# General Knowledge Today



# Prelims Geography-5: Land Relief, Land Forms, Rock & Minerals

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# Contents

# Model Questions

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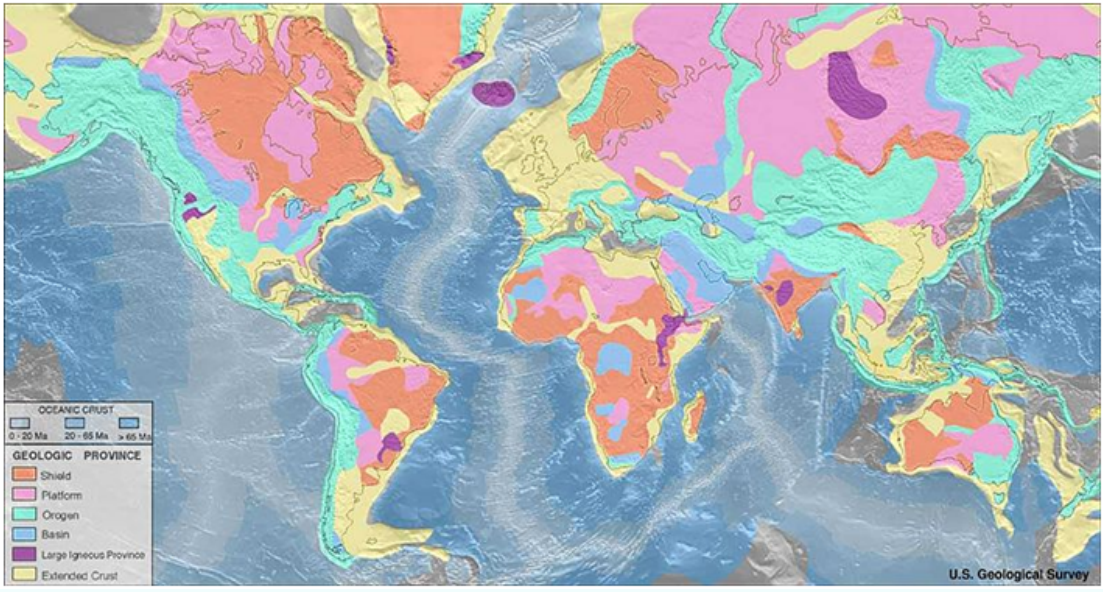
# Relief Features of the Land and Landforms

## Geological Provinces

The entire Earth has been divided into several Geological Provinces on the basis of their origin. A geologic or geomorphic province is an entity with common geologic or geomorphic attributes. The six Geological provinces include:

- **Continental Shield**
- **Platform**-which is a shield covered with sediment
- **Orogen**-which leads to development of mountains
- **Structural Basins**-which are geological depressions, and are the inverse of domes
- **Large igneous provinces**-which are extremely large (More than 100,000 Km² ) accumulation of igneous rocks—intrusive, extrusive, or both—in the earth's crust. One example of large igneous province is India's Deccan trap.
- Extended Crust.






## Continental Shields

The first order of relief contains Earth's continents and ocean basin, which were created by the movements of plates on the surface of the Earth. The lithospheric shell of the Earth is divided into

large pieces called **lithospheric plates**. A single plate can be as large as a continent and can move independently of the plates that surround it. This is very much similar to a great slab of ice floating on the polar sea. The continents can be geologically derived into two types of regions viz.

- Active mountain-making belts and
- Inactive regions of old, stable rock.

The mountain ranges in the active belts grow through **two major complex geologic processes**.

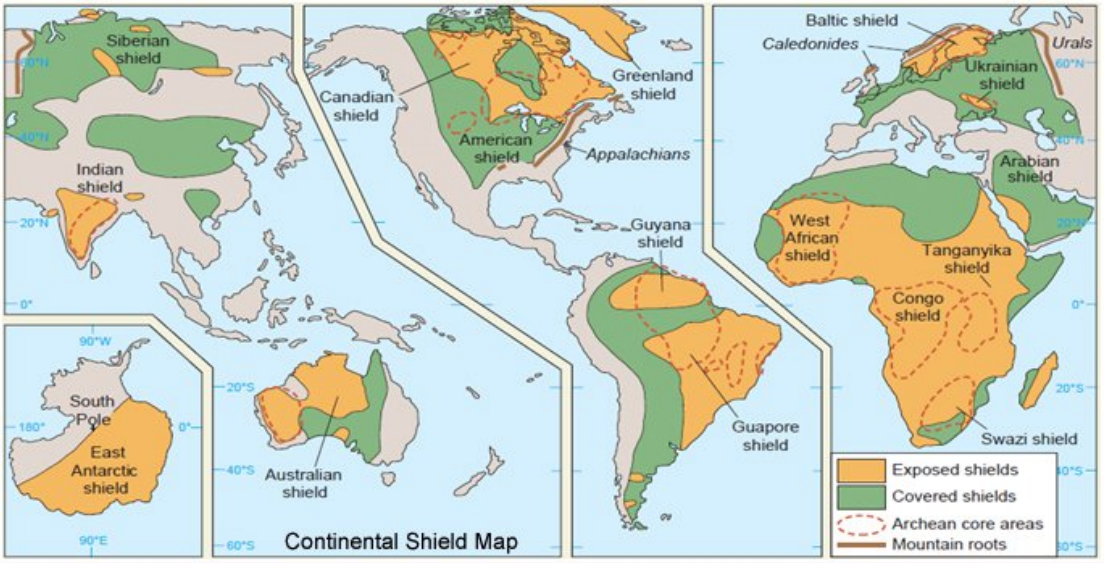
- First of them is **volcanism,** in which massive accumulations of volcanic rock are formed by extrusion of magma.
- Second process is the **tectonic activity**e. the breaking and bending of the Earth's crust *under internal Earth forces.* This tectonic activity usually occurs when great lithospheric plates come together in collision. Crustal masses that are raised by tectonic activity create mountains and plateaus. At some places, both volcanism and tectonic activity combine to produce a mountain range. ***Tectonic activity can not only form mountains but also lower crustal masses to form depressions***.



Please note that the active mountain-making belts are narrow zones that are usually found along the margins of lithospheric plates. The rest of the Lithospheric plates are much older, comparatively inactive rocks. There are two types of stable structures— **continental shields** and **mountain roots**.

The **continental shields** are regions of low-lying **igneous and metamorphic rocks**. The shields may be exposed or covered by layers of sedimentary rock. The core areas of some shields are made of rock dating back to the Archean eon, 2.5 to 3.5 billion years ago. Thus, continental shields are formed on ancient metamorphic rocks such as granitic, batholiths, and dikes. The oldest rocks on Earth are found in the shields.

Mountain roots are mostly formed of Paleozoic and early Mesozoic sedimentary rocks that have been intensely bent and folded, and in some locations changed into metamorphic rocks. Thousands of meters of overlying rocks have been removed from these old tectonic belts, so that only the lowermost structures remain. Roots appear as chains of long, narrow ridges, rarely rising over a thousand meters above sea level.




## Mountain Formation: Orogeny

Orogeny is primarily the mechanism by which mountains are built on continents due to the large structural deformation of the Earth's lithosphere caused by Plate Tectonics. Orogenesis involves the following:

- Structural deformation of the rocks
- Faulting of rocks
- Folding of rocks
- Igneous Processes
- Metamorphism
- Glaciation
- Erosion
- Sedimentation

Mountains are born and have a finite life span. Young mountains are high, steep, and growing upward. Middle-aged mountains are cut by erosion. Old mountains are deeply eroded and often buried.

We have to note here that the constructive processes, like deformation, folding, faulting, igneous processes and sedimentation build mountains up. On the contrary, the destructive processes like erosion and glaciation, tear them back down again.

### Causes of Mountain Building

There are three primary causes of mountain building as follows, which have already studied:

- Convergence at convergent plate boundaries.

- Continental Collisions
- Continent Rifting

## Forms of Mountains

A mountain may have several forms. Important among them are: i) mountain ridge, ii) mountain range, iii) mountain chain, iv) mountain system, v) mountain group, and vi) cordillera.

### Mountain Ridge

It is a linear, steep-sided high hill, or spur. The slope of one side of a ridge is steep, while the other side is of moderate slope. A ridge, however, may have symmetrical slopes on both sides. The Shimla Ridge is a good example of mountain ridge.

### Mountain Range

A mountain range is a linear system of mountains and hills having several ridges, peaks, summits and valleys.

### Mountain Chain

A mountain chain consists of several parallel long and narrow mountains of different periods.

### Mountain System

A mountain system consists of different mountain ranges of the same period. In a mountain system, different mountain ranges are separated by valleys.



### Mountain Group

A mountain group consists of several unsystematic patterns of different mountain systems

### Cordillera

It is a Spanish term referring to a system or major group of mountains. A cordillera consists of several mountain groups and systems. In other words, cordillera is a community of mountains having different ridges, ranges, mountain chains and mountain systems. It usually refers to an orogenic belt at a continental scale, e.g., the Western Cordillera of the U.S.A., which includes all the ranges between the Pacific and the Great Plains.

## Types of the Mountains

No two mountains are the same. They, however, can be classified on the basis of their most dominant characteristics into: i) folded mountains, ii) volcanic mountains, iii) fault-block mountains, and iv) upwarped (dome) mountains.

