1.9 WEATHERING

Weathering refers to the disintegration and decay of rocks *in situ* under the influence of elements of weather such as changes in temperature, moisture and atmospheric gases. Insolation, frost, rainwater, atmospheric gases and the organisms are considered the chief agents of weathering. The process of weathering depends upon both the nature of the climatic elements and the character of the rock including its chemical composition, hardness, texture and the presence of joints and cracks. Where rocks of markedly different properties occur in close proximity, differential weathering may strongly affect the surface.

On the basis of the *nature of changes in rocks*, weathering is said to be either *mechanical* or *chemical*. Although both these types of weathering often operate in conjunction, the mechanical weathering is more pronounced in arid and cold regions while chemical weathering is more important in humid areas. *Mechanical (physical)* weathering refers to disintegration without chemical changes in the composition of the rocks. *Chemical* weathering, on the other hand, involves change in the chemical composition of rocks. It thus refers to decomposition of some or all of the mineral constituents in a rock causing ultimately a collapse within the rock itself, sometimes known as *rotting*. Mechanical weathering tends to break down the rock into progressively smaller fragments, while chemical weathering forms residual materials; the joint result is the production of a loose layer that can be removed by the agents of denudation. Biological agents including man, plants and animals also contribute to the creation of this layer of rock waste.

Mechanical Weathering

Block and Granular Disintegration This type of weathering is carried out in deserts by rapid changes of temperature, or in mountains through frost action. Desert regions experience a large diurnal range of temperature due to direct heating by the sun during the day and rapid radiation at night. The rocks successively expand and contract. The repeated expansion and contraction of the rocks tends to enlarge joints and large rock masses ultimately break into angular blocks. This process is called *block disintegration*. Rocks having vertical joints are more susceptible to this form of weathering. The rocks having curvilinear joints get weathered through the process of *exfoliation*. The top layer of the rocks gets intensely heated during day and cools rapidly at night thereby loosening the joints. As a result of this the top layer of the rock pulls away from the rest of the rock causing the surface rock to peal off. This process is also called *spalling*. Steeply sloping crags are highly prone to these processes. Temperature changes, moreover, will open up fissures into which water can penetrate, thus stimulating chemical weathering.

The rocks contain a number of minerals. All minerals have a different coefficient of expansion. As a result of this, complex strains are set up inside the rock and sudden fractures occur leading to breaking down of the rock into individual particles. This is especially common in large-grained rocks. This process is called *granular disintegration*. A sudden shower in a desert can cause sudden chilling of the rock leading to its shivering into fragments. This process is called *shattering*. However, the effect of heating and cooling to the same extent may cause different results in rocks of different nature.

Block disintegration is effectively carried out by frost action, in a process known as *congelifraction*. When water fills the interstices of a rock, it may freeze at night and its volume increases. It exerts great pressure and the rock tends to shatter. Surface covered with spread of angular blocks thus broken off is known as a *block-spread* or *boulder-field*. Frost can loosen any surface exposed to it, and hence the ploughing of heavy clay land by farmers in order that winter frosts will break it down into a more friable mass. This process, particularly potent in porous rocks, is also called *granular disintegration*. The action of freezing and thawing causes rocks to break into smaller fragments.

Rain hardly enters into mechanical weathering except as a source of water for frost action, for it involves transport, either as rain-wash or in the form of river erosion. But a whole slope may become unstable after rains. Moreover, some clay rich soils are subjected to a process called *slanking*. When a drought succeeds a rainy period, the rocks give up moisture previously absorbed. As a result, a rock such as shale, may crumble into small elongated fragments. When a mass of clay dries out, it shrinks and its surface becomes scarred with cracks, facilitating break up and subsequent removal of the rocks.

One process of physical disintegration of rocks is known as *unloading* or the *pressure release*. As overlying layers of rocks are removed by denudation, the release of pressure may allow the newly exposed rock to expand and form new curvilinear joints causing curved rock-shells to pull away from the mass. This process is known as *sheeting*. Granite is particularly susceptible to this process.

Chemical Weathering

Various changes in the chemical composition of a rock may result from long exposure to weathering agents. Some minerals, such as quartz are virtually unaffected, while others such as olivine and muscovite are very susceptible and a few, such as rock salt can be completely removed in solution. Five main processes of chemical weathering may be distinguished:

- solution
- carbonation
- hydrolysis
- oxidation
- hydration

The result of chemical weathering is the conversion of primary minerals into secondary minerals, usually more readily removable. The consolidation or adhesion of unaffected minerals in the parent rock is weakened and the rock tends to crumble. Mechanical weathering and erosional agents can then act on such rocks with greater potency.

