2. Weathering and Mass Wasting

Let's recall.

Study the diagram given in figure 2.1 and answer the following questions :

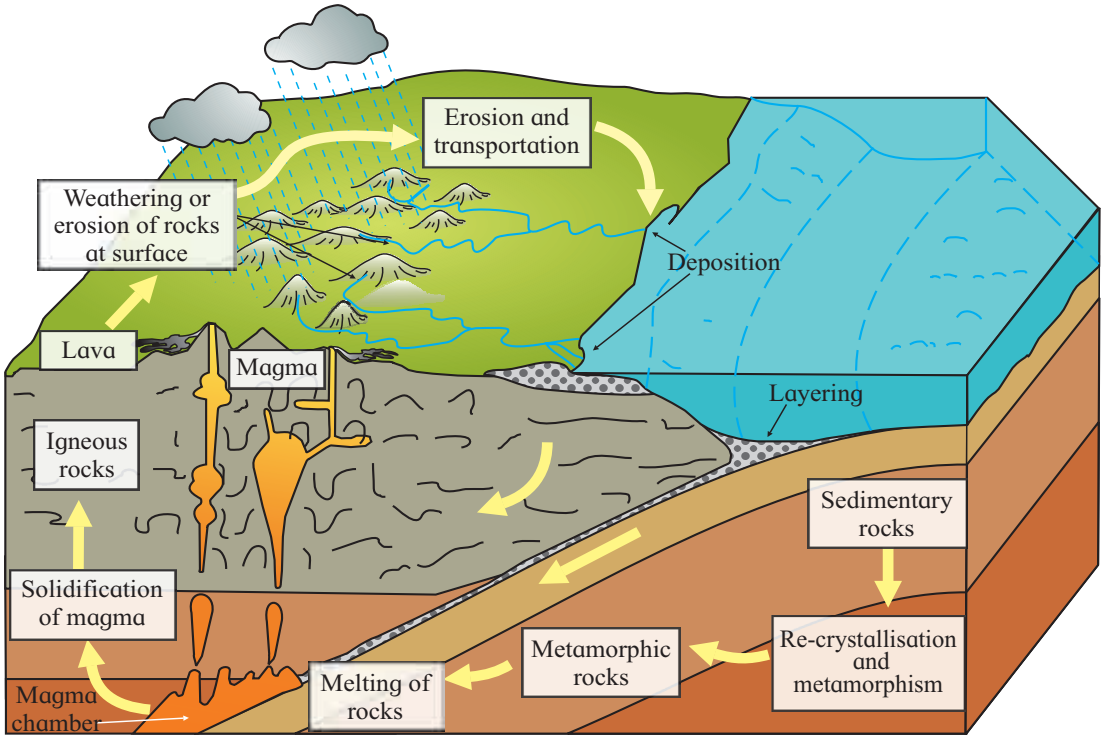


Fig. 2.1 : Rock cycle

1) Identify the types of rocks shown in the diagram.
2) Arrange the rocks according to their chronology of origin.
3) Explain how sedimentary rocks are formed.
4) Think of all the factors which may break the rocks into smaller pieces.
5) Which type of rock will break easily as compared to others? Why?

Geographical explanation

Igneous, sedimentary and metamorphic rocks are the three types of rocks found on the Earth. Igneous rocks are formed from lava which has come from eruptions on the Earth's surface. Igneous rocks are, therefore, the first rocks formed on the Earth's surface. As we have seen in fig. 2.1, when rocks break into smaller pieces, they are carried away from one place to another. In these sediments, organic materials also gets mixed. When layers of sediments deposit on each other, immense pressure acts on them. As a result and also because of the cementing material, sedimentary rocks are formed. Metamorphic rocks are formed when igneous and sedimentary rocks are subjected to immense heat and pressure.

How can rocks break? Rocks which are exposed are affected by the climate of that region. Rock can break because of water, pressure, heat, etc. in various different ways. Those rocks which have joints or layers break

easily than rocks which are homogeneous. Generally, sedimentary rocks break easily than igneous rocks.

Weathering :

When rocks break, the grains in the rocks get disintegrated. This means, they get weakened and over a period of time, they get eroded and break. Weathering is the physical or chemical breakdown due to weather conditions. It occurs mainly through the action of water and temperature on rocks and the reaction of rocks to these processes. As very little or no motion of materials takes place in weathering, it is called in-situ process. Weathering often results in rounding and smoothening of sharp edges of rocks.

