OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

Inaugural Lecture Series 208

ROCKS: THEIR BEAUTY, LANDUAGE AND ROLES AS RESOURCES OF ECONOMIC DEVELOPMENT

By

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1. INTRODUCTION

Mr. Vice-Chancellor Sir, distinguished colleagues, ladies and gentlemen, I welcome you all to this lecture on objects that exhibit beauty, have language which they do not express in words like you and me, and are of tremendous significance to mankind.

My fascination and romance with geology started almost four decades ago when as a young undergraduate at the prestigious premier University of Ibadan I was introduced to the course. I was actually admitted to read Chemistry which was my best subject then. I registered for all the courses in Chemistry and also Geology as I was at crossroad having one leg in Geology and the other out of it. However, when I tasted the honey in Geology, I dumped Chemistry and embraced Geology totally. Thanks to the very well staffed and organised Department of Geology at Ibadan in those days.

I have, indeed, found Geology as a profession that transcends every fabric of the society as when in the field a geologist is like an ordinary man nobody understands what he is doing in his field attire (Fig. 1) while back home he smiles to the banks and even at the national *who is who* level he dines and wines with Mr. President.

2. DEFINITION

Collins Dictionary of Geology (1990 Edition) defines Geology as the study of the earth in terms of its development as planet since its origin. This

Figure 1a: Field Attire (Geologists in the Field)

Figure 1b: Field Attire (Geologists in the Field)

Figure 1c: Field Attire (Geologists in the Field)

Figure 1d: Field Attire (Geologists in the Field)

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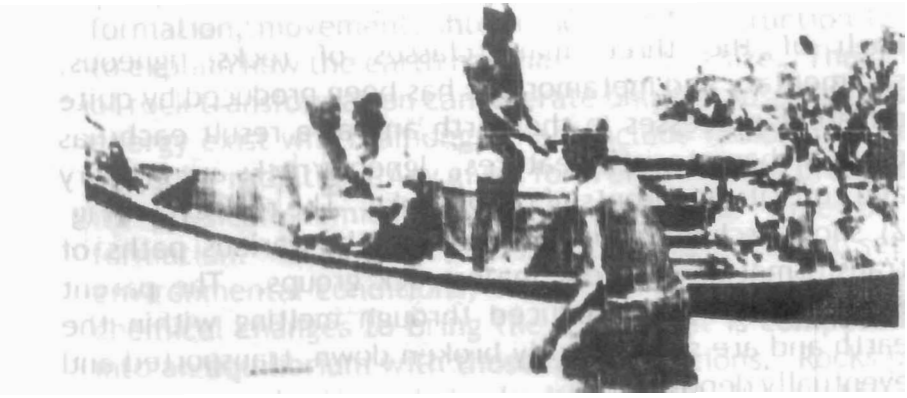

Figure 1d: Field Attire (Geologists in the Field)

includes the history of its life forms, the materials of which it is made, processes that affect these materials of which it is made, and products that are formed of them. The substantial parts of these materials are rocks.

3. WHAT ARE ROCKS?

Rocks are aggregates of one or more minerals whether consolidated or not. A mineral is a naturally occurring inorganic crystalline solid material with its own characteristic definite (but generally not fixed) chemical composition and a set of distinguishable physical properties. A rock may therefore consist of only one type of mineral making it mono-mineralic rock but more commonly it contains a variety of minerals. The geological definition includes materials such as sands and gravels as well as the consolidated sedimentary, igneous and metamorphic rocks.

Petrology is the branch of geology that deals with the origin, distribution, structure and history of rocks. Indeed, it can be regarded as the "father" and basic foundation to all other geological courses. It incorporates petrography which is studying of the rocks by means of microscopic examination.

Each of the three main classes of rocks, igneous, sedimentary and metamorphic has been produced by quite different processes in the earth and as a result each has certain characteristic features. Igneous rocks are primary and constitute parents of other rocks. The rock cycle (Fig 2) shows schematic illustration of the various paths of transformation of these major rock groups. The parent igneous rocks are produced through melting within the earth and are subsequently broken down, transported and eventually deposited as

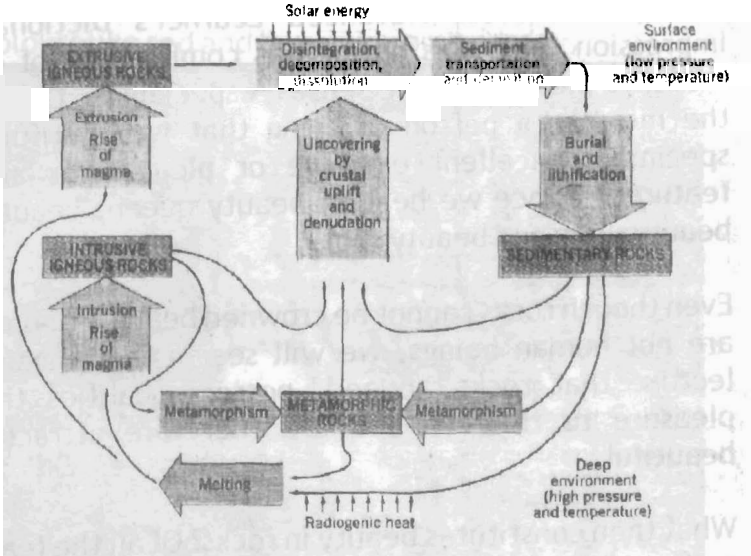

Figure 2: Rock transformation cycle (After Strahler, 1981)

sedimentary rocks which can be subjected to different conditions of high temperatures and pressures to form metamorphic rocks (Gillen, 1982).

The plate tectonics which is the theory and study of plate formation, movement, interactions and destruction helps to explain how the earth has maintained its size. The cycle of rock transformation can operate only because sources of energy exist which among others include radioactive heat and solar radiation. Any given form of rock is the product of its physical-chemical environment at the time of its formation. When it is transported to a different set of environmental conditions, the rock undergoes physical or chemical changes to bring the minerals it is composed of into an equilibrium with those new conditions. Rocks play important roles in our everyday life as we shall see later.

THE BEAUTY OF ROCKS

Beauty, in Oxford Advanced Learner's Dictionary (9th Impression , 1993) is defined as combination of qualities that give pleasure to the senses, especially to the eye or to the mind or a person or thing that is beautiful or fine specimen, excellent example or pleasing or attractive feature. Hence we hear of beauty queen, beauty salon, beauty sleep and beauty spot.

Even though rocks cannot be crowned beauty queens as they are not human beings, we will see in the course of this lecture that rocks, indeed, possess qualities that give pleasure to the eye and are therefore attractive and beautiful.

What then constitutes beauty in rocks? Of all the features of rocks, the ones that constitute mostly to the beauty in rocks are the colour, the structure and the texture.

The attractive colours are red (for example, red granite, red beds or red sandstone), blue (blue marble, blue schist, blue quartzite), green (green schist), pink (pink granite, pink marble). There is even display of a distinctive iridescence in some rocks like larvikite (a variety of syenite) and anorthosite shown by the feldspar crystals. Colours of rocks have, indeed, attracted men to them from time immemorial.

As tattoo which represents marks or designs enhances beauty in human beings and is pleasing to behold so also are structures in rocks. Of all the structures, banding which is a type of foliation defined by alternation of light and dark minerals in the rocks conspicuously stands out in the gneisses such as grey gneiss where the banding is continuous

and can even be traced (Fig. 3). There could be alternation of other colours like red and brown in some cases.

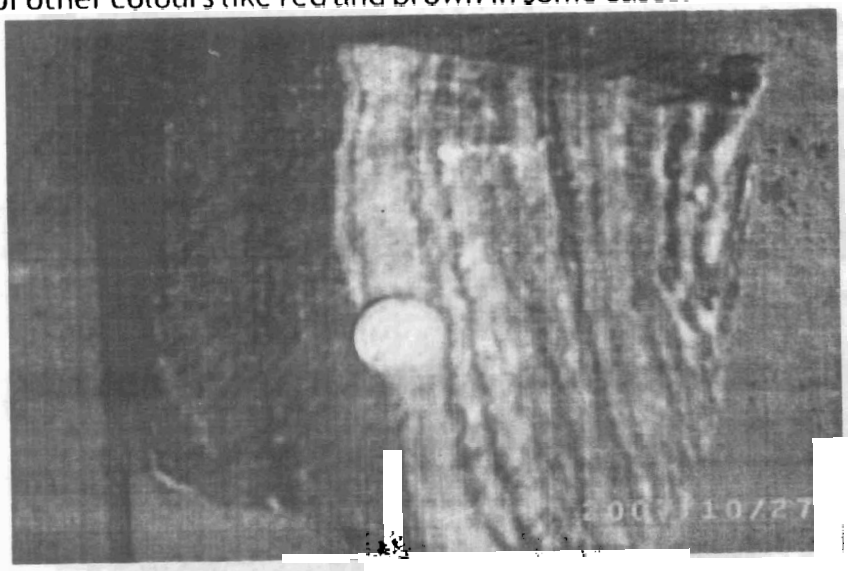

Figure 3a: Foliation in grey gneiss

Figure 3b: Foliation in Migmatite

The varicoloured bands in chalcedony, agate and onyx, which though are varieties of mineral quartz, are of note and contribute to the beauty in rock materials. Flow banding in rocks, for example, rhyolite, could be beautiful to see (Fig. 4).

