DENUDATION

This refers to the exogenic (external forces) agents which wear away the land surface. Denudation involves a number of processes namely soil erosion, weathering, mass wasting, glaciation as well as the transportation of the broken-down particles.

The term denudation is widely used to cover all the agencies / processes by which parts of the earth's surface undergo destruction, wastage and loss. This is the great work of weathering agents, mass wasting, erosion by running water i.e. rain wash, streams and rivers, by moving ice inform of glaciers and ice sheets, by wind and waves, tides and currents in the sea as well as the transportation of the broken-up particles of the rocks.

WEATHERING.

Weathering is the physical disintegration and chemical decomposition of rocks at the surface of the earth in situ. Weathering can be divided into those processes involving chemical reaction and formation of new minerals (chemical weathering)

Weathering can also be referred to the disintegration and decomposition of rocks into increasingly smaller particles or granules in Situ; that is in one place with no movements involved.

Weathering also refers to the disintegration or decomposition of rocks by either mechanical or chemical means resulting into the break up, decay and rotting of the rocks in situ i.e. in one place. This definition suggests that under weathering, there is no transportation of the broken-up particles of the rocks and if this happens, it will be regarded as erosion but not weathering.

The end product of weathering is the formation of layers of weathered rocks known as debris. The action of weathering in the destruction of rocks is dependent upon the removal of weathered layers notably by wind, water or ice.

Rock disintegration is majorly affected by agents of weather mostly rainfall and temperature hence the name weathering. Other agents of weathering are frost, wind, living organisms, lightening, gravity and crystallization.

If the weathered rock is not removed, it may act as a protective layer to the

underlying rock. So, weathering itself doesn't involve the removal of materials but as a process, it depends upon the removal of weathered materials by outside agents. Weathering is an extremely important process in shaping the landscape on the earth's surface.

TYPES OF WEATHERING.

Weathering takes place in three types of physical, chemical and biological processes.

Physical (Mechanical) Weathering; is the disintegration or rocks into smaller fragments without any change in the chemical composition of the rock.

It occurs due to the physical changes of pressure and temperature that puts the rock on stress and leads to rock breakdown. Physical weathering occurs under conditions of temperature fluctuations mainly in semi and areas that experience wide hide high temperatures during day and cold rights as well as the cold mountain peaks of Rwenzori, Kenya and Kilimanjaro.

It takes place in form of exfoliation, block disintegration, granular disintegration, pressure release, frost action and frost heaving.

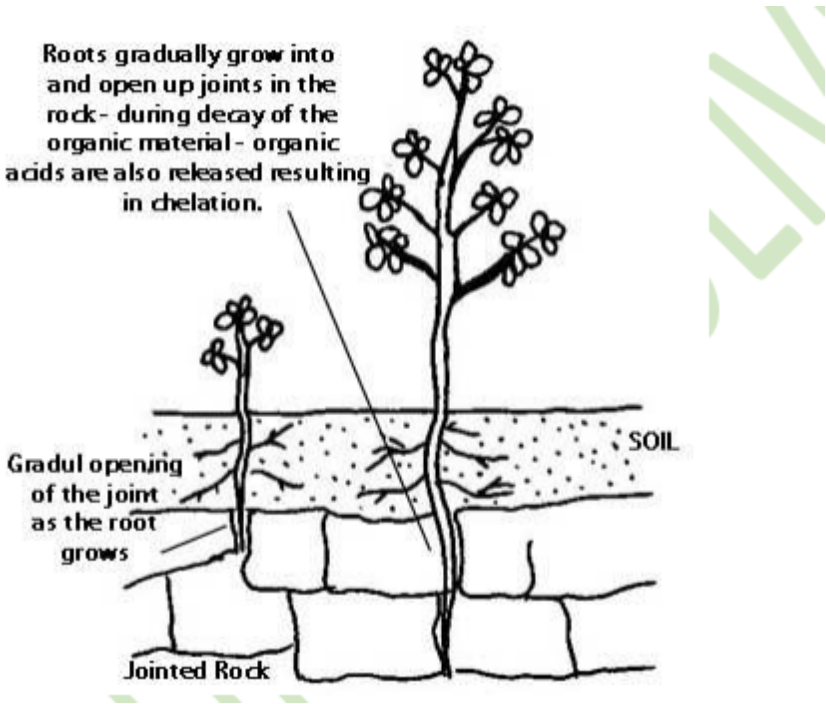
Therefore, this type of weathering works on rocks to make little ones out of big ones without changing the chemical composition of the rock. i.e. rocks disintegrate into smaller particles but maintain their previous chemical characteristics. What changes is only the physical size? It is mostly affected by temperature changes.

Chemical weathering is the decomposition of rocks into residual materials resulting in partial or complete change in the chemical composition of rocks. It is due to chemical reactions between rock materials and the atmospheric elements such as water ang gases like oxygen, carbon dioxide and hydrogen among others. Chemical weathering takes place under conditions of high humidity, high temperatures and heavy rainfall that facilitate the chemical reactions.

It occurs in form of oxidation, carbonation, solution and hydrolysis among others. Basically, as it rains, rain water reaches the earth surface in a mixture of various

gases e.g. oxygen, hydrogen and carbon dioxide. This solution creates a cross section of chemical reactions with greatly weaken the rock and therefore make it decay. Therefore, new chemical compound is produced. This is what is called chemical weathering. It is mostly affected by rain water.

Biological weathering; refers to the breakdown of rocks into smaller particles due to the influence of plants and animals. It takes place in areas of thick vegetation cover and dense settlements. It involves the action of bacteria, plant roots, burrowing animals and human activities.



FACTORS AFFECTING THE TYPE AND RATE OF WEATHERING.

The rate of weathering is the amount of rock disintegration per unit time. It is the **pace** at which a rock breaks down.

Physical and chemical rock break down are the major two types of weathering are a function of several factors acting in conjunction rather than in isolation.

The nature of the rock is one of such factors. This factor, however, works hand in hand with other factors to influence the rate and type of weathering.

(a) Nature of the rock; The nature of the rock refers to rock structure or physical and chemical makeup of the various rocks. It refers to rock attributes such as colour, the hardness and softness, minerals forming the rock, rock texture, the rock structure and joints, permeability among others, like age, texture, size, layering etc.

