

## CHAPTER -6 GEOMORPHIC PROCESSES

This chapter deals with Geomorphic process, exogenic, endogenic processes, diastrophism, volcanism, weathering, types of weathering mechanical (unloading, expansion, temperature change expansion freezing thawing frost wedging salt weathering), chemical (solution, carbonation, hydration oxidation and reduction), biological (plants, animals man). biological activity and weathering, special effects of weathering, significance of weathering, mass movement, slow movement, rapid movement land slide, erosion, deposition, soil formation, process of soil formation soil forming factors, parent material, topography, climate, biological activity, time.

### 1. Why earth is uneven?

Due to internal and external forces earth is changing its surface conditions.

The earth crust is always dynamic

It moves vertically and horizontally

The differences in the internal forces making the surface uneven Wearing down of relief features is called **gradation**.

The endogenic forces always elevate parts of the earth's surface and hence the exogenic processes fail to even out the relief variations of the surface of the earth.

Variations remain as long as there is difference between endogenic and exogenic forces.

The surface of the earth is sensitive. Human being is using the surface intensively and extensively.

### GEOMORPHIC PROCESSES

The endogenic and exogenic forces cause physical stress and chemical actions on the earth material and bring the changes in the configuration of the earth surface is called

### GEOMORPHIC PROCESSES

Diastrophism and volcanism are **endogenic** processes

Weathering, Masswasting, Erosion & Deposition Are **Exogenic** Processes

Any Exogenic Element Of Nature Capable Of Acquiring And Transporting Earth Materials Can Be Called A **Geomorphic Agent**.

They Become Mobile When There Is Gradient The Erosional Agents Are

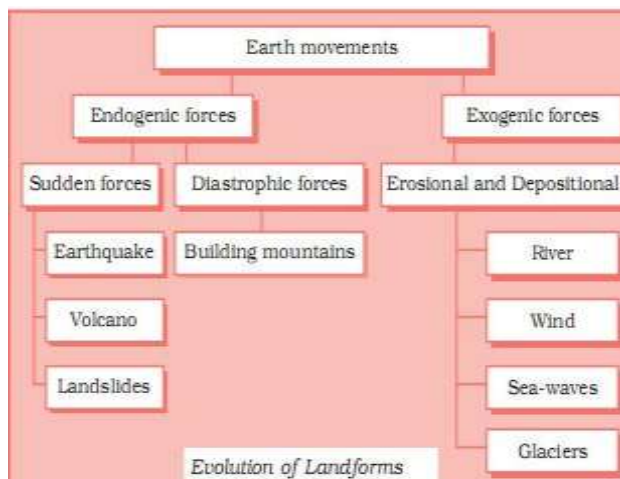
1. Running Water, 2. Moving Ice, 3. Wind, 4. Underground Water, 5. Waves

A process is a force applied on earth materials affecting the same

An agent is a mobile medium which removes transports and deposits earth materials.

Gravity also causes directional forces activating downslope movements of matter

Waves and tides are indirect movements of the earth



caused by gravitation

With out gravity and gradient there is no mobility for erosional agents as a result there is no erosion transportation, and deposition on the earth surface.

All the movements on/in the earth are due to gravitation and gradient. from higher level to lower level and high pressure to low pressure areas

**ENDOGENIC PROCESS:** the energy generating from within the earth is the main force behind the endogenic geomorphic processes.

The energy generated due to

1. Radioactivity 2. Rotational Force 3. Tidal Friction 4. Primordial Heat From The Origin Of The Earth.

Diastrophism And Volcanism Are Due To Geothermal Gradients And Heat Flow From Within The Earth.

Crustal Thickness, Strength, Action Of Endogenic Forces Are Due To Variations In Geothermal Gradients And Heat Flow Are Uneven.

**DIASTROPHISM :** All process that move elevate or build up portions of the earth's crust come under DIASTROPHISM

**THEY ARE TWO TYPES**

1. OROGENIC PROCESSES : mountain building through folding
2. EPEROGENIC PROCESS: uplifting large part of earth crust
3. EARTH QUAKES
4. PLATE TECTONICS: involve horizontal movements

#### DIFFERENCE BETWEEN OROGENY AND EPEROGENY

OROGENY	EPEROGENY
Crust is severely damaged Mountain building process Folding and faulting Cause tension and compression	simple deformation continental formation upliftment of landmass vertical force

**VOLCANISM:** Movement of molten rock towards the earth's surface and also formation of many intrusive and extrusive volcanic forms.

**Volcanism:** it is the process in which volcanoes take place

Volcanoes are the land forms formed due to volcanic process

**EXOGENIC PROCESSES:** They derive their energy from atmosphere determined by the prime source The sun and also gradients created by the tectonic factors.

Gravitational force creates gradient towards down slope direction.

