

UNIVERSITY OF PORT HARCOURT

**NIGERIA'S HIDDEN TREASURES:
OUR UNTAPPED INHERITANCE**

AN INAUGURAL LECTURE

By

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DEDICATION

This work is dedicated to God Almighty, my late mother (Mrs Esther Uzoaru Ukaegbu), and Chief Sunday Ikechukwu Okpanta.

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Mr Vice-Chancellor, Sir, let me begin with an expression of gratitude to the Almighty God for His unfailing love, protection and favour in my life. My sincere gratitude goes to the University for providing me with a conducive environment to reach the peak of my career as a Professor of Geology. My Late mother, Mrs Esther Uzoaru Ukaegbu, was second to none. She was the best a mother could be and she gave it all and filled up the gap of the early loss of my father. She made me believe it was possible to be the best I could be in life. She was a mentor and a worthy role model.

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Mr Nnadi, Chief Land Officer at Land Office, Orlu, for seven months, who insisted I must leave civil service for University admission and my roommates in Hall 1 Room E4 (now Jaja Hall),

Delta Park, Rt. Rev. Collins Ikonne and Chief G. O. C. Mmom, whose son is a Professor in this University, who guided and counselled me, are highly appreciated. Pastor R.O. Mbah and Professors Gbenga Okunlola, E. N. Onyeike, Dulu Appah, Steve Okodudu and Prince O. Asagba epitomize Prov. 18:24b that says *there is a friend that sticketh closer than a brother*; they are friends indeed! Bishop and Rev (Mrs) Isaac Crown, Pastor I.I. Jonathan, Pastor Grant Alubari, Pastor Royland Aliche, Prof. John Oyegun and Pastor Jesubumi Adisa are wonderful spiritual mentors and I appreciate their impacts upon my life.

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I appreciate Dr F.T. Beka, Prof. G.J. Udom, Dr A.C. Tse, Dr J. I. Nwosu, Dr Sylvester Ugwu, Dr Nnamdi Ekeocha, Dr Hycienth O. Nwankwoala, Dr N. Egesi, Dr Kingsley Okengwu, Dr J. N. Onwualu, Dr Selegba Abrakasa, Dr Richmond Udeozu, Dr Edward

Acra Jones, Dr Charles Uwueze, Dr Ferdinand Giadom, Mrs Fortune Nwokocha, Diepiriye C. Okujagu, Mrs Philemena Amadi, Kingsley Worlu, Christopher Nwogu, Mrs Patience Obi, Mr Richard and other members of staff of the Department of Geology, Faculty of Science , as well as the larger University community for their impact in my life..

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ORDER OF PROCEEDINGS

2.45P.M. GUESTS ARE SEATED

3.00P.M. ACADEMIC PROCESSION BEGINS

The procession shall enter the Ebitimi Banigo Auditorium, University Park, and the Congregation shall stand as the procession enters the hall in the following order:

ACADEMIC OFFICER

PROFESSORS

DEANS OF FACULTIES/SCHOOLS

DEAN, SCHOOL OF GRADUATE STUDIES

PROVOST, COLLEGE OF HEALTH SCIENCES

LECTURER

REGISTRAR

DEPUTY VICE-CHANCELLOR [ACADEMIC]

DEPUTY VICE-CHANCELLOR [ADMINISTRATION]

VICE CHANCELLOR

After the Vice-Chancellor has ascended the dais, the congregation shall remain standing for the University of Port Harcourt Anthem.

The congregation shall thereafter resume their seats.

THE VICE-CHANCELLOR'S OPENING REMARKS.

The Registrar shall rise, cap and invite the Vice-Chancellor to make the opening Remarks.

THE VICE-CHANCELLOR SHALL THEN RISE, CAP AND MAKE HIS OPENING REMARKS AND RESUME HIS SEAT.

THE INAUGURAL LECTURE

The Registrar shall rise, cap, invite the Vice-Chancellor to make his opening remarks and introduce the Lecturer.

The Lecturer shall remain standing during the Introduction. The Lecturer shall step on the rostrum, cap and deliver his Inaugural Lecture. After the lectures, he shall step towards the Vice-Chancellor, cap and deliver a copy of the Inaugural Lecture to the Vice-Chancellor and resume his seat. The Vice-Chancellor shall present the document to the Registrar.

CLOSING

The Registrar shall rise, cap and invite the Vice-Chancellor to make his Closing Remarks.

THE VICE-CHANCELLOR'S CLOSING REMARKS.

The Vice-Chancellor shall then rise, cap and make his Closing Remarks. The Congregation shall rise for the University of Port Harcourt Anthem and remain standing as the Academic [Honour] Procession retreats in the following order:

VICE CHANCELLOR

DEPUTY VICE-CHANCELLOR [ADMINISTRATION]

DEPUTY VICE-CHANCELLOR [ACADEMIC]

REGISTRAR

LECTURER

PROVOST, COLLEGE OF HEALTH SCIENCES

DEAN, SCHOOL OF GRADUATE STUDIES

DEANS OF FACULTIES/SCHOOLS

PROFESSORS

ACADEMIC OFFICER

PROTOCOLS

- ❖ The Vice-Chancellor
- ❖ Previous Vice-Chancellors
- ❖ Deputy Vice-Chancellors (Admin and Academic)
- ❖ Previous Deputy Vice-Chancellors
- ❖ Members of the Governing Council
- ❖ Principal Officers of the University
- ❖ Provost, College of Health Sciences
- ❖ Dean, Graduate School
- ❖ Deans of Faculties
- ❖ Heads of Departments
- ❖ Distinguished Professors
- ❖ Directors of Institutes and Units
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- ❖ Esteemed Administrative Staff
- ❖ Captains of Industries
- ❖ Cherished Friends and Guests
- ❖ Unique Students of UNIPORT
- ❖ Members of the Press
- ❖ Distinguished Ladies and Gentlemen.

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1. INTRODUCTION

Mr Vice-Chancellor, Sir, I am greatly humbled and honoured by this opportunity to present the 151st Inaugural Lecture of the University. I have a unique sense of fulfilment as I stand here to render account of my experiences, views and contributions in my research areas (mineralogy, petrology and exploration geology). No doubt, I have been immensely enriched by the earlier Inaugural Lectures and to maintain the tradition of these unique lectures, I will try to minimize the use of technical language. I have consciously titled my lecture, *Nigeria's Hidden Treasures: Our Untapped Inheritance* to draw attention to the valuable treasures we are bestowed with as a nation but which, paradoxically, we have left as untapped inheritance. It is my hope and prayer that my lecture this afternoon will contribute in giving us reason as a nation to think of new ways of doing business.

Mr Vice-Chancellor, Sir, the Earth, on which we live, is one of the several planets that orbit the Sun (Fig. 1). The Sun itself is a star, and indeed, the smallest star, some 148,000,000 km away from us. As a matter of fact, the nearest star to us after the Sun, referred to as Alpha Centauri, is about 4.37 billion light-years away from us. Note that light travels about 300,000 km per sec. This explains why the Sun appears bigger than the other stars. The Sun and the planets with their satellites (moons) constitute what is referred to as the Solar System.



Fig. 1: The Solar System

123rf.com

The Solar System itself is one of several billions of systems bonded together by gravitational force to form a Galaxy. Our own galaxy is referred to as the Milky Way Galaxy (the chain of stars seen in a clear dark night). This galaxy is one of the hundreds of billions of galaxies that form the Universe. Thus, indeed, the Earth is an insignificant speck of dust in the universe. If the Earth is as small as a speck of dust compared to the size of the universe, then the size of any human being living on this Earth is, in every sense, negligible. However, in spite of our negligible sizes, God has graciously given us the brain and power to understand our environment.

Mr Vice-Chancellor, Sir, the Earth is our environment and it remains the best hope for our habitation with its friendly conditions, which support life with abundant water, oxygen and natural resources. In the recent past, explorations have been done on the planet, Mars, and the moon, to find out if there are evidences to show that they can support life as the Earth does. There has been growing fear that with the rate the Earth is presently polluted and heated up (global warming), it may become inhabitable if not controlled. Thus, not long ago, Scientists, using Spitzer Space Telescope of the National Aeronautics Space Agency (NASA), revealed 7Earth-size planets with water, and 3 of them particularly have the highest chances of supporting life, because they are firmly located in a habitable-zone, around a single star outside our Solar System, about 56 trillion kilometres away. Perhaps, the Americans, the Russians and other Europeans will soon leave the planet Earth. But before they leave the Earth for us, the human race still needs to constantly study and explore the Earth for resources that can provide the basic needs of life. This is where geology comes in.

2. GEOLOGY

2.1 What is Geology? The word, Geology, is derived from two Greek words, *geo* meaning Earth and *logos* meaning *study or science of*. It is therefore the study of the Earth. In general, a geologist studies the Earth to:

- (a) understand its nature, origin, age and history;
- (b) know its composition (chemical and mineralogical);

- (c) know its structure and the processes operational within it;
- (d) know the consequences of these processes such as Earthquakes, volcanoes and to mitigate the effects of natural disasters, and
- (e) discover life-improving natural resources..

There are several branches of geology from which a geologist can choose to specialize in. The area of the study determines the area of geology he specializes. It can be basic geology, which includes crystallography, mineralogy, petrology, geochronology, volcanology, geomorphology, structural geology, sedimentology, paleontology and stratigraphy, or applied geology such as engineering geology, hydrogeology, marine geology, petroleum geology, seismology, environmental geology, economic geology, geochemistry, geophysics, among others.