### Folded Mountains

Folded mountains comprise the largest and most complex mountain systems. Although folding is the dominant characteristic, faulting and igneous activity are always present in varying degrees in folded mountains. The Alps, Himalayas, Rockies, Andes, Appalachians, Tien Shan, Caucasus, Elburz, Hindukush, etc., are all of this type. The folded mountains present the world's major mountain systems. They are the youngest mountains in the world.

### Volcanic Mountains

Volcanic mountains are formed from the extrusion of Java and pyroclastic materials, which if

continued long enough, produces gigantic volcanic piles. The Kilimanjaro (Africa), Cotopaxi (Andes), Mt. Rainier, Hood and Shasta (U.S.A.), are some of the examples of volcanic mountains.

### Fault Block Mountains

Fault-block Mountains are bounded by high angle normal faults. Some of them are associated with rift valleys such as those in East Africa, while others appear to be formed by vertical uplifting. A notable example of fault-block mountain is found in the Basin and Range Province of the southwestern USA. The Salt Range of Pakistan, and Siena-Nevada of California (U.S.A.) are also the typical examples of fault-block mountains.

### Upwarped (Domed) Mountains

Upwarped or domed mountains are formed by magmatic intrusions and upwarping of the crystal surface. The lava domes, batholithic domes, laccolithic domes, salt domes, etc., are the examples of Dome Mountains. The Black Hills of South Dakota, and the Adirondack mountains of New York may be cited as the examples of upwarped (domes) mountains.

## Different Stages of Orogeny

Mountains can also be divided on the basis of their making i.e. Orogeny during different geological periods.

### Pre-Cambrian Orogeny



This was the first ever Orogeny on earth and represents the oldest mountains of the earth. The examples are Laurasian of North America, Elogoman etc.

### Caledonian or Mid Paleozoic Orogeny

It occurred during Silurian and Devonian periods. The example are Aravallis of India, Brazilian Highlands in America, Scotland of Europe etc.

### Harcynian or Late Paleozoic Orogeny

This occurred in the Permian period. Example are Appalachian of North America, Black Forest of Europe etc.

### Alpine Orogeny

This took place in Tertiary period and represents the youngest and newest mountain ranges of Earth. The examples are Himalaya, Rocky, Andes, Apennines, Alps etc.

## Plateaus

Plateau is an elevated tract of relatively flat land, usually limited on at least one side by a steep slope falling abruptly to lower land. It may also be delimited in places by abrupt slopes rising to residual mountains or mountain ranges, as in the Tibetan plateau, where it occurs as an intermontane plateau. The term is also used to refer to a structural surface such as Meseta of Spain, in which case it is a tectonic plateau. It is also used to describe extensive lava flows (lava plateau). The surfaces of plateaus may be plain-like in quality, very flat, rolling or hilly, or they may be so dissected by streams and glaciers that it is difficult to recognize their original plateau characteristics.

### Diastrophic Plateaus

Diastrophism is the large-scale deformation of the earth's crust which produces continents, ocean basins and mountain ranges, etc. All the highest plateaus of the earth are the direct products of diastrophism. Since their uplifts they have been modified by various agents of erosion and in many cases by volcanism and minor earth movements. For convenience they may be classified as:

- Intermontane plateaus
- Mountain border plateaus
- Domed plateaus,
- Volcanic plateaus
- Erosional plateaus.

### Intermontane Plateau

Intermontane Plateaus include the highest, largest and in many respects most complex plateaus of the world. Their surfaces show an extraordinary variety of topographic features.

- The best example is the Tibetan Plateau. It stretches approximately 1,000 kilometers north to south and 2,500 kilometers east to west. The average elevation is over 4,500 meters (14,800 ft), and all 14 of the world's 8,000 metres (26,000 ft) and higher peaks are found in the region. Sometimes called "the roof of the world," it is the highest and biggest plateau, with an area of 2.5 million sq. km or about four times the size of France. The Tibetan Plateau is bounded on the north by the Kunlun mountains, and in the south by the mighty Himalayas. These two systems meet to make the western boundary of the plateau, while on the east is the less sharp demarcation between the plateau proper and the lower mountains of western China.The Qinghai-Tibet Plateau not only gives rise to most of Asia's major rivers, it also holds a constellation of salt- and freshwater lakes.
- Another example of Intermontane Plateau is Plateau of Bolivia and Peru. It lies largely in Bolivia at an average elevation of more than 3,692 metres (12,000 ft) above the sea level.
- One more example is Mexican Plateau which extends from the United States border in the north to the Cordillera Neovolcánica in the south, and is bounded by the Sierra Madre Occidental and Sierra Madre Oriental to the west and east, respectively.



### Border Plateaus

Many plateaus border mountain ranges and owe their present position to the same uplifts that raised the mountains. Piedmont plateau is an excellent example of border plateaus. This plateau is a strip of land that stands between tile Atlantic coastal plains and the Appalachian Mountains. Its eastern side is marked by a more or less definite fall-line where the gradient of the rivers is steepest. On the west it terminates against the mountains of the Blue Ridge. Plateau of Colorado is also an example of the border plateau. It is bounded on the northeast by the Rocky Mountains and on the southwest by the

Basin and Range Province.

**Domed Plateaus**

The plateau of Ozark (U.S.A.) is a good example of domed plateau. Ozark plateau was uplifted by folding and faulting into a broad dome some 65,000 sq km (40,000 square miles) in area during the Appalachian Revolution which occurred at the close of the Paleozoic Era.

**Volcanic Plateaus**

Volcanoes also form several varieties of plateaus. The largest are built by the lava flow. Smaller, degraded plateaus are formed by the resistant lava caps that protect the land from erosion and maintain its high elevation after the surrounding land has been worn away.

**Erosional Plateaus**

Such plateaus are formed particularly in semiarid regions where streams have cut away portions of high lands.

## Land Forms

Landforms are defined as the geomorphologic units defined by its surface form and location in the landscape. Landforms are typical elements of the topography. The water body interfaces also called landforms. They are categorized on the basis of elevation, slope, orientation, stratification, rock exposure, and soil types as follows:



- Aeolian landforms
- Coastal and oceanic landforms
- Erosion landforms
- Fluvial landforms
- Mountain and glacial landforms
- Slope landforms
- Volcanic landforms

### Aeolian landforms

Aeolian landforms refer to the Landforms that are formed by the winds. There are two types of the Aeolian Landforms viz. Erosional and Depositional.

**Aeolian Landforms: Erosional**




### Zeugen or Rock Mushrooms

They are also known as rock pedestal or a pedestal rock or Zeugen. Usually Found in Desert Areas.

### Yardangs

Yardangs form in environments where water is scarce and the prevailing winds are strong, unidirectional and carry an abrasive sediment load. They consist of an elongated ridge carved by the unidirections erosion.

Dreikanter

Dreikanter exhibits a 3 faced Pyramidal Shape. They typically form in Deserts due to wind erosion.

### Blow Outs

Blowouts refer to sandy depressions in a sand dune ecosystem, which are caused by the removal of sediments by wind.

### Inselbergs

Inselbergs refer to the prominent steep sided hill of solid rock rising abruptly from a plain of low relief. Inselbergs are generally composed of resistant rocks such as Granites.

### Desert pavement

Desert pavement refers to mountain wash containing pebbles, gravels and sand particles exposed to wind and surface appears as a pavement with closely packed, interlocking angular or rounded rock fragments of pebble and cobble size

**Aeolian Landforms: Depositional**


### Erg or Sand Sea

Erg is a sand sea or a dune sea. They are flat area of desert covered with wind-swept sand with little or no vegetative cover. The area is generally more than 100 square miles and is deposited by windblown sand. Largest Hot Desert in the World viz. Sahara has several sand Seas. The Ergs have 85% of Earth's mobile sand.



### Ripples

Ripples are well marked small waves produced on the surface of sand, mud and even rock by the drag of the wind / water moving over it. They are most common in deserts.

### Barchan

Barchan refers to crescent shaped dunes, which have tips or horns pointing downwards. Barchans are found in desert areas which have low sand quantity.

### Longitudinal dunes

Longitudinal dunes are also known as Seif dunes. Seif is a arabic word for Sword. These are long, slightly sinuous, ridge shapped dunes which are parellel to the wind direction, elongate parallel to the prevailing wind, possibly caused by a larger dune having its smaller sides blown away. Seif dunes are sharp-crested and are common in the Sahara.

### Transverse Dunes

Transverse Dunes are asymmatrical sands in deserts which are at right angle to the wind direction. They are most probably caused by a steady build-up of sand on an already existing minuscule mound.

### Star Dunes

Star Dunes are giant star shapped dunes with 3 or more sinuous arms extending outwards from the center. These shapes can alter due to windspeeds.

## Fluvial Landscapes

The landforms which develop as a result of the water action are known as Fluvial Landforms.

Running water such as rivers are the most important agent of erosion. Other agents such as Glaciers, Groundwater, wind and sea water are locally dominant agents of erosion. *The Fluvial processes are most important of all the exogeneric processes as landforms associated with them have overall dominance in the environment of terrestrial life.* These fluvial processes can be divided into three phases viz. erosion, transportation and deposition.