Force applied per unit area is called

**STRESS.** Stress can be produced in a solid body pushing or pulling

This includes deformation. Forces acting along the faces of earth materials are shear stresses (separating forces). It is this stress that breaks rocks and other earth materials. The shear stress results in angular displacement/slippage. Besides gravitational stress there is molecular stress which is caused by temperature change, crystallisation and melting. Chemical processes normally lead to loosening of bonds between grains, dissolving of soluble minerals or cementing materials.

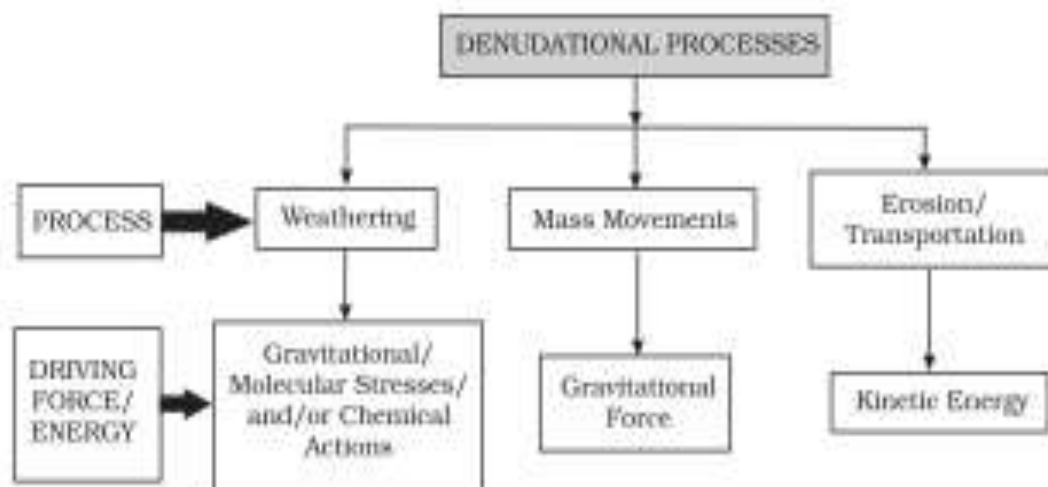
The basic reason for weathering, mass movement erosion and deposition is the development of stress in the earth materials.

Since there are different climatic regions there is variation in the exogenic process from region to region. Temperature and precipitation are the two major elements that control various processes.

All the exogenic processes are covered under general term **DENUDATION**.

The word denude means uncover. Weathering, mass wasting erosion and transportation are included in denudation.

#### DENUDATIONAL PROCESSES AND THEIR Driving Forces



**Figure 6.1 : Denudational processes and their driving forces**

This Chart We Observe That For Each Process There Is Driving Force Called Energy On The Earth Surface Thermal Gradient Is Caused By

1. Latitude
2. Seasons
3. Land And Water Distribution
4. Angle Of Earth's Inclination

The Density of Natural Vegetation Is Greatly Influenced By The Temperature And Precipitation Helps Indirectly The Exogenic Processes.

**THE OTHER FACTORS OF CLIMATIC VARIATIONS ARE** 1. Altitude 2. Angle Of Slope 3. Ocean Currents 4. Amount Of Insolation Received By The Region 5. Wind Velocity And Direction 6. Direction Of The Slope 7. Amount And Kind Of Precipitation 8. Relation Between Precipitation And Evaporation 9. Daily Range Of Temperature 10. Freezing And Thawing Frequency 11. Depth Of Frost Penetration

The Sole Driving Force Behind All The Exogenic Process Is The **Sun**

**When Climatic Factors Are Common The Intensity Of Action Depend On Type And Structure Of Rocks**

**STRUCTURE INCLUDES** folds, faults, orientation inclination of beds, presence or absence of joints, bedding planes hardness, softness of constituent minerals, chemical susceptibility of mineral constituents, the permeability or impermeability.

Different types of rocks offer varying resistances to various geomorphic processes.

Particular rock may be resistant to one process and non resistant to other process

As a result there is varied relief over the earth surface

The effects of exogenic forces may be small and slow but in long run they have greater effects

Finally the surface of the earth is operated by different geomorphic processes and at varying rates

