EVOLUTION OF LANDFORMS

Landforms are features on the earth's surface that make the protrusions or projection and basins or depression. These features include mountains, planes, valley etc.

Landform evolution is a slow and continuous process. They are two broad process that led to landform evolution i.e.

- *Internal forces/ endogenous processes or tectonic processes*
- *External/ exogenic processes or Denudational processes.*

Endogenic forces

These are forces that from the interior of the earth. They include earth movements and volcanism

The earth movement refers to the disturbances of endogenic nature which include earthquakes, plate tectonic, warping, faulting, folding and isostasy.

The earth movement are classified into two groups. It involves the forces which act vertically or upward and downwards are known as epeirogenic forces well as the forces which act horizontally are called orogenic

DAVISION CYCLE OF LANDFORM DEVELOPMENT

William Morris Davis was an America geographer, meteorologist and geologist who contributed much on the study of landforms.

According to him, any landform which was formed onto the land surface was a function of the structure, process and time.

By structure, he meant the nature of rocks and how they differ from each other in terms of hardness, bedding plane, permeability, faults and their age.

The processes include different agents that act on rocks such as weathering, mass wasting, erosion by wind, water and ice as well as endogenic processes such as vulcanicity, faulting, folding, earthquakes, warping etc.

Finally, time is the length of period during which the processes have acted to form landform. Young sedimentary rocks(structure) are acted upon by compressional forces (processes) for a long time leading to the formation of fold mountains.

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.

The origin of faulting

Faulting originates from Radio-activity and Geo-chemical reactions within the interior of the earth (mantle and core); generating intense heat that keeps the weak rock in the upper mantle (Asthenosphere) in molten state/ form.

The rocks in the core of the earth are in a semi molten state as a result of geochemical activities, radioactive decay and intense pressure. The same molten rocks/magma begin moving upwards in the earth's mantle in form of giant convectional currents.

Temperatures within the mantle are very hot exceeding 3700 degrees. this creates pressure and temperature differences between the mantle and the crust resulting into convectional currents.

Molten rock is light therefore tends to rise in form of convective currents which flow horizontally underneath the crust; creating tension, compression and vertical forces responsible for fracturing, dislocation and displacement of hard rocks

When the currents reach the surface, they may move away from each other leading to development of tensional forces which cause normal faults. The currents may move towards each other leading to development of compressional forces

These large scale convectional currents within the mantle are part of what drives the movement of the plates in the crust of the earth. The convectional currents that flow in opposite dirction lead to crustal plates moving apart and hence leading to origin of tensional forces while as

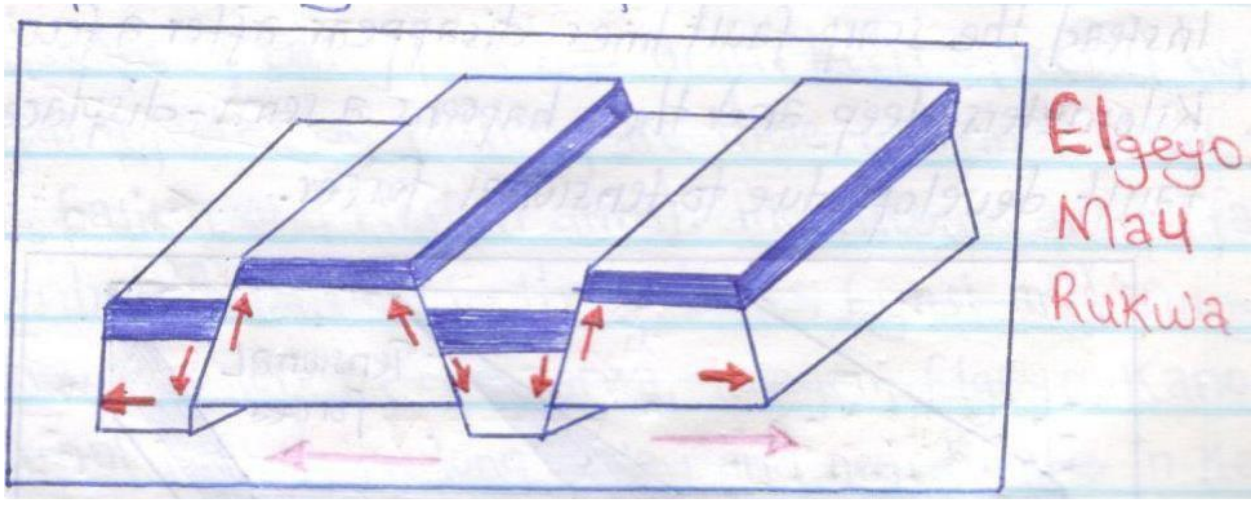
convectional currents flowing towards each other lead to crustal plates colliding hence leading to origin of compressional force.

Faulting is therefore a process by which a rock (crust) develops a line of weakness resulting into displacement of rocks. In geological terms, rocks are not solid. They behave like stiff plastic. When stress develops, the rocks absorb it until the rapture point is reached. This rapture is what is called a Fault line and the process of rapturing and displacement is called faulting.

Faulting is a sign of crustal instability and is found in areas experiencing tectonic activities. The faults or fractures along which movement takes place are of several types.