- Rock hardness and softness; This is relative difficulty and ease with which the rocks can be stretched. Hard rocks are very resistant to physical and chemical weathering process compared to the soft rocks that are broken down easily.

- Mineral composition; igneous rocks with low silica content when exposed to the atmosphere disintegrate at relatively faster rate compared to the acidic rocks rich in silica content. This therefore implies that rocks rich in silica are much harder to weather as compared to those deficient in silica like limestone and carbonate rocks. Calcareous rock such as limestone is broken down very fast when they react with water containing carbon dioxide through carbonation.

- Colour (luster) of the rock; Luster is the intensity of light from the rock surface. Mineral rocks with shiny surface or light colour reflect more solar energy than absorb and this makes them to heat up solely thus reducing the rate of rock break down.

  On the other hand, dark surface rocks absorb a lot of solar energy and heat up to expand very fast during day and lose a lot of heat to contract at night. The repeated expansion and contraction of such rocks makes them to break down at faster rate in form of exfoliation and block disintegration.

- Rock texture; This refers to the crystalline of rocks as well as the particle size.

Rocks are either coarse grained or fine grained. Coarse grained rocks break down faster than fine grained rocks.

- Permeability and impermeability of the rocks; Permeable rocks allow water to go through them and break down very fast while the impermeable rocks do not allow water to percolate them thus do not weather easily.

- Rock structure and joints; Rock joints increase the surface available for rock decay thus accelerating the rate of rock weathering. Therefore, rocks with very much joints tends to break at the faster rate since such joints enable water and the plants roots to penetrate into lower and deeper layers. The joints also facilitate the frost action of physical weathering. On the other hand, rocks with fine structure or few joints do not break down easily.

- The age of the rocks has also a bearing on the rate of weathering. Rocks, which are aged, are more susceptible to breakages (faults) whenever exposed to tectonic pressure while young rocks fold instead of fracturing. These breakages and cracks become zones of expansion and contraction (physical weathering) or through which water enters rocks for rapid chemical weathering.

- The size of the rock also matters when it comes to weathering. Rocks which are massive, will not very much yield to weathering like small rocks. Therefore, the bigger the rock the lesser the weathering, effect and the smaller the rock, the more the weathering effect.

b). Climate; This majorly stress the influence of rainfall and temperature conditions on rock weathering. It can be examined based on various climatic zones for instance;

Equatorial climate with high temperatures and heavy rainfall tends to catalyzes the chemical weathering process like carbonation, solution, hydration and others.

This is because the heavy rainfall provides water that reacts with the rock minerals while the high temperatures catalyse the chemical reactions. Therefore, regions experiencing modified equatorial climate like the Lake Victoria basin are characterized by high rate of chemical weathering.

In savannah regions (transition zones), the alternating wet and dry seasons within these areas give way to both chemical and physical weathering to take place. Chemical weathering is more active during the wet season and physical weathering is more dominant in the dry season.

In and semi-arid areas of East Africa, the climatic conditions of low cloud cover, high absolute temperature and high diurnal temperature range tends to increase the effectiveness of physical weathering.

The very high temperature during day and very low temperature at night leads to rapid expansion and contraction of rocks. Physical weathering processes such as exfoliation and block disintegration are therefore predominant in these regions such as Karamoja and northern Kenya.

Cold climatic conditions tend to promote frost action or freeze thaw processes of rock weathering. The freezing water tends to widen the rock and consequently facilitate rock break down in form of frost action. This occurs on the snow-capped mountains of Rwenzori, Kenya and Kilimanjaro.

c). Relief/Topography; This is the physical appearance of the landscape. It is manifested in slope angle and altitude (height above sea level) o Steep slopes tend to witness rapid removal of weathered material thus exposing underlying rocks to the constant agents of weathering like air and water thus promoting physical weathering processes like pressure release.

- Gentle slopes experience less erosion and some deposition of heavy granules, the deposited materials tend to protect the underlying parental rocks from the atmosphere thus reducing on the rate of weathering.
- Lowlands/valleys experience deposition of weathered materials associated with water flooding. The accumulation of water on parent rocks in such areas facilitate chemical weathering process like solution and hydration.

- In addition, relief creates condition of lee ward and wind ward effects which influence the rate and type of weathering. Physical weathering process tend to be dominant on the lee ward side due to and conditions while chemical weathering processes tend to be dominant on the wind ward side of the mountain due to heavy rainfall received.

(d)Influence of Living organisms; Like plants and animals, when the living organisms die, they decompose into humus. The humus reacts with water to form humic acid which chemically reacts with rocks to facilitate rock break down.

- Vegetation cover especially trees act as agents of rock weathering due to the reaction of their roots. As the roots increase in size and grow deep into the ground, they tend to open up the joints or rock cracks and consequently facilitating deep weathering of rocks.
- Burrowing animals such as rodents, rats, moles, termites and others tend to loosen and break the rocks thus facilitating physical weathering and biological weathering.

man's influence; man may influence chemical weathering through a number of ways e.g.

- Emission of industrial gases in the atmosphere which increases acidity in rainy water which accelerates the rate of chemical weathering processes of carbonation.
- Dumping of industrial or domestic or agricultural influence on land or water which directly react or increase the activity in the environment thus increasing the rate of chemical weathering by carbonation etc.
- Man carries out activities that directly involve the breakdown of rocks e.g. mining, quarrying, road and other activities like agriculture which expose the underlying rocks to chemical weathering processes. Also irrigation avails water that increases chemical weathering processes like hydration, hydrolysis and solution.

e) Drainage:

leaching occurs on flat lands because of poor drainage i.e. rock minerals are dissolved and taken away in solution to deeper layers of the soil profile. This leaves behind residual soils which are rich in iron, magnesium, and calcium compounds. The iron compounds are

oxidized in the process of oxidization to form laterite soils.

Poorly drained areas like flat plains have a high dominance of chemical weathering inform of hydrolysis, hydration, reduction and solution which help to decompose the rock. This is because of the stagnant water in valleys and other low lying areas.