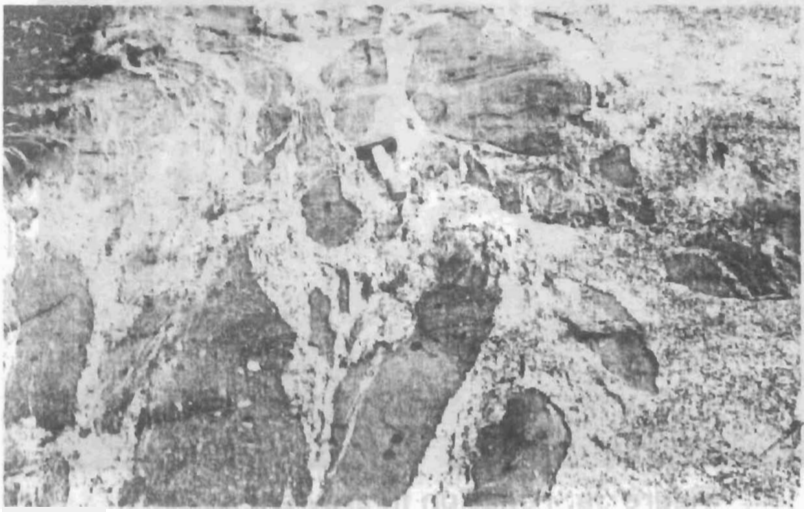

Figure 4a: Flow structure in porphyritic granite.

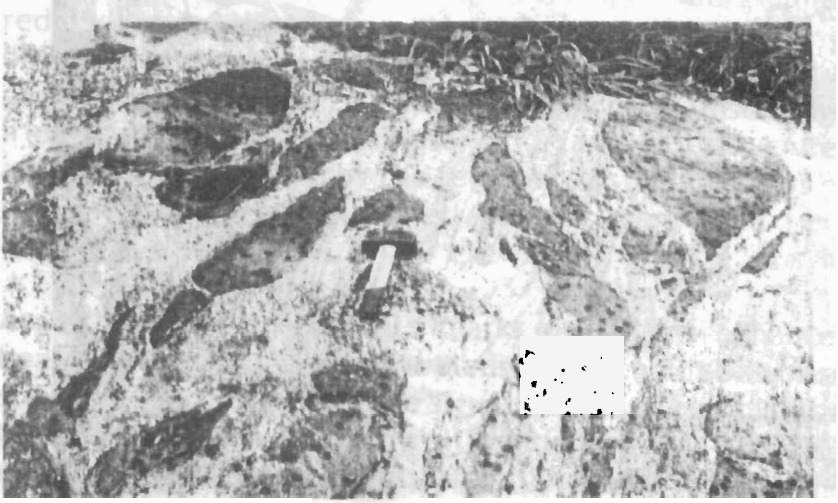

Figure 4b: Flow structure in porphyritic granite

Figure 4c: Flow structure in porphyritic granite.

Other structures in rocks that add to their beauty include microfolds (crenulations) (Fig. 5), layering in layered basic plutons and sedimentary rocks, graded bedding, cross bedding or cross stratification (Fig. 6), especially herring-bone cross bedding (Fig. 7).

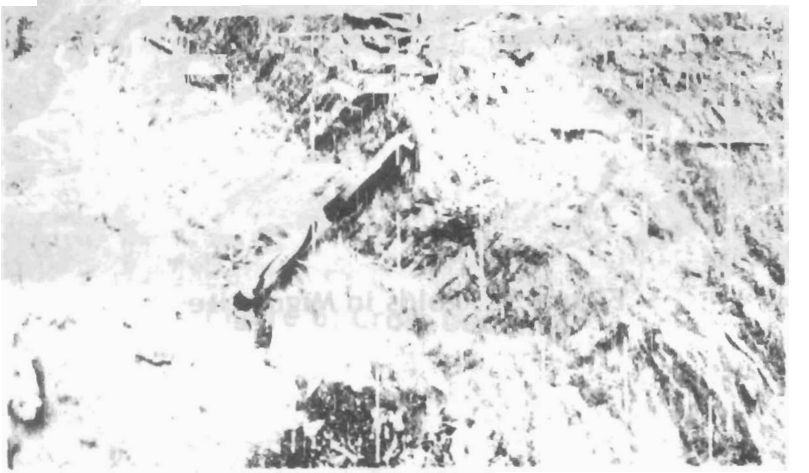

Figure 5a: Microfolds (Crenulation)

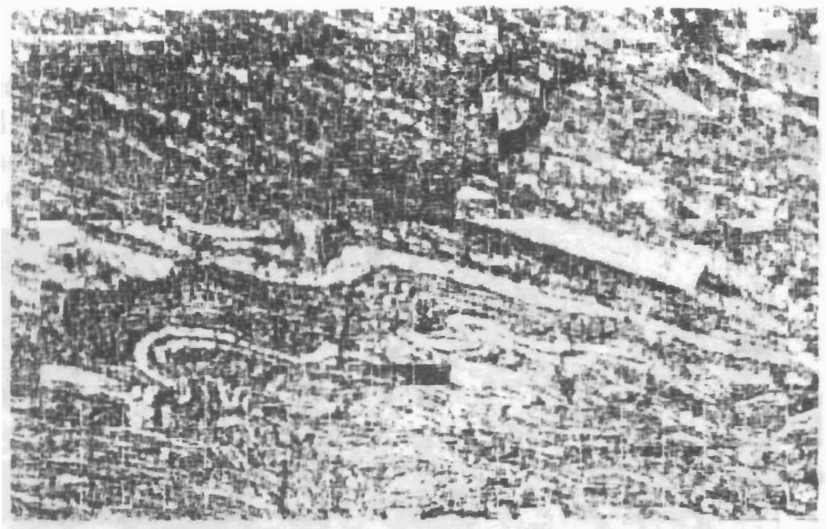

Figure 5b: Folds in Migmatite.

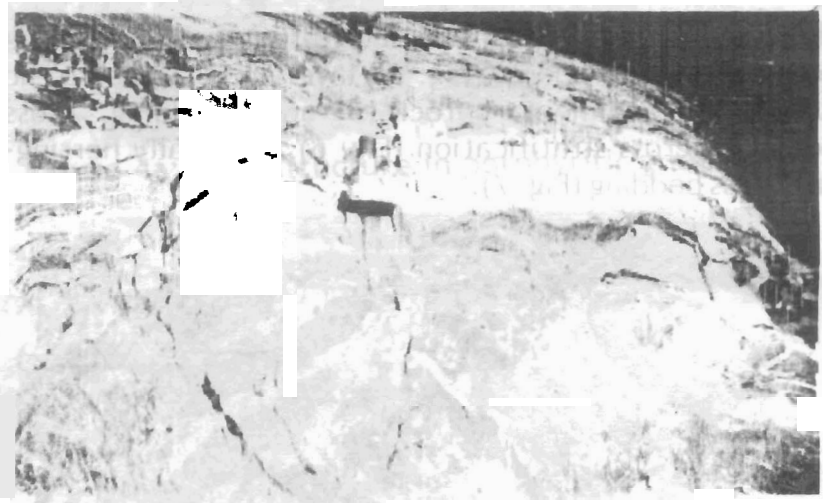

Figure 5c: Folds in Migmatite

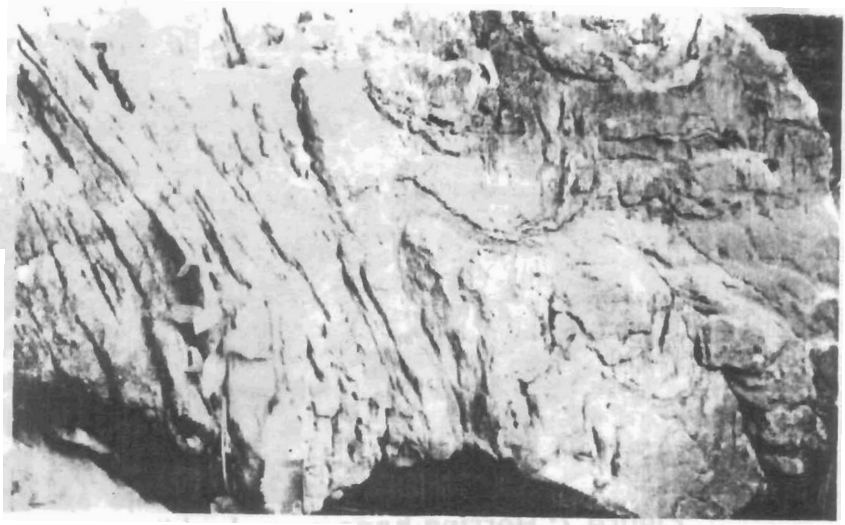

Figure 5d: Folds in Quartzite

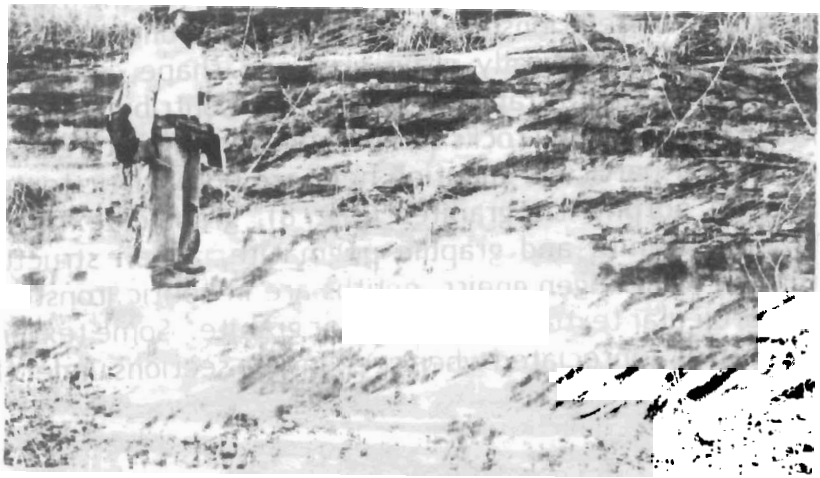

Figure 6: Cross bedding.

