Geomorphic Processes

Geomorphic Processes – The earth's surface is being continuously reshaped by both internal (endogenic) and external forces (exogenic). The changes that the endogenic and exogenic forces bring about in the appearance of the surface of the earth are collectively known as geomorphic processes.

- Geomorphological processes are natural mechanisms of erosion, weathering, and deposition that result in the alteration of the surficial materials and landforms at the surface of the earth.
- The exogenic and endogenic forces cause chemical actions and physical pressures on earth materials.
- This brings about changes in the shape of the surface of the earth which is known as geomorphic processes.
- **The endogenic processes are mainly land building forces while exogenic forces are mainly land wearing forces.**
    - Mass wasting, weathering, deposition, and erosion are exogenic geomorphic processes.
    - Volcanism and Diastrophism are endogenic geomorphic processes. Radioactivity, rotational and tidal friction and primordial heat generating from the interior of the earth are the main sources of energy responsible for the endogenic geomorphic processes.
- **Geomorphic Agent** – It is a mobile medium, running water, wind, currents, waves, etc. which removes, transports and deposits earth materials. All the movements, within the earth or on the surface of the earth occur due to gradients from high pressure to low pressure regions, from higher to lower levels, etc.
- When these elements of nature become portable due to gradients, they remove the materials and transport them over slopes and deposit them at a lower level.
- The gravitational stresses are as vital as the other geomorphic processes.
- Gravity is the force that is keeping us in contact with the surface and it is the force that switches on the movement of all surface material on earth.
- It is the directional force stimulating all downslope movements of matter and it also causes stresses on the earth's materials.
- Indirect gravitational stresses stimulate tide and wave-induced winds and currents.
- Without gradients and gravity, there would be no movement and therefore no transportation, erosion, and deposition are possible.
- All the movements either on the surface of the earth or within the earth happen due to gradients —from high pressure to low pressure areas, from higher levels to lower levels, etc.

Diastrophism – The process by which the earth's surface is reshaped through rock movements and displacement is termed diastrophism. Diastrophism includes –

1. Orogenic processes (mountain building) – which involves mountain building through severe folding and affecting long and narrow belts of the earth's crust.
2. Epeirogenic processes (continent building) – which involves uplifting or warping of large parts of the earth's crust.
3. Earthquakes involving local relatively minor movements.
4. Plate tectonics involving horizontal movements of crustal plates.

All the above processes cause pressure, volume and temperature (PVT) changes which result in the metamorphism of rocks.

The geomorphic process means bringing about changes in the configuration of the Earth's surface, due to physical stresses and chemical actions on materials present on earth. The physical and chemical actions are due to endogenic and exogenic forces. There are 2 main geomorphic processes.

The below table gives the different processes under the exogenic and endogenic process-

Exogenic Process	Endogenic Process
1. Weathering – Physical, Chemical, Biological 2. Erosion/Degradation 3. Transportation 4. Deposition	1. Volcanism 2. Diastrophism 3. Metamorphism 4. Earthquake 5. Landslides 6. Faulting and Folding

Which Process is an Internal Geomorphic Process?

The endogenic process is an internal geomorphic process.

The main force behind this process is the energy emanating from inside the earth. This energy is mainly generated through the 3 processes given below.

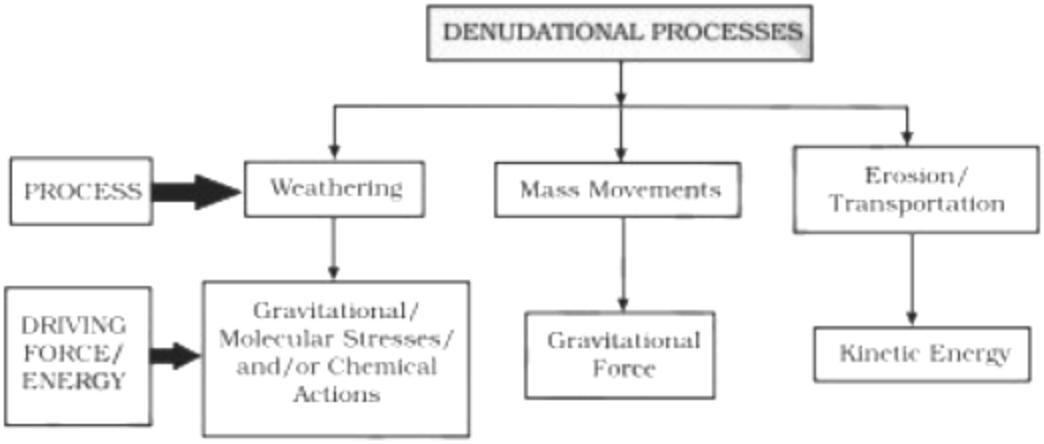
1. Primordial heat that existed right from the time earth was created.
2. Rotational and tidal friction
3. Radioactivity

What are the Geomorphic Agents?