## Erosional Landforms

The **Erosion** can be **normal erosion** which takes place by the natural physical processes or the **Accelerated Erosion**, which is produced by human interference. The **Sheet Erosion** refers to the **s**urface flow removing soil in thin layers. It can be accelerated in the Steep slopes, where innumerable closely spaced channels are formed, which grows larger form in gullies (steep-walled canyon like trench). The Erosion can be of following types:

- Chemical erosion: Corrosion (Or solution) and carbonation.
- Mechanical erosion.
- Impaction (effect of blow upon the river bed or banks by large boulders).
- Cavitations (shattering and breaking up of the stream load through collisions and mutual abrasion).
- Hydraulic action (lifting and quarrying effect of rushing water).
- Corrosion or abrasion (stream uses its load to scrape away its bed, particularly in steep confined sections of stream channels).



## Landforms made by River Erosion


**V-shaped Valley**



Valley starts as small and narrow rills which gradually develop into long and wide gullies. The gullies will further deeper widen and lengthen to give rise to valleys which is V-shaped. The **River valley** is an important erosional landform. They are formed in the youthful stage of fluvial cycle of erosion. The vertical erosion or valley deepening causes the V-shaped valleys.

**Gorge & Canyons**

The V-shaped valley can be a **Gorge**, where steep precipitous wall within which a narrow river is confined (e.g. – Indus, Sutlej, Brahmaputra, Rhine, Zambezi). Thus, we can say that Gorge is a V-shaped valley but its sides becomes so steep that they look almost vertical. Or it can be a **Canyon**, which is basically a very deep and extended gorge. The Grand Canyon in Arizona, United States of America is the largest Canyon in the world.

**Meander**

The meanders or meandering rivers are the low slope rivers which are not choked with the sediment and move back and forth in a zig-zag order of loops. The meander has thus a serpentine path and it helps in accommodating in extra volume of water.

**River Terraces**

River terraces are abandoned floodplains that formed when a river flowed at a higher level than it does today. Thus, these are the surfaces that mark an old valley floor or floodplain levels.

**Peneplain**

When an extensive area has been eroded sufficiently to give the look of almost a plain, it is called a

Peneplain.

## Landforms made by River Deposition

### Alluvial Fans

When the velocity of the running water, as it comes out of hills and meets the plain, decreases, it dumps the transported material at the foothills. The structure made are called alluvial fans. The alluvial fans are formed due to accumulation of materials in the form of fan and cones respectively at the base of foot hills Alluvial cones are made of coarse materials than the alluvial fans.

### Natural leaves

Narrow belt of ridges of low height built by the deposition of sediments by the spill water of the stream on its either bank.

### Food plain

Surfaces on either side of a stream that is frequently inundated.

### Crevasse splays

Formed by breaching of leaves when water escapes through a series of distributaries channels.

### Back swamps

Plain area adjoining a levee may contain marshes called back swamps.

### Yazoo streams

Distributions of rivers occupying lateral positions.



### Delta

Delta is the triangular deposition at the mouth of a river debouching in a lake or a sea. The Factors that help in delta formation are as follows:

- Long courses of rivers.
- Medium size sediments.
- Calm or sheltered sea.
- Suitable place (shallow sea and lake shores).
- Large amount of sediments.
- Accelerated
- Stable condition of sea coast.

On the basis of shape delta can be divided into following categories such as arcuate, bird-foot, Estuarine, Cuspate, Truncated etc.

### Arcuate (lobate form) Delta

The Arcuate delta resembles the fan and is convex towards the Sea. It is semicircular in shape and is commonly found in semi-arid region; growing delta such as Nile, Niger, Ganga, Indus, Mekong, Irrawaddy, Rhine, Volga, Danube, Rhone, Lena rivers.

### Bird-foot Delta

Birdfoot Delta is also known as a finger delta. In these deltas, the sediments deposited are composed of those fine particles which are received from the limestone rocks. The rivers with high velocity

carry suspended finer load to greater distance inside the oceanic water (such as Mississippi).

### Estuarine delta

When a river enters the sea through the single mouth or estuary, then the Estuarine Delta is formed which is submerged under marine water. Examples are Narmada River, Congo River, Amazon River and Hudson River.

### Cuspate Delta

Cuspate delta are pointed. They are shaped by regular, opposing, gentle water movement as seen at the Tiber river.

### Oxbow lakes

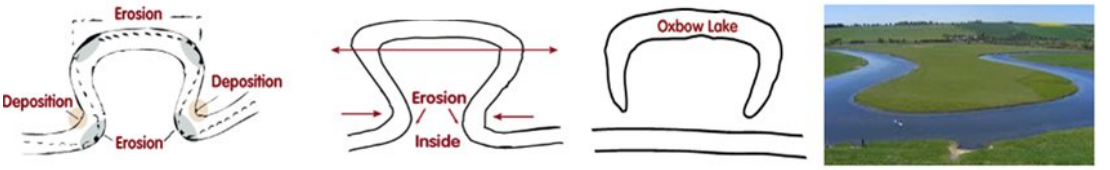
The Oxbow lakes are formed by the depositional and erosional actions taking place simultaneously. Please note that excessive meandering would result in Oxbow lakes.

**How Oxbow lakes are formed?**

On the inside of the loop, the river travels more slowly leading to deposition of silt. Meanwhile water on the outside edges tends to flow faster, which erodes the banks making the meander even wider. Over time the loop of the meander widens until the neck vanishes altogether. Then the meander is removed from the river's current and the horseshoe shaped oxbow lake is formed.

Formation of Oxbow Lakes






### Black Swamps

When the water spills out onto the flood plains, the heaviest material drops out first and finest material is carried over a greater distance. This fine grained alluvium would hold much water and would give rise to a wetland which is called Black swamps or simply swamps.

## Landforms made by River Transportations

The dissolved solids in the rivers travel downstream and become a part of Ocean. The particles of clay, silt and fine grains are carried in suspension. Whenever a soft rock obstructs the course of stream and is eroded and sediments are scattered all around, it would be called **Eddies.** These **Eddies** sometimes look like discs and so are called **potholes**. The large potholes are called Plungepools.

# Rocks & Minerals

## Types of Rocks

Minerals are naturally occurring inorganic substances, often with a crystalline structure. They are composed largely of the most abundant elements in the Earth's crust oxygen & silicon, coupled with metals or the metallic elements of iron, calcium, sodium, potassium, and magnesium.

Rocks are usually composed of two or more minerals. Often, many different minerals are present, but a few rock varieties are made almost entirely of one mineral. Most rock in the Earth's crust is extremely old, dating back many millions of years, but rock is also being formed at this very hour as active volcanoes emit lava that solidifies on contact with the atmosphere or ocean.

The **Great Oxygenation Event** or oxygen catastrophe which happened 2400 million years ago in the Proterozoic eon triggered an explosive growth in the diversity of minerals on Earth.

The three types of Rocks are Sedimentary, Igneous and Metamorphic.

## Igneous rocks

These rocks have crystallized from **magma** which is made up of various components of pre-existing rocks and has been subjected to melting either at subduction zones or within the Earth's mantle.

## Sedimentary rocks

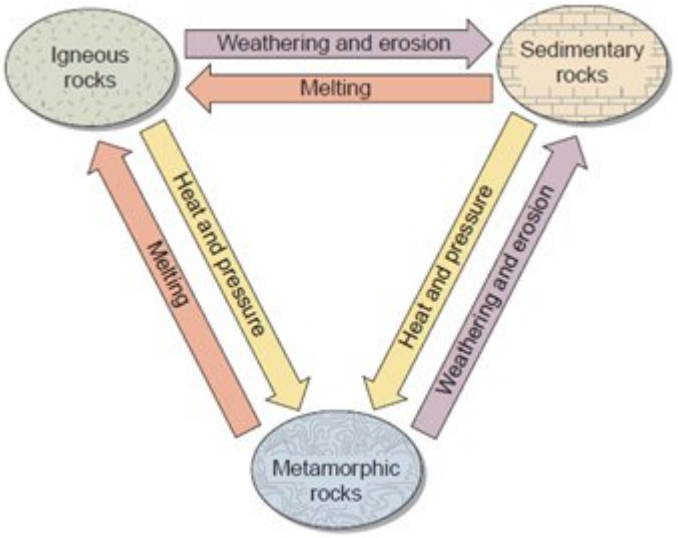
These rocks are formed through the gradual accumulation of sediment, such as sand on a beach or mud on a river bed. The sediment is buried and then it is compacted as more and more material is deposited on top. In several thousand to Lakhs of years, the sediment becomes so dense that it becomes a rock. This process is known as lithification.

## Metamorphic rocks



These rocks once existed as igneous or sedimentary rocks but have been subjected to varying degrees of pressure and heat within the Earth's crust. The processes involved changes the composition and fabric of the rock and their original nature is often hard to distinguish. Metamorphic rocks are typically found in areas of mountain building.

The above three classes of rocks are constantly being transformed from one to another in a continuous process through which the crustal minerals have been recycled during many millions of years of geologic time. The following diagram shows these transformations.




## Igneous Rocks

The upper 16 kilometers of the Earth's crust is made up of 95% Igneous rock, with a thin covering of sedimentary and metamorphic rocks. Igneous rocks are formed when molten rock cools, forming silicate mineral crystals. Felsic minerals are light colored and less dense, and mafic minerals are dark colored and more dense. The igneous rocks are generally hard and water percolates in them not so easily.



