INTRODUCTION TO GEOMORPHOLOGY

A) Definition:

Geomorphology is significant branch of Physical Geography (geomorphology, oceanography, climatology and biogeography). It is the study of land forms. The term Geomorphology has been derived from the Greek word **- Geo** (Earth), **morfe** (form) and **logos** (a discourse). Geomorphology, therefore, is defined as the science of description (discourse) of various forms (morphe) of earth's surface.

The term Geomorphology has come about within the past few decades. The term was first used in its present sense by Keith in 1894.

N. M. Fenneman - Geomorphology means the study and interpretation of the records left by erosion.

F. Hjustroom – Geomorphology is the science of land forms and land forming processes.

Philip G. Worcester – Geomorphology is the interpretative description of the relief features of the earth's surface.

Nature of Geomorphology

The term Physiology was formerly applied to this subject. Geomorphology is principally Geology. In most geography courses landforms are treated as part of the physical environment of man but emphasis is placed upon man's adjustment and uses of landforms.

Geomorphology has achieved a great deal during this time and Geographers, Geologists, Hydrologists and specialists from other fields all have contributed to study of Geomorphology. Because all have been aware that changes in study of Geomorphology also impact their respective study fields.

Geomorphology is the study of the evolution of landforms especially land forms produced by the process of erosion. Though erosional land forms are the main interest of geomorphology, the study of certain types of constructional (depositional) land forms is also a part of Geomorphology. For example – The study of formation of coastal features has always attracted the geomorphologists. They study the erosional land forms features like cliffs, wave – cut platforms, sea caves, and stacks. They also consider the constructional land forms such as beaches, hooks, spits, bars etc.

Similarly, geomorphologists study the land forms produced by glaciation such as erosional features like U – shaped valleys, hanging valleys, cirques, tarns, Nunataks, crag and tails and constructional land forms such as kames, eskers, moraines, drumlins.

Geomorphology is the study of the relations between land forms and the underlying rocks. The basic knowledge of the effect of rocks on relief is fundamental in any regional study because, geomorphology is concerned with interactions between denudation process and rock strength.

Geomorphology is the study of 'denudation chronology' (अपक्षय प्रक्रियेचा कालक्रम) Alteration in earth surface relief is usually caused by changes in base level of the sea and climate. To study the evolution of landforms geomorphologist attempts to reconstruct a succession of pictures of relief of different periods. Thus, the reconstruction of former base levels and the landforms related to these base levels by means of marine and river terraces and long profiles of rivers is one of the parts of the study.

Geomorphology is study of earth relief and process involved in their evolution. Geomorphology is the study of the actual processes of erosion which give rise to landforms. Among them action of waste movement, water movement, ice action, wind action as well as the process of weathering are considered.

SCOPE OF GEOMORPHOLOGY

The scope and limits of the field of Geomorphology are not sharply defined. On one hand, it is closely related to dynamic Geology. Geology however is primarily concerned with the structure and composition of earth materials, forces and processes while Geomorphology although not neglecting these things particularly emphasizes the resulting landforms.

On the other hand, Geomorphology is closely related to Geography. But geographer uses land forms in a more or less static sense. He is not primarily interested in the origin of land forms and other relief features but impact of these land forms on the human life.

Process – oriented Geomorphology (प्रक्रियाधिष्ठित भूरुपशास्त्र) is closely related to climatology because air, temperature, precipitation, winds and atmosphere, humidity largely determine the response of rocks to sub aerial exposure. Much of the information about geomorphic processes is derived from other scientific fields.

The elastic and plastic deformation of rocks under pressure and thermal conductivity (उष्णतेची वहनक्षमता) of rocks are studied by Geophysicist. (भूभौतिकशास्त्रज्ञ)

Seismologists (भूकंपशास्त्रज्ञ) are more concerned with the causes and prediction of earthquakes than with the landforms that earthquakes produce.

Geochemists (भूरसायनशा़स्त्रज्ञ) and mineralogists (खनिजशास्त्रज्ञ) study the chemical reactions of rocks and minerals with hydrous solutions and there by provide about weathering processes.

Pedologist (मृदाशास्त्रज्ञ) studies soil formation. Hydrologists (जलशास्त्रज्ञ) study the work of flowing water. Sedimentologist (गाळशास्त्रज्ञ) studies depositional process of sediments. Glaciologist (हिमशास्त्रज्ञ) studies the physical properties of ice. Oceanographer (सागरशास्त्रज्ञ) describes the submarine topography.

All of these scientists contribute to an understanding of the processes that shape the earth’s surface. A Geomorphologist must know about these subjects.

B) SIGNIFICANCE OF THE STUDY OF GEOMORPHOLOGY

The major role of Geomorphology is to contribute to Geological knowledge. For instance, Geomorphology might reflect the tectonic conditions of relief which prevailed during its evolution.

In Engineering Geology, Geomorphological interpretation is important. It may cause problems in civil engineering projects if land form history is overlooked. Thus, Geomorphology also shares with other earth sciences a common concern for reconstructing former environmental numerous relics of the action of different climatic regimes in the part may be recognized in the forms.

C) FUNDAMENTAL CONCEPTS

i) Principle of Uniformatarianism (समानत्ववादाचे किंवा समरुपकतावादाचे तत्व)

The principle of Uniformatarianism was first postulated by **James Hutton** in 1785. The concept was further modified and developed by his disciple **Jhon Playfair** in 1802. **Sir Charles Lyell** popularized this concept.

Hutton taught that 'the present is key to the past'. It is inferred from his concepts that all the geological processes affecting the earth's crust, which operate at present, were also active in the geological past and hence the past geological and geomorphic history of the earth may be reconstructed on the basis of present processes and their topographic expressions (landform characteristics). But he applied this principle somewhat too rigidly and argued that 'Geologic processes operated throughout geologic time with the same intensity as now'. It is erroneous (चुकीचे) and confusing.

This principle can be stated as '**The same physical processes and laws that operate today, operated throughout geological time, although not necessarily always with the same intensity as now'**. For example, glaciers were more active during Carboniferous and Pleistocene periods than other processes. At the same time, they were more active during aforesaid periods than the present glaciers. The temporal variations in the magnitude of operation of processes are because of climatic changes and there are definite evidences for several phases of climatic changes during past geological time. There were times when volcanism was more important than now.

Thus, numerous other examples would be cited to show that the intensity of various geologic processes has been varied thought geologic time. There is no reason to believe that the more numerous and more extensive valley glaciers of the Pleistocene behaved any differently from existing glaciers.

