

CHAPTER THREE

3.0 GEOLOGICAL PROCESSES

Geological processes can be grouped into two classes:

- (a) Exogenic processes
- (b) Endogenic processes

3.1 Exogenic processes

These are geological processes of external origin. This can be further subdivided into two subclasses: denudation and deposition. They include processes which act on the crust at or very near its surface such as those resulting from the movements and chemical activities of air, water, ice and living organisms.

Denudation: This involves weathering (erosion and transport) of the land surface and removal of the products of rock mechanically and in solution.

Deposition: This involves (i) deposition of the debris transported mechanically e.g. sand, mud, etc., (ii) deposition of the materials transported in solution: by evaporation and chemical precipitation (e.g. rock salt) and by the intervention of living organisms (e.g. Coral, limestone) (iii) deposition of organic matter, largely the remains of vegetation (e.g. peat).

3.1.1 Weathering

Weathering may be defined as the process of alteration of rocks occurring under the direct influence of the hydrosphere and atmosphere. Rock weathering is important in geotechnical engineering since it concerns the behavior of materials used as embankment fill, concrete, roads, or buildings. It is also concerned with the behaviour of weathered materials in rock structure.

Weathering processes: The geological work accomplished by weathering is of two kinds:

- (a) **Physical or mechanical changes:** This is the situation whereby materials are disintegrated by temperature changes, frost action, and organisms and;
- (b) **Chemical changes:** This is the situation whereby minerals are decomposed, dissolved, and loosened by the water, oxygen, and carbon dioxide of the atmosphere and by organisms and the products of their decay.

As a result of the changes, we have three types of weathering

- (1) Mechanical weathering
- (2) Chemical weathering -.
- (3) Biological Weathering

3.1.1.1 Mechanical Weathering

This is the disintegration of rocks into smaller sizes without any chemical change. It is highly dependent on the rock type and the time. The following factors acting for significant period of time may cause it.

(i) Climatic effect: This includes both temperature and rainfall; daily temperature fluctuation and more importantly freeze thaw cycle over long period of time

(ii) Abrasion: the pushing of a large quantity of soil or ice under pressure across an underlying rock by glaciers, grinding or abrading leads to a reduction in the rock size.

Table 3.1: The processes of mechanical weathering

Mechanical Unloading	Vertical expansion due to the reduction of vertical load by erosion. This will open existing fractures and may permit the creation of new fractures
Mechanical Loading	Impact on rock and abrasion, by sand and silt size windborne particles in deserts. Impact on soil and weak rocks by rain drops during intense rainfall storms
Thermal Loading	Expansion by freezing of water in pores and fractures in cold regions, or by the heating of rocks in hot regions. Contraction by the cooling of rocks and soils in the cold regions.
Wetting and Drying	Expansion and contraction associated with the repeated absorption and loss of water molecules from mineral surfaces and structures
Crystallization	Expansion of pores and fissures by crystallization within them of minerals that were originally in solution. Note: expansion is only severe when crystallization occurs within a confined space.
Pneumatic Loading	The repeated loading by waves of air trapped at the head of fractures exposed in the wave zone of sea cliff

(iii) **Organic activity:** Cracking force carried by plant roots and roots in crack and crevices/crevasse of rock can break rocks into fragments.

The processes most commonly involved in mechanical weathering are listed in Table 3.1

3.1.1.2 Chemical weathering

The alteration and dissolution of rock material by chemical processes is largely accomplished by rain water acting as a carrier of dissolved oxygen and carbon dioxide together with various acids and organic products derived from the soil.

Table 3.2: Some commonly occurring processes in chemical weathering

Solution	Dissociation of minerals into ions greatly aided by the presence of CO_2 in the soil profile, which forms carbonic acid (H_2CO_3) with percolating rainwater.
Oxidation	The combination of oxygen with a mineral to form oxides and hydroxides and any other reaction in which the oxidation number of the oxidized elements is increased.
Reduction	The release of oxygen from a mineral to its surrounding environment: ions leave the mineral structure as the oxidation number of the reduced elements is decreased.
Hydration	Absorption of water molecules into the mineral structure. Note: this normally results in expansion. Some clay expand as much as 60%, and by admitting water hasten the processes of solution, oxidation, reduction and hydrolysis.
Hydrolysis	Hydrogen ions in percolating water replace mineral cations: no oxidation-reduction occurs.
Leaching	The migration of ions produced by the above processes. Note: the mobility of ions depends upon their ionic potential; Ca, Mg, Na, K are easily leached by moving water, Fe is more resistant. Si is difficult to leach and Al is almost immobile.
Cation Exchange	Absorption onto the surface of negatively charged clay of positively charged cations in solution, especially Ca, H, K, Mg.