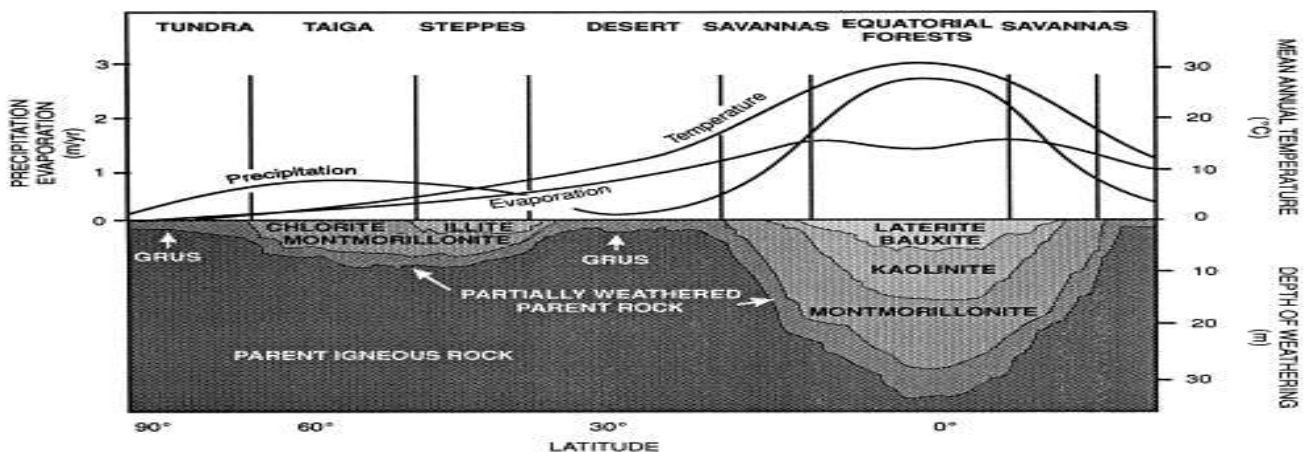
**WEATHERING: it is the action of elements of weather on earth materials**

**Weathering is defined as mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate**

**In weathering there is no motion of materials takes place so it is in-situ or on site process**

**FACTORS INFLUENCING THE WEATHERING & DEPTH OF WEATHERING**

1. GEOLOGICAL STRUCTURE
2. CLIMATE
3. TOPOGRAPHY
4. NATURAL VEGETATION



- (I) **CHEMICAL**
- (II) **PHYSICAL/MECHANICAL**
- (III) **BIOLOGICAL WEATHERING**

### **CHEMICAL WEATHERING PROCESSES**

A group of weathering processes viz; solution, carbonation, hydration, oxidation and reduction act on the rocks to decompose, dissolve or reduce them to a fine clastic state through chemical reactions by oxygen, surface/soil water and other acids. Water and air along with heat must be present to speed up all chemical reactions.

Over and above the carbon dioxide present in the air, decomposition of plants and animals increases the quantity of carbon dioxide underground. These chemical reactions on various minerals are very much similar to the chemical reactions in a laboratory.



**SOLUTION:** the water /acid with dissolved content is called **solution**. This process involves removal of solids in solution and depends upon solubility of a mineral in water or weak acids. when water reacts with any solid many solids may become solution. Ex. Sulphates, nitrates, potassium .

When rain comes these solids dissolve into solution without leaving any residue.

Calcium carbonate , magnesium bicarbonate present in the lime stone are dissolved in and form carbonic acid,  $CO_2$  produced by decaying organic matter along with soil water greatly aids in this reaction . Common salt is also susceptible to this process.

**CARBONATION:** It is the reaction of carbonate and bicarbonate with minerals such as feldspar, & carbonate minerals  $CO_2$  from atmosphere and soil air is absorbed by water to form carbonic acid.  $CaCO_3$  &  $MgCO_3$  are dissolved in carbonic acid and washed away to form the caves in lime stone region.

Clay minerals are easily eroded due to the presence of minerals which can exchange the ions with the water .

**HYDRATION:** it is the chemical addition of water . minerals take up water and expand . this expansion increases the volume of material. ex. calcium sulphate takes water and convert into gypsum. it is unstable than calcium sulphate. it is reversible reaction and when this process continuous for longer time the materials disintegrate.

Many clay minerals swell and contract during wetting and drying and a repetition of this process results in cracking of overlying materials. salts in pore spaces undergo rapid and repeated hydration and help in physical weathering through exfoliation and granular disintegration

#### **OXIDATION AND REDUCTION**

Oxidation means combination of minerals with oxygen to form oxides and hydroxides.

Oxidation occurs when there is sufficient water and atmosphere. EX. Iron, manganese, sulphur, In the process of oxidation breakdown occurs due the addition of oxygen. red colour of iron becomes into yellow colour. when oxidised minerals are kept in the places where there is no oxygen reduction takes place. ex. such conditions occur below water table waterlogged areas. Red colour of iron becomes greenish or bluish grey.

#### **PHYSICAL WEATHERING PROCESSES**

Factors Influencing The Physical Weathering

1. Gravitational Force Overburden Pressure, Load And Shearing Stress
2. Expansion Forces Due To Temperature Changes, Crystal Growth Or Animal Activity
3. Water Pressures Controlled By Wetting And Drying Cycles.

