Weathering is the breaking down of rocks, soils and minerals as well as artificial materials through contact with the Earth's atmosphere, biota and waters.

Weathering occurs in situ, or "with no movement", and thus should not be confused with erosion, which involves the movement of rocks and minerals by agents such as water, ice, snow, wind and gravity.

Two important classifications of weathering processes exist –

1. Mechanical or Physical weathering and
2. Chemical weathering.

Mechanical or physical weathering involves the breakdown of rocks and soils through direct contact with atmospheric conditions, such as heat, water, ice and pressure. The second classification, chemical weathering, involves the direct effect of atmospheric chemicals or biologically produced chemicals (also known as biological weathering) in the breakdown of rocks, soils and minerals.

The materials left over after the rock breaks down combined with organic material creates soil. The mineral content of the soil is determined by the parent material, thus a soil derived from a single rock type can often be deficient in one or more minerals for good fertility, while a soil weathered from a mix of rock types (as in glacial, aeolian or alluvial sediments) often makes more fertile soil. In addition many of Earth's landforms and landscapes are the result of weathering processes combined with erosion and re-deposition.

Physical Weathering:

Physical weathering is the class of processes that causes the disintegration of rocks without chemical change. Physical weathering normally occurs due to the work of external natural agents like wind, water. It can occur due to temperature, pressure, frost etc. Sometimes earthquakes, volcanoes and organisms play a vital role in aiding physical weathering.

Weathering due to wind:

Wind erodes the Earth's surface by three distinct processes known as

1. Deflation (the removal of loose, fine-grained particles)
2. Abrasion (the wearing down of surfaces by the grinding action)
3. Attrition (mutual collision among resulting in the grinding of wind-bone particles while travelling in suspension)

Deflation: The loose soil or particles of rock, forming the mantle, are readily lifted up and swept away due to the impact of blowing wind. As a result of such removal of the loose mantle, only the hard and compact rock-masses remain in their original position and these are, thus, exposed for further erosion (Fig. deflation).

The process of removal of loose soil or rock-particles during storms, along the course of the blowing wind, has been defined as deflation.

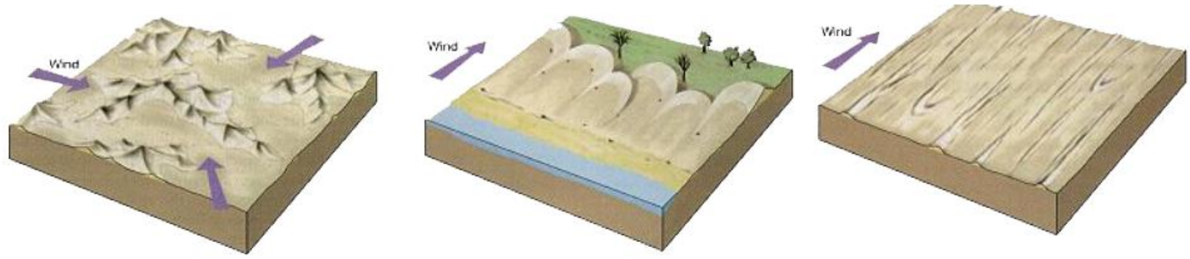
Fig. deflation: The wind deflation process. Sand grains are removed, leaving heavier and larger grains behind

Wind deflation can successfully operate in comparatively dry regions with little or no rainfall and where the mantle is unprotected due to absence of vegetation. If, on the other hand, the mantle be moist, due to rainfall, or if it be covered with vegetation, its constituent particles are firmly held together and therefore find no chance of travelling along with the blowing wind. In India, conditions favourable for deflation exist in Rajasthan as well as in certain portions of Northern India. In Northern India, the process of deflation, under favourable conditions leads to the development of *desert pavement*[1].

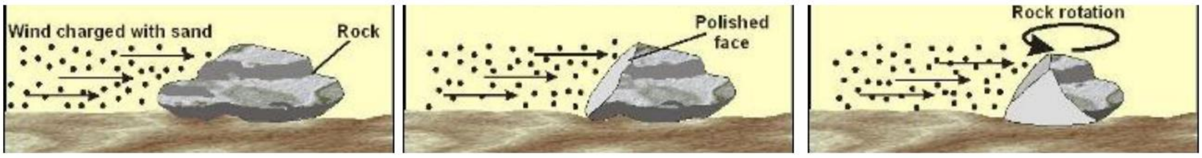
Abrasion: The loose rock particles, which are lifted up and transported by the blowing wind, do always, have a tendency to jump upon and collide with any exposed rock-mass lying along their path of travel. Such collisions between the wind-borne particles and the bare rock-exposures cause a grinding effect upon the exposed rock surfaces with the production of new rock particles, which also travel with the blowing wind. During such impacts, the impinging wind borne particles are, in their turn, reduced to further fineness.

1 - The desert pavement is the layer of residual pebbles and cobbles strewn upon the surface while the intervening finer particles have been removed as a result of deflation.

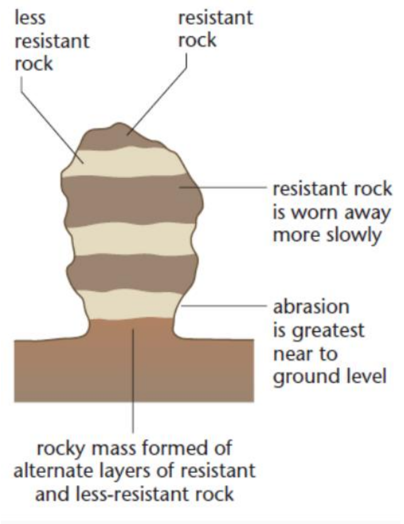
The process of wear and tear of the exposed country-rocks, as described above, is defined as abrasion.