(f). Natural catastrophes: Natural catastrophes like earth quakes, lightning and thunder, volcanic eruptions etc. result into mechanical or physical breakdown of rocks. These catastrophes can further expose the underlying rocks to both physical chemical weathering.

(h) Time; This is the duration in which the rock is exposed to the weathering processes. Time is a passive factor that stress its role that old rocks or those which have been exposed to weathering agents tends to have a faster rate of rock break down compared to the newly formed or recently exposed rocks. In principle the longer the duration of rocks exposure to weathering agents, the more advanced the rate and type/ character of rock weathering.

Guiding Question:

To what extent does the rate and character of rock weathering depend on the nature of the parent rock?

PHYSICAL WEATHERING PROCESSES:

As already defined, physical weathering is the mechanical disintegration of rocks into fragments or development of cracks within rocks. This type of weathering occurs in various ways as shown below:

I. exfoliation:

This process is caused by repeated heating and cooling of the rock surface due to high insolation and terrestrial radiation. During day, the rock surface is intensely heated by the incoming solar rays thus making it expand and develop cracks.

At night, temperatures rapidly fall to cold levels due to outgoing surface radiation and this makes the rock to contract rapidly thus cracking the rock.

The repeated process of rock expansion and contraction created by wide temperature fluctuations makes the rock cracks t widen to a few centimetres thick

and consequently begin to peel off into screes (rock debris). After the peeling off of the outer rock layer, a new rock surface is exposed to the atmosphere in form of oval shape called an exfoliation dome.

In Uganda, exfoliation domes can be traced in Karamoja, Kitgum, Mubende and Soroti. In Tanzania, they can be seen in Songea, Rongwa, Serengeti and Dodoma. In Kenya, they are found in northern eastern Kenya and Turkana land in the northwest.

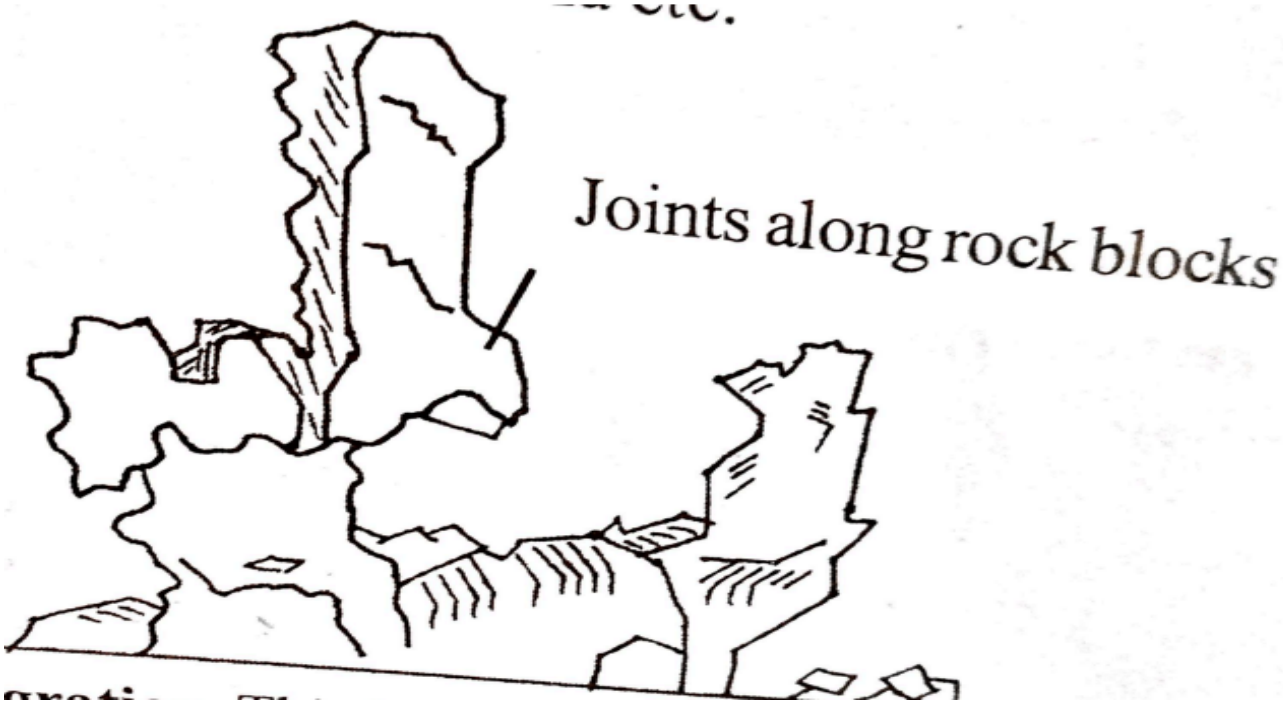
II. Block disintegration.

This occurs in areas where there are jointed rocks which experience extreme temperature fluctuations during day and at night. The high temperatures during day and cold nights lead to rapid expansion and contraction of rocks thus making the rocks to fracture into rectangular blocks a process known as block disintegration.

This type of weathering produces granite tors (inselbergs). These granite tors or inselbergs are of two types; i.e. castellated tors and tors and finger type inselbergs.

Castellated tors are produced when there is both horizontal and vertical joints in a rock such that disintegration is both horizontal and vertical e.g. Kachumba rock in Kumi, Mubende tors in western Uganda, Kit Mikai in Sema location of Lukenya in Kenya and Bismarck rock in Mwanza-Tanzania.

Illustration



III. Frost shuttering;

This type of weathering is experienced in areas that fall below 0° c and in East Africa these are the mountains peak of mt Rwenzori, mt Kenya and Mt Kilimanjaro. During the day, water enters into the cracks of the rocks. During the nights this water freezes and exerting pressure within the cracks.

Water in such mountains freezes almost every night and then thaws the next day

Before freezing after freezing.

It is said that water once frozen, expands by approximately 10% its liquid volume. It is the expansion in these cracks that makes rock particles within the cracks to break off as screes and the rock to disintegrate.

This type of weathering is also called congelifraction. It produces angular screes that may cover extensive areas which are called falsmeer. This can be seen on Batia and Nelion peaks on Mount Kenya, Upper Mubuku valley, around Margherita, Stanely, and Baker peaks on Mount Rwenzori.