They are mostly due to thermal expansion, and pressure release. The repeated action of these processes cause damage to the rocks

**UNLOADING AND EXPANSION:** Removal of overlying rock load because of continued erosion causes vertical pressure release with the result that the upper layers of the rock expand producing disintegration of rock masses. fractures will develop parallel to the ground surface. In areas of curved ground surface arched fractures tend to produce massive sheets or exfoliation slabs of rock. exfoliation sheets result from expansion due to unloading and pressure release may measure hundreds or even thousands of metres in horizontal extent. large smooth rounded domes called exfoliation domes result due to this process

**TEMPERATURE CHANGES AND EXPANSION:** Various minerals found in the rocks expand at different rates when temperature increases. Each one pushes others. When temperature falls contraction takes place. because of diurnal changes in temperature the effects is mostly on superficial layers of the rocks. the effects of this process is significant in hot deserts and cold deserts. though it is small the continuous process for longer time and larger area the effect is greater. The effect is greater at the depth of the rocks. fractures occur parallel to the surface. due continuous expansion and contraction the rock layers become loose and exfoliation takes place. a large dome shaped structures are formed due to this process. Tors which are large boulders also form due this process. exfoliated domes are big in size whereas exfoliated tors are varied sizes.

**FREEZING THAWING AND FROST WEDGING:** due to repeated freezing and melting frost weathering occurs in the pores and cracks of rocks. it is most effective in higher elevations of the midlatitudes.



Glacial areas are subjected to frost wedging daily. In this process the rate of freezing is more important. Rapid freezing causes sudden expansion and high pressure. Finally this process makes the rock to break into pieces.

**SALT WEATHERING;** salts in the rocks expand due to thermal action hydration and crystallisation. ex. Calcium sodium magnesium potassium and barium. high temperature between 30°C to 50°C of surface temperature in deserts favour such salt expansion.

Salt crystals in near surface pores cause splitting of individual grains within rocks, which eventually fall off. This process of falling off of individual grains may result in granular disintegration or granular foliation.

Salt crystallisation is most effective of all salt weathering processes, in areas with alternating wetting and drying conditions salt crystal growth is favoured and the neighbouring grains are pushed aside. sodium chloride and gypsum crystals in desert areas heave up overlying layers of materials and with the result polygonal cracks develop all over the heaved surface. With salt crystal growth, chalk breaks down most readily followed by Limestone, Sandstone, Chalk, Gneiss and Granite.

**BIOLOGICAL WEATHERING:** Removal or contribution of ions to the environment due to biological activity is called biological weathering. burrowing and wedging by organisms like earthworms, termites, rodents help in exposing the new surfaces to chemical attack and assist in the penetration of moisture and air.

**SOME SPECIAL EFFECTS OF WEATHERING:** Exfoliation is a result but not a process. Removal of layers from curved surfaces result into rounded surfaces. it occurs due to expansion and contraction induced by temperature changes. exfoliation domes occur due to unloading where as tors occur due to thermal expansion.

**SIGNIFICANCE OF WEATHERING:** Responsible for the formation of soils and erosion and deposition. biodiversity is basically depending on depth of weathering. erosion may not be significant when there is no weathering. weathering aids mass wasting, erosion and reduction of relief and changes in landforms. weathering of rocks and deposition helps in the enrichment and concentrations of certain valuable ores of iron, manganese, aluminium, copper. it is an important process of soil formation.

**ENRICHMENT:** when rocks undergo weathering some materials are removed through chemical or physical leaching by ground water and thereby the concentration of remaining materials increases. Without such a weathering taking place, the concentration of the same valuable material may not be sufficient and economically viable to exploit, process and refine, this is what is called enrichment.

**MASS MOVEMENT:** these movements transfer the mass of rock debris down the slopes under the direct influence of gravity. air, water, ice do not carry debris, but debris carry them. the movements of mass may range from slow to rapid.

**TYPES OF MASS MOVEMENTS:** creep, flow, slide and fall. mass movements are active over weathered slopes than unweathered slopes. mass movements are aided by gravity not any erosional agent. mass movements do not come under erosion though there is shift of material.

When force is greater than resistance mass movement occurs. Ex. Weak unconsolidated material, thinly bedded rocks, faults, steeply dipping beds, vertical cliffs, steep slopes, abundant precipitation and torrential rains and scarcity of vegetation.