The degree of activity depends on:

- (1) the composition and concentration of the solutions so formed
- (2) the temperature

(3) the presence of bacteria and

(4) the substances taken into solution, from the mineral decomposed. .

The processes most commonly involved in chemical weathering are listed in Table 3.2.

3.1.1.3 Biological weathering

Weathering effects which are small in themselves but noticeable in the aggregate can also be attributed to plants and animals' (biotic weathering). Plants retain moisture and any rock surface on which they grow is kept damp, thus promoting the solvent action of the water. The chemical decay of rocks is also aided by the formation of vegetative humus, i.e. organic products derived from plants, and this helped by the action of bacteria and fungi. Organic acids are thereby added to percolating rain-water and increase its solvent power. Some bacteria are active, and contribute to the making of sulphides; others can convert nitrogen to NH_4 compounds which affect the pH value of soils.

The mechanical break: down of rocks is brought about when the roots of plants penetrate into cracks and wedge apart the walls of the crack.

3. 1.2 Erosion

River, wind, moving ice and water waves are capable of loosening, dislodging and carrying particles of soil, sediment and larger pieces of rocks. They are therefore described as the agents of erosion. Weathering prepares the rock surface for the removal of decomposed or disintegrated materials by the agents earlier mentioned, i.e., it prepares the rock surface for erosion.

3.2 Endogenic Processes

These are geological processes of internal origin. They include the processes which occur within the crust as a result of the physical and chemical activities of the materials of both crust and mantle. These activities include Earth movement, Igneous activity and metamorphism.

Earth movement: Up-lift and depression of land areas and sea floors. Mountain building with associated folding and over thrusting of rocks, earthquakes etc.

Metamorphism: Transformation of existing rocks into new types by the action of heat, pressure, stress and hot chemically active migrating fluids.

Igneous activity: Emplacement of intrusion, emission of lavas, gases, and other volcanic products.

3.2.1 Magma

Magma is generated by local heating and melting of rocks with the earth's crust, mostly at depths between 10 and around 100km. Most compositions of rock melt at temperature of 800-1200°C. When the magma cools, it solidifies by crystallizing into a mosaic of minerals, to form igneous rock. Magma is mobile rock that forces its way into the planes of weakness of the crust to escape quietly or explosively to the surface. The kind and amount of minerals found in any igneous rock depend on chemical composition of the magma from which the rock crystallizes and on the processes taking place during crystallization.

Basically all magmas are molten mixtures rich in O₂ and silicon with lesser amount of the metallic ions – Al³⁺, Ca²⁺, K¹. All contain a small percent of volatile constituents as water, CO₂. They are in a poorly defined zone of the earth crust where local and intermittent temperature becomes high enough to bring about melting.

Magma varies in composition from **MAFIC** to **FELSIC** and the variation is believed to be a result of the following;

- (i) Nature of the origin rock forming magma
- (ii) Heat released from radioactivity.
- (iii) Geothermal gradient: i.e. variation and increase in temperature as one goes deep into the earth.

Classification of magma

Magma can be classified in two ways:

- (a) Magma can be classified by mineral composition as mafic, felsic, intermediate and ultramafic.
 - (i) The **mafic** (dark minerals) are rich in Mg, Fe, and Ca
 - (ii) The **felsic** (light minerals) magma are rich in Na, K, Si (Feldspar and silicon)
 - (iii) The **Intermediate** magma: These types of magma are transitional in composition.
 - (iv) The **ultramafic** magma is extremely rich in Mg and Fe.
- (b) Magma can also be classified by the placement of magma. This type of classification can be grouped into two: **Basaltic magma** and **Granitic magma**
 - (i) **Basaltic magma**: The starting material for the basaltic magma is likely to be **Peridotite** which is an olivine and pyroxene whose partial melting may occur in the upper mantle into

the crust and later crystallized at various temperature and pressure leading to different basaltic rocks. This type of rock makes up the ocean floors.

- (ii) **Granitic magma:** Dominantly, they occur almost exclusively on the continent. Granitic magma is the fractional crystallization of basaltic magma, unlike the basaltic magma, the granitic magma is light and hence predominantly an extrusive rock.

