

LANDFORM EVOLUTION OR DEVELOPMENT IN EAST AFRICA (EARTH MOVEMENTS)

The term earth movements refer to all crustal disturbances of endogenic origin. Therefore, earth movements include volcanicity, faulting, folding, crustal warping and earth quakes.

Other terms used under earth movements are; diastrophism, tectonism, plate tectonism, tectonic movements, endogenic processes, geo-chemical reactions, radioactive elements etc.

The origin of earth movements are the convectional currents in the earth's interior. Whenever convection currents are generated in the mantle, they rise upwards towards the crust. The rising causes epigenetic forces (uplifts) which results into slow but large scale uplifts within the crust. After reaching in contact with the colder earth crust, they move laterally in opposite direction thereby stretching the crust at the point of divergence. This stretching causes the crust to fracture and at times displaced due to generated tensional forces. This fracturing is called **faulting**.

At the point where convectional currents meet and sink back into the earth's interior, compression forces are generated which push continental plates together. This results into **folding** of the crust.

The faults (lines of weakness) created may lead to the escape of hot magma from the mantle and this process is called **volcanicity**.

When rocks fracture, they release pressure which had accumulated in them for a long time. This sudden change in the rocks results into shock waves within the crust causing **earth tremors** normally known as **earth quakes**.

Sometimes the earth's crust has got denser plates (simatic plates) and lighter plates (sialic plates). The simatic plates are forced to sink thus causing crustal warping.

Faulting

Faulting refers to the breaking of rocks within the earth's crust. It's also involves displacement of rocks on either side of the fracture or fault.

Therefore, faulting refers to the fracturing, breaking and displacement of rocks on either sides of the fracture.

Faulting may cause uplifts or subsidence or horizontal displacement of rocks on either sides of the fracture. Faulting results into several landforms in East Africa

like the rift valley, block mountains, fault scarps, fault guided valleys, tilt blocks, grabens among others.

Types of faults.

Normal faults.

A normal fault is formed when crustal blocks are stretched by tensional forces. In other words, these are faults which develop at a divergent boundary where tensional forces are generated stretching the overlying earth's crust.

It can be illustrated as below.

Reverse faults

A reverse fault is formed due to the influence of compressional forces. These are produced by compressional forces. As the crust is being compressed, time will come when one block will override the other.

Illustration.

Tear fault

Tear faults are caused by forces operating parallel to each other in opposite direction.

Illustration.

Effects of faulting on landform evolution in east Africa.

A block mountain.

A block mountain refers to an upland bordered by faults on one or both sides. It has a level summit and stands above the general level of the surrounding land. Its formed as a result of uplifting forces along lines of weaknesses or faults.

Block mountains maybe formed with one scarp or more. For a horst mountain to form, the blocks of the earth's crust may have moved in the following ways;

a. Differential uplift.

In this way, three blocks were forced to rise but the middle block rose faster than the outer blocks. The faster moving blocks (middle block) then became the peak of the horst.

It can be illustrated as below.

b. Differential subsidence.

In differential subsidence, three blocks may subside but the outer two blocks subside faster than the middle block. The middle block remains behind at a higher elevation than the outer two blocks. The middle block then forms the peak of the horst. It can be illustrated as below.

Examples of block mountains include Rwenzori in Uganda, Usamabara, Urunguru, Ufipa in Tanzania among others.

A tilt block.

This is a steep block where land falls from a higher elevation to a lower elevation. Its formed when one side is uplifted higher than the other side. When tilting occurs, the slope top of the middle block will not be flat but inclined or tilted. The middle block then becomes the tilt block. Such landscapes are composed of angular ridges for example the Usamabara tilt blocks in Tanzania.

Illustration

The rift valley.

A rift valley is an elongated depression bordered by in-facing scarps or escarpments. A good example is the great East African rift valley which forms a series of rift valleys by different forces extending for about 7200 km. this rift valley is divided into four sections i.e.

- I. The Ethiopian section which stops at lake Turkana.
- II. The eastern rift valley which extends through Kenya
- III. The Malawian section between Malawi and Zambia.
- IV. Western rift valley covering western Uganda and Tanzania.

The width of the rift valley varies from place to place with some areas extending for about 60 km in width and its depth or height also varies from place to place.

The formation of a rift valley is mainly due to compressional forces, tensional forces, differential uplift or differential subsidence.

Tension force theory.

These develop with forces pulling in opposite directions, cracks or the lines of weakness then developing leading to the formation of the normal faults. The middle block is then separated from the outer two blocks. The loose heavy middle block sinks downwards displacing the underlying rocks further below in the interior. This leaves a depression behind on the earth's surface which is called a rift valley. It can be illustrated as below.

Compressional force theory.

This is the stress in the earth's surface which develops when forces are pushing towards each other. Compression sometimes forces the side block to override the central block. The fault scarps are then smoothed by erosion and a wide rift valley is formed. It can be illustrated as below.

Differential uplift theory.

Under this theory, three blocks were forced to rise but the outer two blocks rose faster than the middle block. As the outer blocks rise at a higher speed, they gradually form a high edge of a depression called a rift valley. It can be illustrated as below.

A fault scarp or an escarpment.

A fault scarp is an inward facing of a rift valley. It is a steep slope caused by vertical earth movements along a fault. Examples include Songwe fault scarp in Rukwa valley in Tanzania, Ufipa, Manyala, Buhati fault scarp near Nakuru Valley, Mau fault scarps, Nandi fault scarps, Butiaba around lake Albert, Bunyaruguru scarps among others. A fault scarp can be illustrated as below.

A fault line scarp.

By contrast, a fault line scarp is a steep slope whose original profile has been modified by denudation processes. It does not therefore look like the original fault scarp. It can be illustrated as below.

A graben or rift valley lake.

Further faulting within a rift valley may create a rift valley basin. This occurs when the land on the rift valley floor is further acted upon by secondary or further faulting i.e. the rift valley floor is faulted lower than the surrounding parts and there after it forms a depression known as a graben. A graben is a result of secondary faulting or further faulting within the rift valley floor. These depressions are usually deep, steep sided, elongated and narrow. In east Africa, these depressions have been filled with water to form rift valley lakes for example lake albert, Tanganyika, Malawi, among others. It can be illustrated as below.

Fault guided valleys.

In east Africa, faulting has led to the formation of fault guided valleys. As faulting takes place, rocks are displaced and shattered and therefore relatively weakened than the adjacent ones which are not similarly affected. Weathering and erosion may take advantage of these lines of weaknesses. A river may flow along the line of weakness or along the fault curving out a valley. This valley normally flows following the nature of the fault line. An example is river Aswa in Acholi

land in northern Uganda which evolved in this way, Kerio valley between Elegeyo escarpment and Kamasiya ridge in Kenya. It can be illustrated as below,

Influence of faulting on drainage.

Drainage refers to all surface water like lakes, rivers, swamps etc. in many parts of east Africa. Faulting has had a great significance on the flowing rivers and on the drainage systems as seen below.

Vertical faulting across a river valley may cause the occurrence of water falls, rapids and other related features such as plunge pools. A water fall is a sharp break in the channel gradient over which water flows. Examples in east Africa include the Murchison falls, Kisizi falls etc. It can be illustrated as below.

Faulting has resulted into the formation of grabens or rift valley lakes. Grabens develop within the rift valley floor after secondary or further faulting on the rift valley floor. When the resultant depression is filled with water, it then forms a rift valley lake. This has therefore accounted for water surfaces like Lake Edward, Albert, Tanganyika, Malawi, Turkana among others. These lakes are usually elongated, deep, narrow and steep sided. It can be illustrated as below.

Faulting has also led to the development of fault guided river valleys for example river Aswa in Acholi land in northern Uganda. During faulting, the faulted zones became more prone to weathering and erosion. A valley was carved out following the fault line in which a river passed leading to the formation of a fault guided river valley. It can be illustrated as below.

Horizontal or lateral displacement of tear faulting across a river may cause a river to be offset at the point it crosses a fault as shown below.

Faulting has also resulted into the formation of tilt block lakes. A tilt block is a steep slope where land falls from a higher elevation to a lower elevation. It is formed when one side of the fault is uplifted higher than the other. When tilting occurs, the top part of the block will not be flat but instead inclined or tilted. The middle block then becomes a tilt block. The depression may be filled with water to form a tilt block lake for example Lake Obolsat.