Activating causes precede mass movements:

(i) removal of support from below to materials above through natural or artificial means

(ii) increase in gradient and height of slopes

(iii) overloading through addition of materials naturally or by artificial filling



(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 macunery

(vii) excessive natural seepage




(viii) heavy draw down of water from lakes, reservoirs and rivers

(ix) indiscriminate removal of natural vegetation

## CLASSIFICATION OF MASS MOVEMENTS



Figure 6.5 : Relationships among different types of mass movements, their relative rates of movement and moisture limits (after Whitehead, 2001)

Type of Movement		Type of Material	
Fall		Rock	Regolith Debris: coarse > fine Earth: fine > coarse
		Rock Fall	Debris/Earth Fall
		Extremely rapid	Rapid to extremely rapid
Slide		Rock Slide	Debris/Earth Slide
		Very slow to extremely rapid	Very slow to very rapid
		Rock Slump	Debris/Earth Slump
Slump		Extremely slow to moderate	Very slow to very rapid

Extremely slow	Very slow	Slow	Moderate	Rapid	Very rapid	Extremely rapid
0.3 m/5yrs	1.5 m/yr	1.5 m/month	1.5 m/day	0.3 m/min	3 m/sec	

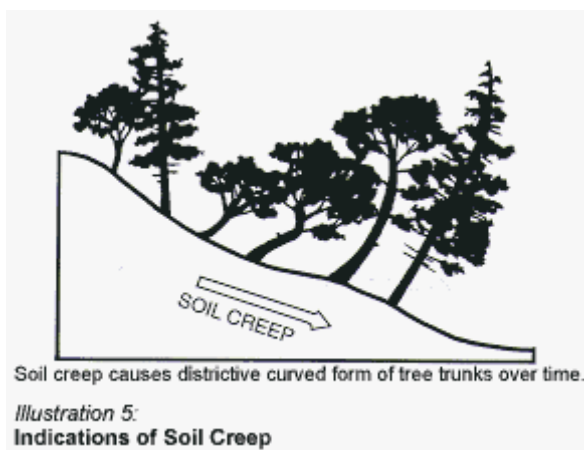
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Heave ,flow and slide are the three forms of movements the relationship is shown in the figure no.

The mass movements can be grouped into three types

1. slow movements 2. Rapid movements 3. Land slide

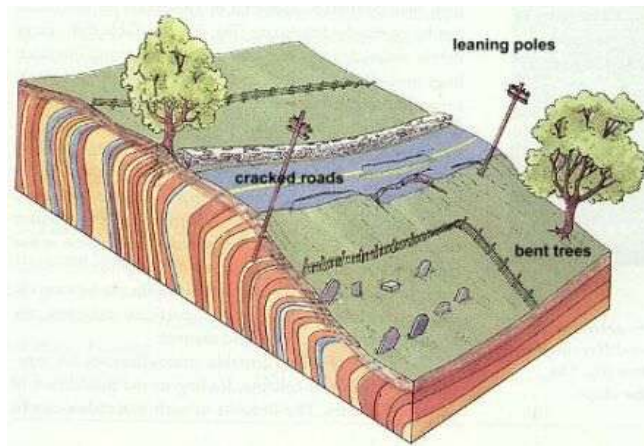
## SLOW MOVEMENTS



**CREEP:** It generally occurs on moderately steep, soil covered slopes.

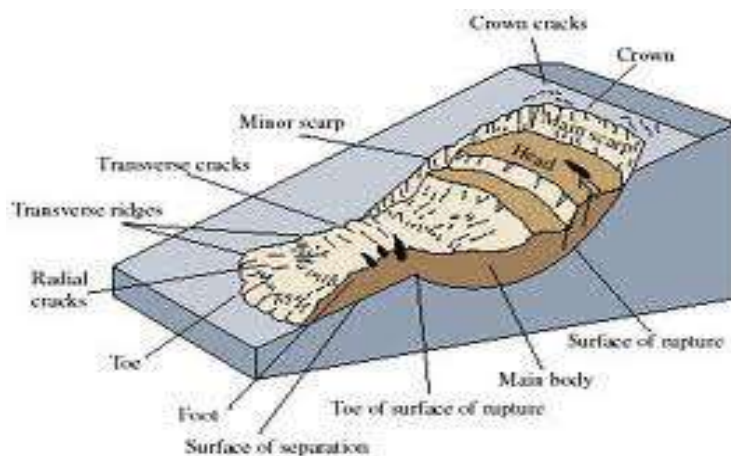
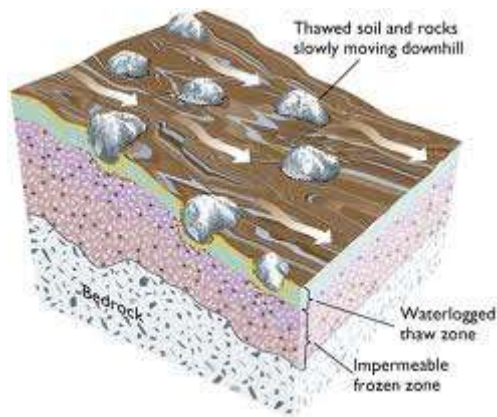
Movement of material is extremely slow. Material may be rockdebris or soil

Ex. Bending of telephone pole, and fence poles.