3.2.2 Volcanic eruptions

Eruptions may be violent and explosive if a viscous magma has a high gas pressure, or may be quiet and effective if the magma is very fluid. There is a continuous range of eruptive styles between the two extremes and a single volcano may show some variation in the violence of its individual eruption.

Volcanoes and Extrusive rocks (Lava)

A volcano is essentially a conduit between the earth's surface and a body of magma within the crust beneath it. It is an opening in the earth's rock layers through which intensely hot rocks (in a fluid state), gases and other matter are extruded or hurled into the air. This is accompanied by smoke, noise and earth vibration.

Sometimes magma reaches the surface through a vent (hole) or a fissure (crack) in the surface rocks. When magma emerges on the surface, it is called **LAVA**. If lava emerges via a vent, it builds up a volcano (cone-shaped mound) and if it emerges via a fissure, it builds up a lava platform or lava flow.

Types of volcanoes

Active volcanoes: When volcanoes frequently erupt or at least when they have erupted within recent time, they are said to be active e.g. The Cameroon Mountain.

Dormant volcanoes: Volcanoes which have been known to erupt and show signs of possible eruption in the future are described as dormant volcanoes.

Extinct volcanoes: Volcanoes which have not erupted at all in historic times but retain the features of volcanoes are termed extinct volcanoes.

Rocks formed by volcanic eruption are classified as either Extrusive or Intrusive.

Extrusive rocks: These are formed when magma/lava reached the surface of the earth before solidification. There are two types called Basalt and Rhyolite.

Basalt: This is a fine grained igneous rock. The lava flows in bedded sequences and cools after flowing from volcano. It has fine interlocking crystal mosaic with a textural orientation. It may have open vesicles or mineral-filled amygdaloids (old gas bubbles) with 50% feldspar and 50% mafics. The structure is usually sheets or lenses and maybe interbedded with ash or tuff. Basalt weathers and decays to clay soils. Young lavas are generally good aquifers. Basalt gives good aggregate and valuable roadstone.

Rhyolite: This is fine grained product of granite magma that has escaped to the surface via a volcano. The liquid rock may emerge as lava flow, forming a mass of rhyolite when it cools and solidifies

Intrusive igneous rocks

These are formed when magma solidifies below the surface of the earth. They may later be exposed at the surface when the cover rocks are eroded away. A large mass of magma, many cubic km in volume, is **major intrusion** and cools slowly because of its size. When magma rises and fills fractures or other openings in the country-rocks it forms **minor intrusion**, i.e. smaller igneous bodies.

Major intrusion

This includes Plutons, stocks, and batholiths

Pluton: This is used to denote a moderately large body of magma which is intruded essentially at one time and is contained within a single boundary, Plutons have various shapes but are commonly nearly circular in cross section; an average size for many granitic plutons is about 150 km² but many are larger.

Stock: This denotes a vertical nearly cylindrical body of igneous rock, cutting across the rocks into which it is intruded, with a cross-sectional area up to 100 km².

Batholith: This was formerly defined as large bottomless igneous mass (the word means 'depth-rock'), rising as an irregular projection into sedimentary and other rocks of the crust. Recent research, however, has shown that most batholiths consist of a cluster of plutons, located by some structural control during intrusion.

Minor intrusion

This includes dykes, sills, and laccolith and phacolith

Dykes: These are smaller sheet intrusions formed where magma has flowed into a fissure. Mostly 1-50m wide and may extend for many kilometers. A remarkable example, several km in width (formerly known as the Great Rhodesian Dyke), extend 450km through Zimbabwe into South Africa. They are generally of dolerite.

Sill: These are sheet intrusions parallel to the bedding of the country rocks into which the magma was intruded. In contrast to dykes, have been intruded under a flat cover. A columnar structure is often developed in such an igneous sheet by the formation of sets of joints which lie at right angles to its roof and floor; the joints in general result from the contraction of the igneous body.

Laccolith and Phacolith: A laccolith is a small intrusion having a flat floor and domed roof, the roof having been arched by the pressure of the incoming magma. A phacolith is a somewhat similar body but has both a curved floor and roof, magma having been intruded into rocks that were already folded.



Figure 3.1: Forms of igneous rocks

Earthquakes:

Earthquakes occur when relative movement of plates or faults blocks overcomes shear resistance of a fault. The movement builds up elastic strain in rocks; limit rupture and rock rebound release strain energy as ground shock waves. The point at which the shock originates is known as the **origin or focus**, and the earth's surface directly above this is known as the **epicenter**. Most

earthquakes originate at focus less 20 km deep. Surface displacement may be a few meters or absent. Fault breaks may extend over lengths 1-100km.