2.2 Geology in the Field

In carrying out this mandate, we study geology in the classroom/office, laboratory and field. The field component is the soul of geology though it is expensive and laced with challenges but it gives the geologist an opportunity to interact with rocks in their natural domain (Plate 1).



Plate 1. M.Sc. students on geological field mapping at Igarra. Read (1952) recognized the importance of fieldwork when he said *The best geologist is he who has seen most rocks.*

Therefore, we move our students every year to the field because geologists are made in the field and not in the classrooms or offices. To underscore how important field mapping is for the training of a geologist, in 2008, Exxon/Mobil sponsored sixteen of us, selected from Departments of Geology across the Nigerian Universities for a workshop in Benin City to brainstorm on how to standardize geological field mapping in Nigeria. We published a standard textbook on Field Mapping after the workshop. Copies of the field mapping textbook were sent to all Departments of Geology in Nigeria.

As a matter of standard, our regulatory body, the Council of Mining Engineers and Geoscientists (COMEG), stipulates that a B.Sc. student should be trained in the field for 100 days before graduation. That is why field vehicles are very important for Departments of Geology.

2.3 The Internal Structure of the Earth

From geology, we have been able to know the nature of the internal structure of the Earth; that it is a spherical body of approximately 6,400 km radius. Suppose the Earth is cut into two equal halves, the inside would be similar to the inside of an apple cut into two halves (Fig. 2).

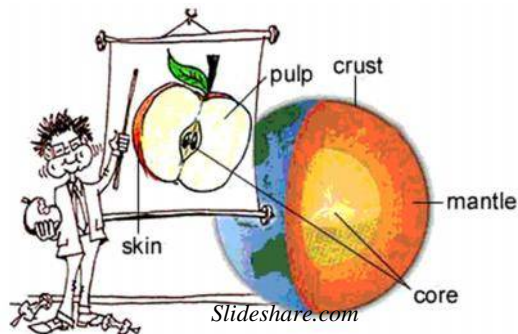


Fig 2: Cartoon of a geologist studying the Earth

Just like the inside of the apple reveals that it has three layers (core with seed, middle pulp and outer skin), the inside of the Earth also reveals that it has three layers (innermost layer called *core*, 3,450 km thick; middle layer called *mantle*, 2,900 km thick and outer skin called *crust*, 8-7 km thick). Each of these layers has different composition, temperature, pressure and density. Seismic waves in geophysical studies help us to have this understanding about the internal structure of the earth.

However, of interest in this lecture is the middle layer, the *mantle*, which is further subdivided into *upper*, *middle* and *lower mantle*. The middle *mantle*, referred to as *asthenosphere*, is semi-plastic and weak. The solid upper *mantle* and the *crust*, which lie on the weak and semi-plastic *asthenosphere*, are referred to as the *lithosphere*. This arrangement creates instability and generates motion of the lithosphere, which results in splitting of the original single solid Earth into the lithospheric plates and drifting of these plates.

2.4 Pangea and Plate Tectonics

The original single solid Earth or supercontinent is referred to as *Pangea* (Fig. 3). It was surrounded by a primitive ocean or super-ocean, referred to as *Panthalassan Ocean*. This ocean occupied over 70% of the Earth's surface. When the lithosphere started drifting, the *Pangea* split into two lithospheric plates: a northward-moving, *Laurasia*, and a southward-moving, *Gondwanaland*, and a part of the *Panthalassan Ocean* formed a new ocean, *Tethys Ocean* or *Tethys Sea* or *Neotethys*, between these two continents. The lithosphere, at present, has split into seven major plates: African, North American, South American, Eurasia, Pacific, Indian-Australian and Antarctic plates, and several minor plates. We can demonstrate that the different plates we have now were once together, by looking at their coastal fitness (Fig.4), among others.



Fig.3 Break up of Pangea occurred 250 million years ago

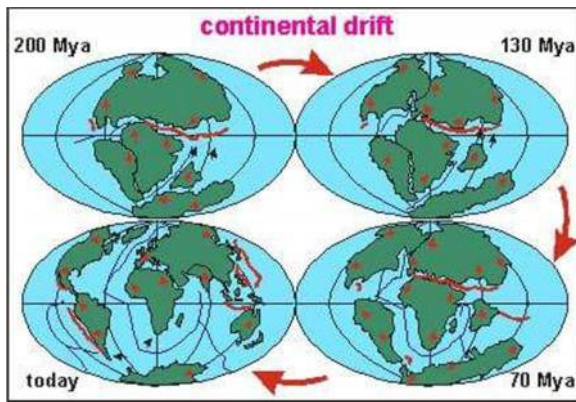


Fig. 4. Continental drift of the Earth, showing positions of the different plates from about 200 Ma to the present

2.5 Plate Tectonics, Earth Resources and Human Development

Mr Vice-Chancellor, Sir, these movements were followed by reconfiguration of the Earth, development of basins, fold mountain ranges, subduction zones (where metallic minerals form), distribution and redistribution of Earth resources, and development of life on Earth. The movements of the lithospheric plates are in three ways: two plates can move towards each other or away from each other or slides pass each other. Also, as a result of these activities, different life forms have appeared and disappeared over time.

Some 3 million years ago, humans fashioned stone and wooden tools essentially for hunting and defence from predators. With increase in human population, emphasis on occupation shifted from hunting to agriculture, and the source of energy was essentially raw muscles. The Industrial Revolution of the 17th century saw change of source of energy to *water* and *wind energy (wind mills)*. By the 18th century, high energy industries that needed ores for smelting of metals for production of implements emerged and *coal* subsequently followed as a key energy source as it was converted by external combustion engines (Steam Engine). However, coal was displaced by *petroleum* as the leading source of energy with the invention of the internal combustion engine.

At present, high energy sources such as nuclear and solar energy are gaining ground in using metals, minerals, rocks and other Earth materials for the development and production of industrial plants and machines, and high rise buildings. With the emergence of high energy industries (coal, oil and gas), ores, especially iron ores, were used for smelting of metals for production of implements, tools and other metal products. It therefore became imperative that geology took the centre stage of advancement and development by constantly striving to locate the needed Earth materials for industries.

The wealth enjoyed by nations of the world today and the comfort and lifestyle displayed by people across the world depend largely on the mineral resources available in their countries. The knowledge of the composition of the Earth resources and the right technical knowledge and tools, have helped the geologist to develop the competence to explore, locate and assess these minerals and rocks, and if economically viable are recommended for exploitation.

The exponential increase in demand for better standard and quality of life by a rapidly growing world population has resulted in a corresponding ever increasing need for massive exploitation and supply of these materials to the world market. We are in constant search for how to meet our ever changing needs in our natural dynamic environment (Ukaegbu, 1999). Thus, in cases of depletion

of some of these resources, the world frantically searches for new reserves, recycling reserves and, in many cases, employing new technology in hitherto economically unattractive resources, such as is done in shale in USA.

If you look first around this auditorium, those window glasses, iron pillars, the floor, columns, the sensors of the microphone, the projector, the cameras, and secondly at ourselves, the necklaces, ear rings, chains and the wedding rings, are direct or indirect geological products.

Geology is very important because God, in His wisdom, stuffed treasures in the Earth for the benefit of mankind, as aptly captured in

Isaiah 45:3

And I will give you the treasures of darkness, and hidden riches of secret places, that you may know that I the Lord which call you by your name, Am The God of Israel”.

After hiding these treasures in the Earth’s bowels, God mandated the kings (geologists) to find them for the rest of humanity, when He said in

Proverbs 25:2

It is the glory of God to conceal a thing: but the honour of kings to search out the matter.

Ekwueme (2006) quoted Coates (1981) who correctly stated that:

The level of society is often measured by the types of usage a nation makes of its own or imported mineral resources. The economic health and sustenance of a government hinge on its ability to distribute effectively the goods that have been manufactured from the mineral industries. Minerals and society are so intertwined as to be inseparable. Thus the geologist has a significant role in assuring a predictable and plentiful supply of minerals.

2.6 What is a Mineral?

The word, *mineral*, is derived from “*minera*”, meaning a specimen of ore, won from mining. The use of the word dates back to the beginning of mining. However, today, the meaning of mineral has

been expanded to include non-ore Earth materials. Thus, currently a mineral is defined as a naturally occurring homogeneous inorganic solid substance with a definable chemical composition and an internal structure characterized by a highly ordered arrangement of atoms, ions, or molecules in a lattice.

Mr Vice-Chancellor, Sir, let me emphasize three points from this definition:

(i) A mineral is naturally-occurring: It is formed by natural processes in or on the Earth surface, and not man-made. All artificial or imitation gems (e.g. diamond or ruby) and other substances that have exactly the same characteristics as minerals are not minerals. Note that natural gems have greater value than those made by man.

(ii) A mineral is inorganic in nature: Compounds like coal and petroleum that are organic are not minerals. However, inorganic substance includes carbon(C), so that pure carbon (graphite or diamond) and calcium carbonate (CaCO_3) are minerals.

(iii). A mineral is solid: A mineral is a solid that can maintain its shape always. Solids have geometric patterns, all of which belong to one of seven crystal systems that characterize minerals. Liquids (like oil or water) and gases are not minerals. So the term, *Solid Mineral* is a misnomer. There are no liquid and gaseous minerals.