Types of creep : soil creep, talus creep rock creep rock glacier creep

**Solifluction:** slow down slope flowing soil mass or fine grained rock debris saturated or lubricated with water. It is common in moist temperate areas where surface melting of deeply frozen ground and long continued rain respectively occur frequently.



**MUD FLOW**

**RAPID MOVEMENTS**

**CONDITIONS:** 1. humid climatic regions  
2. gentle to steep slopes 3. Heavy rain 4. Loose soils

**EARTH FLOW:** movements of water saturated clayey or silty earth materials down low angle terraces or hillsides .

#### EARTHFLOW



In the absence of vegetation cover and with heavy rainfall, thick layers of weathered materials get saturated with water and either slowly or rapidly flow down along definite channels. It looks like a channels of mud. When they overflow the channels they engulf the roads and rail bridges.

They generally occur due to volcanic eruptions. 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 the human settlements.



USGS Photo by Lyn Topinka, April 16, 1990

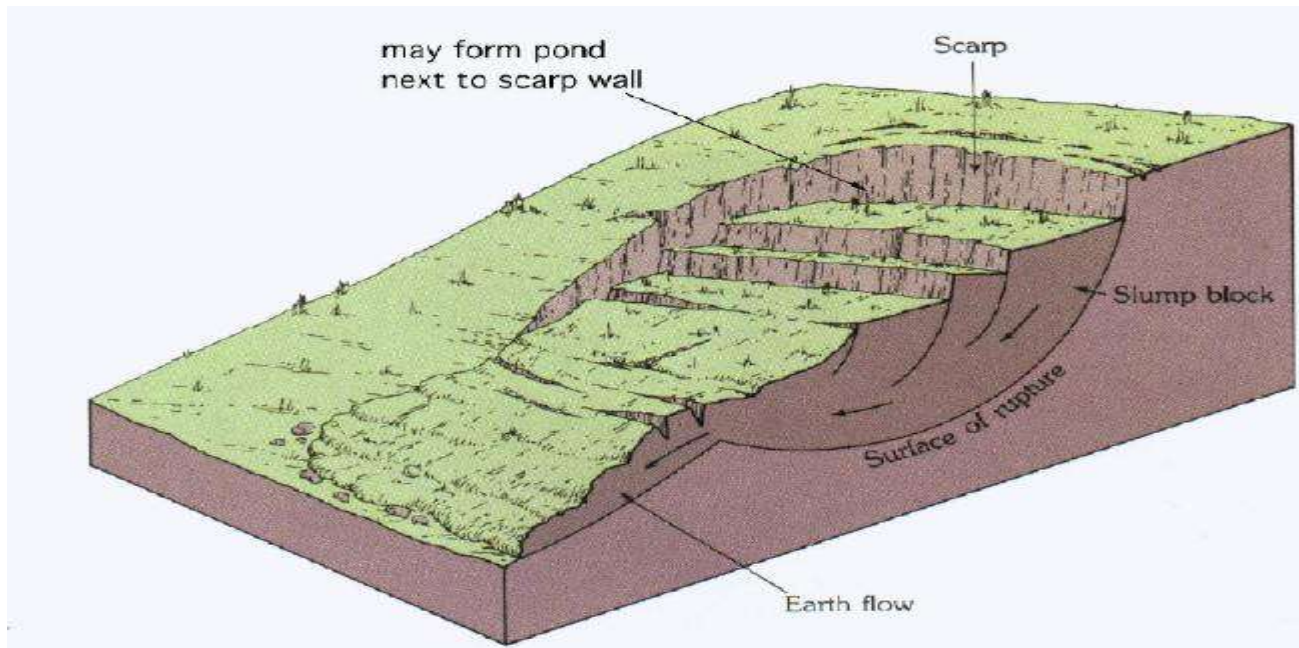
**DEBRIS AVALANCHES:** Found in humid regions with or without vegetation in narrow tracks of steep slopes. It is much faster than mud flow, it is similar to snow avalanches.



**LANDSLIDES:** these are rapid and perceptible movements. Dry materials are found. The size and shape of the materials are depending on the nature of the rock, degree of weathering, steepness of slope.



