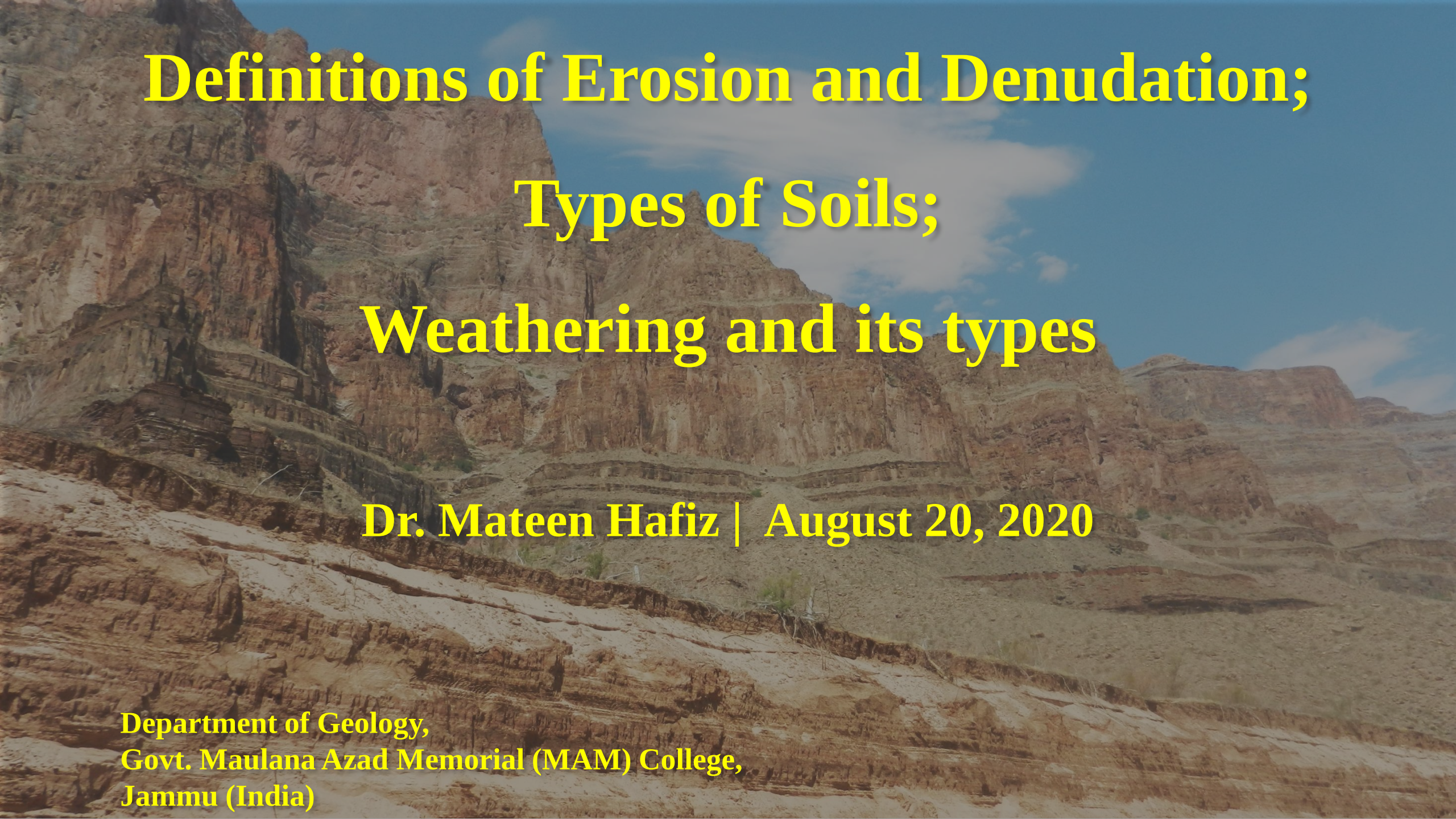

Definitions of Erosion and Denudation;

Types of Soils;

Weathering and its types

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Erosion: It is the geological process in which earthen materials are worn away and transported by natural forces such as wind or water. A similar process, weathering, breaks down or dissolves rock, but does not involve movement.