Formation of Minerals: Minerals can form by crystallization from magma or sedimentary processes, or are re-crystallized from an existing rock referred to as metamorphic rocks or even still sedimentary processes. The type and nature of the mineral formed depend on the major elements present, temperature, pressure and the chemical environments. Minerals can be identified by combinations of their hardness, form, cleavage, streak, colour, smell, taste, specific gravity, magnetic properties and chemical compositions. There are well over 4000 minerals known to man, but only few of them (quartz, feldspar, mica, amphibole, pyroxene, olivine and calcite) are important and are referred to as rock-forming minerals.

2.7 Rocks

Rocks are naturally formed aggregates of minerals occurring in variable proportions. Rocks are classified as *igneous*, if they crystallize from molten magma; as *metamorphic*, if they recrystallize from pre-existing rocks, or *sedimentary*, if they are formed by processes of denudation. The study of rocks is referred to as *Petrology*. Petrology is derived from two Greek words, *Petros* or *Petre* (meaning Peter or rock) and *logos* (study of).

Mat. 16 vs 18 is instructive.

And I say also unto you, That you are Peter, and upon this rock I will build my church; and the gates of hades shall not prevail against it.

Mineral aggregates form a very strong unit referred to as a rock, which often requires geological hammer and technique to break off a small piece of it, especially igneous or metamorphic rock. Petrology deals with the origin, mode of occurrence, classification and composition of rocks. Samples obtained from the field are prepared and studied with the aid of a special microscope referred to as petrographic microscope (Plates 2-4).



Plate 2

Plate 3

Plate 4

Plates 2-4: Images of thin sections of the three groups of rocks

Plates 2-4 are images of rocks under the thin section and should be of interest to my colleagues in Fine Arts and Design, who I believe should derive inspiration from these Master Designer's works. The different minerals in Plates 2 and 3, usually three to four in number, are so interlocked and united in a pattern that does not only show the amazing beauty of unity but also strength in unity. Every mineral in

this union (rock) is very important. The unity and closeness are such that even water poured on the rock will run off the rock. If you try to break any part of the rock with bare hand, you get injured. Some rocks can remain intact for millions of years. These are referred to as hard rocks. The minerals in Plate 4, usually less than three in number, also form an assemblage (rock), but their union is loose and weak that they can be broken with bare hands. Water and other fluids can penetrate them easily. We refer to such rocks as soft rocks. This is how the beauty and strength of a rock are expressed in the unity of the minerals it is made up of.

My late senior colleague, Dr I. P. Okonny, who loved field geology a great deal, once rhetorically asked, “*How can I be happy if I am not a geologist?*”

By studying rocks, we know their origin, how they were formed, classify them and discover their hidden wealth.

3. NIGERIA AND ITS ECONOMIC MINERAL AND ROCK RESOURCES

3.1 Geology of Nigeria: Nigeria as product of plate tectonics, is a beneficiary of the development of high lands and basins and distribution of Earth resources. Nigeria can be divided into two rock groups of igneous and metamorphic rocks, which form 50% of the surface area of Nigeria, and sedimentary rocks which form the other 50% (Fig. 5). The igneous and metamorphic rocks form in three basement areas in the North, Southwest and Southeast and the sedimentary rocks in six main basins (Sokoto, Chad, Benue Trough, Bida, Niger Delta, Eastern Dahomey). Precambrian (ancient) igneous and metamorphic rocks form the basement to the younger igneous rock of Jos Plateau and sedimentary basins.

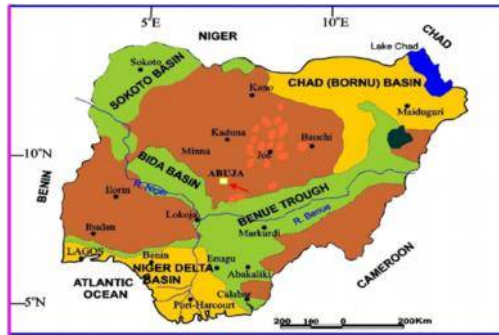


Fig. 5. Geological Map of Nigeria

My research works have been concentrated on the igneous and metamorphic rocks of the Nigerian Basement Complexes, Younger Granites, Benue Trough and the Niger Delta. Works with my Ph.D. supervisors Professors B.N. Ekwueme and M.N. Oti, on the origin and tectonic emplacement of the metamorphic rocks in Obudu Plateau, showed that where the Plateau is now was originally under an ancient ocean basin into which sediments (shales and sands) were deposited and later deformed to form the Plateau, which today is as high as 1.5 km (Ukaegbu *et al.*, 2002a, Ukaegbu and Oti, 2004 and Ukaegbu and Ekwueme, 2005).

In another research, we also found out that the transcontinental fault zone passing from the Middle East through Africa to Brazil created major sutures in Obudu Plateau (Ukaegbu *et al.*, 2002b and Ukaegbu and Oti, 2005). These findings are significant because they aid in exploration activities. Faults and ocean basins control emplacement of Earth resources. In some other works in the Plateau, we mapped the various rocks in the area and carried out mineralogical and textural evaluations of the rocks, and found them to be of high quality and occur in great abundance to meet the needs of the construction industries (Ukaegbu and Ekwueme, 2005; Ukaegbu and Ekwueme, 2006 and Ukaegbu and Ekwueme, 007).

In a work Dr Egesi and I published from his Ph.D programme in Boki area, southwest of Obudu Plateau, we discovered abundance of

rare earth elements (REE) in some of the igneous rocks. These metals are very important in high-tech production activities (Egesi and Ukaegbu, 2010). At present, our Ph.D student is extending the size of the studies in the area to, among other things, evaluate the REE compositions and mineralization in more of the rocks in the area.

3.2 Economic Mineral and Rock Resources of Nigeria: Economic mineral resources are abundant accumulations of one or more minerals, which are economically important and can be mined for the benefit of man. Examples include metals, non-metals and gemstones. Only very few countries of the world can boast of these rare and scarce minerals that are very economically important. Nigeria is one of these few fortunate countries. For instance, there are about 450 locations in this country where at least 44 important minerals and rocks have been found. Nigeria is endowed with different types of high quality rocks, in both the Basement Complex and the sedimentary basins. In the basement unit of northern Nigeria, granites, gneisses, migmatites, schists and quartzites are abundant; in the Southwest basement unit, granites, gneisses, migmatites, marble, schists, quartzite and charnockites are in abundance and in the eastern basement unit, granodiorites, charnockitic rocks, granites, gneisses, schists and quartzites are abundant (Ukaegbu and Okonny, 1998; Ukaegbu, 2003, 2011). Abundant cassiterite (tin), columbite and tantalite occur in the Younger Granites of Jos Plateau. In the sedimentary basins, there are abundant deposits of limestone, sandstones, shales, clay and other economic resources such as petroleum, iron ore, coal, lead-zinc and evaporate (Amajor and Ukaegbu, 2008).

Records from the Federal Ministry of Mines and Steel Development show that every State of Nigeria, including the Federal Capital Territory, is endowed with at least one very important mineral or rock resource (Table 1). The *minerals* include but not limited to iron ore, cassiterite (tin), tantalite, columbite, gold, barite, galena-sphalerite (lead-zinc), diatomite, uranium, salt, phosphates, gemstones and the rock resources include granite, marble, gneiss,

limestone, quartzite, kaolin, charnockite (Fig.6 and Tables 1 and 2). Such energy resources as oil, gas and coal are not included in the tables because they are not minerals or rocks.



Fig. 6: Map of Nigeria showing mineral resources and their locations

Table 1: Mineral and Rock Resources of Nigeria

State	Natural Resources	State	Natural Resources
FCT (Abuja)	Marble, granite, gneiss and tantalite	Kano	Pyrochlore, cassiterite, copper, glass sand, gemstone, lead-zinc, tantalite
Abia	Limestone, iron ore	Katsina	Kaolin, marble and salt
Adamawa	Kaolin, bentonite, gypsum, magnesite, baryte, bauxite, granite, gneiss	Kebbi	Gold
Akwa Ibom	Clay, limestone, lead-zinc, salt, uranium.	Kogi	Iron ore, kaolin, gypsum, feldspar, marble, dolomite, talc, tantalite, kaolin, limestone, gemstone
Anambra	Lead-zinc, clay, limestone, iron ore, salt, glass sand, phosphate, gypsum.	Kwara	Gold, marble, iron ore, cassiterite, columbite, tantalite,, and feldspar and mica in traces.
Bauchi	Amethyst, gypsum, lead-zinc, granite, uranium, gneiss,	Lagos	Glass sand, clay, bitumen, tar sand

	(partially investigated)		
Bayelsa	Clay, partially investigated gypsum, manganese and traces of lead-zinc	<i>Nasarawa</i>	Emerald, aquamarine, dolomite marble, sapphire, tourmaline, quartz, amethyst, garnet, topaz, zircon, cassiterite, tantalite, columbite, ilmenite, galena, iron ore, barite, feldspar, limestone, mica, talc, clay, salt, chalcopyrite
Benue	Lead-zinc, limestone, iron ore, clay, marble, bauxite, salt, gemstone, gypsum, granite, and baryte in traces	Niger	Gold, talc, lead-zinc, iron ore
Borno	Diatomite, clay, limestone, gypsum, kaolin, bentonite.	Ogun	Phosphate, clay and traces of feldspar
Cross River	Limestone, uranium, manganese, lignite, lead-zinc, salt, baryte, granite, gneiss	Ondo	Bitumen, kaolin, gemstone, gypsum, feldspar, granite, clay, glass sand. Dimension stones, bauxite
Delta	Glass sand, clay, gypsum, iron ore, kaolin	Osun	Gold, talc, tantalite, columbite, cassiterite, granite
Ebonyi	Lead-zinc, salt	Oyo	Kaolin, marble, clay, sillimanite, talc, gold, cassiterite, aquamarine, dolomite, tantalite
Edo	Marble, clay, limestone, iron ore, gypsum, glass sand, gold, beryl, dolomite, phosphate, bitumen, granite, gneiss, calc schist	<i>Plateau</i>	Emerald, cassiterite, marble, granite, tantalite, columbite, lead-zinc, baryte, iron ore, kaolin, bentonite, dolomite, clay, pyrochlore, wolfram, salt, mismuth, fluorite, molybdenite, bauxite, gold partially investigated
Ekiti	Kaolin, feldspar, tantalum, granite, syenite, gneiss.	Rivers	Glass sand, clay