Figure 7: Herring-bone cross bedding

Texture which is the general appearance of the rock as indicated by relationships between its component minerals or crystals specifically grain size and shape, degree of crystallinity and arrangement has also contributed to the beauty of rocks. All rocks exhibit one form of texture or the other. Of particular mention here are porphyritic texture seen in porphyritic granites (Fig. 8), graphic texture in graphic granite and graphic pegmatite, augen structure (Fig. 9) as in augen gneiss, ooliths are in oolitic ironstones and orbicular texture as in orbicular granite. Some textures are better appreciated when seen in thin sections under the microscopes.

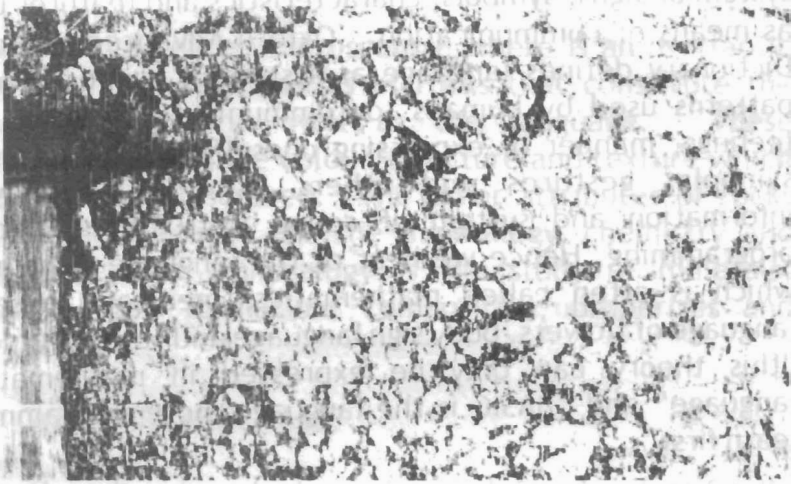

Figure 8: Porphyritic texture.

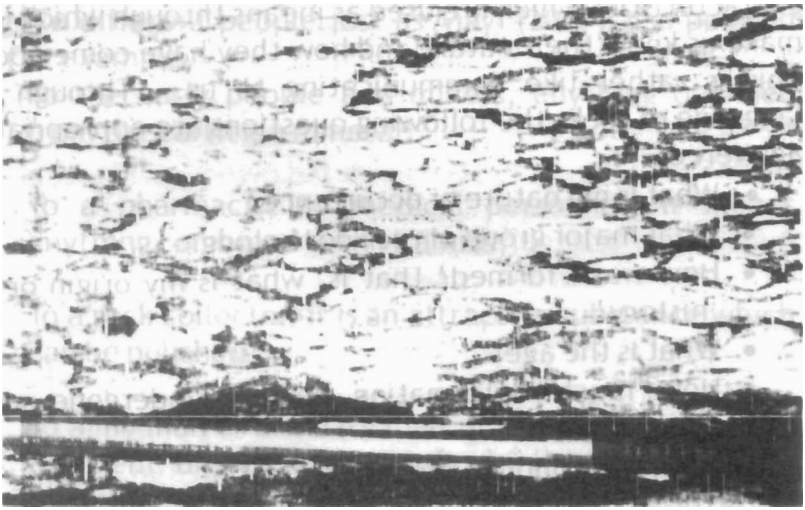

Figure 9: Augen texture

5. THE LANGUAGE OF ROCKS

Language in a real sense is a system of vocal sounds by which a group of persons can communicate. It also refers to any

system of signs, symbols, characteristics and features used as means of communication. Oxford Advanced Learner's Dictionary defines language as system of sounds, words, patterns used by humans to communicate thoughts and feelings, manner of expressing oneself, system of signs, symbols, gestures and others used for conveying information and system of coded instructions used in programming. Hence we hear of the language of science which is often called mathematics, medical language, language of flowers, body sign language and statements like "this theory can only be expressed in mathematical language" and "BASIC is the language most programmers learn first".

Language as used here for rocks refers to the constituents or components of the rocks and their features and characteristics which are used as means through which they make us know their nature and how they have come about. This is rather like communicating to us. Through the language of rocks the following questions are appropriately answered:

- What is my nature or occurrence?
- What major group of rock do I belong?
- How was I formed? That is, what is my origin or my history?
- What is the age?
- How much deformation have I undergone since formation?
- Of what economic use can I be made?

With these questions it is seen that every rock exposure or outcrop that we see have a story of itself to tell and this story can only be unravelled through the language. What then represents or stands for language in the rocks.

As will be noticed in the discourse, there is an overlap in some of the characteristics of rocks that constitute the beauty of rocks as well as the language. These characteristics include colour, structure and texture which have just been discussed. The other attributes of rocks making the language are the mineralogy, chemistry and radiometric age. Mineralogy is the study of minerals, including their formation, composition, properties and classification.

6. WHAT ARE MINERALS?

Even though minerals have been defined scientifically before, it is pertinent to give some comments on the use of the word "mineral". The word "mineral" means different things to different people just as Ajayi (2007) also pointed out. For example,

(i) To the early people and miners, anything quarried from the earth is a mineral,

(ii) To a pharmacist or medical personnel, it means anything combined with vitamins,

(iii) To a rock collector, it is an attractive substance which can be polished,

(iv) To a lay man or ordinary man, it can simply mean the different brands of our soft drink like Coca-Cola, Fanta, or Sprite as once thought by a Civilian Governor in Nigeria and

(v) To a mineral prospector, it is, indeed something of economic value.

But to us as scientists, we need the scientific definition

which even though has been given previously is repeated here thus: Minerals are naturally occurring homogeneous inorganic solids with definite internal atomic arrangement, definite chemical composition or that which varies between stated limits.

The main rock-forming silicate minerals are the feldspars, feldspathoids, quartz, amphiboles, pyroxenes, olivines and the micas. These minerals form the bulk of igneous rocks. Rocks are named and classified based on these minerals since the minerals make up the rocks. The silicate minerals are generally divided into two classes namely the mafic (dark looking) and the felsic (light coloured) minerals. The word "mafic" being an acronym from "magnesium" and ferric" and felsic from the words "feldspar" and "silica". A predominance of mafic minerals, like olivine and pyroxene, produces rocks of ultramafic type or a mafic rock type like basalt/gabbro whereas a predominance of felsic minerals, like the feldspars and quartz, produces rocks of a felsic rock type as granite/rhyolite. Mafic rocks are denser than the felsic rocks.

Minerals therefore constitute some form of "language" which can be used to characterize rocks. The Quartz Alkali Plagioclase Feldspathoid (QAPF) Streickensen (1976) Classification of rocks which is the International Union of Geological Sciences (IUGS) adopted method is based on mineralogical constituents in the rocks and as can be seen from the QAPF double triangle diagrams (Figs. 10a and 10b) each rock type is simply placed in the field it rightly belongs based on the "language" it communicates with, that is, here the mineralogy.

The Chemistry of a rock tells a lot about the rock. From Chemistry we are able to have some idea about the

variation in composition of igneous rocks expressed as follows:

SiO_2	35 - 75%
Al_2O_3	0 - 25%
FeO and FiO;	0 - 20%
MgC	0 - 45%
CaO	0 - 20%
Na_2O	0 - 16%
K_2O	0 - 12%

(Rutley's Element of Mineralogy, 1971, 2nd Impression).

Chemistry, as a language of rocks, tells us whether a rock is basic (mafic), ultrabasic (ultramafic), intermediate or acid (felsic). This is known based on the percentage SiO_2 content of the rock as the acid rocks usually have more than about 66% SiO_2 as in granites; intermediate rocks between about 52 66% SiO_2 as in diorite/andesite; basic rocks with between 45 52% SiO_2 as in gabbro/basalt and ultrabasic with less than 45% SiO_2 as in dunite, periodotite or pyroxenite.

Chemistry is of immense help in the classification of volcanic rocks which are so fine-grained in texture thereby making determination of modes difficult by point counter. The Total Alkali versus Silica (TAS) diagrams of Le Bas *et al.*, (1986) and Cox *et al.*, (1979) in Figs 11a and 11b come into use and adequately complement the QAP diagram earlier discussed.