The most important characteristics of Igneous rocks are as follows:

- They usually do not occur in distinct beds or strata like sedimentary rocks.
- Igneous rocks are generally not having any fossils
- They are generally granular and crystalline.
- They are less affected by chemical weathering as the water does not percolate in them easily.

### Magma as source of Igneous Rocks

The mixture of the Molten Rocks which makes the Igneous rocks is called Magma. Magma in fact is a mixture of molten rocks, volatiles (gas) and other solids. It originated from the partial melting of the lower crust and the upper mantle, mainly at depths of 15-200 kilometers. Most magma is as hot as 700 °C to 1300 °C and is silicate mixtures mostly.

*Most igneous rock consists of silicate minerals*. These rocks also *contain mostly metallic elements*. The mineral grains in igneous rocks are very tightly interlocked, and so the rock is normally very strong. Quartz, which is made of silicon dioxide ($SiO_2$), is the most common mineral of all rock classes. It is quite hard and resists chemical breakdown.

The chambers under a volcano where Magma collects are called magma chambers. The magma chambers feed a volcano. Bulks of the igneous rocks are result of the cooling and solidifying of Magma. There are two processes by which Magma cools and solidifies. These are called "plutonic" and "Volcanic Eruption". When the Molten Magma goes down deep within the earth and gets solidified, it is called **Plutonism**. On the contrary, the molten Magma can also come out on the surface of earth via a **volcanic eruption**.

## Intrusive and Extrusive Igneous Rocks

Magma that solidifies below the Earth's surface and remains surrounded by older, pre-existing rock is called **intrusive igneous rock**. Because intrusive rocks cool slowly, they develop large mineral crystals that are visible to the eye. They are further classified into Plutonic, Hypabyssal, Batholiths and Laccoliths as follows:

- **Plutonic:** Generally very large crystal and they were formed due to cooling of magma very deep inside the Earth
- **Hypbyssal / subvolcanic :** Consolidated in a zone above the base of Earth's crust and hence has distinct structural characteristics.
- **Batholiths:** They extend to greater depths and larger areas
- **Laccoliths:** A sheet intrusion that has been injected between two layers of sedimentary rock

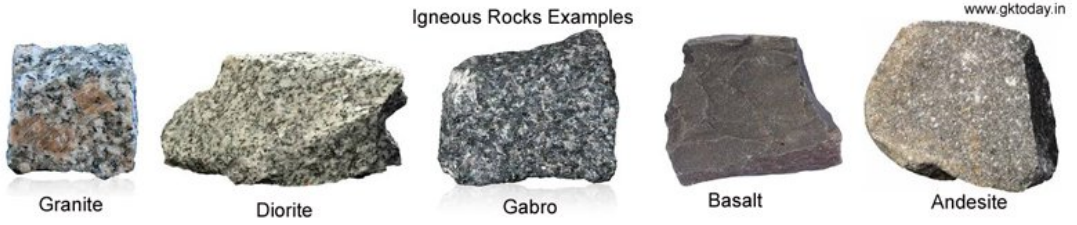
If the magma reaches the surface and emerges as lava, it forms **extrusive igneous rock**. Extrusive igneous rocks cool very rapidly on the land surface or ocean bottom and thus show crystals of only microscopic size.

We note here that **Granite** typically accumulates in batholiths. A single batholith sometimes extends down several kilometers and may occupy an area of several thousand square kilometers.

## Felsic Rocks and Mafic Rocks

Whatever may be the process of cooling and solidifying, the magma while converting into a rock, undergoes numerous chemical and physical changes. Accordingly, there are two major types of Igneous rocks are produced viz. **Felsic Rocks** and **Mafic Rocks**. *Felsic rocks are rich in silicon, oxygen, aluminium, sodium, and potassium, while the mafic rocks are rich in magnesium and iron. If the rock is highly dominated by Magnesium and Iron, it is called Ultramafic.*

## Examples of Igneous Rocks



- Granite: Intrusive (batholith generally), Felsic, igneous rock. Worldwide average chemical composition of Igneous Rocks has $SiO_2$ — 72.04% & $Al_2O_3$ — 14.42%
- Diorite: intermediate intrusive igneous rock
- Gabbro: Mafic igneous rocks equivalent to basalt.
- Peridotite, Rhyolite, Andesite, Basalt, Komatiite, Diabase etc.

## Sedimentary Rocks

Sedimentary rocks are made from layers, or strata, of mineral particles found in other rocks that have been weathered and from newly formed organic matter. Sedimentary rocks are important because they preserve a record of ancient landscapes, climates, and mountain ranges, as well as the history of the erosion of Earth. In addition, fossils are found in abundance in sedimentary rocks younger than 600 million years and provide evidence of the evolution of life through time. Earth's geologic time scale was worked out using this record of sedimentary rocks and fossils.

### Salient Features of Sedimentary Rocks

Sedimentary rocks **form at Earth's surface by the hydrologic system**. Their origin involves the **weathering of pre-existing rock**, transportation of the material away from the original site, deposition of the eroded material in the sea or in some other sedimentary environment, followed by compaction and cementation. Some common features are:

- They contain strata or layers. The layers are **rarely horizontal** and ***generally tilted*** due to lateral compressive and tensile forces. They are formed of sediments derived from the older rocks, plants and animals remain.
- Most part (around 75 percent) of the surface area of the globe is covered by Sedimentary Rocks.
- Most of the sedimentary rocks are permeable and porous.
- Sedimentary rocks are generally characterized by different sizes of joints, generally perpendicular to the bedding plains.

### Types of Sedimentary Rocks

When rock minerals are weathered, their chemical composition is changed, weakening the solid rock. The rock breaks up into particles of many sizes. When these particles are transported in a fluid such as air, water, or glacial ice, we call them **sediment**. There are three major classes of sediment: **clastic sediment**, chemically precipitated sediment, and organic sediment. On this basis, three main types of sedimentary rocks are recognized viz. **clastic rocks, organic rocks** and **chemically precipitated** rocks.

- **Clastic:** Made up of discrete fragments or clasts of materials derived from other minerals, largely of quartz and others such as feldspar, amphiboles, clay minerals

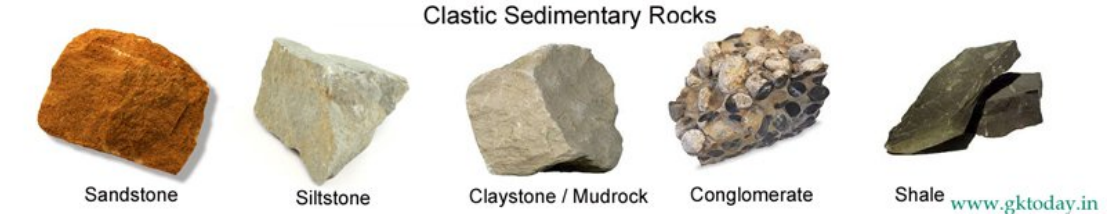
- **Organic :** They contain the materials which are generated by living organisms such as corals, mollusks, and foraminifera, which cover the ocean floor with layers of calcium carbonate, which can later form limestone.
- **Chemical:** Formed by the Chemical & Biological Processes like limestone, rock salt, gypsum and dolostone

### Clastic Sedimentary Rocks

Clastic sediment is made up of inorganic rock and mineral fragments, called clasts. These can come from igneous, sedimentary, or metamorphic rocks, and so they can include a very wide range of minerals. Quartz and feldspar usually dominate clastic sediment. When layers of clastic sediment build up, the lower strata are pushed down by the weight of the sediments above them.

This pressure compacts the sediments, squeezing out excess water. Dissolved minerals recrystallize in the spaces between mineral particles in a process called cementation, thus giving rise to the **Clastic Sedimentary Rocks**. Due to the mechanical process, the clastic sedimentary rocks are also sometimes called ***mechanically formed*** *Sedimentary Rocks.*

Common examples of clastic / mechanically formed sedimentary rocks include Sandstone {cemented sand grains}, Siltstone {Cemented silt particles}, Congomerate {sandstone containing pebbles of hard rocks}, Mudstone {mainly silt and clay}, Claystone {mainly clay} and shale {clay and mud rock which breaks easily into flat flakes and plates}.

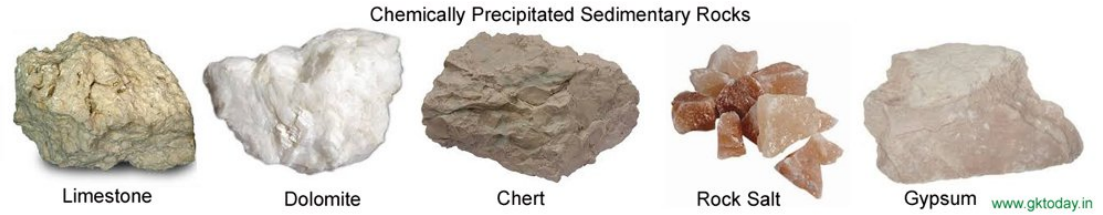



### Chemically Precipitated and Organic Sedimentary Rocks

Chemically precipitated sediment is made of solid inorganic mineral compounds that precipitate from water solutions or are formed by organisms living in water. One of the most common sedimentary rocks formed by chemical precipitation is limestone.

The third class of sediment is **organic sediment**. This is made up of the tissues of plants and animals. Peat is an example of organic sediment. This soft, fibrous, brown or black substance accumulates in bogs and marshes where the water stops the plant or animal remains from decaying.