Size and scale of earthquakes

Ground movement is measured in different planes on seismographs.

Magnitude: This is the size of an earthquake on the Richter scale: log 10 of the maximum wave amplitude in microns on a Wood Anderson seismograph 100 km from the epicenter.

Intensity: is the scale of earthquake damage at any one point, described on the modified Mercalli scale, and declining, away from the epicentre.

Damage: This relates to peak ground acceleration, also to peak velocity, frequency and duration.

Duration: Usually less than 10s for magnitude 5, may last 40s for magnitude 8; increases away from epicenter.

CHAPTER FOUR GEOLOGICAL STRUCTURES

Geologic structures are usually the result of the powerful tectonic forces that occur within the earth. These forces fold and break rocks, form deep faults, and build mountains. **Structural geology** is the study of the processes that result in the **formation** of **geologic structures** and how these **structures** affect rocks

4.1 Fractures

These can be grouped into two namely; Faults and Joints.

4.1.1 Faults

Faults are major breaks (fractures) in the earth's crust producing displacements which range from vertical to horizontal depending on the fault type. Faults are of major significance in civil engineering. They are often major sources of ground water. Not all faults are of such a large magnitude, but their scale is virtually larger than any other fractures. Faults commonly create zones of broken ground - weaker and less stable than the adjacent rock - with implications for foundation bearing capacity, slope stability and tunnel roof integrity.

Types of Faults

Faults types are recognized by the relationship of downthrow to dip of the fault plane. The two major types are **normal** and **reverse** fault (Figure 4. 1). Others are vertical, thrust, tear faults and grabens.

Normal fault: These are faults caused by tensional forces. A normal fault occurs when one block moves or slips relative to the other. The downthrow is on the down dip side. The effect of a normal fault is to increase the original horizontal extent between points on either side of the fracture.

Reverse faults: These are faults caused by compressional forces. It occurs when one block slips underneath the other block. In this case the downthrow side is opposite to the dip. The effect of reverse faulting is to reduce the original horizontal of the broken bed; the two displaced ends of a stratum overlap in lap.

Vertical faults: These are not easily distinguished as normal or reverse fault.

Thrust faults: These are reverse faults with low angles of dip.

Grabens: These are downfaulted blocks between two normal faults.

Tear faults: In this type of fault, the relative movement along the fault plane is predominantly horizontal, the fault plane being vertical or nearly so.

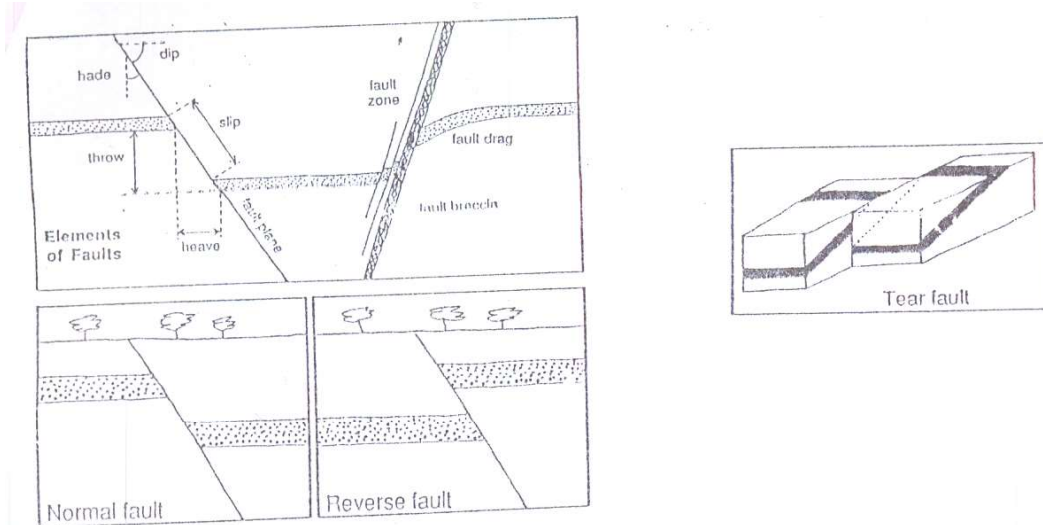
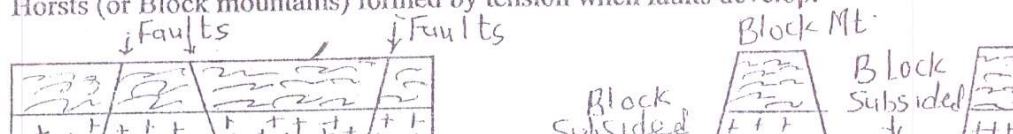


Figure 4.1: Types of faults

Features which result from faulting

(a) Horsts (or Block mountains) formed by tension when faults develop.