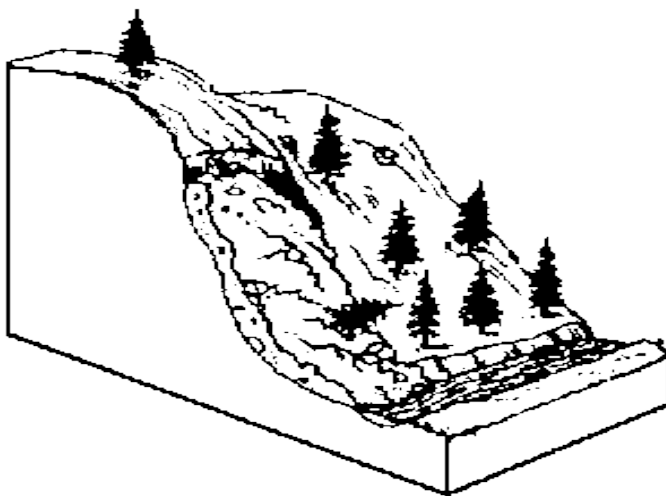
## SLUMP:



slipping of one or several units of rock debris with a backward rotation with respect to the slope over which the movement takes place

**DEBRIS SLIDE:** rapid rolling or sliding of earth debris without backward rotation of mass is known as debris slide.

## Debris slide

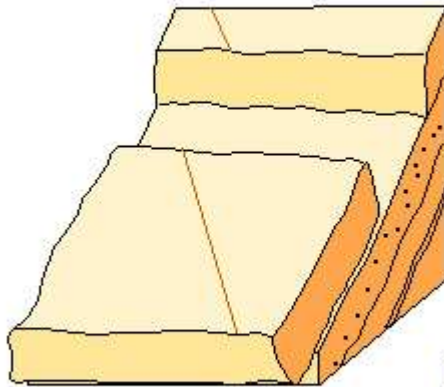


## ROCK FALL



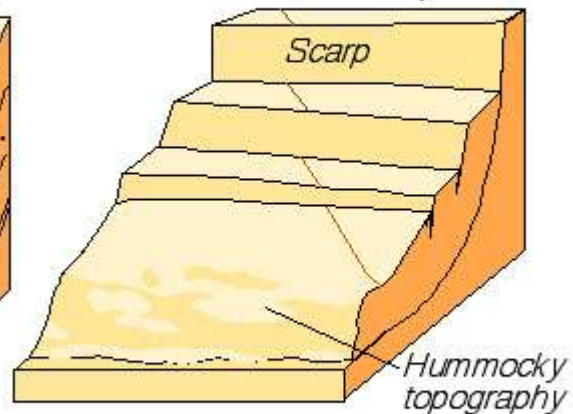
## Styles of Mass Wasting

Glide (or Slide)



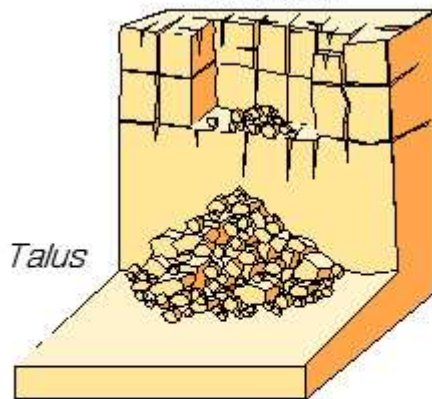
Most likely in layered rocks with bedding planes or fractures parallel to slope

Slump



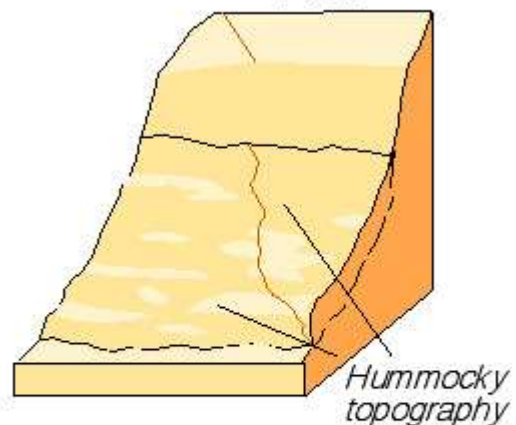
Most likely in consolidated clays or soils

Rockfall



Most likely in fractured rocks at cliffs

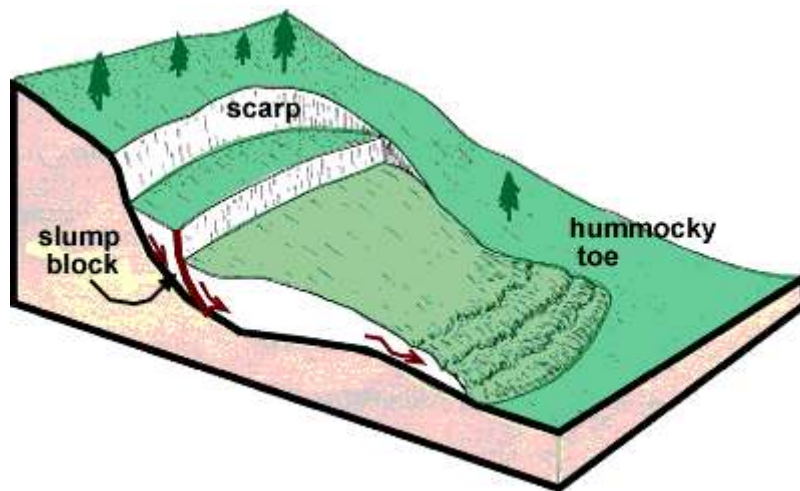
Flow



Most likely in sandy sediments or soils, or unconsolidated clays; especially if wet.