Illustration

Faulting has also indirectly affected water surfaces through creation of block mountains. These mountains experience frequent orographic rainfall and are sources of rivers. Block mountains are characterized by radial drainage whose subsequent streams also develop dendritic patterns for example on mountain Rwenzori rivers like Mubuku, Mpanga, Sebwe, Nyamwamba among others are

radiating from its top creating radial drainage system and as they flow downstream, their subsequent streams have resulted into dendritic drainage patterns or systems for example river Nyamwamba

Faulting in conjunction with warping, resulted into the formation of open enclosed basins e.g. Lake Victoria and Kyoga which were as a result of these processes. After the formation of the Victoria basin by down warping, the rivers that were flowing westwards into the Congo basin for example Kagera and Katonga all were reversed into the basin forming Lake Victoria.

The up thrust in western Uganda led to the formation of Rwenzori mountains and it was followed by a slight up thrust in the east making the rivers that were flowing eastwards to also flow back into the basin. These included river Mara, Nzoia eventually leading to the formation of Lake Victoria and Kyoga.

Today much of Lake Victoria is a vast shallow depression of papyrus swamps and its peculiar outline is due to river Kafu being forced to flow back into its own valley and tributaries. Therefore, it's important to note that crustal warping (up warping) across a river valley will gradually force a river to reverse its direction of flow and run back if it's unable to maintain its original flow.

It can be illustrated as below.

Importance of faulting to man.

(research)

FOLDING

A fold is a geographical structure in which beds of rocks are bent. Folding is therefore a process through which rocks are forced to bend hence developing undulations or undulating structures. Rocks that fold are normally geologically young and compressible.

Folding principally produces two structures i.e. anticlines and synclines.

Illustration

Types of folds

Simple folds / symmetrical folds. These are folds produced by gentle compression that causes the rock strata to develop simple crests and synclines that are similar and uniform.

Asymmetrical folds. These are folds produced by an increase in the degree of compression and particularly when the pressure on one side is greater than the

pressure on the other side. Hence one crest is steeper than the other. In other words, they are asymmetrical or not uniform.

Over folds. These are produced when the degree of compression is very high due to high pressure such that the land folds so much that the crest is pushed over the other syncline.

Over thrust fold. These are produced when the degree of compression is so intense that folding occurs in the overriding crests.

EARTH QUAKES

An earth quake is a rapid movement and adjustment of the land within the rocks of the earth's crust causing propagations of a series of elastic shock waves outside in all directions.

One can define earth quakes as strong vibrations of the earth or violent movement on the earth's surface.

Earth quakes originate from plate tectonism. The collision of plates causes an impact that triggers off strong vibrations of plates causes an impact that triggers off vibrations within the earth's crust.

The plates are light and float on the upper mantle. They are therefore mobile and may move vertically or horizontally. This movement is caused by radioactive elements and convection currents that are generated within the earth's interior. When the plates converge, deformations occur on either sides of the edges within the mantle.

As the plates are dragged, the rocks become more plastic and elastic thus storing energy. Frictional resistance holding the rocks together is overcome by compression and eventually, the edges become slippery. The rapid release of energy makes the energy radiated in all directions from the focus to form explosive shock waves thereby causing vibrations which are known as earth quakes.

Eventually, rock elasticity returns to its original shape and this is referred to as elastic rebound. It should be noted major earth quakes produce small ones after few years or days. The waves travel from the center of disturbance as one shock wave.

The point in the earth's crust from which vibrations originate is called a focus while an epicenter is a point on the surface of the earth above the origin of the earthquake (a vertical point above the focus).

Shock waves are transmitted quickly through the earth's crust to the surface. When an earthquake occurs, these shock waves decrease in strength as they travel away from the focus.

Earthquakes usually occur in areas of china, japan, California, India, Mexico, Peru and in East Africa they are commonly experienced in Kabarole (Toro), Bundibugyo among others.

Effects of earth quakes

There is loss of lives especially in the 1966 earth quake where about 150 people died in Toro and in 1994 in Bundibugyo where many people perished.

Earth quakes trigger off landslides particularly in highland areas and are associated with many problems of communication blockage.

Earth quakes result into the destruction of socio-economic infrastructures like schools, roads, hospitals etc. like in 1994 when vilica hospital was destroyed.

Leave some people homeless or displaced for example in 1994 in Toro.

Increased government expenditure in areas prone to earthquakes in form of emergency funding for disaster preparedness. In addition to that, there are high costs of replacing destroyed property like roads, buildings among others.

Flooding in the coastal areas due to the tsunamis created or generated by earth quakes in the sea and this may also result into drowning.

Earth quakes can also be used for study purposes.

Question

Explain the cause of earth quakes in east Africa.

Examine the effects of earth quakes to the people of east Africa.

Vulcanicity.

This refers to the total process by which gases and molten rocks from the earth's interior are intruded into the earth's surface or extruded onto the earth's surface.

When the molten material (magma) is intruded into the earth's surface, it solidifies giving rise to intrusive features. When the materials reach on top of the earth's surface (lava), it solidifies to form extrusive features.

The molten material originates from the upper plastic layer of the earth's mantle. This material is kept in a semi molten or plastic state due to the high temperatures and additional heat sufficient enough to take the material to melting point.

Through the natural process of radioactivity, heat is generated and this makes the rocks to be plastic and fluid. Any additional increase in heat can trigger off upward movement of molten rock. The lighter elements of the material begin to rise upwards to the surface. The rising is made possible along lines of weakness like cracks or faulting.

The magma then forces its way out to the surface along fault lines and forms various landforms on reaching the surface.

It should be noted that when magma erupts on the surface and loses its gases, it is then known as lava.

It's the escaping gases and steam which expand rapidly and its due to high pressure that makes the eruptions to be explosive.

Lava varies considerably in its composition particularly in its silica content. The nature if lava partially affects the nature of landforms.

Basic lava is very fluid and mobile and therefore forms extensive lava plains. On the other hand, acidic lava is so viscous and largely immobile and consequently solidifies quickly to form steep sided landforms like volcanic plugs. Sometimes acid lava solidifies so quickly and blocks the fissures resulting into explosive eruptions.

When an eruption takes place explosively, the magma is often ejected in form of ash, cinder, stones, blocks and gases and the finest is ash. The fragmental materials are referred to as pyroclasts.

Lava varies considerably in chemical composition particularly in its silica content. The silica content determines the degree of mobility.

Because of this, there are three types of lava and these include acidic lava, intermediate lava and basic lava.

Type of lava	% of silica content	Degree of mobility	Example of rock type
Acidic	Above 66 %	Extremely viscous and immobile and solidifies quickly.	rhyolite
Intermediate lava	Between 52-65%	Fairly viscous and able to flow for a far distance	Trachyte
Basic	Between 42-51%	Very fluid and mobile able to flow for long distance before solidifying.	Basic

The process results into formation of volcanic landforms namely;

Extrusive volcanic landforms

Intrusive volcanic landforms.

Extrusive volcanic landforms or features.

These are formed when magma is extruded onto the earth's surface. They take various forms depending on the type of lava which forms them. They include the following;

A volcano. A volcano is a hill or mountain formed by eruption of molten lava from the central opening known as a vent onto the earth's surface. The material erupted builds around the vent and generally forms a dome or cone with a funnel like structure or depression on top called a crater.

As long as there is continued supply of magma, the volcano will continue to grow to a height to which the difference in pressure can still force the erupted materials onto the earth's surface. If the pressure becomes insufficient for magma to reach the main crater, the mountain rock may then force its way on the earth's surface through other vents and may build up parasitic or secondary cones on the slopes of the main volcano.

Illustration.

Volcanoes vary in size from small ones to few meters high to large mountains like Kilimanjaro and Elgon among others.

They can also be classified according to the present state of activity i.e. active volcanoes, dormant volcanoes and extinct volcanoes.

Active volcanoes. An active volcano is one that has erupted or is thought to have erupted within the last 500 years. Examples include Longnot, Meru, Oldoinyo-Lengai all in the eastern arm of the rift valley.

Dormant volcanoes. This is one which has not been known to have erupted and yet it is not extinct. Some dormant volcanoes show limited activity in form of fumaroles like Kilimanjaro.

Extinct volcanoes. These refer to the volcanoes which show no further signs of eruptions and much of their original structure may have been destroyed by denudation processes of erosion and weathering for example mountain Elgon.

