



## Chapter 6

# Weathering and Soil Formation

### Learning Outcomes

- Identifying types of weathering
- Understanding factors that affect weathering
- Understanding the relation between weathering and soil formation
- Recognising the importance and methods of soil conservation



21<sup>st</sup> critical thinking

### Thinking Cap

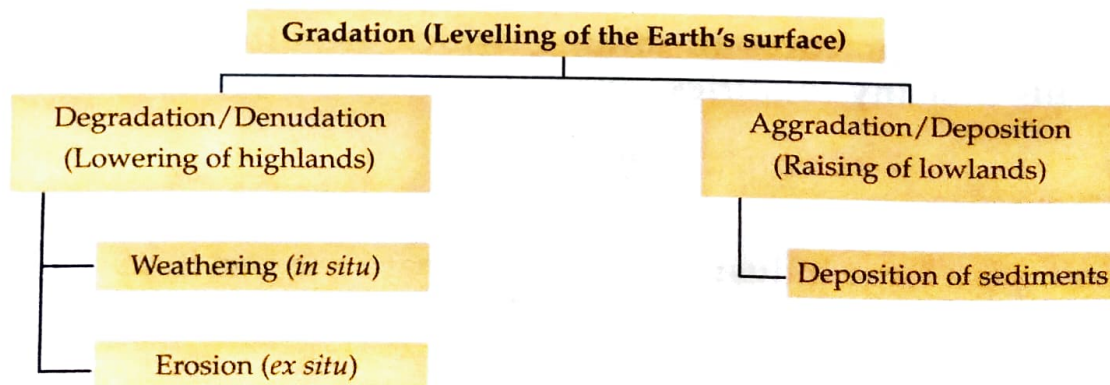
The Deccan Plateau region has mostly black soil while the Great Northern Plains have alluvial soil. Why do you think different regions have different types of soil?

All landforms on the Earth's surface are constantly exposed to external natural forces, some of which are mobile, while others are immobile. The mobile agents are rivers, wind, glaciers and seas, while the immobile ones are changes in atmospheric conditions. All these agents are simultaneously breaking down the highlands and raising the lowlands to level the surface of the Earth. This process

of levelling of the Earth's surface is called **gradation**. Lowering of highlands is called **denudation** or **degradation**, while raising of lowlands is **aggradation**.

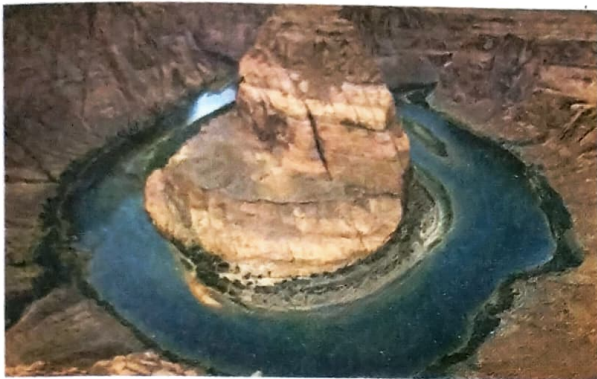
Denudation and degradation are not the same. Denudation means 'laying bare', while degradation means 'wearing away' or flattening of elevated surfaces.

Degradation, when achieved by immobile agents is known as **weathering**, and when achieved by mobile agents is called **erosion**. In this chapter, we will focus on the relationship between weathering and soil formation.



## Weathering

Weathering includes all natural processes of denudation. These cause physical disintegration and chemical decomposition due to the effect of immobile natural conditions such as a high range of temperature. Since the agents are immobile, the disintegration also occurs in the same place as the parent rock. Here, it is *in situ* breakdown.



*Horseshoe bend at Grand Canyon formed by weathering of rocks*

## Factors Affecting Weathering

Weathering takes place gradually over a long time, in contrast to earthquakes and volcanic eruptions that occur suddenly.

Many factors, such as temperature, local climate, mineral composition and structure of rocks, vegetation cover in the region, amount of exposure or bare rock surface, acids, salts, plants and animals, and human activities contribute to weathering.

