**ENVIRONMENTAL GEOSCIENCES**

**Prof. Prasoon Kumar Singh**

**Department of Environmental Science and Engineering**

**Indian Institute of Technology (Indian School of Mines), Dhanbad**

**Lecture-45**

**Process of Soil Formation**

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. Today we will start for the discussion of module nine. In this module, we will learn about the process of soil formation, impact of soil erosion, physical and chemical properties of soils. Today we will discuss the first lecture that is the process of soil formation. In this lecture, the important concepts will be covered like introduction to soil formation, soil forming processes, factors affecting soil formation, interaction of soil forming factors, weathering of soil, physical weathering, chemical weathering, biological weathering and lastly the factors affecting weathering.

Now, let us see about, how the soil is forming? Well-formed soil from regolith or newly deposited parent material is the outcome of several processes which are collectively called pedogenic or soil-forming processes. Physical and chemical weathering continues to operate even during pedogenesis there are several other processes involving addition, leaching, redistribution, neo-synthesis or reorganizations which lead to the development of a soil with distinct profile. Now one by one we will understand first is the addition, it is nothing, it is only the buildup of humus or salts redistribution. It is movement of clay or lime from the upper part of a soil profile to lower depths. Leaching, it is the removal of entire soil profile of soluble salts.

Neo-synthesis, it is a formation of organo-mineral, clay humus or free sesqui-oxides. Reorganization, the development of soil structure is a reorganization phenomenon. Redistribution of lime or build-up of humus takes place at a faster rate and reach a near equilibrium state in a few hundred to few thousand years, others like lateralisation require a few thousands to millions of years to reach maturity. Soil Genesis is brought about by a series of processes, the most significant of which are, Weathering and organic matter breakdown, by which some constituents are modified or dissolved or others are synthesized, Translocation of inorganic and organic materials up and down the soil profile, the materials being moved mainly by water but also by soil or organisms and Accumulation of soil materials in layers approximately parallel to the soil surface. In the diagram also you can see the different steps of the soil genesis. The role of these major processes can be seen by following the changes that take place as soils form from relatively uniform parent material. When plants begin to grow and their residues are deposited on the surface of the parent materials, soil formation has truly begun. Here you can see from the bedrock to the different horizon of the soil, A, B and C horizon.

Now, we will discuss about the soil forming processes. Different soil forming processes are: structural development, humification, translocation of lime, leaching, salinization, clay migration or lessivage, ferruginisation, braunification, regur formation, gleization, laterization and podzolization. Structural Development is the grouping of individual particles say clay silt and sand together with humus and free sesquicides into aggregates or pits of fairly distinctive size and shape. Then humification, transformation of raw organic matter into humus. Translocation of lime, removal in solution of lime from the upper part of the profile, and its partial or total accumulation in the lower part. The process leads to the formation of a kankar or calcic horizon.

Leaching, removal in solution of a constituent from soil, for example, soluble soils. Salinization, accumulation of soluble salts in soil. In the figure also you can see. Clay migration, removal of clay, particularly of fine clay in suspension from the upper part of soil profile and its accumulation in the lower part. Ferruginization, release of iron from primary minerals and their dispersal as coating on soil particles or as complexes with organic matter, clay or as discrete aggregates to impart a brown to red color to the soil. Regur formation, formation of intensely dark colour complex of smectitic clay and humus.

It is a dominant process in black cotton soils. Gleization, The reduction of iron under anaerobic conditions with production of bluish to greenish grey colour with or without mottles or ferro-manganese concretions. Laterization, removal of silica from soil and accumulation of sesquioxides that is goethite, gibbsite with or without the formation of iron stone and concretions. Podzolization is the removal of iron and aluminium, often as complexes with humus, from the upper part and its deposition at some depth. So in the figure, you can see the laterization process.

The residual iron and aluminum silica oxide is denoted by A. Accumulation of iron and aluminum denoted by B. And then the C, much soluble material to water table. So these are the processes of laterization. Now factors affecting the soil formation. At any specific location on the surface of the earth, At least five factors act simultaneously to produce the soil.

These are, the first is the parent material, second is the climate, third is the relief, fourth is the biosphere, and fifth is the time or age. Factors affecting soil formation are not of equal significance in development of different soils. Joffe divided these factors into two groups, that is active and passive factors of soil formation. Passive factors represent the source of soil-forming mass and conditions affecting it. Active factors represent the agents which supply energy that acts on the parent materials for the development of soils.