The efficiency of the abrasion process, however, is dependent upon the velocity of the blowing wind, the relative hardness of the constituents of the attacked county-rocks and the attacking particles, the size and shape of the impinging particles and the frequency of collision. Due to wind abrasion, the exposed irregular surface of a rock-mass is gradually converted into a plane surface which may, sometimes, be smooth and even polished. Such structures are called *ventifacts*. *Ventifacts* are pebbles of rocks or minerals which have developed some plane faces due to wind abrasion.



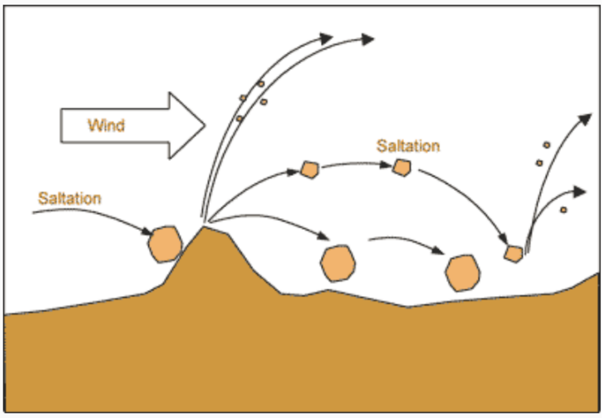
It has been found that the rock particles, which travel along with blowing wind, are commonly more concentrated near the surface of the earth than higher up in the atmosphere. Blasts of wind, therefore, cause more of abrasion nearer the earth's surface than what is possible in the comparatively higher horizons. This process readily worn out the vertical columns of rocks towards the lower portions, forming rock structures called pedestal rocks. The pedestal rocks have wider tops supported on comparatively narrower basses.



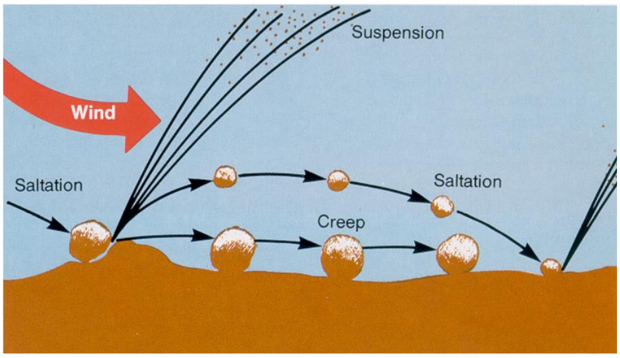
Attrition: The wind-borne particles, travel in suspension, do often has the chance of colliding with one another. Such mutual collision amongst themselves causes a further grinding of the particles and the process is described as attrition.

Some of the processes or structures that occur during wind erosion are:

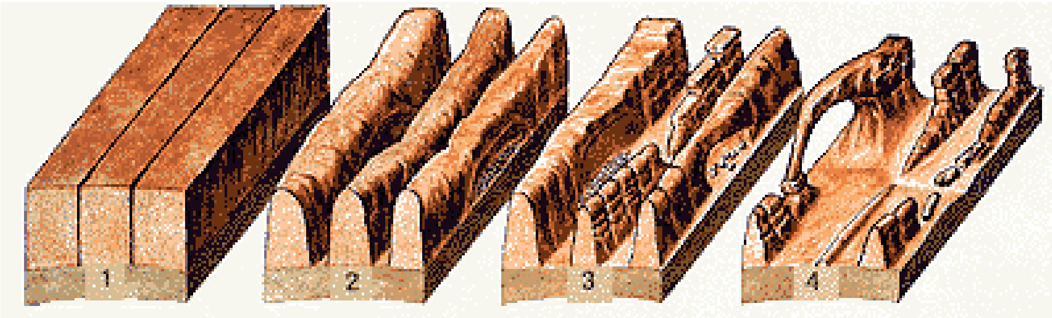
A. Saltation: The loose rock particles occurring in the mantle, or those which have been produced due to abrasion and attrition are transported readily from one place to another along with the blowing wind. In case of sand particles, the transportation takes place due to the forward movement of the grains in a series of jumps and the processes is called saltation.



B. Suspension: The movement of fine grain-size dust particles, conveniently lifted up in the air and their movement due to turbulence of air currents is known as suspension.



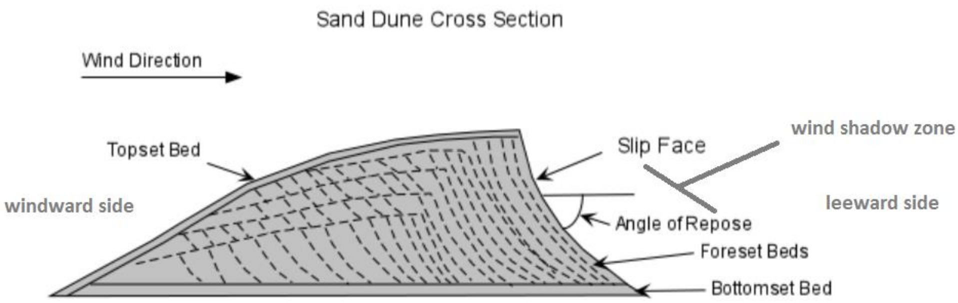
C. Yardangs: Occasionally, wind causes the development of U-shaped troughs with in relatively softer rocks. The ridges left between such successive troughs are known as yardangs.