## Types of Weathering

Depending upon the nature of the agent, weathering may be classified as follows:



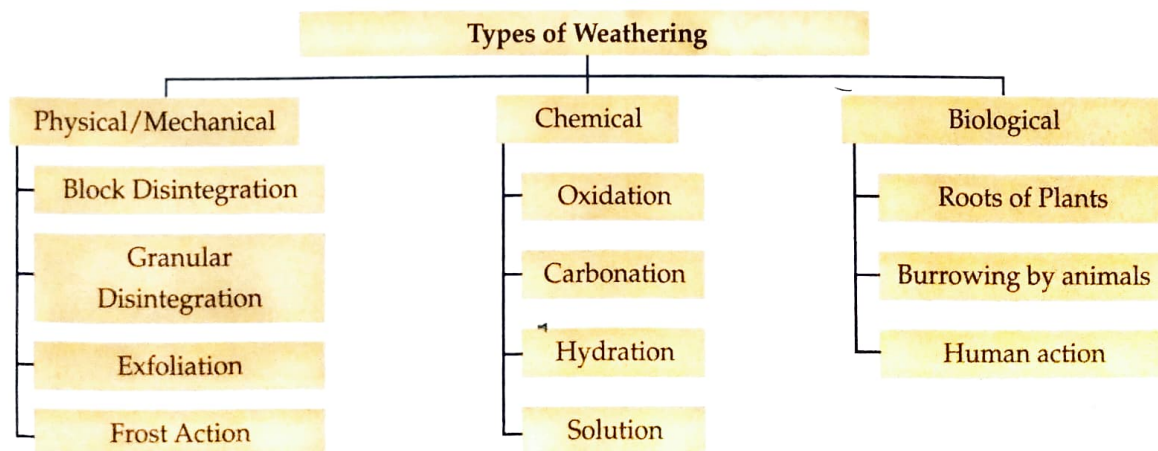
### Physical or Mechanical Weathering

Physical weathering is physical or mechanical disintegration of large rocks and boulders into smaller fragments. This occurs due to differential rates of expansion and contraction of layers and minerals comprising the rocks, which is due to variation in atmospheric temperature. Hence, the most important tool for mechanical weathering is thermal action.

Significant features of mechanical weathering are:

- It is an *in situ* process.
- Rocks change only in form and size and not in chemical composition.
- Dry air facilitates these processes.
- A high diurnal range of temperature is essential for its occurrence.

All processes of mechanical weathering occur due to the high diurnal range of temperature. Therefore, it is called **thermal action**. Such thermal action causes alternate expansion and contraction of rocks during





the day and night. Dry air facilitates block and granular disintegration and exfoliation processes. presence of water is essential for frost action.

### Block Disintegration

When a large rock breaks down into smaller fragments along cracks and joints present on its surface, it is known as block disintegration. It occurs due to differential rates of expansion and contraction of **heterogeneous** rocks, due to the high diurnal range of temperature.

### Granular Disintegration

Minerals comprising a rock may react differentially to changes in temperature. Some may expand and contract more than others. These may break the rocks into very tiny fragments, collecting at the base. This is known as granular disintegration. The rock surface becomes pitted and irregular. This type of weathering is most common in desert regions, with high diurnal range of temperature.

### Exfoliation

In a rare situation, when a rock is made up of homogeneous minerals, it may break down in layers, like the peels of an onion. This layer-wise peeling away of the rocks as a result of high diurnal range of temperature is known as exfoliation.



*Enchanted Rock in the USA shows exfoliation*

### Frost Action of Water

In mid-latitude areas, during the winter season, there may be high temperature

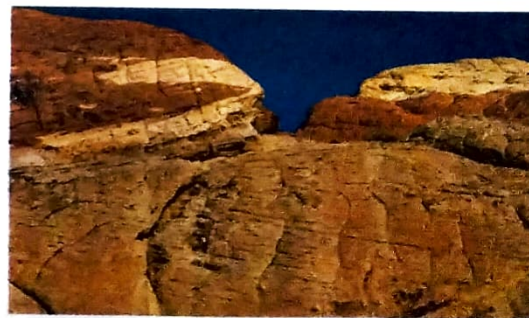
during the day and freezing temperature at night. In such conditions, water trapped in cracks and joints of rocks, freeze into ice at night and thaw into water during daytime. Due to the expansion of water, the cracks deepen, gradually breaking down the rocks into smaller fragments. Alternate freezing and thawing of water over a period of time is essential for this. It is most common in polar, mountainous and temperate regions.

### Chemical Weathering

As the name suggests, this method of weathering brings about a change in the chemical composition of rocks. It happens when minerals in the rock react with gases in the atmosphere to form compounds that are easily degraded. These atmospheric gases are oxygen, carbon dioxide and hydrogen, and these give rise to the process of **oxidation**, carbonation and hydration, respectively. A fourth method is the reaction of rocks with the water present on Earth's surface. This is called solution.