Iv. Pressure release; (unloading process).

This occurs when the overlying weight on the parent rock is removed by denudation especially soil erosion thus causing the underlying rock to be relieved. When such weight is removed, rocks begin to expand and develop curved joints parallel to the rock surface. These joints widen and deepen and eventually facilitate rock break down. It occurs on exposed batholiths, sills and dykes and can lead to the formation of Inselbergs.

Pressure release process occurs in the regions of poor vegetation cover where there is severe soil erosion. Examples can be witnessed in Turkana Land, Karamoja region and Ankole-masaka corridor, panyjok in Apach, Mayanjo in Kampala, between Mwanza and Iringa, Serengeti and Rukwa region of Tanzania.

V. Granular Disintegration:

Granular disintegration takes place almost in the same way as exfoliation except that in this type, rock disintegrate into small particles called granules. Granular disintegration is produced in two ways:

a) By differences in thermal expansion and contraction: some rocks are composed of minerals and particles that respond to temperatures differently. If a rock is for example made up of white and black particles will absorb more temperature than the white particles and both will expand at different rates. The same applies when the rock has got minerals that expand and contract differently with thermal heating. This will cause strains and stresses within the rock and it will break up into its granules.

b) Frost heaving; This type of granular disintegration is common in ice capped margins where freezing and thawing occur. It also occurs in porous rocks such that when temperatures are high (day), ice melts and water enter the rocks. When temperatures drop below 00 c, this water freezes within the rock particles and expands hence detaching these particles a part. The rock crumbles into small particles (granules).

Frost heaving leads to the formation of stone polygons or patterned ground seen in valleys e.g. Teleki valley on Mount Kenya and also on mount Rwenzori. Alternatively, frost heaving is called congeliturbation.

VI. Crystallization:

This is one of the physical processes of weathering in which some rocks may absorb salty water. This salty water will later collect in rock cavities and pores. This water may later start to evaporate and hence salt crystals will begin to form. As these salt crystals grow bigger and expand in size, they exert pressure on surrounding rock particles hence making them peel off. It is a common process in arid areas and coastal areas of East Africa.

Elsewhere, it is cited around Lake Katwe, Lake Nyamunuka and Lake Kasenyi in western Uganda. It is also common around Lake Magadi, Natron and Nakuru (which are salty lakes).

VII. Aridity shrinkage

This type of weathering occurs in areas experiencing extremes of weather i.e. wet and dry seasons. It occurs when drought succeeds a rainy season such that the rock loses the water that was previously taken up during the rainy season. As a result, the rock crumbles into smaller elongated fragments. For example, when a sample of clay dries out, it shrinks and its surface becomes filled with cracks hence facilitating its break up and its subsequent removal especially on a slope.

Viii. Organic activity:

This is the physical activity of biological organisms namely plants and animals. Plant roots searching for minerals and water grow into the rock. As the roots increase in size, they wedge the rock apart. Burrowing animals further break down the rock by moving fresh material to the surface and underground rocks where they live.

Wild game and large domestic animals contribute to physical rock disintegration as they trample on the ground in the course of their movement across the range-land.

QN: (a) Distinguish between physical and chemical weathering

(b) Giving specific examples, describe the physical weathering processes taking

place in East Africa.

CHEMICAL WEATHERING PROCESSES.

The process of chemical weathering or rock decomposition transforms rocks and minerals into new chemical products. This transformation (change) is usually assisted by the presence of water and air, particularly, oxygen. In chemical weathering, the internal structures of minerals may be charged decomposition is camed out in several ways.

The key weathering processes are described below.

1. **Oxidation**.

This is a process which involves the absorption of oxygen in the atmosphere by rock mineral especially iron and aluminium compounds. For example, the iron compounds react with oxygen in water to form iron oxide which forms a rust line over the rock.

The rusting of the rock indicates the decomposition process. Rocks are mostly affected by oxidation process include Olivine, feldspar and mica.

Below the water table the ferrous compounds in the clay give it grey or blue colour but in the zone above the infiltrating water, the oxygen oxides ferrous compounds into red brown compounds.

In central Buganda, the process forms hard crust on top of the hills which are laterites (duricrusts). Oxidation also takes place in Kigezi and Tororo where there are rocks with iron ore.

$Fe + O_2 \longrightarrow$ FeO (iron oxide

$4Fe0 + 02 \longrightarrow 2Fe2{+}03$

Ferrous oxide+ oxygen = Hematite

$2Ca(s) + O_2 \longrightarrow 2CaO(s)$

$2Mg(s) + O_2 \longrightarrow 2MgO(s)$

Oxidation of a rock can result in a series of reactions and processes taking place. E.g.

The oxidation of olivine rocks results into production of magnesium hydroxide, ferrous oxide and silica acid as shown by the equation below.

Mg FeSi04 + 2HOH → Mg(0H)2+ Fe0+ H2Si03

(Olivine) + (Hydroxy) (Magnesium hydroxide) + (Ferrous oxide) + (silica acid)

2. **Hydration**.

This is a process of weathering by which rocks absorb water and expand in size. This expansion reduces the cohesiveness of the rock particles hence internal stress is created in the rock and therefore a rock crumble. Some rocks e.g. hematite and anhydrite completely breakdown after hydration and produce new compounds. Calcium sulphate (anhydrite) is after absorbing water into Gypsum as shown by the equation below.

CaSO4 + 2H20 = CaSO4.2H2O

(anhydrite) + (water) (Gypsum)

3. **Reduction**.

This is a chemical weathering process that is a characteristic of waterlogged swampy soils where the amount of oxygen ions is removed and hydrogen ions added. In these waterlogged areas, spaces in rocks are filled with stagnant water coloured ferric compounds (Fe2O3) are chemically reduced or given away to a grey, blue appearance of ferrous oxide (FeO3)

That is a reason as to why clay soils or swampy soils have a grey colour. Whenever such rocks (soils) are exposed to dry ground, a reddish colour appears at the surface simply because the ferrous oxide (FeO) has been oxidized to form rust/ferric oxide (Fe2O3) called hematite. Reduction occurs in all swampy and water-logged areas e.g. at Kajansi, Aswa valley, Tana, Pangani and Athi areas.