Basalt dome or shield volcano. A basalt dome is a large flat topped or convection dome which is formed from basic lava with gently sloping sides. It's usually low in height relative to its large base. Its flat topped shape is caused by very fluid lava which is able to flow for some time before solidifying. Usually a shallow steep sided sunken crater is found located on the basalt top. A good example is found near Muhavura ranges in south western Uganda. In this case, lava flows through numerous fissures other than a single vent.

Illustration

Volcanic plug / neck. A volcanic neck is formed as a result of magma which is so viscous that it is forced out as a rigid cylindrical plug. The base of the plug is surrounded by exploited debris. The eruption that leads to the formation of the plug is very explosive and the plug is extruded amidst clouds of hot ash and cinder for example Tororo rock in eastern Uganda.

Illustration.

Explosion crater. An explosion crater is a shallow flat floored depression which is surrounded by a low rim of pyroclasts and local rock. Craters are usually less than 50m in depth. Explosion craters may appear singly or in groups. Their formation is based on two theories i.e.

The first theory states that a crater is formed as a result of explosive eruption which blows off the upper part of a volcano creating a small depression called a crater.

The second theory states that as magma is poured on the earth's surface from the earth's interior, a chasm (empty space) is created and with the weight of the material, the volcanic plug sinks in creating a depression called a crater. This process of sinking is called couldronesubsidence. Examples are found in western Uganda. Some of these craters are dry whileothersremainswampy and marshy. When these craters are filled with water, they now form the crater lakes like Katwe, nyamunuka, nyamusingwe among others.

Lake Katwe is the largest crater lake and it's a source of salt.

It should be noted that craters are as wide as 500m in diameter.

Illustration

A caldera. A caldera is another landform resulting from volcanicity. A caldera is a wide depression or big crater. It can be formed in two ways i.e.

The first theory states that a caldera is formed as a result of explosive eruption which blows off the upper part of a volcano leaving behind a big depression called a caldera.

It can also be formed through the process of couldrone subsidence. Major eruption may reduce magma supply and leaves a big space (chasm) beneath a volcano. Consequently, the weight of the overlying solidified magma becomes too great, faults develop and collapses into the chasm leaving behind a big depression known as a caldera.

Calderas can also develop from a combination of both explosion and subsidence. Prominent calderas in East Africa include menengai near the Nakuru valley in Kenya, Suswa in Kenya, Napak in south western Karamoja, Ngorongoro in Tanzania among others. When a caldera is filled with water, it forms a caldera lake for example lake Ngonzi in Tanzania.

It should be noted that a caldera extends for about 1km in diameter.

A cumulo-dome. A cumulo dome is a steep sided convex feature of acidic lava. It is formed from very viscous lava which doesn't flow for far but instead it piles around the vent where it hardens quickly. Where the extrusions are unable to reach the earth's surface, the overlying layers will be curved outwards. When a cumulo

dome develops in a crater, it's called a theloid. An example can be seen at the Ntumbicumulo dome in Tanzania. It can be illustrated as below.

Lava plateau or plain. A lava plateau is a highland with more or less a monotonous relief and is formed of successive layers of lava. It is formed by the eruption of very fluid or mobile or basic lava that upwells the surface through various fissures. The lava reaches the surface and then spreads out for long distances. Eventually, the depth of lava may be hundreds of meters thick completely covering the original hills and valleys. Vertical jointing may cause the plateau edges to be abrupt and where a plateau has been dissected by rivers, a valley tends to be steep sided and gorges are formed. Examples of lava plateaus include Laikipia lava plateau and Kisolo lava plateau in south western Uganda.

Illustration.

Ash and cinder cone. These are steep sided hills formed by volcanicity. Pyroclasts of all sizes are ejected and accumulate around the fissures to build up a volcanic hill or an ash and cinder cone. Such cones are steep sided and approximately 150m high above its base. Examples are in Kisoro district and Lakaiyu cinder cones in the south of lake Turkana. Illustration

Geysers and hot springs. A geyser refers to hot water accompanied by steam. A hot spring is natural hot water issuing out of the ground. It is also hot or warm. Both features owe their origin from the existence of hot rocks associated with volcanicity beneath the surface of the earth. They are formed when rain water sinks into the ground and comes into contact with rocks associated with volcanicity (hot rocks). The water is therefore heated and due to the pressure differences, the water upwells the earth's surface in form of geysers and hot springs.

They differ in a way that a hot spring is super-heated water which flows quickly whereas a geyser; water is thrown with a great force and accompanied by steam (geysers are ejected explosively / as jets). Examples include the Sempaya hot spring in Bundibugyo, Kitagata hot springs in Bushenyi and Kisiizi in Rukungiri.

Lava dammed lakes. They are formed when basic lava comes out from a volcanic mountain and may block a flowing river creating a lava dammed lake. Examples include lake Bunyonyi, Mutanda, Mulehe among others.

Intrusive volcanic landforms.

In general, intrusive volcanic landforms affect relief only after they have been exposed by denudation processes. Intrusions of various forms depend on the relative hardness or may depend on resistance of the surrounding rocks.

The various forms of intrusions can be seen as below;

A batholith (s). This is a very large intrusion formed at a great depth. They are usually bottomless and are usually from granitic rocks. Batholiths are the largest forms of intrusions and they result from large scale intrusion of magma which cools slowly beneath the surface of the earth. Examples include the Tanganyika batholith which outcrops between Mwanza and Iringa, batholiths are also found in Mubende district particularly the single batholiths. In Kenya, they are found in Maragoli.

When they are exposed by denudation forces, batholiths form uplands when their rocks are more resistant than the adjacent rocks. However, if the rocks making up the batholiths are softer than the surrounding rocks, they then are then eroded away forming depressions called arenas.

Illustrations.

A dyke. A dyke is a vertical or steeply inclined igneous intrusion. It's said to be discordant with the rock layers. Dykes are formed when molten magma up wells across the layers and solidifies within the earth's crust before reaching the earth's surface. Sometimes they occur in groups and they are referred to as ring dykes. Examples are found in south and west of lake Turkana in Kenya.

After denudation, if the dyke is more resistant than the surrounding rocks, it may form an upland with steep slopes. If on the other hand, its less resistant than the adjacent rocks, it may form a trench.

It can be illustrated as below.

A sill. Sills are horizontal intrusive features which lie between rock layers. They are therefore concordant with the rock layers. Magma rises from the earth's interior and spreads horizontally along the bedding planes. After denudation, a resistant sill may form escarpments of flat topped hills. In a river valley, resistant sills may form waterfalls and rapids for example the Thika falls in Kenya are as a result of this. Sills may appear singly or in groups and examples of sills are found in Thika district in Kenya.

It can be illustrated as below.

Laccolith. This is a dome shaped intrusion with more or less a flat base. Its formed when magma rises and solidifies within the crust before reaching the earth's surface. Its formed from viscous magma which is unable to move and spread for long distances. Magma accumulates in large mass forcing the over lying rocks to arch upwards. Laccoliths are found in Madagascar and Algerian coast. If the formed laccolith is more resistant than the adjacent rocks, it may form an upland.

Illustration

Lapolith. It's a very large saucer shaped intrusion formed when magma forces its way out of the earth's surface but cools very quickly before reaching the earth's surface. Its saucer shape is due to the increased weight of the crust which may cause sinking. If the lapolith is exposed by denudation processes, then then up turn edges may sometimes form out facing scarps. Examples are in Zimbabwe north of Harare. It can be illustrated as below.

Economic importance of volcanicity to man.

Volcanism leads to the formation of volcanic soils which are fertile and useful for agriculture for example in Mbale on the slopes of mountain Elgon.

Some water falls formed on the slopes of volcanic mountains provide and are suitable sites for construction of hydro Electric power plants for example the Siipi falls in Kapchwora.

Volcanic mountains moderate climate i.e. relief or orogenic rainfall.

Water from hot springs and geysers are used for medicinal values i.e. in Kitagata hot springs in Bushenyi.

The peculiar landforms promote tourism like volcanic plugs, the highest mountain in East Africa is Kilimanjaro with 5895 meters above sea level and snowcapped in the equatorial region. This attracts many tourists throughout the year. Others include hot springs and geysers.

Some volcanic mountains help in the demarcation of country boundaries in East Africa for example mountain Kilimanjaro which demarcates Kenya and Tanzania, Elgon which demarcates Uganda and Kenya.