### Oxidation

Certain rock-forming minerals combine with atmospheric oxygen forming compounds that are easily degraded. For example, oxygen present in rocks combines with gaseous oxygen to form iron oxides (rust), which change the colour of the rocks to reddish-brown. They are easily degraded to give reddish brown soil.



*Oxidised sandstone at Rock Canyon National Conservation Area, USA*



## Carbonation

Rainwater, while falling towards the ground, mixes with atmospheric carbon dioxide, to form weak carbonic acid. If this rainfall occurs in areas made up of rocks like limestone (calcium carbonate) and dolomite, then water soluble bicarbonates are formed. These rock surfaces may have etched out cavities and deep cracks. This process gives rise to the formation of karst landscapes.

## Hydration

When rock-forming minerals react with the hydrogen present in atmosphere, they become soft and weaken the rocks, causing these to breakdown. For example, hydrogen in water combines with mineral feldspar to form a water soluble soft rock called Kaolin. It is powdery in texture and soluble in water.

## Solution

Some rock-forming minerals directly dissolve in water found on the surface of rocks or within cracks or joints. Rainwater falling on these rocks may also dissolve these minerals. These water-soluble minerals (like silica, rock salt and gypsum) may get etched out of the rock surface, creating pores inside the parent rocks. Eventually, this breaks the rocks down.

## Biological Weathering

Although the agents of biological weathering are mobile, they do help to facilitate the *in situ* breakdown of rocks. Hence, they are more of facilitators rather than a direct agent of weathering.

- Roots of plants grow despite soil profile through rock layers, cracking them up and loosening them. The strong and penetrating roots of plants may widen cracks in rocks.
- Burrowing animals, such as rodents, rabbits and earthworms make their

homes in rock crevices. This loosens and weathers the rocks eventually.

- Using dynamites for road construction, constructing large dams, deep and underground mining are some human activities that accelerate weathering.



*A prairie dog burrowing in land*

## Soil Formation

Soil is best described as loose, unconsolidated mineral layer forming a thin layer of the Earth's surface (on the crust). It is comprised of fine fragments of rocks (called sediments), organic matter (humus) and water and air. Formation of soil is a long-drawn-out process and can only be achieved naturally. Soil is one of the precious natural resource, which is fast getting depleted.

Soil is formed by weathering of rocks. In this process, rocks are continuously broken down into smaller fragments. Later, the rock sediments settle in layers to form soil. Factors controlling soil formation are—nature of parent rock, climatic conditions, terrain, organic content and time.

### ACTIVITY

21<sup>st</sup> collaboration



**Form groups of five. Collect different types of soil. Observe the differences in colour and texture of the samples.**

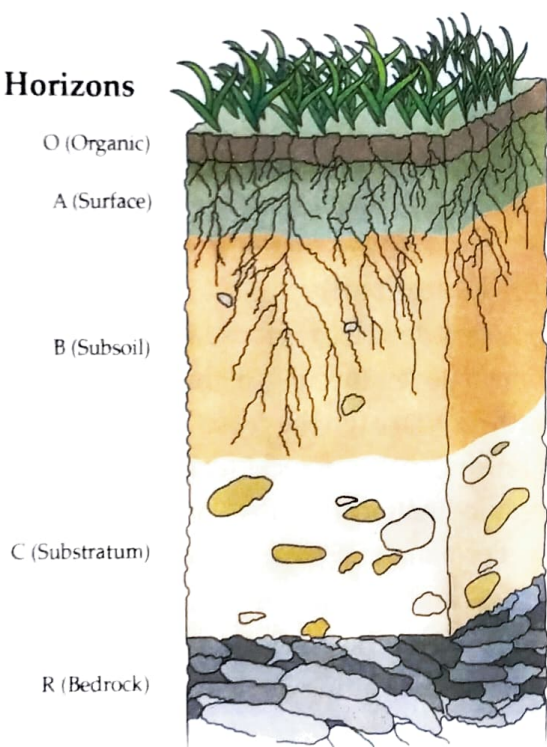
## Soil Profile

Soil profile is a vertical section of the soil from the ground surface to the point where it meets the underlying rocks.



A soil profile shows the horizontal layers of soil or horizons. There are four main horizons. These are topsoil, subsoil, weathered rock and bed rock. Topsoil is further divided into two layers—the organic layer and the surface layer.

### Horizons



*A soil profile showing different horizontal layers*

The topsoil is very fine. The organic layer contains a thin layer of plant residues, mostly in non-decomposed form. The surface layer is rich in organic matter. Most of the humus is found in this layer of the soil. Generally, it contains clay, silt and sand.