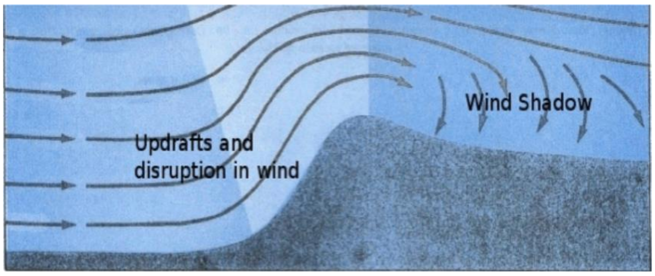
D. Loess: The finest particles of dust, travelling in suspension with the wind are transported to a considerable distance. When under favourable conditions, these have been found to accumulate in the different continents in the form of paper thin laminae, which have aggregated together to form a massive deposits known as loess. Deposits of loess occur at variable altitudes and, in their characteristics; they can be recognised as *Aeolian*. Loess is extensively seen in China as well as Europe and America.

Loess deposits of China.

E. Dunes: The wind formed deposits of sand are commonly described as dunes.

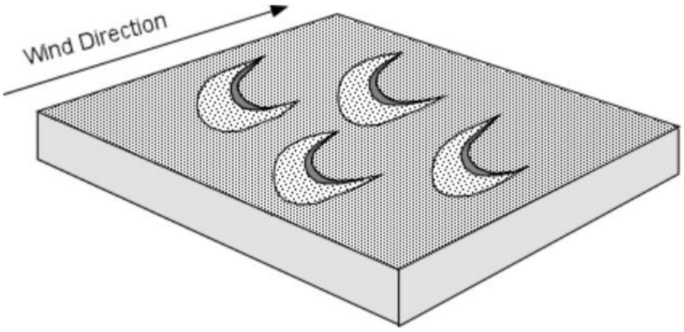


Wind-shadow: the presence of any barrier across the direction of flow of wind causes the development of a zone, within which the velocity of wind is much reduced; such a zone is called wind-shadow.

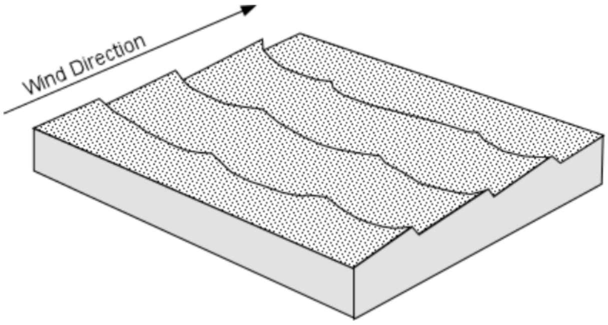


Basing upon the occurrence of obstacles, slip face, and wind shadow regions, the sand dunes are of the following kinds.

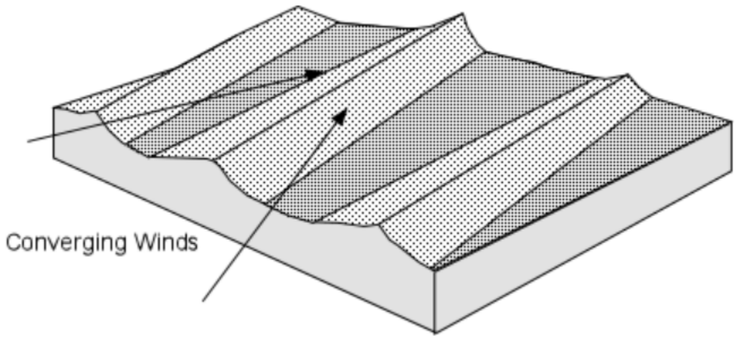
a. Barchan Dunes - are crescent-shaped dunes with the points of the crescents pointing in the downwind direction, and a curved slip face on the downwind side of the dune. They form in areas where there is a hard ground surface, a moderate supply of sand, and a constant wind direction.



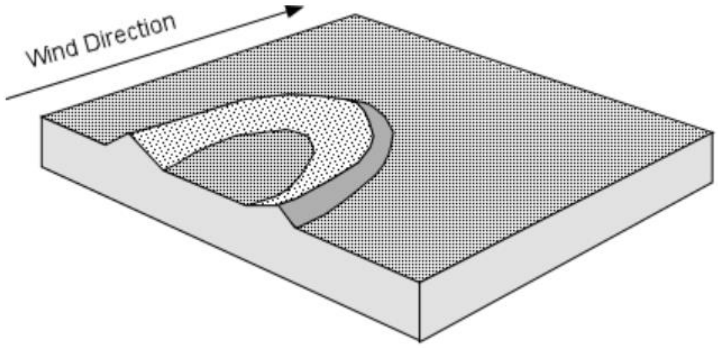
b. Transverse dunes - are large fields of dunes that resemble sand ripples on a large scale. They consist of ridges of sand with a steep face in the downwind side, and form in areas where there is abundant supply of sand and a constant wind direction. Barchan dunes merge into transverse dunes if the supply of sand increases.