Without the Principle of Uniformatarism there would hardly be a science of geology that was more than pure description.

iii) THE CONCEPT OF MORPHOGENTIC REGIONS (भूरुपे उत्पत्तीजन्य भूप्रदेश संकल्पना)

The concept that tells something about the origin of landforms in a region is called as the concept of morphogenetic regions.

It is recognized that different geomorphic processes produce different landforms.

Characteristics of the topography reflect the climatic conditions under which the topography developed.

Geographers are more interested in understanding the similar pattern in the distribution of major soil groups, vegetation types and climatic regions. The common factor which helps to explain these similarities is climate. We know that there is a similar relationship in the distribution of landform types and climate.

The concept of morphogenetic region was first suggested of Budel (1944, 1948)

The concept of morphogenetic region implies that under a certain set of climatic conditions particular geomorphic processes will predominant and give to the landform characteristics which will set it off from landscapes develop under different climatic conditions.

Budel has postulated the existence of four major morphogenetic zones **-**

1) A zone of dominant planation (समतलीकरण) in the equatorial and savanna belts of the tropics.

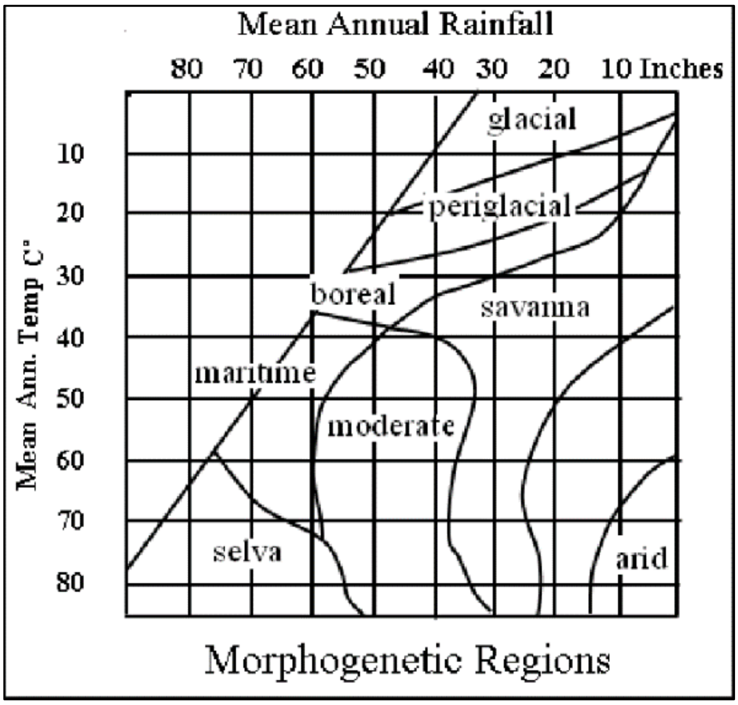
2) A sub-tropical zone in which pedimentation (पद्स्थलीकरण) in dominant.

3) A broad extra tropical belt in which fluvial (पाण्याचा) processes are most important.

4) A high latitude zone known as the cryergic or periglacial zone in which processes related to the existence of permafrost (सदा हिमाच्छादित) combine with fluvial processes to develop a distinctive topography.

PELTIER

Peltier has suggested a tentative list of morphogenetic regions. He has considered these regions in terms of temperature and moisture conditions and has graphically suggested the climatic attributes of each region.



Criticism:

Except for the suggested boreal (समशितोष्ण कटिबंधीय) and maritime (सामुद्रिक हवामान) morphogenetic regions, all of those suggested by Peltier have been recognized.

Davis in his normal cycle applied it chiefly to those areas which Peltier classified under the moderate morphogenetic region.

Davis further recognized the importance of climatic difference in classing under climatic accidents. Men like Cotton, Sapper and Friese have also used the idea of morphogenetic regions in their works.

Thus, the basic idea of morphogenetic regions is not entirely new.

Not all geologists regard climate as a major factor in determining landscape characteristics. King (1957) thought that climate plays an unimportant role in influencing landform characteristics. He contended that in all areas which flow of water over slopes in the prominent agent of denudation, landforms will develop in the same general way.

WEGENER'S CONTINENTAL DRIFT THEORY

The basic problem of the earth has been and continues to be debated at length is to what extent the continents and their geographical portions have remained stable and constant during geologic time.

There are two in schools of thoughts -

1) The first believes that the general frame work of the earth has remained essentially stable throughout the greater part of earth history and second is

2) The second believes that continental changes and movements have happened on a large scale is that the earth plan has been continuously modified!

The suggestion that laterals movement of the continental landmasses might have occurred was first mooted by Antonia Snider in 1858. However, Snider's suggestion was dismissed as fantastic and became forgotten.

At the beginning of the 20th century American F. B. Taylor and an Australian Alfred Wegener postulated continental displacement on a gigantic scale.

Wegener published his book 'The origin of Continents and Oceans' in 1915. The idea of continental drifting given in the book attracted world attention and began to-receive serious consideration.

Wegener was a biologist. He was trying to explain the distribution of flora throughout the world. He found that certain distributions were only explainable if land bridges existed linking one land mass to another. He found that there is no evidence for such land bridges and therefore considered that the landmasses themselves must formerly have been close together. He was struck by the parallel coasts of the Atlantic and their jigsaw fit. Thus, he was led to develop his theory.

PANGEA: According to Wegener the present-day distribution of the continents is due the breaking up by rifting of original single major landmass or **Proto Continent** or **Super Continent** which he called Pangea.

As a result of its initial breaking two Continental landmasses developed.

NORTHERN CONTINENTAL BLOCK

Northern Continental Block was known as **Laurasia** Comprised North America, Europe and Asia

SOUTHERN CONTINENTAL BLOCK

South Continental Block known as **Gondwanaland** included most of South America, Africa, Arabia, the Indian Deccan and Australia.

The two great continents landmasses come to be separated by a great midland east- west stretching the **sea of Tethys.**

Subsequently these continental blocks of Laurasia and Gondwanaland were shattered into smaller fragments and by a process of drifting become dispersed and gradually attained their present-day positions and shapes.

WANDERING OF CONTINENTS FROM THE POLES:

Wegener's theory postulated not continental drifting in an east west direction but also extensive wandering from the poles.

The drift theory pre-supposes that the landmasses of the American were Joined to Eurasia and Africa and they moved westwards.

