1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 01 (Class XI, Semester - 1)
Module Name/Title	Geomorphic Processes: Endogenic, Exogenic and Weathering – Part 1
Module Id	kegy_10601
Pre-requisites	Basic concepts about plate tectonics, volcanism earthquakes and weathering
Objectives	After going through this Module, the learners will be able to : • Acquire knowledge and understanding of landform development. • They will understand endogenic, exogenic the weathering processes. • They will understand the concept of diastrophism. • They will be able to differentiate between physical, chemical and biological weathering.
Keywords	Endogenic forces, exogenic forces, diastrophism, geomorphic agents, weathering.

2. Development Team

Role	Name	Affiliation
National MOOC Coordinator (NMC)	Prof. Amarendra P. Behera	CIET, NCERT, New Delhi
Program Coordinator	Dr. Mohd. Mamur Ali	CIET, NCERT, New Delhi
Course Coordinator (CC) / PI	Prof. Aparna Pandey	DESS, NCERT, New Delhi
Course Co-Coordinator / Co-PI	Dr. Archana	CIET, NCERT, New Delhi
Subject Matter Expert (SME)	Rajeev Kumar Sinha	NCERT textbook " Fundamentals of Physical Geography" TGT (Geography) St. Xavier's Sr. Sec. School, Delhi
Review Team	Prof. S.R. Jog Dr. Preeti Tiwari	Department of Geography, University of Pune, Pune Shivaji College, New Delhi

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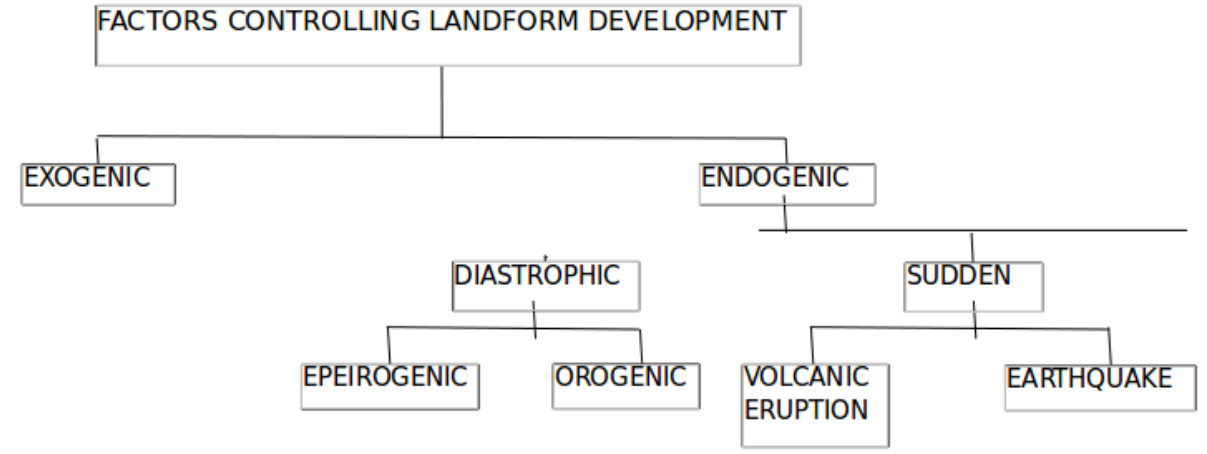
The surface of earth constitutes a great aggregation of physical features each having a form, dynamics, and uniqueness. It is called landform. Landform is not permanents, each is changing some slowly while other fast. Landforms vary to size from continents to minor rivulets.