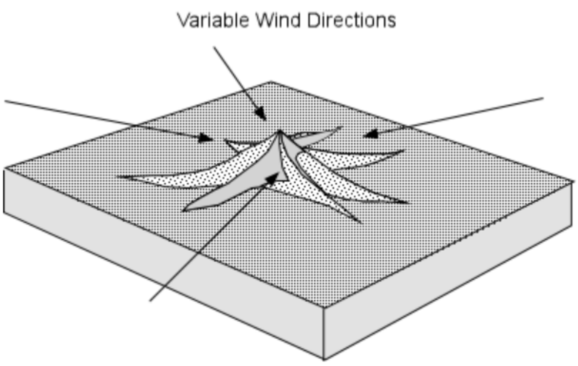
c. Linear Dunes - are long straight dunes that form in areas with a limited sand supply and converging wind directions.



d. Parabolic (also called blowout) Dunes - are "U" shaped dunes with an open end facing upwind. They are usually stabilized by vegetation, and occur where there is abundant vegetation, a constant wind direction, and an abundant sand supply. They are common in coastal areas.



e. Star Dunes - are dunes with several arms and variable slip face directions that form in areas where there is abundant sand and variable wind directions.

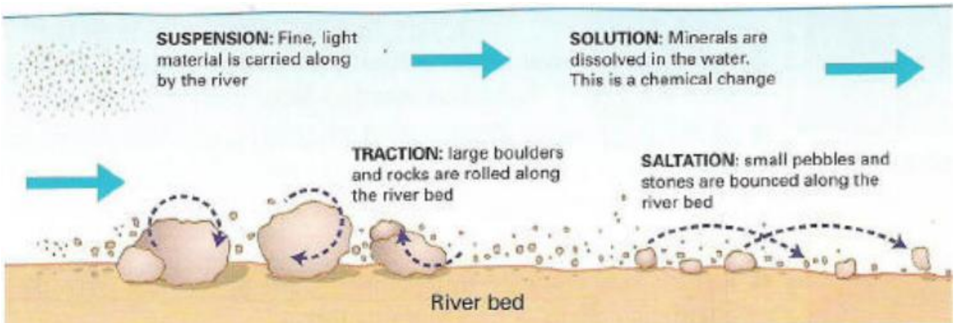


Weathering due to water:

The geological work of running water occurs in several distinct processes:

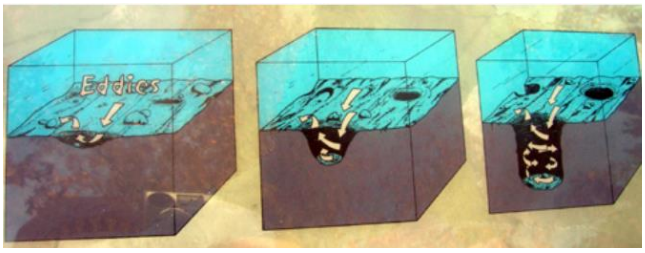
a. Hydraulic action: Hydraulic action is an erosive process that occurs when the motion of water against a rock (or earth) surface produces mechanical weathering. It is the continuous impact of running water with exposed rock-masses that breaks the rock masses and broken rock debris are removed further downstream. In rocks, containing sets of cracks (joints) the inherent energy of the flowing water often takes an important role in quarrying out the individual blocks (of rock, formed due to the joints present in them) and once displaced from their original position, these tend to roll downstream along the valley-floor.

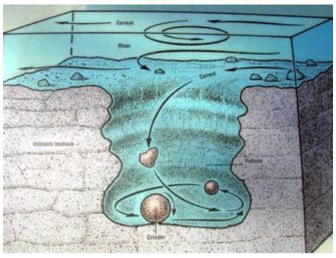
b. Abrasion: The water running along a river channel is necessarily armed with some amount of rock debris formed due to hydraulic action of the river. The larger boulders and pebbles roll along the valley floor and move downstream while the smaller fragments travel in saltation or suspension. The rolling boulders and pebbles naturally collide themselves against the valley-floor during their travel while the smaller fragments, travelling in suspension, impinge periodically upon the floor of the river valley. The process of mechanical breaking down of the bed rocks due to the impacts described above is known as *abrasion*.



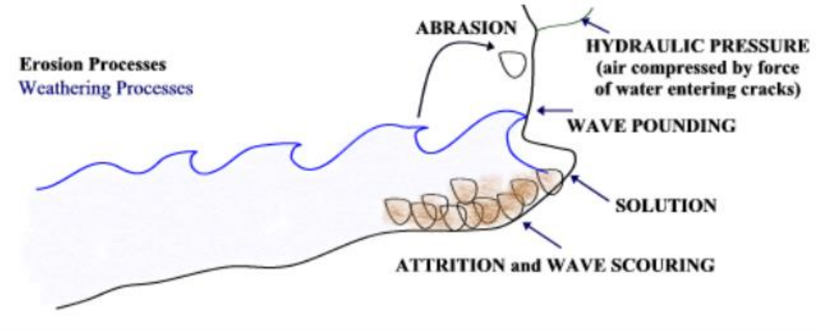
During abrasion at certain places, softer rocks and pebbles of harder rocks are caught up in eddies of water and allowed to have a swirling motion upon the floor of the channel. As a result, the depressions are formed and they gradually formed, resulting in the structures called *Pot-holes*.

In torrential rivers, pot-holes are formed more conveniently, along the upper part of the course of the Damodar river, large number of pot-holes have been excavated on the river-bed (made up of weak sandstone).