Australia formerly united with south - east Africa moved away to the north east and the Peninsular India drifted to the north.

According to Wegener the great landmass of Gondwanaland lay somewhere near the south pole that it broke up by rifted alone radial cracks to give the triangular forms of the southern continents and that the pieces all except Antarctica which was left stranded at the South Pole then drifted equatorward.

Thus, the theory envisages a drift away from the South Pole. Wegener described this movement as **'Flight from the Pole'**.

Mountain Building –

Wegener's theory offers a simple and apparently adequate explanation of the problem of mountain building. As a result of the westward drift of the Americas the rocks of the leading edge crumpled and folded to produce the North American Cordillera and the Andes.

Similarly, the building of the Alpine Himalayan Mountain system could be explained in terms of the squeezing, crumpling and uplifting of the sediments which lay in the sea of Tethys.

Supporting Evidence: -

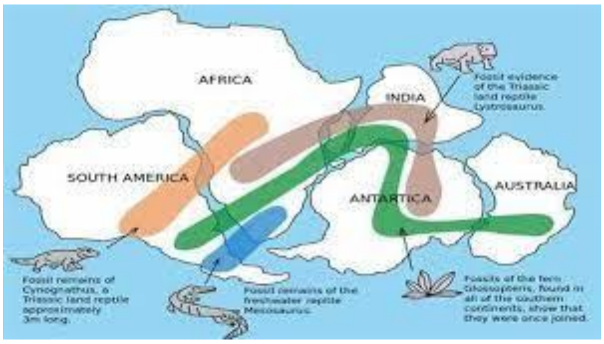
Evidence in favour of the theory is provided by the following -

1. The parallelism of the opposing the coasts Atlantic is a striking feature and it's the two coasts were drawn together they would make a rough jig - Saw fit.

Wegener also drew attention to similar parallelism elsewhere nothing especially the relation of Greenland to Ellesmere Land, Baffin land and Labrador.

2. There is a close resemblance in many structural features of the American and African Coasts for example the transverse orogenic zones match up well and the same types of rock occur in Africa and South America. Geological similarities on the two coasts of the Atlantic thus provide strong evidence which ties up with parallelism.

3. There is evidence from the distribution of certain past plant and animal species whose occurrence is inexplicable unless continental drifting is invoked. Striking correspondences are to be found in the fossil remains of the rocks of perma - carboniferous age found in South America, Africa and India.



4. Traces of glaciation dating from the Carboniferous period are to be found in the far-separated Landmasses of South America, Australia Africa and India.

5. If the great Tertiary fold mountain system were formed by geosynclinal sediments being squeezed, folded and uplifted by advancing shield forelands then Wegener postulated equatorward drift might explain the young fold mountain ranges of Europe North Africa and Asia and his postulated westward drift the creation of the American Cordilleran systems.

<u>Difficulties OR Weaknesses</u>

A. The greatest weakness in the theory is to find a means of 'engineering' continental drift. The forces suggested by Wegener

I. to cause the disruption of Pangea and later Laurasia and Gondwana land into gigantic fragments and
II. to cause lateral displacement of those fragment over distances of thousands of miles are utterly inadequate

Upon this key problem the theory has largely foundered.

B. These is another important weakness which relates to the times of drifting. According to Wegener the breaking up of Proto Continent mainly occurred in early tertiary times. Thus, even If as we accepted continental drifting causing mountain building and being responsible for the tertiary mountain ranges, we are still left with the problem of accounting to the formation of mountain systems of which there are many before the tertiary period.

If all the points in the theory could be established and an adequate motive force discovered then we should have to credit Prof. Wegener with the greatest piece of geological synthesis.

Many geologists even if they do not go all the way with Wegener, still adhere to the Principle of Continental wandering.

<u>EARTH'S PALEOMAGNETISM</u> (पृथ्वीचे पुराचुंबकत्व)

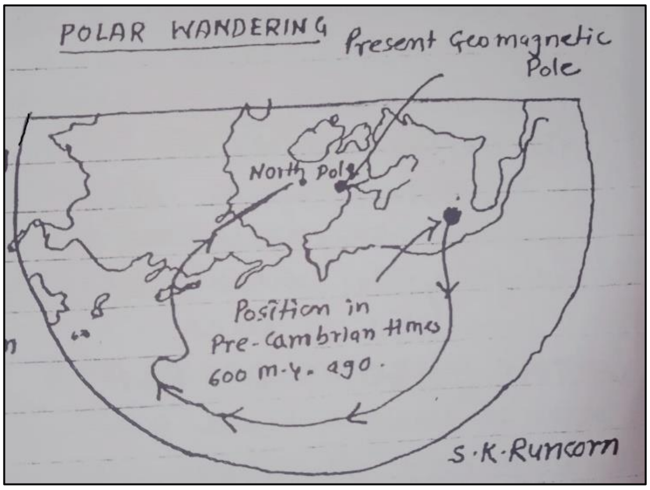
Paleomagnetism is the study of the earth's magnetism during the geological past. Palaeomagnetic investigation discloses the orientation of the magnetic field of the rocks when they were originally laid down. This orientation arises in the following way.

When igneous rocks are initial laid down or extruded the magnetic particles within them take on the same direction. The same dip as the local geomagnetic field at the time of their consolidation.

Recent research into the magnetic structure of rocks shows that magnetic orientation of the fields of rocks of the continents varies between one geological period and another.

Expressing this in a different way, fossil magnetism offers a means whereby the positions of the continents may be located at various time during past geological ages.

The curve of wondering traces route by which a continental block has moved science Pre Cambrian times i. e. during the past 160 million.



The use of the term 'poler wandering is rather unfortunate as it suggests that the Poles have moved this is not so. It is the continents which have changed their positions.

By using the evidence from the rocks, it has become possible to track the past movements of a continental area relative to its nearest magnetic pole.

'A Polar wandering curve' as Prof. Runcorn termed it is a reflection of the past movements of continent.

Runcorn's term pole wandering curve is confusing in that it implies a large-scale movement of the poles which in fact has not taken place. It has been shown that each continent has its own wandering curve.

Thus, because the magnetic poles have been more or less stationary throughout geological time and because each continent possesses rocks showing different magnetic orientation the following conclusions may be made -

A. Since each continent has a polar wandering curve it must have moved about the surface of the earth.

B. Since these curves are different for each continent then the continents must have moved relative to each other

Palaeomagnetic studies have therefore greatly strengthened the idea that continental drifting has taken Place.