4.1.2 Joints

Joints are minor fractures in rocks that can be tensional and shear in nature. They are closely spaced. While faults are larger structures with significant displacements of rock bodies across the plane. They are minor fractures with little or no displacements. They are formed by tectonic stressing and are developed in nearly all rocks. Joint densities and individual joint lengths are infinitely variable. Group of sub parallel joints form joint systems. All joints are structural weaknesses, whose density, extent and orientation are major influences on rock mass strength.

The presence of joints is important to nearly all fields of economic geology. The folds associated with joints allow increased circulation of ground water through them which in turn result in a pronounced effect on the strength and stability of the rock mass.

Types of joints

(a) **Shrinkage joints:** This result from prolonged drying or freezing and resultant shrinkage of sedimentary deposits.

(b) **Strike Joints and Dip joints:** The direction of one of these sets frequently corresponds to the strike of the beds and the other to the dip direction respectively. See figure

(c) **Contraction joints:** These are formed as a hot mass cools and contracts

(d) **Cross joint** or Q- joint

(e) **Longitudinal joints** (or S- joints)

(f) **Flat-lying joint** (or L-joints)

The spacing or frequency of joints varies considerably. This is an important factor in quarrying as joints may be well spaced in limestone and mudstone yielding large blocks of stones whereas other rocks may be so closely jointed as to break up into small pieces. The ease of quarrying, excavating or tunneling in hard rocks largely depends on the regular or irregular nature of joints and their direction and spacing. The presence in rocks of joints is a main factor in promoting rock weathering.

4.2 Folds

Folds occur when the earthcrust bends. These are caused by enormous compressive forces in the earth's crust in geological time along the lines of weakness. These are probably the most obvious indication of ductile deformation of rocks.

(a) **Syncline folds:** These are the type of folds in which the rocks are folded downwards to form a concave shape.

(b) **Anticline folds:** These types of folds occur from the upward folding of rocks to form a convex shape. It is also called simple fold.

(c) **Symmetrical folds:** These are the types of fold which occur when the axial plane of the folds are 90° to the horizontal.

(d) **Asymmetrical folds:** These are the types of folds which occur when the axial plane of the folds are not equal to 90° to the horizontal.

(e) **Monocline or flexure folds:** These are the types of folds in which there is no axial plane.

(f) **Over folds:** These are the types of folds in which the crest of a fold is pushed too far.

(g) **Recumbent folds:** When the crest of a fold is pushed further (that the limbs/axial planes are virtually horizontal).

(h) **Overthrust folds:** Under extreme stresses, fractures may occur in the crust, so that the upper part of the recumbent fold slides forward over the lower part along a thrust plane (which is also known as a fault line) forming what is called overthrust fold. (The overriding portion of the thrust fold is termed **nappe**).

(i) **Isoclinal folds:** These are successive asymmetrical folds with parallel axial planes and limbs which are virtually parallel.

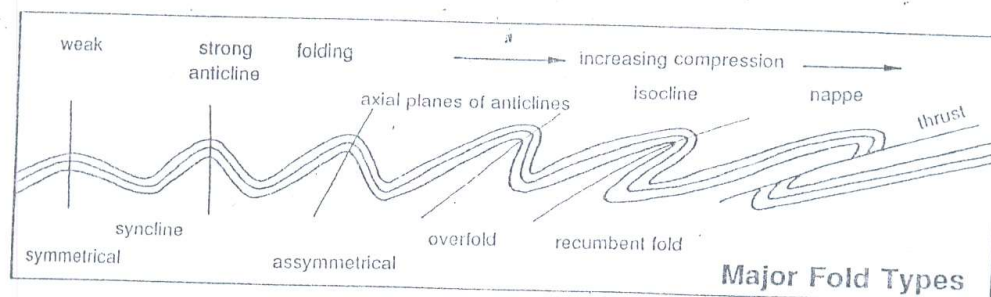


Figure 404: Major Fold types

CHAPTER FIVE

5.0 STRATIGRAPHY

Stratigraphy is the geological study of strata and their succession. It is the description, organization and classification of stratified rocks, particularly the sedimentary rocks. It is subdivided into lithostratigraphy and biostratigraphy.

