salts in the soil. Such salts form into a crust in the soil known as ***hardpans***. In tropical climates and in areas with intermediate precipitation, calcium carbonate nodules (kanker) are formed.

Temperature controls the rate of chemical and biological activity. Chemical activity except the process of carbonation is rapid in higher temperatures and slow in cooler temperatures its tops altogether freezing conditions. As a result, tropical soils forming under higher

temperatures show deeper profiles and in the frozen tundra regions, soils largely contain mechanically broken materials.

Biological Activity

Plants, animal and microorganisms living on and within the soil in various stages of its formation affect its properties in various ways. They add organic matter and help in retention of moisture and nitrogen. Dead plants provide humus, the finely divided organic matter found in soil. Organic acids which form during *humification* aid in decomposing the parent material.

Intensity of bacterial activity leads to differences soil formation in cold and warm climates. Organic matter accumulates in cold climates, as bacterial growth is slow. This undecomposed organic matter is converted into layers of peat common in sub-arctic and tundra climates. In humid tropical and equatorial climates, bacterial growth and action is intense and dead vegetation is rapidly oxidised, reducing the humus content of the soil. Some, bacteria and other soil organisms take gaseous nitrogen from the air and convert it into chemical form that can be used by plants. This process is known as *nitrogen fixation*. Rhizobium, a type of bacteria, lives in the root nodules of leguminous plants and fixes nitrogen beneficial to the host plant. The influence of animals like ants, termites, earthworms, rodents etc. are mechanical, but it is nevertheless important in soil formation as they rework the soil mixing in its layers. Organisms like earthworms, as they feed on soil altering, the texture and chemistry of the soil as it passes through their digestive systems.

Time

Time is also an important controlling factor in soil formation. The length of time for which the soil forming processes operate, determines the maturity of soils and extent of profile development. A soil becomes mature when all soil-forming processes have acted for a sufficiently long time, developing a profile. Soils developing on recently deposited alluvium or glacial till are considered young and they exhibit no horizons or only poorly developed horizons. No specific length of time in absolute terms can be fixed for soils to develop and mature.

6. Soil Profile

There are different layers in the soil and these layers are called horizons. The arrangement of these horizons in a soil is known as soil profile. These horizons differ in the physical

characteristics such as colour, texture, structure and thickness. Soil scientists use the following capital letters O, A, B, C and R from top to bottom. Not all of these layers are present in every region. The uppermost layers have been changed the most because the weathering of the soil occurs first at the surface whereas the lower layers retain similar to the original parent material.

The soil profile is explained below:

O – HORIZON: Here “O” stands for organic matter. It is the topmost layer of the soil profile and is rich in organic material derived from dead plant and animal residue in relatively non-decomposed form. The O horizon is absent in grassland regions and is common in forested areas.

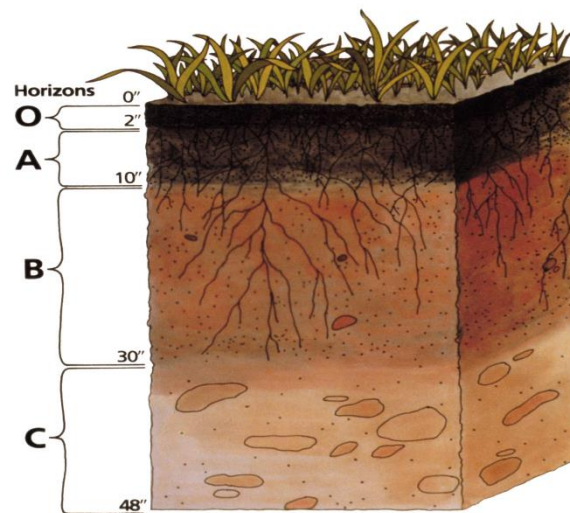


Fig No. 12 Soil profile

Source : https://upload.wikimedia.org/wikipedia/commons/9/95/Soil_profile.png

A – HORIZON: -It is called the surface soil in which organic matter is mixed with mineral matter. Due to high organic content, the colour of the soil is darker than that of the lower horizons.

B - HORIZON: - It is called the sub surface soil. It has undergone sufficient changes during soil genesis. It contains iron, aluminium oxide and organic material, which is brought from the upper layers accumulated through a process known as *illuviation*. Therefore, this layer is also called *azone of accumulation*.

C –HORIZON: - This layer is also termed as sub-stratum. It contains unconsolidated material that is very relatively less affected by soil forming processes. This layer is below the zones of greatest biological activity. The A and B layers are usually developed from the C-horizons. It contains rocks with cracks and crevices.

R – HORIZONS: -It is also termed as bedrock. This is the partially weathered bedrock at the bottom of the soil profile. It consists of consolidated masses of hard rock, which cannot be excavated by hand.

7. Summary

In this Course, we have discussed different types of mass movements, and the processes of erosion and deposition, soil formation and the soil profile, soil genesis.