THE THEORY OF PLATE TECTONICS (भूमंच विवर्तनिकी सिध्दांत)

(Tujo wilson/mongan)

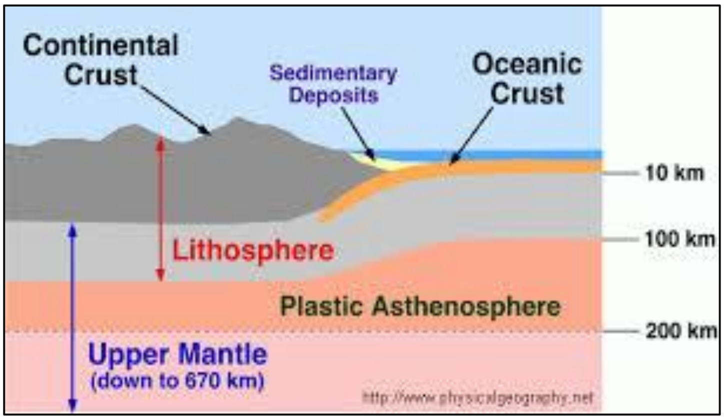
The theory describing the movements and evolution of the continents and ocean basins and the processes that fracture and fuse them is called Plate Tectonics.
Tectonic is a noun meaning is 'The Study of tectonic activities.

LITHOSPHERE (शिलावरण)

The Lithosphere is much thicker zone than the crust. It includes not only the crust but also the cooler upper part of mantle that is composed of brittle rock. The lithosphere ranges in thickness from 60 to 150 km.

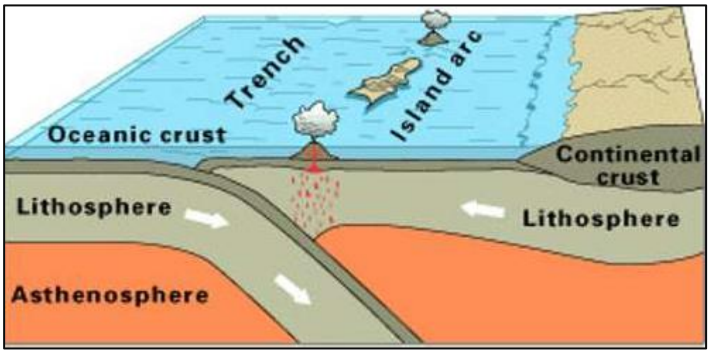
ASTHENOSPHERE: (शिलावरणाच्या खाली मृदु व लवचिक आवरण /दुर्बलावरण)

Some tens of kilometers deep in the brittle conditions of Lithosphere rock gives way gradually to a plastic or 'soft' layer named the on Asthenosphere. (Greek word asthenes meaning weak)



However, at still greater depth in the mantle the strength of the rock material again increases.

Thus, the Asthenosphere is a soft layer sandwiched between 'brittle' lithosphere above and a 'strong' mantle rock bellow. In terms of states matter, the asthenosphere is not a liquid even though its temperature reaches 1400^0 c.



LITHOSPHERIC PLATES- Because the asthenosphere is soft and plastic, the rigid lithosphere can easily move over it. The lithospheric shell consists of large pieces called lithospheric plates.

A single plate can be as large as continent and can move independently of that plates that surround it.

OCEANIC LITHOSPHERIC PLATES - Plates that lie beneath the ocean basins consist of oceanic lithosphere. This form of lithosphere is comparatively thin (about 60 km).

The two kinds of Lithosphere can be thought of as floating on the soft asthenosphere.

(Consider two blocks of wood one thicker than the other floating on surface of water. The surface of thick block will rise higher above the water surface than that of the thin block. This principle explains why the continental surfaces rise high above the ocean floor.)

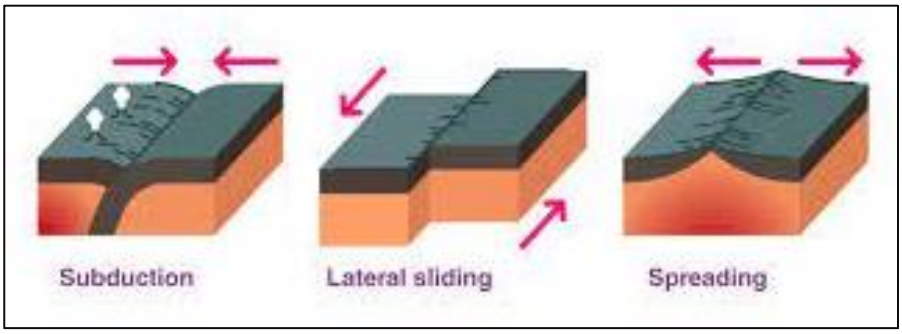
PLATE MARGINS OR BOUNDARIES -

1. SPREADING BOUNDARY (पसरणारी सीमा)

As shown in following figure plates are pulling apart along their common boundary which lies along the axis of mid ocean ridge. This pulling apart tends to create a gaping crack in the crust but magma continually rises from the mantle beneath to fill it. The magma appears as basaltic lava in the floor of the rift and quickly congeals. (गोठणे, थिजणे, घट्ट होणे) At greater depth under the rift magma solidifies into gabbro, an intrusive rock (आंतरिक खडक) of the same composition as basalt. Together the basalt and gabbro continually form new oceanic crust. This type boundary between plates is termed as spreadingboundary.

2. CONVERGING BOUNDARY (संमिलीत सीमा)

At the right in diagram the oceanic lithosphere plate is moving toward the thick mass of continental lithosphere that comprises at C where these two plates collide, they form a converging boundary.