Volcanic activity results into the formation of valuable minerals like salt in Katwe in Uganda, limestone in Tororo and Toro region.

Plutonic igneous rocks are potential and actual resources as far as quarrying is concerned. These rocks can be excavated and crushed to get materials which are used in building and construction purposes.

Volcanic mountains are associated with heavy rainfall and luxuriant vegetation on their slopes. The vegetation can be used for forestry and lumbering.

Negative.

Volcanic eruptions can be destructive to both life and property for example of the most destructive volcanic natural disaster was mountain Nyivagingo in Zaire which erupted in 1977 and 2002 which destroyed many coffee plantations, many people died and many people were left homeless.

Volcanic mountains create rainfall on the windward side but influence aridity on the lee ward side. The lee ward side is located in the rain shadow and therefore largely dry for example the water parts of Kenya are in the rain shadow of mountain Elgon.

The steep slopes of volcanic mountains have rendered volcanic highlands inaccessible. The regions have remained remote because of difficulty and high costs involved in construction of transport and communication infrastructures for example some of the highlands in kigezi are not well served with transport infrastructures.

Steep slopes of volcanic mountains are prone to soil erosion and land slide and rock falls. This is common in kigezi, Kenya and kipengere ranges in southern Tanzania.

Revision questions

1. Examine the influence of volcanicity on drainage.
2. Examine the relationship between the nature of material ejected and extrusive volcanic landforms in East Africa.
3. Examine the impact of volcanicity on landform evolution in East Africa.

ROCKS IN EAST AFRICA.

A rock is an aggregate or combination of minerals in a solid state. In other words, a rock is an aggregate of one or more elements existing in a solid state.

Rocks form the upper layer of the lithosphere. Minerals that make up the rocks include potassium, calcium, iron, aluminum, magnesium among others. Some minerals such as gold, diamond and silver have only one element while others like quartz, bauxite have more than one element in them.

In popular use, a rock is something hard, consolidated, compact and massive. Rocks can therefore be classified by their mineralogical composition but not necessarily their hardness. Rocks of the earth's surface are commonly classified according to their origin into three types and these are; igneous rocks, sedimentary rocks and metamorphic rocks.

Igneous rocks.

They are formed from crystallization and solidification of molten magma. They may be deposited onto the earth's surface or within the earth's crust i.e. extrusive or intrusive rocks respectively. The main process for the formation of igneous rocks is volcanicity. This is due to the radioactivity and connectivity within the earth's mantle. Lines of weakness or fault lines are created in the earth's crust through which magma is either extruded or intruded.

Igneous rocks are usually described as fire formed rocks, igneous rocks are characterized by being hard, don't contain fossils and they are crystalline in nature. As magma is pushed from deep in the earth's interior, it cools in different parts of the earth's crust thus forming different types of rocks. They include

Volcanic rocks or extrusive rocks

Hypabyssal or intermediate rocks

Plutonic or abyssal or deep seated rocks.

Volcanic or extrusive rocks.

These are igneous rocks formed on top of the earth's surface. They are formed from fast flowing surface cooling lava with much smaller crystals due to exposure to oxygen. Examples include basalt, rhyolite, trachyte and andesite etc. extrusive rocks are generally hard.

Hypabyssal or intermediate rocks.

These are igneous rocks formed between volcanic and plutonic rocks. They are formed near the earth's surface and cool at a moderate rate or average rate with medium sized crystals. Like plutonic rocks, hypabyssal rocks are also intrusive. Examples include quartz and dolerite.

Plutonic rocks or deep seated rocks.

These are igneous rocks that are formed at a greater depth within the earth's crust. They are also described as deep seated rocks. The magma which forms these rock type rises for a short distance and cools in the crust very far from the earth's surface. This magma cools extremely slowly at a greater depth due to lack of oxygen and results into formation of rocks with large crystals and examples include gabbro, granite, diorite among others.

Igneous rocks can be illustrated as below.

Summary of various types of igneous rocks.

Rock type	Where it is found	Cooling rate	Size of crystals	Example
Volcanic or extrusive rocks	On top of the earth's surface	A fast rate	Small crystals	Basalt, andesite etc.
Hypabyssal or intermediate rocks	Shallow depth or near the earth's surface	An average rate or medium rate	Medium sized crystals	Quartz, diorite etc.
Plutonic or deep seated rocks	At greater depth	Cools at a slow rate	Forms large crystals	Gabbro, granite etc.

Magma from the mantle which is ejected varies in chemical composition which has an effect on its viscosity or thickness. This in turn influences the cooling rate and the process of crystallization.

Acidic igneous rocks have a higher amount of silica content; intermediate igneous rocks have a mixed structure of minerals (average silica content) whereas basic igneous rocks contain less content.

Igneous rocks in East Africa are found around volcanic mountains of mountain Kenya areas, Kilimanjaro areas, Muhavura areas and around the great east African rift valley.

It should be noted that formerly intrusive rocks may later be exposed by denudation processes and when they are resistant, they form uplands for example the Mubende batholith, Tanganyika batholith and the inselbergs of Eastern Uganda.

Question

Account for the formation of igneous rocks in East Africa.

Sedimentary rocks.

These are rocks composed of deposited minerals and rock fragments or sediments produced by mechanical or physical or chemical weathering of former rock masses of igneous rocks. They are therefore derived from already existing igneous rocks and because of this, they are sometimes referred to as derived rocks or secondary or laid down rocks.

The weathered materials are then transported by erosion agents of water, ice, and wind and are later deposited in layers (strata) on either a dry land or in valleys or under water (in oceans and seas). The layers are separated by bedding planes which demarcate the end of one deposition cycle and the beginning of another. Layers can be horizontal, gently sloping or steeply dipping.

Generally speaking, sedimentary rocks have the following characteristics;

- They contain fossils of dead plants and animals.
- They have layers i.e. strata (they are stratified)
- They are non-crystalline in nature
- Stratas are either horizontal or gently sloping or steeply dipping.

Processes of formation of sedimentary rocks.

- Weathering of the already existing igneous rocks
- Erosion and transportation of weathered materials

- Deposition of sediments by ice, wind or running water or ocean waves.
- Stratification of deposited materials.
- Compression of stratified materials by overlying weight.
- Compaction of layers
- Consolidation of materials.
- Cementation of deposited layers.
- Transformation of sediments into sedimentary rocks

The formation of these sedimentary rocks can be classified into three types and these include;

- Mechanically formed rocks
- Organically formed rocks
- Chemically formed rocks.

Mechanically formed rocks.

Mechanically or physically formed sedimentary rocks result from the breakdown of the already existing rocks into valid textures then forming valid rock types depending on the agent of erosion. These agents cause erosion, transportation and deposition of the eroded materials. These deposited materials accumulate and become compact and as time goes on or elapses, the deposited materials are cemented and consolidated and then turn into a mass of rock called mechanically formed sedimentary rocks.

River deposition creates alluvial soils, ice or glacier, till or moraine, wind deposits loess and marine or wave action creates marine deposits.

Examples of resulting rocks include sandstone, mudstone, clay, shale, gravel among others.

Organically formed sedimentary rocks.

Organically formed are formed from remains of once living plants and animals for example coral reefs or coral rocks. Coral rocks are derived from coral polyps which are small marine organisms or animals which live in sediment free water of about 200C and above all rich in plankton which is their food. Their skeletons are made up of calcium carbonates so when they die they are deposited on the sea or ocean floor, accumulate and are cemented together with other marine organisms or features like algae.

They are then compressed by their own weight. With time, they turn into hard rocks known as coral rocks. Coral rock is therefore an organic limestone rock and is very common along the East African coast.

On the other hand, when plants die, their leaves and branches decompose and are compacted together to form rocks. For example, plant accumulation during the carboniferous period were compressed by sediments and formed coal of varying types for example pit coal, brown coal and lignite coal among others.

Chemically formed sedimentary rocks.

These are rocks which result from the chemical precipitation and evaporation of salt solution in hot tropical regions. When water evaporates, the beds of salt known as evaporites are left behind as a residue or deposit which dries up, get compact, cemented, consolidated and transformed into a hard rock i.e. chemically formed sedimentary rock. Examples include dolomite, rock salt among others.

Question

Account for the formation of sedimentary rocks in East Africa.

Metamorphic rocks

These are rocks whose original forms have been changed. They were originally sedimentary or igneous rocks but they have drastically changed by massive forces of heat (thermo-metamorphism), pressure (dynamic metamorphism) or both heat and pressure (thermo-dynamic metamorphism) working on them from either within the earth's crust or outside the earth's surface.