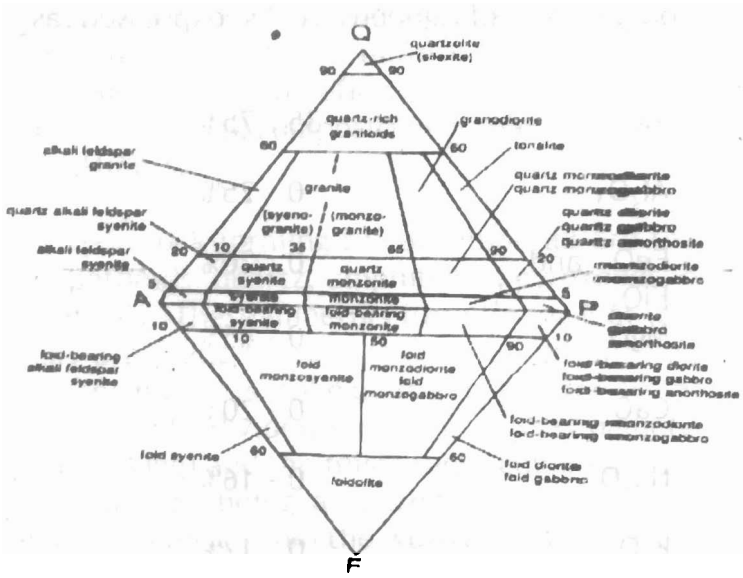

Figure 10a: QAPF double triangle Streckeisen diagram for plutonic rocks

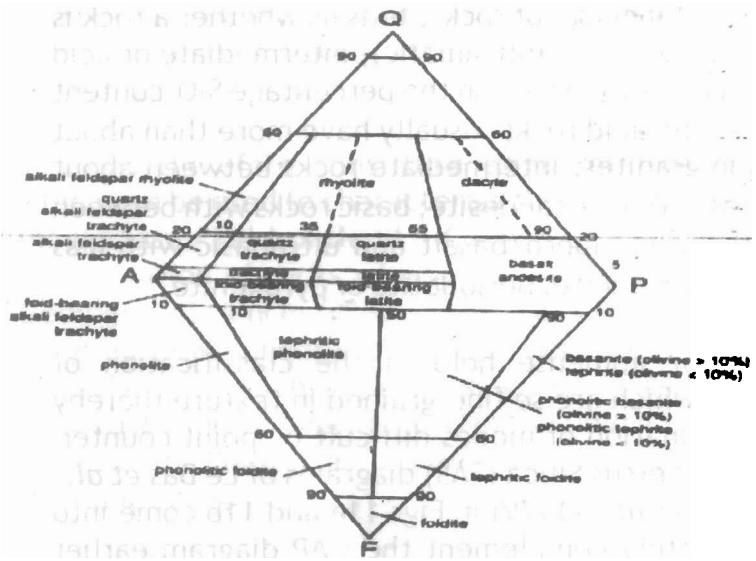

Figure 10b: QAPF double triangle Streckeisen diagram for volcanic rocks

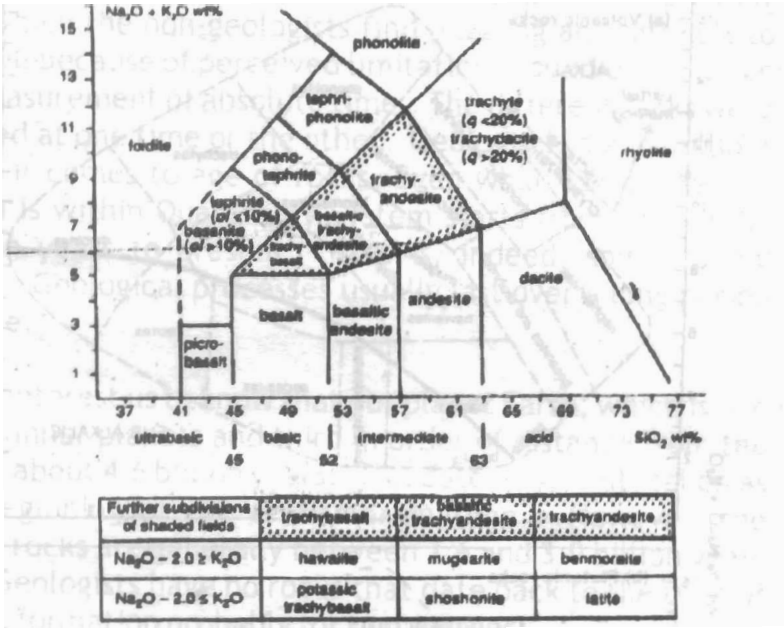

Figure 11a: Total Alkali versus Silica (TAS) diagram of Le Bas *et al.*, (1986)

Chemistry also plays a significant role in indication of a common origin for a group of igneous rocks, for example, a common origin (consanguinity) may be given by chemical trends of associated rock types with the use of variation diagrams, if the rock compositions form relatively regular distributions, consanguinity is indicated.

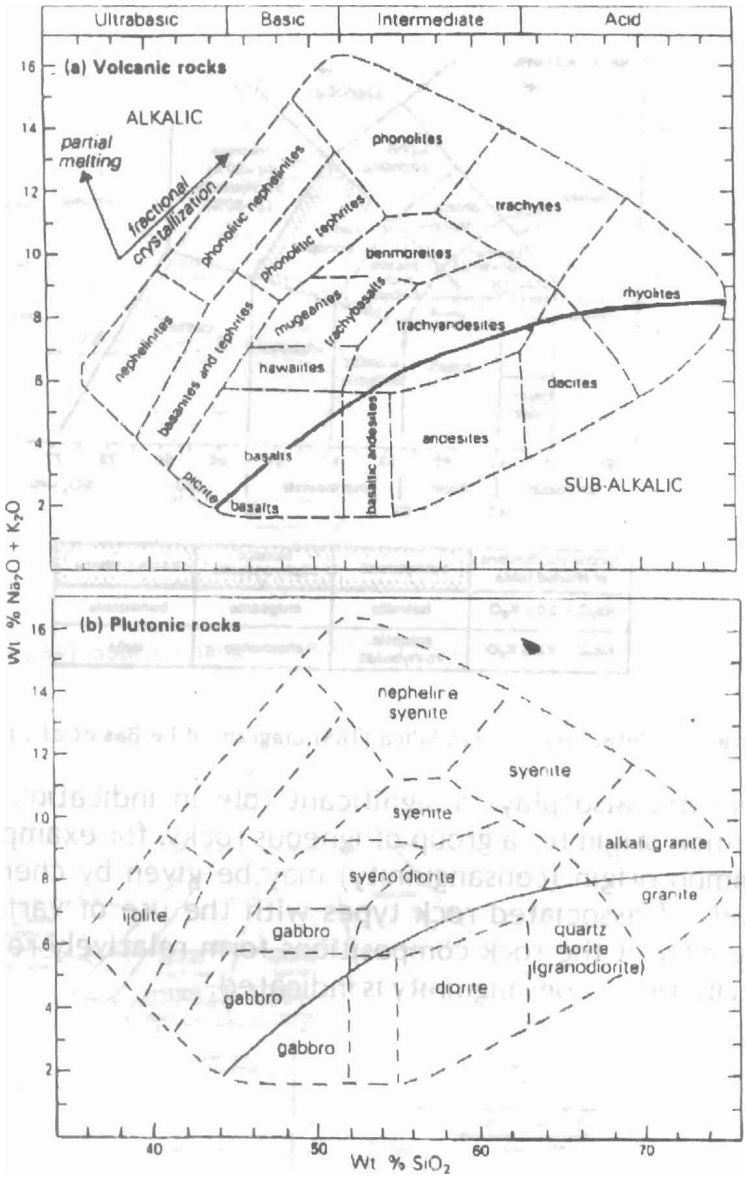

Figure 11b: Total Alkali versus Silica (TAS) diagram of Cox *et al.*, (1979)

The next language of rocks which is found very interesting and which the non-geologists find puzzling and difficult to believe because of perceived limitations, is radiometric age or measurement of absolute time. The different rocks were formed at one time or the other. Geologists talk in millions when it comes to age of rocks. Even what we call *Recent* which is within Quaternary System starts from about 0.01 million years to present. This is, indeed, some 10,000 years. Geological processes usually last over a long period of time.

It will interest us to know that our planet Earth, which is one of the inner planets and third in order of distance from the sun, is about 4.6 billion years. This date is typically taken as the beginning of the Precambrian time. However, the oldest rocks are generally between 3.6 and 3.9 billion years old. Geologists have no rocks that date back to the time of earth's formation probably for two reasons:

(i) the early earth was very hot and the surface might have been molten for some time and the radiometric "clocks" would not start until rocks formed and cooled to temperatures more nearly approaching modern earth surface temperatures,

(ii) the earth has undergone so much geologic change, with formation and destruction and alteration of rocks over time, that survival of unaltered samples of the earliest rocks to have formed is highly unlikely.

Apart from radiometric age of rocks, relative age is also an important language or indication of age relationships. In fact, our understanding of geologic time has been built up

from these two components. Radiometric age of the rock is empirically determined while the relative age is not, as it relates to disposition of the rocks in the field. In this respect, Steno's Stratigraphic Principle is relevant. This Principle is the Principle of Superposition which states that in undisturbed sequence of strata, the oldest strata lie at the bottom and the successively, higher strata are progressively younger, that is, oldest at bottom, youngest at the top. Another relevant Principle in this discourse is the Principle of intrusive relationship which states that the intrusive igneous rock is also younger than the rock that it invades. The other important Principle is the Principle of Components stating that when fragments of one body of rock are found within a second body of rock, the second body is always younger than the first. The fragments are, for example, xenoliths when found in an igneous body.

Through both the radiometric and relative ages, rocks communicate to us their age relationships and thus their periods of formation or emplacement as the case may be. Through radiometric ages, we know that Nigerian basement is polyclic in nature having been affected by the following events which have or bear their signatures in the basement:

- Early crustal growth of ca 3.5 Ga and subsequent metamorphism at 3.0 Ga. An example is the Archaean migmatite in Kaduna (Dada, *et al.*, 1993).

- A Late Archaean period of intrusive activity that occurred between 2.8 2.5 Ga and which involved juvenile addition to the crust.

- Eburnean Orogeny from about 2.1 to 1.8 Ga. The pink granite gneiss of Ibadan, Ile-Ife and Igbetti belong here (Rahaman and Lancelot and

Lancelot and Rahaman, 1988).
Our Hills 1, 2 and 3 here on the Campus are about 1,850 m.y ear old.

- The Pan-African Orogeny that occurred about 600 Ma (The Older Granites and charnockites of Ado, Ikere and Akure are good examples here).

In Nigeria, this language of geochronology has enabled general names or terms like Younger Granites, Jurassic Granites (for some of the high level granites emplaced in Jurassic times about 170 180 m.y. ago), Older Granites which are Precambrian in age and referred to by some as Pan African granites, that is granites emplaced during the Pan-African Orogeny of around 500 - 600 m. y. ago.