These factors are the driving forces that promote the processes causing changes in soil during the course of soil genesis. Climate and organisms are the active factors of soil formation. Now we will discuss the different factors. The first factor is the parent material. So here you can see the different types of material for formation of the, here you can see.

Now the first factor is the parent material. The parent materials on which soils are developed can be divided into two broad groups. Sedentary, that is formed in place and transported. The transported materials can be subdivided according to the agencies of transportation and deposition. Different types of parent materials are there.

The first is the residual parent materials, then the colluvial, then the parent materials transported by water, then the marine deposits, then the aeolian deposits. Residual parent materials, when the soils develop at a place from the underlying rocks, they are said to have been formed from the residual parent materials. Such materials develop in situ from the underlying rock. Typically they have undergone prolonged and often intense weathering. In a warm, humid climate, as in some parts of eastern states, northeastern states, Kerala, Tamil Nadu and Karnataka, the parent materials are likely to be thoroughly oxidized and well leached.

Red and yellowish brown colours imparted by hematite and goethite minerals, are characteristics of intense weathering in hot, humid climates.  In cool and especially dry climates, weathering is less drastic and the oxidation and hydration of iron is hardly noticeable. On the other hand, such parent materials may contain high contents of calcium and magnesium due to limited leaching. Residual parent materials are encountered mainly in the Deccan Plateau and some parts of Central India and are of relatively limited significance in the Aravalis and the Himalayan region. Colluvial parent materials.

Rocks or soil debris at the foot of a slope that have moved there due to gravity, are called colluvial materials. A colluvial material exists to some extent at the base of all slopes, but it is especially noticeable in the mountainous or hilly topography where rock slides, slips and avalanches are common. It is made up of fragments of rock detached from the higher parts and is carried down the slopes, mostly by gravity. The frost action has also much to do with the development of such deposits. A parent material developed from colluvial accumulation is usually coarse and stony because physical rather than chemical weathering is dominant.

Soils developed from the colluvial materials are not of significant agricultural importance generally because of their small surface area, inaccessibility, and unfavorable physical and chemical characteristics. However, some useful timber, horticulture, plantation, and grazing lands in mountainous regions have colluvial materials. Now parent materials transported by water. Sediments that are deposited by the flowing water such as streams, rivers, etc. are called alluvial materials. These deposits include floodplains, alluvial terraces, alluvial fans, and deltas.

Marine deposits. These deposits are formed by the deposition of sediments carried by streams into the bodies of static water. The stream-carried sediments are eventually deposited in oceans, lakes, seas, and gulfs. The coarser fragments are deposited near the shore and the finer particles away from the shore. Lacustrine deposits, the sediments deposited in freshwater lakes are known as lacustrine deposits.

Lakes are inland bodies of static water. As a result of deposition of sediments, these lakes that were once filled with water may become filled with mineral sediments. The source of these sediments is erosion of lake banks and or particles suspended streams which get discharged into the lakes. The lacustrine deposits are relatively rare. These may also be formed as a result of glacial activity.

Glacial deposits. In polar regions, snow continues to accumulate and the pressure of its weight changes the snow to ice. The glaciers transport materials embedded in them and also remove rock protuberances which come in their way. Materials deposited by the glaciers are called glacial deposits. The materials deposited directly by the glacial ice are called glacial till. These are heterogeneous mixtures of debris of wide diversity vary from rocks and boulders to clay.

And then the Aeolian deposits, sand dunes and depositions from the materials transported by wind are called aeolian deposits. These occur in the Thar desert covering western parts of India and the adjoining areas. Except for places where they have been stabilized by vegetation, sand dunes are of limited agricultural value and may become menace to agriculture if they are moving. During the glacial period, conditions were ideal for wind erosion. The weather was cold and windy and the vegetative cover in areas to the south of the glacier in North America was sparse or non-existent.

Now second factor is the climate. Climate is a dominant factor in soil formation mainly because of the effects of precipitation and temperature. Some direct effects of climate on soil formation include, retention or accumulation of lime at shallow depths in areas having low rainfall. It is because calcium carbonate and bicarbonate are not leached out due to limited amount of water moving through the soil. Such soils are usually alkaline in nature.

