FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

GEOLOGY: THE SUBJECT OF THE FUTURE IN NIGERIA

By

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Inaugural Lecture Series 1

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GEOLOGY: THE SUBJECT OF THE FUTURE IN NIGERIA

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Vice-Chancellor, other Principal Officers of the university, Deans of Schools, Professors and other colleagues, distinguished ladies and gentlemen, I am highly honoured to have to give the very first Inaugural Lecture in this University. For various reasons, it has not been possible to start off this important academic tradition in the University. And I have always been the Chairman of the committee charged with the responsibility of organizing University Seminars, Public Lectures and Inaugural Lectures. It is with a sense of responsibility and humility that I offered to give the first lecture in the hope that it will help break the ice and other people can follow.

Inaugural Lecture is an established tradition in Universities in many parts of the world. It is an occasion when an academic, who has attained the position of Professor is formally introduced to the academic community and the enlightened public at large. He/she is inducted or "inaugurated" into office so to speak. The new Professor is expected to give a public lecture on any topic of his choice. The lecture is usually either on his/her personal research work or his broad subject area (or academic discipline) to show his work's (or his subject's) contribution, and/or relevance, to the University, the local society, the nation or even to humanity at large. He may also proffer solutions to some problems that he identifies. From the point of view of being "inaugurated", this lecture is some 12 years late for me.

Ever since I registered for geology as a student, by accident, in 1964, my colleagues, friends, and relations have been asking various questions about the subject. The questions, which have persisted up to now, show how ignorant many highly educated Nigerians, including other scientists, with whom I should be collaborating, really are about geology (and about the earth). However, I should quickly add here that such ignorance is not peculiar to Nigerian scientists and professionals; it is fairly common in other parts of the world. Cooray (1987) in his Presidential Address to the Association of Geoscientists for International Development (AGID) wrote:

"We geoscientists often complain that planners, engineers and others who we think should know better are generally ignorant of the importance of our discipline in development projects. They do not, we moan, consult us and they should... Most laymen are ignorant of the geosciences, and it is we who should go out of our way to explain the importance-and relevance-of the geosciences to the laymen, the planner and the administrator".

One of the aims of my lecture is to attempt to answer some of the questions I have been asked over these past 35 years.

Geology is the science of the earth. It concerns the whole earth and all that is in it, the processes that take place within and on the earth, its origin and history and the history of life on earth. Since other professors in other

disciplines will be concerned with only aspects of the earth, or materials and organisms contained in or on the earth, I believe it is appropriate for us to start off our Inaugural lecture series by a geologist who would give an overview of the earth, the environment of man.

It is also my intention to educate people on the subject of Geology and to show how the natural 'geological' processes that take place on earth have influenced man's cultural, religious, intellectual and social development. Human civilization, at any point in his history, has depended on man's ability to use particular earth or geological materials (rocks and minerals) i.e. civilization has always depended on minerals *AND* man's ingenuity *(TECHNOLOGY)* to get and use the rocks and minerals. The present space and information/communication technology age would not have been possible without minerals. Computers, cell phone, satellites etc. are constructed or made largely of minerals. In particular, I will show that geology is a practical subject which has helped, and will continue to help, in solving practical human problems and in providing the most basic human needs such as food, drinking water and sanitation, shelter, health and safety from natural and man-made hazards and, of course, employment (Table 1).

Finally, as an African geologist working in a University of Technology, at the dawn of a new millennium, to sensitize people to the fact that our world is divided into the *Developed* countries on the one hand and the *Developing-(Less Developed- or Underdeveloped)* countries on the other hand. The difference between these two groups lies primarily in the relative ability *(technology or know-how)* to get the minerals available in the earth and use them to make useful things. It must also be said that some countries e.g. Korea and Brazil are making this simple two-fold classification redundant. Black Africans have, so far, been non-participatory observers in the evolving global village and are, in the main, consumers of goods and services provided by other people. We have no choice but to make efforts to join the rest of the world in the new century. We can only do this by acquiring the necessary TECHNOLOGY and the skill to get and use the minerals around us and learn to engineer the earth (build dams, tunnels, canals etc.) as may be needed. The universities of technology have a big role to play in this bid for technology acquisition. The acquisition of technology will lead to demand for raw materials (minerals and other materials) for the industries.