The Vice-Chancellor Sir, it can be clearly stated that with all the above, one is convinced that, indeed, rocks are beautiful and they possess features that are akin to languages even though they do not have expressions in words like human beings as said earlier. It has also been shown that once the "decoding" of these features of language in rocks is done then the understanding of these rocks and the supposedly hidden meanings about the stories they tell concerning what they are, how they occur, what they have suffered and how old they are become more clearly appreciable, natural and real.

The surface area of Nigeria (923,768 km^2) is underlain in nearly equal proportions by crystalline and non-crystalline (sedimentary) rocks (Fig. 12). The crystalline rocks are further divided into three main groups:

- The Basement Complex of Precambrian age (>570 Ma).
- The Younger Granites of Carboniferous to Cretaceous (300 - 140 Ma).

- The Tertiary to Recent Volcanics (65Ma 0.01 Ma). Based on some form of chronological order, the Basement Complex rocks are subdivided into six groups (Rahaman, 1988) which are:
- Migmatite gneiss - quartzite complex (the oldest),
- Slightly migmatised to non-migmatised metasedimentary and metaigneous rocks referred to as Schist belts (Ajibade, 1976),
- Charnockitic, gabbroic and dioritic rocks,
- Members of the Older Granite suite and syenite,
- Metamorphosed to unmetamorphosed calc-alkaline volcanic and hypabyssal rocks (McCurry, 1976; McCurry and Wright, 1977) and
- Unmetamorphosed dolerite dykes, other basic dykes, syenite dykes, lamprophyre dykes and others that are believed to be the youngest.

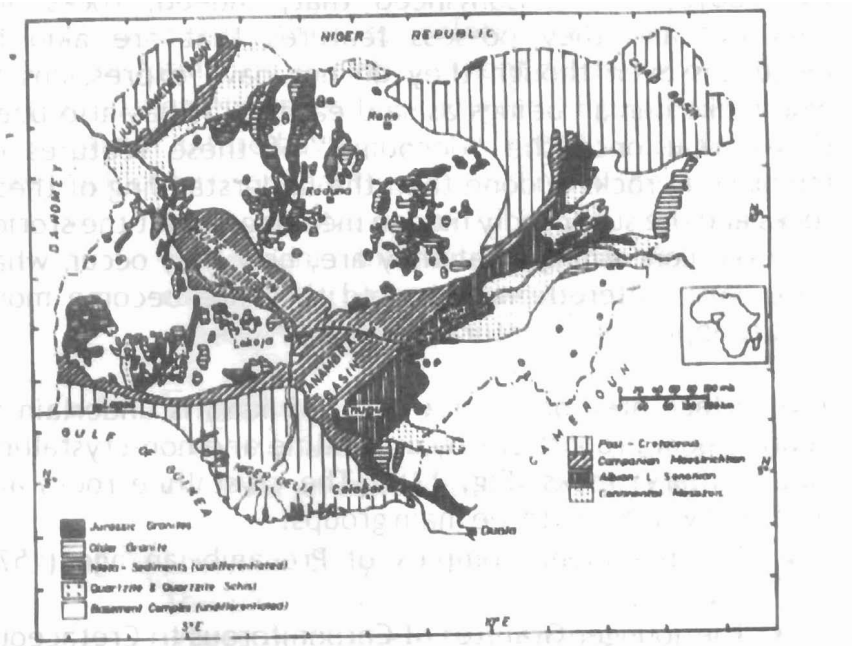

Figure 12: Geological map of Nigeria (after Elueze, 2002)

7. THE ROLES OF ROCKS AS RESOURCES OF ECONOMIC DEVELOPMENT

Janet Watson (1983), our late Research Professor at Imperial College in her book "Geology and Man-An Introduction to applied Science" stated thus "Many of the natural resources used by man come directly from the Earth and have been formed by the geological processes that are responsible for the evolution of the Earth as a Whole". She further stated that "human communities have had a working knowledge of the land in which they live and a familiarity with useful rocks and minerals since prehistoric times. With the increase in world population and the spread of industrial development, the need to assess the resources available to mankind and to make rational decisions about future development has become more urgent, and many people concerned with government, industry and land-use need to understand the geological factors affecting such decisions".

Rocks are resources that bring a lot of revenues for the technological take off of a nation (Ekwueme, 2006). They are the sources of mineral wealth and with a sound knowledge of their structures indications of possible areas of mineral occurrences can be reasonably predicted based on geological principles.

Mr. Vice-Chancellor Sir, I make bold to say that all rocks whether sedimentary, metamorphic or igneous are useful. The usefulness starts from what is contained in rock to what the rock itself can be used for. For example, petroleum, which is the main source of revenue in the country means oil of rock (coined from Greek word "OLEUM", that is "petro-oleum". It is contained in a reservoir rock like sandstone and even a source rock (shale) is needed for its generation. The water that we drink is from aquifers which are simply

water-bearing rocks. Even seemingly unimportant pumice which is a highly vesiculated pyroclastic material sold in local markets finds use in scrubbing the feet and heels to remove dirt and enhance beauty.

All rocks from the major groups of rocks in Nigeria have proved useful in the construction industry (Table 1). Dimension stone has for centuries been the principal load-bearing material of buildings, bridges, dams, harbour works and so on. The common building stones are granites and similar plutonic rocks with massive texture, low porosity and stable minerals. These rocks have high compressive and shear strengths which are required for load-bearing structures (Table 2). Nigeria has enormous reserves of attractive granites, charnockites, tonalites and syenites that have been exported to Europe for use as dimension stone (Table 3).

Table 1: Commercial Characterisation of crystalline rocks for commercial stones (After Elueze, 2002)

Rock types	Potential commercial products	Application and functional uses
Gneisses and migmatites tiles	multi-colour, diadema, nylandia, African jurarans, and others	Interior and exterior decorations, orienta, vibro verde, spriana
Quartzites and schists	Oakley schiefer, favang, verde fundres, verde vermion, schiefer brands etc	Interior and exterior, tiles
Amphibolites and mafic schists	Verde shades, nero tones	Interior and exterior, monumentals
Marbles and calc-gneisses	Bianco brands, zebrino, maharani and so on	Interior and exterior, monumentals pulpit and alter slabs
Granites, granodiorites and diorites	Grigio, star flash, sertzzo, verde lights, nero tijuca	Interior and exterior, tiles, stone items
Syenites and charnockites	Nero "icheku", verde coloured, tijucas	Interior and exterior, monumentals, counter, alter tops etc.
Gabbros, dolerites and lamprophyres	Nero oriental, verde, nero assoluto, grunporphyr	monumentals, tiles, stone items and decoratives.

Table 2: Physical parameters of some of the basement rocks (mean values with ranges in brackets (After Elueze, 1995).

Rock types	Specific gravity	Standard strength index	Water absorption capacity (%)	Oil absorption capacity (%)
Gneisses and migmatites	2.64 (2.48 - 2.80)	7.65 (4.30 - 10.50)	0.39 (0.29 - 0.51)	0.13 (0.08 - 0.22)
Quartzites and schists	2.52 (2.42 - 2.70)	5.49 (3.20 - 8.80)	0.56 (0.36 - 0.72)	0.23 (0.17 - 0.30)
Amphibolites	2.79 (2.73 - 2.89)	7.16 (5.40 - 10.07)	0.34 (0.28 - 0.42)	0.06 ((0.05 - 0.08)
Granites and granodiorites	2.67 (2.53 - 2.78)	7.13 (3.75 - 10.85)	0.36 (0.23 - 0.58)	0.08 (0.06 - 0.09)
Syenites and charnockites	2.79 (2.62 - 2.90)	9.38 (7.30 - 11.77)	0.31 (0.13 - 0.59)	0.09 (0.08 - 0.10)
Gabbros and dolerites	2.86 (2.72 - 2.93)	10.91 (6.75 - 14.50)	0.26 (0.18 -0.432)	0.08 (0.06 - 0.12)

TABLE 3: INVENTORY OF DIMENSION STONES IN NIGERIA (MODIFIED FROM MSMD 1997 REPORT)

S/NO	DIMENSION STONES	LOCATION (STATES)
1.	Granite	Ekiti, Ondo, Oyo, Osun, Kwara, Plateau, Benue, Kogi, Niger, Kaduna, Kano, Katsina, Zamfara, Nasarawa, Cross Rivers, Bauchi, Gombe, Edo, Ogun.
2.	Charnockite	Bauchi, Ekiti, Oyo, Osun, Ondo.
3.	Gabbro	Edo, Kogi, Plateau.
4.	Gneisses	Osun, Ondo, Ekiti, Oyo, Edo, Kwara, Kogi, Niger, Plateau, Kaduna, Nasarawa, Kano, Zamfara, Abuja, Ogun
5.	Syenites	Iwo (Osun), Shaki (Oyo), Oke Iho (Oyo), Igarra (Edo), Plateau.
6.	Tonalities	Niger.

In addition to granites are massive sandstones and limestones which can also be quarried in sizeable rectangular blocks free from internal fractures and without yielding an undue proportion of waste fragments.

Hard crystalline rocks of the Basement Complex that occur in the north central, south west and eastern parts of the country are crushed into aggregates for various

construction works. Fossiliferous limestones (as in Yandev, Benue State and Ashaka in Gombe) and travertine (fine crystalline calcium carbonate) are used as decorative stone for facings, paving and interior walls. Slate which is characterized by a closely spaced cleavage that facilitates the separation of thin layers is a traditional roofing material as in North Wales (U.K).

Cement is an artificial powder which sets rapidly to a rock-like hardness after being mixed with water. The principal component of cement is calcium carbonate from which a proportion of the CO_2 has been expelled by heating. Portland cement, which was a 19th Century invention, is made by heating limestones with clay to temperatures high enough for calcium silicates to be formed by reaction between clay minerals and calcium carbonate. The resulting stony clinker is powdered and must be kept dry until the time of use. Most Nigerian limestones are suitable for Portland Cement Production. About eight cement works are already established in the country and more are being contemplated.

