Chapter 3

Weathering, and sediment production

- **Weathering** is the in place (in situ) breakdown of rock materials at or near Earth's surface. Weathering processes are fundamentally important in the generation of the soils, sediments and sedimentary rocks that cover more than 80% of Earth's surface.

- Major weathering processes may be subdivided into disintegration and decomposition processes.

- **Decomposition** is any breakdown of rock materials that involves changes in chemical composition. Decomposition generally alters a rock's mineralogy so that minerals stable at higher temperatures or pressures are altered to minerals stable at the temperatures and pressures near Earth's surface.

- Decomposition involves both inorganic and organic chemical processes and is strongly dependent on the availability of water, which plays a significant role in decomposition processes .

- ***Disintegration*** includes any mechanical or organic weathering process that breaks rocks into smaller pieces of the same material.
- **Disintegration** is the breakdown of larger, more coherent rock bodies into smaller fragments of the same composition.
- Disintegration generates an increased number of smaller rock or mineral fragments of the original material that is being disintegrated.
- Types of weathering processes and the degree of weathering that occur at a particular place vary greatly depending upon factors such as climate, rock type, slope and time. Disintegration is more prevalent in cold and dry climates; decomposition processes dominate in warmer and wetter climates.
- Steep slopes favor short-term, incomplete decomposition as rock materials are removed rapidly by erosion before decomposition is complete, whereas gentle slopes favor longer term, more through weathering.

- ***Joint formation*** .

  Joints are fractures in rocks relative to which little or no tangential (fracture parallel) movement has taken place. Joints originate in response to stresses of various kinds and can have rather complicated histories. Most of the joints that act as conduits for fluids during weathering are produced by the decrease in confining pressure that occurs as formerly buried rocks approach the surface.

- Stratification is not significantly offset parallel to the near vertical joints. Weathering is clearly accelerated along the joints, which in turn influence the differential weathering .

- ***Mechanical Weathering;*** consists chiefly of extensive fracturing of rocks without any relation to the chemical changes which may be occurring simultaneously. Several of the physical processes which produce mechanical weathering are;

 Freezing of Water; Most water systems in rocks are open to the atmosphere, but preliminary freezing on the surface encloses the system.

When water freezes it expands nearly one-tenth its volume, creating great pressures in enclosed spaces. This expansion of the ice fractures the rock and breaks it into smaller particles. .

- ***Temperature Changes;*** Daily and seasonal temperature changes cause differential expansion and contraction in rocks which result in spalling or exfoliation. This type of weathering is most noticeable in moist, cold climates and results from a combination of frost action, chemical decomposition, and temperature expansion and contraction.
- ***Action of Plants;*** Trees and plants have an amazing capacity to grow in the joints of rock masses. The wedging action caused by root growth hastens the disintegration process near the earth's surface.
- many other methods by which mechanical weathering is accomplished. Animals, by their burrowing activities, can accelerate disintegration Crustal movements, such as faulting and folding, create much damage in a short time.

- The rate at which weathering proceeds depends not only on the vigour of the weathering agents but also on the durability of the rock mass concerned. This, in turn, is governed by the mineralogical composition, texture, porosity and strength of the rock on the one hand, and the incidence of discontinuities within the rock mass.
- Hence, the response of a rock mass to weathering is directly related to its internal surface area and average pore size.
- Coarse-grained rocks generally weather more rapidly than fine-grained ones. The degree of interlocking between component minerals is also a particularly important textural factor, since the more strongly a rock is bonded together, the greater is its resistance to weathering.
- The closeness of the interlocking of grains governs the porosity of the rock. This, in turn, determines the amount of water it can hold, and hence, the more porous the rock, the more susceptible it is to chemical attack. Also, the amount of water that a rock contains influences mechanical breakdown, especially in terms of frost action.

- The type and rate of weathering varies from one climatic regime to another. The degree and rate of weathering in humid regions depends primarily on the temperature and amount of moisture available.
- An increase in temperature causes an increase in weathering. If the temperature is high, then weathering is extremely active; an increase of 10∞C in humid regions more than doubles the rate of chemical reaction. On the other hand, in dry air, chemical decay of rocks takes place very slowly.
- The mechanical effects of weathering are well displayed in hot deserts, where wide diurnal ranges of temperature cause rocks to expand and contract. Because rocks are poor conductors of heat, these effects are mainly localized in their outer layers where alternate expansion and contraction creates stresses that eventually rupture the rock.
- In this way, flakes of rock break away from the parent material, the process being termed exfoliation. The effects of exfoliation are concentrated at the corners and edges of rocks so that their outcrops gradually become rounded.