Examples of Chemically precipitated rocks are Limestone {Calcium Carbonate, formed by precipitation on sea or lake floors}, Dolomite {Magnesium and Calcium Carbontes}, Chert {a microcrystalline form of silica} and Evaporites {minerals formed by evaporation of salty solutions in shallow inland lakes or coastal lagoons}.




**Limestone**

Limestone is by far the **most abundant chemically precipitated rock**. It is composed principally of calcium carbonate (CaCO3 or calcite) and originates by both inorganic chemical and biochemical processes. Limestone has a great variety of rock textures such as skeletal limestone, oolitic limestone, and microcrystalline limestone. Marine sediments form largely by biochemical precipitation. *Carbonate sediments dominate at shallow depths and in warm near-shore waters. Elsewhere, siliceous sediment, which eventually forms chert, is typical in deeper water.*

Skeletal Limestone

Some marine invertebrate animals construct their shells or hard parts by extracting calcium and carbonate ions from seawater. Corals, clams, algae, snails, and many other marine organisms construct their skeletons of calcium carbonate. After the organisms die, the shells accumulate on the seafloor. Over a long period of time, they build up a deposit of limestone with a texture consisting of shells and shell fragments. These particles may then be cemented together as more calcite precipitates between the grains. This type of limestone, composed mostly of skeletal debris, can be several hundred meters thick and can extend over thousands of square kilometers.



- **Chalk** is a skeletal limestone in which the skeletal fragments are remains of microscopic plants and animals.

Oolitic Limestone

Other limestones are composed of small semi spherical grains of calcium carbonate known as oolites. Oolites form where small fragments of shells or other tiny grains become coated with successive thin layers of CaCO3 as they are rolled along the seafloor by waves and currents.

Microcrystalline limestone

A third important type of limestone forms in quiet waters where calcium carbonate is precipitated by algae as tiny, needle like crystals that accumulate on the seafloor as limy mud. Soon after deposition, the grains commonly are modified by compaction and recrystallization.

- Some kinds of algae produce calcium carbonate particles that accumulate to form limestone.These are found near the Kuril Islands of the north Pacific.
- Diatoms are the shells of tiny single-celled algae that are made of silica. Some deepmarine sediments are dominated by diatoms. Some accumulations convert to chert.

**Dolostone / Dolomite**

Dolostone or dolomite rock is a sedimentary carbonate rock that contains a high percentage of the mineral dolomite. Dolomite is a carbonate mineral composed of calcium magnesium carbonate $CaMg(CO3)2$. ***It is similar to limestone in general appearance, but reacts with acid only when powdered***. Dolostone is commonly dull brownish yellow or light gray.

**Chert**

Chert is a common rock composed of microcrystalline quartz. In a hand specimen, it is hard, dense, and typically breaks like glass, but under a high-power microscope, it has a fibrous or granular texture. A distinctive type of deep-marine chert develops from deposits of siliceous shells of microscopic organisms, such as radiolaria and diatoms.

**Rock salt**

Rock salt is made of the mineral halite (NaCl). It crystallizes when evaporation concentrates sodium and chlorine ions to the point that salt is stable in the residual brine. Strong evaporation creates saline lakes in closed desert basins (for example, the Great Salt Lake and the Dead Sea). Enhanced evaporation also occurs in restricted bays along the shore of the ocean.

**Gypsum**

Gypsum, $CaSO_4 \cdot 2H_2O$ too originates from evaporation. It collects in layers as calcium sulphate is precipitated from water.



**Hydrocarbons**

Coal is an important biochemical precipitate. It forms by the decomposition of organic material buried within sedimentary rocks. Lush vegetation may form in an ancient swamp and then be converted by burial into coal. The coal beds on the left are interlayered with sandstone.

The accumulation of partially decayed vegetation is called Peat. Peat is a compound of hydrogen, carbon, and oxygen. They formed from plant remains that built up over millions of years and were compacted under thick layers of inorganic clastic sediment. Hydrocarbons can be solid (peat and coal), liquid (petroleum), or gas (natural gas). Coal is the only hydrocarbon that is a rock. We often find natural gas and petroleum in open interconnected pores in a thick sedimentary rock layer, such as in porous sandstone.

## Metamorphic Rocks

The mountain-building processes of the Earth's crust involve tremendous pressures and high temperatures. These extreme conditions alter igneous or sedimentary rocks, transforming them into metamorphic rock. Thus, metamorphic rocks are formed from the pre-existing rocks within the Earth's crust by changes in temperature and pressure and by chemical action of fluid. This means that Both the Igneous and Sedimentary socks undergo profound physical and chemical changes under the increased pressure and temperature. The process is called "metamorphism". Some metamorphic Rocks are Schist, Gneiss, Slate, Quartzite, Marble and Granite.

There are two basic types of metamorphic rocks:

- Foliated metamorphic rocks such as gneiss, phyllite, schist and slate which have a layered or banded *appearance that is produced by exposure to heat and directed pressure. This is called Foliation.*
- Non-foliated metamorphic rocks such as marble and quartzite which do not have a layered or banded appearance.

In the surface environment, rocks weather into sediment. In the deep environment, heat and pressure transform sediment into rock that is eventually exposed at the surface.

# Weathering & Mass Wasting

## Weathering

There are two types of the processes that affect the landforms viz. **Exogenic** and **Endogenic**.

- Endogenic are the processes that **occur within the earth's surface** such as Plate tectonics, earthquakes, volcanoes etc.
- Exogenic are the processes that occur on or near the earth's surface. The tidal force is Exogenic. The radiation from Sun is also Exogenic.

Further, there are 3 Exogenic geological processes which refer to the process of disaggregation which lead to the reduction in the elevation & relief of the landforms and landscapes such as rocks and mountains. These 3 important phenomena are **weathering, mass wasting and erosion**. These all together are called "**Degradation**" or "**Denudation**". Endogenic processes uplift and expose continental crust to the Exogenic denudation. Exogenic denudation works in opposition and reduces landscapes to sea level.



**Weathering** is the breaking down of Rocks, soils and minerals through "direct Contact" with the atmosphere of the earth. It occurs *in situ*, means there is **no movement** involved.

### Erosion

This is distinct from **erosion** which involves the movement of rocks and minerals such as water, ice, wind and gravity.

### Mass wasting

**Mass wasting** involves the movement of the rocks and particles across a slope **due to gravity.**

### Weathering

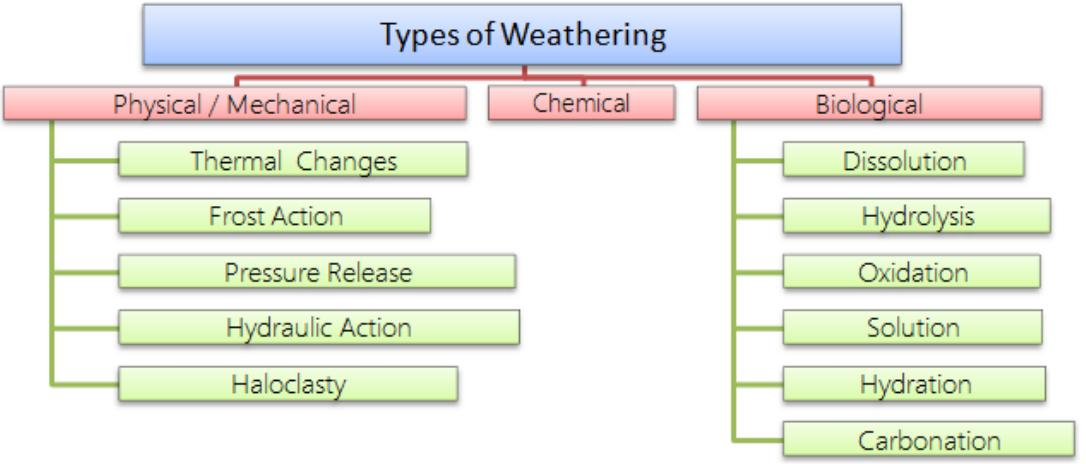
Weathering refers to the combined action of all processes that cause rock to disintegrate physically and decompose chemically because of exposure **near the Earth's surface**. Weathering produces **regolith.** Weathering also creates a number of distinctive landforms.

- **Regolith** is a surface layer of weathered rock particles that lies above solid, unaltered rock.

Weathering is the *in situ* disintegration and breakdown of rocks, soils and minerals.

## Types of Weathering

There are three types of weathering viz. Mechanical or Physical Weathering, Chemical Weathering & Biological Weathering.




## Physical Weathering

Physical Weathering can be caused by thermal changes, Frost Action, Pressure Release, Hydraulic action and Haloclasty. These terms have been discussed below:

### Thermal Changes

Repeated changes in the temperature (heating and cooling) exert the stress on the outer layers of the rocks which is called as **Thermal Stress**. The rocks expand when there is a rise in the temperature and contract when there is a fall in the temperature. *In deserts, the phenomena are more common as there is large diurnal temperature range. The Forest fires can raise the temperature suddenly and this leads to* ***thermal shock****.*

#### Thermal Expansion versus Thermal Contraction

Please note that all materials respond by changing volumes because of temperature. Most materials expand when there is a rise in temperature. But there are some rare example which contract when temperature increases and expand when temperature decreases. This is called Thermal contraction.