Limestones and some marble deposits are good for producing lime which is useful for water treatment, correcting soil acidity, animal feeds and making calcium carbide which is required for preparing acetylene gas used for welding. Marble is useful as constructional material like terrazzo, palladiana, slab flooring, tombstone, church pulpit, table and counter tops. Dolomite, magnesite as well as pure limestone are used in glass making industry as well as refractories and fluxes in steel production. Magnesite is used also in sorrel cement with yellowish brown colour.

Bricks and tiles are made from clays. A satisfactory brick clay has a fairly low water content (7.5-19%) which limits shrinkage during drying. Small proportions of calcium carbonate and silt increase strength and reduce shrinkage while small amounts of iron give a pleasing colour, and

organic matter which releases energy when burned, reduces fuel costs during firing.

Fire clays are common in Nigeria and are generally suitable for brick making. Most of the clays, after beneficiation, can be used for making ceramic wares. Kaolinitic clay can be used for fillers, extenders and carriers in paints, rubber, plastic, textile and paper industries. Pure kaolin is used for drugs such as mist kaolin and also sought after for making high quality chinawares and in serving as carriers for insecticides. Montmorillonitic clays are useful as drilling mud in oil and water well drilling and also used for bleaching vegetable oil.

For manufacturing of glass which is a super cooled liquid in which extremely high viscosity has prevented the ordering of ions into crystal lattices, the principal source rocks are glass sands, quartz sands, sandstone with silica cement and quartzite. Oluwa Glass in Ondo State is a good example where glass sands are used.

The coal resources of Nigeria are very large. The proven coal reserve is 639 million tons with inferred reserves up to 2.75 billion metric tones (Rahaman, 2004). Eighteen (18) deposits and occurrences of coal spread through about ten States of the Federation (Adekoya, 1999). Analysis of some Nigerian coals indicate that they are sub-bituminous (black coal), low in sulphur and moderate in ash content (7.0-10.0%). This low sulphur and tolerable ash content make Nigerian coals acceptable and attractive in international market.

Reserves of 320 million tons of lignite (brown coal) have been estimated from preliminary investigations and detailed work has proved about 71.12 million tons in the Obomkpa and Ogwashi Asaba area (Adekoya, 1999). Coal as a fossil fuel can provide the energy required to drive the national economy. The energy is used to power most engines and other devices ranging from electricity

generating plants, industrial plants and machinery. Part of the energy is also required to generate heat for cooking. Lignite has a good potential to support several industries such as manufacture of fertilizer.

Bitumen or tar sands occur in a 120km long east-west belt stretching from east of Ijebu-Ode in Ogun State to the western margin of Edo State and with an average N-S outcrop width of 5km (Adekoya, 1999; Rahaman, 2004). Huge reserves have been proven in this belt. Bitumen is a versatile resource which is capable of producing heavy crude oils which can be refined to obtain large quantities of diesel, fuel oil, lube oil, asphalt, pitch and small amounts of motor spirits. Research has shown that sulphur, phenol, ammonia, nickel and vanadium are recoverable as by products of refining the heavy oils derivable from bitumen (Ekweozor, 1990).

Diatomite which can be regarded as a minor, white rock composed entirely of the siliceous shells of microscopic organisms called diatoms or simply called consolidated diatomaceous earth is used as an abrasive and also in filtration. Table 4 gives a summary of the products, sources and desirable properties of different rocks.

Table 4: Summary of the products, sources and desirable properties of different rocks (Watson, 1983)

Product	Sources	Desirable properties
Dimension stone	Limestone, sandstone, granite, other igneous rocks. Ornamental stone includes limestone, marble, tufa, granite, syenite etc.	Regular, widely spaced partings (bedding, joints), high compressive strength, resistance to weathering, especially in industrial regions
Slate	Strongly cleaved fine -grained metamorphic rocks, usually of politic composition, locally pyroclastic	Regular, closely spaced cleavage, resistance to weathering
Roadstone	Crushed basalt, dolerite, fine granite, greywacke, quartzite, hornfels, flints etc., industrial waste in combination with bitumen	Resistance to abrasion (massive, fine to medium grain size), low porosity, binds well with bitumen, non -slip surface, does not acquire polish
Aggregate (for concrete and as fill for road and building foundations, dams)	Sand and gravel (fluvial, glacial, marine), crushed rock as for roadstone, industrial waste	Appropriate range of particles sizes, low contents of impurities, especially sulphides, organic matter, coal, micaceous rocks, opal, chalcedony
Bricks, tiles	Clay, marine, alluvial, glacial or in deep weathering zones: raw materials fired at high temperatures	No excess water, low irons, sulphides, sulphates $CaCO_3$ > 5% minimizes shrinkages, carbonaceous matter (? 5%) assists firing
Cement	Limestone, argillaceous limestone, often mixed with clay: limestone converted to lime by calcining in kiln, product ground to powder	Constant composition, correct ratios CaO, Al_2O_3, SiO_2, Fe_2O_3, low S, MgO, P, alkalies
Glass	Quartz sand, quartzite	Absence of impurities, low iron
Plaster, plasterboard	Gypsum, anhydrite from evaporites	-
Insulating materials	Fibrous and flaky metamorphic minerals, asbestos, mica, vermiculities: diatomite	Not injurious to health
Bitumen	Residue from distillation of oil: natural residues of oil seepages	Appropriate 'melting' temperature for conditions of use, e.g. in road making

Kimberlites and carbonatites are interesting types of rocks. Kimberlites are volatile-rich ultramafic igneous rocks that contain a variety of minerals, both as phenocrysts and xenocrysts in a finer groundmass. Serpentinized olivine is the principal constituent, with variable amounts of phlogopite, ilmenite, spinel, garnet, orthopyroxene, clinopyroxene and carbonate (calcite). They commonly contain xenoliths of mantle and crustal rocks.

Kimberlites are usually diamond rocks but not all kimberlites are diamondiferous. Kimberlites with diamond pipes occur in places like some parts of southern Africa and Sierra Leone which are typically old cratonic areas.

Carbonatites are of great economic values as associated with them are minerals like REE, Th, Nb, phosphate, calcium carbonate, fluorite, nepheline, Ti and Zr. In addition to this, carbonatittes where they occur help prospectors to delineate areas to explore for diamond. In countries that lack limestones, for example, Uganda in East Africa, carbonatite has been used for cement production.

In discussing the roles played by rocks, the ornamental aspect must come readily to mind. We have just seen that rocks radiate beauty. In Nigeria, the red granite in Kano, the Oke Iho syenite, the Iwo- Osuntedo and Bauchi and Ado-Ekiti-Ikere-Akure charnockitic rocks all exhibit brilliance and beauty and are good for slabs and flooring. Larvikite, which is a special type of syenite, and also anorthosite show radiant display of colours, iridescence, from the labradorite and this certainly makes these rocks sought after for ornamental/decorative purposes.

Mr. Vice-Chancellor Sir, it is an understatement to say that rocks do not contribute greatly to tourism in the world. In many places of the world, rocks constitute tourist attraction from the ranges they form, the scenery they give, beautiful smooth shapes in form of inselbergs in some places (Fig. 13) and even the environments where they are located. In such places the rocks contribute to revenue generation from tourism. Examples in Nigeria include Olumo Rock in Abeokuta, Ado-Ekiti-Ikere-Akure axis, the Younger Granite Complex of Jos Plateau, The Biu and Longuda Plateaux, the Panyam volcanic craters, Bamenda Massif and Obudu Plateau. The stone images kept in Esie Museum in Kwara State were carved from talcose rocks in

the area. In other parts of the world, we have Mount Everest and Mount Kilimanjaro towering well above the surrounding levels.

Canyons which are long gorges or valleys bounded by steep slopes and caves occur in rocks and they usually constitute tourist sites all over the world. The Grand Canyon of the Colorado river within the different rock strata makes/presents one of the world's most awe-inspiring scenic wonders.

Waterfalls result from disposition of rocks whereby a resistant rock underlain downstream by a weaker formation, which is relatively quickly worn down thereby undercutting the resistant bed/rock and steepening the river bed or having the face of the resistant bed/rock becoming vertical making the stream to plunge over the crest or even, in addition, arising as a result of drop from hanging valleys. Among the important falls of the world are Niagara Falls in Canada/USA border. Erin Ijesha Falls in Osun State, Owu Falls in Kwara State

Figure 13a: Inselbergs scenery in Ikere-Ekiti

Figure 13b: Inselbergs scenery in Idanre

Springs, warm springs and geysers are all formed in rocks and they are also sites for tourism in many parts of the world. A local good example is the Ikogosi Warm Spring in Ekiti. Here warm water comes from fractures within the rock quartzite

Mr. Vice-Chancellor Sir, perhaps the most important role played by rocks *viz-a-viz* economic development is that of "repository" of minerals of value. The definition of a rock has previously been given simply as an aggregate of one or more minerals, it therefore means that if there are no rocks there cannot be minerals. In Nigeria, exploration activities have resulted in the discovery of over 60 economic minerals in different rocks in about 450 locations. Thirty-four (34) of these mineral commodities are of various stages of further exploration and exploitation. In general, these minerals which are distributed in almost all the States of the Federation can be divided into six major groups of:

i) Metallic Minerals: about 21 metalliferous minerals have been identified in the country. Examples include cassiterite (tin ore) in the Younger Granites of Jos Plateau of which

Nigeria was one of the leading world's producers, iron ore in the gneisses at Itakpe and Lead/Zinc/Sphalerite in the Cretaceous Sediments of Abakaliki.

ii) Precious Minerals: Gold is in this group. At least there are thirty-one (31) reported gold occurrences in the country. Gold occurs as fine dusts or grains and even nuggets in small quartz veins, quartz stringers, and aplite dykes conformable with or cross-cutting rock types like amphibolites, schists, phyllites, quartzites, gneisses, pegmatites and granites. The Schist Belts of Nigeria are well known for gold mineralization.

iii) Gemstones like aquamarine, emerald, amethyst, beryl, tourmaline occur in pegmatites in Keffi Nasarawa and Ijero among others.

iv) Specialty metals of Tantalite, Columbite, Lithium and Beryllium found in Younger Granites and also in the pegmatites.

v) Mineral fuels and Radioactive minerals like coal, lignite, bitumen (tar sands) discussed previously, uranium, thorium, monazite, xenotime and uraniferous pyrochlore in the Younger Granites and in Mika in Taraba State and Ghuchi in Adamawa State.