Types of weathering : The rocks are weathered physically or chemically. So, basically, there are two types of weathering: physical and chemical. Factors such as water, heat and pressure which affect weathering can cause both the types of weathering chemical and physical. Effect of such factors can be varying on different rocks in different climates.

Let us have a look at these factors that affect weathering :

1) **Water :** Water is a very common factor which plays an important role in weathering. The availability of water largely depends on the climate of the place. It enters the small pores, cracks and fissures inside the rocks.

In areas, where diurnal range of temperature is high, water inside the cracks freezes during nights. During daytime, it again becomes water. When water freezes, its volume increases. It starts exerting pressure on the walls of the rock and widens the cracks. Eventually, the rocks break down. This process is called freeze-and-thaw weathering. See fig. 2.2. It is particularly effective in high altitudes in mid and low latitudes, high-latitudes as well as mountainous regions. The sedimentary rocks such as sandstone, grit and conglomerate get easily disintegrated due to water.

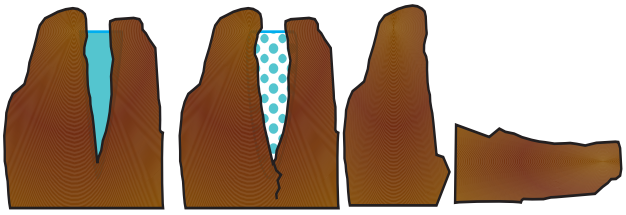


Fig. 2.2 : Freeze and thaw weathering

Water also breaks down the rocks chemically. This can happen in two ways. The water molecules react with minerals present in the rocks. This process is called hydrolysis. If the rock is made up of those minerals which react easily with water, the compounds of those elements will form and break the rock. This process can happen with those igneous rocks which have silicate minerals. The resultant compounds will break the rock by changing the chemical composition of the minerals in the rock after hydrolysis. For physical and chemical weathering to happen, the water present as moisture in the soil or air is also enough to cause weathering.

Another way by which water can cause chemical weathering is by solution . When some minerals in the rock react with water in the rock or moisture in the air and get dissolved, the process is called solution. They form acids, get leached from the main rock and lead to decomposition of the rock. Minerals like calcium, magnesium, nitrates, etc. dissolve in water. For example, the calcium present in the limestone reacts with the water and air to form carbonic acid. The minerals dissolve in water and get carried away in the water.

A) **Oxygen :** Oxygen in the air and water reacts with certain elements in the minerals inside the rock. In this process, the minerals

in the rock react with the oxygen in the air or water. Metals, particularly iron and aluminum, commonly oxidize forming iron or aluminum oxides. Compared to the original rock, these oxides are less hard, larger in volume and have a distinct color. See fig. 2.3. Generally, the iron oxides are red in colour and aluminum oxides are yellow. When oxidation happens on steel or iron objects we call it rust.

Fig. 2.3 : Oxidation

B) Carbon Dioxide : This process involves reaction of carbon dioxide with the minerals in the soil. The decomposition of dead matter in the soil produces CO_2. This CO_2 and the CO_2 in the air reacts with minerals in the rock. Minerals such as feldspar and carbonates decompose when this happens. This is particularly true for sedimentary rocks such as limestone. In humid climates, water adds to the weathering process. In arid climates, the absence of water in the region leads carbonate rocks to form cliffs that are resistant. Often, carbonation and solution occur simultaneously. During carbonation, the calcium and carbonate in limestone detach from each other, thereby decomposing the limestone.

C) Salt : Though salt is a chemical compound, it can also carry out physical weathering. The salts of calcium, sodium, magnesium, potassium etc. present in the rocks have a tendency to expand due to their thermal properties. This leads to crystallization of salts and individual grains split from the main rocks which fall off at the end. Such a type of weathering is, especially, very dominant in areas with alternative dry and wet periods and in coastal areas. It leads to formation of honeycomb structures. See fig. 2.4. e.g. Hareshwar in Raigad district. These structures are examples of the combined effect of physical and chemical weathering by water.