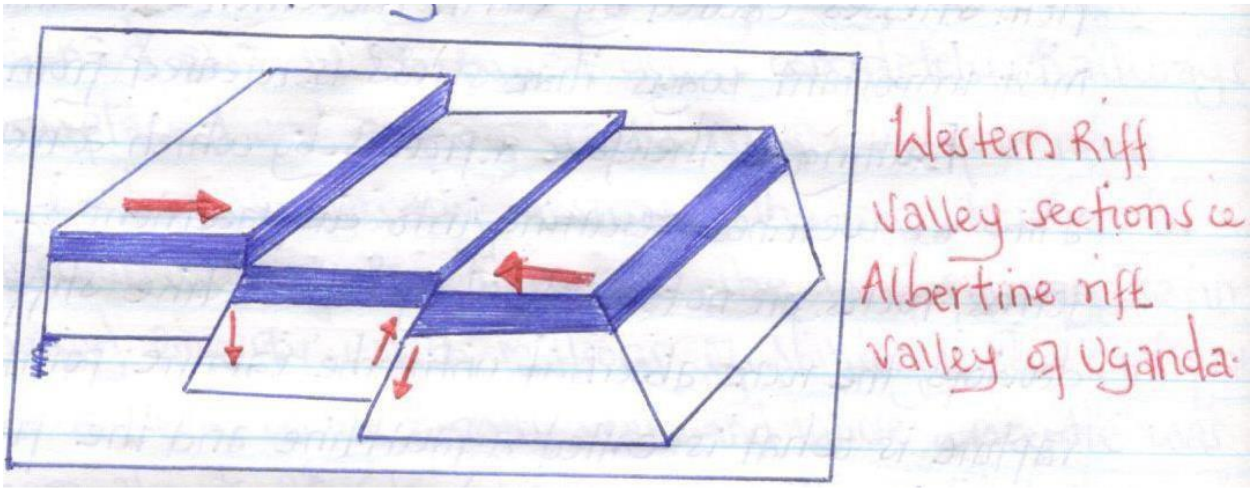
TYPES OF FAULTS:

1.**Normal faults:** these are faults which develop at a divergent plane boundary where tensional forces are generated stretching the overlying earth crust until it reaches it‟s rapture hence faulting. The intrusion of rocks such as basalt or granite may create strong tensional forces that may stretch the overlying rocks creating faults. Such faults produced by tensional forces are called normal faults. Normal faults produced as a result of downward displacement of the dismembered wall blocks along lines of weakness produced by tensional forces.

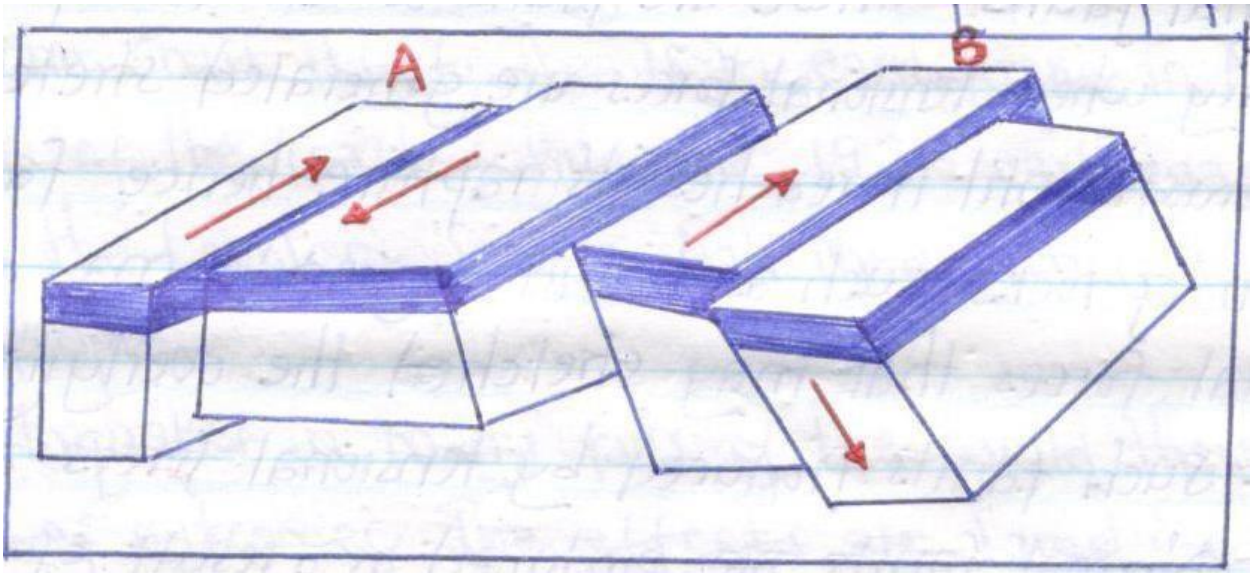


2.Reverse faults; these are produced by compressional forces. As the crust is being compressed a time will reach when one block will over ride another. This may result from a high angle or low angle compression. Reverse faults occur when compressional forces cause one block to

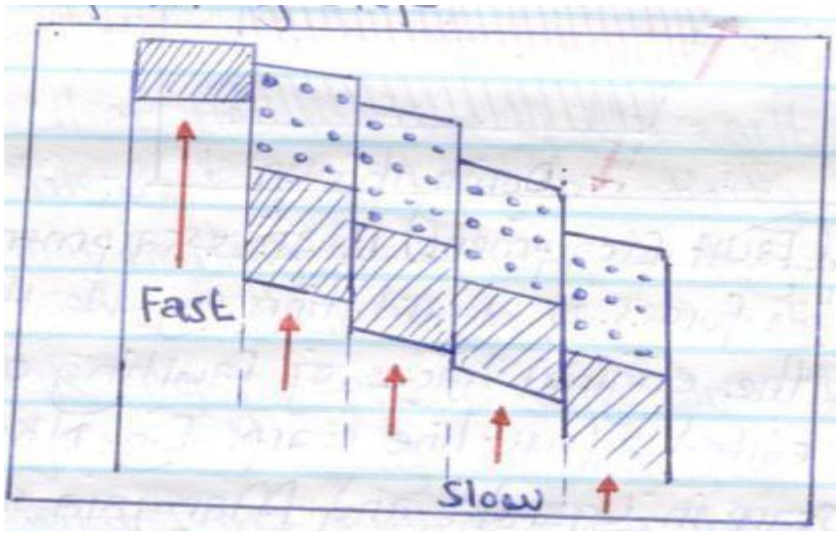
thrust/over ride the opposite block. The angle between the fault plane and the foot wall is less than 45 degrees.



3.Tear faults: These are faults involving only horizontal movements. These are formed when the stresses come from opposite directions but act obliquely to each other. Tear faults involve horizontal movements only (A). when displacement is both horizontal and vertical (B) the fault is called an oblique slip fault.