Fig.No:1 Glacier

Source:https://upload.wikimedia.org/wikipedia/commons/thumb/a/a3/Glacier_park1.jpg/1280px-Glacier_park1.jpg

The earth's crust is dynamic. It has moved vertically and horizontally. dynamic. It has moved vertically and horizontally. Its movement was faster in the past than it is today. Variations seen on the surface of the earth are a result of forces operating within the earth as well as that operating externally. A host of Internal and external forces are involved in the creation of landforms. The external forces are known as exogenic forces and the internal forces are known as endogenic forces. The endogenic forces continuously elevate or build up parts of the earth's surface and tend to create irregularities on the surface by raising or lowering certain areas. Exogenic forces tend to remove irregularities by wearing down (degradation) of elevated areas and filling up (aggradation) of basin and depressions The phenomenon of wearing down of relief variations of the surface of the earth through erosion is known as gradation. In general terms, the

endogenic forces are mainly land building forces and the exogenic processes are mainly land wearing forces



Geomorphic Processes

Forces capable of bringing about changes in the configuration of the surface of the earth are known as geomorphic processes. Diastrophism and volcanism are endogenic geomorphic processes that originate inside the earth. Weathering, mass wasting, erosion and deposition are exogamic geomorphic processes that operate on the surface of the earth.

Any exogamic element of nature (like water, ice, wind, etc.,) capable of acquiring and transporting earth materials can be called a geomorphic agent. When these elements of nature become mobile due to gradients, they remove the materials and transport them over slopes and deposit them at lower level. Geomorphic processes and geomorphic agents especially exogenic, unless stated separately, are one and the same. A process is a force applied on earth materials affecting the same. An agent is a mobile medium (like running water, moving ice masses, wind, waves and currents etc.) which removes, transports and deposits earth materials. Running water, groundwater, glaciers, wind, waves and currents, etc., can be called geomorphic agents. The force of gravity too plays an important role in shaping the earth surface waves can be called geomorphic agents.

Gravity besides being a directional force activating all down slope movement of matter, also causes stresses on earth's materials. Indirect gravitational stresses activate wave and tide induced currents and winds. Without gravity and gradients, there would be no mobility and hence no erosion, transportation and deposition. Therefore, gravitational stresses are as important as the other geomorphic processes. All movements, either within the earth or on the surface of the earth occur due to gradients — from higher levels to lower levels, from high pressure to low pressure etc.

Endogenic Processes

The energy emanating from within the earth is the main force behind endogenic geomorphic processes. This energy is mostly generated by radioactivity, rotational and tidal friction and primordial heat from the origin of the earth. This energy due to geothermal gradients and heat

flow from within induces diastrophism and volcanism in the lithosphere. Due to variations in geothermal gradients and heat flow from within, and in crustal thickness and strength, the action of endogenic forces is not uniform and hence the tectonically controlled original crustal surface is uneven.

Diastrophism

All processes that move, elevate or build up portions of the earth's crust come under diastrophism. They include:

(i) Orogenic processes: Involving mountain building through severe folding and affecting long and narrow belts of the earth's crust. In the process of orogeny, the crust is severely deformed into folds. Orogeny is a mountain building process.

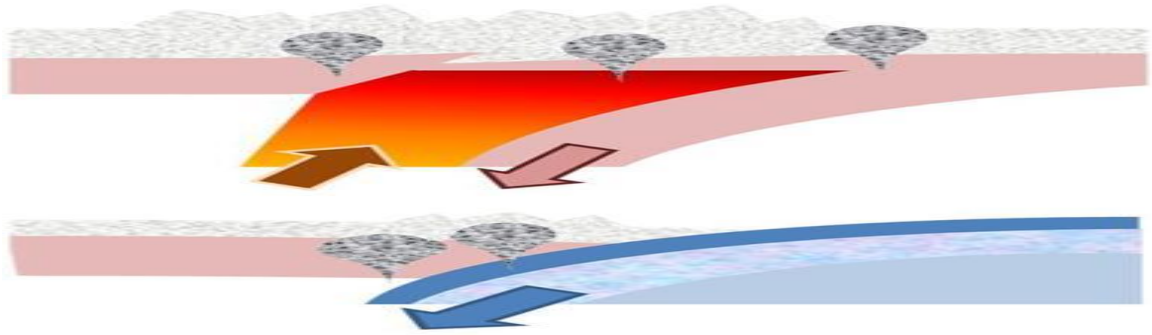


Fig No. Process of an orogen

https://en.wikipedia.org/wiki/Orogeny#/media/File:SubductionDelamination.JPG

(ii) Epeirogenic processes: Involving uplift or warping of large parts of the earth's crust. Due to epeirogeny, there may be simple deformation. Epeirogeny is a continent building process.