The coefficient of thermal expansion is positive for the material which expand when there is a rise in temperature. If the coefficient of thermal expansion becomes zero, there is no expansion or contraction. At negative coefficient, the material contracts when there is a rise in temperature. Best example is water. Water when cooled till 4°C, the coefficient of thermal expansion decreases and become zero at 4°C. After that, when temperature is further reduced, it expands. So, at 4°C, water has maximum density. After that, density is reduced and this is the reason why ice floats and the

water bodies are able to retain a temperature of 4°C at sub zero weathers. Similarly, Pure Silicon has a negative coefficient of thermal expansion between -255°C to -153°C.

### Frost Action

One of the most important physical weathering processes in cold climates is frost action. As water in the pore spaces of rocks freezes and thaws repeatedly, expansion can break even extremely hard rocks into smaller fragments. Water penetrates fractures in bedrock. These fractures, called joints, are created when rocks are exposed to heat and pressure, then cool and contract. Joints typically occur in parallel and intersecting planes, creating natural surfaces of weakness in the rock. Frost action then causes joint-block separation. Water invades sedimentary rocks along their stratification planes, or bedding planes.

### Pressure Release or exfoliation

This refers to the release of the pressure from unloading of existing rock on the rocks that lie beneath it due to other processes such as erosion. The igneous rocks are formed deep in earth and when the rocks above them get removed, the igneous rocks expose and the pressure is released. This causes their outermost surfaces to expand. This expansion leads to weathering.

### Hydraulic Action



This phenomenon takes place due to very high powered water waves. When water rushes into cracks in the rocks with a very fast speed, the trap of air in the cracks get compressed and thus weakens the rocks. When water retreats, the trapped air is suddenly released with explosive force.

### Salt Crystallization or Haloclasty

This refers to the process in which the rocks are denudated due to salt formation. This is a two step process. The first step is started when saline water seeps into cracks and evaporates depositing salt crystals. In the second step, when the rocks are heated up, the crystals expand putting pressure on the surrounding rock. Over the period of time, it splinters the stone into fragments.

### Biological Weathering

Biological Weathering refers to the contribution made by the organisms such as **Lichens and mosses**, which grow on essentially bare rock surfaces and create a more humid chemical microenvironment. Biological weathering is both physical as well as chemical breakdown of the surface micro layer of the rock. The animals such as earthworms and other annelids, moles, rabbits all contribute to the biological weathering.

### Chemical Weathering

Chemical weathering refers to the changes in the chemical composition of the rocks and generally refers to the chemical reactions of water with minerals.

### Hydration

Hydration means absorption of water by some kinds of rock, leading to expansions and disintegrations. When water molecules bind with the mineral molecules, it is called Mineral

Hydration.

**Hydrolysis**

The chemical breakdown of the rocks caused by rainwater is called Hydrolysis. The result may be secondary minerals with different chemical structure.

**Oxidation**

Oxidation or rusting occurs when atmospheric oxygen reacts with the minerals such as Iron Ores. This leads to decomposition of the rocks.

**Solutions**

This refers to dissolving of the minerals in water.

**Carbonation**

Carbonation refers to the chemical weathering in which Carbon dioxide attacks the rocks after it makes weak acid reacting the water. The rocks are generally made up of calcium carbonate such as Limestone and Chalk.

## Mass wasting

In Mass Wasting, the gravitational force of the earth acts directly on the loose material and the unstable slopes result the slide of the rocks and rock debris. This is known as Mass movement. This movement may be slow or fast depending upon the slope angle. The steepest angle that cohesion less slope can maintain without losing its stability is known as its **Critical angle of repose.**

Thus, mass wasting is spontaneous movement of soil, regolith, and rock under the influence of gravity. There are many forms of mass wasting, depending on the speed of the motion and the amount of water involved.

Mass wasting is of following types:

### Creeps

It is a long term process which refers to the small movements of soil or rock in different directions over time, directed by gravity. The speed is so slow that naked eye is not able to show the movement.

### Landslides

It includes the rock slides, slumps (short distance moving of rocks) & sturzstroms (more horizontal movement when compared to its initial vertical drop*). Landslides are most common type of mass wasting.*

### Flows

Flows refer to the movement of the soil, dust, rock particles and bigger pabbles resembling the fluid behavior. Examples of the flows are avalanches, mudflows, debris flows, earth flow, lahars and sturzstroms. The water and air may contribute to the fluid like behaviour.

### Topples

When rocks break away and fall from a slope , it is called Topples.

### Slump

Slump refers to slipping of the rock material.

### Falls

Rocks fell from the steep slopes such as a cliff face, and the movement may be contributed by the earthquakes, rain, plant-root wedging, expanding ice, among other things.

### Induced Mass wasting

Human activities can induce mass wasting processes by creating unstable piles of waste soil and rock and by removing the underlying support of natural masses of soil, regolith, and bedrock. Mass movements produced by human activities are called induced mass wasting.

### Erosion

Erosions refer to the earth-sculpting processes in which the debris produced by weathering is "transported". So it's a kind of weathering in which the soils break up and get carried away. The agents of erosion are Rainwater, River water, ice, wind, sea waves, and underground water.

Erosion is a very important topic physical and well as human geography. Apart from the transport by wind, water, or ice; erosion also involves the down-slope creep of soil and erosion by the living organisms, such as burrowing animals, in the case of bioerosion, and human land use.

# Soil Basics

## Soil Basics

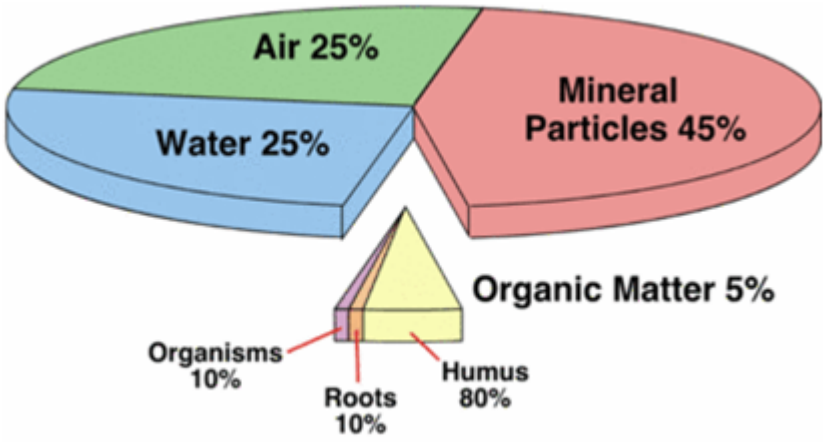


The fine particles of the solid rocks along with the organic / inorganic matter are called soil. The naturally occurring soil is influenced by parent material, climate, relief and the physical, chemical and biological agents such as microorganisms living in it. The naturally occurring soil is influenced by Parent rocks, Climate, Organic content, Topography, Land use practices/ Human interference, Time etc.

Soil contains mineral particles, decayed organic material, soil water, soil atmosphere, and living organisms, which exist in a complicated and dynamic relationship with one another. Soil is a dynamic natural body made up of the materials covering the earth's surface in which plants grow. It is composed of both mineral and organic matter.

### Complex Nature of Soil

The above mentioned factors do not work on soil independently or in isolation, but in close association with each other, leading to a whole network of inter-relationships of quite a complex nature. The material of the soil or the parent material is derived from the rocks ex-posed on the surface. The relief and slope along with the work of various materials. Soils weathering determine conditions for the disintegration of the rock materials. Soils may be transported by the running water, wind or other agents of the rock materials. Soils remain in the original position.




When the soil remains in its original position, it is said to be in situ, and in that state it is further modified by the climate, particularly moisture supply, plant growth ,and bacterial activity dependent on these factors . A brief supply, plant growth ,and bacterial activity dependent on these factors.

A soil is made up of four elements: **inorganic or mineral fraction** (derived from the parent material), **organic material, air and water.** The abundance of each component and its importance in the functioning of the soil system vary from horizon to horizon and from one soil to another.

## Humus

The end-product of the breakdown of dead organic material is known as Humus. Humus is a structure-less, dark-brown or black jelly found beneath the soil surface. In uncultivated land, the humus is derived from the natural decay of previous generations of plants, while in the ploughed and cultivated land it is supplied as some kind of manure. The humus of ordinary soil is black, and is thus responsible for making the soil darker than the subsoil. It plays an important but very complicated part in maintaining the fertility of soil. The amount of humus in different soils varies considerably; some, like the peat soil, consist largely of slightly decomposed organic matter which has not yet become humus.

## Soil Texture

A soil is generally characterized by the size of its particles. A clayey soil may thus be described as fine, a sandy soil as coarse, while a silly soil is intermediate. If one handles a moist soil sample of each of these he feels gritty, sticky and silky, respectively. The standard unit for the measurement of soil particles is the millimeter, but a smaller unit is the micron (1 micron= 0.001 mm), which is applicable, for instance, to the measurement of soil colloids.

## Sandy Soil

Sandy soil is a light soil that consists mainly of sand, i.e., grains of quartz with considerable air spaces between them. The sand may either be 'coarse' where the particles are between 0.2 and 2 mm in

diameter, or 'fine' where the grains between 0.05 and 0.2 mm are just visible to the naked eye. These light soils allow water to drain through rapidly, taking soluble plant foods with it. Sandy Soils are known as 'hungry' soils, which not only **need constant manuring** but **may dry out completely during a period of drought** so that shallow-rooted crops fail and pastures 'burn'. They are good for horticulture (vegetables and fruits), legumes (such as moth and pulses), ground nut and bajra.