4.Step Faults: There could be a general uplift of the land but the rates of uplift could be different such that some parts are lifted up faster than others. This will cause a number of faults that will develop at the margins of different uplifted blocks. The landscape will be in form of steps.



The step faults can also develop when tension allows each rock section between parallel faults to slip relative to their neighboring. Bench-like-landscape are a reflection of step faulting.

FAULTING IN EAST AFRICA

The landscape of East Africa has much been affected by faulting. Major areas affected by faulting are those within the rift valley region (both the East and West arms).

The Aswa valley (fault guided valley), central Tanzania south of Lakes, Eyasi and Manyara (Trap door), Songwe region of Tanzania, Tugen, Elgeyo, Kano and Mau (normal faults), Kedong valley and near Kijabe in Kenya (step faults).

Land forms caused by faulting in East Africa

i) Escarpments

ii) Fault guided valleys

iii) Tilt blocks

iv) Grabens

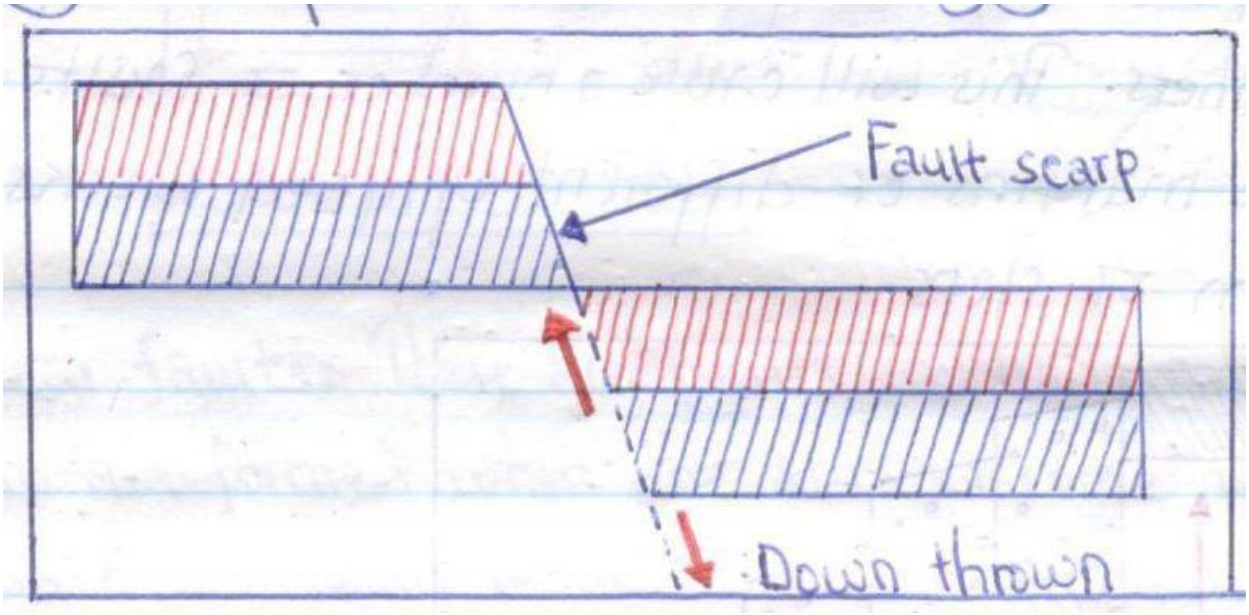
v) Block mountains/horsts

vi) Rift valleys

LANDFORMS OF FAULTING

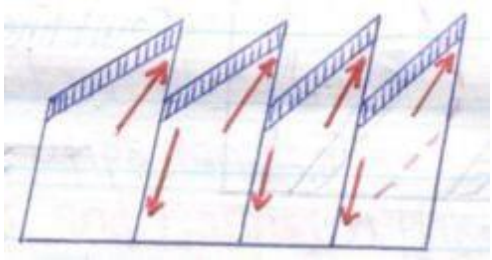
1. **Fault scarp;**

A fault scarp is a steep feature produced when one of the blocks on one side of the fault line sinks down along a line of fault but on which fresh evidence of faulting is seen. In short, the line of has not been distorted completely by weathering and denudation. Examples of fault scarps are Chunya scarp in Tanzania and Elgeyo scarp in Kenya.



2. **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 north west of aberdare ranges in Kenya and the Usambara tilt blocks in Tanzania



