# NDA PREPARATION MATERIAL

## GAT– GEOGRAPHY

## TOPIC 4

## WEATHERING & EROSION

### Weathering

Weathering is the process of disintegration and decomposition of rocks while erosion is the process of removal, transportation and deposition of the weathered particles. These processes together are known as "Denudation".

Weathering is defined as mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate. Weathering process brings mechanical disintegration and chemical decaying of rocks. Weather conditions are the most decisive phenomenon hence the name weathering. However, the type and rate of weathering are also influenced by rock structure, topography and vegetation. Weathering is a static process. It is also the process of soil genesis. It is of three types:

**I. Mechanical Weathering**: When a region undergoes mechanical weathering, rocks are broken into small pieces. Physical or mechanical weathering processes depend on some applied forces. The applied forces could be: (i) gravitational forces such as overburden pressure, load and shearing stress; (ii) expansion forces due to temperature changes, crystal growth or animal activity; (iii) water pressures controlled by wetting and drying cycles.

Many of these forces are applied both at the surface and within different earth materials leading to rock fracture. Most of the physical weathering processes are caused by thermal expansion and pressure release. These processes are small and slow but can cause great damage to the rocks because of continued fatigue the rocks suffer due to repetition of contraction and expansion.

This mechanical disintegration takes place in different ways.

**(a) Frost Action**: Frost weathering occurs due to growth of ice within pores and cracks of rocks during repeated cycles of freezing and melting. This process is most effective at high elevations in mid-latitudes where freezing and melting is often repeated. Glacial areas are subject to frost wedging daily. In this process, the rate of freezing is important. Rapid freezing of water causes its sudden expansion and high pressure.

The resulting expansion affects joints, cracks and small inter granular fractures to become wider and wider till the rock breaks apart.

**(b) Thermal Expansion and Contraction**: Various minerals in rocks possess their own limits of expansion and contraction. With rise in temperature, every mineral expands and pushes against its neighbor and as temperature falls, a corresponding contraction takes place. Because of diurnal changes in the temperatures, this internal movement among the mineral grains of the

superficial layers of rocks takes place regularly. This process is most effective in dry climates and high elevations where diurnal temperature changes are drastic. Though these movements are very small they make the rocks weak due to continued fatigue.

The surface layers of the rocks tend to expand more than the rock at depth and this leads to the formation of stress within the rock resulting in heaving and fracturing parallel to the surface. Due to differential heating, the resulting expansion and contraction of surface layers and their subsequent exfoliation from the surface results in smooth rounded surfaces of rocks.

In rocks like granites, smooth surfaced and rounded small to big boulders called **tors** form due to such exfoliation. In the area of hot deserts, the diurnal range of temperature brings the expansion and contraction of surface rocks, leading to their disintegration into smaller pieces.

**(c) Exfoliation**: This is the expansion by unloading process. Unloading occurs when large igneous bodies are exposed through the erosional removal of overlying rock and the reduction in the pressure. On being exposed to the surface they expand slightly in volume. This leads to the peeling of thick shells like an onion's layers from the parent rock.

(**d) Spalling:** When there is a sudden shower in the hot desert area, the highly heated rocks when struck by sudden drizzle develop numerous cracks.

**(e) Cavernous Weathering**: It occurs generally in hot arid region and also in the rocks of coastal area.

**(f) Salt Weathering**: Salts in rocks expand due to thermal action, hydration and crystallization. Many salts like calcium, sodium, magnesium, potassium and barium have a tendency to expand. Expansion of these salts depends on temperature and their thermal properties. High temperature ranges between 30°C and 50°C of surface temperatures in, deserts favour such as salt expansion.

Salt crystals in near-surface pores cause splitting of individual grains within rocks, which eventually fall off. This process of falling off of individual grains may result in granular disintegration or granular foliation.

Salt crystallization is most effective of all salt-weathering processes. In areas with alternating wetting and drying conditions salt crystal growth is favoured and the neighbouring grains are pushed aside. Sodium chloride and gypsum crystals in desert areas heave up overlying layers of materials and with the result polygonal cracks develop all over the heaved surface. With salt crystal growth, chalk breaks down most readily, followed by limestone, sandstone, shale, gneiss and granite etc.