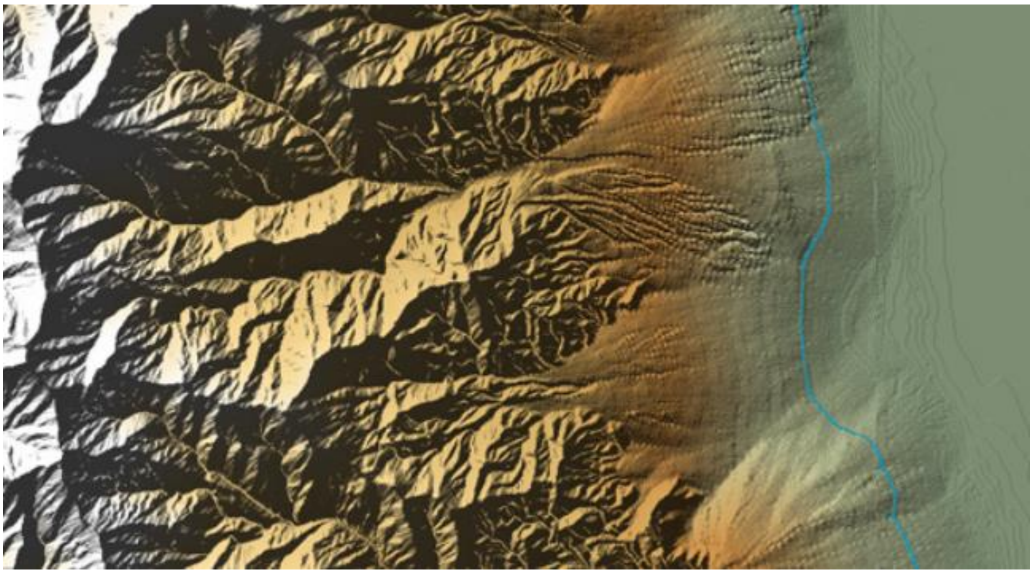

c. Attrition: The process of breaking down of the transported rock-fragments, due to impact among themselves, has been described as *attrition*. Attrition occurs when waves causes loose pieces of rock debris (scree) to collide with each other, grinding and chipping each other, progressively becoming smaller, smoother and rounder. Scree[1] also collides with the base of the cliff face, chipping small pieces of rock from the cliff or has an abrasion effect (corrosion), similar to sandpapering.



d. Solution or Corrosion: Corrosion or solution/chemical weathering occurs when the sea's pH (anything below pH 7.0) corrodes rocks on a cliff face. Limestone cliff faces, which have a high pH, are particularly affected in this way. Wave action also increases the rate of reaction by removing the reacted material.
e. Transportation: Material which has been added to the load of the river by erosion is transported in three ways:-
   a. Suspension: Some particles (i.e. Silt and Clay) are small enough to be held up by turbulence in the channel, and form the suspended load. The more turbulent the water the larger the particles which can be transported in suspension.
   b. Traction and Saltation: Larger particles (i.e. sand and gravel) roll and side (traction) or bounce (saltation) along the bed of the river under the hydraulic force of the moving water. The particles moving close to or along the bed or the river are known as bed load.
   c. Solution: The dissolving of rocks adds to the rivers load, and is known as the dissolved load.
f. Deposition: It is the process of settling of all the particles of transport on to any surface. The factors like particle size, shape, density, and the velocity etc. will affect the deposition.

(The following image was created from DEMs (Digital Elevation Model) for the following 1:24,000 scale topographic quadrangles: Telescope Peak, Hanaupah Canyon, and Badwater, California. To the left is the Panamint Mountain Range. To the right is Death Valley. Elevation spans from 3368 to -83meters and generally decreases from left to right. The blue line represents an elevation of 0 meters. Large alluvial fans extending from a number of mountain valleys to the floor of Death Valley can be seen in the right side of the image. The sediments that make up these depositional features came from the weathering and erosion of bedrock in the mountains located on the left side of the image.)

1-Scree- collection Broken rock fragments



Weathering due to water is the major factor in formation of rivers. Rain along with weather shapes the rivers and takes major part in river formation.

Formation of Rivers:
Every river has a point of origin and the gravity plays a significant role in the direction of the flow of a river. In areas where the climate is humid, the point of origin of the rivers is from springs. The points of origination of rivers are the marshes, lakes, and melting glaciers.

One of the sources of water that replenish the rivers is either the melting snow or the rainwater. This process is known as the precipitation.

Another major source of river water is the rain. When it rains heavily in the hills, the water trickles down the steep slopes and flows onto a riverbed. Initially, the water from the hills flows in an evenly distributed fashion and is called surface run-off. When this water flow travels a certain distance, it begins to flow in parallel rills and also gathers momentum. Soon these parallel rills unite to form a stream. As the rills converge with the stream a brook is formed. This brook flows through a valley. The volume of the water in a brook becomes constant when it gains sufficient volume of groundwater. The brook becomes a river when the water level in the brook increases.

Types of Rivers
The rivers are classified on the basis of the sediments it carries. The sediment carried is controlled by factors such as climate, geology and the stream gradient. Here are a few classifications of the rivers.

Youthful River - A youthful river has a steep gradient and very few tributaries. A youthful river is bound to flow quickly and swiftly. A few examples of youthful river include Trinity River and Brazos in the USA, and Ebro River in Spain.

Mature River - A mature river is less steep and flows slowly compared to the youthful river. There are many tributaries that feed a mature river. The sediment deposit is also less. Examples of mature river include St.Lawrence River, Ohio River and River Thames.