SUBDUCTION (अधोगमन)

Because the oceanic plate is thin and dense in contrast to the thick and buoyant continental plate the oceanic lithosphere bends down and plunges into the soft layer or asthenosphere. The process in which one plate is carried beneath another is called Subduction

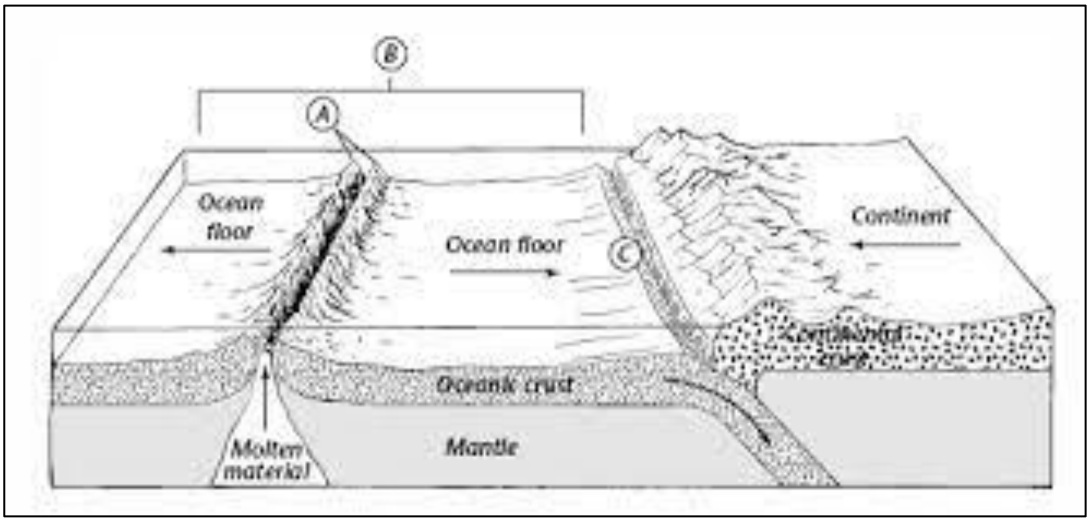
<u>**SEA FLOOR SPREADING**</u> (सागरतळ अपसरण)

The leading edge of the descending plate is cooler and therefore denser than the surrounding hot soft asthenosphere as a result the slab sinks under its own weight once subduction began. However, the slab is gradually heated by the surrounding hot rock and thus eventually softens. However, the descending plate is covered by a thin upper layer of less dense minerals matter derived from oceanic and continental sediments. This material can melt and become magma. The magma tends to rise because it is less dense than the surrounding material.

When the balloons of magma reach the earth's surface, they form a chain of volcanoes lying about parallel with the deep oceanic trench that marks the line of descent of the oceanic plate. As in figure we see that this single lithospheric plate is simultaneously undergoing both accretion (growth by addition) and consumption (loss by softening and melting in subduction zones). Thus, sea-floor spreading, builds lithospheric plates by accretion.

If the rates of accretion and construction are equal the plate will maintain its overall size.

If Consumption is slower the plate will expand. If accetion is slower, the plate will shrink.



3. TRASFORM BOUNDARY

We have got to consider a third type of lithospheric plate boundary. Two lithospheric plates may be contact along a common boundary on which one plate merely slides past the other when no motion that would cause plates either to separate or converge. This is a transform boundary. The plane along which motion occurs is a nearly vertical fracture extending down through the entire lithosphere and it is Called transform fault. Transform boundaries are associated with mid oceanic ridges and are Shown in fig No. 2

In Summary there are three major kinds of active plate boundaries.

Spreading boundaries: New lithosphere is being formed by accression
Example: sea floor spreading along the axial rift.

Converging boundaries: Subduction is in Progress and lithosphere is being Consumed. Example: Active Continental margin.

Transform boundaries: Plates are gliding past one another on transform fault.
Example: Transform boundary associated to mid oceanic ridge.

THE GLOBAL SYSTEM OF LITH OSPHERIC PLATES

Six Great Plates: The global system of lithospheric plates consists of great plates Several lesser plates and Subplates are also recognised.

The lithospheric Plates

Great plates	Lesser Plates
1. Pacific	1. Nazca
2. American (North, South)	2. Cocos
3. Eurasian	3. Philippines
Persian Subplate	4. Caribbean
4. African	5. Arabian
Somalian Subplate	6. Juan de Fuca
5. Austral – Indian	7. Caroline
6. Antarctic	8. Bismark
	9. Scot

1. THE GREAT PACIFIC PLATE

The great Pacific Plate occupies much oceanic ocean basin and consists almost entirely of oceanic lithosphere. Its relative motion is north westerly. So that it has a subduction boundary along most of the western and northern edge. The eastern and southern edge is mostly a spreading boundary.

A Sliver of continental lithosphere is included and makes up the coastal portion of California and all of Baja California. The California is bounded by an active transform fault – The San Andreas fault.

2. THE AMERICAN PLATE

The American plate includes most of the Continental lithosphere of North and South America. It also includes the entire oceanic lithosphere lying west of the mid oceanic ridge that divides the Atlantic Ocean basin. For the most part the western edge of the American plate is a Sub duction boundary with oceanic lithosphere dividing beneath the continent lithosphere. The eastern edge is a spreading boundary.

3. THE EURASIAN PLATE:

The Eurasian plate is mostly continental lithosphere but it is fringed on the west and north by a belt of oceanic lithosphere.

4. THE AFRICAN PLATE:

The African Plate has a central core of continental lithosphere nearly surrounded by oceanic lithosphere.

5. THE AUSTRAL INDIAN PLATE: -

The Austral - Indian plate takes the form of long rectangle. It is mostly oceanic lithosphere. But it contains two cores of continental lithosphere - i) Australia ii) Peninsular India. Recent evidence Shows that there two continents' masses are moving independent and may actually be considered to be parts of Separate plates.

6. THE ANTARCTIC PLATE: -

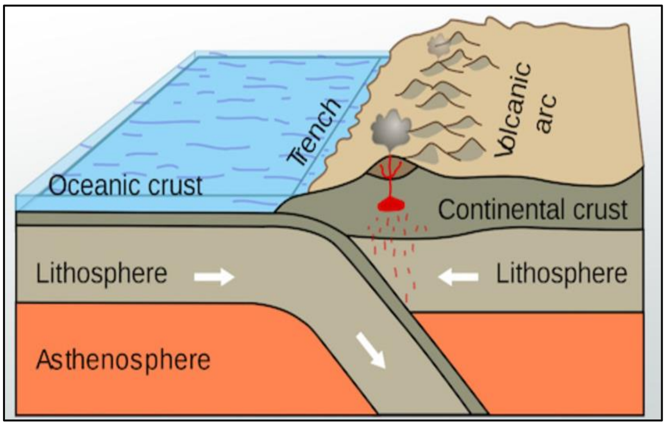
The Antarctic Plate has an elliptical shape is almost completely enclosed by a spreading plate boundary. This means that the other plates are moving away from the pole. The continent of Antarctica forms a central core of continental lithosphere completely surrounded by oceanic lithosphere.

<u>EFFECTS OF PLATE MOVEMENTS</u>

1. SUBDUCTION TECTONICS:

Converging plate boundaries with subduction in progress are zones of intense tectonic and volcanic activity. The narrow zone of a continental that lies above a plate undergoing subduction is therefore an active continental margin.