**(g) Sheeting**: The development of cracks and fractures, parallel to the ground surface, caused by removal of superincumbent load.

**(h) Cambering process**: Due to expansion caused by unloading of super incombitant load and consequent release of corifining pressure.

**(i) Flaking**: Different heating of outer and lower shells of a rock mass causes flaking.

**II. Chemical Weathering**: It changes the basic properties of the rock. Principal processes of chemical weathering are:

**(a) Solution:** Here the rocks are completely dissolved. This process involves removal of solids in solution and depends upon solubility of a mineral in water or weak acids.

On coming in contact with water many solids disintegrate and mix up as suspension in water. Soluble rock forming minerals like nitrates, sulphates and potassium etc. are affected by this process. So, these minerals are easily leached out without leaving any residue in rainy climates and accumulate in dry regions. Minerals like calcium carbonate and calcium magnesium bicarbonate present in limestones are soluble in water containing carbonic acid (formed with the addition of carbon dioxide in water), and are carried away in water as solution. Carbon dioxide produced by decaying organic matter along with soil water greatly aids in this reaction. Common salt (sodium chloride) is also a rock forming mineral and is susceptible to this process of solution.

**(b) Oxidation and Reduction**: In weathering, oxidation means a combination of a mineral with oxygen to form oxides or hydroxides. Oxidation occurs where there is ready access to the atmosphere and oxygenated waters. The minerals most commonly involved in this process are iron, manganese, sulphur, etc. Though it is a universal phenomenon but it is more apparent in rocks containing iron.

In the process of oxidation rock breakdown occurs due to the disturbance caused by addition of oxygen. Red colour of iron upon oxidation turns to brown or yellow. When oxidized minerals are placed in an environment where oxygen is absent, reduction takes place. Such conditions exist usually below the water table, in areas of stagnant water and waterlogged ground. Red colour of iron upon reduction turns to greenish or bluish grey.

**(c) Hydration**: Hydration is the chemical addition of water. Most of the rock-forming minerals absorb water. Minerals take up water and expand. This not only increases their volume but also produces chemical changes resulting in the formation of new minerals which are softer and more voluminous. e.g. this process converts hematite into limonite. Calcium sulphate takes in, water and turns to gypsum, which is more unstable than calcium sulphate.

This process is reversible and long, continued repetition of this process causes fatigue in the rocks and may lead to their disintegration. Many clay minerals swell and contract during wetting and drying and a repetition of this process results in cracking of overlying materials. Salts in pore spaces undergo rapid and repeated hydration and help in rock fracturing. The volume changes in minerals due to hydration will also help in physical weathering through exfoliation and granular disintegration.

**(d) Carbonation**: Carbonation is the reaction of carbonate and bicarbonate with minerals and is a common process helping the breaking down of feldspars and carbonate minerals. Carbon dioxide from the atmosphere and soil air is absorbed by water, to form carbonic acid that acts as

,a weak acid. Calcium carbonates and magnesium carbonates are dissolved in carbonic acid and are removed in a solution without leaving any residue resulting in cave formation.

**(e) Hydrolysis**: The mineral of the rocks and water molecules react in such a way that new mineral compounds are formed. Silicate minerals are most affected by defrosts.

**(f) Chelation**: Chelation is a complex organic process by hydrocarbon molecules. Chelation is a form of Chemical weathering by plants.

These weathering processes are interrelated. Hydration, carbonation and oxidation go hand in hand and hasten the weathering process.

**III. Biological Weathering**: This type of weathering is performed by the tree roots, animals and human beings. As the plant roots grow, they wedge the rocks apart and cause the widening of joints and other fractures. Micro animals like earthworms, ants, termites and other burrowing animals move materials to or near the surface where they are more closely subjected to chemical weathering.

**Erosion**

Erosion is concerned with the various ways in which the mobile agencies acquire and remove rock debris. The acquisition of materials by the mobile agencies and their transport, i.e. corrasion and transportation are considered to be the integral part of erosion. The principal erosional agents are running water, groundwater, glaciers, wind and coastal waves. Each of the agents does erosion by distinctive processes and gives rise to distinctive landforms. There are five common aspects of erosion by the above mentioned agents.

(1) The acquisition of rocks fragments.

(2) Wearing away of rocks fragments.

(3) The breaking down of the rock particles by mutual wear while in transit.