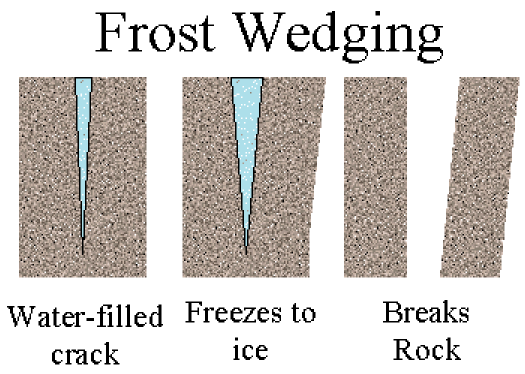
Old River - An old river has a low gradient and is depended on flood plain is known as Old River. At this stage river movers very slowly with a heavy load. Its energy is nearly exhausted. Under such conditions, deposition of sediments begins. Ultimately the deposits grow to the extent of splitting the river. Such deposits which are characteristic of the old stage are usually triangular in plan and are called deltas (Δ). Some of the world famous old rivers include the Ganges, Nile, and Euphrates. In India along with Ganges (Ganga), Indus, Godavari, Krishna, Cauvery, and Pennar are mighty rivers. Yet Tapti and Narmada rivers are notably larger, they deviate from the trend in not having deltas and have straight courses. This unusual feature is because they flow the valleys which are not carved out by them. They have occupied trenches formed due to faulting.

Thermal stress: (Exfoliation)

Thermal stress weathering (sometimes called insolation weathering) results from expansion or contraction of rock, caused by temperature changes. Thermal stress weathering comprises two main types, thermal shock and thermal fatigue. Thermal stress weathering is an important mechanism in deserts, where there is a large diurnal temperature range, hot in the day and cold at night. The repeated heating and cooling exerts stress on the outer layers of rocks, which can cause their outer layers to peel off in thin sheets. Although temperature changes are the principal driver, moisture can enhance thermal expansion in rock. Forest fires and range fires are also known to cause significant weathering of rocks and boulders exposed along the ground surface. Intense, localized heat can rapidly expand a boulder.


Frost weathering:

Frost weathering, frost wedging, ice wedging or cryofracturing is the collective name for several processes where ice is present. These processes include frost shattering, frost-wedging and freeze-thaw weathering. This type of weathering is common in mountain areas where the temperature is around the freezing point of water. Certain frost-susceptible soils expand or heave upon freezing as a result of water migrating via capillary action to grow ice lenses near the freezing front. This same phenomenon occurs within pore spaces of rocks. The ice accumulations grow larger as they attract liquid water from the surrounding pores. The ice crystal growth weakens the rocks which, in time, break up. It is caused by the approximately 10% (9.87) expansion of ice when water freezes, which can place considerable stress on anything containing the water as it freezes.



Freeze induced weathering action occurs mainly in environments where there is a lot of moisture, and temperatures frequently fluctuate above and below freezing point, especially in alpine and periglacial areas. An example of rocks susceptible to frost action is chalk, which has many pore spaces for the growth of ice crystals. When water that has entered the joints freezes, the ice formed strains the walls of the joints and causes the joints to deepen and widen. When the ice thaws, water can flow further into the rock. Repeated freeze-thaw cycles weaken the rocks which, over time, break up along the joints into angular pieces. The angular rock fragments gather at the foot of the slope to form a talus slope (or scree slope). The splitting of rocks along the joints into blocks is called block disintegration. The blocks of rocks that are detached are of various shapes depending on rock structure.

Effect of Pressure:

In pressure release, also known as unloading, overlying materials (not necessarily rocks) are removed (by erosion, or other processes), which causes underlying rocks to expand and fracture parallel to the surface.

Intrusive igneous rocks (e.g. granite) are formed deep beneath the Earth's surface. They are under tremendous pressure because of the overlying rock material. When erosion removes the overlying rock material, these intrusive rocks are exposed and the pressure on them is released. The outer parts of the rocks then tend to expand. The expansion sets up stresses which cause fractures parallel to the rock surface to form. Over time, sheets of rock break away from the exposed rocks along the fractures, a process known as exfoliation. Exfoliation due to pressure release is also known as "sheeting".

Chemical Weathering:

Chemical weathering changes the composition of rocks, often transforming them when water interacts with minerals to create various chemical reactions. Chemical weathering is a gradual and ongoing process as the mineralogy of the rock adjusts to the near surface environment. New or secondary minerals develop from the original minerals of the rock. In this the processes of oxidation and hydrolysis are most important.

The process of mountain block uplift is important in exposing new rock strata to the atmosphere and moisture, enabling important chemical weathering to occur; significant release occurs of Ca^{++} and other minerals into surface waters.

Dissolution and carbonation:

Rainfall is acidic because atmospheric carbon dioxide dissolves in the rainwater producing weak carbonic acid. In unpolluted environments, the rainfall pH is around 5.6. Acid rain occurs when gases such as sulfur dioxide and nitrogen oxides are present in the atmosphere. These oxides react in the rain water to produce stronger acids and can lower the pH to 4.5 or even 3.0. Sulfur dioxide, SO2, comes from volcanic eruptions or from fossil fuels, can become sulfuric acid within rainwater, which can cause solution weathering to the rocks on which it falls.

Some minerals, due to their natural solubility (e.g. evaporites), oxidation potential (iron-rich minerals, such as pyrite), or instability relative to surficial conditions will weather through dissolution naturally, even without acidic water.