Enugu	Limestone, iron ore, lead-zinc	Sokoto	Kaolin, gold, limestone, phosphate, gypsum, silica sand, clay, laterite, potash flakes, granite, salt
Gombe	Limestone, uranium, gemstone, gypsum	Taraba	Kaolin, lead-zinc
Imo	Limestone, phosphate, gypsum, salt.	Yobe	Diatomite, soda ash partially investigated
Jigawa	Baryte	Zamfara	Gold
<i>Kaduna</i>	Sapphire, kaolin, nickel, gold, clay, serpentine, asbestos, amethyst, kyanite, tantalite, tourmaline, fluospar, topaz, rock crystal, ruby, aquamarine, traces of mica and sillimanite and graphite partially investigated.		

Source: Federal Ministry of Solid Minerals, Abuja; Amajor and Ukaegbu (2005).

Table 2: Estimated Reserves of some Minerals and Rocks Resources in Nigeria

S/N	Commodity	State/Locality	Conservative Estimated Reserve (million tonnes)	Industrial uses
1	Cassiterite	Jos-Bukuru, Egbe, Wamba-Jemaa	0.3	Plating, alloys, printing, solder, dyeing, ceramic, silk-making
2	Lead-Zinc	Abakaliki, Wase, Zurak, Ishiagu	0.4	Alloys, chemicals, batteries, construction
3	Baryte	Azara, Obubra	2000	Drilling mud, white paints, chemicals,
4	Kaolin	Jos Plateau, Abeokuta, Kankara, Jaga/Jwa, Alkeleri (Bauchi)	2000	Ceramics, paper, paints, rubber, pharmaceutical
5	Diatomite	Abakire and Bularaba (Borno)	0.1	Filter aids, fillers, absorbent, polishing powder, insulator
6	Tantalite	Jos-Bukuru	0.38	Alloys
7	Feldspar	Ajaokuta, Ondo, Ogun, C/River	2500	Glass making, ceramics, paints

8	Limestone	Yandev, Sokoto, Ewekoro, Mfamosing, Ashaka, Nkalagu, Gboko, Kalambaina	1200	Cement, flux, chemicals, fertilizers
9	Marble	Jakura, Ukpilla, Burum, Igbeti, Awe, Keana, Okposi, <i>Ikue-Oke</i> , Ikpeshi, Igarra	115	Construction, flux, chemicals, cement, fertilizers, phamarceuticals
10	Iron Ore	Itakpe, Agbaja, Koton Karifi, Muro Hills	3	Steel, construction, tools, machinery, armour plates, guns, rails, etc
11	Bauxitic Clays	Workum, Oju	1.5	Refractories, aluminium metals
12	Bentonite	Edo, Borno, Plateau, Kogi, Ondo	1500	Foundry, drilling mud, paints, etc
13	Manganese	Tudun Gudu, Mallam Ayuba (Kaduna)	4	Steel alloys, chemicals
14	Columbite	Jos-Bukuru, Odegi	0.5	Alloys
15	Copper	Rishi, Kogo (Bauchi)	Small	Electrical cables, alloys, insulators
16	Asbestos	Shemi (Kaduna)	Small	Insulators, brake linings
Reserves under investigation				
17	Gemstones	Kaduna, Nasarawa, Plateau, Bauchi, Kwara, Taraba, FCT	-	Jewelleries and ornaments
18	Phosphate	Ifon (Ogun), Imo, Sokoto	-	Fertilizers, chemicals
19	Uranium	Borno, Gongola, Bauchi and Plateau		Nuclear power and electricity
20	Salt	Awe, Keana, Okposi	-	Chemicals, food preservative,
21	Gold	Ilesha, Niger, Kwara, Zamfara, Sokoto	-	Money, jewellery

Sources: Ogezi, 1985; FMMSD, Abuja, 2016; Nwosu and Ugwu,

4. GOVERNMENT MINING POLICIES

4.1 Introduction: Geological Survey of Nigeria was established in 1903 to form a component of the Mineral Surveys of the Southern and Northern Protectorates of Nigeria under the British colony. It carried out reconnaissance of mineral resources of the Protectorates with the prospect of using the raw materials for British industries. This exercise led to the discovery of cassiterite, columbite, limestone, bitumen, lead-zinc ores, coal, clays, iron ore, gold, and

marble in different parts of the Protectorate. Thus, Nigeria was found to be blessed with abundant natural resources. Even after independence, the nation's mineral raw material resources contributed a lot to the export earnings of the country. To further boost mining operations, Government established parastatals (Nigeria Ministry of *Solid Minerals Development*, Raw Material Development Research Council) with mandate to establish comprehensive data list for mineral resources in the different geological locations across Nigeria.

4.2 Stages of Application for Mining Rights: Government introduced Mining Law and Allied Regulations to enable it govern and regulate the mining of minerals and rocks in Nigeria.

Step 1: Application must be made for Certificate of Entry into Mining Industry with the company's Certificate of Registration, evidence of technical competence and financial capability.

Step 2: Application and acquisition should be made for prospecting right (PR) for the categories of minerals within the prospecting right.

Step 3: Application must be made for an exclusive prospecting license (EPL) for the minerals in the State Mines Office where the mineral is located, and should not exceed 22 square kilometers. This license is renewable every one or two years.

Step 4: On the availability of the mineral in commercial quantity on the EPL, application for grant of a Mining License over the whole or part of the area covered by the EPL is made.

4.3 Mining Titles: Mining Titles are in six categories:

- i. Reconnaissance Permit (renewable yearly),
- ii. Exploration Licence (3 years duration and covering 200 km²),
- iii. Small-Scale Mining Lease (5 years covering 3 km²),
- iv. Mining Lease (25 years covering 50 km²),
- v. Quarry Lease (10 years covering 5 km²), and
- vi. Water Use Permit.

Mining Licence was granted to a prospective company with proof of economic reserve of the commodity. Geological Survey became the repository of information to the private sector.

4.4 Incentive to Mining Companies: To encourage investment in the minerals and rocks industry, Government offered the following incentives:

- a. 3-5 years Tax Holiday
- b. Deferred royalty payments
- c. Possible capitalization of expenditure on exploration and surveys
- d. Extension of infrastructure such as roads and electricity to mining sites, and provision of 100% foreign ownership of mining concerns.
- e. The percentage of royalty charged ranges from 3%-5% in the mining industry in Nigeria.

5. MINING AND ITS CHALLENGES IN NIGERIA

5.1 Introduction: With the discovery of the huge resources, mining of the nation's mineral and rock resources became a strategic source of export earnings for Nigeria, even up to the post-independence era. Nigeria was a major producer of tin, columbite and tantalite from 1950s to 1970s. Mining activities were thriving such that there were over 100 mining companies in Jos alone up to the 1970s, which mined tin, columbite and tantalite. Private companies were the key drivers of the mining activities. The British dominated the sector with over 100 mining companies in Nigeria.

5.2 Challenges of Mining in Nigeria: The advent of the civil war in late 1960s caused a decline in mining activities especially in southern part of the country. And the decision of Government to use Nigerian Enterprises Promotion Decree of 1972 through the Nigerian Coal Corporation and the Nigerian Mining Corporation to exercise direct control in the foreign dominated mining sector was not well received in the mining sector. The last straw was the second Nigerian Enterprises Promotion Decree of 1977 (Indigenization

Decree 1977), which resulted in massive exodus of the foreign companies from the Nigerian mining sector.

Mining was left in the hands of artisanal miners, and production nose-dived. But the effect of this decline on the economy was minimal because Nigeria was already experiencing an oil boom, which brought so much economic wealth. The Head of State in the first half of 1970s, General Yakubu Gowon, confessed that Nigeria had so much money and that the problem was how to spend it. Government gradually began to shift attention to the petroleum sector, and this significantly contributed to shift in labour. This marked the beginning of the neglect of mineral and rock sector, resulting to inevitable massive decline in mining activities in Nigeria today.

Thus the contribution of the mining sector to the gross domestic product (GDP) sharply declined from 4-5% up to late 1960s to 0.33% in 2015. Close to two decades of reforms such as Minerals and Mining Act (2007), Nigerian Mineral and Metals Policy (2008), creation of a modern Mining Cadastre and acquisition of better geological data on rocks and minerals endowment (MMSD, 2016), from the return of democracy in 1999, have not improved the fortunes of the mining sector. These reforms were not structured to diversify the economy from petroleum, and thus the mining industry has remained underdeveloped. At present, the mining sector is suffering from limited access to long-term financing, poor infrastructure (access roads, electricity, rail and water ways), absence of modern machinery, multiple taxation, high interest rate and poor human capacity development.