(4) Transportation of the acquired rock debris.

(5) Ultimately the deposition in the low lying areas.

**Mass Wasting**: Mass wasting is the movement of material down a slope under the influence of gravity .It is a transitional phenomenon between weathering and erosion. Mass Wasting is of Various Types: Land-slide, Debris avalanche, Earth-flow, Mud-flow and Sheet-flow etc.

**(a) Soil creep**: In soil covered slope extremely slow downslope movement of soil and over burden may be found. This process is called as soil creep.

**(b) Talus cones**: Steep rocks walls of gorges and high mountains shed countless rock particles under the attack of physical weathering processes.

**(c) Earth Flows**: In humid climate region, if slope are steep, masses of water-saturated soil due to over burden or weak bedrock may side down slope during a period of few hours.

**(d) Mud flow**: Rapid flowage of mud stream down a canyon floor and spreading out on plain at the foot of a mountain range is called as mud flow.

**(e) Landslide:** The down slope movement of regolith of bed rock is called as landslide.

Multiple choice questions:

1. Exfoliation domes are features of
a) Thermal expansion
b) Volcanic activity
c) Frost action
d) Tectonic origin

2. Match the contents of the following two columns and select the right answer from the given codes.

| Column A | Column B |
|---|---|
| A. Carbonation | 1. Causes feldspar to become a powdery mass |
| B. Hydration | 2. Is the simple form of chemical weathering |
| C. Oxidation | 3. Mainly affects limestone region |
| D. Solution | 4.Results in the rusting of iron |

| Codes: | A | B | C | D |
|---|---|---|---|---|
| a) | 4 | 2 | 3 | 1 |
| b) | 3 | 4 | 1 | 2 |
| c) | 2 | 4 | 1 | 3 |
| d) | 3 | 1 | 4 | 2 |

3. The following item consists of two statements, one labeled the 'Assertion A' and the other labeled the 'Reason R'. You are to examine these two statements carefully and decide if the Assertion 'A' and the Reason 'R' are individually true and if so, whether the Reason is a correct explanation of the Assertion. Select your answers for these items using the codes given below and mark your answers accordingly.

Codes:

(a) Both A and R is true and R is the correct explanation of A.
(b) Both A and R is true but R is not a correct explanation of A.
(c) A is true but R is false
(d) A is false but R is true.

Assertion (A): The most important single agent of physical weathering is the freeze/ thaw action of water in open spaces in rock.
Reason (R): Repetition is the key to understanding the force of frost shattering.

4. Mechanical weathering produces _____.
(a) Clay minerals
(b) Quartz
(c) Smaller particles
(d) Calcium carbonate

5. When liquid water freezes:
(a) It does not change in volume
(b) It expands by 5% in volume

(c) It expands by 9% in volume
(d) It decreases in volume
6. What is the term for the general process by which rocks are broken down at the Earth's surface?
(a) Deposition
(b) Erosion
(c) Lithification
(d) Weathering
6. Which of the following affect the rate of weathering?
(a) The soil type and extent
(b) The rock type
(c) The climate
(d) All of these
7. Soil is composed of_____.
(a) Organic matter produced by organisms
(b) Fragments of bedrock
(c) Clay minerals formed by the chemical alteration of bedrock
(d) All of these
8. In which of the following climates will chemical weathering be most rapid?
(a) Hot and dry
(b) Hot and humid
(c) Cold and dry
(d) Cold and humid
9. Which of the following statements about weathering is false?
(a) Rocks of different composition weather at different rates
(b) Heat and heavy rainfall increase the rate of chemical weathering
(c) The presence of soil slows down the weathering of the underlying bedrock
(d) The longer a rock is exposed at the surface, the more weathered it becomes.
10. Which of the following minerals has a low solubility and therefore is least susceptible to chemical weathering at the Earth's surface?
(a) Calcite
(b) Plagioclase
(c) Quartz
(d) Olivine
11. The rate of chemical weathering is increased by acids. The most common natural acid on the Earth's surface is _____ .
(a) Nitric
(b) Hydrocloric
(c) Carbonic
(d) Sulfuric
12. Carbon dioxide makes up about _____ of the Earth's atmosphere.
(a) 0.1 %
(b) 1%
(c) 10%
(d) 25%
13. Carbonic acid, the primary agent of chemical weathering is produced by _____ .
(a) Carbon dioxide dissolving in rainwater
(b) Plant roots
(c)Bacteria that feed on plant and animal remains
(d) All of these
1**4**. Which of these is least likely to form a clay mineral during weathering?