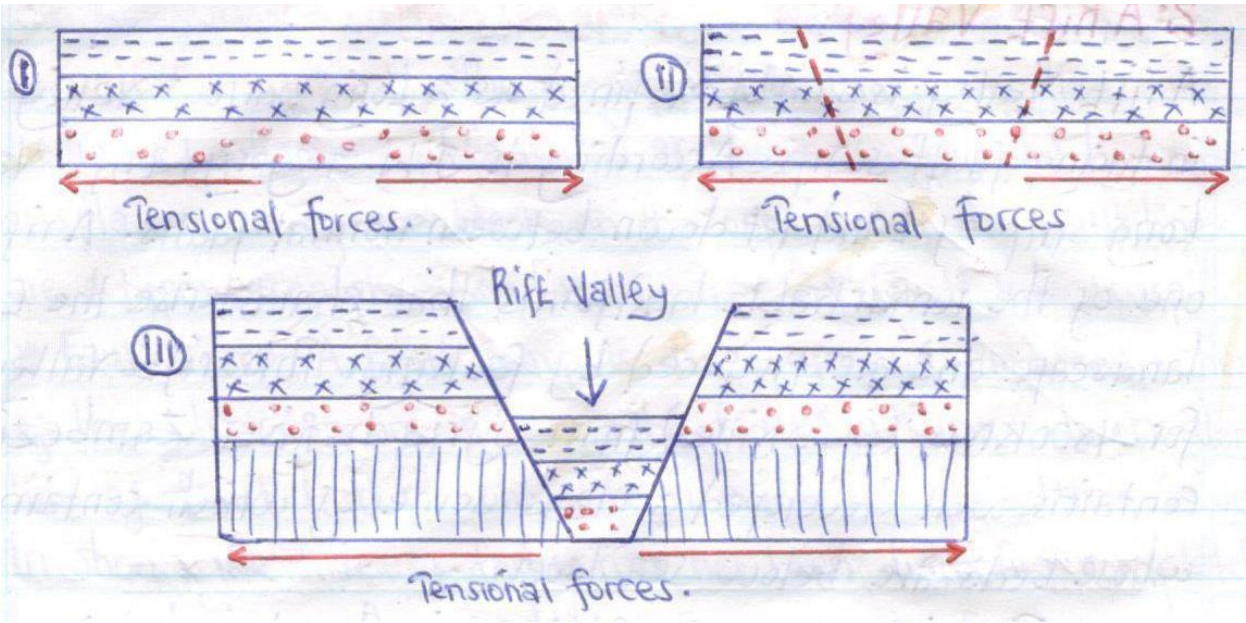
3. Riftvalley

a rift valley is simply defined as a long narrow valley bordered by in facing fault scarps. According to J.W. Gregory, a rift valley is a long strip of land let down between normal faults. A rift valley is one of the remarkable landforms that characterize the East African land scape and are produced by faulting. This rift valley extends for 4800kms (3000 miles) from Syria to river Zambezi. The belt contains well developed valleys some of which contain lakes whose beds are below sea level.

The rift valley in East Africa has two sections and these are western rift valley in Western Uganda and Tanzania and another eastern rift valley in central Kenya and central Tanzania. The formation of the rift valley is explained by the process of tensional and compressional forces.

Tensional theory; The tensional theory was advanced by J.W Gregory. It states that the interior of the earth exists in a molten state and there is tense heating by radio activity and geo chemical reactions. This internal heating therefore tends to generate rising convective currents in the asthenosphere that reach the bottom part of the crust following laterally to opposite directions.

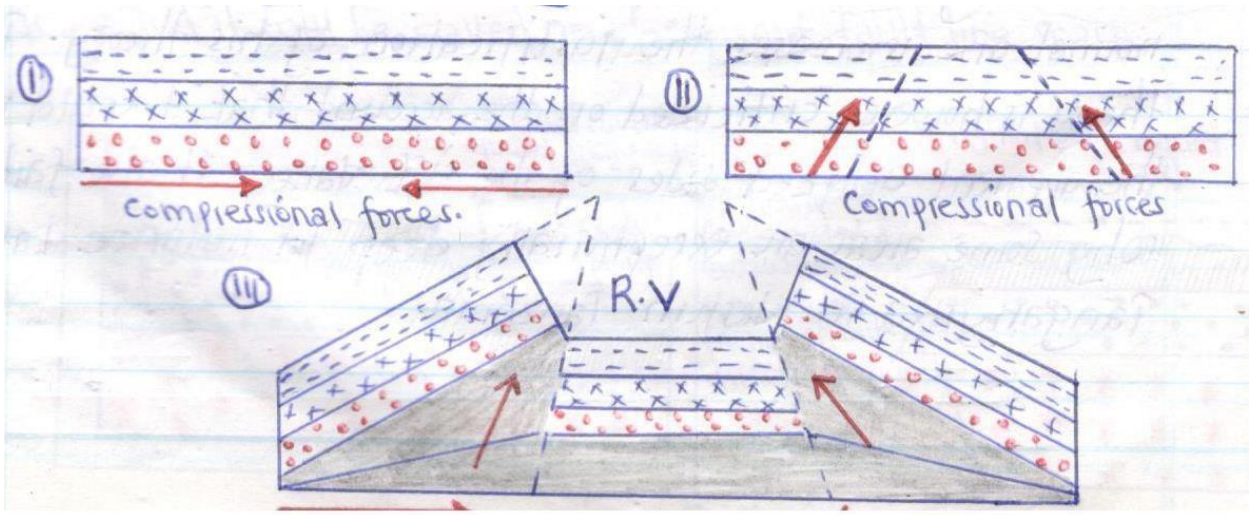
This lateral flow of the currents generated strong tensional forces that caused normal faulting. The tensional forces pulled away the side blocks from central block thus making the central block to subside (sink) below the surrounding blocks forming from a rift valley. The theory is called the dropped key stone of the arch theory.



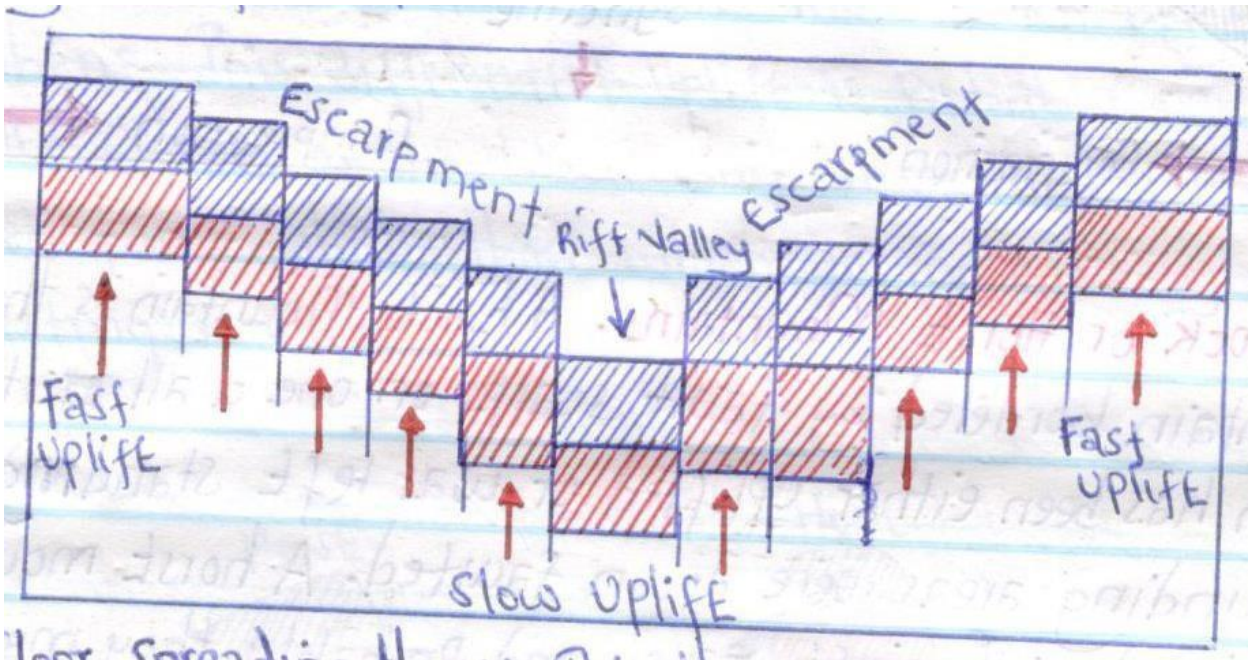
Compressional theory; compressional theory was put forward by E.J Wayland. According to the theory, the interior of the earth exists in a molten state and there is immense heating by radio activity and geo-chemical reactions.