The metamorphic rocks are quite different from the original rock. The rocks are changed in structure, texture, chemical composition and the general appearance. Metamorphism is usually a cooking process i.e. it partly melts the rocks causing the mineral components to be changed. The chemical nature and character changes hence metamorphism.

Examples include

Original rock	Changed rock after metamorphism
clay	shale

shale	slate
limestone	marble
granite	gneiss
coal	Graphite
Sandstone	quartzite

DENUATION

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 in form 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 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.

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.

These include;

Chemical weathering

This refers to the decomposition or rotting of rocks using water involving a change in the chemical composition of the rock to form new compounds or minerals.

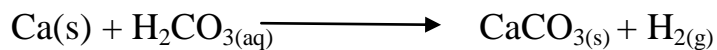
Chemical weathering is most common in the humid tropical areas that receive heavy rainfall although it can also take place in deserts since they also receive occasional showers.

Chemical weathering involves a chemical reaction between the minerals of the rock as well as the atmospheric gases like carbon-dioxide, oxygen and acids from rotten plants and animals.

In chemical weathering, water acts as a medium of chemical reaction and the hot temperatures accelerate the rate of chemical reactions. Chemical weathering involves a number of processes or types and these include;

a. Carbonation

This takes place when rain water mixes with carbonates in the atmosphere to form weak carbonic acids. These carbonic acids react with minerals in the rocks like limestone rocks which contain calcium to form calcium carbonate which can easily be dissolved in water and hence carried away. This leads to creation of holes (solution hollows) on the surface and caves beneath. When the calcium carbonate is removed in solution by ground water, karst landforms are formed like stalactites and stalagmites, underground caves etc. at Nyakasura in fort portal, Bamburi and Kilifi in Kenya.



Calcium carbonate + H₂O + CO₂ → calcium hydrogen carbonate.

Limestone + weak carbonic acids → calcium hydrogen carbonate.

b. Hydration.

This is a process of chemical weathering by which rocks absorb water and expand in size. This expansion reduces the cohesiveness of the rock particles hence internal stress is created within the rock and therefore crumbling and fracturing of the rock and changing their chemical compounds. Some rocks like hematite absorb water changing to limonite. Others are calcium sulphate, after absorbing water changes to gypsum and feldspar mineral in granite absorbs water and disintegrates to form mud.

c. Hydrolysis.

This is the reaction between water and mineral elements i.e. the hydrogen ions of water and ions of the minerals (in the rocks). This water and mineral ions react chemically which gives rise to the formation of new compounds e.g. feldspar is broken down to produce potassium hydroxide and aluminosilic acid.

The aluminosilic acid is further decomposed into clay minerals while potassium hydroxide reacts with water CO₂ to produce potassium carbonate. The potassium carbonate is removed in solution leaving silica and residual clay minerals as the end product for example in the broad valleys of Buganda like at Kajjansi.



d. Oxidation

This is the reaction that occurs when additional oxygen is taken up by mineral compounds within the rocks. The oxidation of minerals nearly always occurs in association with water in which atmospheric oxygen has been dissolved. It is most active in the zone above the water table and particularly in sedimentary rocks such as clay which contain iron compounds. In this zone, water oxidizes the ferrous compounds into red or brown ferric compounds. In the zone below the water table, the ferrous compounds in clay are oxidized to give a grey or blue color.

This form of chemical weathering is common in rocks which contain mineral elements like iron, calcium and magnesium which can easily be oxidized to form oxides. The laterite soils / murrum soils on many hill tops in Buganda where we get murrum for road construction were formed through this process. Mineral oxides can be formed as below.

$\text{Fe} + \text{O}_2 \rightarrow \text{FeO}$ (iron oxide)

$2\text{Ca(s)} + \text{O}_2 \longrightarrow 2\text{CaO(s)}$

$2\text{Mg(s)} + \text{O}_2 \longrightarrow 2\text{MgO(s)}$

e. Chelation.

In this process of chemical weathering, organic acids and humic acids from decayed materials/ leaf litter and other remains of plants react with certain minerals. The exchange of organic acids with mineral elements or rock minerals causes the decomposition and change in the chemical composition in the rock particles hence chemical weathering (fracturing and decomposition).

f. Solution.

Under this process of chemical weathering, some soluble rock particles are dissolved and weathered in solution form e.g. water may mix with rock salts and form a solution. This means that rock salts have been weathered in that way.

FACTORS AFFECTING CHEMICAL WEATHERING.

1. Nature of the parent rock

Mineral composition of the parent rock: some rocks like those having calcium carbonate react with carbonic acids which are due to combining of rain water with carbon-dioxide in the atmosphere to produce calcium bi carbonate by a process known as carbonation e.g. at Nyakasura. The calcium-bi-carbonate can easily be dissolved in water.

Some rocks have minerals like feldspar which when mixed with water decompose to produce other mineral compounds like potassium hydroxide and aminocilic acids through the process of hydrolysis. However, in the absence of water, feldspar is a very hard element to weathering.

Some rocks have mineral compounds which react with oxygen in the presence of water to form new compounds or oxides through the process of oxidation e.g. ferrous rocks (rocks rich in iron compounds) are turned into brown or red ferric compounds or laterite soils.

Some rocks have minerals that can easily dissolve in water and the solution is carried away leading to the decomposition of the rocks through a process of solution e.g. limestone rocks, rock salts etc.

Jointing of the rock: the presence of joints or cracks increase the surface area for chemical reactions to take place and also allow water to penetrate to the deeper layers of the rocks to chemically weather the rock.

Permeability of the rock: when a rock is permeable, it allows water to penetrate and weather the deeper rock layers through the processes like carbonation, hydration and hydrolysis etc.

2. Climate:

The nature of climate experienced in area determines the type of weathering as indicated below;

Rainfall or precipitation provides the water needed for chemical weathering to take place. Many areas in East Africa receive heavy rainfall amounts almost year throughout (equatorial climate). Other areas like the savannah regions receive moderate rainfall and hot temperatures and such humid conditions are conducive for chemical weathering to take place for most of the year.

Areas having hot temperatures for most of the year have physical weathering as the most dominant weathering process. However, most of the humid areas in East Africa have hot temperatures of over 20°C which increase the rate of chemical reactions thus promoting chemical weathering.

3. Relief:

chemical weathering is more dominant on gentle slopes and low lying areas as water accumulates and percolates to chemically weather the rock than on steep slopes. However, erosion on the steep slopes exposes the rocks to chemical weathering.

4. 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 in form 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.

5. Living organisms:

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

- a. Emission of industrial gases in the atmosphere which increases acidity in rainy water which accelerates the rate of chemical weathering processes of carbonation.
- b. 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.
- c. 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.

Vegetation: the dead decaying organic matter produce humic acids that assist in rock decomposition. These humic acids react with minerals in the rocks and eventually decompose.

Plant roots release mineral substances into the rock while extracting other mineral substances from the rock in a process known as chelation. This weakens the rock and it eventually breaks up.

Other living organisms like animals secrete acids that chemically decompose the rocks e.g. uric acids. Burrowing animals make holes through the soil e.g. moles, termites etc. and through these holes water penetrates to the deeper layers of rocks which aids chemical weathering through processes like solution, hydration, hydrolysis, carbonation etc.

6. **Time:**

it takes time for the rock to undergo chemical weathering. The longer the time, the more the rock is chemically weathered and the shorter the time, the lesser the rock is chemically weathered.

Revision question

Examine the chemical weathering processes that take place in the humid areas of East Africa.

Approach

- Define weathering
- Define chemical weathering
- Identify the humid areas in E.A or areas prone to chemical weathering

- Give the processes of chemical weathering explaining them with relevant examples.