The subsoil contains finer rocks, along with silt and clay, but is low in humus content.

The weathered rock layer and **bedrock** layers comprise hard rocks that do not

support plant growth. The weathered rock layer contains sedimentary deposits and is also called **substratum**.

Bedrock is the lowest layer and is also called the **parent rock**.

## Importance of Soil Conservation

Agents like water, wind and ice displace or wear away the top layers of soil. This is called erosion. It involves transportation and deposition of weathered rock material and soil from one place to another due to the action of these natural agents.



*Soil erosion in agriculture lands in Brazil*

Soil erosion is mainly of two types—sheet erosion and gully erosion. Sheet erosion occurs when heavy rainfall washes away the top layer of soil in large, exposed areas. Gully erosion involves formation of deep, narrow furrows as rainwater flows down the slopes.

Erosion causes loss of soil fertility. Continuous erosion can create **badlands** and render a land unfit for cultivation. Deforestation, **overgrazing**, floods and improper farming practices contribute to erosion.



### Did you know?

Van Mahotsav is a programme that was initiated by the Government of India in 1950. It is an annual tree planting initiative aimed at reducing soil erosion.

## Methods of Soil Conservation

Soil conservation refers to the protection of soil against erosion. Soil conservation is important because the soil is the source of our basic needs, such as food and clothing.

Soil is also crucial for filtering air and water.

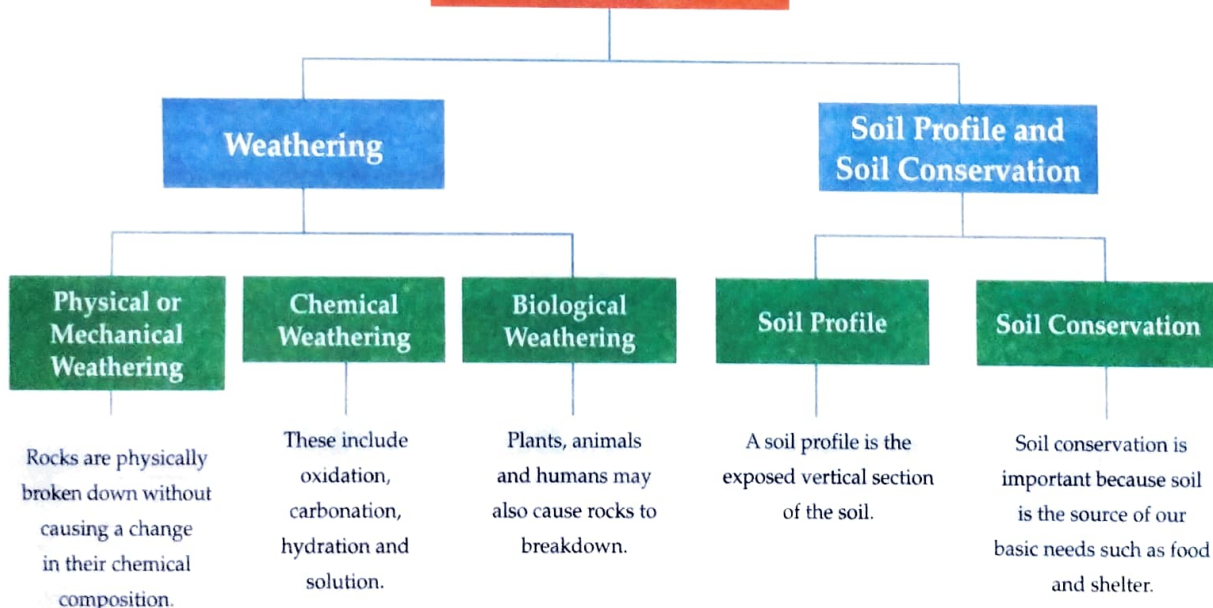
To reduce the rate of erosion, many soil conservation measures are undertaken. These include the use of proper farming methods such as levelling of fields, terracing of hill slopes, construction of mud walls or bunds and ploughing fields in circles. Other initiatives, such as afforestation, controlled grazing, plugging gullies and crop rotation also help check soil erosion.

### Did you know?

'Badlands' are formed by extensive erosion of soft sedimentary rocks and clay-rich soils by wind and water. Steep slopes, little or no vegetation and high drainage density are some characteristics of badlands. The Chambal Valley in Madhya Pradesh is an example of badlands.