Second is the formation of acidic soils in the humid areas. It is due to the intense weathering and pronounced leaching of basic cations such as calcium, sodium, magnesium and potassium. Third is the erosion of soils on sloping lands. Constantly removes developing soil layers. Fourth is the deposition of soil materials.

Downslope buries the developing soils. Fifth is the weathering, leaching and erosion. These are more intense and of longer duration in the warm and humid regions where the soil does not freeze. The reverse is true in cold climates as in the central Himalayas. Third is the biosphere.

The activities of living plants and animals and the decomposition of their organic waste and residues significantly influence the soil development. Differences in soils that have resulted primarily from the variability in vegetation are especially noticeable in the transition zone where trees and grasses meet. Under the humid forest vegetation, soils that develop may have many horizons but are leached in the surface layers and have slowly decomposing organic matter layers on the surface. In contrast, some grassland soils near the transition zone of forest have surface horizons rich in well-decomposed organic matter, frequently extending down to a depth of thirty centimeter or more into the mineral soil. Burrowing animal rodents, earthworms, ants and termites are very important in the soil formation if present in large numbers.

Soils that are habitat of many burrowing animals have fewer but deeper horizons because of the constant mixing within the profile which nullifies the organic colloid and clay movements downward. Microorganisms help the soil development by decomposing organic matter slowly and forming weak acids that dissolve minerals faster than water. Some of the first plants to grow on weathering rocks are crust-like lichens, which are beneficial, that is symbiotic, combination of algae and fungi. Now fifth is the relief, the topography. The configuration of land surface is generally known as topography or relief.

Topography influences soil formation primarily through its effects on modifying water and temperature relations. Soils within the same general climatic area developed from the similar parent materials and on steep hillsides typically have thin horizons because limited amount of water moves down through the profile as a result of rapid surface runoff and rapid erosion of surface. Similar materials on gently sloping hillsides have more water passing vertically through them than do materials on steeper slopes. The soils on gentle slopes generally are deeper, have more luxuriant vegetation, and the organic matter level is higher than in soils on similar materials on steep slopes. The materials lying in land-locked depressions receive runoff waters from the surrounding higher areas.

Such conditions favor better vegetation growth but exhibit slower decomposition of dead plants because of oxygen deficiency in water-locked soils. This results in soils with a large amount of organic matter. If the area remains wet for many months of a year, organic soils develop. If the accumulating water dissolves salts from the surrounding soils, the depression may become a salt mass with unique salt-tolerant plants, or it may develop toxic salt conditions where no plants can grow. When soils in a watershed are strongly acidic, iron may leach from them and get deposited in depressions to form the bog iron that is limonite.

Alkaline soils on the sloping topography in humid regions may result in lime leaching which gets eroded into depressions leading to the formation of a marl. And the last is the time and age, the length of time required for a soil to develop the distinct layers called the genetic horizons. It depends on many interrelated factors of climate, nature of parent material, organisms, and the topography. Horizons tend to develop rapidly under the warm, humid, and forested conditions when there is adequate water to move the colloids. Acid-sandy loams lying on the sloping topography appear to be the soils most conducive for a rapid soil profile development.

Under ideal conditions, a recognizable soil profile may develop within two hundred years. Under less favorable circumstances, the time may be extended to several thousand years. Therefore, the soil development proceeds at a rate determined by the combined effects of time and intensities of climate and biota and further modified by the effect of land relief that is topography on which the soil is situated and the kind of parent material from which it is developing. More recently, rivers have flooded and covered flood plains and valley bottoms with recent deposits. These land surfaces may be only a few years or decades old, and the soil development has just started.

The soil on different aged surfaces have been forming for different lengths of time. Recent deposits have shown little soil development, whereas the land surface exposed for thousands of years may have well-developed profiles that are quite different. Now, next important point is the interaction of soil forming factors. The formation of soil is a diverse and complex process with effects from the five major factors working in combination. For instance, soils with good drainage, mild temperature, high rainfall will probably support ample plant life because favorable drainage provides an aerated locations for the plant roots.