4. **Hydrolysis**.

This is a chemical process that occurs in rocks, which absorb water. Hydrolysis is a reaction of hydrogen and some minerals within certain rocks. This reaction

undermines the strength of the rock and also turns it into new compounds. Hydrosis is common in granite rocks that are rich in field spar, which feldspar is turned into whitish clay called Kaolin as shown by the equation below.

$K_2.Al_2O_3.6SiO_2 + H_2O = AL_2O_3.2SiO_2.2H_2O$

(Feldspar) + (water) (Kaolin)

This clay occurs near opete in Kilungu hills of Machakos and Keratin in Kenya. The kajasi clay in Gulu, and in Amatafali (South of Lira town) are all products of hydrolysis.

5. **Solution**.

This is a process where certain rock minerals dissolve in water thus resulting into fundamental chemical changes it is common among rocks with sodium chloride, calcium chloride, magnesium chloride, calcium sulphate and common salt as witnessed at Lake Katwe in Uganda and Lake Magadi in Kenya.

6. **Carbonation**.

This is a process which involves the decomposition of rocks by carbonic especially on carbonic carbonate rocks such as Lime stone and dolomite. Carbonic acid is a weak acid formed when rain water reacts with carbon dioxide in the atmosphere. Carbonic acid changes calcium carbonate rocks into bi carbonate which is easily removed in solution form by running water.

$CO_2 + H_2O = H_2CO_3$

(carbon dioxide) (water) (carbonic acid).

$H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2$

(carbonic acid) (limestone) (calcium hydrogen carbonate)

When carbonation affects the rocks, various land forms are created. For instance, part of the rock is dissolved in water to form grikes separated by sharp ridges of resistant rocks known as clints. Similar reactions occur underground to form stalactites on the roof of the underground cave and stalagmites on the floor of the

caves.

They form when calcium carbonate rocks are dissolved and transported downwards in solution form as calcium bi carbonates. When the water evaporates, the limestone is left as deposit on either the roof of the cave or the floor. Such features can be seen in Nyakasura, Kiliffi on the Kenyan Coast, Kajansi on Entebbe road.

7. **Chelation**.

This is a chemical weathering process that involves the exchange of minerals between the plants and the rocks. The plants extract mineral nutrients from the rock causing a change. The plants on the other hand release some minerals back into the rock that changes the mineral structure on the rock hence leading to chemical decomposition. This occurs due to the thick vegetation cover.

THE INTERDEPENDENCE OF PHYSICAL AND CHEMICAL WEATHERING.

Weathering as earlier pointed out can be either physical, chemical or biological, Biological weathering however, is either physical or chemical and hence cannot form an independent category of its own. Therefore, we remain with two major types of physical and chemical weathering. For purposes of clarity, the two processes were considered in isolation, they are not always exclusive and are therefore interdependent because one can lead to another as illustrated/described below.

a) The joints, crack and weaknesses found in a rock as a result of physical weathering allow deeper penetration of water hence providing a favourable ground for rock decay (chemical weathering).

b) Some rocks are dissolved in water and weathered away in solution. The solutions formed may later undergo precipitation leading to crystal growth. When crystal growth happens in rock cavities, they will exert a lot of pressure that will disintegrate the rocks physically. This occurs in chlorides, carbonates, sulphates etc.

c) Hydration (a chemical process) results into rocks absorbing a lot of water e.g. hematite, Limonite and montinorillonite which makes these rocks particles to pill off in a physical process called spheroidal weathering.

Spheroidal weathering: This process involves the expansion of the outer shell of the

rock when there is water penetration. The penetration of rain water forces the outer shell to pull successively away from the rock and this loosens the rock thus contributing to its decomposition

d) The physical process of frost shuttering opens up and crashes the rock and when these cracks are occupied by water chemical weathering takes place e.g. carbonation.

e) Roots of plants which expand within bedding planes of rocks and burrowing animals which drill holes in rocks all allow water entry into these rocks which accelerates chemical weathering.

f) Chemical weathering weakens rocks making them easily disintegrate by physical weathering.

DIFFERENCES BETWEEN PHYSICAL WEATHERING AND CHEMICAL WEATHERING

Physical weathering is the disintegration or breakdown of rocks into smaller particles or fragments in situ while chemical weathering is the decomposition or decay or rotting of rocks in situ at or near the earth's surface.

Physical weathering occurs due to temperature fluctuations (temperature changes) like alternate heating and cooling while chemical weathering occurs as a result of heavy or adequate rainfall and high humidity that provide water to act as a medium of chemical reactions and the hot temperatures to accelerate the rate of chemical reactions.

In physical weathering, there is no change in the chemical composition of the rock but instead the rock is broken down into smaller particles while in chemical weathering there is a change in the chemical composition of the rock i.e. new compounds are formed.

Physical weathering occurs inform of block disintegration, thermal expansion, granular disintegration, frost action etc. while chemical weathering occurs inform of carbonation, solution, hydrolysis, hydration etc.

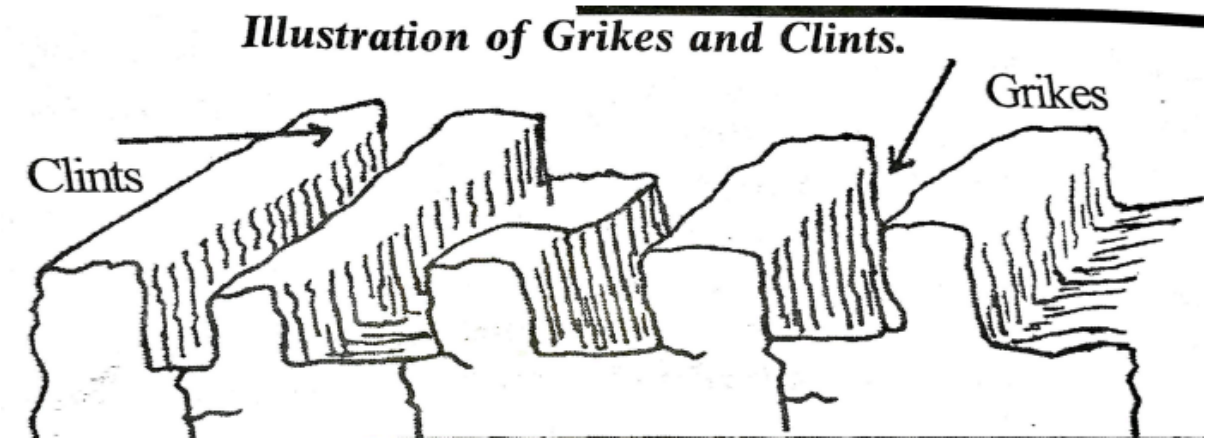
LANDFORMS OF WEATHERING.