Although I will mention metallic ores such as gold, tin, silver, iron etc. most of which we are usually interested-in only in terms of export and foreign exchange earning, my primary interest is in such lowly materials as clays, sands, limestone and ordinary stones. These lowly minerals, which cannot be exported, have wide usage in many industries and are in fact more relevant to

Table 1 **Basic Human Needs and Geology**

Food	Application of mineral fertilizers for soil improvement and improved crop yield; groundwater for irrigation and livestock
Safe Drinking Water	Hydrogeologists and geophysicists locate groundwater for domestic use in areas where there is no surface water.
Shelter	Apart from plant products used in building (planks for roofing, furniture and doors), virtually all other parts of a house are made of minerals or rocks–stones, clays, sand, cement and metals (iron, copper, aluminum etc.)
Energy	Coal and Petroleum products – (kerosene, petrol, diesel) for cooking, lighting, heating etc.
Health	Clean drinking water from boreholes protects us from water-borne diseases such as typhoid, guinea worm, dysentery, cholera etc. Geologists also monitor groundwater against pollution by toxic metallic elements, which may come from diverse places.
Clothing	Synthetic material such as nylon, teryleen, rayon etc. are obtained from coal and petroleum.
Protection from hazards	Geologists help monitor and predict natural phenomena such as earthquakes, floods, volcanic eruption etc. so as to lessen the possible effects on man. They also help provide data and advice on engineering projects so as to avoid failure e.g. dams, slopes and environmental pollution.
Education	Education about the earth will go a long way in freeing people from ignorance and disease. The more we know about the earth the more we can use its resources and protect it.
Employment	Mining industry has a multiplier effect on the society in form of various service-industries and manufacturing industries-leading to employment opportunities. As the demand for minerals and water increases, there will be need for more geologists, mining engineers, metallurgists and other professionals; technologists, technicians, artisans and various others.

development than all the gold and silver of this world. *Whether gold or sand, you require geologists to locate it.*

A consequence of mining and other engineering activities, industrialization and urbanization is environmental problems. Environmental issues will take a central stage in these parts of the world in the coming years. Geologists and other environmental scientists will be required to help solve some of the problems.

The key words of this lecture are **geology, development, technology, education and the environment.**

THE EARTH AND MANKIND

"You and I are from the earth. We carry its substances in our bones, in our flesh, and in our blood. We are the culmination of ceaseless centuries of biologic trial and error and thousands of years of cultural development and learning. We cannot erase our kinship with the earth, because our origin contains all that we may become. Our future is in understanding our planet, over which we have more and more uncertain domination." *(Barnes 1980)*

There are as many mythologies about the origin of the earth and the origin of man as there are cultures and religions. The important thing is that man found himself on earth. It is believed that he was just like any other animal, gathering fruits and living a nomadic life. However, he was different from other animals both physically and mentally and he possessed the power of reasoning and language. He soon discovered fire and learnt to use the most abundant earth materials around him-stones- as a weapon for hunting and as a tool. He later found that some stones took on edge and made better weapons and tools than others. Geology can be said to have started when the early man chose those stones that were good and useful and discarded those that were not useful. He progressed from using 'found' stones to actively look for (or prospect) and mine particular stones such as flint stones, obsidian and, to some extent, quartz and quartzite all of which can take on sharp edges.

As man developed and settled in communities, agriculture replaced hunting as the main source of food. Stone continued to be the main tools. Archeologists have discovered stone ax heads and other tools as well as flint mines dating back to 20,000 BC in many parts of the world. In addition to stones for hunting, early man also mined several pigments such as oxides of iron and manganese, which he used for body decoration, and for painting cave walls.

It is most probable that commerce started with the exchange of these special stones and pigments between communities that had, for food from those *who did not have or who did not know-how to get (mine) them or how*

to shape them into tools and weapons. The Archeologists believe that copper was the first metal to be used by man. Native (natural) copper was probably discovered by accident when the Stone Age man had his foot cut in a streambed by the sharp edge of the metal. Copper is a soft metal but early man found that it became hardened when hammered. He thereafter started to look for the metal like a modern day geologist. Somehow either through experimentation or by accident, he was able to smelt copper and tin from their ores to obtain bronze about 3000 BC. This was the Bronze Age.

