2.4 Weathering

Weathering is the process of disintegration and decomposition of rocks and minerals to more stable forms under atmospheric conditions. It transforms the original rock (parent rock) into soil parent material. Weathering does not cease after giving rise to parent material, but continues within the soil solum (A and B horizons) or underneath it in the C horizon. The intensity and nature of reactions vary depending upon conditions of moisture, temperature, and biological activity. Two types of weathering—geochemical and pedochemical—can be recognized during soil development. **Geochemical weathering** takes place during rock alteration and below the soil solum. **Pedochemical weathering** is the continuous disintegration or alteration/decomposition of minerals in the soil solum. It is evident that **weathering is** mainly a **destructive** process. However, simultaneously a **constructive process** or synthesis may take place. Certain constituents, set free during weathering, can react with each other giving rise to secondary minerals including clays. Weathering processes include physical, chemical, and biological actions. This division, however, is an academic one, and in nature these weathering types overlap or operate concurrently.

2.4.1 Physical weathering

Physical weathering is the process whereby rocks and minerals are cracked, crumbled, crushed, and mellowed. The result is a material that varies in size from boulders to very fine particles with no appreciable change in chemical or mineralogical composition. The forces responsible for physical weathering are overburden pressure and shearing stress (e.g. grinding of particles under an ice sheet), expansion forces due to temperature change and growth of crystals (e.g ice), animal or plant activity, or water pressure, which may be important in processes controlled by wetting and drying cycles.

These forces produce stress either within the bedrock, which causes breaking along fracture and cleavage planes and usually results in large blocks or sheets, or along mineral grains or boundaries, which creates the small-sized materials of sand and silt.

Physical weathering takes place either through agencies which act on rock in place, or which move the rock about and abrade it. Physical weathering in place is brought about by the processes of unloading by erosion, expansion of freezing water, or crystallizing salt in cracks along grain boundaries, fire, and possibly thermal expansion and contraction of the constituent minerals. Agencies which move rocks include (a) glacier ice, (b) moving water, (c) gravity displacement on steep slopes, and (d) wind (e.g. sand blasting).

Unloading by erosion. Fractures can be caused by the expansion of rock masses when the pressures confining them are reduced by uplift and erosion. Ultimate rock strength is higher under the conditions of increased pressure caused by overlying rock mass. When the overlying rock mass is decreased by surface erosion, the confining pressure is also decreased. The internal stress then set up in the rock is relieved by elastic expansion of the rock. This expansion eventually causes rupture, and a series of cracks is formed parallel to the surface of the rock.

Crystal growth. Volume changes due to crystal growth set up stresses within rocks that lead to breakdown and thus constitute a part of physical weathering. These volume changes are due to freezing of water to form ice, crystal growth from solution, or chemical alteration of pre-existing minerals.

A. FROST WEATHERING. Water expands by about 9% on freezing at 0°C. This great change in volume has a potentially great disruptive effect, and frost-shattering is an important mechanical agent in weathering. When water freezes in a confined space, tremendous pressure is exerted on the enclosing rock. A theoretical pressure of several thousand pounds per square inch is possible at lower temperatures (30,000 lb/sq in at −22°C) which is far greater than the compressive strength of rock. Frost-shattering of rock also takes place in unconfined cracks or crevices. The effects of this process are most pronounced in environments where surface temperatures fluctuate across O°C many times each year. The result of this process is the presence of angular blocks of rock, and sometimes also granular disintegration if water has access to voids or cracks between the grains.

B. SALT WEATHERING. The growth of salt crystals from solution in porous rocks may lead to disintegration of these rocks either into blocks or individual grains. Salt weathering causes rock breakup in several ways. (1) Crystal growth from solution creates rupturing pressure. Examples are the crystallization of calcium carbonate and gypsum from saline solution. (2) The thermal expansion properties of crystalline salts are much higher than those of common rocks, and weathering in desert climates with great daily temperature fluctuations may occur by this process. (3) Volume increase of salts and clay with hydration creates stress sufficient to disintegrate rocks.

Thermal expansion and contraction. Diurnal fluctuation in surface temperature, if great enough, can bring about surface fracturing or granular disintegration of some rocks. Differential expansion upon heating and shrinkage upon cooling is an important weathering process in heterogeneously composed rocks. With surface temperature fluctuation, each mineral expands and contracts at a different rate, especially in desert and high mountain areas. With time, the stresses produced are sufficient to weaken the bonds along grain boundaries and cause flaking of rock fragments or dislodging of rock grains.

Some scientists, however, have expressed doubt about the efficacy of weathering by this process. Laboratory experimental evidence is inconclusive, because the elastic strength of the granite rock measured was more than the stresses set up by these processes, which did not effect the breakup of the rocks in the experimental setting. Others argue, however, that small stresses applied over long periods of time (conditions not duplicated in the laboratory) may lead to permanent strain. This process might explain some types of weathering in arid regions.

Fire. Fire is probably an important factor in the physical weathering of rocks in forest areas. Rock is a poor conductor of heat, therefore during fires a very steep temperature gradient from the rock surface to its interior is created. Thus differential expansion can lead to rupture of the rock into thin sheets that eventually fall to the ground. Repeated fires in forest areas, even after 100 or more years, can weaken the rock surface; and over thousands of years the effects of this process become very significant.