This internal heating therefore generates rising convective currents in the asthenosphere that reached the bottom part of the crust and begun flowing laterally towards each other. This created strong compressional forces that led to reverse faulting.

The side blocks were forced towards the central block thus making them to over ride the middle block to form a rift valley with steep and sharp edges.
The overhanging sharp edges of the rift valley were later weathered eroded and deposited into trough. This applies to the western rift valley section in western Uganda.

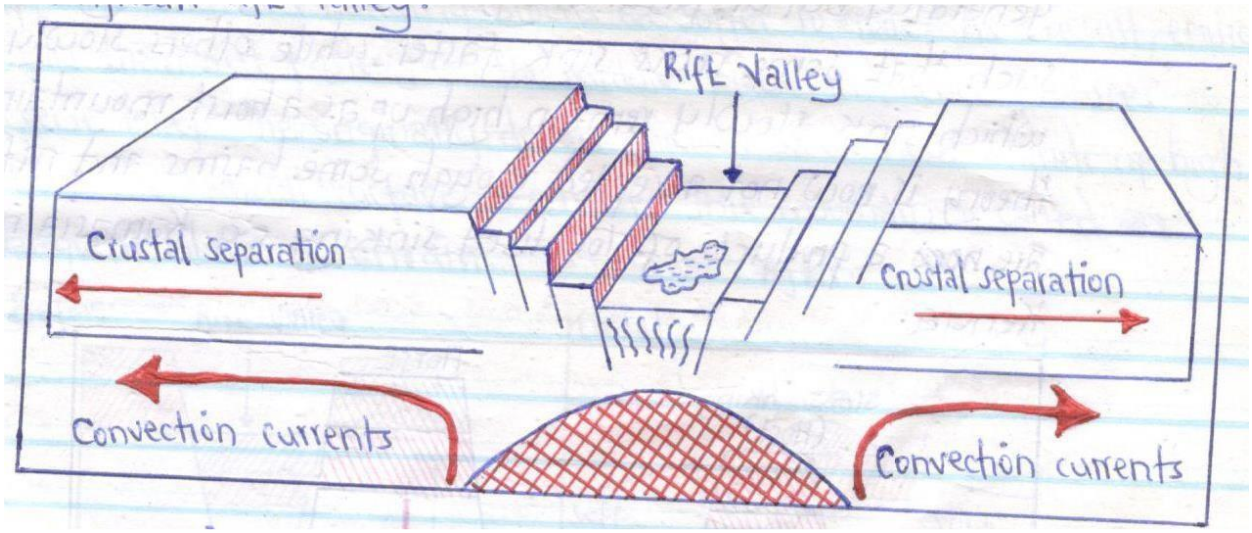


Differential Uplift theory; This theory was advanced by **Dixey and supported by** supported by Troup. According to him, rift valleys were formed by the general uplift of the middle block was lifted slowly. Numerous parallel fault lines were formed by normal faulting before uplift such that when uplift began the land was already subdivided into independent blocks. With the middle block lagging behind a rift valley was formed.

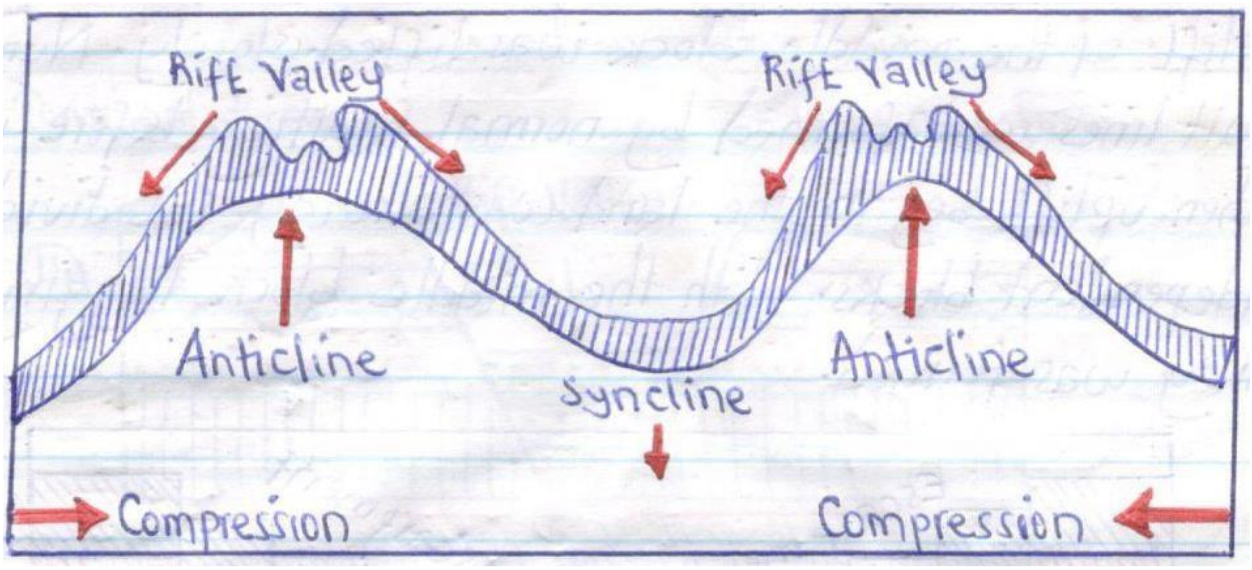


Seafloor spreading theory; this theory of sea floor spreading was advanced by **Girdler** following **H. Hess** theory of crust separation and spreading. According to this theory, the great East African rift valley represents the first stage of movement in which East Africa is breaking