Lithostratigraphy is the study of stratified sequence purely on the basis of lithological characteristics.

Biostratigraphy encompasses the various phases of biology and palaeontology applicable to stratigraphy study.

Stratigraphy seeks to interpret past events recorded in rocks. It therefore aims to reconstruct the past geography, the pale climate and the paleo environment, if the planet earth from records of rocks and their enclosed fossils.

The relative age of every fossil-bearing stratum is revealed by the stage of development reached by the forms of fossil life found in it. Geologists therefore divided the history of the earth into two broad parts, one called the **PRE-CAMBRIAN** which covers approximately the first 4000 million years, and the **PHANEROZOIC** which deals with the last 600 million years.

Geological time is called **ERA**.

The PHANEROZOIC is subdivided into three eras;

- (i) The **PALAEZOIC** (Ancient life)
- (ii) The **MESOZOIC** (Intermediate life) and
- (iii) The **CAINOZOIC** (New life)

Most of the phanerozoic has been divided upon the basis of fossils found in rocks. Although some plants and animals did exist before that time, they were generally very primitive, and did not leave many "hard parts" to become fossilized. Only after the pre-cambrian did shelly marine animals begin to flourish and diversify. Eras consist of several periods which in turn may be subdivided into lower, middle and upper parts. Conventionally, when writing or drawing geological succession, the oldest formation goes at the bottom of the page, thus obeying the law of superposition.

5.1 Principles of stratigraphy

Principles of stratigraphy: In stratigraphy study more commonly evoked principles are; (i) the uniformitarian principle (ii) the law of original horizontality (iii) the principle of superposition and (iv) the principle of faunal succession.

The principle of uniformitarian: This states that the “present is the key to the past”. This means that rocks formed long ago at the earth’s surface may be understood and interpreted in terms of the physical processes operating today.

The law of original horizontality: This states that water laid sediments are deposited in the beds that are not far from horizontal and parallel or early parallel to the surface in which they are accumulated.

The principle of superposition: This states that the order of deposition of sediments is from the bottom upwards.

The principle of fauna succession: This states that fossils faunas and Horns as they occur in a stratified rock sequence succeed one another in a definite and determinable order. This implies that the like assemblages of fossils organisms indicate like geologic ages for the rocks containing them.

5.2 Stratigraphy sequence

The first step in stratigraphy study is to identify and group stratas into lithological units like sandstone, shale, limestone, etc. The next is to establish sequence of the lithological unit in time. For this the principle of superposition is regarded as the basis of all stratigraphic undertaking. This generalization has been applied worldwide to establish the correct sequence of strata in **stratigraphic columns**.

Stratigraphic Columns: A stratigraphic column is a succession of sedimentary rocks in an area. This is subdivided and differentiated into significant and useful units. This is achieved based on the physical and biological characteristics of various horizons or levels that constitute the column. The biological characteristics are represented by the numbers and type of fossils present in the sequence. The lithology and unconformity represent the physical events. The basic unit into which the geological column is subdivided is the **formation**. A formation is characterized by the following:

- (a) A distinctive lithological composition or a distinctive interbedded or intergraded succession of lithological types
- (b) Observable lithological separation from adjacent units above and below, and
- (c) Traceability from exposure to exposure in the field or from well in the subsurface.

Table 5.1: Stratigraphic column

Period/System	Era	Age M.Y
Holocene = Recent	Quaternary	1.6
Pleistocene		
Pliocene } Neogene	Tertiary	
Miocene }		
Oligocene }		
Eocene } Paleogene		
Paleocene }		
Cretaceous	Mesozoic	65
Jurassic		
Triassic		
Permian	Paleozoic	570
Pennsylvanian		
Carbonifeorous		
Mississippian		
Devuian		
Silurian		
Ordivician		
Cambrian		
		245
(origin of the earth)	Precambrian	4600

5.3 Transgression and Regression

The geologic history and the successive build up of rocks of many regions are influenced by natural phenomena such as worldwide **Orogenesis** and **Epirogeny**. The former is

the process of mountain building while the latter is the uplift or depression of the levels. These phenomena result in abrupt uplifts and depression of portions of the earth's crust, withdrawal of sea from land surfaces known as Regression and invasion of land surface by the sea known as **Transgression** as well as the climate changes and biological changes as were recorded in fossils that occur in rocks. The changes leave their tell-tales of unconformities.