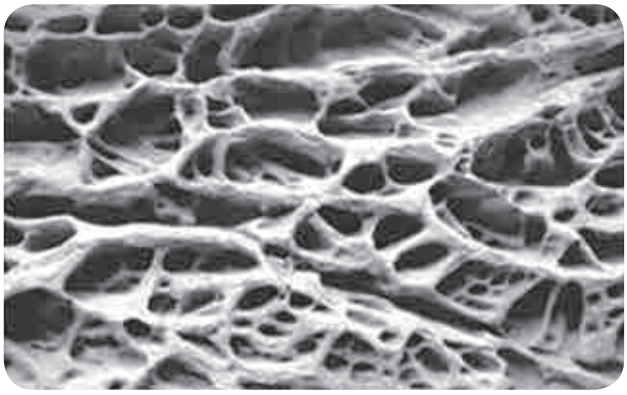


Fig. 2.4 : Honeycomb weathering

Think about it.

In which regions will freeze-thaw weathering not be effective?

2) Heat : In areas where water availability is rare, weathering process is mainly induced by temperature. Hot deserts are the areas of high diurnal range of temperatures. As the temperature increases with the rising sun, the rock gets heated. The minerals in the rock react differently to temperature increase. Therefore, the rock as a whole does not expand but different minerals expand separately. This leads to the development of stresses within the rock. This molecular stress becomes the prime factor in disintegration of the rock. This differential thermal expansion and contraction contributes to granular disintegration. It means the breaking free of individual mineral grains from a rock. See fig. 2.5.

Fig. 2.5 : Granular Weathering

In a similar process, the rocks break away due to heat. This is called shattering. In hot deserts, this shattering produces a sound similar to firing of pistols. This breaking of the rock is very intense and hence such a sound is produced. See fig. 2.6.

Fig. 2.6 : Shattering

In rocks such as granite which have joints, heat can cause weathering by breaking the rocks along the joints into blocks. This type of weathering is called block disintegration. See fig. 2.7. It is particularly effective in areas where diurnal range of temperature is high. The repeated expansion and contraction of minerals in the rocks produces stress along the joints. The joints then widen, deepen and finally break down the rock, block by block.

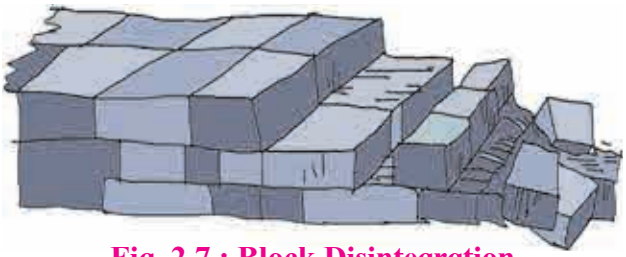


Fig. 2.7 : Block Disintegration

Though heat may not directly cause chemical weathering, it certainly speeds up chemical weathering. It can become more effective with increase in heat.

3) **Pressure :** Because of the overlying rocks, the rocks beneath the surface experience a lot of pressure. When the underlying rocks get exposed to the surface, they are now subjected to low pressure than before because the overlying rocks have been removed. As a result of the pressure differences, at depth (high) and surface (low), the outer part (a few centimetres to metres) of the rock mass expands outward. This expansion causes the outer layer to separate from the lower layer. This type of weathering is called dislodgement which happens due to pressure release or unloading. It is common in igneous rocks, particularly granite, where rock forming material is homogeneous. The successive removal of these outer layers of the rocks is called exfoliation. See fig. 2.8.

In areas where coarse grained igneous rocks like granite are found, the cracks in the outer surface form a dome–shape. In Deccan Plateau areas such as Karnataka, Andhra Pradesh, Telangana and Odisha, one comes across such domes.

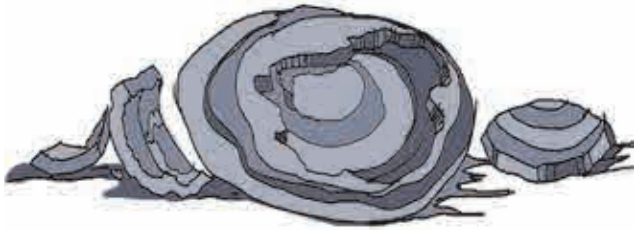


Fig. 2.8 : Exfoliation

Use your brain power!

Can animals and plants also influence weathering? Will that be physical or chemical weathering? Which type of weathering does stone quarrying cause?

Geographical explanation

Biological Weathering : It is the disintegration of rocks as a result of the action by living organisms. Roots of trees and other plants can wear away rocks as they penetrate into the soil. The roots get bigger, they exert pressure on rocks and makes the cracks wider and deeper. Eventually, the plants break the rocks apart. Some plants also grow within the fissures in the rocks which lead to widening of the fissures and then eventual disintegration. See fig. 2.9 A.