Thus, revenue from non-oil sources such as minerals and rocks has remained inconsequential. The country has practically lost unending opportunities to join the leading global economies by neglecting her rock and mineral resources. The paradox is that presently Nigeria is a dumping ground for substandard imported Earth materials from China, South Korea and others.

Oti (2016) in his Valedictory Lecture on 23 August had this to say:

“At Independence in 1960, Nigeria had so much going for it. There was much optimism for the emerging Giant of Africa’. Things were looking good, and the future was bright and promising. Much of that optimism stemmed from its rich natural resource endowment, particularly mineral resources, which formed the very incentive for colonial rule by the British. Ordinarily, these Geological resources should have catalyzed unprecedented and sustained growth and development in all aspect of our dear country Nigeria, spanning the whole spectrum of our infrastructural, economic, socio-political and cultural development as a people and nation.

By all reckoning, with these resources and a large population, Nigeria had momentum, indeed unparalleled momentum, with which it could have run the cost of sustained development, but it did not and has not”.

Oti (2016) continued

“Nigeria’s peers with similar circumstances ran with their own momentum, and today they constitute some of the so-called Transition Economies that have escaped the derogatory tag euphemistically called Third World Countries or Developing Countries”.

The President of NMGS, Gbenga Okunlola, in an interview with Punch Newspapers, August 4, 2015, on the Extractive Industry aptly captured the paradox this way:

“The truth is that the mining sector in Nigeria is currently moribund. This is unfortunate. It is a mistake that started since the early 70s when this sector was practically neglected. All the institutions that could support sustainability were allowed to deteriorate and almost die. The Nigerian Geological Survey Agency (NGSA), Mining Corporation, Steel Council, Metallurgical Centre and others were rendered comatose. Exploration stopped virtually, mining collapsed, mines

inspection monitoring was neglected and miscreants took over and devastated the land. Unfortunately little has changed.

As at now, there are no real mines in Nigeria, only small quarries. There is yet no functional underground mine. The coal mines of Enugu are long abandoned”.

6. NIGERIA’S HIDDEN TREASURES: OUR UNTAPPED INHERITANCE

Nigeria is endowed with all mineral and rock resources to run a modern economy but the widespread poverty and despair due to untapped huge resources remain a paradox. Government Mining Policies have done very little to reverse the challenges faced by mining companies; three examples of these resources will illustrate our lost opportunities in the mining sector.

6.1 Iron and Steel: Iron (Fe) is the fourth most abundant element in the Earth after oxygen, silicon and aluminum. Iron (Fe) forms ores as oxides {magnetite, Fe_3O_4 (72.4Fe), hematite, Fe_2O_3 (69.9Fe)}, hydroxides {limonite, $\text{FeO}(\text{OH})\cdot n(\text{H}_2\text{O})$ (48.2Fe) and goethite, $\text{FeO}\cdot\text{OH}$ (62.9Fe) and carbonates {siderite, FeCO_3 (48.2Fe)}.

(a) Magnetite (Fe_3O_4) with 72.4Fe and hematite (Fe_2O_3) with 69.9Fe are the main ores of iron. Nigeria is the 12th largest iron ore resource country in the world, and the second largest in Africa. Magnetite and hematite are the main ores mined for steel production and others, and when in high quantities, they can be fed directly into iron-making blast furnace even without upgrade. Iron ore is also used for making transformers and motor cars, metals for electrical shielding, electro-magnetic devices, electric bells, electric fan cage, equipment rack, instrument body, engineering works, among others. Iron ores occur near Enugu, Birnin-Kebbi in the northern region, Agbaja area in the Kabba province, Itakpe Hill near Ajaokuta, Muro Hill Plateau State and Chokochoko in NW of Lokoja, among others (Table 3).

Table 3: Ferro-Alloy Mineral Deposits in Nigeria

S/N	Location	State	Fe%	Reserves (tones)
1	Agbaja	Kogi	45-54	2 billion
2	Itakpe	Kogi	38-45	200-300 million
3	Ajabanoko	Kogi	36.61	30 million
4	Chokochoko	Kogi	37.43	70 million
5	AgbadeOkudu	Kogi	37.43	70 million
6	Nsude Hills	Enugu	37.43	60 million
Iron Ore Reserves under Investigation				
1	Muro Hill	Nasarawa	25-30	
2	Dakingari	Kebbi	22-52	
3	Tajimi	Kaduna	22-52	
4	Ayaba	Kaduna	27.5	
4	Rashi	Bauchi	14-19	
	Gamawa	Bauch	40-45	
5	Karfa	Borno	34-45	
6	Eginija	Benue	34-45	
7	Oko	Anambra	34.4	

Source: Ohimain (2013); Raw Materials Research and Development Council (2010).

At present, only six iron ore deposits, constituting 30%, are proven in Nigeria, accounting for approximately 3 billion tonnes of iron ore. Out of this six, only one, the Nigerian Iron Ore Mining Company (NIOMCO) at Itakpe in Kogi State was fully developed (Plate 5).



Plate 5: Iron ore mining operation

Recently, one of the findings from a graduate work Dr Nwosu and I supervised showed that the Itakpe iron ore can be recovered at greater depth than hitherto thought. This means an increase in Itakpe iron ore reserve. This work will be extended to other iron ore deposits. Thus, Nigeria sits atop many unexplored iron ore deposits of diverse quality, with the purest and largest known reserve at Itakpe, Kogi State. Nigerian iron ore deposits qualify for direct export as Direct Shipping Ore (DSO) because they meet the 62 per cent Fe content benchmark even without beneficiation. Iron now goes for \$83 per ton in the international market, putting the value of the Nigeria iron ores in billions of dollars. This offers a unique opportunity to mine and export the ores as DSO. Thus, Nigeria can kick-start the diversification of the economy and industrialization of the country through revenue from DSO.

Steel is the main product from iron. It has excellent strength, it is rugged and durable and stands as the engine room for world's industrialization. Today, it is difficult to imagine industrialization in the world without steel. Nigeria is endowed with all the raw materials for steel production; there are approximately 3 billion tonnes of iron ore (Bamalliet *al.*, 2011), 3 billion tonnes of coal (Nig. Embassy, Hungary, 2012), 187 billion SCF of natural gas and over 700,000 tonnes of limestone (RMRDC, 2001). If the steel industry is developed in Nigeria, it will provide industrial materials (iron rods, iron door frames and metal doors, wires, among others),

give massive employment to hundreds of thousands of Nigerians and generate revenues, including foreign exchange earnings.

Apparently, Nigeria recognized this in the early 70s, because when Tiajpro export of Soviet Aeromagnetic Survey discovered huge iron ore deposits at Itakpe in 1972, Nigeria followed up by signing an agreement with this team in 1975, to build an integrated steel making plant (Ajaokuta Steel Company, ASC, in Kogi State) at a cost of \$4.6bn. The initial production was to be 1.3 million metric tonnes per annum of long products (iron rods, bars) (Plate 6), to be expanded to 2.6 million in flat products (plates and sheets) (Plate 7), and an eventual third phase to raise the annual production to 5.2 million tonnes.

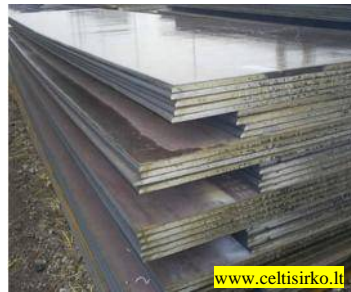


Plate 6. Long sheet products Plate 7. Flat sheet products

In 1979 the project started on 12,000 plots of land to accommodate the steel complex with 43 plants, 24 housing estates (some with over 1000 homes), 68-kilometre road network and another 24-kilometre underground road network, hospital, ND-awarding institution, among other facilities.

Nigeria was not done yet, as it went on to sign a “Turn-Key” contract with German-Austrian Consortium in 1975 to build a second plant (Delta Steel Company, DSC, in Aladja, Delta State) in 1977 with production capacity of 320,000 metric tonnes. Again, Government went further to set up three other mills - the Jos Rolling Mill, Katsina Rolling Mill and Oshogbo Rolling Mill (Fig. 7); each with 210,000 metric tonnes capacity. In addition to these efforts by

Government, there were 22 other independent small scale steel producing companies.



Fig.7: Map of Nigeria showing Ajaokuta, Aladja, Oshogbo, Jos, Katsinaans Railway Extensions

Itakpe iron ore was to provide the high grade ores to the steel plants, grading from 64% Fe for Ajaokuta to 68% Fe for Aladja. Nigeria appeared ready for a vibrant iron and steel sector to make it one of the 20 industrialized nations, as it targeted production of 12.2 million tonnes of steel per annum, with 5.2 million tonnes/ annum from ASC, 2 million tonnes/annum from DSC and the balance from the rolling mills.

The establishment of these Steel plants was a product of a clear strategy to develop technology, promote transfer of technology, save foreign exchange, create employment and supply steel components to the four Automobile Assembly plants and Agro-equipment development. However, only the DSC plant was completed and commissioned in 1982; it began to supply steel billets to the Inland Rolling Mills, and the steel Mills produced met international standard. On the other hand, over forty years down the line, the Ajaokuta plant, the largest integrated steel company in West Africa, is yet to be completed. ASC attained 98% completion but production cannot start because the furnace and all infrastructure (rail system and waterway) must be in place before the furnace can be started as it cannot be switched off till after at least 10 years. Some of the

reasons for this monumental failure are poor planning and implementation, corrupt leadership, policy inconsistencies, international conspiracy, lack of political will, poor contract agreement, technical and logistic challenges, inadequate funding and misapplication of funds, ministerial strangle-hold and insincere directives, over-costing of inputs, under-costing of products, and the general poor attitude towards government owned enterprises, poor design, weak technological base, poor reward system and lack of adequate manpower development.