The two types transgression (depositional and erosional) result in a stratigraphic sequence in which deeper water facies overflow shallow marine deposits i.e. the sequence gets finer upwards at any point (e.g. marine sediments over terrestrial sediments).

Regression can also be viewed in another light. Where the volume of sediments supplied to an area requires more energy for its removal than is available, base level rises and the surplus sediments accumulate, with the extension of land the facies prograde. The first concept results in erosional depression while the latter derived concept leads to depositional regression. Deltas are good examples of depositional regression.

5.3.1 Unconformities

Sedimentary rocks accumulate in successive layers of deposition, which are not only horizontal but parallel. The beds are said to lie conformably one on the other, causing stratification. When beds are deposited on a tilted, folded or eroded surface of an older series, so that an obvious demarcation boundary occurs, such a junction between the older and newer series is known as an UNCONFORMITY. Unconformity results from reversals of the local process of erosion and sedimentation in an area. There is nearly always an angular difference between the beds comprised in each series, but should the beds above and below such a junction be parallel, it is called **DISCONTINUITY**.

The term **NON-CONFORMITY** refers to a type of unconformity in which sedimentary rocks are deposited in layers over a stratum over a layer of igneous rocks.

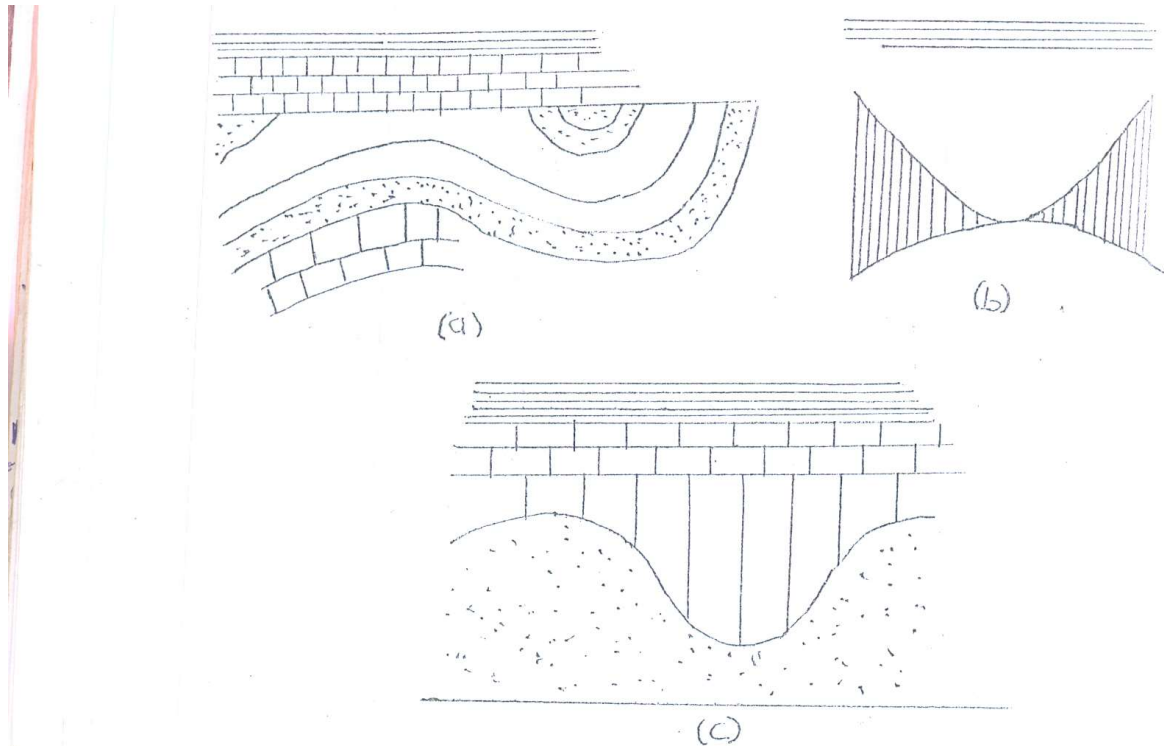


Figure 5.1 (a) Unconformity (b) Minor conformity (c) Non-conformity

5.4 Significance of stratigraphy

The established succession or sequence of sedimentary rock implies relative ages and this has some engineering significance.