Denudation: From the Latin *denudare* to uncover, the term ***denudation*** is one of the oldest technical terms in geology, referring to a consequence of the stripping of loose, weathered material from the landscape by various processes of *erosion* and *mass-wasting*. It is the complement to *deposition*, the phenomenon of sedimentation, the two together representing the fundamental exogenic phases of the *geological cycle*. It is the combined action of weathering, erosion and or transportation to lower the landscape and landforms.

- *Denudation* rates are high in *subtropical* and *arid* regions were the absence of vegetation accelerates soil erosion and movement. Rainy tropics have vegetation which usually binds soil together impeding soil movement which reduces denudation. Areas with high vegetation cover and low temperatures (humid temperate) typically have reduced denudation rates since solution weathering is low and vegetation holds soil together.

1. Physical Erosion: Physical erosion describes the process of rocks changing their physical properties without changing their basic chemical composition. Physical erosion often causes rocks to get smaller or smoother. Rocks eroded through physical erosion often form clastic sediments. Clastic sediments are composed of fragments of older rocks that have been transported from their place of origin.

2. Erosion by Water: Liquid water is the major agent of erosion on Earth. Rain, rivers, floods, lakes, and the ocean carry away bits of soil and sand and slowly wash away the sediment.

Rainfall produces four types of soil erosion: splash erosion, sheet erosion, rill erosion, and gully erosion.

- Splash erosion describes the impact of a falling raindrop, which can scatter tiny soil particles as far as 0.6 meters (2 feet).
- Sheet erosion describes erosion caused by runoff.
- Rill erosion describes erosion that takes place as runoff develops into discrete streams (rills).
- Finally, gully erosion is the stage in which soil particles are transported through large channels.

3. Erosion by Wind: Wind is a powerful agent of erosion. Aeolian (wind-driven) processes constantly transport dust, sand, and ash from one place to another. Wind can sometimes blow sand into towering dunes. Some sand dunes in the Badain Jaran section of the Gobi Desert in China, for example, reach more than 400 meters (1,300 feet) high.

In dry areas, windblown sand can blast against a rock with tremendous force, slowly wearing away the soft rock. It polishes rocks and cliffs until they are smooth—giving the stone a so-called "***desert varnish***."

Wind can also erode material until little remains at all. ***Ventifacts*** are rocks that have been sculpted by wind erosion.

4. Erosion by Ice: Ice, usually in the form of glaciers, can erode the earth and create dramatic landforms. In frigid areas and on some mountaintops, glaciers move slowly downhill and across the land. As they move, they transport everything in their path, from tiny grains of sand to huge boulders.

Rocks carried by glaciers scrape against the ground below, eroding both the ground and the rocks. In this way, glaciers grind up rocks and scrape away the soil. Moving glaciers gouge out basins and form steep-sided mountain valleys. Eroded sediment called moraine is often visible on and around glaciers.

5. Other Forces of Erosion: Thermal erosion describes the erosion of permafrost along a river or coastline. Warm temperatures can cause ice-rich permafrost to break off coastlines in huge chunks, often carrying valuable topsoil and vegetation with them. These eroded "floating islands" can disintegrate into the ocean, or even crash into another piece of land—helping spread new life to different landscapes.

Mass wasting describes the downward movement of rocks, soil, and vegetation. Mass wasting include landslides, rockslides, and avalanches. Mass wasting can erode and transport millions of tons of earth, reshaping hills and mountains and, often, devastating communities in its path.

Types of soil

Soil is the mixture of rock debris and organic materials which develop on the Earth's surface. The major factors affecting the formation of soil are relief, parent material, climate, vegetation and other life-forms and time. Besides these, human activities also influence it to a large extent. Components of the soil are mineral particles, humus, water and air. The actual amount of each of these depend upon the type of soil. Some soils are deficient in one or more of these, while there are some others that have varied combinations.