away and drifting from the main African land mass. The separation of Arabian block from Eastern Kenya and Somalia block shows clearly the closeness to continental drifting that seems to be taking place in the East African rift valley.



The basin and swell theory; This theory was advanced by **L.C. King.** according to him, the East African rift valley was produced by powerful up arching to which central and East Africa was subjected since pleistorene period. As a result, tensional forces were produced which stretched the crests of the up arched regions that later cracked open. As more up arching continued, the crests continued widening and finally produced a **rift valley.**

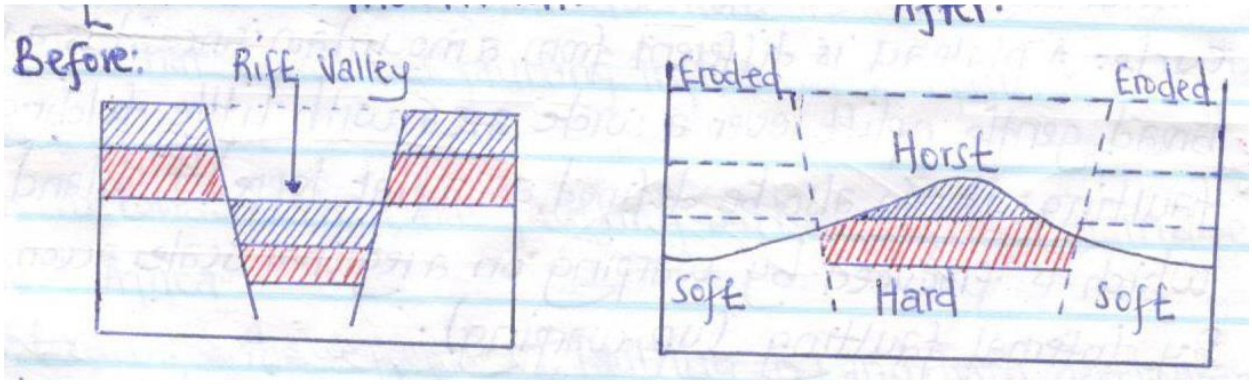


4. **A block mountain.**

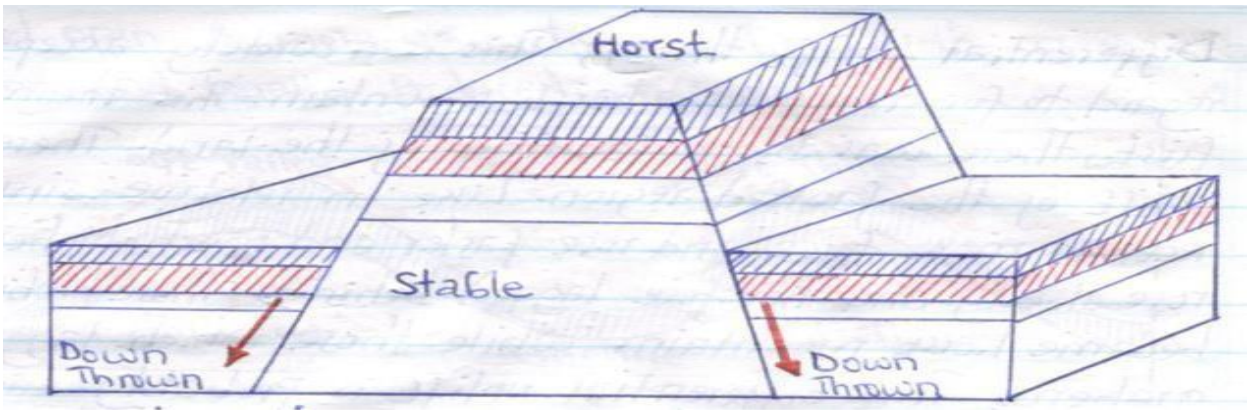
A block mountain refers to an upland bordered by faults on one or both sides. It has a level summit and stands above the general level of the surrounding land. Its formed as a result of uplifting forces along lines of weaknesses or faults.

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;

The topographic inversion theory; According to this theory, normal faulting produces a rift valley. The block of land that sinks down to produce a rift valley is composed of harder and more resistant rocks while the two opposite and over hanging blocks are softer to erode. As a result, erosion wears them out faster than the middle block and hence produces reverse relief. The originally down thrown block now stands up high above the general surface as a horst. This mountain is called **an obsequent block mountain.**