(a) Feldspar
(b) Quartz
(c) Amphibole
(d) Olivine
15. Caves are most lively to form in which of the following rock types?
(a) Granite
(b) Limestone
(c) Basalt
(d) Sandstone
16. Which of the processes is not an example of chemical weathering?
(a) Dissolution of calcite
(b) Breakdown of feldspar to form clay
(c) Splitting of a rock along a fracture
(d) Rusting of a nail
17. As a rock breaks into smaller pieces, the surface area to volume ratio _____ .
(a) Increases
(b) Decreases
(c) Stays the same
(d) Can increase or decrease depending on the size of the pieces
18. The physical and chemical weathering of a granite will produce _____ .
(a) Ions dissolved in rainwater and soil water
(b) Mineral fragments and granite fragments
(c) Clay and iron oxides
(d) All of these
19. Which of the following factors would increase the rate of weathering?
(a) Increasing rainfall
(b) Increasing temperature
(c)Increasing organic activity
(d) All of these
20. What is the term geologist's use for the layer of loose, heterogeneous weathered material lying on top of the bedrock?
(a) Humus
(b) Laterite
(c) Regolith
(d) Soil
21. Which of the following farming practices helps to prevent the erosion of topsoil?
(a) Ploughing a field perpendicular to the contour lines
(b) Ploughing a field parallel to the contour lines
(c) Ploughing a field in the direction that the water drains
(d) None of these will help prevent soil erosion
22. What is the name for soils that are rich in calcium?
(a) Laterites
(b) Evaporites
(c) Pedocals
(d) Pedalfers
23. The physical and chemical weathering of granite will produce _____.
(a) Ions dissolved in rainwater and soil water
(b) Mineral fragments and granite fragments
(c) Clay minerals and iron oxides
(d) All of these
24. Which of the following minerals found in a granite is not altered by chemical weathering?

(a) Biotite
(b) Feldspar
(c) Magnetite
(d) Quartz
25. Which of the following minerals would be most likely to form a clay mineral during chemical weathering?
(a) Iron oxide
(b) Mica
(c) Calcite
(d) Quartz
26. Which of the following conditions promotes slow chemical weathering?
(a) Cold temperature
(b) Thick soils
(c) High rainfall
(d) Fracturing
27. Which of the following human activities has resulted in increased rates of weathering?
(a) The release of sulfur and nitrogen oxides that cause acid rain
(b) The physical disintegration of rocks during construction and mining
(c) Both A and B
(d) Neither A nor B
28. One expects talus cones to be most abundant in areas:
(a) Where abundant rainfall is available to dissolve limestone
(b) In tropical areas where thick soil and abundant vegetation occurs
(c) In high mountains that have many days of sub- freezing temperatures
(d) None of the above
29. Exfoliation domes form from:
(a) Frost wedging
(b) Pressure release
(c) Hydrolysis
(d) Root wedging
30. Laterite solis:
(a) Are red in color
(b) Are formed in tropical climates
(c) Often contain high concentrations of aluminum
(d) All of the above

**Q.1.Denudation process happens in which order?**
**a.** Erosion, Weathering, Transportation, Deposition
**b.** Weathering, Erosion, Deposition, Transportation
**c.** Erosion, Transportation, Weathering, Deposition
**d.** Transportation, Weathering, Erosion, Deposition
**Answer: b**
**Explanation:** Weathering is gradual disintegration of rocks by atmospheric forces, erosion is active wearing away of earth surfaces, Transportation is removal of eroded debris to new positions; Deposition is dumping of debris in certain parts of the earth.