PHYSICAL / MECHANICAL WEATHERING

This is the breaking down of rocks into successively smaller fragments or particles. It doesn't involve mineralogical change or change in the chemical bond of the rocks. Its common in arid and semi-arid areas of Ankole-Masaka dry corridor, Karamoja area, northern Kenya and on the lee ward side of mountains like mountain Kilimanjaro, Kenya, Rwenzori and mountain tops which involve temperature changes and have a wide diurnal range and also on the mountains with very cold temperatures where rocks are broken down by frost action. The physical weathering processes include;

a. Thermal expansion / exfoliation

In this process, daily temperature ranges result into expansion and contraction of certain minerals that cause stress and strain into the rocks. Eventually, this stress and strain leads to fracturing of the rocks. Since the rocks are bad conductors of heat, no heat from the outer part of the rock is transferred to the inner part. The outer part then expands more than the inner part hence leading to expansion and peeling off of the outer rocks. This process of peeling off is called exfoliation and results into the formation of exfoliation domes. This is dominant in the arid and semi-arid areas of Nakasongola, Kumi, Soroti, Serengeti etc. which receive high temperatures during the day and abrupt cooling at night.

b. Freeze thaw action or frost action / shattering

In areas subjected to alternating freezing and thawing, water sips into the cracks. When it freezes, the frozen water expands and widens the cracks. The jointed cracks are very prone to this process that leads to total disintegration of the rocks. Its common in Rwenzori areas, mountain Kilimanjaro areas and the mountain Kenya areas.

NB. Water expands by 10% of its liquid when it freezes.

c. Block disintegration.

In this process, the rocks are disintegrated, breaking down into blocks. It's is common in granitic rocks. As these rocks develop cracks, they cool down after exposure to thermal heating and cooling. The rocks expand and cool along the developed cracks and as they widen, the rock will fall apart in blocks (bigger

particles). This block disintegration is very common in Kachumbara areas in Kumi district and the Mubende Batholiths along Mubende-Kyenjojo road.

d. Granular disintegration.

This takes place almost in the same way as block disintegration except that in this process, rocks break down or disintegrate into smaller particles called granules. This occurs when the rocks have different types of minerals of different heating and expansion co-efficient. So the various minerals heat and expand at different rates causing the rock to break into angular blocks.

e. Pressure release or unloading

Some rocks like plutonic rocks and metamorphic rocks are formed under great heat and pressure. The pressure comes from the weight of the overlying rocks. In case denudation removes the overlying rocks and exposes them, they will expand in the process of shedding off. This pressure release causes cracks to develop on the rock surface and particles start to peel off in a manner similar to exfoliation. It is common in Mubende.

f. Crystallization

This is one of the physical weathering processes in which some rocks absorb salty water. This salty water will collect into the rock joints or cracks. This water later evaporates and hence crystals begin to form or are left behind. As these crystals grow bigger and expand in size due accumulation, they exert pressure on the surrounding rocks hence leading to fall off of rocks (physical disintegration). Its common in Katwe areas.

g. 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.

Question

Examine the weathering processes that take place in arid and semi-arid areas of East Africa.

Approach

- Define weathering

- Define physical weathering
- Point out areas in East Africa prone to physical weathering
- Give the processes of physical weathering explaining them with relevant examples.

BIOLOGICAL WEATHERING

This refers to the breakdown of rocks with the help of living organisms. Plants and animals help in rock weathering by both chemical and mechanical means i.e. bio-physical and bio-chemical weathering.

Plants like algae, mosses, lichens and other hydrophytes retain water on rock surfaces which result into chemical decomposition.

The roots of plants in the process of sucking water from the rocks release some acids (humic acids) that may react with rocks and disintegrate them.

Animals and plants can also disintegrate the rock or break the rocks. The roots of plants which are growing in the rocks may enlarge the cracks or joints which are already existing in the rocks thus making them to breakdown physically. The animals also physically break down the rocks as they move on the rock surfaces due to the pressure exerted on them.

Barrowing animals like rabbits, rats, termites and other animals drill holes into the rocks and therefore directly disintegrate the rocks.

Man through his activities of cultivation, mining, quarrying, rock blasting, road construction, etc. directly breaks down rocks and then disintegrates them physically.

Living organisms whether living or dead play a positive role. Urine of animals once exposed on rocks, reacts with rocks making them to breakdown.

The chemicals man uses in agriculture like herbicides, insecticides, pesticides and fertilizers also weaken the rocks and lead to their break up.

Decomposing organic matter release organic acids which are absorbed by the rocks hence making them to decay and decompose thus weathering.

However, a layer of decaying organic matter may prevent disintegrating since it mulches the soil and underlying rocks hence preventing them from exposure to agents of weathering.

NOTE: All the three types of weathering are interdependent because physical weathering may open up some areas through disintegration and chemical weathering act deeper in the rock. While physical weathering is at its maximum in

arid and semi-arid areas because of high temperatures onto which the rocks are exposed to during day time and low temperatures at night which leads to a lot of stress and strain, chemical weathering is at its maximum in humid areas because of the presence of water.

However, it's important to remember that in general, all types of weathering operate hand in hand and are usually complimentary although in a given area, one maybe more important than the other.

DIFFERENCES BETWEEN PHYSICAL WEATHERING AND CHEMICAL WEATHERING

Physical weathering is the disintegration or breakdown of rocks into smaller particles or fragments instu while chemical weathering is the decomposition or decay or rotting of rocks instu 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.

FACTORS THAT INFLUENCE THE RATE AND NATURE (TYPE AND CHARACTER) OF WEATHERING.

THE NATURE OF THE PARENT ROCK.

Mineralogical composition of the rock: the mineral composition of the rock is very important in determining the rate and character of weathering from rock to rock e.g. igneous rocks are more prone to chemical weathering because they are formed under conditions very different from those operating on the earth's surface and they are therefore not chemically stable on the earth's surface. So when rocks come into contact with water, chemical weathering sets in at a very fast rate when

exposed onto the earth's surface. Examples of such rocks which can easily be weathered are basic igneous rocks with low silica content.

On the other hand, rocks with high silica content like granitic rocks are more stable and react to chemical weathering at a slow rate.

Rock jointing: rock jointing also influences the rate and nature of weathering. This is because joints are weak lines which are exposed by agents of weathering to cause rock break down. Water can easily penetrate thus enhancing chemical weathering processes of hydration to take place at a faster rate.

Physical weathering processes of freeze thaw action and thermo-expansion are very fast in rocks which are poorly jointed.

Similarly, biological weathering will also take place at a fast rate with the penetration of plant roots and animals which will only take place when cracks only exist on the rock. On the other hand, rocks which are well jointed, chemical, physical and biological weathering processes take place at a slow rate.

Rock color: rocks which are dull and dark colored absorb heat and therefore expand more quickly and with continuous expansion and contraction, cracks are then created and eventually lead to the fracturing of the rocks at a very fast rate by thermal expansion and block disintegration.

On the other hand, rocks which are light and shiny are less affected by weathering processes of thermo-expansion because they reflect heat. Therefore, dark colored rocks are weathered much faster than shiny rocks.

Rock hardness: hard rocks like quartzite are more resistant to weathering processes of carbonation and hydration. On the other hand, rocks which are soft like clay are weathered at a faster rate by chemical weathering processes of oxidation.

Rock permeability: rocks which are permeable like sandstone allow water to penetrate through them. Such rocks that allow water to penetrate through them are weathered at a faster rate by chemical weathering through the process of carbonation. On the other hand, rocks which are impermeable are weathered by chemical weathering processes at a slow rate.

Rock solubility: rocks which are soluble in water like rock salts dissolve in water at a fast rate. So rocks which are soluble in water are easily weathered by chemical weathering processes of solution.

Rock texture: rocks with rough texture can easily allow water to collect on such rocks on giving way for chemical weathering processes of hydration to take place

at a faster rate. On the other hand, rocks which are smooth are weathered at a slow rate by physical and chemical weathering processes.

Influence of climate

Climate also determines the rate and nature of weathering. Rainfall and temperature are also the major elements that affect the rate and nature of weathering.

Areas with equatorial climate are characterized by high rainfall totals of about 1500mm. this rainfall is high throughout the year with double maxima (two rainfall peaks/seasons). These rainfall amounts facilitate chemical weathering processes since they require water as a medium of chemical reaction. Chemical weathering is common in areas which receive high rainfall totals like Northern shores of Lake Victoria, slopes of mountain Elgon and Kilimanjaro (humid areas) among others and very slow in areas with little or no rainfall. The humid areas are also characterized by high temperatures which acts as a catalyst to chemical weathering processes. Therefore, chemical weathering is more dominant in humid areas i.e. areas with high rainfall and temperatures.

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.

On the hand, arid and semi- arid areas that receive low amounts of low rainfall of less than 500mm per annum and a prolonged dry season characterized by very high temperatures of above 30⁰C provide suitable conditions for physical weathering processes of thermal expansion, block disintegration and granular disintegration. This therefore means that physical weathering is more dominant in such areas like in the Ankole-Masaka dry corridor, north Eastern Uganda, Eastern Kenya in the Turkana and Masai land among others.