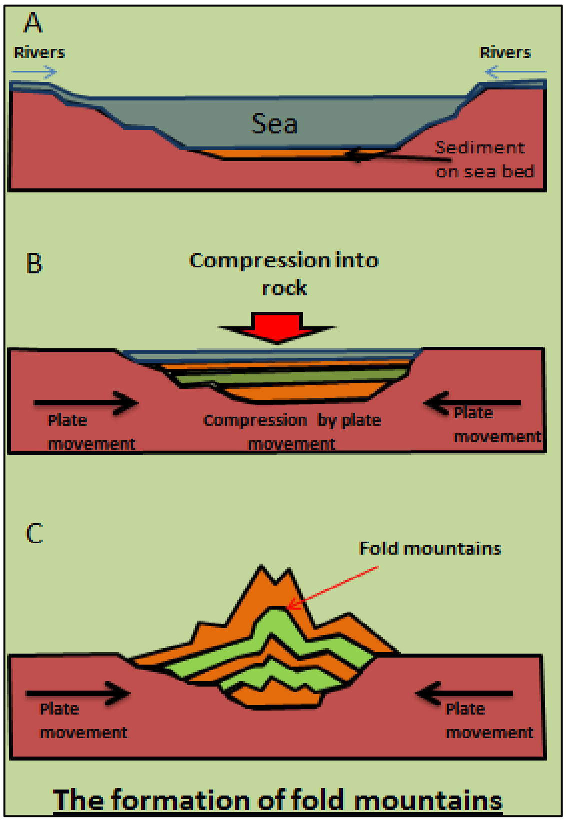
In the bottom of the trench sediments are intensely deformed and are dragged down with the moving plate. The deformed sediment is then scraped off the plate and shaped into wedges that ride up one over the other. The Sediment wedges accumulate into a large mass in which metamorphism takes place. In this way, the continental margin is built outward as new continental coast of metamorphic rock is formed.



Intense heating of the upper surface the descending plate melts the oceanic crest, forming magma. Some of oceanic the magma rises and reaches the surface to form Volcanoes

2. OROGENES AND COLLISIONS: -

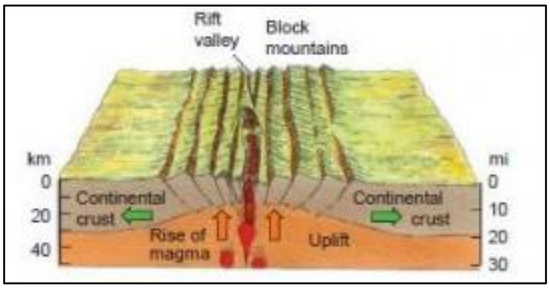
Two Continental lithospheric plates converge along a subduction boundary. Ultimately the two masses must collide. The result is an orogeny in various kinds of crustal rocks are crumpled into folds and sliced into nappes. The collision zone is named as continental suture. A mass of metamorphic rock formed between the joined continental plates, welding them together. Thus, new continental mass is the continental suture.

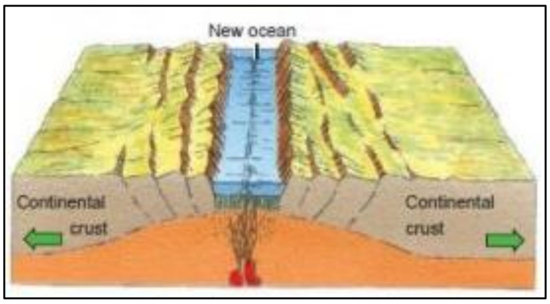


1. Alps was formed when the African plate collided with the Eurasian plate.
2. Himalayan ranges are formed due to the collision of the Indian Continental portion Austral-Indian plate with the Eurasian plate.

3. CONTINENTAL RUPTURE AND NEW OCEAN BASINS

The continental margins bordering the Atlantic Ocean basin on both its eastern and western slides are very different from the active margin of a subduction zone.

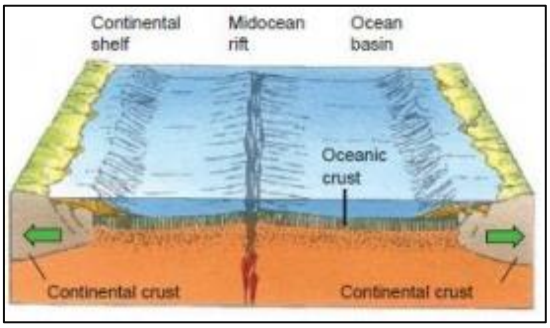




At present the Atlantic margins have no important tectonic activity and are passive continental margins. Passive margins are formed when a single plate of continental lithosphere is rifted apart. This Process is called Continental rupture.

The adjoining figures show how continental rupture likes place and leads to the development of passive continental margins. The widen crack in its centre is continually filled in with magma rising from the mantle below.

The magma solidifies to form new crust in the floor of the rift valley Rift Valley.

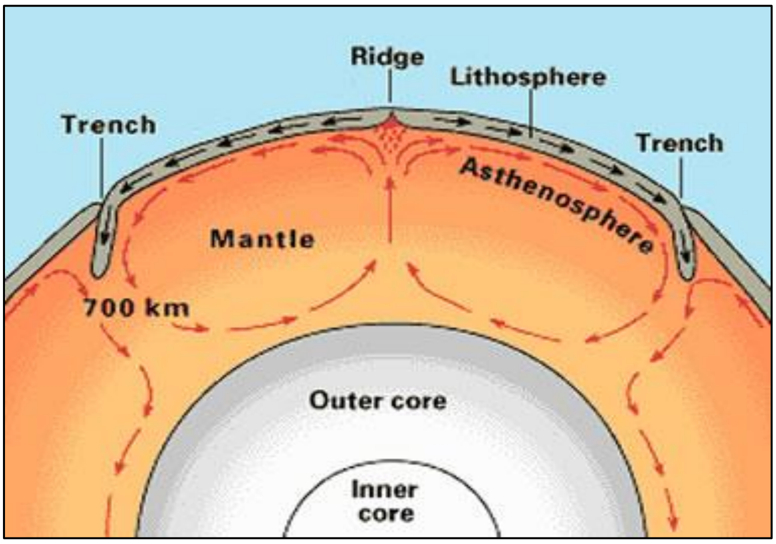


The rift valley system of east Africa is notable example of this stage of continental rupture.

The Red Sea is a good example of the recent continental rupture. Its straight coasts mark the edges of the rupture.