(iii) Plate tectonics: Involving horizontal movements of crustal plates.

Through the processes of orogeny, epeirogeny and plate tectonics, there can be faulting and fracturing of the crust. All these processes cause pressure, volume and temperature (PVT) changes which in turn induce metamorphism of rocks.

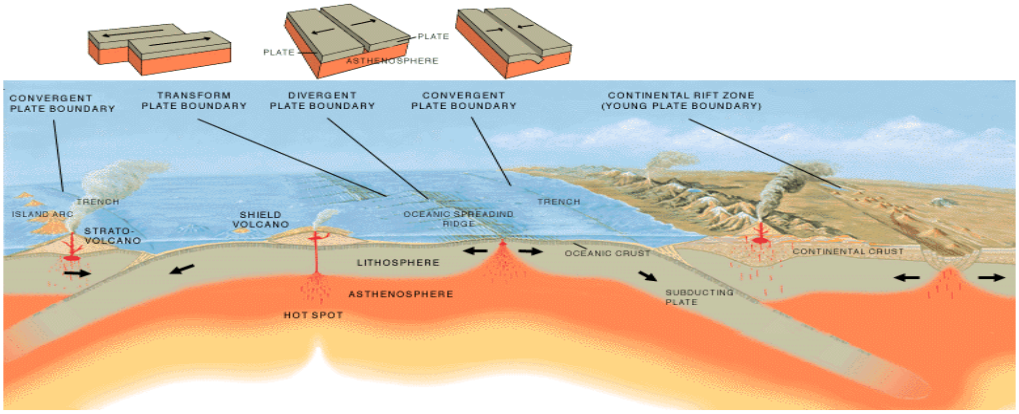


Fig.No.2.PlateTectonic

Source:https://upload.wikimedia.org/wikipedia/commons/4/40/Tectonic_plate_boundaries.png

Volcanism

It is the movement of molten rock (magma) onto or toward the earth's surface and also formation of many intrusive and extrusive volcanic forms.

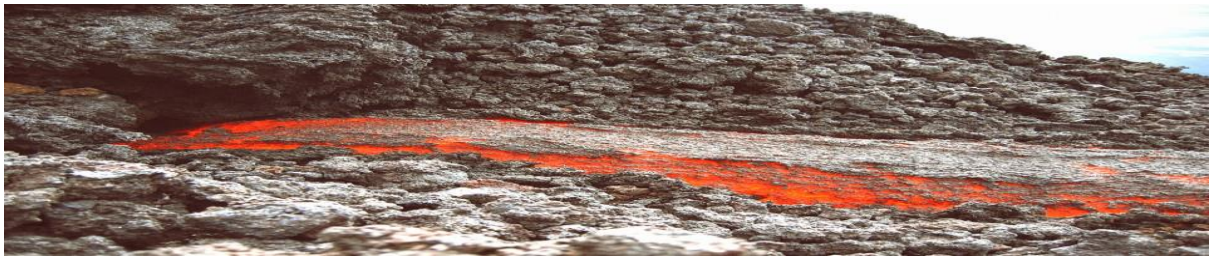


Fig No. Volcanism

https://cdn.pixabay.com/photo/2014/07/31/21/19/magma-406818_960_720.jpg

Exogenic Processes

The Exogenic processes derive their energy from the atmosphere due to the unequal distribution of solar energy and also from the gradients created by tectonic factors.

Gravitational force acts upon all earth materials and tends to produce a down slope movement of matter. Force applied per unit area is called stress. Stress is produced in a solid by pushing or pulling. This induces 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 stresses result in angular displacement or slippage.

Besides gravitational stress earth materials are subjected to molecular stresses that may be caused by a number of factors amongst which temperature changes, crystallisation and melting are the most common. Chemical processes normally lead to loosening of bonds between grains, dissolving of soluble minerals or cementing materials. Thus, the basic reason that leads to weathering, mass movements, and erosion is development of stresses in the body of earth materials.