Microscopic organisms such as algae, moss, lichens and bacteria can grow on the surface of the rocks and produce chemicals that have the potential of breaking down the outer layer of the rock. They eat away the surface of the rocks. These microscopic organisms also bring about moist chemical micro-environments which encourage the chemical and physical breakdown of the rock surfaces. The amount of biological activity depends upon how much life is in that area. Burrowing animals can speed up the development of fissures. See fig. 2.9 B.

Fig. 2.9 : A) Biological Weathering

Fig. 2.9 : B) Biological Weathering

Think about it.

Besides climatic factors, rock type and structure, can you think of some more factors that affect weathering?

Do you know?

Air pollution contributes to the accelerating weathering rates. Burning coal, natural gas, and petroleum releases chemicals such as nitrogen oxide and sulfur dioxide into the atmosphere. When these chemicals combine with heat and moisture, they change into acids. They then fall back to earth as acid rain. Extensive damage has already occurred in some regions to historically important structures made of limestone and marble. There is a growing concern about world's monuments and sculptures. The Parthenon in Greece, the Taj Mahal in India and the Great Sphinx in Egypt are getting damaged.

Anthropogenic Weathering : Man being a biological agent affects weathering. With economic and technological development, man has become the most powerful weathering and erosion agent. Mining, blasting of hills and ridges for road and dam construction,

quarrying for industrial and building materials, etc. results in a fast rate of disintegration of rocks. This may be accomplished by natural weathering processes in thousands to millions of years. Man accelerates the rate of weathering on hill slopes through activities like deforestation.

Different rates of weathering :

Try this.

Take the following three materials : • Two pieces of chalk. • Two glass test tubes. • Two wax candles.

On a sunny day, keep one chalk and one test tube in the sun. Make sure they will not be disturbed there. Light one of the candles. See what happens. Take two vessels and fill them with water. Put a chalk and a candle in water. Observe what happens. After you keep the materials in the sun for around 6 hours, observe what happens. Pour some cold water on the heated glass test tube. Now answer the following questions :

1) What happened to the chalk kept in the Sun?
2) What happened to the glass test tube when cold water was poured over it?
3) What happened to the chalk kept in the water?
4) What happened to the candle kept in the water?
5) What happened to the candle when you lighted it?

Geographical explanation

You saw three examples of materials reacting differently to different conditions. Chalk dissolved in water but nothing happened to it when kept in the sun. Similarly, heated test tube cracked when cold water was put on it. Also, wax melted when candle was lighted but nothing happened to it when kept in water. In nature, similarly, rocks react differently to the physical conditions. Different amount and degree of temperatures and rainfalls affect both physical and chemical weathering. Thus, there is a direct impact of climate on weathering.

In almost all environments, physical and chemical weathering processes work together but usually one of them dominates. Chemical weathering is effective and rapid in humid climates.

From the above explanation can you conclude and complete the table below using the words : intense, moderate, slight and very slight or no weathering.

Rate of Physical Weathering :

	High rainfall	Moderate rainfall	Low rainfall
High temperature			
Moderate temperature			
Low temperature			

Rate of Chemical Weathering :

	High rainfall	Moderate rainfall	Low rainfall
High temperature			
Moderate temperature			
Low temperature			

Use your brain power !

A region is having an annual mean temperature of 5° C and an annual rainfall of 1000 mm. Can you comment upon the weathering and the type with the help of following questions? Discuss in class.

1) Which type of weathering will be dominant here?
2) Where will such a region be found?

Can you tell ?

See the diagram in fig 2.10 and answer the following questions :

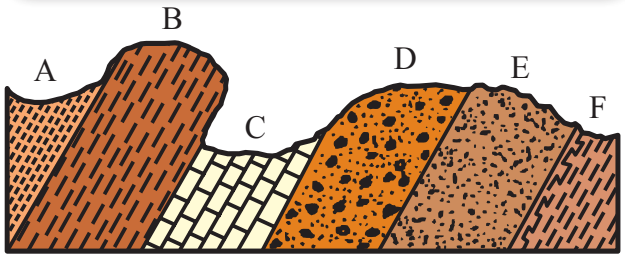


Fig. 2.10

1) Which rock layer has experienced the most weathering?
2) Which rock layer has experienced the least weathering?
3) What could be the reason behind difference in weathering?