Weathering like other earth processes produces some features on the earth surface

which include;

1. **Grikes**; These are landforms found in chemically weathered limestone rocks. Chemical weathering especially carbonation weathers down the surface of these rocks to produce deep narrow grooves which are called grikes.

2. **Clints**; These are formed together with grikes. As grikes are being dug deep into the rock, some flat or round topped ridges remain separating the two adjacent grikes. These ridges are called clints. These can be seen on western side of Tororo rock, Karasuka region of Karamoja, Tanga region in Tanzania and Kilifi in Kenya.



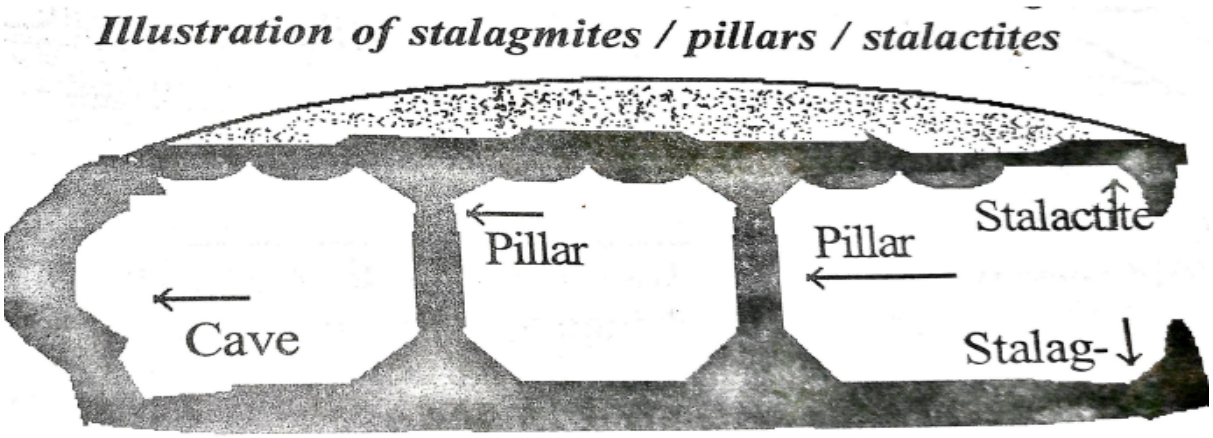
3. **Stalactites**. These are features found on karst landscape (limestone) region. They appear as whitish or grey protrusions found on the roof of a chemically weathered limestone cave. Its formed when rain water combines with carbon dioxide gas in the atmosphere to form weak solution of carbon acid.

The carbon acid dissolves the limestone rock on the cave and the solutions start dripping onto the floor. When water evaporates, dripping stops leaving behind protrusions on top of the cave. These harden to form stalactites. Examples are found at Nyakasura in Uganda and Tanga in Tanzania.

4. **Stalagmites**; These are formed together with stalactites in limestone regions. They are whitish or grey protrusions on the base of a cave in limestone regions. They are formed from accumulation of dripping bicarbonate (dissolved limestone) after the process of solution. When water evaporates from the limestone, it leaves behind a dry and compact mass of limestone which protrudes upwards forming a stalagmite. Examples are seen at Nyakasura.

5. **Pillars**; These are verticle stands of calcium carbonate which form after the accumulation of stalactite and stalagmite accumulate and converge/meet to form a stand pillar. Examples are found at Nyakasura and Tanga.

Illustration of Stalagmites/pillars/stalactites.

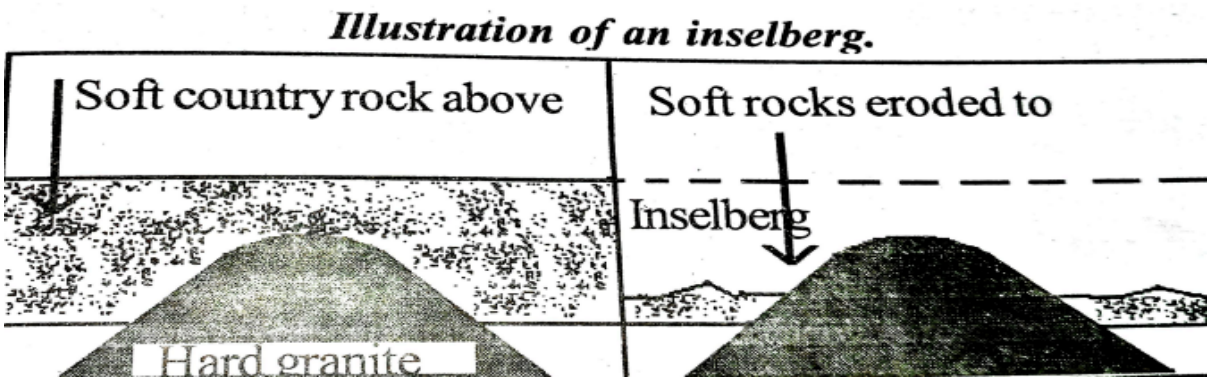


6. **Underground caves**; these are natural underground chambers in the limestone rock usually joined to the land surface by a system of interconnecting shaft and galleries (pillars). They are formed due to solution effect and mechanical erosion by underground streams and occasional rock collapse.

Ground water circulating in the zone below the water table dissolves limestone and forms cavities by attacking joints and bedding planes. As the water table falls, water percolating down through the rock continues the process of enlarging the cavities. Finally, rivers taking underground course may increase the size of the cavities by the stream erosion.