## Clayey Soil

Clayey soil is an exceptionally fine grained soil, very retentive of moisture. It often becomes plastic when mixed with water. The individual grains of clayey soil are 0.002 mm in diameter. These particles consist mainly of **hydrated aluminium silicates**.

Clay **contains little air and can hold more water, so forming a sticky mass,** but when it dries out completely, it forms a hard, concrete like surface, seamed with numerous cracks. Sometimes, a compacted solid layer of clay in the subsoil is formed, which is known as **claypan**, and is often hard and difficult to dig or plough. Clayey soils are often rich in plant food and give much better yields than that of sandy soils. They are devoted to rice, perennial grasses other crops such as clover. Efficient drainage methods, modern machinery and careful liming enable clayey soils to grow roots, green crops and cereals.



## Silty Soil

Silty soil is finer than sand but coarser than clay. Its particles are assumed to have a diameter between 0.02 and 0.002 mm. These soils are rich in humus contents and are devoted to numerous cereal and non-cereal crops.

## Loamy Soil

It is highly fertile soil consisting mainly of a mixture of sand and day, together with silt and humus. It has the good qualities of both sand and clay, but not their bad qualities. It comprises an almost equal mix of sand and silt with less than 30 per cent clay. It can retain some moisture and plant food even under the adverse weather and climatic conditions. It is well· aerated and drained, and can be readily worked. It is generally devoted to wheat, barley, legumes, sugarcane, sugar beet, maize, millets, rice, grasses, vegetables and orchards.

## Soil pH

Soil pH is a measure of the acidity or basicity in soils. As we know, the pH below 7 is acidic and above 7 is basic. Soil pH is considered a master variable in soils as it controls many chemical processes that take place. It specifically affects plant nutrient availability by controlling the chemical forms of the nutrient. The **optimum pH range for most plants is between 6 and 7.5,** however many plants have adapted to thrive at pH values outside this range.

*The first thing we should note that in cool and moist areas, percolating groundwater leaches out the soluble bases (such as calcium). As a result, the soils gradually become lime-deficient which increases the acidity of the*

*soil.*

Both the highly acidic and alkaline soils are injurious to crops. If the soil becomes unduly acidic, the farmers **apply lime** in various forms to meet the requirements of the soil. In practice, a pH value between 6 and 6.5, i.e., very slightly acidic, is desired. Lime not only helps to neutralize the excess adds and so 'sweeten' the soil, but it also **encourages bacteria** and helps to improve the physical , texture of heavy soils. **High soil acidity is typical of cold, humid climates. In arid climates, soils are typically alkaline.**

### How to Increase soil pH?

Acidity can be corrected by the application of lime, a compound of calcium, carbon and oxygen (CaCO3), which removes add ions and replaces them with the base calcium.

### How to Decrease soil pH?

To decrease the pH of the soil, the Iron sulphates or aluminium sulphate as well as elemental sulfur (S) are used through the formation of sulphuric acid. Further, Urea, urea phosphate, ammonium nitrate, ammonium phosphates, ammonium sulphate and monopotassium phosphate fertilizers have a organic matter in the form of plant litter, compost, and manure will decrease soil pH through the decomposition process.



Certain acid organic matter such as pine needles, pine sawdust and acid peat are effective at reducing pH.

## The problem of Alkaline Soils

Alkali or alkaline soils are the soils with high pH (> 9). The fist visible impact of Alkaline soil is that it has a **poor soil structure and a low infiltration capacity.** The Alkali soil is generally having **a hard calcareous layer at 0.5 to 1 metre depth**. Alkali soils have dominated presence of minerals such as Sodium Carbonate which causes the soil to swell. Please note that **all alkaline soils are basic, but NOT all basic soils are alkaline.** This is because even presence of basic salts, the soil may not become alkaline due to other chemical reactions. For example, pH of a solution can be lowered by the addition of CO2. This will reduce the basicity; however, the alkalinity will remain unchanged.

The reason is that net reaction produces the same number of equivalents of positively contributing species (H+) as negative contributing species ($HCO^{3-}$ and/or $CO_3^{2-}$).

### How Gypsum helps in Treatment of Alkali soils?

Gypsum (calcium sulphate, CaSO4. 2H2O) can be applied as a source of Ca++ ions to replace the sodium at the exchange complex in the soil. However, there must be enough natural drainage to the underground, or else an artificial subsurface drainage system must be present, to permit leaching of the excess sodium by percolation of rain and/or irrigation water through the soil profile, while using Gypsum.

## Soil Air

Soil air is vital both to soil itself and to organic life within it. A certain amount of air is contained between the individual particles except for the waterlogged soils. The air in the soil helps in the process of oxidation which converts part of the organic material into nitrogen in a form readily available to the plants.

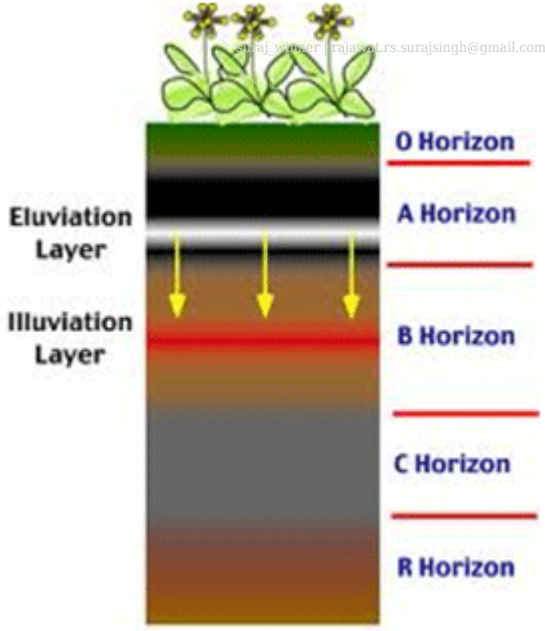
On the other hand, too high degree of oxidation may consume so much organic material that the soil becomes increasingly sterile.

## Soil fertility

Soil fertility is the ability of soil to sustain plants. Soil has fertility when it contains organic substances and clay minerals that absorb water and certain elements needed by plants. The boundary between horizons is usually visible in the field, using the properties of colour, texture consistency, porosity, the presence or absence of certain minerals, moisture, and chemical processes.

## Soil horizons

Soil horizons are the building blocks of soil classification. The various layers exposed in a pedon; roughly parallel to the surface and identified as O,A,E,B, and C are known as soil horizon.




- The **O horizon** is the topmost layer of most soils. It is composed mainly of plant litter at various levels of decomposition and humus.
- **A horizon** is found below the O layer. This layer is composed primarily of mineral particles and has two characteristics: it is the layer in which humus and other organic materials are

mixed with mineral particles, and it is a zone of translocation from which eluviation has removed finer particles and soluble substances, both of which may be deposited at a lower layer. Thus the A horizon is dark in color and usually light in texture and porous. The A horizon is commonly differentiated into a darker upper horizon or organic accumulation, and a lower horizon showing loss of material by eluviation.

- The **B horizon** is a mineral soil layer which is strongly influenced by illuviation. Consequently, this layer receives material eluviated from the A horizon. The B horizon also has a higher bulk density than the A horizon due to its enrichment of clay particles. The B horizon may be colored by oxides of iron and aluminium or by calcium carbonate illuviated from the A horizon.
- The **C horizon** is composed of weathered parent material. The texture of this material can be quite variable with particles ranging in size from clay to boulders. The C horizon has also not been significantly influenced by the pedogenic processes, translocation, and/or organic modification.

The final layer in a typical soil profile is called the **R horizon**. This soil layer simply consists of unweathered bedrock. 

## Soil Taxonomy

Soil classification based on observable soil properties actually seen in the field is known as soil taxonomy. There are a number of soil classifications presented by the experts of soil science. The major types of the soils have been discussed here:

### Oxisols

These soils develop in the hot and humid climates of the equatorial region. These soils are called oxisols because they have distinctive horizon with a mixture of iron and aluminium oxides. Related vegetation is the luxuriant and diverse tropical and equatorial rain forest. Typical are red-dish and yellowish from the iron and aluminium oxides left behind, with a weathered clay-like texture. In fact, these are the lateritic soils in which the leaching process is very strong. The Laterite can be quarried in blocks and used as building material. They are traditionally being used for shifting cultivation. When oxisols are disturbed, soil loss can exceed a thousand tones per sq km per year.

The regions dominated by oxisols by oxisols and rain forests are attracting the much worldwide environmental attention.

### Aridisols (desert soils)

The largest single soil order occurs in dry regions of the world. These soils occupy nearly 19 per cent of the earth's land surface. Pale and light near the surface, deficit in moisture. Lack in organic matter. Salinisation is the main problem of these soils. Salinisation complicates farming in Aridisols.