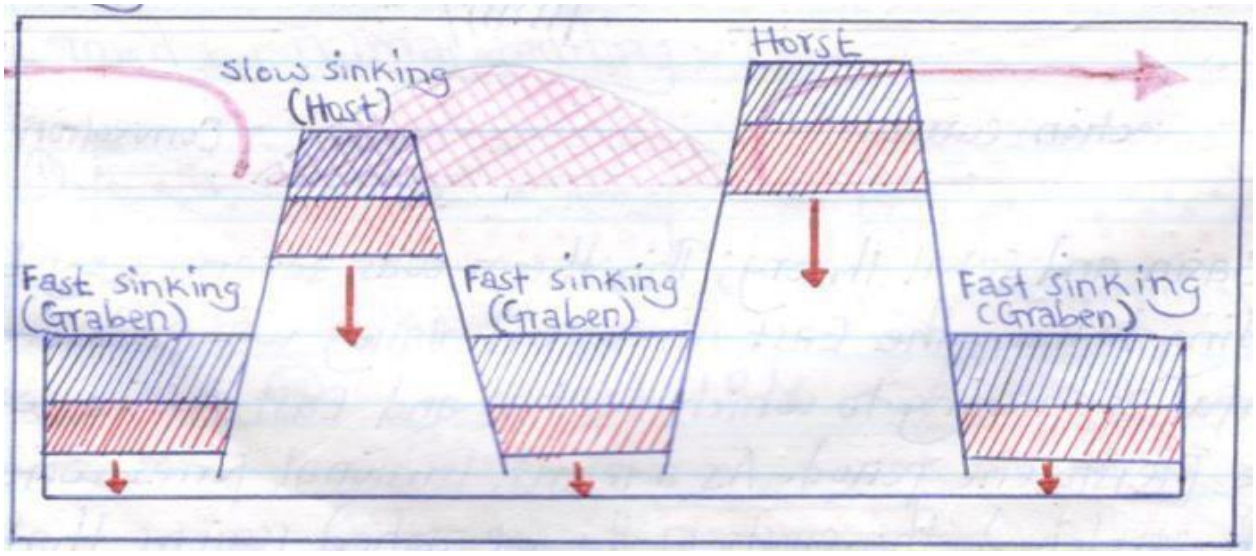


A horst mountain can also be formed when there develops **block faulting** within the crust. Later on, the peripheral blocks are made to sink leaving the middle block stable and hence standing high up above the general surface as a horst mountain.



The theory of relative sinking; This theory was advanced by **suess** who believed in the theory of the contracting earth.

According to him, as the earth contracts down wards forces are generated but unfortunately, the rates of sinking are different such that some rocks sink faster while others slowly. Those which sink slowly remain high up as a horst mountain. This theory is now not accepted though some basins and rift valleys are a product of localized sinking e.g. Kamasia ridge in Kenya.

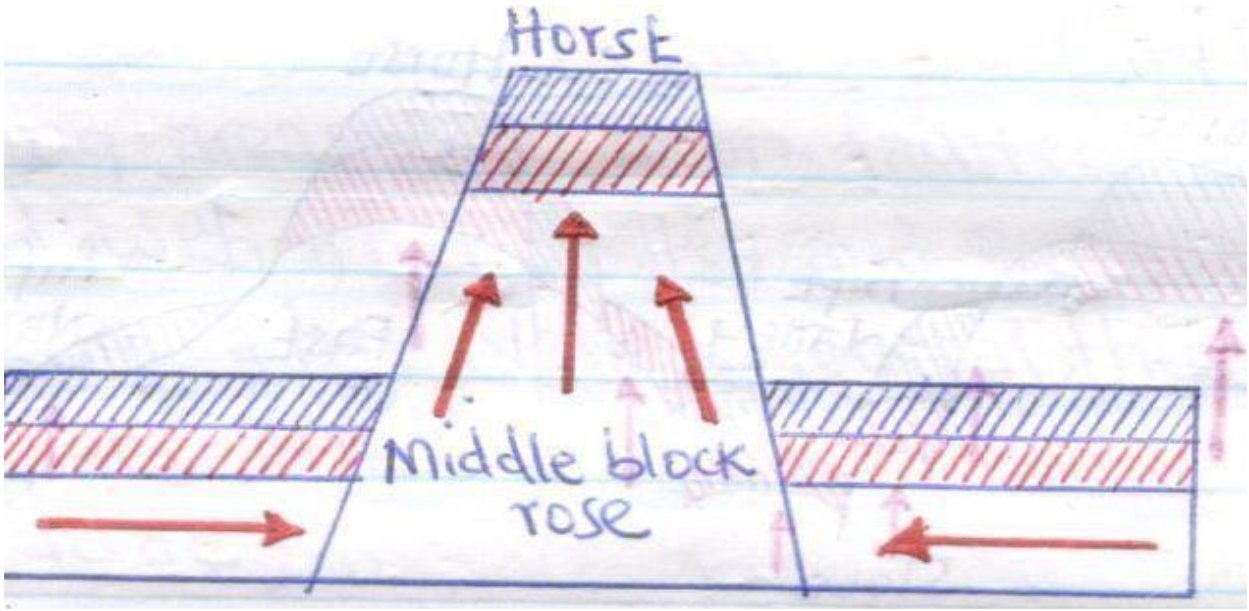


Differential uplift theory; This is a widely accepted theory with regard to formation of a horst mountain. This theory asserts that a first, there was block faulting of the land. There followed a general uplift of the faulted region.

Like in relative sinking, some regions received more force and rose fasted and much higher while other regions rose slowly and therefore lagged behind. Those, which rose faster, became

horst mountains while those which lagged behind became grabens. This differential uplift if probably caused by differences in the weight of the blocks such that those which are light are lifted faster while those which are more heavy slowly. This uplifting is vertical.