Vi) Industrial minerals which can also be sub-divided into:

(a) Chemical subgroup which includes salt, NaCl (brine) as in Benue Trough and Abakaliki sedimentary rocks. The significance of common salt (brine or halite), trona (kaun), phosphates and rock salt, $CaSO_4.2H_2O$ (gypsum) which are all evaporites (chemical sedimentary rocks) cannot be over-emphasized.

(b) Metallurgical and refractory subgroup including marble, limestone, dolomite, refractory clays, fluorspar.

(c) Abrasives subgroup including corundum, quartz sand, diatomite as mentioned before, monazite.

(d) Other industrial and manufacturing subgroups which include asbestos found in serpentinite at Shemi and Mallam Tanko (Adekoya, 1999), talc from talcose rock/talc schist, barites, ($BaSO_4$), gypsum.

(e) Dimension stone subgroup. This has been discussed previously.

See Table 5 for Inventory of some Minerals in Nigeria and 1996 NIMAMOP Preliminary Market Assessment of some Economic Minerals (Elueze, 1998).

TABLE 5: INVENTORY OF SOME MINERALS IN NIGERIA AND 1996 IMAMOP PRELIMINARY MARKET ASSESSMENT OF SOME ECONOMIC MINERALS (ELUEZE, 1998)

Minerals	Uses	Annual Demand (Tons)	Local Value (Naira/Ton)	International Value (US$/Ton)
1. Ore Minerals				
a) Precious Metals				
Gold	Ornamental			
Silver	Iron and Steel Alloy			
Cadmium				
b) Non-Ferrous				
Cuprite (CU_2O)	Ore of copper, ornamental			
Chalcopyrite ($CUFeS_2$)	Ore of copper, ornamental			
Galena (PbS)	Ore of lead, accumulator			
Sphalerite (ZnS)	Ore of zinc, galvanizing			
Cassiterite (SnO_2)	Ore of tin, canning, steel			
Pyrolusite (MnO_2)	Ore of manganese, steel			
Pentlandite (NIS)	Ore nickel, steel, alloy			
Rutile (TiO_2)	Ore of titanium, steel, alloy	60,000-80,000		85-700
c) Ferrous				
Magnetite (Fe_3O_4)	Iron ore, Iron and Steel		3,000	30-50
Hematite (Fe_2O_3)				
Geothite ($Fe_2O_3.H_2O$)				
Siderite ($FeCO_3$)				
2. Industrial Minerals:				
Silica (SiO_2)	Electronics			
Mica	Electronics			
Barytes	Chemicals, Drilling mud	100,000-225,000		
Flourspar (CaF_2)	Chemicals			
Asbestos	Insulators			
Magnesite	Insulators			
Sillimanite	Refractories			
Graphite	Refractories			
Garnets	Gemstone			
Beryl	Gemstone			
Silica Sands	Abrasives	180,000-2,000,000		
Gypsum	Retarder, Plaster of Paris	150,000-300,000		
Kaolin	Chinaware, Filler	150,000		
Bentonite	Drilling Mud, Bleaching	60,000-80,000		

Feldspar		60,000 100,000		250-500
Diatomite	Abrasive, Filtration			
Talc	Chemicals	50,000-100,000	9,000	50-250
Phosphate	Chemicals	200,000-300,000	4,400	24-25
Salt		300,000-500,000		6-7
Soda Ash		50,000-60,000	7,000	105-115
3. Energy Resources:				
Uraninite (UO_2)	Mineral Fuels/Nuclear/Radioactive Minerals			
Thorite ($ThSiO_4$)				
Thorianite ($ThO_2.U_3O_8$)				
Bitumen	Fossil Fuels			
Lignite				
Coal				
Petroleum*		*2.2 million barrels/day	**N10,200/barrel	About $85/barrel now
Natural Gas*		* 4 bcf/day	**N708/Mcf	About *$5.9/Mcf

**Source: Nwachukwu (2007); **At the rate of N120 for 1 US$*

Even water which can be regarded as mineral for the purpose of this lecture is contained in the rocks. As stated by Ako (1996), water is one of the most important but often assured to be always and even available mineral. No wonder we drill boreholes into rocks and obtain good water. The Lord commanded Moses to strike the rock at Horeb (Exodus 17:1-16) for water to come out for Israelites to drink and it was certainly so even though it is totally believed and accepted that our Lord could make it from anything. Praise be to Him. With all the above we have seen that rocks are, indeed, very useful and that their roles as resources for development are inexhaustible.

8. MY CONTRIBUTIONS TO RESEARCH AND MANPOWER DEVELOPMENT

My career as a geologist commenced in 1972 after obtaining my first degree from University of Ibadan. I joined the Geological Survey Department (now the Nigerian Geological Survey Agency) in the erstwhile Federal Ministry of Mines and Power as Geologist Grade II. As a career geologist, I was engaged in geological mapping of an area of about 3,000km^2 on the scale of 1:100,000, Sheet 126, Ririwai. Before this time the expatriate geologists have mapped the Younger Granite ring complexes in the Sheet. This was driven by the Colonial interest in mineral exploration as some of the Younger Granites in the Sheet have minerals of economic value. My assignment was then to map the Basement Complex in the area. I successfully completed the mapping and produced the geological map of the area in 1975 and thus became the first Nigerian Geologist to work on the Basement Complex rocks of the region. The work was used as research and it earned me an M.Sc. in Geology (Olarewaju, 1976, 1978). This singular feat marked the beginning of my journey into the world of academics as I thereafter joined the services of Geology Department. Ahmadu Bello University, Zaria, as an Assistant Lecturer. I was attracted to the Geology Department of the then University of Ife (now Obafemi Awolowo university) by the strong team of both my former teacher, Prof. M. A. Rahaman, and other very senior colleagues and could not resist the attraction and therefore had to transfer my services to Ife in 1976. I have been at Ife since that time which is thirty-one (31) years now.

It has, indeed, been a rewarding, worthwhile experience at Ife. For the past three decades I have focused my research contributions on the petrology, mineralogy and geochemistry of the Older Granites and the

charnockitic rocks with emphasis on their occurrence, relationships and petrogenetic considerations (Olarewaju and Rahaman, 1982). I have been opportuned to visit and carry out analyses on rocks in many laboratories in countries like United Kingdom, Germany, Italy and France. As at 1981, I have geochemically analysed 150 samples of charnockitic and granitic rocks from Ado- Ikere- Akure axis (Olarewaju, 1981). This was the first time so much data would be generated on so many samples of Nigerian rocks as prior to this time analysis on only a few number of samples was done and published any where in the country. I have also carried out microprobe and fluid inclusion studies for the first time on these rocks and others (Olarewaju, 1998; 1999; Olarewaju and Ajayi, 1993; Olarewaju and Rahaman, 1999).

From the mapping of the granitic and charnockitic rocks I have been able to give detailed petrological descriptions and to establish a general chronology based on the field relationships. Geochemical and mineralogical (microprobe) analyses have enabled the development of a model for the Charnockite-Granite close association in some parts of Nigeria and have also helped to provide information on the conditions that operated during the emplacement of these rocks during the Pan-African Orogeny (Olarewaju, 1982, 1987, 1988a, 1988b, 1998, 2004). I have contributed to the first multidisciplinary approach to the study of origin of Esie (Kwara State) soapstone (talcose rock) sculptures using petrological and mineralogical studies combined with Particle Induced Xray Emission (PIXE) spectroscopy (Olabanji *et al.*, 1990). In collaboration with other colleagues, I have also been able to apply my geochemical knowledge to the quality assessment of groundwater and also combine my petrological knowledge with geophysical studies in investigation of a fault zone on Hill 1 at Obafemi Awolowo University here and

in the interpretation of aeromagnetic data in addition to contribution to prediction of groundwater yield in the basement Complex areas (Olorunfemi *et al.*, 1986; 1991; Aina and Olarewaju, 1992; Olarewaju *et al*, 1997).

I have therefore both individually and in collaboration with other colleagues in the Petrology Team made up of Prof. Rahaman and Dr. Ocan contributed significantly to our present knowledge of the Precambrian Basement Complex rocks of Nigerian by my research efforts on the Mineralogy/Petrology and Geochemistry. I have also contributed both singly and jointly with others to technical reports on various projects in my profession as Consultant Geologist. I am currently one of the Resource Persons for the NGSA engaged in supervision of the geologists in techniques of mapping and geological map production. Field manuals and training guides have been produced for use in this national assignment (Rahaman *et al.*, 2005a, 2005b and 2005c).

Mr. Vice-Chancellor Sir, the primary duty of an academic is the training of students both at the undergraduate and postgraduate levels following meaningful and relevant research activities. In my three decades as an academic staff of various levels in this great University, I have contributed in the training of close to one thousand graduates many of who are occupying important positions in both the private and public sectors today. In higher institutions at least two of the students I taught are professors now. I have supervised many B.Sc. Theses in the Department. One of the B.Sc. theses supervised by me shared a prize of the prestigious NMGS Award in 2000. At the postgraduate level, I have trained and supervised successfully M.Sc. theses. I am currently a co-supervisor for two (2) Ph.D. candidates and supervisor for another M.Sc. Student. I have been external examiner for undergraduate B.Sc. Courses and Postgraduate M.Sc. and Ph.D. studies in

many Universities.