- ***Chemical processes*** act to change the chemical composition of the parent rock. Materials produced chemically will have a greater volume but a lower specific gravity than that of the original material.
- The products of both types of weathering include materials moved in solution or colloidal suspension, and residual substances. The former usually are transported from the scene of activity to become sediments. The residual products remain after the soluble constituents have been leached.
- The chief residual product is clay. Oxides of iron and aluminum are also residual products of weathering and usually are formed, but not exclusively, in tropical climates. Other end products are minerals such as quartz, zircon, and rutile, which are not appreciably soluble under ordinary conditions of weathering.
- Chemical weathering leads to mineral alteration and the solution of rocks. Chemical weathering also aids rock disintegration by weakening the rock fabric and by emphasizing any structural weaknesses.

- When decomposition occurs within a rock, the altered material frequently occupies a greater volume than that from which it was derived and, in the process, internal stresses are generated.
- If this expansion occurs in the outer layers of a rock, then it eventually causes them to peel off from the parent body. In dry air, rocks decay very slowly.
- The presence of moisture hastens the rate of decay, firstly, because water is itself an effective agent of weathering and, secondly, because it holds in solution substances that react with the component minerals of the rock. The most important of these substances are free oxygen, carbon dioxide, organic acids and nitrogen acids.
- The rate of oxidation is quickened by the presence of water; indeed, it may enter into the reaction itself.
- Carbonic acid is produced when carbon dioxide is dissolved in water, and it may possess a pH value of about 5.7.

- The principal source of carbon dioxide is not the atmosphere but the air contained in the pore spaces in the soil where its proportion may be a hundred or so times greater than it is in the atmosphere. An abnormal concentration of carbon dioxide is released when organic material decays.

- Quartz is the most abundant mineral in the studied parent rocks, and occurs as equidimensional hard grains. Micas, which include muscovite and biotite, are flaky minerals present in the granite. Muscovite is resistant to weathering, while biotite is easily broken-down. Clay results mainly from the breakdown of feldspar minerals because they are very flaky, and therefore, have large surface areas. Feldspars are major constituents of the parent rocks, although; the clayey lateritic soils also contain silt-sized particles.

- In general, weathered rock will ***be softer, less dense, and will have more voids*** than the original material. The greater the decay, the greater will be the potential water and clay content. Weathered material may become highly unstable.

- Weathering leads to a decrease in density and strength, and to increasing deformability. An increase in the mass permeability frequently occurs during the initial stages of weathering due to the development of fractures, but if clay material is produced as minerals breakdown, then the permeability may be reduced. Widening of discontinuities in carbonate rock masses by dissolution leads to a progressive increase in permeability.
- All over the world, the ***laterites*** are so common and so important as to deserve special mention. Laterites are found throughout the tropical regions. Because of an absence of organic material in the topsoil and a consequent lack of a humic-acid leaching agent, such soils have a high alumina and iron oxide content. The clay content is naturally soft, but hardens appreciably on exposure to the atmosphere.
- Residuals soils are found only in regions that have not been geologically disturbed over at least Pleistocene time (the last two million years). Except in isolated cases of deep pockets, glaciated terrane is generally devoid of residual soil; coastal areas, subject to sea-level fluctuations, seldom contain residual soils.

- **Residual soils** are products of chemical weathering and thus their characteristics are dependent upon environmental factors of climate, parent material, topography and drainage, and age.
- These conditions are optimized in the tropics where well-drained regions produce reddish lateritic soils rich in iron and aluminum oxides and kaolinitic clays..
- Conversely, poorly drained areas trend towards montmorillonitic expansive black clays. Andosols develop over volcanic ash and rock regions and are rich in allophane (amorphous silica) and metastable halloysite
- The geological origins greatly affect the resulting engineering characteristics.
- Both lateritic soils and andosols are susceptible to property changes upon drying, and exhibit compaction and strength properties not indicative of their classification limits.

- Both soils have been used successfully in earth dam construction, but attention must be given to seepage control through the weathered rock. Conversely, black soils are unpopular for embankments
- Lateritic soils respond to cement stabilization and, in some cases, lime stabilization. Andosols should also respond to lime treatment and cement treatments if proper mixing can be achieved.
- Black expansive residual soils respond to lime treatment by demonstrating strength gains and decreased expansiveness.
- Rainfall induced landslides are typical of residual soil deposits.

Surficial Deposits

- Surficial geology is the study of loose, unconsolidated material overlying the bedrock foundation. These layers were deposited, rearranged and eroded by glaciers, fluctuating sea level, streams, landslides.

They occur as two major classes:

- Transported deposits generally derived from bedrock materials by water, wind, ice, gravity, and man's intervention and
- Residual deposits formed in place as a result of weathering processes. Surficial deposits may be stratified or unstratified such as soil profiles, basin fill, alluvial or fluvial deposits, landslides, or talus.