On the basis of genesis, colour, composition and location, the soils of India have been classified into:

1. Alluvial soil
2. Black soil
3. Red and Yellow soil
4. Laterite soil
5. Arid soil
6. Saline soil
7. Peaty soil
8. Forest soil

1. Alluvial Soil: Alluvial soils are widespread in the northern plains and the river valleys. These soils cover about 40 per cent of the total area of the country. They are depositional soils, transported and deposited by rivers and streams. Through a narrow corridor in Rajasthan, they extend into the plains of Gujarat. In the Peninsular region, they are found in deltas of the east coast and in the river valleys.

The alluvial soils vary in nature from sandy loam to clay. They are generally rich in potash but poor in phosphorous. In the Upper and Middle Ganga plain, two different types of alluvial soils have developed, viz. *Khadar* and *Bhangar*. *Khadar* is the new alluvium and is deposited by floods annually, which enriches the soil by depositing fine silts. *Bhangar* represents a system of older alluvium, deposited away from the flood plains. Both the *Khadar* and *Bhangar* soils contain calcareous concretions *(Kankars).* These soils are more loamy and clayey in the lower and middle Ganga plain and the Brahamaputra valley. The sand content decreases from the west to east.

2. Black Soil: Black soil covers most of the Deccan Plateau which includes parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu. In the upper reaches of the Godavari and the Krishna, and the north western part of the Deccan Plateau, the black soil is very deep. These soils are also known as the 'Regur Soil' or the 'Black Cotton Soil'. The black soils are generally clayey, deep and impermeable. They swell and become sticky when wet and shrink when dried. So, during the dry season, these soil develop wide cracks. Thus, there occurs a kind of *'self-ploughing'*.

3. Red and Yellow Soil: Red soil develops on crystalline igneous rocks in areas of low rainfall in the eastern and southern part of the Deccan Plateau. Along the piedmont zone of the Western Ghat, long stretch of area is occupied by red loamy soil. Yellow and red soils are also found in parts of Odisha and Chattisgarh and in the southern parts of the middle Ganga plain. The soil develops a reddish colour due to a wide diffusion of iron in crystalline and metamorphic rocks. It looks yellow when it occurs in a hydrated form. The fine-grained red and yellow soils are normally fertile, whereas coarse-grained soils found in dry upland areas are poor in fertility. They are generally poor in nitrogen, phosphorous and humus.

4. Laterite Soil: Laterite has been derived from the Latin word *'Later'* which means brick. The laterite soils develop in areas with high temperature and high rainfall. These are the result of intense leaching due to tropical rains. With rain, lime and silica are leached away, and soils rich in iron oxide and aluminium compound are left behind. Humus content of the soil is removed fast by bacteria that thrives well in high temperature. These soils are poor in organic matter, nitrogen, phosphate and calcium, while iron oxide and potash are in excess.