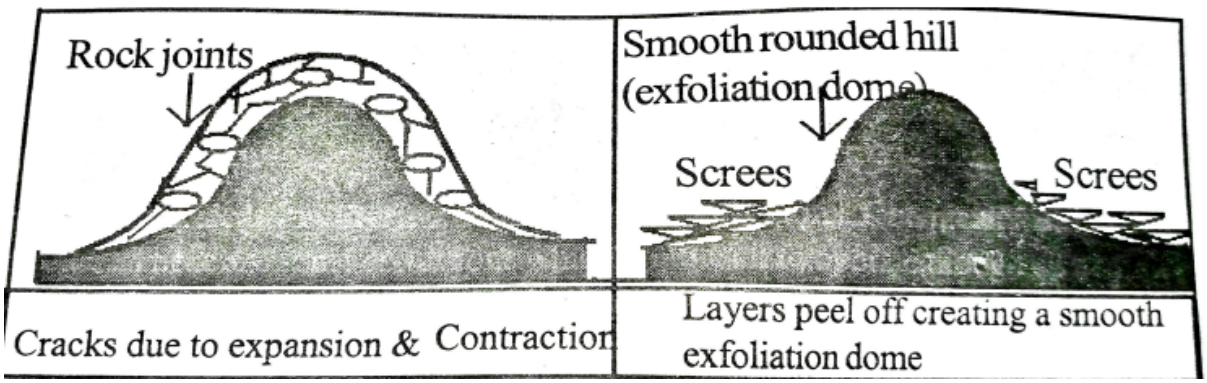
7. **Inselbergs**; These are hills formed by the weathering and eroding away of the surface rock leaving the hard-resistant granitic rocks. They are therefore remnant of

older higher peneplains which have been removed except for these island hills that have proved more resistance within the basement complex. They can be seen in Mubende, Kangole in Moroto, Nakasongola in Uganda, seme near Kisumu, Bismarck rock near Mwanza-Tanzania and Koma near Nairobi.

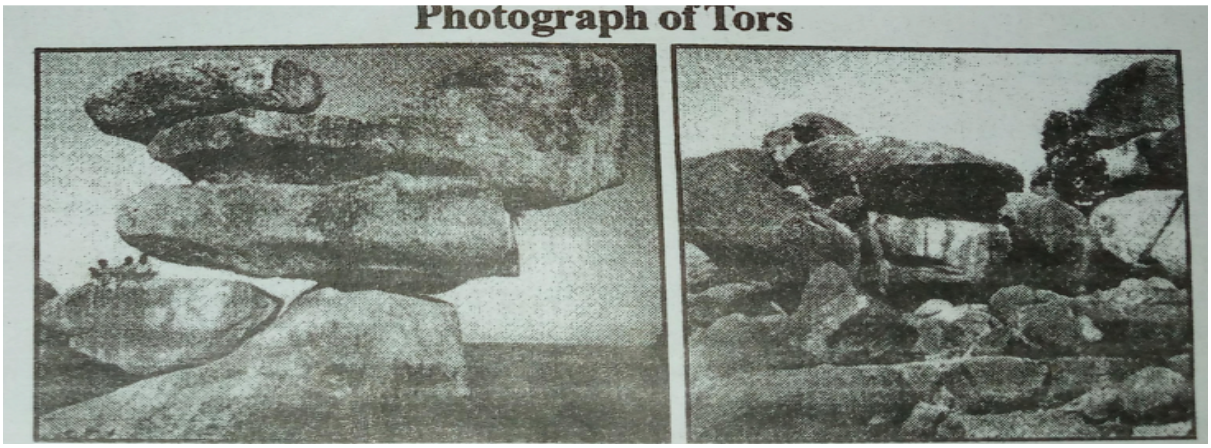


8. Dry valley; Rivers flowing from non-limestone regions may finally enter limestone rocks, which are very permeable and may disappear underground only to re appear on the ground again at the end of the limestone rocks. Within the limestone permeable rocks where the river disappears, remains a former valley where river disappeared deep down as a dry valley.

9. **Exfoliation domes**; These are smooth and rounded topped hills found in arid and semi-arid regions like chalbi desert in Kenya, near Olduvai Gorge in Tanzania, Moroto and Kotido in Uganda. They are formed to alternate expansion and contraction of rocks under different temperature extremes. During day it's too hot so the rocks expand, during right, it's too cold, the rock contracts considerably. The rocks on the outer side start peeling off rock pieces leaving behind a smooth round topped hill called an exfoliation dome.



10.Tors. These are pillars of rounded weathered boulders rooted in the bed rock. They are formed rooted in the bed rock. They are formed when block disintegration (physical weathering) weathers away jointed rocks like granites thus leaving behind resistant rock structures rooted in the earth as tors. Examples of tors are Kitmikaye near Seme in Kenya, Kachumbala rock in Kumi, Bismarck rock in Mwanza-Tanzania, Mubende tor etc.



11.Core stones; These are generally boulders and rocks left behind when weathered material that surrounded the are removed. They often appear isolated when left in a totally different landscape. They are often found near tors and examples can be found at Mwanza, Mubende and Nakasongola.

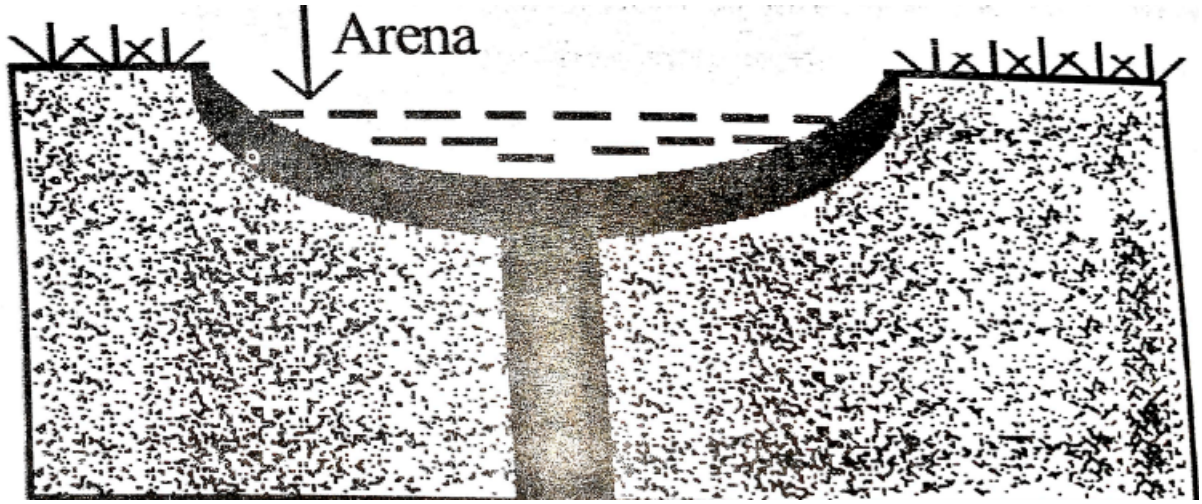
12.Dolines; These are shallow depression or hollows with gently sloping sides generally circular or oval in shape. They originate from water percolating underground at the intersection of the major joints. The carbonic acid formed by carbonation slowly dissolves the rock to form a small basin which is later enlarged.