For mountainous areas where the temperatures are low like in areas of mountain Rwenzori, Mountain Kenya and Kilimanjaro, physical weathering processes of frost action / freeze and thaw is dominant. In this case, water freezes in the cracks and since ice is bigger in volume, cracks are widened and deepened leading to eventual breakdown of rocks therefore physical weathering is very fast in areas with low temperatures.

Effect of plants and animals (living organisms)

Living organisms like plants act as agents of weathering by the action of their roots in the process of sapping water underground where they dig dip and create cracks

and keep on expanding the joints within the rocks in that way. In this process they therefore facilitate physical, chemical and biological weathering. However, thick vegetation may act as a protective layer against physical weathering and it may slow down the removal of the weathered layers.

Animals such as rats, termites etc. loosen the compactiveness of the rocks thus causing physical fracturing of the rocks. Water easily penetrates through the rocks giving room for chemical weathering processes of hydration. Therefore, where animals exist, physical, biological and chemical weathering take place at a faster rate than where animals are absent.

When living organisms (plants and animals) die, they decompose into humus and organic matter. With the addition of water, the humus turns into humic acid which decomposes the rocks plus organic acids. Therefore, in such areas, chemical weathering processes of chelation take place at a faster rate.

Man himself does his activities of rock blasting with explosives, mining, road construction among others facilitate physical break down of rocks (physical weathering/ fracturing). He also aids chemical weathering processes through his activities of application of irrigation, fertilizers, spraying with pesticides, insecticides, herbicides etc. since they involve the element of water. Therefore, there is chemical weathering in such areas.

Relief

Relief also determines the rate and type of weathering. The rate at which weathering takes place is related to the speed at which weathered rocks are removed. On steep slopes, the weathered rocks are quickly removed and the parent rock is exposed to further physical weathering. In other words, steep slopes encourage faster rates of physical weathering because of high rates of erosion that exposes the underlying rocks to further physical weathering.

However, gentle slopes and low lying areas promote the occurrence of chemical weathering due to the high retention capacity of water. In other words, this results into the occurrence of chemical weathering processes of hydration, oxidation, chelation among others at a faster rate because water accumulates on gentle slopes and low lying areas than on the steep slopes.

Time: It takes time for rocks to be broken down by physical and chemical weathering processes. The longer the time the rock has been exposed to the weathering, the more easily such a rock will be weathered and the shorter the time, the more resistant the rock will be to weathering agents.

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

Sample questions.

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

LANDFORMS RESULTING FROM WEATHERING IN EAST AFRICA. (EFFECT OF WEATHERING ON LANDFORM EVOLUTION IN EAST AFRICA)

Although weathering is all about wear and tear of the earth's surface, in the process it leads to formation of landforms especially within the karst regions. These landforms include;

Karst regions are regions made up of limestone rocks.

Grikes and clints:

These are formed during the process of carbonation where by rainfall dissolves CO₂ in the atmosphere to form weak carbonic acids. These carbonic acids act on limestone rocks to form calcium carbonates or converted to a more readily dissolvable form of calcium bi carbonates. In areas where limestone rocks alternate with rocks with different minerals, the weak CaCO₃ are removed in solution to form ditch like depressions called grikes while the hard resistant rocks remaining behind form round topped ridges called clintse.g. at Kajjansi near Kampala.

Stalactites.

These are features found mostly in karst regions (areas with limestone rocks). They are protrusions found on the roof of a chemically weathered limestone cave. Stalactites are therefore formed when rain water mixes with carbon dioxide in the atmosphere to form weak carbonic acids. These carbonic acids dissolve the limestone rock on the roof of the cave and the solution starts dripping on the floor. When water evaporates, dripping stops and finger like projection are left on the cave and are called the stalactites. Best examples are found at Nyakasura in Fort-Portal in kabarole district in Uganda and Tanga in Tanzania.

Illustration

Stalagmites

These are formed together with stalactites in the karst regions. A stalagmite is a landform that arises from the floor of the cave due to the accumulation of materials deposited on the floor from ceiling drippings. These are therefore formed on the floor of the cave by dripping water from the roof of the cave. When water evaporates from the dissolved calcium carbonate, it leaves behind a dry and compact mass of limestone protruding upwards and this forms a stalagmite and are also found at Nyakasura.

Illustration

Pillars.

A pillar is an upright shaft or structure of stone or any other mineral relatively slender in proportion to its height and can be of any shape in section. Pillars are formed when stalagmites and stalactites meet in a limestone cave. They appear as vertical stands of calcium carbonates.

Illustration

Underground caves.

These are natural hollows formed under ground by rivers. They are formed when a river flowing into a karst region disappears underground hence removing the limestone rocks in solution. They are formed due to solution. Solution is the removal of rock in solution by acidic rain. Some rocks are chemically weathered by being dissolved in water for example limestone and after weathering off such rocks, it forms impressive features like widened hollows for example the caves at Nyakasura.

Illustration

Sinkholes.

A sinkhole is a depression or hole in the ground caused by some form collapse of the surface area. Sinkholes occur due to erosion or underground water. They start developing long time before it actually appears. Most of the sinkholes occur due to karst processes of chemical dissolution of carbonate rocks. The formation of sinkholes involves the process of erosion or gradual removal of slightly soluble bedrock such as limestone by percolating water, the collapse of cave roof, or a lowering of water table. Sinkholes often form through the process of suffusion for example ground water may dissolve the carbonate cement holding the sandstone particles together and then carry away the loose particles gradually forming a void or sinkhole.

Exfoliation domes

An exfoliation dome is a large dome-shaped form, developed in massive homogenous coarse-grained rocks especially granite by exfoliation. Exfoliation is a term used to describe the peeling away of sheets of rock millimeters to meters in thickness from a rock's surface due to a range of physical and chemical processes during exhumation and weathering. Therefore, it is a form of mechanical weathering in which curved plates of rocks are stripped from the rock below.

Exfoliation domes therefore a result of physical weathering by exfoliation. The rapid heating and cooling especially in the areas of high temperatures cause expansion and contraction of rocks. The outer most layer of the rock is eventually detached from the original and it peels off. This leaves behind a round topped rock called an exfoliation dome. Best examples are seen at Mubende along Mubende-kyenjojo road.

Arenas: these are lager circular depressions on the earth's surface. They are formed in areas of alternating bands of hard and soft rocks. So the soft rocks are weathered away leaving behind the hard and resistant rocks. The soft rocks are removed leaving behind circular depressions which may or may not be filled with water to form arenas. Examples can be seen on the slopes of mountain Rwenzori in the areas of Ntoroko.

Tors: these are remnants of weathered rocks rooted in the bed rocks. These appear onto the earth's surface as basaltic remnants. They are common in jointed rocks which are weathered deep and when denudation forces remove these debris, tors remain as resistant rocks bedded in as un-weathered. Best examples can be seen in Kenya at Kitmikaye near Seme, Bismark rock in Lake Victoria near Mwanza.

Illustration

MASS WASTING

Mass wasting refers to the movement of materials downhill or down slope under the influence of gravity. Its therefore the falling, creeping, sliding or falling of rocks and weathered materials downhill under the influence of gravity. The major factor that helps to overcome any resistance is water. Therefore, water acts as a lubricant for material to move down easily. A water saturated mass moves more easily than a dry one because water both increases the weight of the mass and also decreases the cohesive power of the material.

In other words, mass wasting is a largescale movement of materials downhill in which the stability of the slope has failed. As a result, the materials move downhill under the influence of gravity with water acting as a lubricant. It is alternatively referred to as slope failure or slope collapse.

Mass wasting is a general terminology which includes all forms of movement along a slope ranging from the slowest to the fastest. Therefore, mass wasting

refers to the creeping, flowing, sliding or falling of rocks and weathered materials downslope under the influence of gravity using water as a lubricant.

It's different from erosion in a sense that in erosion, water physically transports away the soil particles but in mass wasting, water doesn't physically wash away the materials but assists the rock to slide under the influence of gravitational pull.

Mass wasting occurs in highland and mountainous areas of East Africa like along the slopes of mountain Elgon, Rwenzori, Kilimanjaro, Kenya, Kigezi highlands, Kisoro, Rwampara hills, Kipengere ranges of southern Tanzania, Bulecheke areas in Mbale, Sirinko areas among others.