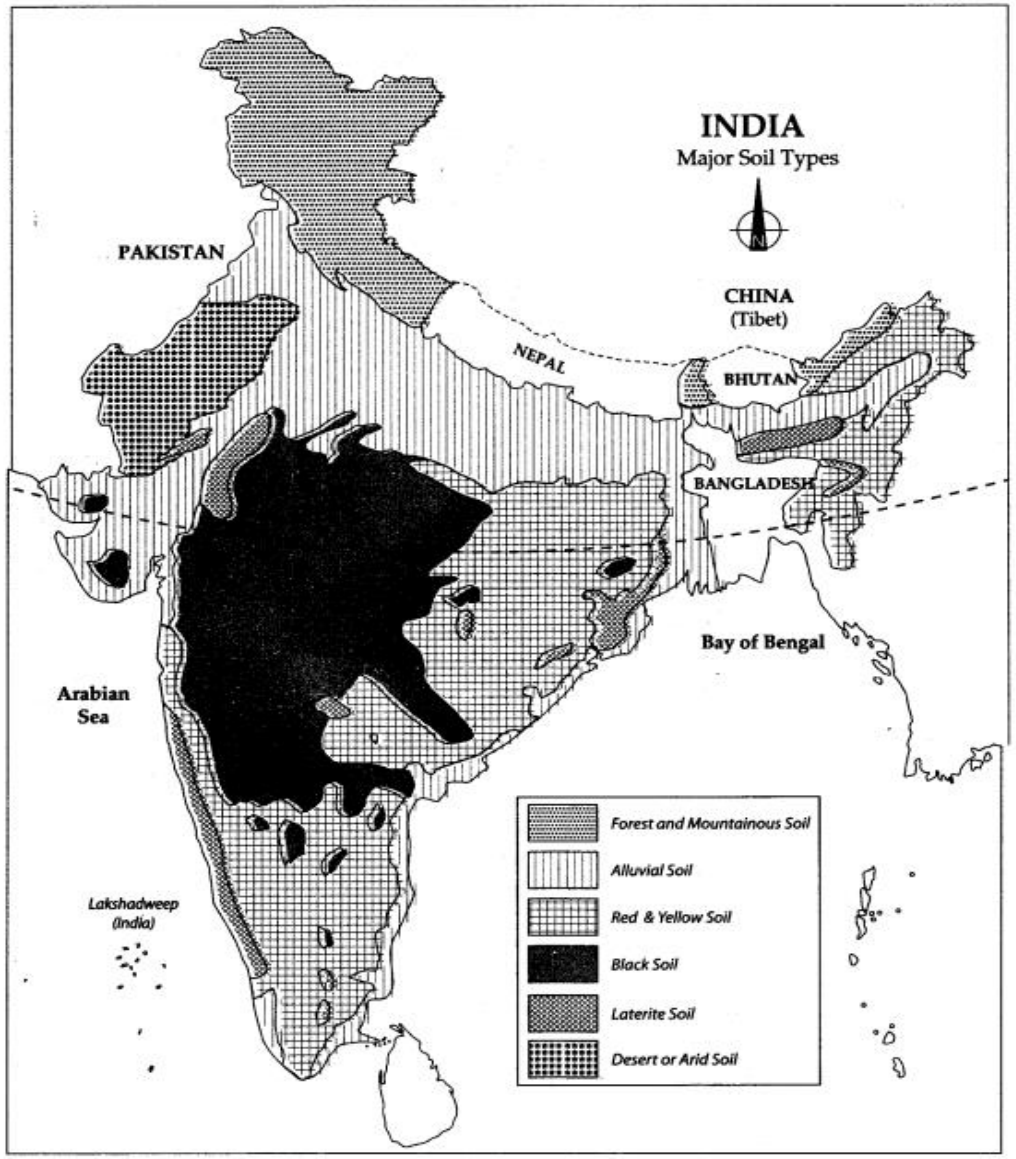
5. Arid Soil: Arid soils range from red to brown in colour. They are generally sandy in structure and saline in nature. In some areas, the salt content is so high that common salt is obtained by evaporating the saline water. Due to the dry climate, high temperature and accelerated evaporation, they lack moisture and humus.

6. Saline Soil

They are also known as *Usara* soils. Saline soils contain a larger proportion of sodium, potassium and magnesium, and thus, they are infertile, and do not support any vegetative growth. They have more salts, largely because of dry climate and poor drainage. They occur in arid and semi-arid regions, and in waterlogged and swampy areas. Their structure ranges from sandy to loamy. They lack in nitrogen and calcium. Saline soils are more widespread in western Gujarat, deltas of the eastern coast and in Sunderban areas of West Bengal.

7. Peaty Soil: They are found in the areas of heavy rainfall and high humidity, where there is a good growth of vegetation. Thus, large quantity of dead organic matter accumulates in these areas, and this gives a rich humus and organic content to the soil. Organic matter in these soils may go even up to 40-50 per cent. These soils are normally heavy and black in colour. At many places, they are alkaline also. It occurs widely in the northern part of Bihar, southern part of Uttaranchal and the coastal areas of West Bengal, Orissa and Tamil Nadu.