13.Sink holes; These are oval shaped holes that are formed when chemically decomposed rocks at the surface sink or collapse creating a steep sided depression or basin. Swallow holes may be enlarged into funnel shaped depressions called dolines and these may further be enlarged to give features known as uvalas.

Through the process of carbonation or solution, limestone is dissolved and removed in solution from leaving behind deep holes which penetrate into the cave. They can also form due to sub-surface collapse.

14.Arenas; These are large circulation depression on earth's surface. They develop

in areas with alternating portions of soft and hard rocks or rocks with different mineralogical composition. For example, rock salt is weathered by solution; Limestone and dolomite are decomposed by carbonation and removed leaving behind a circular depression called an arena. Once filled with water they form ponds examples are found at Ntungamo and Mbarara.



NB: Equatorial regions experiences chemical weathering due to mostly luxunant climatic conditions of high rainfall (up to 2000+mm) and high temperatures of up to 25°C.

In Tropical regions chemical weathering dominates in rainy seasons as well as physical weathering in dry seasons.

In arid and semi-arid climatic regions due to high temperatures and low rainfall in absence of vegetation cover favour physical weathering as the most dominant type of weathering however occasional showers and high radiational cooling provide moisture to rocks in deserts which make them undergo chemical weathering.

In montane climatic regions especially at higher altitudes where temperature falls below 0°C and characterized by ice sheets frost shuttering is most common and pressure release due to steep slopes thus physical weathering is common in higher altitudes. Whereas in lower slopes, organic weathering occurs due to presence of forests.

IMPORTANCES OF WEATHERING.

• Landforms such as Granitic tors, stalactites, Stalagmites and caves at Mwanza and

Nyakasura in Tanzania and Uganda respectively are tourists‟ attractions which generate a lot of foreign exchange.

• Weathering is the first process of soil formation. It produces different types of soils such as laterites which are used in civil engineering, clay or kaoline is also formed when feldspar reacts with water under the hydrolysis process. Such clay is used for house construction, domestic ware like cups, pots etc. at Kajjansi in Uganda.

• Weathering helps to expose minerals. Block disintegration and Granular disintegration along the Kimberly rocks in Mwadui-Shinyanga province in Tanzania exposed the existence of Diamonds in the volcanic plug. Similarly, the Tororo rock was exposed in a similar process and today is used in the processing of cement

However, weathering has negative importance as well. These are,

frost shattering on steep slopes like mt Rwenzori and Kilimanjaro is followed by landslides which cause great damage down slope.

The disintegrated rock pieces slide off and may freely fall down destroying crops and animals.

Infertile and moderate fertile soils which don’t support agriculture have been formed by weathering. Such soils include laterites in Buganda and clays in Iganga and Bugiri along Naigombwa and Mpologoma wetlands which are usually acidic.

Weathering has left behind a ragged landscape in limestone regions composed of clints, Grikes and arenas. These limit agricultural practices as well as settlement in Tororo, Tanga and Nyakasura. Weathering on steep slopes encourages soil erosion thus affecting land productivity in kigezi highlands and the slopes on mt Kilimanjaro in Tanzania.

Revision Questions.

1.Examine the weathering processes that take place in either the desert or the humid areas of East Africa.

2.Using diagrams, illustrations and examples from East Africa, write short notes on any five of the following processes

• Exfoliation

• Hydration

• Laterization

• Frost thawing

• Block disintegration

• Carbonation.

3(a) Discuss the processes of chemical weathering

b) Giving specific examples, explain the effects of chemical weathering on the economic geography of either Uganda or Kenya.

4.To what extent does the rate and character of weathering depend on the nature of the rock. 5.Describe the landforms resulting from weathering in East Africa.

6 (a) Distinguish between physical and chemical weathering

b). Examine the effects of weathering processes on landform formation in East Africa

c). Assess the importance of weathering in East Africa

7a) What is chemical weathering?

b) Describe the landforms resulting from chemical weathering

8. Account for the landforms produced by carbonation process in East Africa.

9. Examine the influence of rock weathering on landform development in East Africa.

Sample questions approach.

1. ***To what extent does the parent rock influence the rate and nature of weathering.***

   Define weathering

   Talk about the types of weathering briefly

   Explain the influence of the parent rock on the rate and nature of weathering

Then say, however it's not only the parent rock which influences the rate and nature of weathering in east Africa but there are other factors which include climate, living organism, relief, time etc.

NOTE

All factors identified should be explained with relevant examples.

Give your personal stand or evaluation

2. ***'Physical weathering is the most dominant weathering process in arid and semi-arid areas of East Africa". Discuss***

   Approach

   Define weathering

   Define physical weathering

   Give the areas prone to physical weathering in east Africa

   Give the semi-arid areas in east Africa

   Talk about the physical weathering processes excluding free thaw action

   However, when it rains, chemical weathering may also occur.

3. ***Examine the weathering processes that take place in the mountainous areas of East Africa.***

   Approach

   Define weathering

   Identify the mountainous areas in east Africa

   Give the types of weathering occurring on the different sides of the mountains i.e. on top where we have physical weathering e.g. freeze thaw action, and other processes of physical weathering on the lee ward side.

   On the wind ward side, we have chemical weathering

END.