TYPES OF MASS WASTING

The types of mass wasting include soil creep, talus creep, mud flow, rock slump, rock slide, solifluction, rock falls, avalanches and they can be classified as slow and fast or rapid movements.

Slow movements. Sometimes loose soil particles can flow extremely slowly down slope sometimes as slow as 1 cm per year. Slow movements involve the following types;

a. Soil creep:

this refers to a very slow movement of the soil and fine materials downslope on a very gentle slope. Soil creep can be detected by bending of trees, electric poles, fencing poles etc. in the direction of the slope. It can be illustrated as below.

b. Solifluction:

this is limited to glaciated regions of cold climatic zones or areas. Solifluction refers to the slow movement of saturated solid gravel materials underlying a frozen ground on a moderate slope. It can be illustrated as below.

c. Talus creep:

this refers to the slow movement of angular wastes or particles of all sizes on a moderate slope.

Illustration.

Fast or rapid movements.

Mud flow: this refers to the fast downhill movement of semi liquid material saturated by heavy rains on a moderate slope.

Illustration

Rock falls: this refers to a very fast movement of individual rocks falling freely from a very steep slope under the influence of gravity.

Illustration

Rock slump: this refers to a very fast movement of rocks on an over steepened slope like scraps, creeps and road cuttings. In slumping, a rock doesn't break up into different particles in the process of slope failure but the materials just slide as a whole mass. It moves in a back ward rotation such that the slump strata which was originally horizontal is tilted backwards. Slumping is mainly caused by massive rocks overlying weak rocks.

Rock slide: this refers to a fast movement of large masses of rocks and debris over a steepened slope and road cutting. Here, the rocks slide from faces of slope or jointed steep slope downwards.

Illustration

Avalanches: this refers to a large scale movement of materials embedded in ice. It's also a fast movement.

NOTE: the rapid movements of materials down the slopes usually involving large boulders and rock particles is sometimes called *Landslides*.

CAUSES OR FACTORS THAT INFLUENCE THE RATE AND NATURE OF MASS WASTING

Climate: some areas in east Africa experience heavy rainfall sometimes exceeding 2000mm per year which leads to the absorption of water by the soils or rocks. This leads to the increase in weight of the soils and rocks and also reduces the cohesion of the material in the mass of the rock. Therefore, the loose rock materials can easily slide downhill under the influence of gravity.

Secondly the pounding effect of direct rainfall destabilizes the rock surfaces resulting into mass wasting.

Temperature fluctuations results into expansion and contraction of rocks which results into weathering of these rocks. The loosen particles can the easily fall down under the influence of gravity.

Relief / nature of the slope. Steep slopes usually encourage fast or rapid movements of materials downhill e.g. rock slides, rock falls, rock slumps etc. due to the steep gradient. Gentle slopes on the other hand lead to limited mass wasting and also encourage slow movements e.g. soil creep, solifluction etc.

Nature of the rock. The structure, permeability or porosity of the rock and its jointing determine whether mass wasting will occur or not. Highly jointed rocks are prone to rock falls. This is because jointed rocks are easily affected by physical weathering involving block disintegration. The loose blocks of rocks can easily slide down wards or downhill in form of rock falls.

Where a permeable layer of rocks over lie an impermeable layer, the saturated permeable layer can easily slide downhill under the influence of gravity.

Nature of soils. Clay soils become slippery after absorbing water. The absorbed water increases the weight of the soil and also lubricates it and the ground where it's seated i.e. between the soil and ground hence facilitating downhill movement.

Loose sandy soils are affected by increasing temperatures. The temperatures turn the sandy dust which can easily creep downhill.

Earth movements (crustal instability). Areas in east Africa which are affected by increasing landslides are the ones that are prone to the occurrence of the earth's movement is greatest for example earth quakes and earth tremors, volcanicity etc... these destabilize loose particles of rocks and weathered rock materials resulting into mass wasting.

Over steepening of the slope by either river or lake erosion. Lakes may lead to the creation of cliffs due to wave erosion. This over steepened cliff can facilitate mass movement of weathered materials.

Over loading of the slopes by weathered materials where the excess load can easily be destabilized hence fall off by the influence of gravity.

Heavy moving objects like lorries, heavy machinery like trains cause vibration of the earth's surface that trigger off mass movements.

Human activities like mining, quarrying, road construction, grazing of animals on steep slopes, lumbering in mountainous areas etc. result into destabilization of loose rocks on steep slopes resulting into landslides and rock falls.

Effects of living organisms e.g. burrowing animals like rats which loosen the rocks and the soils resulting into weathering which eventually makes the rocks prone to mass wasting. Wild animals grazing in mountainous areas trample on the surface and cause vibrations hence disturbing unconsolidated rock materials and finally results into landslides.

EFFECTS OF MASS WASTING

Loss of lives. Severe landslides especially those associated with heavy rains and earth quakes result into rock falls and rock slides that destroy settlements and kill people living in such settlements like on the lower slopes of mountains like the Bulecheke landslides in 1996 killed about 100 people, in Buhweju many people were killed by the landslides that occurred in May 2002, 2010 and 2018 on the slopes of mountain Elgon.

Loss of property by the falling and sliding of rocks of various sizes. Many houses and settlements are normally destroyed for example in 1996 in Bundibugyo, a landslide occurred and destroyed several homes and properties for example roads, and electric poles connecting Bundibugyo to Fort Portal were destroyed and that from Kabale to Kisoro. Many crops and the would be agricultural land are often destroyed as they are buried by the debris from the upper slopes.

Destruction of forest resources. When a slope with forests fails, chances are that those forests are rolled down and totally buried and therefore destroyed for example the landslide that occurred in 1985 in Bundibugyo destroyed some good forested area in the Semiliki National Park.

It results into displacement and resettlement of people to other areas e.g. the recent transfer of people from mountainous areas of Elgon to Bunyoro. This resulted into loss of cultural identity as well as heavy government expenditure to resettle these people.

Mass wasting results into damming of rivers which may result into back ponding to form temporary water reservoirs or permanent lakes eh lake Bujuku on mountain Rwenzori, Lake Mbaka in southern Tanzania.

Results into exposure of fresh rocks to weathering.

Creation of landforms e.g. terracets, scars, etc. and this has promoted both local and foreign tourists who earn the government income.

Mass wasting results into the provision of fertile soils on lower slopes of hills, mountains by soil creep, exfoliation, etc. which has promoted agriculture in valleys e.g. vegetables growing in the valleys of kigezi.

MEASURES TO REDUCE LANDSLIDES OCCURRENCE

Among the measures taken to combat the problems of landslides' occurrence include the following;

Re- afforestation and afforestation. Planting of trees on the slopes where the trees were cut should be done in order to increase the cohesiveness of rocks. This has been on the slopes of the Kigezi highlands where eucalyptus trees have been

planted. The government should establish forest reserves on the slopes and protect them against people's encroachment. This helps to increase the firmness on the slopes and reduces the chances of landslides to occur.

Hillslope drainage. A lot of water on the slopes increases the lubrication, saturation and weight levels of the rock particles on the slope which accelerates the chances of slope failure and landslides. This therefore means that excess water should be drained away through the drilling of pine lines on the slopes or construction of deep channels or trenches. This has been done on the Kenyan and Kigezi highlands. This can also be done through the planting of eucalyptus trees so that they can drain away the excess water on the slopes of highland areas.

The government should come in to stop people from cultivating on the slopes of mountains and highland areas like on the slopes of Mountain Elgon, the Kigezi highlands among others whose stability is doubtful. This will help to reduce the chances of landslide occurrence and their associated impacts on the environment and people.

(research for other measures)

Revision questions

- 1. With reference to specific examples from East Africa, examine the causes of mass wasting**

Approach

Define mass wasting and site the areas prone to mass wasting in East Africa.

Identify, explain and illustrate the various forms of mass wasting (both the slow and fast movements)

Give and explain the causes of mass wasting linking them to various types of mass wasting

- 2. To what extent are the various forms or processes of mass wasting influenced by climate in East Africa.**

Approach

Define mass wasting and site areas prone to mass wasting in East Africa.

Identify, explain and illustrate the various forms of mass wasting (both the slow and fast movements)

Thoroughly explain the influence of climate on mass wasting

However, give other factors

Give an evaluation or conclusion