The plants in turn decompose, producing carbon dioxide, which combines with water from rainfall to form carbonic acid. The resulting acidity increases the solubility of parent materials. Sodium, potassium, calcium and magnesium are dissolved and leached in the draining soil water and the soil becomes more acidic. High rainfall also translocate some clays and organic colloids deeper into the horizons. The same climate but different topography, that is,  a low-lying valley or depression in stead of a gentle slope, might produce a waterlogged soil which has very, very poor drainage.

The poor drainage results in stagnant water and non-aerated soil, often with the resultant poor plant growth and decreased rates of organic matter decomposition. The accumulating drainage waters also lead to the accumulation of dissolved salts. The horizon of these soils develop from common factors but with different topography will become very different. The regions of high rainfall and good drainage typically develop acid soils having upper horizons of the organic matter accumulation and removal of colloids from the upper horizons and their accumulation in the deeper horizons. The soluble materials move deeper or completely below the rooting depth.

If the soils have been developing for a long time, they tend to have high clay content, very differentiated horizons, acidity in wet climates and salt accumulation in some soils of arid regions. The wet and cool forest soils become strongly acidic, accumulate slowly decomposing organic matter on their top and exhibit extensive colloid translocation. The wet and warm climates promote a faster organic matter decomposition. In the semi-arid areas, vegetation is sparse and carbonates often accumulate at shallow depths to form whitish carbonate zones. Accumulation of soluble salts is also common.

A parent material may not be highly altered during its exposure to the factors of soil formation because of many other conditions that retard the development of a soil profile. So some of the conditions that retard the development of soil profile are generally first is the low rainfall, slow weathering, washing of little soluble material from the soil, generally shown in the thar deserts. Low relative humidity, this is another factor, which is also seen in the hard desert. High lime or carbonate content of parent material, such as limestone. Parent material that are mostly quartz sands with low amounts of silt and clay, it shows slow weathering, few colloids to move.

High clay content, poor aeration, slow water movement is there. Assistant parent rock materials, such as quartzite, which shows the slow weathering. Very steep slopes, erosion removes soil as fast as the upper horizon develops, that is low water intake reduces leaching, high water table, slight leaching and low weathering rate take place. Cold temperatures, slowing of all chemical processes and microbial activity, constant accumulation of soil material by decomposition as in the case of flood plains. Severe wind or water erosion of soil material generally it exposes new material to begin a fresh to develop a profile. Mixing by animals that is burrowing and humans that is tillage and digging minimizes the net downward colloid movement. Presence of substances toxic to plants such as excess salts, heavy metals, or high concentration of herbicides and pesticides which also gives us the different types of the soil.

Now weathering of the soil. Weathering plays a crucial role in soil formation by breaking down rocks into smaller particles and enriching them with minerals essential for plant growth. Weathering refers to the chemical and physical disintegration and decomposition of the rocks and the minerals contained in them. It is basically a combination of transformation and synthesis. As a result of weathering, the rocks are broken down physically into smaller fragments and eventually into individual mineral grains.

Simultaneously the rock fragments and minerals undergo chemical changes to form new minerals by either minor modifications or complete chemical or structural changes. The chemical changes are usually accompanied by a reduction in the particle size and release of soluble constituents which may be lost through drainage water or may be recombined to form new, that is, secondary minerals. Weathering of the initial materials precedes soil formation in hard rocks and accompanies it in soft rocks and soil materials. It is a continuing reaction during soil development to the point where no more reactants are available. Thus weathering results in mechanical and chemical breakdown of rocks.

The former is often designated as disintegration. However, both these processes operate simultaneously in drier thar desert or in cooler upper Himalayas climates, physical breakdown is more pronounced. In humid tropical climates, chemical breakdown predominates, resulting in the formation of deep to very deep soils. Now weathering processes generally are two types. First is the physical weathering and second is the chemical weathering.

Now physical weathering. Physical weathering is a mechanical process causing disintegration of consolidated massive rocks into smaller pieces. Whereas under very cold or very hot and dry conditions such as in the central Himalayas or the Thar Desert, physical weathering is prominent. The physical weathering is operated through various agents like temperature, water, ice, wind and living organisms. Temperature, the first agent, rocks may be classified into two types, monomineralic, which is made up of only one type of mineral, and polymineralic, rocks made up of more than one mineral.