But a cursory look at the ASC, referred to as the *bedrock of Nigeria's industrialization*, shows that this company would have had a multiplier effect on the national economy. For instance, if Phase 1 of the ASC project alone (i.e. production of 1.3 million tonnes), had been completed and put into commercial use, the direct benefits would have been direct employment of 10,000 technical workers (each with capacity to create 50 more jobs) at the ASC plant, 20,000 in the raw materials industries supplying ASC plant with iron ore, coal, cement, gas, and 30,000 workers in downstream industries utilizing iron and steel products (Mohammed, 2002). It would have also provided spare parts and solution to engineering challenges for smaller outfits, provided steel products needed by industries and conserved foreign exchange

Instead, all the publicly-owned iron and steel companies (ASC, DSC and 3 Rolling Mills) folded up. The 22 privately-owned small iron and steel rolling mills which were left incidentally depended on the integrated plants for billets and so were starved of raw materials (Ohimain and Jenakumo, 2013) and expectedly they produced well below their installed capacity. However, recently Premium Steel and Mines (DSC), DANA Steel (Katsina), Zuma Steel (Jos) and Dangote Steel (Oshogbo) took over these mills and some have resumed production. But ASC has remained a very bad case of project abandonment.

To worsen matters, application of backward integration policy resulted in the installation of the rolling mills before of the iron and

steel productions facilities (like the ASC furnaces) that would feed them with billets. Thus policy summersaults placed *the cart ahead of the horse!* The Ajaokuta (Plates 8 and 9) remains a quintessential white elephant project and drain pipe for the national resources at various times, including the period of their privatization between 2000 and 2005.

The Private Steel Rolling Mills cannot meet the steel need of the country due to their low production capacity and production below their installed capacities due to dearth of billets. To develop her economy, Nigeria’s steel production should be more than her steel consumption, but the paradox as demonstrated by 2010 statistics is that Nigeria consumes over 20 million tonnes/annum and produces mere 300,000 tonnes/annum. At present, Nigeria spends huge foreign exchange for importation of steel products, and allows her huge iron deposits untapped and huge potential for steel production unexploited.



Plate 8. Ajaokuta Steel Company
(Rolling Mill section)



Plate 9. Ajaokuta Steel Company
(Blast Furnace section)

According to Vanguard Newspapers of June 6, 2018, ASC, which started over 40 years ago, has gulped \$80 billion. Emeritus Prof. N.D. Briggs captured it very well as reported by the Uniport Weekly Magazine of August, 2017:

“Look at what has befallen a huge investment at the Ajaokuta Steel Plant that could have given Nigeria a technological lift”.

Meanwhile, the world is galloping away with steel production growing in leaps and bounds, from 28 million tonnes per year at the beginning of the 20th century to 781 million tonnes per year at the end 20th century, and by 2015, the world production stood at 1.6 billion metric tonnes, China accounts for 50%, South Africa 80 million metric tonnes and Nigeria, 300,000 metric tonnes. A country like Japan, which has no iron ores but imports same from Brazil to produce steel, ranks among the world leading producers of steel. Thus, our natural endowment became a lost opportunity for our dear country.

At present, the nation's steel requirement is met by imports from western countries (USA, Britain and Germany) and from some Asian nations for cheap, but sub-standard steel products (Agbu, 2007). The history of many collapsed buildings in the country that have claimed several lives and loss of billions of naira, is a confirmation of the poor quality of most of the imported products from China and Korea, among others.

If we continue the mass importation of substandard steel products into Nigeria, more buildings will collapse, unemployed engineering graduates will increase, foreign exchange earnings will continue to dwindle, unemployed youth will become more restive, and all these have serious consequences on the development and security of the nation. The bulk of our huge iron ore resources are still lying below the Earth surface untapped.

6.2. Dimension Stones:Dimension Stones are rocks, quarried and trimmed to suite predetermined sizes and/shapes for structural construction or decoration or monument uses. Good examples of dimension stones are granite, gneiss, marble, migmatite and quartzite. The Basement Complex of Nigeria (North central, Southwest and Southeast), hosts a wide range of reserves of the dimension stones and most of them possess fascinating aesthetics, textures and structures. Thus, they have unassailable potentials to

meet domestic and export needs. Some good examples of dimension stones in Nigeria are shown in Plate 10.



a. Granite



b. Granite



c. Marble



d. Semi-polished Marble



e. Calc Gneiss



f. Gneiss

Plate 10. Images of dimension stones

Let me use one example, marble, for illustration. Nigeria has over 100,000,000 tonnes of known marble reserves (Table 4), which have huge potentials to meet both domestic and export needs.

Table 4: Deposits of Marble in Nigeria

S/N	Location	State	Reserve (tones)
1	Jakura	Kogi	46,738,000
2	Ubo		22,000,000
3	Itobe		144,062
4	Ajaokuta		Not fully evaluated
5	Ekinrin-Adde, Itobe, Ubo River, Okoloke		Not evaluated
6	Igbeti	Oyo	About 25,000,000
7	Alaguntan		Not evaluated
8	ToloMuro Hill	Nassarawa	10,500,000
9	Ugya		Not evaluated
10	Ukpillia	Edo	10,161,000
11	Igarra, Ikpesi		Being evaluated
12	Ikue-Oke, Agor, Etsako		Not evaluated
13	Kwakuti	Niger	Not evaluated
14	Elebu, Bugum, Oreke, Owa-Kajola, Babanloma, Eleja, OkeOyan, Ibare/Oja/Agunjin	Kwara	Not Evaluated
15	Jalingo	Taraba	Not evaluated
16	Ijero	Ekiti	Not assessed
17	Kankara	Katsina	Not assessed
	Burum, Takalafia, Takusara, Kusaki, Kenada, Ele	FCT	Not evaluated
Total known reserves			114,543,062

Source: Federal Ministry of Mines and Steel Development, Abuja.

What is prevalent in many dimension quarry sites across the country is artesinal mining. In many cases, illegal miners over-run the whole sector. At present, the cost of producing these materials locally is very high due to unfriendly climate for the development of dimension stones. The right tools (mechanized) are simply not there. For instance, (Plate 11) shows a marble quarry site in Ugue-Oke, near Agor, Edo State, with the miner using a simple and ineffective mining tool that needed the support of one of his feet. Percentage purity of this marble increases with depth. He will not go far before the onset of rainy season, which easily turns the pit to a pond, leading to abandonment of the quarry site (Plate 12).



a. Artisanal drilling b. Marble quarry pit



c. Ukaegbu and geology students in the pit d. Quarried marble displayed for sale
Plate 11. Marble quarry at Ugue-Oke near Agor, Edo State



Plate 12. Abandoned marble quarry pit in Agor area, Edo State.

Plate 12 shows that just when the miners are beginning to access pure marble, the rains come, fill the pit/quarry, and the pit gets converted to a pond. Activity stops, and abandonment of the quarry

follows! With the artisanal approach, miners cannot get much of the pure marble before the rains commence to chase them away. The entire terrain gets mutilated due to frog jumping in mining activities by the artisans.

Plate 13 shows a typical semi mechanized marble quarry site in Ikue-Oke in Edo State, capable of yielding 300 metric tonnes of high quality products per day and these unprocessed dimension stones are sold at N2,500 per tonne. Full mechanized mining activity will guarantee thousands of metric tonnes per day, and generate huge employment opportunities. What a mechanized mining operation can achieve in one week, artisanal quarrying may not be able to achieve in a lifetime. With depth of excavation, the quality of the marble increases (Plate 14). Sadly, only very few dimension stone quarries are mechanized in Nigeria. While Nigeria appears not to value her enormous endowment of high quality dimension stones (Plate 15), other countries value theirs even those with lower quality.



Plate 13. Semi-mechanized quarry site



Plate 14. High quality marble unEarthed at quarry site



Plate 15. Market-ready high quality marble fragments from quarry site

The potentials of these dimension stones are practically truncated by the the nation's unparalleled taste for finished imported *dimension stones* from Asia, Europe and America. Infact, Nigeria is so obsessed with the importation of these products that where the original dimension stones are not handy, synthetic ones are imported from China, Korea and Italy. We devalue what we have in preference to others, even if they are inferior to our own. Government prefers to give licences to our entrepreneurs to

import tiles and other dimension materials than developing the huge resources in this sub-sector.

Dimension stones are worth over US\$50 billions globally, and China, Italy, Turkey, Brazil, France and Spain are some of the leading producers of dimension stones, while Nigeria is one of the major consumers, even as exotic and very high quality dimension stones abound in this country. Nigeria imports over 90% of her 4,000,000 m² dimension stones needs worth about US\$50 million per annum, from China, Italy and Spain.

Government is yet to pay adequate attention to the mineral and rock sector. Other countries place them in strategic positions to tell their stories. For instance, Ekwueme (2006) stated how the United States Geological Survey (USGS) was proud to let the American public know that physical development of the nation's capital, Washington, D.C. was done using marble, granite, limestone and sandstone from USA (Withington, 1975). USGS stated that:

“The buildings of our Nation's Capital serve as an unusual geologic display, for the city has been constructed with rocks from quarries throughout the United States.... Each building is a unique museum that not only displays the important features of various stones and the geologic environment in which they were formed, but also serves as an historic witness to the city's growth and to the development of its architecture”.