One of the most well-known solution weathering processes is carbonation, the process in which atmospheric carbon dioxide leads to solution weathering. Carbonation occurs on rocks which contain calcium carbonate, such as limestone and chalk. This takes place when rain combines with carbon dioxide or an organic acid to form a weak carbonic acid which reacts with calcium carbonate (the limestone) and forms calcium bicarbonate. This process speeds up with a decrease in temperature, not because low temperatures generally drive reactions faster, but because colder water holds more dissolved carbon dioxide gas. Carbonation is therefore a large feature of glacial weathering.

The reactions as follows:

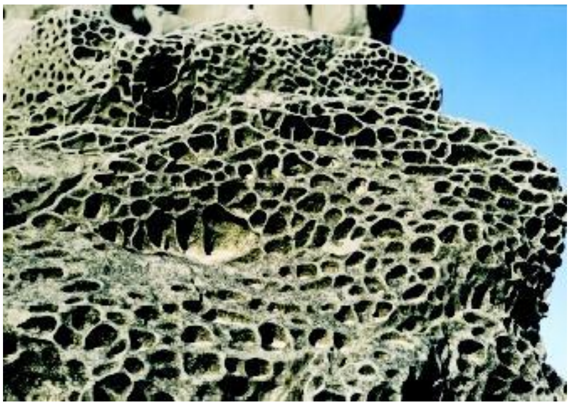
$CO_2 + H_2O => H_2CO_3$

Carbon dioxide + water => carbonic acid

$H_2CO_3 + CaCO_3 => Ca(HCO_3)_2$

Carbonic acid + calcium carbonate => calcium bicarbonate

Carbonation on the surface of well-jointed limestone produces a dissected limestone pavement. This process is most effective along the joints, widening and deepening them.



Dissolution

Carbonation

Hydration:
Mineral hydration is a form of chemical weathering that involves the rigid attachment of H^+ and OH^- ions to the atoms and molecules of a mineral.

When rock minerals take up water, the increased volume creates physical stresses within the rock. For example iron oxides are converted to iron hydroxides and the hydration of anhydrite forms gypsum.

Hydrolysis on silicates and carbonates:
Hydrolysis is a chemical weathering process affecting silicate and carbonate minerals. In such reactions, pure water ionizes slightly and reacts with silicate minerals. An example reaction:

$Mg_2SiO_4 + 4H^+ + 4OH^- \rightleftharpoons 2Mg_2+ + 4OH^- + H_4SiO_4$

Olivine (forsterite) + four ionized water molecules ⇌ ions in solution + silicic acid in solution

This reaction theoretically results in complete dissolution of the original mineral, if enough water is available to drive the reaction. In reality, pure water rarely acts as a H^+ donor. Carbon dioxide, though, dissolves readily in water forming a weak acid and H+ donor.

$Mg_2SiO_4 + 4CO_2 + 4H_2O \rightleftharpoons 2Mg_2+ + 4HCO_3^- + H_4SiO_4$

Olivine (forsterite) + carbon dioxide + water ⇌ Magnesium and bicarbonate ions in solution + silicic acid in solution

This hydrolysis reaction is much more common. Carbonic acid is consumed by silicate weathering, resulting in more alkaline solutions because of the bicarbonate. This is an important reaction in controlling the amount of CO_2 in the atmosphere and can affect climate.

Aluminosilicates when subjected to the hydrolysis reaction produce a secondary mineral rather than simply releasing cations.

$2KAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightleftharpoons Al_2Si_2O_5(OH)_4 + 4H_4SiO_4 + 2K+ + 2HCO_3^-$

Orthoclase (aluminosilicate feldspar) + carbonic acid + water ⇌ Kaolinite (a clay mineral) + silicic acid in solution + potassium and bicarbonate ions in solution

Oxidation:

Within the weathering environment chemical oxidation of a variety of metals occurs. The most commonly observed is the oxidation of Fe^{2+} (iron) and combination with oxygen and water to form Fe^{3+} hydroxides and oxides such as goethite, limonite, and hematite. This gives the affected rocks a reddish-brown coloration on the surface which crumbles easily and weakens the rock. This process is better known as 'rusting', though it is distinct from the rusting of metallic iron. Many other metallic ores and minerals oxidize and hydrate to produce colored deposits, such as chalcopyrites or $CuFeS_2$ oxidizing to copper hydroxide and iron oxides.

$$CuFeS_2 + 16Fe^{3+} + 8H_2O \rightarrow Cu^{2+} + 17Fe^{2+} + 2SO_4^{2-} + 16H^+$$

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$$

Biological Weathering:

A number of plants and animals may create chemical weathering through release of acidic compounds, i.e. moss on roofs is classed as weathering. Mineral weathering can also be initiated and/or accelerated by soil microorganisms. Lichens on rocks are thought to increase chemical weathering rates.

The most common forms of biological weathering are the release of chelating compounds (i.e. organic acids, siderophores) and of acidifying molecules (i.e. protons, organic acids) by plants so as to break down aluminium and iron containing compounds in the soils beneath them. Decaying remains of dead plants in soil may form organic acids which, when dissolved in water, cause chemical weathering. Extreme release of chelating compounds can easily affect surrounding rocks and soils, and may lead to podsolisation of soils.