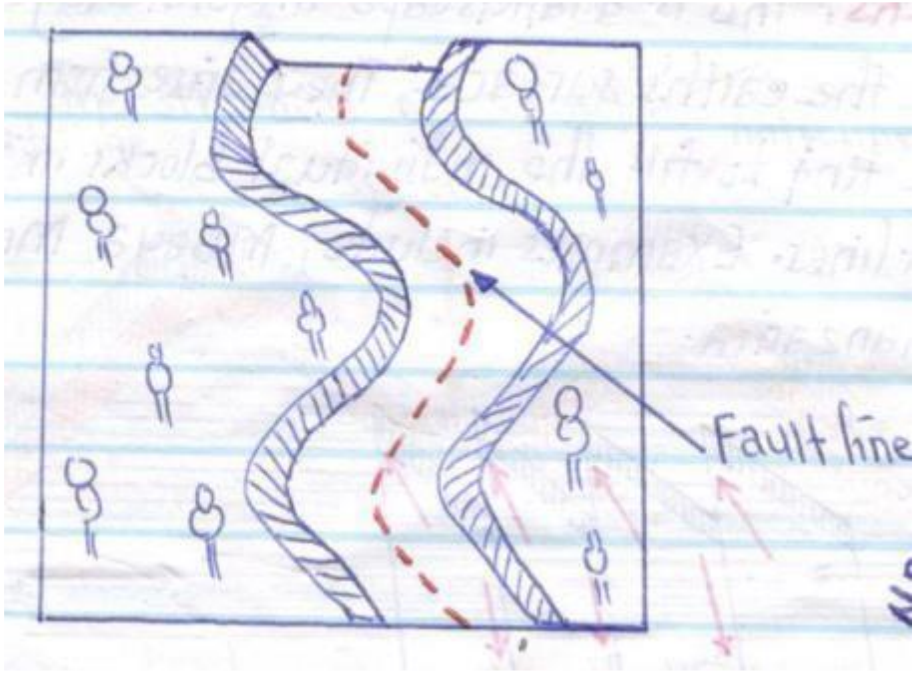
The compressional theory; Compressional forces that develop the earth crust result into some faulting. With compression, the middle block may be forced to rise up high leaving the peripheral blocks at a lower level. This raised middle block forms a horst mountain.



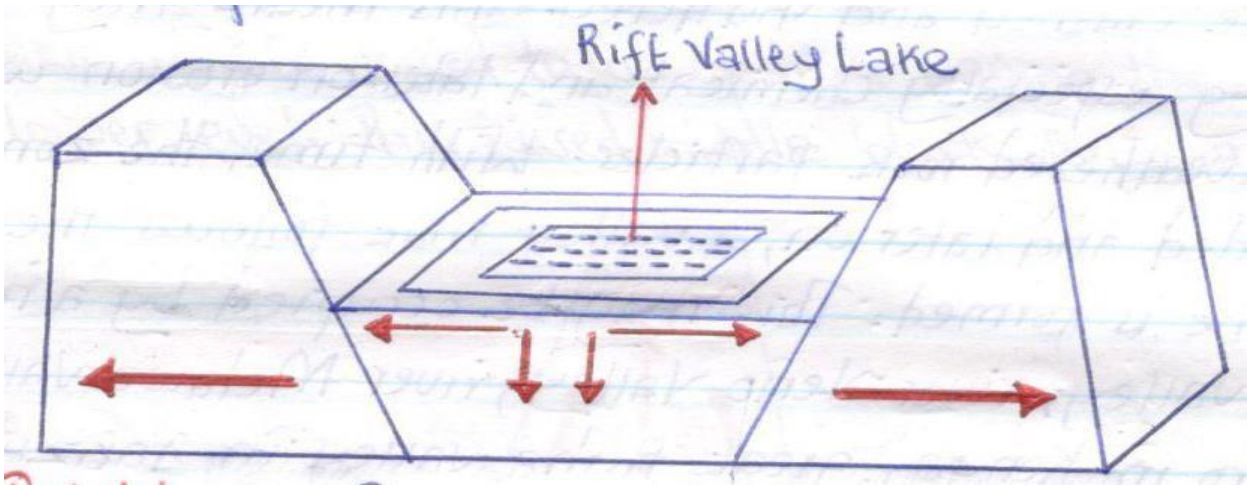
Horst mountains in East Africa include; Mountain Rwenzori, Bunhweju hills, Bunyaruguru and Bunyoro-Toro uplands, Apach hills and Masindi hills all in Uganda. In Kenya, they include; Abedare ranges, Ndoto, Nyiru and Mathew‟s ranges, while in Tanzania, they are; Pare, Usambara, Ulunguru, Mahenge, Iramba, Kungwe, Mbeya, Iringa and Ufipa ranges.

5.A fault guided valley; This is a valley as the name suggests that is guided by the fault line. This means they easily fall prey to weathering especially chemical and later on erosion

which wears away the weathered rock particles. With time, the zone continues being expanded and later on, a valley that follows the direction of the fault line is formed. This may be occupied by a river e.g. the river Aswa valley, river Veno valley, river Melawa valley and river Ewaso Ngiro in Kenya, great Ruha valley in Tanzania.



6.Rift valley Lakes; (Grabens) these are lakes formed at the bottom of the rift valley. Due to secondary faulting at the rift valley bottoms, small depressions called **Grabens** were created and when the depressions got filled up with water, they formed lift valley lakes. Examples of such Lakes include; Lake Albert, Lake Edward, Lake George, Lake Tanganyika in the western lift valley also Lake Turkana, Lake Baringo, Lake Nakuru, Lake Magadi, Lake Eyasi, Lake Manyara, in eastern rift valley. such Lake tend to be long narrow and deep and tend to be surrounded by fault scarps.



8.Waterfalls and rapids; *This is an indirect effect where by faulting along sections of a river profile have led to the elevated landscapes and resistant rocks along the river profile thus leading to the development of waterfalls and rapids for example Murchison falls along Victoria Nile between Lake Kyoga and Lake Albert.*

9.Drainage reversal. *Large scale faulting has indirectly led to reversal in the drainage patterns especially rivers. For instance, rivers like Katonga, Kagera, Kafue, which used to flow towards Congo basin were forced to reverse the course of flow towards central Uganda and Southern East parts. On addition, tear faulting across a river tends to off set the river profile at a point when it crosses a fault line.*

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 waterfalls, 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, and 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 curved 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. Its 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 Olbolsat.

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 to the formation of Rwenzori mountains and it was followed by a slight up thrust in the east making the rivers that were flowing east wards 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 rule that crustal warping (up warping) across a river valley will gradually force a river to reverse its direction of flow and run back if its unable to maintain its original flow.

NB. Research about the importance of faulting to man

Revision questions.

1. To what extent has faulting influenced the formation of high lands in East Africa?

2. To what extent has faulting influenced the drainage of East Africa?

3. Examine the effects of faulting on land form development in East Africa.

4. To what extent was faulting responsible for the formation of relief land forms in East Africa?

5. Describe the theories which have been put forward to explain the formation of East Africa rift valley system.

End