A geomorphic agent is a mobile medium which removes, transports and deposits earth materials. The examples of geomorphic agents are running water, glaciers, wind, waves, ocean currents, groundwater etc. All the movements occur due to gradients, from higher levels to lower levels or from high-pressure areas to low-pressure areas.

Exogenic Processes

The general term "denudation" includes all the exogenic geomorphic processes. The word "denude" means to uncover or strip off. All the exogenic processes – erosion, weathering, mass movements/wasting and transportation are included in denudation. For each process, there exists a distinct driving force or energy.



The exogenic geomorphic processes vary from place to place due to variations in thermal gradients created by seasonal, latitudinal, land and water spread on the surface of the earth. The type and distribution of vegetation, which mainly depends upon precipitation and temperature, also indirectly influence the exogenic geomorphic processes. The intensity of action of exogenic geomorphic processes depends upon the type and structure of rocks. Different types of rocks with differences in their structure offer varying resistances to various geomorphic processes.

Weathering

Weathering is the process of disintegration and decomposition of rocks through the actions of various elements of weather and climate. It involves very little or no motion of materials, so it is an in-situ or on-site process.

There are three types of weathering processes: physical weathering, chemical weathering and biological weathering.

1. **Physical Weathering** – Physical or mechanical weathering is the disintegration of rocks mainly induced by elements of weather. It is caused by the change in pressure, temperature, wind and water. It is further categorised into thermal weathering, frost weathering and exfoliation. More on physical weathering here.
    a. Thermal weathering – Due to high temperature in arid and semi-arid areas, rocks expand during the day and contract at night due to the fall of temperature. Under extreme temperature conditions, the rocks crack and eventually split due to alternate expansion and contraction. Thermal weathering is of two types – granular disintegration and block disintegration.
        i. Granular disintegration – The alternate expansion and contraction of minerals in the rocks due to temperature variations makes the rocks break down into small pieces. Due to this, the break up of rocks occurs, grain by grain. This is known as granular disintegration.
        ii. Block disintegration – Due to the great diurnal range of temperature, the rocks may break up along the joints and crack into large rectangular shaped blocks. It occurs in rocks like granite rocks.
    b. Frost wedging – Frozen water takes up more space. When water enters into the cracks of rocks and freezes, the pressure of the frozen water becomes sufficient to expand and further deepen the crack.
    c. Exfoliation – Due to weather variations, rocks generally heat or cool more on the surface layers. These alternate changes in temperature cause the outer layers to peel off from the main mass of the rock in concentric layers just as the skin of an onion. This process of breaking away curved layers of a rock from the rock beneath and leaving behind a dome-shaped monolith is called exfoliation. Exfoliation usually occurs in arid areas and is also called onion weathering.

2. **Chemical weathering** – A number of weathering processes e.g solution formation, oxidation, reduction, carbonation, and hydration act on the rocks to disintegrate, decompose and dissolve them into a fine state. The presence of water, oxygen, carbon dioxide and temperature speeds up the chemical reactions. The different types of chemical weathering are –
    a. Solution – Soluble minerals present in the rocks get dissolved in water. Over a long period of time, soluble minerals get washed away from the rocks and this can even lead to the formation of caves.
    b. Hydrolysis – It is the chemical breakdown of a rock material when it comes in contact with water and forms an insoluble precipitate like clay mineral. For example, hydrolysis of feldspar, found in granite changing to clay.
    c. Carbonation – It is the formation of carbonic acid when water reacts with carbon dioxide. This acid reacts with minerals in the rocks. This reaction is important for the formation of caves.
    d. Oxidation – When oxygen combines with water and iron, it weakens the rock and disintegrates it. For example, rusting of iron.
    e. Hydration – Hydration (absorption of water) expands volume and results in rock deformation. For example, absorption of water by anhydrite ($CaSO_4$) leading to the formation of gypsum ($CaSO_4.2H_2O$).
3. **Biological weathering –** It is the alteration of rock by the action of plants, animals and humans. Burrowing and wedging by organisms like termites, rodents, earthworms, etc. help in exposing the rock surfaces to chemical changes with the penetration of moisture and air. Human beings by disturbing vegetation, ploughing and cultivating soils, also help in mixing and creating new contacts between water, air and minerals in the earth's materials. Decomposition of animal and plant matter helps in the production of humic, carbonic and other acids which increase decomposition and solubility of some elements. Plant roots exert enough pressure on the earth materials and break them apart.