The first essential of chemical weathering is the presence of water. A number of minerals such as sodium chloride can be easily removed through solutire action. Where percolating water contains carbon dioxide derived from the atmosphere, it acts as a dilute acid upon calcareous rocks such as limestone, dissolving and removing them in the form of calcium carbonate or bicarbonate. This is known as *carbonation*. Feldspars break down when attacked by rainwater, a process known as *hydrolysis*. In this process the crystalline feldspar rocks crumble and form clays, while silica is removed in solution. Thus granite may break down to form a friable clay mass mixed with resistant quartz crystals and mica-flakes. Such a deep, rotted layer resulting from hydrolysis is called *saprolite*. The results of *oxidation* are most readily shown when the rocks affected contain iron. The weathered surface of many rocks reveals a yellow or brown crust; the ferrous state of iron changes into oxidised ferric state and this crust readily crumbles. This process is similar to the formation of a layer of rust on iron objects in rainy season and it involves the process of oxidation. In deserts, a varnish, rind, or film of iron or manganese oxide is formed on rocks by solution drawn to the surface through intense evaporation. Sometimes, such a hard broken varnish may be an actual protection against other weathering or erosion, yet inside the rock the cementing material may have collapsed. Therefore, once the rind is ultimately broken, the whole rock may be removed by eroding forces, such as wind. Finally, certain minerals have the property of absorbing water, and thus expanding and stimulating the disintegration of the rock containing them. This process is called *hydration*.

One result of chemical activity, akin to mechanical weathering, is known as *spheroidal* weathering and its effects are very similar to exfoliation. The outer shell of such rocks as salt is affected by penetrating water and the chemical reactions cause this to swell or expand, and so pull away from the solid core, presenting a fresh surface to the atmosphere. A well-jointed rock allows this to go on readily, so that the blocks become more and more rounded as each shell of decayed rock breaks away.

Biological or Organic Weathering

Plants assist in surface weathering by both chemical and mechanical means. Algae, mosses, lichens and other vegetation retain water on the surface of the rock, and various organic acids help to decay the rock beneath so that a tuft of moss may lie in a small and growing hollow in the rock. The presence of vegetation increases the acid content of the soil water. It is an effective medium of chemical disintegration of calcareous rocks. Presence of moisture also increases bacterial activity and it assists the decomposition of some rocks. Mechanical disintegration effect of vegetation is mainly due to the penetrating and expanding capacity of roots. They exert considerable force as they grow and help to widen cracks and crevices, thus allowing water and air to enter the rocks up to fair depths.

If must be remembered, however, that a close net of vegetation may actually prevent disintegration. As it binds the surface layer it hinders its removal, holds up water and prevents the exposure of the surface of a fresh rock to the weather elements. The injudicious removal of vegetation by man is a major cause of soil erosion.

Various forms of animal life, such as worms, rabbits and moles may also contribute to weathering. Worms bring large quantities of fine materials to the surface in the form of waste, while burrowing animals help to loosen the surface material. Grazing animals remove the vegetation, trample the surface and thereby help in breaking of surface rocks. Likewise, man's usage of land may also contribute to weathering. Another impact of organisms on the rocks is in the form of change of chemical composition of some rocks. Some of the rocks get chemically modified as they pass through the digestive system of some organisms that eat them.

Different types of weathering are specifically potent in different types of regions. In equatorial areas, where both humidity and temperature are constantly high both chemical and biological types of weathering are active producing large amounts of weathered material. Similarly in tropical regions with a marked dry season during which evaporation is potent but with a wet season that allows leaching, a great thickness of laterite may be formed. In desert areas, the dominant type of weathering is the mechanical or physical one, whereas in mid-latitudes and higher areas, frost action is particularly important.

Rate of weathering is related to the nature of the rocks. Stronger rocks get weathered at a lower rate than the weaker rocks. The concept of rock strength, however, is relative. It refers to the type of weathering or the agent of weathering to which it is exposed. A rock resistant to one type of weathering may be most susceptible to another agent. Limestone and granite provide a fine example in this regard. Limestone is very resistant to wind action but it is highly susceptible to rain water. On the other hand granite is quite resistant to water action but can be weathered and eroded rather easily in areas of dry climate.

1.10 MASS WASTING

Movement of material down-slope under the influence of gravity is called *mass movement* or *mass wasting*. The term includes a variety of gravity induced movements of slope material, but the movements involving movements of material directly by a transporting medium such as running water, are excluded. However, the process of *sheet wash* which involves removal of surface debris by overland flow on low gradient slopes, is included under the term mass movement. Mass movement is transitional between weathering, a process occurring *in situ*, and erosion, involving transport of surface materials by some agent or medium. Mass wasting thus combines elements of both weathering and erosion, but occupies an intermediate position separating the two categories of processes.

The rate of mass wasting depends upon a number of factors. *Weathering*, for example, reduces the shearing strength of rocks thus making them more susceptible to movements under gravity. *Structure* and *composition* of rock material are also critical factors in the rate of mass movement. Materials such as sand, schist, gravel, shale, etc. are easy to shear and they are more susceptible to processes like fall, slide, flow or creep. Presence of *joints*, *fault plains*, *cleavages*, etc. may also facilitate movement of material. Changes in the *environmental conditions* such as climatic factors and vegetal coverage also influence the rate of mass movement. A very important factor is the *slope gradient*. Steeper the slope, faster the rate of removal of material under gravity.

Although it is not a necessary requirement, *water* plays an important role in mass wasting. Presence of water reduces the shearing strength of the material. It acts as a lubricant thus making them move more readily down slope. That is why rapid mass movements often take place following heavy rains or melting of snow.