**Q.2. With reference to chemical weathering, which of the following is true?**
**1.**It is rapid.
**2.**Only rocks exposed to water experience chemical weathering.
**3.**Thick soil cover enhances chemical weathering.
**Select the correct answer from the following codes**
**a.**Only 3
**b.**Only 1 and 2

**c.**Only 2 and 3
**d.**1,2 and 3
**Answer: a**
**Explanation:** It is extremely slow. Chemicals present in air and water set up chemical reactions in surface layers of exposed rocks.
**Q.3. Consider the following statements?**
1. Granite is made of feldspar, Quartz, shale
2. Quartz crystals are quickly weathered than feldspar.
3. Regolith is remains of rock which forms basis of soil.
**Select the correct answer from the following codes**
**a.**Only 3
**b.**Only 1 and 2
**c.**Only 2 and 3
**d.**None
**Answer: a**
**Explanation:** Granite is made of feldspar, Quartz and mica. Feldspar are quickly weathered than feldspar Quartz crystals
**Q.4. which of the following is strong weathering agent?**
1. Rainwater absorbed by soil cover
2. Pure rain water on bare rock
**Select the correct answer from the following codes**
**a.**Only 1
**b.**Only 2
**c.**Both 1 and 2
**d.**Neither 1 nor 2
**Answer: a**
**Explanation:** soil absorbs rainwater and keeps underlying rocks in moisture. Rainwater absorbs organic acids from soil and thus becomes stronger weathering agent than pure rain water acting on bare rock.
**Q.5. Consider the following statements**
1. Limestone is the only rock suffers from chemical weathering process called “solution”.
2. Rate of weathering is directly related to the pore-spaces in rocks.
**Select the correct answer from the following codes**
**a.**Only 1
**b.**Only 2
**c**.Both 1 and 2
**d**.Neither 1 nor 2
Answer: b
**Explanation:** all rocks are subject to solution, though the process is much slower than limestone. Sedimentary rocks have pore spaces between grains in which air and water can lodge and thus attack rock. The density of joints/cracks/pore-spaces is crucial to speed weathering.
**Q.6. Consider the following statements**
1. Climate influences weathering.
2. Dry climates provide good conditions for chemical weathering.
3. Warm wet climates promote rapid physical weathering.
**Select the correct answer from the following codes**
**a.**Only 1
**b.**Only1 and 2
**c.**Only 2 and 3
**d.**1, 2 and 3

**Answer: a**
**Explanation:** Dry climates provide good conditions for physical weathering. Warm wet climates promote rapid chemical weathering.

**Q.7. Consider the following statements?**

1. Brownish crust formed on rock by oxidation of iron strengthens rock.
2. Micro organisms use elements of rocks as food.
3. Micro organisms are both chemical and mechanical weathering agents.

**Select the correct answer from the following codes**

**a.**Only 1
**b.**Only 1 and 2
**c.**Only 2 and 3
**d.**1,2 and 3

**Answer: b**
**Explanation:** Brownish crust Crumbles easily and can be easily eroded which looses the overall structure of rock. Micro organism use elements of rocks as food and produces organic acids. Brownish crust formed on rock by oxidation of iron weakens rock.

**Q.8. With reference to physical weathering, which of the following statements?**

1. Chemical weathering catalyses the physical weathering.
2. During daytime outer layers of rock expand rapidly than interiors.
3. During night interior layers contract slowly than outer layers

**Select the correct answer from the following codes**

**a.**Only 1
**b.**Only 1 and 2
**c.**Only 2 and 3
**d.**1,2 and 3

**Answer: d**
**Explanation:** Processes of physical weathering work much more easily when surface of rock has already been weakened by action of chemical weathering.

**Q.9. Consider the following statements**

1. Physical weathering is faster in crystalline rocks.
2. Physical weathering is always greater near the surface of rocks.
3. Exfoliation is chemical weathering.

**Select the correct answer from the following codes**

**a.**a.Only 1
**b.**Only 1 and 2
**c.**Only 2 and 3
**d.**1,2 and 3

**Answer: b**
**Explanation:** In Crystalline rocks such as granite the crystals of various minerals (quartz, mica, feldspar) will expand and contract at different rates, enhancing the stresses and accelerating disintegration. Exfoliation is physical weathering.

**Q.10. Which of the following is true about frost shattered peaks?**

1. It is Common in Tropical latitudes.
2. Physical weathering by frost is rapid during night and winter.

**Select the correct answer from the following codes**

**a.**Only 1
**b.**Only 2
**c.**Both 1 and 2
**d.**Neither 1 nor 2

**Answer: b**
**Explanation:** In temperate latitudes frost is a potent rock breaker.