8. **Forest Soil**: As the name suggests, forest soils are formed in the forest areas where sufficient rainfall is available. The soils vary in structure and texture depending on the mountain environment where they are formed. They are loamy and silty on valley sides and coarse-grained in the upper slopes. In the snow-bound areas of the Himalayas, they experience denudation, and are acidic with low humus content. The soils found in the lower valleys are fertile.



Source: NCERT

Weathering and its Types

Weathering is the combination of processes that break up and corrode solid rock and may eventually transform it into loose debris. The left over from the breakup of once solid rock, and to a layer of debris as **regolith**. Regolith can include both loose sediment and soil.

Physical weathering

Physical weathering, sometimes also referred to as *mechanical weathering*, breaks intact rock into unconnected **clasts** (grains or chunks). Many different phenomena contribute to physical weathering, as described below.

1. Jointing: Natural cracks that form in rocks due to removal of overburden or due to cooling are known as **joints**. Almost all rock outcrops contain joints. Some joints are fairly planar, some are curving, and some are irregular. Large granite plutons may split into onion-like sheets along joints that lie parallel to the mountain face, a process known as *exfoliation*, while sedimentary rock beds tend to break into rectangular blocks.

Joint-bounded blocks tumble from a cliff and accumulate in talus aprons

The contrast between fresh and weathered granite. Weathered granite can break apart. Grains fall off and collect as regolith at the base of the outcrop.

2. Frost wedging: Freezing water can burst pipes and shatter bottles because water expands when it freezes and pushes the walls of the container apart. The same phenomenon happens in rock. When water trapped in a joint freezes, it forces the joint open and may cause the joint to grow. Such **frost wedging** (Fig a) helps break blocks free from intact bedrock.

3. Root wedging: As roots grow and expand they apply forces to their surroundings. Tree roots that grow into joints can push joints open in a process known as **root wedging** (Fig. b).

Chemical weathering

Chemical weathering refers to the chemical reactions that alter or destroy minerals when rock comes in contact with water solutions or air. Common reactions involved in chemical weathering include the following.

• *Dissolution:* Chemical weathering during which minerals dissolve into water is called **dissolution**. Dissolution primarily affects salts and carbonate minerals, which dissolve relatively easily. But even quartz can dissolve slightly. Some minerals, such as halite, dissolve rapidly in pure rainwater. But others, such as calcite, dissolve rapidly only when the water is *acidic*, meaning that it contains an excess of hydrogen ions (H^+). Acidic water reacts with calcite to form a solution of Ca^+ and $CO3^{2-}$, and releases carbon dioxide gas.

How does the water in rock near the surface of the Earth become acidic? As rainwater falls, it dissolves carbon dioxide gas in the atmosphere, and as the water sinks down through soil containing organic debris, it reacts with the debris. Both processes yield carbonic acid. Because of the solubility of calcite, limestone and marble—two types of rock composed of calcite—dissolve sufficiently to yield underground caverns.

• *Hydrolysis:* During hydrolysis, water chemically reacts with minerals and breaks them down to form other minerals (*lysis* means loosen in Greek). For example, potassium feldspar (orthoclase), a common mineral in granite, reacts with acidic water to produce kaolinite (a type of clay) along with a variety of dissolved ions. Hydrolysis reactions break downnot only feldspars but many other silicate minerals as well—amphibole, pyroxene, mica, and olivine all react slowly and transform into various types of clay. Quartz also undergoes hydrolysis but does so at such a slow rate that quartz grains survive such weathering in most climates.

• *Oxidation:* Chemists refer to a reaction during which an element loses electrons as an *oxidation reaction*, because such a loss commonly takes place when elements combine with oxygen. The oxidation, or rusting, of iron serves as an example. Oxidation reactions in rocks transform iron bearing minerals (such as biotite and pyrite) into a rusty brown mixture of various iron-oxide and iron-hydroxide minerals.