In sharp contrast, the Federal Republic of Nigeria gives licenses for importation of the marble, granite, migmatite and gneiss. I do not know how many of us here have had the opportunity to use Nigerian dimension stones (for slabs or floor tiles, wall tiles, staircases, kitchen tops) in building our houses, among others, even, as we have high quality grades of all these rocks in great abundance in Nigeria may not have because the finished products are not there and the few available ones are expensive due to high cost of production. Here lies the buried opportunity!

Nigeria has about 180m people, very young population of 62% below 30 years and median age just 28 years (Stonechange, 2016), high level entrepreneurship, large mining and natural stones potential and rapid population growth. Nigeria can easily make good fortunes by harnessing her huge reserves of natural dimension stones, which are still in their early stages of exploitation, if Government could provide the enabling environment. Thus, the dimension stones sector represents a possible key sector to grow the Nigerian economy. These huge resources are largely left untapped, while we purchase same materials from countries that are less endowed.

6.3. Gemstones or Gem Minerals

A gemstone, commonly referred to as a gem, is a mineral that can be appropriately cut and polished to improve its value, aesthetics and attraction so that it can be used as jewelry, ornament, and some other adornment or decoration. Gemstones are timeless treasures with potent images that captivate the minds with their dazzling brilliance. Some of the important gemstones in Nigeria are corundum (ruby, sapphire), beryl (emerald, aquamarine), topaz, tourmaline, amethyst and rose quartz (Plate 16).



(a) Ruby



(b) Sapphire



(c) Emerald



d) Aquamarine



(e) Topaz



(f) Amethyst

Plate 16: Showing images of some of the gemstones found in Nigeria

Also, it is important to note that metals such as gold and silver are very important ornamental minerals generally referred to as precious metals. Nigeria is home to most high quality gemstones and precious minerals, and many parts of the country, particularly along the NE-SW pegmatite axis of Nigeria, are host to the gems (Ukaegbu and Ukwang, 2014).

This reminds me of **Rev 21:18-22**, which has this information to give. Sure, it will interest you.

The wall was made of Jasper and the city of pure gold, as pure as glass, 19, the foundations of the city walls were decorated with every kind of precious stone, the foundation was jasper, the second sapphire, the third agate, the fourth emerald, 20, the fifth onyx, the sixth ruby, the seventh chrysolite, the eighth beryl, the ninth topaz, the tenth turquoise, the eleventh jacinth, the twelveth amethyst. The twelve gates were twelve pearls, each gate made of a single pearl, the great street of the city was of gold as pure as transparent glass. 22 I didn't see a temple in the city because the Lord God Almighty and the Lamb are its Temple.

Mr Vice-Chancellor, Sir, this passage underscores the value, God Himself, attaches to gemstones. It further appears to advise all to first be geologists here on Earth, so that in Heaven we will be able to recognize gemstones and make good choices. This is in tandem with what Warren (2004), the author of the book, *Purpose Driven Life*, wrote:

This is the warm-up act – the dress rehearsal. God wants us to practice on Earth what we will do forever in eternity.

And Pope Francis re-echoed this, when he said:

Here (Earth) is an opportunity to learn.

You can see that geologists are already better placed to make the right choices. See why I am a geologist?

Mr Vice-Chancellor, Sir, I brought in this illustration to underscore the importance of these special minerals – the minerals that even heaven uses to adorn beauty and excellence! We have a wide range of gemstones in Southwest, Northcentral and Northeast of Nigeria but most of them occur in the Northcentral and Northeast. Table 6 shows some gemstones and gold found in Nigeria and their current prices at the international market.

Table 5: Some gemstones and gold deposits in Nigeria and their price/carats in USD

S/N	Name of Gemstone/ gold	State	Price/carats in US dollars 1 Carat = 0.20
1	Ruby	Nassarawa, Plateau, Kaduna, Abuja	100 –274,656
2	Sapphire	Nassarawa, Plateau, Kaduna, Abuja, Taraba, Bauchi, Yobe	1000 - 135,000
3	Emerald	Nassarawa	49 - 3,076
4	Aquamarine	Nassarawa, Plateau, Kaduna, Oyo, Ogun, Kogi	150 - 200
5	Tourmaline	Nassarawa, Plateau, Kaduna, Kogi, Abuja, Niger, Kwara, Edo, Osun, Bauchi, Oyo, Sokoto, Taraba	2,500 -16,000
6	Amethyst	Bauchi, Kaduna, Kano, Oyo, Abuja, Nassarawa, Plateau	10-50
7	Topaz	Nassarawa, Plateau, Oyo, Bauchi, Kwara, Niger, Kaduna	20 – 253.07
8	Zircon	Plateau, Kaduna, Oyo	75 -125
9	Crystal quartz		1.12 – 4.66
10	Gold		258

Source: Federal Ministry of Mines and Steel Development, Abuja; Ukaegbu and Ukwang (2014).

But does the country show keen interest in this awesome endowment? The answer is, No! It is indeed very sad and unfortunate that the mining of these precious materials is largely controlled by illegal miners. Nigeria prefers to import finished

products of these gems, many of which were mined in Nigeria and polished in Europe.

6.4 Where We Are Now

So far, I have discussed only three items from a large pool of valuable mineral and rock resources, which include many others such as baryte, limestone, cassiterite, granite, gneisses et cetera, which time and space will not allow me to discuss in this lecture. If we put all in context, we would appreciate how huge our losses have been in neglecting the mining sector. Thus, there are so many hidden treasures not tapped, Nigeria paints a picture of a poor nation.

A World Bank Report (1996) on Nigeria titled: *Nigeria: Poverty in the Mist of Plenty*, stated:

Nigeria is a paradox. The country is rich in land, people, oil and natural gas and other mineral resources, but the people are poor.

The situation is even worse today than when this statement was made over two decades ago.

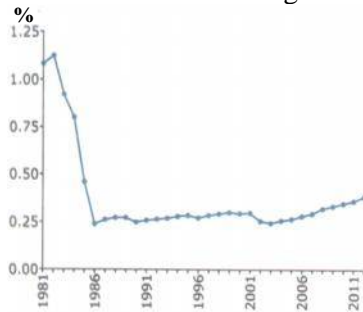


Fig. 18. Nigeria's mining sector's contribution to GDP in decline

Source: National Bureau of Statistics

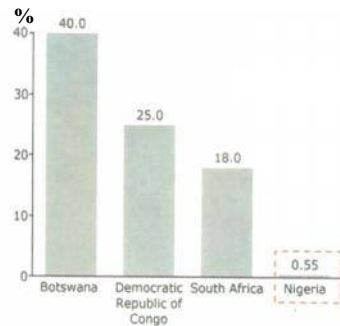


Fig. 19. Nigeria's mining sector's contributor to GDP compared to some African countries

AllAfrica.com, 2015

7. WAY FORWARD

What is the way forward? Diversification! Restructuring!! We need to diversify our economic portfolio. Let there be a paradigm shift

from mono-economic mindset. We should take a total look at the prevailing economic climate worldwide in respect of petroleum products, and expand the space of our economic activities. Let us consider just two reasons why we should adjust our way of doing business. At present, the automobile industry is experiencing revolution. Tesla unveiled the first batch of its electric car middle 2017, which the company said was affordable and can run for 350km to 500kmafter charging it (Port Harcourt to Abuja is 479km). The car has no valves, no plugs, no gasket to replace, no combustion engine and so no need for mechanics. It is a technology that is software based, and does not pollute the environment and it promotes green economy.

Volvo has also announced the stoppage of the production of diesel and petrol powered vehicles from 2019; next year! Diesel and petrol-powered vehicles will suffer from electric-powered vehicles what type-writers suffered from computers. So the demand for oil globally will start going down. Peugeot has joined the race. These are the features that convinced Britain to plan the ban sale of cars and vans that use diesel and petrol from 2040; France, Germany, India, Korea, Spain, Japan, the Netherlands and Portugal are some of the countries that have set targets to phase out internal combustion engines and switch over to battery-powered and electric-powered cars, to encourage low gas-emission technologies and boost clean air. This, no doubt, will take a bite off and effectively alter the balance for the energy sources in the automobile companies.

Secondly, Nigeria was the 5th biggest exporter of crude oil to USA. But three years down the line, the U.S. stopped buying our crude oil because they discovered they have the technological capacity to extract crude oil from shale, and so there was no need for our oil. This situation sent oil prices crashing freely since 2015, with serious negative implications for revenues of only petroleum-based economies, like Nigeria and Venezuela. The result was low price of crude oil; low sales of our crude oil; naira crashed; prices of goods and services hit the roof; retrenchment replaced employment.

Therefore, the twin impact of the automobile and shale revolutions on our petroleum dependent mono-economy, should get us thinking, and thinking fast! Examples from Saudi Arabia and UAE are apt. These two countries are the biggest economies in the Middle East and are also two leading petroleum countries in the OPEC family with petroleum quota of 10.06 million bpd and 2.31 million bpd respectively. However, they appear to understand the imperative of a diversified economy, and have gone into tourism while maintaining their strong presence in the petroleum industry. In 2016 alone, Saudi Arabia earned \$12.139 billion, while UAE earned a whopping \$64 billion from tourism. It is of interest to know that while America and UK remain our tourism destinations, the same UK and USA are the leading tourism nations to Dubai with 1.63 million (3rd) and 623,000 (6th) tourists respectively in 2017.