## Mollisols (grassland soils)

- They are most productive soils of the earth. They are rich in humus content. They have dark –colored surface.
- Mollisols are soft, even when dry, with granular pads, loosely arranged when dry. These humus rich organic soils are high in basic cations and have high fertility.
- **Soils of the steppes and prairies of the world belong to this group.** These soils are being utilized for large-scale commercial grain farming and grazing.
- The process of calcification is very strong in these soils. When cemented or hardened, these deposits are called ***calche or kankar.***

## Alfisols (moderately weathered forest soils)

- These are the most widespread of the soils orders, extending form near the equator to high latitudes. Pale, grayish brown to reddish in colour and are considered moist versions of Mollisols soil group.
- Alfisols have moderate-to-high reserves of basic cations and are fertile. How-ever, their productivity depends on moisture and temperature. They are supplemented by the moderate application of lime and other chemical fertilizers. Some of the best agricultural farms of usa have this type of soil.



## Ultiosols

- These highly weathered forest soil are found in the temperature climates. These soils tend to be reddish in colour because of residual iron and aluminium oxides in the a horizon.
- The increased precipitation in ultisol regions means greater mineral alteration, more leaching, and therefore, a lower level of fertility.
- Fertility is further reduced by certain agricultural practices and the effect of soil damaging crops such as cotton and tobacco. These soils need substantial management.

## Spodosols (coniferous forest soils)

- Found in the humid continental mild summer climates. Their distribution is found in North America and Eurasia.
- They are not found in the southern hemisphere.
- Spodosols lack in humus and clay in the horizons.
- The leaves of the conifers add acidity in soil. Their colour is ash gray and they are also known as podozal soils. These are not very fertile soils.
- To enhance the fertility, the application of lime required.

## Entisols ( recent, underdeveloped soils)

- Usually young or underdeveloped.
- Lack vertical development of horizons.

- These are less fertile soils. The sand dunes ergs outwash glacial plains, and the poorly drained tundra, tidal mud flats, etc. are the examples of Entisols.

### Inceptisols (weakly developed soils)

- These soils are inherently infertile.
- They are usually the weakly developed young soil though they are more developed than entisols.
- They include the soils of most of the arctic tundra and outwash moraines.

### Andisols ( volcanic parent materials)

- The term andisols has been derived from **volcanic ash and glass.**
- Highly fertile and have a high water holding capacity.
- These soils occupy relatively smaller area, especially around the volcanic ring of fire in the pacific rim. Examples are the fertile soils of Hawaii that produce sugarcane and pineapple as important cash crops.

### Vertisols (expandable clay soils)

- Composed of more than 30 per cent clays.
- Vertisol clays are black when wet and become iron hard when dry.



- When drying, Vertisols crack and the cracks widen and deepen as the soil dries ; this produces cracks 2-3 cm wide. These are productive soils .
- The **regur** soils of India are an example of vertisols.

### Histosols (organic soils)

- Formed from accumulation of thick organic matter.
- Bog marsh are the examples of Histosols. Dried Histosols are used as low-grade fuel.

## Prelims Model Questions

### Rocks and Landforms Model Questions

1. With reference to the Felsic and Mafic rocks, consider the following statements:

1. While the Felsic rocks are rich in silicon, Mafic rocks are rich in Magnesium
2. Quartz is an example of Felsic Rock, while Granite is an example of Mafic Rock
3. Mafic Rocks are produced by Volcanic Eruption

Which among the above statements is / are correct?

**[A]** Only 1 & 2

**[B]** Only 2 & 3

**[C]** Only 1 & 3

**[D]** 1, 2 & 3

**Answer: [C] Only 1 & 3**

The first statement is correct. Felsic rocks are rich in silicon, oxygen, aluminium, sodium, and potassium, while the Mafic rocks are rich in magnesium and iron. If the rock is highly dominated by Magnesium and Iron, it is called Ultramafic. Second statement is not correct because Granite is a Felsic rock. Third statement is correct.

2. With reference to metamorphic rocks, consider the following statements:

1. Metamorphic rocks may develop from igneous as well as sedimentary rocks

2. Metamorphic rocks are typically found in regions of orogeny

Which among the above statements is / are correct?

**[A]** Only 1

**[B]** Only 2

**[C]** Both 1 & 2

**[D]** Neither 1 nor 2

**Answer: [C] Both 1 & 2**

Metamorphic rocks once existed as igneous or sedimentary rocks but have been subjected to varying degrees of pressure and heat within the Earth's crust. The processes involved changes the composition and fabric of the rock and their original nature is often hard to distinguish. Metamorphic rocks are typically found in areas of mountain building. Thus, both statements are correct.

3. Consider the following differences about Intrusive and extrusive igneous rocks:

1. While Intrusive rocks have larger crystals, extrusive rocks have smaller crystals

2. While Intrusive rocks are result of fast cooling of magma, extrusive rocks are result of slow cooling of magma

Which of the above statements is/are correct?

**[A]** Only 1

**[B]** Only 2

**[C]** Both 1 & 2

**[D]** Neither 1 nor 2

**Answer: [A] Only 1**

Magma that solidifies below the Earth's surface and remains surrounded by older, pre-existing rock is called intrusive igneous rock. Because intrusive rocks cool slowly, they develop large mineral crystals that are visible to the eye. If the magma reaches the surface and emerges as lava, it forms extrusive igneous rock. Extrusive igneous rocks cool very rapidly on the land surface or

ocean bottom and thus show crystals of only microscopic size.

4. Sedimentary rocks are important because __:

1. They keep a record of early thermal history of earth
2. They keep a record of history of the erosion of Earth
3. They provide us information about paleoclimate
4. They provide us information about evolution

Choose the correct options from the codes given below:

**[A]** Only 1, 2 & 3

**[B]** Only 2, 3 & 4

**[C]** Only 2 & 3

**[D]** Only 2

**Answer: [B] Only 2, 3 & 4**

Thermal history is something which is more commonly related to Igneous rocks. Sedimentary rocks are important because they preserve a record of ancient landscapes, climates, and mountain ranges, as well as the history of the erosion of Earth. In addition, fossils are found in abundance in sedimentary rocks younger than 600 million years and provide evidence of the evolution of life through time. Earth's geologic time scale was worked out using this record of sedimentary rocks and fossils.



5. Which among the following is not a rock that is similar to other three?

**[A]** Sandstone

**[B]** Limestone

**[C]** Dolomite

**[D]** Chert

**Answer: [A] Sandstone**

Sandstone, a rock made of sand, is an example of Clastic Sedimentary Rocks. Rest three are Chemically Precipitated sedimentary rocks.

6. Consider the following statements:

1. Exposure of rock to the changes in temperature causes chemical weathering
2. Lichens and mosses are agents of physical as well as chemical weathering

Which among the above statements is / are correct?

**[A]** Only 1

**[B]** Only 2

**[C]** Both 1 & 2

**[D]** Neither 1 nor 2

**Answer: [B] Only 2**

Physical Weathering can be caused by thermal changes, Frost Action, Pressure Release, Hydraulic action and Haloclasty. Biological Weathering refers to the contribution made by the organisms such as Lichens and mosses, which grow on essentially bare rock surfaces and create a more humid chemical microenvironment. Biological weathering is both physical as well as chemical breakdown of the surface micro layer of the rock. The animals such as earthworms and other annelids, moles, rabbits all contribute to the biological weathering.

7. With reference to the metamorphic rocks, which among the following is NOT a correct sequence?

**[A]** Limestone → Marble

**[B]** Sandstone → Quartzite

**[C]** Talc → Soapstone

**[D]** Graphite → Slate

**Answer: [D] Graphite → Slate**



Slate is a fine-grained, foliated, homogeneous metamorphic rock derived from an original shale-type sedimentary rock composed of clay or volcanic ash through low-grade regional metamorphism.

8. An Igneous rock can be converted into a sedimentary rock by __:

1. Weathering and Erosion
2. Melting
3. Heating and Pressure

Choose the correct option from the codes given below:

**[A]** Only 1

**[B]** 1 & 2

**[C]** 1, 2 & 3

**[D]** 1 & 3

**Answer: [A] Only 1**

9. Which among the following processes play role in formation of sedimentary rocks:

1. Weathering and Erosion
2. Hydrological Processes
3. Compaction and Cementation

4. Lithification

5. Upwelling

Choose the correct option from the codes given below:

**[A]** Only 1 & 2

**[B]** Only 1, 2 & 3

**[C]** Only 1, 2, 3 & 4

**[D]** 1, 2, 3, 4 & 5

**Answer: [C] Only 1, 2, 3 & 4**

Sedimentary rocks are made from layers, or strata, of mineral particles found in other rocks that have been weathered and from newly formed organic matter. Sedimentary rocks form at Earth's surface by the hydrologic system. Their origin involves the weathering of pre-existing rock, transportation of the material away from the original site, deposition of the eroded material in the sea or in some other sedimentary environment, followed by compaction and cementation. In the above question, term Upwelling is not related to formation of sedimentary rocks.

10. Which among the following generally occur in-situ?



1.Weathering

2.Erosion

3.Mass Wasting

Choose the correct option from the codes given below:

**[A]** Only 1

**[B]** 1 & 2

**[C]** 1, 2 & 3

**[D]** 2 & 3

**Answer: [A] Only 1**

Weathering is the breaking down of Rocks, soils and minerals through "direct Contact" with the atmosphere of the earth. It occurs in situ, means there is no movement involved. Erosion is is distinct from erosion which involves the movement of rocks and minerals such as water, ice, wind and gravity. Mass wasting involves the movement of the rocks and particles across a slope due to gravity.