Site investigation for sensitive structures like dam, nuclear power plants, bridges, high rise buildings aim to establish the soil rock interface as boring depths for the structures are usually taken as far down on the bedrock. In other civil engineering structures, the boring depths are taken as far down as to all beds whose physical behaviour is likely to have a bearing on the stability of the proposed superstructure.

Knowledge of local stratigraphy is also very important in mineral resource exploration and exploitation, particularly petroleum hydrocarbons. Carbonate reefs remain the only type of stratigraphy feature that has been particularly discovered and mapped successfully by reflection seismic technique.

The knowledge of depositional stratigraphy of an area is of vital importance in predicting the most favourable area for oil accumulators.

5.5 Fossils

Fossils are recognizable organic structures or impression of such structures, preserved mainly in sedimentary rocks. The term implies enormous age as it is used only for remains of organisms. They occur only in strata of 600 million years and younger. However, precambrian limestones in Zimbabwe bear records of plant life- calcareous algae. This occurrence takes the record of life back in time to 2600 million years - the age of the limestone. Fossils are most abundant in rocks laid down in relative shallow seas. They are relatively sparse or lacking in rocks of continental origin.

5.5.1 Classes of fossils

As in their living representative, the main categories used for classifying fossils are those in use for the higher classification organisms. Related species constitute a genus, related genera comprise a family, related families an order of class and classes comprise a phylum. The phylum animals and division for plants are the largest categories of the two primary groups into which living organisms are fitted. For example

Kingdom: Onimalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Primate
Family: Hominidae
Genus: Homo
Species: Sapiens.

Stratigraphically, the most significant fossils are the protozoa and the mollusca. Protozoans include a variety of one called aquatic organism mostly less than a millimeter in diameter. They are foraminifera, radiolarians and conodonts.

5.5.2 Significance of fossils

The study of fossils has contributed much to the broader fields of economic geology and historical geology. Of far more significance in the former fields is the role of fossils in petroleum exploration and oil field development. Distribution of hydrocarbons in the field often

depends on underground geologic structure and especially on how the deeply buried strata are flexed, filled and folded.

Correlation of beds from wells to wells using species of foraminifera affect in part, some insight on how to determine the sub-surface structure. Worldwide correlation of beds of several kilometers apart is affected in part on the basic fossil content. In general, resolution in fossil correlation is claimed to be better than that provided by radiometric methods or by physical stratigraphy.

In interpreting the past as records in rocks and the fossils content recourse is made to the uniformitarian principle. In projecting of the present to the past, insight can be gained into the past ecology, the past climate, the past geography and environment of deposition of strata bearing fossils.

CHAPTER SIX

6.0 GEOLOGY OF NIGERIA

The geology of Nigeria can be grouped into two broad categories, the crystalline basement rock and the Cretaceous and younger sedimentary rocks. The surface of the country is almost covered by these two groups.

6.1 The crystalline basement rocks

These are of various kinds including the Precambrian basement rocks, a wide range of granitic rocks which are grouped into the older and the younger granite as well as a wide suite of volcanic rocks.

The Precambrian basement rocks: Nigeria's Precambrian basement forms part of the West African shield rocks. Worldwide, Precambrian rocks are widely exposed on every continent. Other major Precambrian shield areas include Canada, Finland, Sweden, North and Western Siberia, India, much of the rest of Africa, Western Australia and eastern part of Brazil. At their borders, these shields disappear beneath Cambrian and younger sedimentary rocks that cover an unconformity of relatively low relief. The shields are known to be structurally very stable. Most of the shields stand just a little above the sea level though some like the shield area of Africa, Brazil expose Precambrian terrains at elevations of several thousands on broad plateaux.

In Nigeria, the Precambrian basement rocks consist of migmatites, metasedimentary schists and quartzite, all of Precambrian age (over 600 million years old.) Migmatites are a composite group of rocks of various lithology, texture and structure. Generally, the mineralogy is that in which a discrete light coloured granitic component alternates with more basic metamorphic host rocks. The granitic component is usually made up of pegmatite as well as feldspathic and granitic material. At the close of Precambrian, the basement rocks were included in places by a wide suite of granitic rocks. The oldest member of these suites is probably the metasedimentary rocks. Together with the gneiss the metasedimentary rocks are known to have been affected by two cycles of metamorphism.