## AT A GLANCE

### Weathering and Soil Formation



## EXERCISE



INT



### A. Fill in the blanks.

1. Weathering is the \_\_\_\_\_ or decomposition of rocks and minerals on the Earth's surface.
2. \_\_\_\_\_ weathering refers to breakdown of rocks without causing a change in their chemical composition.
3. In oxidation, certain chemicals inside rocks react with \_\_\_\_\_.
4. Plants, animals and humans are not really agents of weathering but effective \_\_\_\_\_.
5. A soil \_\_\_\_\_ is a vertical section of the soil from the ground surface to the point where the soil meets the underlying rocks.

### B. State whether true or false.

1. A rock once disintegrated is further eroded by forces of nature like water, heat from sunlight and wind.
2. Weathering takes place suddenly.
3. Generally, low temperatures cause faster chemical changes in rocks.
4. Human activities such as mining and construction causes corrosion of rocks.
5. Sheet erosion involves formation of deep, narrow furrows as rainwater flows down the slopes.

INT



### C. Match the following.

	Weathering Process		Description
1.	Thermal action	a.	It involves reactions between certain elements of rocks and hydrogen present in the air or water.
2.	Oxidation	b.	Rainwater, while falling towards the ground, mixes with atmospheric carbon dioxide, to form weak carbonic acid.
3.	Carbonation	c.	It causes alternate expansion and contraction of rocks during day and night.
4.	Hydration	d.	Soluble minerals such as rock salt, gypsum and silica are washed away in water, creating pores inside the parent rocks.
5.	Solution	e.	Iron in rocks reacts with atmospheric oxygen to form iron oxide or rust, which changes the colour of the rocks to reddish-brown.

INT





#### D. Choose the correct answer.

INT



- Which of the following is a chemical factor that causes weathering?  
☐ frost action ☐ carbonation  
☐ exfoliation ☐ thermal action
- Which type of weathering is most common in desert regions, where the diurnal range of temperature is high?  
☐ granular disintegration ☐ frost action  
☐ exfoliation ☐ hydration
- Which activity facilitates soil erosion?  
☐ afforestation ☐ crop rotation  
☐ plugging gullies ☐ overgrazing
- In which of these regions is weathering by frost action not common?  
☐ polar ☐ mountainous  
☐ desert ☐ temperate
- In carbonation, which compound is produced as rainwater absorbs atmospheric carbon dioxide?  
☐ carbon trioxide ☐ carbon monoxide  
☐ carbonic acid ☐ carbide

#### E. Give reasons.

- Exfoliation causes peeling of rocks.
- Low temperature speeds up carbonation.
- It is important to prevent soil erosion.

#### F. Answer in a paragraph or two.

- Explain the factors affecting weathering.
- Describe the process of frost action.
- How does oxidation cause weathering in rocks?
- Describe biological weathering.
- Explain the layers in a soil profile.



#### Picture Study

21<sup>st</sup>

media literacy

Observe the picture and answer the following questions.

- Identify the type of weathering in the picture.
- What causes this type of weathering?







## Integrate



Biodiversity within a soil profile is determined by its physical properties. These properties decide the characteristics of soil, such as water content, atmosphere and chemical composition. The chemical composition of soil is responsible for its nutrient richness and life-sustaining environment.

List the nutrients that are required by plants from the soil.



## Life Skills

21<sup>st</sup>

problem solving

environmental literacy



To improve the productivity of soil, the Government of India has already launched the Soil Health Card Scheme. Since February 2015, the Indian government has started issuing crop-wise recommendations. These recommendations are aimed at nutrients and fertilisers required in a given land.

List the soil conservation initiatives being carried out in your state. Discuss the effects of such schemes. Suggest additional efforts or improvements in the current work to ensure better soil conservation.



## Project

21<sup>st</sup>

creativity & innovation



Take a small piece of chart paper (about 10–15 cm long). Now create a model of soil profile on this chart using different types of soil and pebbles.

## Enrichment Worksheet 2

- A. Using the Internet, study the climate of any particular state/country, and describe it. List the factors that make the climate of the place that way.



environmental literacy

technology literacy

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- B. Divide yourselves into three groups. Assign one type of rock to each group: igneous, sedimentary and metamorphic rocks. Research on your respective soil types. Now organise a discussion in the class about how these rocks are formed. Write what you found out below.



collaboration



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- C. With the help of your classmates, make a colourful chart on *Van Mahotsav* to create awareness about planting more trees.



environmental literacy



art integration