Know more on biological weathering in the link.

Importance of Weathering

- Weathering processes help in the formation of regolith and soils. It also prepares the soil for erosion and mass movements.
- Due to the processes of weathering, some materials are removed through physical or chemical leaching by groundwater, thereby increasing the concentration of remaining valuable materials. This process is called enrichment and helps in increasing the concentration of certain valuable ores like copper, aluminium, iron, etc.

For more on the significance of weathering, click on the linked article.

Mass Movements

These movements transfer the mass of rock debris down the slopes under the direct influence of gravity. The debris may carry along with it water, air or ice. It is also called mass wasting. It may occur suddenly or slowly. Weathering aids mass movements, however, it is not the prerequisite for mass movements. Weak unconsolidated materials, faults, thinly bedded rocks, steeply dipping beds, steep slopes or vertical cliffs, abundant precipitation, torrential rains and scanty vegetation aids in mass movements.

Following are the types of mass movements:

1. Rock falls – Rock fall is the free-falling of rock blocks over any steep slope keeping itself away from the slope. It occurs from the superficial layers of the rock face. The accumulation of rock debris at the base of a steep slope is called talus.
2. Rock slides – Rock slides usually follow a zone of weakness. The presence of water increases slippage. Collisions down the slope generally break the rock mass into rubble that eventually results in rock slides. Rock slides affect the materials up to a substantial depth.
3. Landslides – Landslides occur when a large piece of rock breaks off and slides down a hill. It is often initiated by earthquakes and very heavy rain.
4. Slump – Great mass of bedrock moves downward by a rotational slip from a high cliff is known as slump. The main cause of slumping is erosion at the base of the slope which reduces the support for overlying sediments.
5. Debris slide – Debris slide is more extensive and occurs on a large scale. The materials involved in debris slide are a mixture of soils and rock fragments.
6. Debris flow – Debris flow includes mudflow, earth flow and debris avalanches. In this type of mass movement, turbulence occurs throughout the mass. It usually occurs when the rock or soil mass loses coherence due to a large amount of water involved. Debris mixes up with water and flows as liquid mud. It may carry large boulders which are very destructive.
    a. When earth material moves down a hill as a fluid-like mass, it is called an earth flow. These usually occur in humid regions on steep slopes with thick, clay-rich soil that becomes saturated with water during storms.
    b. Mud flow is a liquid mass of soil, rock debris and water that moves quickly down a well-defined channel. It mostly occurs in mountainous semi-arid environments. A mud flow originating on a volcanic slope is called a lahar.
    c. The deadliest type of debris flow is the debris avalanche. It is a rapidly churning mass of rock debris, soil, air and water that moves down steep slopes. The air in the flow may enhance the speed of an avalanche by acting as a cushion between the debris and the underlying surfaces.
7. Creep – It is a slow and gradual movement of soil downhill. Its velocity is usually less than a centimetre per year. Freezing and thawing contribute to the soil creep by progressively moving soil particles down the hill.