Table 6: Revenues from Crude Oil and Tourism in 2016

Rank	Exporter	Crude oil export earning in US\$	Earning from tourism	Total Income	Population
1	Saudi Arabia	133.6 billion	12.11 billion	145.71 billion	32.28 million
2	UAE	49.3 billion	64 billion	113.3 billion	9.27 million
3	Nigeria	33.0 billion	5.5 million	33.01 billion	186 million

Source: <http://www.investorpedia.com>; <http://tradingeconomics.com>; <http://www.thefirstgroup.com>

What is the lesson here for us? Diversify and still maintain active participation in the petroleum sector. After all, we have abundant natural gas in great abundance. Natural gas has no production quota and has low carbon emission to the environment. African and other developing countries such as Venezuela and Trinidad and Tobago will continue to use vehicles with internal combustion long after 2040. Also the plastic, petrochemical, aviation and shipping industries will need petroleum or its derivatives for their operations, but the major user of diesel and petrol combustion engines will leave the market. Thus, it is expedient to diversify our economic portfolio now.

Nigeria as the 12th largest iron ore resource country in the world, and the second largest in Africa will have strong regional economy if it develops the steel industry, because infrastructural developments (irrigation, farm mechanization, road and bridge construction, military hardware, transport and housing development) require steel products. We also have almost inexhaustible volumes of high grade and exotic dimension stones, beautiful and very valuable gemstones, vast high grade clay deposits, limestone deposits in almost all the sedimentary basins and over 40 other different minerals and rocks found in about 450 locations in Nigeria. At present, these are Nigeria's Hidden Treasures: Our Untapped Inheritance!

Nigeria has enough resources of these minerals and rocks and we are capable of stopping the present importation of roughly 6 million metric tonnes of steel, 300,000 metric tonnes of clay, virtually all dimension stones and gemstones needs, about 90 percent of which come from China and other Asian countries, and turn this country to an economic giant. With the two steel complexes, three public inland rolling mills and twenty two privately-owned rolling mills across the country, reactivated and functioning, the iron and steel sector should be set to revolutionize the Nigerian economy. Nigeria can take advantage of the present international iron price at \$83/ton to kick-start the diversification of the economy and industrialization of the country.

So our petroleum resources should be adequately complemented by our abundant mineral and rock resources in revenue generation for the country. It is encouraging that we now have Ministry of Mines and Steel Development and this has raised expectations for a significant turnaround in the economic fortune of the country, if Government adequately motivates and challenges technically competent stakeholders to drive the mineral and rock industries in Nigeria. And the recent pronouncements by Government that described the dimension stones as the gem for Nigeria, and the inclusion of Small and Medium Scale Enterprises as part of its strategic plan for industrialization are the right signals investors need, and Government is also expected to translate its position to

actionable programmes that will provide the enabling environment for robust mining activities by the private sector (Table 7). This will help in diversification of the economy.

Nigeria’s large population has an unprecedented great potential for domestic market that can spur and sustain rapid growth in mineral and rock consumption. This will create great opportunities in employment, foreign exchange earnings, diversification of the economy and import substitution. For value addition, encouragement of the downstream industries to export, after meeting domestic needs, will fetch foreign exchange earnings for the country. Like the NMGS President (Okunlola, 2015) said:

“We need to start again and get the sequence right – map, explore, open it up for investment, get the appropriate policies right, make the laws working, ensure transparency in licensing and strengthen the institutions”.

Table 7: Suggested Action Plan for the Mining Sector

Short-term	Medium-Term	Long-term
Reduce importation of steel and the products of other minerals and rocks.	Encourage indigenous mining operations	Train technical personnel
Remove mineral resources from the Exclusive List. Allow States to control mining of the resources in their domain.	Review mining rights, licensing and incentives to encourage local and international participation.	Extend financial facilities to mining companies
Generate requisite geological data needed by investors.	Provide adequate security and tackle the activities of illegal miners	Complete ASC and make it functional. Develop rocks and minerals in the country.
Encourage local cluster groups to develop minerals and rocks in their localities.	Sustain infrastructural development in the mining sector	Provide infrastructure (electricity, roads, railways, waterways) to mining sites.
Provide feeder roads and electricity to communities for ease of operations and evacuation of products.	Encourage production of raw earth materials, which should be accessible to industrial plants for growth of enterprise and economy.	Encourage export of products for foreign exchange earnings, after meeting domestic needs.

8. CONCLUSION

Mr Vice-Chancellor, Sir, a sincere development of our vast high quality mineral and rock endowments will be our greatest drive to economic boom. It is a paradox that Nigeria has become a dumping ground for substandard steel and dimension stones, as well as other earth materials (iron ore, bentonite, baryte and salt) and synthetic gems, when large quantities of these resources lie fallow and at best, merely scratched on the surface and, in some cases, mutilated, all over Nigeria. We must therefore deliberately shift from importation of finished products of those raw resources that abound in Nigeria and invest in developing them to enable our economy grow. Let the climate show attractive indices and incentives for private investors to drive this promising project. It is a sad commentary that our enormous endowments have remained a lost opportunity for our country for a very long time.

Mr Vice-Chancellor, Sir, the University of Port Harcourt is an entrepreneurial and a leading university in Nigeria. I recommend that the Investment Unit acquires leases for some dimension stones for commercial production of tiles, slabs for staircases, kitchen tops, and also for training of small scale enterprises on how to cut and polish rocks for beautification. The Department of Geology can drive the project. This will increase the tempo in our community service and public relations delivery as well as boost the revenue profile of our university.

Mr Vice-Chancellor, Sir, as I conclude this lecture, let me inform us that Japan cannot match Nigeria in mineral and rock resources endowments, but it has the 2nd best technology and the 3rd largest economy in the world. Nigeria is not anywhere close to the harsh climate of Israel, which sits in the heart of the Sahara desert and yet has the best irrigation in the world, and Mauritius, a small African country, with no exploitable natural economic resources, is not battling unemployment on a scale like Nigeria. Records show that Nigeria is undoubtedly the most endowed country in the whole of Africa in both natural and human resources, and perhaps only second to the United States of America in the whole world. With a dynamic,

young and technology-driven large population base to support innovations and enterprise, investment in mineral and rock resources will create the necessary drive to the diversification and restructuring of the Nigeria economy. Because if we diversify our sources of revenue, we diversify business opportunities, we diversify employment options, we diversify our global image and visibility, we diffuse youth restiveness and other social vices.

Our inability to tap our resources is the bane of a nation in conflict with itself. We need to let the world know about our mineral and rock endowment so that we can enjoy the benefits of our inheritance. Therein lies the challenge that we must face with both hands on the plow as a nation.

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Professor Ukaegbu worked briefly as a Land Officer in Imo State Ministry of Works from February 1978 to September 1978 after his secondary education, before he got admission into the university. After his NYSC in August 1983, he was employed by Bauchi College of Arts and Science as an Assistant Lecturer in the Geology

programme. In 1988 he joined the Bauchi State Polytechnic, Bauchi, and later switched over to Tatari Ali Polytechnic, Bauchi. He rose to the rank of a Senior Lecturer before he joined the Department of Geology, University of Port Harcourt in 1995 as Lecturer II. Fifteen years later (March 2010), he was promoted to the rank of a Professor of Geology.

Professor Ukaegbu was Coordinator of the Geology Department (2003-2004) and Ag. HOD, Geology Department (2004-2007), before proceeding to Shell Petroleum Development Company (SPDC) for Sabbatical Leave in 2007/2008 session. He was the pioneer Dean of the former Faculty of Physical Sciences and Information Technology (2013 – 2015). Professor Ukaegbu has supervised many postgraduate projects including PGD, M.Sc. and Ph.D works and over 200 undergraduates.

Professor Victor Uchechi Ukaegbu has over sixty scientific articles in national and international reputed journals, 8 books and 3 book contributions to his credit. He was one of the sixteen (16) authors selected from Geology Departments in the country to write an ExxonMobil-funded standard textbook on field mapping. Professor Ukaegbu has been External Examiner to UI, UNN, Unical, FUTO, NAUN, EBSU, Nassarawa State University, Kogi State University and Anambra State University and has done Professorial assessments for Uniyo, FUTO, FUTA, UNN, Unijos and Akwalbom State University.

He is a member of the Nigerian Mining and Geosciences Society (NMGS), Nigeria Association of Petroleum Explorationists (NAPE) and a registered member of the Council of Mining Engineers and Geoscientists (COMEG). Professor Victor Uche Ukaegbu is a Resource Person to the Nigerian Geological Survey Agency (NGSA), Abuja. He was recently appointed by the Federal Government into the Federal Ministry of Mines and Steel Development 6-man Steering Committee on Research Collaboration with Tertiary Institutions. Recently Professor Ukaegbu facilitated an academic collaboration between the Departments of Geology,

University of Port Harcourt and University of Western Cape, South Africa.

In his community he is the Chairman of the Education Committee of Uturu Development Association (UDA). Professor Ukaegbu is married to Dr (Mrs) Bernadette Chinasa Nkeiruka Ukaegbu and the marriage is blessed with five children.

Distinguished ladies and gentlemen, permit me to present to you, Professor Victor Uchechi Ukaegbu, the 151st Inaugural Lecturer.

Professor N. E. S. Lale
Vice-Chancellor