As there are different climatic regions on the earth's surface the exogenic geomorphic processes vary from region to region. Temperature and precipitation are the two important climatic elements that control various processes.

All the exogenic geomorphic processes are covered under a general term, denudation. The word 'denude' means to strip off or to uncover. Weathering, mass wasting/movements,

erosion and transportation are included in denudation. For each process, there exists a distinct driving force or energy.

Factors Controlling Exogenic Geomorphic Processes

a) Exogenic geomorphic processes differ from region to region.This is because the earth has different climatic regions with different thermal gradients created due to variations in latitude season and distribution of land and water.

b) The density, type and distribution of vegetation which largely depend upon precipitation and temperature indirectly influence exogenic geomorphic processes.

c) Within broad climatic regions local variations are caused by altitude and other aspect for example, south facing slopes in the northern hemisphere receive more sunlight than north facing slopes.

d) Further differences arise due to variations in wind velocity and direction, due to differences in wind velocities and directions, amount intensity and the precipitation and its relationship with evaporation, daily range of temperature, depth of frost penetration and frequency of freeze and thaw.

e) Climatic factors being equal, the intensity of exogenic geomorphic processes depends upon type and structure of rocks. The term structure includes such aspects of rocks as folds, faults, orientation and inclination of beds, presence or absence of joints, bedding planes, hardness or softness of constituent minerals, chemical susceptibility of mineral constituents; the permeability or impermeability etc.

Depending on their structure rocks offer varying resistance to various geomorphic processes. A particular rock may be resistant to one process and nonresistant to another. In addition, under varying climatic conditions, similar rocks may exhibit different degrees of resistance to geomorphic processes therefore processes operate at differential rates gives rise to differences in topography.

Most of their impact exogenic geomorphic processes operate and slowly and on a small scale. Therefore it may be imperceptible in a short time span however, in the long run, rocks may be severely affected due to continued fatigue.

Finally, it can be said that the differences on the surface of the earth though originally related to crustal evolution, continue to exist in some form or the other due to differences in the type and structure of earth materials, differences in geomorphic processes and in their rates of operation. Some of the exogenic geomorphic processes have been discussed in detail here.

Weathering

Weathering is action of elements of weather and climate over earth materials. There are a number of processes within weathering which act either individually or together to affect earth materials in order to a reduce them to fragmental state.

Weathering is defined as the mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate. As very little or no motion of materials takes place in weathering, it is an in-situ or on-site process.

Fig. No. Weathering Process

http://2.bp.blogspot.com/-RyIzfZdE2kI/VdNrqPvsYuI/AAAAAAAABhQ/XeofJD0xdjM/s1600/chemical.honycomb.weathering.jpg

Weathering processes are conditioned by many complex geological, climatic, topographic and vegetative factors. Climate is of particular importance. Not only do weathering processes differ from climate to climate, but the depth of the weathered mantle also show similar variations.

There are three major groups of weathering processes:

1. Chemical
2. Physical or mechanical
3. Biological

Very rarely does any one of these processes operate completely by itself, however quite often, a dominance of one process over others can be seen.

Chemical Weathering Processes

A group of weathering processes, viz. solution, carbonation, hydration, oxidation and reduction act on trucks to decompose, dissolve or reduce them to a fine clastic state through chemical reactions by oxygen, surface and/or soil water and other acids. Water and air (oxygen and carbon dioxide) 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.

Fig No. Mechanical and Chemical Weathering

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a) **Solution**

When something is dissolved in water or acids, the water or acid with dissolved contents is called a solution.This process involves the removal of solids in solution and it depends upon the solubility of a mineral in water or weak acids. On coming in contact with water, many solids disintegrate and their particles are dissolved in water. Soluble rock forming minerals like nitrates, sulphates, and potassium etc. are affected by this process. Therefore, these minerals are easily leached out without leaving any residue in rainy climates, but tend to accumulate in dry regions.

Minerals like calcium carbonate and calcium magnesium bicarbonate present in limestone are soluble in water containing carbonic acid (formed by the addition of carbon dioxide in water), and are carried away in water as solution. Carbon dioxide produced by decaying organic matter along with soil water greatly aids in this reaction. Common salt (sodium chloride) is also a rock forming mineral that is susceptible to this process of solution.