• *Hydration:* Hydration, the absorption of water into the crystal structure of minerals, causes some minerals, such as certain types of clay, to expand. Such expansion weakens rock.

Controlling Factors of Weathering

The nature and magnitude of weathering differs from place to place and region to region. Weathering of rocks is affected and controlled by the agents of weathering, lithological and structural characteristics of rocks, height and slope factors. Besides, climatic conditions, topography and reliefs, flora and microfauna also affect different processes of weathering to greater extent.

For example, disintegration of rocks is more effective in hot and dry region and in the regions where frost action is more dominant while chemical decomposition is more prevalent in hot and humid and temperate humid regions.

- *Composition and Structure of Rocks*

Since weathering involves disintegration and decomposition of rocks and hence mineral composition, joint patterns, layering system, faulting, folding etc. largely affect the nature and intensity of weathering. For example, carbonate rocks (e.g. calcium carbonate, magnesium carbonate etc.) having more soluble minerals are easily affected by chemical weathering. Well jointed rocks are more subjected to mechanical disintegration.

Rocks having vertical strata are easily loosened and broken down due to temperature changes, frost action, water and wind actions. On the other hand, the rocks having horizontal beds are more compact and are less affected by the mechanisms of disintegration and decomposition.

- *Nature of Ground Slope*

Ground slope controls mechanical disintegration of rocks and mass-movement of weathered products down the slope. The rocks in the regions of steep hill-slope are easily disintegrated due to mechanical weathering and the weathering materials are instantaneously moved down the hill-slope in the form of rock-fall, debris fall and slide, talus creep etc.

Instantaneous removal of weathering products allows continuous exposure of rocks to atmospheric conditions for further weathering. The regions of gentle and moderate ground slope are less affected by mechanical disintegration.

- *Climatic Variations*

Climate is considered to be very important factor of all types of weathering. Climatic geomorphologists are of the view that each climatic type produces definite conditions for a particular type of weathering. For example, chemical weathering is more dominant in humid tropical areas because of more available water and high temperature.

Because of abundance of moisture and high temperature leaching process and solution of rocks are more effective in the humid tropics. Mechanical weathering is less effective. On the other hand, mechanical disintegration of rocks is more dominant in the tropical and semi-arid regions. Rocks are weakened due to alternate expansion on heating during daytime and contraction on relative cooling during nights because of diurnal change of temperature.

Rocks are least affected by mechanical disintegration in cold climate but chemical decomposition of rocks may be effective provided that the ground surface is not covered by ice cover for longer duration in a year. Both, mechanical and chemical weathering cease when the ground surface is covered by permanent ice sheets.

Not only this, seasonal variations in climate of a region generate different conditions for weathering. For example, in monsoon climate rocks are subjected to mechanical disintegration during hot and dry summer months whereas chemical and biochemical weathering is more dominant during wet monsoon months.

Questions to Consider

Sheet erosion describes erosion caused by _____:

- ❑ Wind
- ❑ Air
- ❑ Water
- ❑ Glacier

Rocks whose surface has been faceted by the wind are called:

- ❑ Mushroom rocks
- ❑ Ventifacts
- ❑ Pedestrian rocks
- ❑ Yardangs

The major factors affecting the formation of soil are:

- ❑ Relief
- ❑ Climate
- ❑ Vegetation
- ❑ All of the above

Which one of the following soils develop in areas with high temperature and high rainfall?

- ❑ Laterite
- ❑ Red Soil
- ❑ Arid Soil
- ❑ All of the above

Which one of the followings is not the controlling factors of weathering?

- ❑ Composition of rocks
- ❑ Nature of slope
- ❑ Climate
- ❑ Type of vegetation

Suggested Readings: Earth – Portrait of a Planet by Stephen Marshak

Earth's Dynamic Systems by Hamblin and Christiansen

Fundamentals of Physical Geology by Sreepat Jain

nationalgeographic.org/encyclopedia/erosion/

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