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**Rockslide** sliding of individual rock masses down bedding joint or fault surfaces . it generally occurs at the steep slopes. Superficial layers of the rock gnerally fall.



mass movement

Reasons for land slides along the Himalayas

1. Tectonically active
2. Made of sedimentary rocks
3. Steep slopes
4. Heavy rains
5. Unconsolidated material is found

#### EROSION AND DEPOSITION

Erosion involves acquisition and transportation of rock debris

Abration by rock debris carried by geomorphic agents also aids erosion

By erosion relief degrades . the landscape is work down. Weatherin may not be pre condition for erosion.

Weathering , mass wasting, and erosion are degradational processes. It is the erosion largely responsible for continuous changes that the earth surface is undergoing.

Erosion and transportation are controlled by kinetic energy.wind running water and glaciers are controlled by climate.

Comparison of wind runing water and glacier

wind	Running water	glacier
Predominant in hot deserts	Found most parts of the earth	Found only in high latitude and altitude
Sand dunes are common features	Valleys and deltas are common features	U shaped valleys and morians are common
Ex. Sahara, atacama kalahari	Amazon.Nile, Bramhaputra	Greenland, Antarctica
Air is gas	Water is liquid	Glacier is solid
Limited land forms	Extensive land forms	Limited land forms
High speed	Normal speed	Very slow movement

**EROSION:** "application of kinetic energy associated with the agent to the surface of the land along which it moves". It is computed as  $KE = \frac{1}{2} mv^2$

M=mass v= velocity KE= kinetic energy

**SOIL FORMATION:** Soil is the collection natural bodies on the earth's surface containing living matter and supporting or cpable or suporting plants.

Soil is a dynamic mateial in which many chemical , bioligical , and physical activities go on constantly. It is the result of decay, it is also a medium of growth. It is changing and developing body. Characteristics are changing from season to season.

Too cold ,too hot , and dry areas biological activity stops.organic matter increases when leaves fall and decompose.

**PROCESS OF SOIL FORMATION:** weathering is basic process for soil formation. The weathered material is transported and decomposed due to bacteria lichens and moss. The dead remains increases the humus of the soil.minor grasses and ferns can grow. Bushes , trees also grow .plants roots and burrowing animals help the soil formation.

**PEDOLOGY:**is Sceince of soil formation

**PEDOLOGIST:**is the scientist of soil formation



**SOIL FORMING FACTORS:** 1. Parent material 2. Topography 3. Climate 4. Biological activity. 5. time

**PARENT MATERIAL:** passive control factor, it is insitu, onsite, or transported. it depends on texture, structure, chemical composition of the soil. Nature and depth of weathering is an important factor. chemical composition, texture are the characteristics derived from parent material

**TOPOGRAPHY:** passive control factor, amount of exposure to the sun light, drainage system, steep slopes have less deposition, gentle slopes have thick soils. Plains have thick and dark coloured soils. In mid latitude southern slopes expose to the sun light and get decomposed more.

**CLIMATE:** it is an active factor in soil formation. Climatic elements are (i) moisture (in terms of its intensity, frequency and duration of precipitation - evaporation and humidity

(ii) **Temperature in terms of seasonal and diurnal variation.**

Precipitation increases the biological activity.

Excess of water helps to transport the dissolved particles to downward (eluviation)

**Deposition of these particles is called 'Illuviation'**

Heavy rainfall removes the calcium, magnesium, sodium, potassium along with silica.

Removal of silica is called **desilication**

In dry areas excess of evaporation leads to deposition of salts on the surface of the soil

These salt layers are called 'hard pans' in the hot deserts

In tropical climates, under moderate rainfall conditions calcium carbonate nodules are formed.

**Biological activity:** plants and animals add organic matter to the soil. also helps in moisture retention. Dead plants add humus to the soil. In humid areas, the bacterial activity is higher than cold areas

As a result undecomposed material is found in cold areas

In hot areas bacteria fix the nitrogen in the soil which is used by the plants

**Rhizobium** is the bacteria fix the nitrogen in the soil and live in the roots of leguminous plants. ants, termites, rodents, earthworms change the chemical composition of the soil.

**Time:** Important controlling factor of soil formation. Longer the time, thicker the soil layers. No time limit for the formation of the soil layers.