Geographical explanation

Some rocks are more resistant while others are less resistant to weathering process. Some rocks react differently to different types of weathering. For example, quartzite, a metamorphic rock, is harder than even steel. It does not easily react chemically but is easily fractured by physical weathering. Under arid conditions, limestone does not easily weather away but it does so easily in humid regions. Granite resist weathering in arid and semi arid regions but the minerals inside it are prone to chemical weathering easily. 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.

Additionally, the rock structure also influences weathering. If the rocks have lots of fractures or joints in them, they will be more susceptible to weathering. Larger the grains of the rock, faster will it get weathered. This is because there will be lot of space in the rock for water to enter.

Importance of weathering :

Weathering prepares the way for formation of soils and various landforms that we see on the earth. Weathering is the first step as it gives materials to be eroded by agents of erosion, transported from one place to another and deposited to form landforms such as deltas, beaches, plains, etc.

Weathering helps in the enrichment and concentration of ores. In regions of high rainfall, the leaching process removes bases from parent rocks. As a result, iron or aluminium gets concentrated in upper layers. e. g., laterite or bauxite.

Mass wasting :

Can you tell ?

The satellite images given in fig. 2.11 A and B belong to the same location but different timeline. Study the images and answer the following questions.

1) Compare the images and tell what differences do you find in these images.
2) In 2019 what does the patch of land going from north-west to south-east signify? Why was it not there in 2011 image?
3) To what extent is the climate of the place responsible for this disaster?
4) Which other factors are responsible for the disaster?

Geographical explanation

The satellite images show village Malin, Ambegaon Taluka, near Pune. On 30th July 2014, mud came down the slope from the top of the hill. Many villagers lost their lives. The incident happend after heavy rainfall in the area. The sweeping portion from north -west to south-east is visible in the second image. This happened because the village is located at the foot of a hill. Thus, relief and

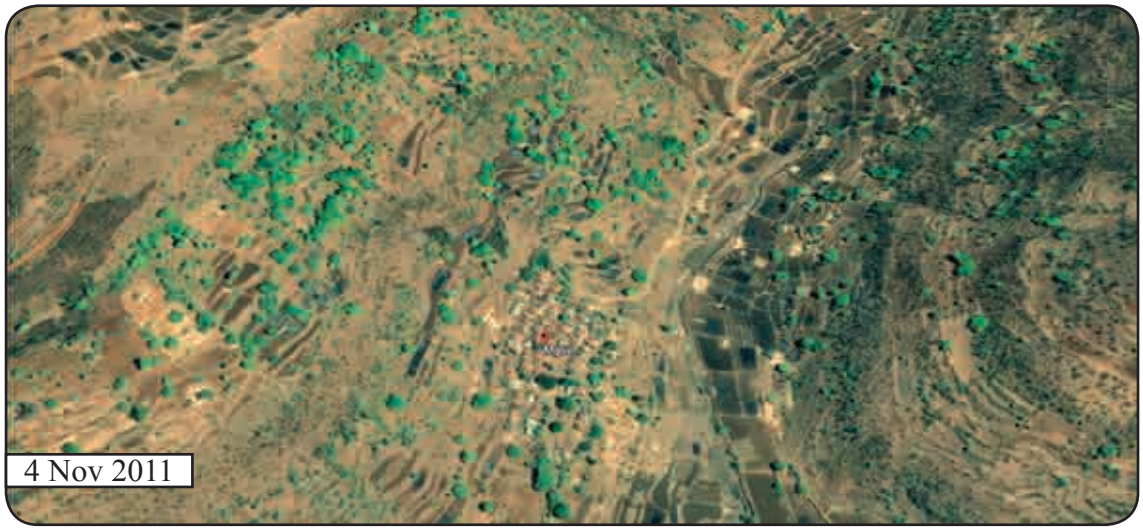


Fig. 2.11 : A)

Fig. 2.11 : B)

slope were responsible for the mudslide. Heavy rainfall and absence of vegetation aggravated the situation.

Mass movements or mass wasting is the down-slope movement of loose mixture of soil, land and rock particles by the force of gravity. In mass movements, the materials come down the slope without the aid of a transporting medium like running water, ice or wind. Mass movements occur continuously on all slopes. Some act very slowly other very suddenly, often with disastrous results.