Erosion and Deposition

- Erosion involves the acquisition and transportation of rock debris. Erosion like weathering and mass wasting is a degradational process. This process is caused by the dynamic activity of erosive agents like wind, running water, glaciers, waves and groundwater. The agents, wind (gaseous state), running water (liquid state) and glacier (solid state) are controlled by climatic conditions. The other two agents – waves and groundwater do not depend on climate. In the case of waves, the location along the interface of litho and hydrosphere (coastal region) determines the work of waves, whereas the work of groundwater is determined more by the lithological character of the region.
- Erosion degrades relief, i.e., the landscape is worn down. The process of erosion is hugely responsible for continuous changes that the earth's surface is undergoing. Denudational processes like erosion and transportation are controlled by kinetic energy.
- The erosional agents lose their velocity and energy on gentler slopes and the materials carried by them start to settle themselves. Thus, deposition is a result of erosion. The coarser materials get deposited first and finer ones settle later. The same erosional geomorphic agents – running water, wind, glacier, waves and groundwater act as depositional or aggradational agents also. Depositions fill up the depressions.

Soil Formation (Pedogenesis)

Soil formation, pedogenesis, depends primarily on weathering. The depth of the weathered material (weathering mantle) forms the basic source for soil formation. First, the weathered material or transported deposits are colonised by bacteria and other inferior plant bodies like lichens and mosses. Also, several minor organisms may take shelter within the mantle and deposits. The dead remains of plants and organisms help in the growth of humus. Minor grasses and ferns may grow, then bushes and trees start growing through seeds brought in by wind and birds. Roots of the plants grow and penetrate down, burrowing animals bring up particles, mass of material become porous with a capacity to hold water and to permit the passage of air and finally a mature soil- a complex mixture of mineral and organic products form.

Soil forming factors – The following five factors control the formation of soil;

1. Parent material
2. Topography
3. Climate
4. Biological activity
5. Time.

The relative influence of each other varies from place to place, but the combination of all the different factors usually determine the form of soil growing at any given location.

1. Parent material – Parent materials can be any in-situ or on-site weathered rock debris (residual soils) or transported deposits (transported soils). Soil formation depends upon the size of debris and structure as well as the chemical composition of the rock debris/deposits. Younger soils show strong links with the type of the parent rock but as they age, the exposure to moisture, the addition to organic matter and other environmental factors may change its features.
2. Topography (relief, altitude and slope) – Soils are thin on steep slopes because water runs down faster and erodes the surfaces of slopes. Also slopes may be exposed to direct sunlight which may dry out soil moisture and render it less fertile. Over gentler slopes where erosion is slow and percolation of water is good, soil formation is very favourable. Soils over flat areas develop a thick layer of clay with good accumulation of organic matter giving the soil its dark colour.
3. Climate – It is one of the key factors in the formation of soil. Two important climatic components – precipitation and temperature are involved in soil development.
    1. Precipitation – Precipitation gives soil its moisture content which makes the chemical and biological activities possible. Excess water transports soil components through the soil (eluviation) and deposits these components down below (illuviation). In regions with high rainfall, elements like sodium, potassium, magnesium, calcium and a major part of silica are removed from the soil. The process of removal of silica from the soil is known as desilication. In regions with dry climate, evaporation exceeds precipitation leaving the soils rich in salts. Such salts form into a crust in the soil known as hardpans. In tropical climates and regions with intermediate rainfall, calcium carbonate nodules (kankers) are formed.
    2. Temperature – Chemical activity is enhanced in higher temperatures, reduced in cooler temperatures (with an exception of carbonation) and stops in freezing conditions. Thus, tropical soils with higher temperatures show deeper soil profiles and in the frozen tundra regions, soils contain largely mechanically broken materials.
4. Biological activity – The vegetation and organisms in the soil help in adding organic matter, moisture retention, nitrogen, etc. Dead plants add humus, a finely divided organic matter of the soil. During

humification, some organic acids are formed which help in decomposing the minerals of the soil parent materials.

1. Biological activity in the soil depends upon the climate of that region. In cold climates, humus accumulates as bacterial growth is slow. With undecomposed organic matter due to low bacterial activity, layers of peat develop in sub-arctic and tundra climates. In humid tropical and equatorial climates, due to intense bacterial activity, dead vegetation is rapidly oxidised leaving very low humus content in the soil. Bacteria like rhizobium fix nitrogen beneficial to the host. The process of conversion of atmospheric nitrogen into ammonia or related nitrogenous compounds is called nitrogen fixation. Ants, termites, earthworms, rodents, etc. are also important in soil formation as they rework the soil up and down.

5. Time – A fully mature soil is formed when all soil-forming processes act for a sufficiently long time developing a profile. Freshly deposited alluvium is considered young with no or only poorly developed horizons.