In nature, polymineralic rocks are very common. As a result of diurnal temperature changes, the rock gets heated during the day and cooled during the night. Different minerals in the rocks have different coefficient of expansion and thus heating and cooling of rocks result in differential expansion and contraction of minerals. With every temperature change, therefore differential stresses are set up which eventually produce cracks in rocks thus facilitating their mechanical breakdown. Because of slow heat conductance, the outer surface of a rock is often warmer or cooler than the inner parts which are more protected.

With the passage of time, this differential heating and cooling produce lateral stresses which may cause the surface layers to peel away from the underlying parent mass. This phenomenon is referred to as exfoliation. Some rocks may have entrapped water also. Water expands by about nine percent on freezing. The freezing of this entrapped water thus may exert a tremendous force on the rock surface if space is not available to dissipate this pressure.

Role of temperature thus can be overwhelming in the physical weathering of rocks. Water, the water falls on the land and travels towards the low-lying areas such as rivers, lakes and oceans, continuously detaching and shifting, sorting and reworking the sediments that it carries. When loaded with sediments, flowing water has a tremendous cutting power, resulting in the formation of gorges, ravines and valleys. Of all the agents of physical weathering, the effect of water perhaps is more pronounced and widespread. The rounding of the sand grains on ocean beaches in the Eastern and Western Ghat is indicative of the abrasion that accompanies the water movement.

Next is the ice. The moving ice is an erosive detachment and transporting agency of the tremendous capacity. Snow received at higher elevations or polar regions accumulate and starts moving in the form of glaciers. During their movement, glaciers cause great deal of cutting and crushing of the bedrock. Although glaciers are not so extensive in the present day environments, in the recent geological past they had transported and deposited parent materials over millions of hectares on this planet. At present, glaciers are active in upper parts of the Himalayas.

Next is the wind. Wind, an important agent of transportation of suspended particles, also exerts an abrasive action. Generally, the effect of wind is more pronounced during arid climates. Dust storms of almost continental extent have occurred in the past. Particles from the bare land surface are picked up by the blowing winds, particularly during the dry months.

Purely aggregated or single-grained deposits are prone to wind erosion. As dust is transported and deposited, abrasion of one particle against the other occurs. Dust-ladden winds also act as an abrasive agent against such obstacles as rock outcrops and exposed rocks which come in their way. The rounded rock remnants in the Aravalis are caused largely by wind action. Wind in combination with ocean waves causes mechanical disintegration along the sea coast as in the Eastern and Western Ghats.

Fifth is the living organisms. Some plants like mosses and lichens grow on the exposed rock. They accumulate dust which further encourages plant growth and a thin film of highly organic material is formed. Sometimes roots of higher plants exert a prying effect on rocks that is as the root girth increases with plant growth which results in some disintegration. Burrowing by rodents, movement of animals and human activities like cultivation, quarrying, land leveling, construction of roads, building, railway lines etc. also result in physical weathering.

Such influences however are of relatively limited importance in producing parent material when compared to the drastic physical effects of water, ice, wind and temperature changes. These are all about the physical weathering. Now we will look after the chemical weathering. Physical disintegration is accompanied by chemical decomposition which produces changes in the nature and composition of rocks and minerals. Chemical weathering takes place mainly at the surface of the rocks with the alteration or disappearance of some minerals and formation of new secondary minerals.

The process of chemical weathering is controlled by various agents like temperature, water and different organisms. The presence of water facilitates chemical weathering. The rate of chemical reactions increases with increase in the amounts of dissolved carbon dioxide and other minerals in water and with increase in temperature. Chemical weathering is minimal in the desert areas due to scarcity of water and in the cold regions due to the low temperatures. Due to availability of sufficient water and the presence of favorable temperature, chemical weathering is well pronounced in the humid tropical climate.

The presence of organic and inorganic acids, which are formed as a result of microbial breakdown of plant residues, also accelerates the chemical weathering. These agents commonly act in a synergetic manner to convert primary minerals, that is, feldspar, mica, and amphiboles, into secondary minerals that is kaolinite vermiculite, hydrous oxide etc. with release of water soluble ions. The principal processes of chemical weathering are solution, hydration, hydrolysis, oxidation, reduction, carbonation, integrated weathering processes. Solution, water is a universal solvent its solubilizing action is enhanced when it contains dissolved carbon dioxide organic and inorganic acids or salts in it. Most of the minerals are affected by the solubilizing action of water through by varying degrees. Some minerals such as halite, dissolve, readily in water, whereas the solubility of some silicates such as quartz in water is very low.