Fig No. Salt Weathering

https://upload.wikimedia.org/wikipedia/commons/c/cd/Qobustan-salt.jpg

b) Carbonation

Carbonation is the reaction of carbonate and bicarbonate with minerals and is a common process helping the breaking down of feldspars and carbonate minerals. Carbon dioxide from the atmosphere and soil air is absorbed by water, to form carbonic acid that acts as a weak acid. Calcium carbonates and magnesium carbonates are dissolved in carbonic acid and are removed in a solution without leaving any residue, resulting in cave formation.

Fig. No. Pebble Beach at Tafori

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c) Hydration

Hydration is the chemical addition of water. Minerals take up water and expand; this expansion causes an increase in the volume of the material or rock. Calcium sulphate takes in water and turns to gypsum, which is more unstable than calcium sulphate. This process is reversible and long, continued repetition of this process causes fatigue in the rocks and may lead to their disintegration.

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 rock fracturing. The volume changes in minerals due to hydration also helps in physical weathering through exfoliation and granular disintegration.

Fig No. Chemical weathering

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d) Oxidation and Reduction

In weathering, oxidation means a combination of a mineral with oxygen to form oxides or hydroxides. Oxidation occurs where there is ready access to the atmosphere and oxygenated waters. The minerals most commonly involved in this process are iron, manganese, sulphur etc. In the process of oxidation rock breakdown occurs due to the disturbance caused by addition of oxygen. Red colour of iron upon oxidation turns to brown or yellow. When oxidised minerals are placed in an environment where oxygen is absent, reduction takes place. Such conditions exist usually below the water table, in areas of stagnant water and waterlogged ground. Red colour of iron upon reduction turns to greenish or bluish grey.

These weathering processes are interrelated. Hydration, carbonation and oxidation go hand in hand and hasten the weathering process.

Physical Weathering Processes

Physical or mechanical weathering processes depend on some applied forces. The applied forces could be: (i) gravitational forces such as overburden pressure, load and shearing stress; (ii) expansion forces due to temperature changes, crystal growth or animal activity; (iii) water pressures controlled by wetting and drying cycles. Many of these forces are applied both at the surface and within different earth materials leading to rock fracture. Most of the physical weathering processes are caused by thermal expansion and pressure release. These processes are small and slow but can cause great damage to rocks because of continued fatigue the rocks suffer due to repetition of contraction and expansion.

Fig No .Physical Weathering in Corrie Fee

http://s0.geograph.org.uk/geophotos/03/00/79/3007965_92f34506.jpg

a) 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 roughly 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 resulting 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.

b) Temperature Changes and Expansion various minerals in rocks possess their own limits of expansion and contraction. With rise in temperature, every mineral expands and pushes against its neighbour and as temperature falls, a corresponding contraction takes place. Because of diurnal changes in temperatures, this internal movement among the mineral grains of the superficial layers of rocks takes place regularly. This process is most effective in dry climates and high elevations where diurnal temperature changes are drastic. As has been mentioned earlier, these movements are very small. yet they make the rocks weak due to continued fatigue. The surface layers of the rocks tend to expand more than the rock at depth and this leads to the formation of stress within the rock resulting in heaving and fracturing parallel to the surface. Differential heating and the resultant expansion and contraction of surface layers and their subsequent exfoliation results in smooth rounded surfaces in rocks. Smooth surfaced and rounded small to big boulders, called tors, form due to such exfoliation in hard rocks we granite.

c) Freezing, Thawing and Frost Wedging

Frost weathering occurs due to growth of ice within pores and cracks of rocks during repeated cycles of freezing and melting. This process is most effective at high elevations in mid-latitudes where freezing and melting is often repeated. Glacial areas are subject to frost

wedging daily. In this process, the rate of freezing is important. Rapid freezing of water causes its sudden expansion and high pressure. The resulting expansion causes joints, cracks and small inter granular fractures to widen until the rock finally breaks apart.