Let us look at the factors responsible for their movement :

a) Relief and slope : There should be considerable elevation in an area for down slope movement to occur. Such movements will not occur in plain areas. Hilly, mountainous and plateau areas are more vulnerable to such movements. The steeper the slope, higher are the chances of occurrence of mass movements. Gentle slopes will have slow movements while steep slopes will have rapid movements.

b) Gravity : Gravity is the main force responsible for mass movements. It is a force that acts everywhere on the Earth's surface, pulling everything down.

c) Water : Although water is not always directly involved as transporting medium

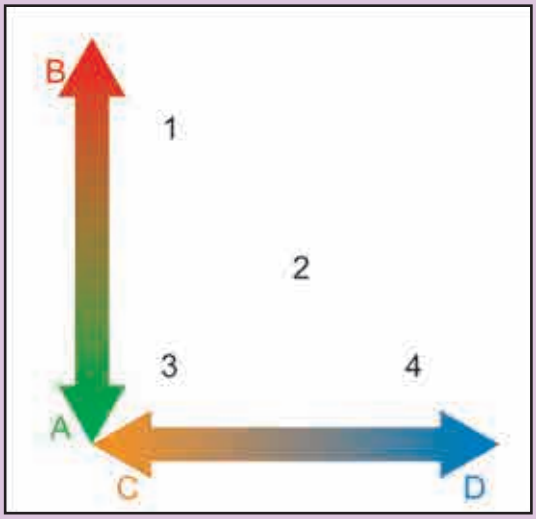
in mass movement process, it plays an important role.

Addition of water from rainfall or snowfall or melting of snow makes the material on the slope heavier. Water can seep into the soil and rock and increase their weight. Water can reduce the friction along a sliding surface. All these factors increase the chances of materials coming down the slope.

d) Weak material and structures : Some rocks are weaker than others. Rocks which have joints break easily. In particular, rocks contains calcium or clay minerals tend to have a low strength. Such areas will be more susceptible to mass wasting.

Give it a try.

Study the following schematic diagram. It shows the relationship between speed of material and moisture content. Read the index, and answer the following questions :



A) Fast B) Slow C) Dry D) Wet

1) Creep 2) Slide 3) Fall 4) Flow

Questions:

1) What will happen when the weather conditions are dry?
2) When will a flow occur?
3) When will a creep occur?

Now can you enumerate the factors which affect mass wasting?

Geographical explanation

Mass movements can be divided into four main classes. The classification is based on how quickly the rock and weathered material moves and how much water there is :

1) Fall or topple happens when rocks have a free fall and land at the bottom of a slope.
2) Flows are a mixture of water, rock and weathered material. They move very quickly. Large flows can bury entire villages, smaller flows can block roads.
3) A slide happens when a section of soil or rock suddenly gives way and moves down a slope. The material moves as a single mass along a slippery zone.
4) Creep is a very slow mass movement that goes on for years or even centuries.

If the friction on a rock is stronger than gravity for a particular slope, the rock material is likely to stay. But if gravity is stronger, movement will occur in the direction of slope.

Another factor that determines mass wasting is the material of the slope. Mass wasting is effective on slopes that are made up of clay and shale. The shape and composition of individual clay particles can absorb water and prevent water from percolating through the ground. A layer of clay on a slope can prevent water from filtering through the slope. Instead, the water stays near the surface and saturates the ground. This can cause the surface layers to lose friction and slide.

A third factor that influences mass movement is the load or weight on that slope. Construction activities on slopes and heavy rainfall can add weight to the material on the slope. There are several other ways friction can

be reduced along a slope e.g. wildfires, removal of vegetation, or adding too much water. Due to this, materials will move down the slope.

A region's climate can also determine the likelihood of mass movement. Humid climates tend to have slides.

The amount of water in the soil is a major factor in the stability of a slope. A little water can actually prevent slopes from sliding. But too much water lubricates the individual grains of weathered material decreasing friction between each grain. So the possibility of mass wasting increases. The increase of water within the soils can come from over irrigation, pipe leaks, or prolonged wet spells. In many mountainous regions, melting of snow increases the water content within the soil.

Vegetation plays a big role in stabilizing slopes. The strong root systems of trees and other plants help hold the soil in place. When these trees are removed, the soil becomes weak. This is why deforested areas are likely to be sites of mass wasting.