THE POWER SOURCE FOR PLATE MOVEMENTS

Plate movements are thought to be powered by radiogenic heat released by decay of naturally occurring radioactive. Isotopes found in the upper layers of the crust and mantle. The heat is thought to generate convection currents in the plastic mantle rock of the asthenosphere. Upwelling mantle rock lifts lithospheric plates causing them to fracture and slide away from the rift.



Questions- 1. Name the Six great lithospheric plates. Identify on example of the spreading boundary by general geographic location and the plates involved. Do the same for a converging boundary.

2. Describe the process of subduction as it occurs at a converging boundary of continental and oceanic lithospheric plates. How is the continental margin extended? How is subduction related to volcanic activity?

3. How does continental rupture produce passive continental margins? Describe process of rupturing and its various states.

4. What are transform faults? Where do they occur?

5. Identify and describe two types of lithospheric plates. Sketch a cross section showing collision between two plates?

6. Sketch a continent collision and describe the formation process Suture with proper examples.

WEATHERING AND MASS WASTING

WEATHERING

DEFINITION:

Strahler: Weathering is the combined action of all processes that cause rock to disintegrate physically and decompose chemically because of exposure near the earth's surface.

Spark: Weathering may be defined as the mechanical fracturing or chemical decomposition of rocks in situ by natural agents at the surface of the earth.

FACTORS AFFECTING WEATHERING:

I. The degree and nature of the weathering depends upon several factors
II. The kind of rocks: Its mineral composition, structure, hardness, softness.
III. The Climatic condition
IV. The presence or absence of a vegetation cover and the character of this cover.
V. Fortuitous (आकस्मिक) conditions: The slope of the land surface, the degree of exposure to sun, wind, rain etc.

1) **Mineral Composition of Rocks -**
Minerals present in the igneous rocks may be divided into
a. Light coloured minerals - felspars- alumins - silicalis of potassium, sodium and calcium
b. The dark-coloured minerals are silicates of iron, magnesium and calcium ferro magnesium mineral

The mineral composition varies considerably from class to class and consequently chemical weathering is different. Dark coloured minerals are more susceptible to chemical weathering than the light-coloured minerals.

- **Texture of Rocks**: •Texture may be defined as crystalline state of the rock, whether coarse grained, fine grained under certain conditions coarse grained rocks get weathers more rapidly than fine grained rocks.

- **Minor Structures:** Minor structures found in rocks are principally joints. These joints greatly increase the surface available for weathering and accelerate the general rate of weathering of the rock.

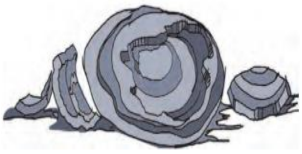
2) **Effect of Climate on weathering** -: Climate affects the relative importance of the different types of weathering. Physical weathering predominates in cold and dry regions and chemical weathering in humid climates.

3) **Relief:** In areas of high relief and steep slopes weathering can operate effectively. Water will run quickly and chemical weathering may be reduced.
In areas of gentle relief, a thick layer of soil and other weathered material is usually present. This protects the rocks from further mechanical weathering and by holding water enhances chemical decomposition.

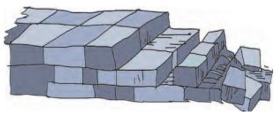
1) **Vegetative Cover:** Plants may act as a protective cover and so prevent the wasting of soil on the other hand their roots may assist the penetration of water and so help solution. Plants may also extract certain constituents from the soil and so help to break them down.

Important Terms:
Granular disintegration, Exfoliation, Block Separation, Shattering, Regolith

Granular disintegration: (कणीय विखंडण) Rocks composed of rather coarse mineral grains (intrusive igneous rocks) commonly fall apart grain by grain. This form of break up is termed as granular disintegration.



Exfoliation: (अपपर्णन किंवा विलगीकरण) Exfoliation is the formation of curves rock shells which separate in succession from the original rock mass leaving behind successive smaller sphenoidal bodies. This type of break up is called spalling.



Joint black Separation: (खंड विखंडन) Where a rock has numerous joints previously by mountain making pressures or by shrinkage during cooling from a magma. The common form of break up is by joint block separation

Shattering: (तुकडीकरण) Shattering is the disintegration of rock along new surfaces of breakage in otherwise massive strong rock to produce highly angular pieces with sharp corners and edges.

Regolith: - (संचयन) Layer of mineral particles overlying the bedrock may be derived by weathering of underlying bedrock or be transported from other locations by fluid agents.
Types - 1) Residual regolith 2) Transported regolith

TYPES OF WEATHERING-

Weathering processes may be subdivided into

- Physical (Mechanical) Weathering (कायिक किंवा यांत्रिक विदारण)
- Chemical weathering (रासायनिक विदारण)
- Biological weathering (जैविक विदारण)

1) PHYSICAL/MECHANICAL WEATHERING

Definition- The physical / mechanical processes of weathering produce fine particles from massive rock by the exertion of stresses sufficient to fracture the rock but do not change its chemic Composition.

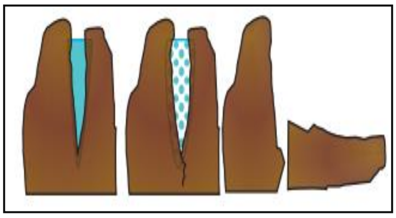
Factors of Mechanical Weathering

A. **Temperature variations:** When bare rock surfaces are exposed to the direct rays of the sun they become greatly heated. This heating is confined to the surface of the rock. However, since rock is poor conductor of heat the underlying layers are scarcely affected. This means that the heated surface layers of rock are expanding away from the underlying rock that has not been heated. The constant alternate heating and cooling of the rock surface causes mineral expansion and contraction with the various mineral constituents expanding at different rate. This repeated action may lead to the breaking off of the individual mineral grains the splitting off of thin layers of rock and the shattering of the bedrock into blocks.

Granular disintegration- The grain by grain break up of rocks is called granular disintegration.
Exfoliation- The peeling shelling off in onion like layers in called exfoliation or spalling.
Block disintegration- The breaking up of bedrock into blocks is termed block disintegration.

Mechanical weathering due to the process of temperature variations is more powerful in the regions of subtropical and tropical deserts.

B. **Frost Action:** In cold climates the physicals weathering takes place by the repeated growth and melting of ice crystals in the pore spaces or fractures of soil and rock. As water in joints freezes it forms needle like ice crystals extending across the openings. As these ice needles grow, they exert tremendous force against the walls and can easily pry apart the joint blocks.