d) Salt Weathering

Salts in rocks expand due to thermal action, hydration and crystallisation. Many salts like calcium, sodium, magnesium, potassium and barium have a tendency to expand. Expansion of these salts depends on temperature and their thermal properties. High temperatures ranges between 30o and 50o temperatures 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 the most effective of all salt-weathering processes. In areas with alternating wet and dry conditions, salt crystal growth is favoured and neighbouring grains are pushed aside. Sodium chloride and gypsum crystals in desert areas heave up overlying layers of materials as a result, polygonal cracks develop all over the heated surface. With salt crystal growth, chalk breaks down most readily, followed by limestone, sandstone, shale, gneiss and granite etc.

Fig No.Salt Weathering in Gozo

https://upload.wikimedia.org/wikipedia/commons/b/ba/Salt_weathering_in_gozo.jpg

Biological Activity And Weathering

Biological weathering result from an addition to, or removal of, minerals and ions from the weathering environment, and physical changes due to growth or movement of organisms. Burrowing and wedging by organisms like earthworms, termites, rodents etc., help in exposing new surfaces to chemical attack and assists in the penetration of moisture and air. Human beings by disturbing vegetation and ploughing and cultivating soils, also help in mixing and creating new contacts between air, water and minerals in the earth materials.

Decaying plant and animal matter help in the production of humus, carbonic and other acids which enhance decay and solubility of some elements. Plant roots exert tremendous pressure on the earth materials, mechanically breaking them apart.Large plants affect weathering in number of ways. Cracks may be widened by root pressure. The accumulation of elements by plants and their return to the surface of the soil affects the nature of weathering. Vegetation litter and decaying vegetation are important in conserving moisture which in turn enhances weathering.

Fig No. Biological weathering

http://s0.geograph.org.uk/photos/07/15/071562_a27ff58b.jpg

Special Effects of Weathering

Exfoliation

Exfoliation is a result but not a process. Flaking off of more or less curved sheets of shells from over rocks or bedrock (like the peeling off layers of onion) results in smooth and rounded surfaces. Exfoliation can occur due to expansion and contraction induced by temperature changes. Exfoliation domes and tors result from unloading and thermal expansion respectively.

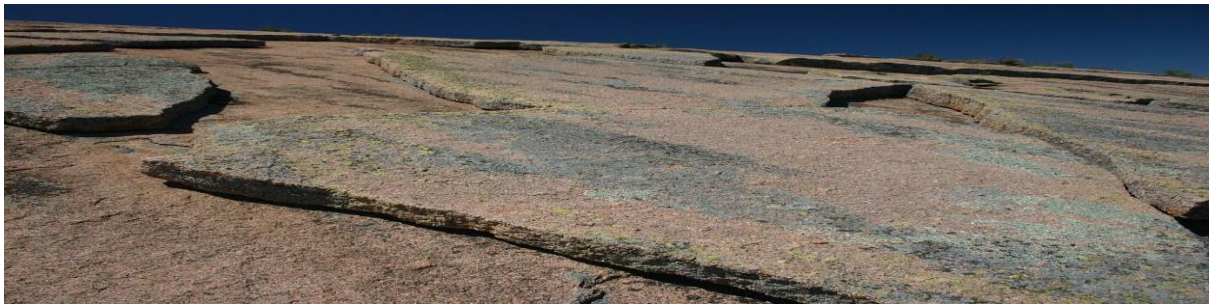

Fig No. Geological Exfoliation of Granite Rocks

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Conclusion

Natural mechanisms of weathering, erosion and deposition is called Geomorphological processes.Weathering processes are responsible for breaking down the rocks into smaller fragments and preparing the way for formation of not only regolith and soils, but also for erosion and mass movements.Weathering of rocks and deposits helps in the enrichment and concentrations of certain valuable ores of iron, manganese, aluminium, copper etc., which are of great importance for the national economy.It is an important process in the formation of soils.When rocks undergo weathering, some materials are removed through chemical or physical leaching by groundwater, increasing thereby the concentration of remaining (valuable) materials. Which makes it able to extract a mineral enrichment.