Think a little

Think of the reason why landslides should be more frequent in foothill zone of the Himalayas and Western Ghat region. Why do landslides not occur in Marathwada in Maharashtra or Maidan area in Karnataka?

Types of Mass Wasting :

Try this.

Different types of materials flow down the slope. Types of mass wasting depend on their speed. Observe the pictures given in figure 2.12. Match the explanation given below with the diagrams. Identify them as slow or rapid movements.

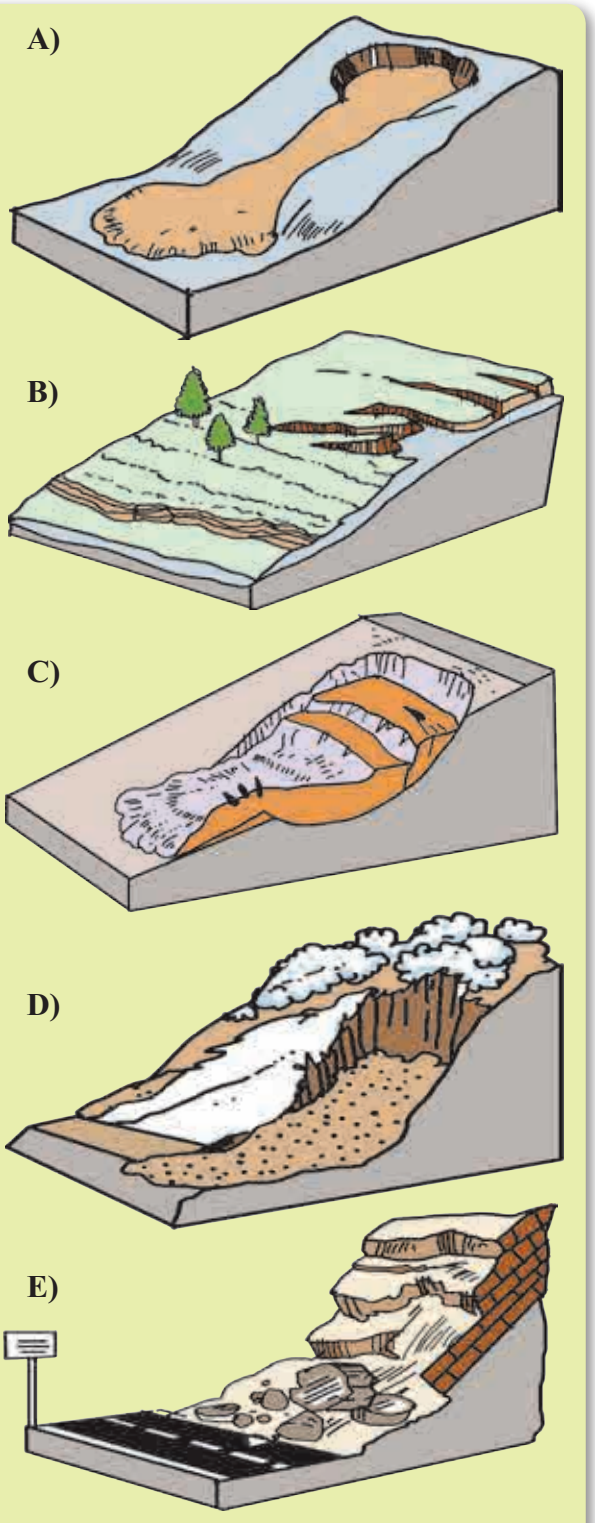


Fig. 2.12 : Types of mass Wasting

1) **Creep :** i) Slowest moving, ii) Down slope movement of soil tops of the hills, iii) Occur along tops and basal portions of hills.
2) **Rock fall :** i) Rapid fall of rock material down a cliff face, ii) Occurs mainly in rocky areas.

3) **Earth flow :** i) Rapid or slow, ii) Water saturates the soil, iii) Typically occurs on hillsides in humid regions.

4) **Solifluction :** Solifluction is the name for the slow downhill creep of soil in periglacial or alpine regions. It occurs slowly and is measured in millimetres or centimetres per year. As permafrost is impermeable to water, soil overlying it may become oversaturated and slide slope down under the pull of gravity.

5) **Land slide :** i) Occurs on moderately steep slopes, ii) Movement of rock, earth or debris down a section of land as a single unit.

Think about it.

Can tectonic forces be responsible for mass movements?

Give it a try.

On the basis of the given points, differentiate between weathering and erosion.