Solution helps in the continuous removal of weathered materials but the total removal by simple solubilizing action is very limited. In the arid climates due to the paucity of water, even water soluble minerals remain in rocks and sediments whereas these are completely washed away in the semi-arid and humid regions. Hydration means chemical combination of water molecules with a mineral to form a new mineral. Many anhydrous minerals undergo hydration when they come in contact with water. Hydration reactions occur primarily on the surface and edges of mineral grains but may pervade the entire structure in simple salts.

Next is the hydration. Hydration is always accompanied by increasing volume. The characteristics of hydrated minerals are different from those of their anhydrated counterparts. The hydrated minerals are usually soft and are readily weatherable. The absorbed water provides a bridge or entryway for the hydronium ions or protons to attack the structure.

Slaking of certain rocks is mainly due to the hydration of their mineral constituents. Under the hot desiccating conditions, dehydration can also occur. Next is the hydrolysis. Hydrolysis is one of the most important processes in chemical weathering and results in complete disintegration of weatherable primary minerals. Hydrolysis is double decomposition processes and a hydroxide of some kind is usually formed.

The products of hydrolysis are wholly or partially removed by the percolating water depending on the climatic conditions and permeability of the residual materials. They may also recombine with other constituents to form clays. In a way, hydrolysis reactions may be considered as the forerunners of clay formations. Next is the oxidation. It is an important chemical reaction occurring in well-aerated rock and soil materials where oxygen supply is high and biological demand is low.

It is particularly important in rocks and minerals that contain iron and manganese elements that are easily oxidized. Oxidation of iron is a disintegrative weathering process in minerals containing ferrous as part of their crystal structure. Rocks containing ferromagnesian silicates such as pyroxenes, hornblende, biotite, glauconite, and chloride are susceptible to the oxidation. In other cases, ferrous iron may be released from the mineral and is almost simultaneously oxidized to the ferric form. An example of this is hydration of mineral, olivine and the release of ferrous ions from it, which may be immediately oxidized to ferric form which has very low solubility.

Reduction occurs where a material is water saturated such as below the water table level, oxygen supply is low and the biological oxygen demand is high. The net effect of this condition is the reduction of a metal, say iron, to its highly mobile form, ferrous in this case. In this form, it may be removed from the system if there is a downward and outward movement of groundwater. If ferrous iron persists in the system, it tends to form sulfides and other ferrous compounds. These impart characteristic green and blue colors to many reduced soil materials.

Under certain conditions, there could be formation of lepidocrocite, resulting in the characteristic orange and yellow mottles. Next is the carbonation. Carbonic acid, although a weak acid of carbon dioxide, is very important in chemical weathering of rocks and minerals as it makes minerals more soluble. The atmosphere contains only zero point zero three percent carbon dioxide, but the rainwater may contain as high as zero point four five percent carbon dioxide. The decomposition of organic matter and the respiration of roots and other soil organisms liberates carbon dioxide in large amounts. The concentration in soil is thus much higher than atmosphere.

Integrated weathering processes, different types of chemical reactions described above occur simultaneously and are interdependent. For example, hydrolysis of a given primary mineral may release ferrous iron that is quickly oxidized to ferric form which in turn is hydrated to give a hydrous of iron. Hydrolysis also may release soluble cations, silicic acid and aluminium or iron compounds. These substances can be combined to form secondary silicate minerals such as silicate clays. Now, factors affecting weathering.

Different minerals weather at different rates. The major factors which affect weathering of rocks and minerals are climatic conditions, physical characteristics, chemical and structural characteristics, and stability of minerals. First, the climatic conditions. The climatic conditions influence the rate and nature of weathering profoundly. Under arid conditions, the physical weathering predominates. The size of particles decreases with relatively little change in the chemical composition of a mineral.

The original primary minerals are prominent, whereas the content of secondary minerals is low. Physical changes due to temperature fluctuations and wind action are accompanied by only limited chemical changes. Consequently, the soils of arid regions are remarkably like the parent materials from which they are formed. Similarly, in extremely cold climates, the rocks and minerals undergo mechanical disintegration with little modification in chemical composition. In humid regions, the forces of weathering are more varied and vigorous chemical changes accompany physical disintegration.