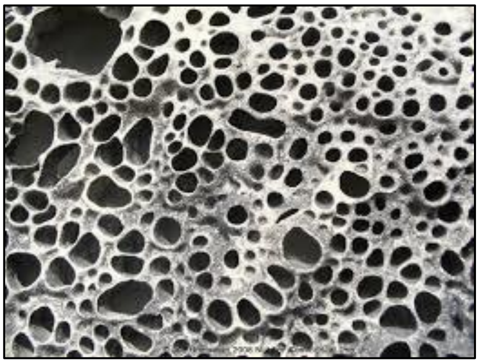
Frost action naturally is most common in cold lands and at high altitudes where low temperatures are experienced. In such areas the process usually active. Exposed summit areas suffer frost wedging and show shattered needle shaped peaks.

The piles of sharp, angular rock fragments that lie at the foot of or the slopes of mountains known as scree (डबर) or talus (उभ्या कड्याच्या पायथ्याशी असलेला दगड धोड्यांचा थर) originate from frost action.

C. **Action of Rain -:** The mechanical weathering action of rain occurs wherever rain falls but is especially pronounced when the rain is torrential in its character. Heavy rain will rapidly wash away loose sands.

The continual swelling and shrinking of soils take place when the particles fine silt and clay absorb or give up soil water in alternate periods of rain and drought. Shrinkage forms cracks in dry periods making the infiltration of rainfall much more rapid.

D. **Mechanical weathering by the growth of salt crystals: -**



The weathering process of rock disintegration also takes place by growth of salt crystals in rock pores. This process, salt crystal growth, operates extensively in dry climates and is responsible for many of the nitches, shallow caves, arches formations and pit seen in sandstone.

During long drought periods groundwater is drawn to the surface of the rock by capillary action. As evaporation of water takes place in the porous outer zone of the sandstones tiny crystals of salts are left behind. The growth force of these crystals produces grain by grain breakup of the sandstone which crumbles into sand and is swept away by wind and rain.

E. **Plant Roots:** Another mechanical weathering of rock break up is the growth of plant of roots; which can wedge joint blocks apart. This process is also active when roots grow between rock layers or joint blocks. Even fine rootlets fractures can cause in the loosening of small scales and grains.

2) CHEMICAL WEATHERING

Definition- Chemical change in rock forming minerals through exposure to atmospheric conditions in the presence of water mainly involving oxidation, hydrolysis, carbonic acid action or direct solution.

Chemical weathering processes includes many chemical processes. Chemical changes involve actual chemical reactions. The chemical changes that occur in weathering involve chiefly solution, oxidation, reduction, hydration and carbonation.

1. Solution: Much chemical weathering results from various acids in weak solutions in water penetrating and attracting the mantle and bedrock. Some mineral particles may be completely dissolved away and removed in solution.
2. Oxidation: Oxidation affects metals and various metallic compounds to produce oxides, this is seen in rocks containing iron. Iron is common element but usually occurs in the ferrous state. This may become oxidized to the ferric condition forming a brown or yellow crust which crumbles easily.
3. Reduction: The reverse process of oxidation or loss of oxygen is known as reduction. This is less common occurrence. It happens when percolating water becomes changed with humic acid, a complex organic acid formed by the partial decay of vegetable matter. This helps in the chemical weathering of rocks. For examples, ferric compounds are affected by the solution and undergo reduction to the ferrous state.

4. Hydration: Hydration means the taking up of water as a chemical constituent. The hydration of felspar for instance, results in the formation of clay. The china caly results in the formation of rotting of granite which is composed mainly of the minerals quartz, felspar quartz and mica are almost insoluble. Felspar becomes changed to soft kaolinite.

In warm humid climates of the equatorial tropical and subtropical zones, hydration and oxidation often results in the decay of igneous and metamorphic rocks.

The hydration of exposed granite surfaces is accompanied by the grain-by-grain breakup of the rock. This process creates many interesting boulder and pinnacle forms by the rounding of joint blocks. These forms are particularly found in arid regions. Large joint blocks of granite are gradually rounded into smooth forms by gain by disintegration in desert environment.

5) Carbonation -: Carbonation involves conversion of carbonates into the much more soluble bicarbonates. Rainwater which has the more carbon dioxide gas from the air is turned into a weak carbonic acid. This diluted reacts upon such acid calcareous rocks as chalk limestone converting the calcium carbonate of which they are composed into the much mare soluble form calcium carbonate.

Carbonic acid reaction with limestone produces many interesting surface forms. Outcrops of limestone typically show Cupping, rilling, grooving and fluting in intricate designs.

Dissolution of limestone by carbonic acid in ground water can produce underground caverns as well as distinctive landscape that are formed when underground caverns collapse.

6) Desilication: Desilication is the process of removing silica from rocks. Many rocks contain much silica and igneous and metamorphic contain silicate minerals. Chemical action readily breaks up the complex molecules of Silicate minerals.

The rate of chemical weathering varies considerably in different parts of the world. It is at its maximum in the hot, humid regions of low latitudes, where both the high temperatures and abundant moisture accelerate the speed at which chemical reaction take place.

On the other hand, in high Latitudes and high altitudes and even in the hot arid desert regions, chemical weathering tends to be at its minimum.

3) BIOLOGICAL WEATHERING

Definition: Biological or organic weathering refers to the weathering activities made by animal and plant action.

Biological weathering is at once mechanical and Biological. Biological weathering is significant for the formation of soil.

Prying action of Plants:

Tree roots penetrate cracks and as the roots grow, they exert a powerful force widening the cracks and sometimes dislodging rocks.

The playing action of roots also allows water and air to penetrate more deeply into the rocks. Thus, allowing them to carry their work of weathering to greater depths.

Prying action of animals:

Animals such as moles, rabbits and other burrowing creatures and earthworms help to loosen and weaken the soil and rock and make it more easily movable by other agents. Certain marine organisms are capable of boring into rock and in this way, they may weaken the rock structure.

The organic acids produced by animals and plants and secreted by them also aid the process of weathering by promoting decay. Plants produce humic acid which helps in the reduction of ferric compounds and affects the processes of soil formation by encouraging the removal of strong bases from the upper layers. The bacteria in the decaying vegetable matter of soils play a very of important role in the formation of soils.

In these and various other ways organisms undertake useful work in decomposition and disintegration of the land surface.

Summing up, we can say that the weathering process is the outcome of physical, chemical and biological action.