The symbiotic mycorrhizal fungi associated with tree root systems can release inorganic nutrients from minerals such as apatite or biotite and transfer these nutrients to the trees, thus contributing to tree nutrition. It was also recently evidenced that bacterial communities can impact mineral stability leading to the release of inorganic nutrients.[8] To date a large range of bacterial strains or communities from diverse genera have been reported to be able to colonize mineral surfaces and/or to weather minerals, and for some of them a plant growth promoting effect was demonstrated. The demonstrated or hypothesised mechanisms used by bacteria to weather minerals include several oxidoreduction and dissolution reactions as well as the production of weathering agents, such as protons, organic acids and chelating molecules.

Plants, animals, man also help in disintegration of rocks. The developing roots of growing trees and plants, some times, penetrate into the cracks, widen them and ultimately disintegrate rocks. Some animals make burrows underground and help in the weathering of rocks.

Man ranks top in the list of various factors responsible for forced unnatural weathering of rocks. He is all powerful and to satisfy his various requirements he undertakes large-scale construction of building, dams, bridges, roads, etc. For all these purpose he quarry and break down rocks causing disintegration.

Products of weathering:

The products of weathering usually include the following

(i) The first products of weathering is a mantle of broken and decomposed material of varying thickness and composition, called the regolith which covers the areas except those from which it is removed as soon as formed.

(ii) Soluble salts, which are produced, are carried away along with the transporting media in solutions.

(iii) Colloidal substances like $Al(OH)_3$ and $Fe(OH)_3$ which are the products of weathering, are carried away by ground water and streams.

(iv) Insoluble products, which include clay minerals, quartz grains, undecomposed feldspars and some resistant minerals like zircon, tourmaline, quartz etc. are usually found at the site of weathering and later transported to the sites of deposition.

Importance of Weathering:

Some useful effects of weathering are:

1. Weathering produces soil which is vital for agriculture and for the production of different crops.

2. Weathering makes rocks porous and permeable. This is very important form ground water occurrence point of view in case of hard rocks like granites and gneisses.
3. The cheap building stones like laterites are the result of weathering.
4. The economic deposits like bauxites are also the result of weathering.
5. The process of oxidation and supergene enrichment (occurring of material on surface) particularly for sulphide deposits are also the processes of weathering.

However, form the civil engineering point of view, weathering is not a welcome process, because it reduces the strength, durability and good appearance of rocks.

Importance of Weathering with Reference to Dams, Reservoirs and Tunnels:

Weathering transports rocky material after the process of weathering has broken bedrock down into smaller, moveable pieces. Through erosion the surface of the earth is constantly being sculptured into new forms. The shapes of continents are continuously changing, as waves and tides cut into old land while silt from rivers builds up new land. Weathering initiates the erosion of rock, causing alterations in the surface layers.

Weathering is a process that applies major role of engineering mechanics, e.g. kinematics, dynamics, fluid mechanics, and mechanics of material, to predict the mechanical behavior of erosion. Rock mechanics & weathering process are plays a theoretical and the mechanical behaviour of rock and rock masses; it is useful in the branch of mechanics concerned with the response of rock and rock masses to the force fields of their physical environment. The fundamental processes are all related to the behaviour of erosions. Together, soil and rock mechanics are the basis for solving many engineering geologic problems with references to dam reservoir and tunnels.

WEATHERING OF COMMON ROCK LIKE “GRANITE”:

Granite is a common and widely occurring type of intrusive, felsic, igneous rock. Granites usually have a medium- to coarse-grained texture.

Weathering processes affecting granite

1. Chemical Weathering—Hydrolysis, oxidation and hydration
2. Physical Weathering—Freeze thaw Weathering, insolation (Sudden prostration due to exposure to the sun or excessive heat) Weathering, salt crystal growth and pressure releases.

i. Deep weathering in tropic areas

- Rapid chemical weathering to a depth of up to 60m
- Result deep layers of weathered material
- Thickness of the weathered mantle: 30 to 60 m

Factors promoting deep weathering in the tropics

- Climate—high prevailing temp. favoring rapid rates of chemical reaction, for e.g. Hydrolysis is speeded up 2 ½ times for every 100 C rise in temp.

- Long periods of tectonic stability—for e.g. large parts of the ancient African land mass has experienced little uplift over long periods of geologic time.
- Basal surface of weathering—often the weathered layed has very clearly defined base with a sharp change from highly weather to completely un-weathered rock. This boundary or surface that separates altered (decomposed or disintegrated) rock form, un-weathered rock is referred to as the basal surface of weathering (BSW) or weathering front. It marks the downward limit to deep weathering.

ii. Ruxton and berry (1957) model of deep weathering granite in tropical areas

- Based on actual weathering observation horizon in Hong Kong.
- The gradual decomposition of granite from the surface downward will produces in 4 zones

Those are

Zone 1

- Uppermost zone of residual debris.
- Structure-less mass of clay minerals such as kaolinite and quartz sand.
- Vary in thickness form 1-25 m.
- Results from protracted and complete decay of the granite over a long period

Zone 2

- Less decomposed.
- Comprises some residual debris, some gruss and a number of floating and rounded core stones.
- Referred to as zone of residual debris and gruss together with rounded core stones.
- Occupy up to 50 % of the zone may up to 60 m in thickness

Zone 3

- Dominated by large number of rectangular core stones separated from each other by partially decomposed gruss.
- Up to 17 m thick

Zone 4

- Base of weathering profile.
- Up to 30 m thick.
- Partially weathered rock, resulting from the initial penetration of acidulated water and opening of joints.