In the figure also, you can see the chemical weathering is affected by temperature and rainfall. Here we are getting the x-axis with the annual rainfall and y-axis with mean annual temperature changes. You can see the different type of chemical changing is taking place. New minerals such as silicate clays and oxyhydroxides and oxides of iron and aluminum are predominant. Chemical alteration is accelerated and intensified by the action of organic acids formed by the decomposition of larger quantities of organic matter produced by abundant plant growth. In the humid tropical regions as in the southern and northeastern India, the year-round high temperatures and the luxuriant plant growth provide optimum condition for intensive weathering.

In these regions, the primary silicate minerals succumb to weathering and only the highly weathered silicate clays persist. Resistant products of chemical weathering, such as oxides of iron and aluminum, tend to dominate soils of the humid tropical regions. Physical characteristics. The physical characteristics that influence weathering include particle size, hardness, nature and degree of cementation. Second is the physical characteristics.

The physical characteristics that influence weathering include particle size, hardness, nature and degree of cementation. Rocks comprising minerals with large crystals disintegrate easily than those with fine crystals because of pronounced expansion and contraction due to changes in temperature. Once the rocks get disintegrated into smaller fragments, the finer crystals undergo relatively rapid chemical changes than the larger ones because the fine-grained materials provide larger surface area for chemical attack. Rate of weathering also depends on the hardness and cementation. For example, a dense quartzite or a sandstone cemented strongly by a slowly weatherable mineral can resist mechanical breakdown and presents only a small total surface area for chemical activity.

Porous rocks such as volcanic ash, coarse limestone or sandstone are readily broken down into smaller particles and are easily decomposed. Next is the chemical and structural characteristics. Chemical composition and structural characteristics of minerals also influence the ease of their removal or breakdown. Some minerals such as gypsum or calcite can be solubilized in water saturated with carbon dioxide and can be easily removed from the parent material. Some minerals such as ferromagnesian silicates like olivine and biotite contain readily oxidizable and their component ions are not very tightly packed in the mineral crystal structures and therefore can be easily weathered.

In contrast, the relatively tightly packed nature of crystal units and lack of oxidizable iron in muscovite impart considerable resistance to weathering. And the last is the stability of the mineral. Minerals can be arranged in the order of stability or weatherability. In view of the differences in surface area and consequent reactivity, it is desirable to separate mineral particles into two classes that is clay size and the sand-silt size. The weatherability of the common primary minerals is illustrated by the stability series proposed by Goldich. The least stable mineral, olivine, has independent tetrahedron and the silicon tetrahedron are held together by forming bonds with easily hydrolyzable magnesium or oxidizable iron.

On the other hand, in quartz, one of the most stable minerals, there is a three-dimensional network of silicon tetrahedra. All the oxygen atoms are shared with adjacent tetrahedra. Also, there is a decrease in the content of easily hydrolyzable bases from the least to the most stable mineral. So now I will conclude the lecture. First we have discussed about the introduction to soil formation in which we have seen the soil formation in natural processes resulting from the breakdown of rocks and the accumulation of organic matter over time, creating a medium that supports plant growth.

It involves complex interactions between the atmosphere, biosphere, lithosphere, and hydrosphere. Secondly, we have learned about the soil forming processes in which we have discussed the soil develops through various processes, which includes weathering, leaching, organic matter decomposition, and horizon differentiation. These processes contribute to soil structures, texture, and fertility over time. Thirdly, we have discussed about the factors affecting the soil formation. Soil formation is influenced by five main factors i.e. parent material, climate, topography, organisms, and time.

Each factor plays a crucial role in determining the soil particles, such as texture, mineral composition, and nutrient availability. And fourthly, we have discussed about the interaction of soil farming factors in which we have learned about the soil farming factors which interact dynamically to save soil properties and fertility over time. Climate and organisms influence wetting rates, while parent material and topography determine the soil composition and drainage patterns. Then we have discussed about the weathering of the soil. Weathering is the breakdown of rocks into smaller particles through physical, chemical and biological processes.

It is a fundamental step in soil formation, contributing to the release of essential minerals. And lastly, we have discussed about the factors which are affecting the weathering. We have seen that weathering is influenced by climate, rock type, biological activity, time and topography. Warmer, wetter climates enhance chemical weathering while colder climates favor physical weathering. Thank you very much to all.