	Weathering	Erosion
Definition		
Causes/Agents		
Effect/Results		
Examples		

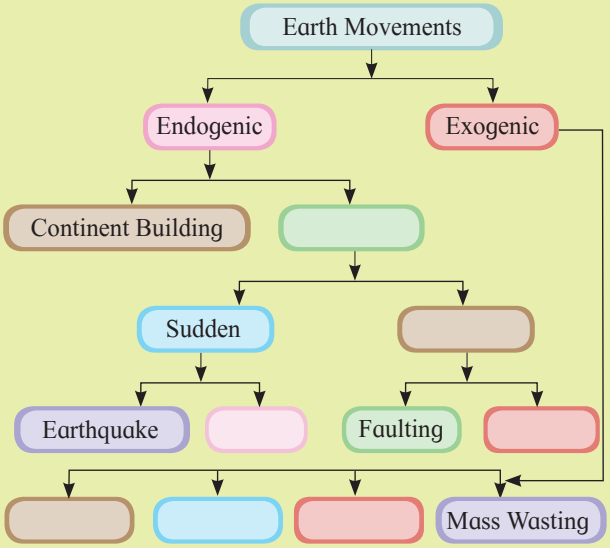
Erosion : It is one of the denudational processes. It involves segregation of rock particles from rock mass through the action of friction. Erosion involves the application of kinetic energy to the surface along which material moves. It is the wind (air), streams (water) and glacier (ice) that move under the influence of gravity or effect of pressure differences from one place to another. These are therefore called the 'agents of erosion. We will study about them in detail in the next chapter.

Think about it.

There is a shift of materials in mass movements as well as in transportation from one place to the other. So, why can't both not be treated as one and the same?

Try this.

Complete the following flowchart.



Exercise

Q. 1) Complete the chain :

Rock type	Name of the rock	Dominant type of weathering
1) Igneous	1) Dolomite	1) Physical Weathering
2) Sedimentary	2) Slate	2) Chemical Weathering
3) Metamorphic	3) Basalt	
	4) Limestone	
	5) Granite	

Q. 2) Identify the correct correlation :

A : Assertion; R : Reasoning

1) A : In areas of high rainfall, slides are very common.

R : Types of mass wasting movements are dependent on a region's climate.

1) Only A is correct
2) Only R is correct
3) Both A and R are correct and R is the correct explanation of A.
4) Both A and R are correct but R is not the correct explanation of A.

2) A : Gravity is a major factor in mass wasting.

R : Gravity pulls all things down to the earth's surface.

1) Only A is correct
2) Only R is correct
3) Both A and R are correct and R is the correct explanation of A.
4) Both A and R are correct but R is not the correct explanation of A.

3) A : Freeze and thaw weathering is common in desert areas.

R : Water gets into cracks and breaks the rocks.

1) Only A is correct
2) Only R is correct
3) Both A and R are correct and R is the correct explanation of A.
4) Both A and R are correct but R is not the correct explanation of A.

4) A : Surface water helps solifluction

R : Water table is responsible for the same.

1) Only A is correct
2) Only R is correct
3) Both A and R are correct and R is the correct explanation of A.
4) Both A and R are correct but R is not the correct explanation of A.

Q. 3) Identify the correct group :

A) 1) Oxidation
2) Carbonation
3) Freeze-thaw weathering
4) Shattering

B) 1) Solution
2) Salt Weathering
3) Oxidation
4) Carbonation

C) 1) Fall
2) Creep
3) Slide
4) Flow

D) 1) Pressure
2) Temperature
3) Slope
4) Rainfall

Q. 4) Give geographical reasons :

1) Temperature is the main factor behind granular weathering.
2) Human is an agent of weathering.
3) Slope is a major factor in mass wasting.
4) Oxidation changes the size and colour of the rocks.
5) Effect of mass movement will be greater along the western slope of the Sahyadris than the eastern slope.

Q. 5) Write short notes on :

1) Gravity and Solifluction
2) Role of water in mass wasting
3) Exfoliation
4) Weathering and homogeneity in rocks
5) Carbonation

Q. 6) Draw neat and labelled diagrams for :

1) Freeze and thaw weathering
2) Block disintegration
3) Biological weathering

Q. 7) Answer in detail :

1) Explain with examples the process of weathering happening in Konkan.
2) Explain the correlation between Himalayas and mass movements. Give examples wherever necessary.

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