I have served and I am still serving the University community in various capacities. I have been Acting Head of Geology Department for two years during which the Department hosted successfully well attended international conference of the Nigerian Mining and Geosciences Society (NMGS). I have also been Vice Dean of Faculty of Science in the past. My service also includes membership of various Departmental and Senate Committees and currently, by the Grace of God, I am the Dean, Faculty of Science, the largest Faculty in this great University.

RECOMMENDATIONS

The Vice-Chancellor Sir, I have shown in the course of this lecture that Nigeria is wonderfully endowed with natural resources of rocks that are not only beautiful but are of great economic potential. As it is usual on an occasion of this nature to make some recommendations based on one's experience and findings which I believe will be useful, I wish to make the following well thought and expedient suggestions:

1). On the basis of the petrography, physical appraisals of density, strength, porosity and polishing tone, many of the Basement Complex rocks in Nigeria like the granites, gabbros, charnockites, dolerites, syenites and even some of the gneisses have good promise and prospects to be utilized for polished items and ornamental stones. Nigeria therefore has no reason relying mainly on petroleum for her to earn foreign exchange when these rock resources can be properly exploited and marketed. There must be awareness of investment opportunities in rock polishing or ornamental industry following sound information

and appropriate data from reliable geological mapping and delineation of locations of these rock types.

2). Quarry and Crushing industry can be established in more locations in the country especially in South west where large bodies of these rocks occur. Many States like Osun, Ekiti, Ondo, Oyo, Ogun and Kwara need to consider this as it will constitute cheap source of materials for building and construction purposes. Even in this University Sir, we have Hills 1, 2 and 3 which could huge resources for quarrying and rock polishing industry. With proper establishment and management of this venture, Mr. Vice-Chancellor Sir, we will be very buoyant financially and close to being self sufficient.

3). Rocks harbour solid minerals making it possible for Nigeria to be blessed with over sixty (60) economic minerals comprising twenty-one (21) metalliferous minerals and thirty-nine (39) nonmetallic or industrial minerals including petroleum. These minerals are so widely distributed within the rocks and there is hardly any Local Government that does not have a mineral resource that can be developed. We need intelligent and prudent exploitation of our mineral resources to create more national wealth and have veritable basis for effective industrialization of the country which will provide hope and jobs for the populace and open up remote and rural areas of the country.

4). It is a wise thing to invest the huge revenue derived from petroleum on the development of solid

minerals that are more widespread in Nigeria as the development of this sector is definitely a stronger base than oil for the industrial take off of the country. Nigeria, which we like to refer to as the Giant of Africa, stands the risk of becoming a beggar nation if today much cheaper sources of energy are embraced and improved upon by our buyers of petroleum.

5). If we must find all our treasures that are hidden in the rocks, then the Federal Government must ensure a speedy geological mapping of the whole country on larger scales. The present pace of mapping is too slow. The Nigerian Geological Survey Agency (NGSA) must be well funded to carry out its statutory duties. All geologists produced in the country should henceforth be fully employed by NGSA to carry out a lot more aggressive mapping of the country. This will stop the current trend of having geologists working as bankers, coke sellers, air hostesses and so on. Your answer is as good as mine if we ask what rocks these people are mapping in the bank, coca-cola depots or in the air? This is certainly a waste of geoscientists.

6). I suggest the re-establishment of NGSA state Offices to pave way for a more realistic collection of information and data on rocks and minerals of individual states. A situation where any State will not have NGSA base or office is not good enough as NGSA office is usually, the first place of call for anybody that needs/wants information on investment in solid minerals. Having offices in all States, in addition, brings NGSA closer to grassroots people who at times act as even pathfinders in

mineral exploration. NGSA should rather be asking for more funds to be able to maintain offices in all States of the Federation.

7). Each Local Government must be mandated to employ at least a geologist to coordinate information from time to time in the locality with respect to exploration and exploitation of mineral resources and liaise accordingly with the State Office of NGSA.

8). Appointment of a Geoscientist to Head Ministry that concerns solid minerals is advocated rather than having a lawyer or an accountant. This ensures putting a round peg in a round hole and not a square one in a round hole or vice versa. A geoscientist will always have an advantage of drawing a relevant road map and following it faithfully for the benefit of all. This will help minimize the corruption and inefficiency that go on and which are presently making revenue from solid minerals poor. With the prudent management of revenue that can be generated from solid mineral sector there will be better standard of living for the citizenry. We should always remember that when a mineral deposit is mined out in a place it is gone for ever and this is why "high prudence" are the key words.

9). The greatest problem facing the Nation now is that of electrical power outage/shortage. It is desirable now more than any other time to review our national energy policy with a view to seeing to the possibility of using our abundant coal resources to generate power. Happily, the present Government is very serious and is prepared to face this problem with sincerity it deserves. Nigeria has over 650 million

tons of proven reserves of coal distributed over sixteen (16) States. In the whole world coal contributes about 70%to power generation. South Africa is a good example where they don't have oil and even produce oil from their coal in addition to its other uses. Almost 90% of the electricity generated here is from coal and even USA generates about 50% of her electricity from coal. In our country, coal should contribute at least 30% to the power generation mix. The development and revitalization of the Nigerian Coal Industry should be the Government's priority now. What was stated in an article in PUNCH Newspaper of 18th October, 2007, Page 29, to emphasize the coal option is reproduced thus "Since Nigeria has the capacity to generate about 10,000MW of electricity through coal, if the industry is fully tapped into, it will be a win-win situation for our country". The shortage of coal mining engineers must be urgently looked into.

10). In order to enhance solid mineral development in the country, the Federal Government must fund adequately researches in our Universities which focus on peculiar characteristics of our mineral deposits and ways of upgrading their qualities so that they can attract good prices worldwide. Funds must be made available for Departments of Geology in the country to purchase research equipment like microscopes, ore microscopes, microprobe machines and analytical facilities like AAS, XRF among others as all these are relevant for meaningful mineral exploration. Mineral exploration is capital intensive but in many cases the end justifies the means. In addition, well equipped laboratories are needed for proper and thorough training of geologists.

11). There is a serious dearth of petrologists in the nation and something must be done to halt the dangerous trend. People no longer want to study rocks. No wonder we have very few number of PG students all over the country in this aspect of Geology compared to other areas people erroneously think and believe can make quick money by specializing in them.

The truth of the matter is whether or not we like it, there cannot be proper understanding of any geological investigation without a good grasp of petrology since all data on earth are on rocks. People must be encouraged by giving incentives in form of scholarships and grants in this seemingly dying area of geology which indeed, could be regarded as "father" of all other aspects of the subject. There must be availability of the relevant facilities mentioned earlier. A situation where some Departments of Geology graduate students without microscopes and proper field training is certainly not acceptable, and it gladdens the heart that COMEG is looking into this.

10. CONCLUDING REMARKS

Mr. Vice-Chancellor Sir, in the course of this inaugural lecture, I have been able to illuminate our thoughts on the beauty and language of rocks and the important and crucial roles these resources play in economic development of the nation. I have also shown that we are highly blessed in this country with enormous rock resources and that proper harnessing of these resources is the key to a sustainable development which can eventually usher in a better and improved standard of living for the citizenry.

I have also highlighted my contributions in the areas

of petrology, mineralogy, geochemistry and other collaborative works and I have given suggestions and recommendations based on my experience and findings which I believe will go a long way in helping in the effective utilization of our rock resources. However, it is important to note that the totality of our lives is dominated and controlled either by minerals (which are contained in the rocks) or the need of them. They surely play important roles in our everyday life, starting from the houses we live in that are made of cement blocks which are products of limestone, gypsum, clays and sand to cooking pots, chinaware, cars we drive, wristwatches, earrings, necklaces and pendants and to even the powder applied on faces to mention a few. For this reason, I would like to stand the risk of making geologists out of many of us here just like the Great Apostle Paul in Acts of Apostles Chapter 26 Verses 1 to 28 almost made a Christian out of King Agrippa (Vs. 28) by his great conviction of faith and presentation of Gospel to the King and the others with him.

On this task, my own is a simple advice to everybody and this is as follows: When next you come across any rock, don't just walk over but stop and study the rock by simply following these ten (10) steps and answering the questions. Your wealth and what you need may be in that rock. These are:

- What is the nature of the rock and how is it exposed?
- How many rock types can I observe in the location?
- What is the extent?
- What is the colour of the rock?
- What is the texture?
- What structure can I observe?
- What are the minerals contained in the rock?
- What is the name of the rock?
- What is the geologic history?

- Of what economic use can the rock be?

What else can be so simple and interesting? Good luck as you continue to look at and study rocks from tomorrow because it is already dark today.

Mr. Vice-Chancellor Sir, please permit me to express my gratitude to those who God has used to do great things in my life and to be able to make the modest achievements thus far.

First and foremost, I give glory to the Almighty God for knowledge, wisdom, understanding and good health which have enabled me to reach the top of my career and for making today a reality. I owe my late parents, Pa Ige Olarewaju and Mama Ebe Ige Olarewaju, a debt of gratitude for realizing the value of education and allowing me to go to school, even then as the only boy in the family, and with meager resources at their disposal. May their souls rest in perfect peace (Amen).

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I am equally grateful to members of my nuclear family, particular my wife and children for standing by me all along. I like to express my gratitude to both the Obafemi Awolowo University as well as the Federal Government of Nigeria for the beautiful environment to work and for sponsorship for my Ph.D.

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