Other metals followed and by the time of the Christian era, 2000 years ago, the "seven metals of antiquity" namely: copper, tin, gold, silver, lead, iron and mercury were known. Of these metals, gold took a special position. Davies (1971) observed that gold's rarity and beauty and long lasting characteristics were soon appreciated by most societies. It was used primarily for personal body adornment and was sought to please the women-folk. It was later used as currency and for holding wealth. The hope to find gold led to many voyages and, later, colonization. The study of alchemy, which is believed to be the foundation of modern chemistry, was primarily aimed at transforming base metals into gold.

Iron made it possible for man to work other earth materials such as stones and clays for building his shelter and fortifications and for erecting monuments like the Egyptian Pyramids, and temples for the gods. The metal also made it possible for man to till the ground for agriculture better and to work timber for building boats, which enabled him to explore regions far from his immediate environment. (The Yorubas appreciated iron so much that they worship it as a god - *Ogun*).

It is conceivable that war started between communities over rights to minerals and that the transition from one age to another was marked by the emergence of the group that first started to use, or that developed the technology to use, a particular metal or earth material. For example the bronze swords of the Greek armies at the Battle of Marathon were said to have torn through Persian leather armour and led to the rise of Greek civilization and the collapse of the Persian Empire and civilization.

It was soon discovered that minerals are exhaustible. Once mined, they are gone forever and new deposits must be found either within one's own territory or elsewhere. This apparently led to more wars and slavery, destruction of one empire and its civilization and the emergence of new empires.

According to Davies (1971),

"The Romans set the pattern. Minerals were equated to power. So the conqueror first plundered the accumulated metal and jewel stocks of the vanquished, completing this with the exaction of annual tribute. When this proved insufficient, the Romans operated the mines themselves using the

vanquished as slaves. Thus Greek gold and silver; Spanish gold, silver, copper, tin and mercury and British lead all moved to Rome. The decline in the supply of the minerals from the mines led to decline in the purchasing power of Rome and the resultant decrease in trade and military power of Rome and eventual decline and collapse of the Roman Empire"

The Industrial Revolution in Europe in the late 18th century led to great demand for different metals and energy sources among other things. This eventually led to the conquering and colonization of other lands in Asia, Africa, Australia and the Americas. In the 20th century, the Second World War was said to have been partly caused by Germany's interest in the oil fields of Romania and the coal and iron of Alsace-Lorraine. The Apartheid system of Southern Africa was sustained up to 1994 because of the rich mineral resources to which the European settlers and the European investors had monopoly. Nigeria and Cameroon almost went to war over the Bakassi peninsular in 1994 primarily because of the oil deposits in that region. The areas of conflict in Africa right now are those countries with huge amounts of mineral resources – Angola, Congo (Kinshasha), Sierra Leone and Liberia.

Side by side with the extraction of useful materials from the earth, man has from the beginning of history, been faced with the reality and the finality of death. He was aware, and many times victim, of certain happenings such as massive floods, hurricanes, earthquakes, landslides, volcanic eruptions, lightning etc. which must have struck fear into him. His fear of these unpredictable happenings, over which he had absolutely no control, apparently led him to conclude that there were invisible beings, greater than himself, who were responsible for them. It is easy to see, from the violence and fieriness of the fires of erupting volcanoes, why people relate hell to fire and the underground and heaven likened to places of scenic beauty on earth or in space.

At the same time, man started to wonder why, how and where it all began - the origin of man and the origin of the earth and what happened after death. This obviously led to the invention of gods, spirits, mermaids, demons and other invisible beings and myths about the earth and eventually, to the birth of religion and the emergence of the institution of priesthood.

The Yorubas, for example, believe that the world started from Ile-Ife and they have stories about *Oya*, the goddess of the River Niger and *Sango*, the god of thunder etc.

Although most natural phenomena were associated with one god or the other, the priests in many of the early civilizations were knowledgeable people and some of them were able to keep track of the movements of the sun, the moon and the planets relative to the stars, for religious purposes. This led eventually to the development of calendars and prediction of eclipses - this is the birth of astronomy. The ancient priests were able to mix medicine,

mathematics, astronomy and magic and they held a spell over the people. Priests still do in many societies (including some of the most advanced countries) and some of their followers have been made to commit mass suicide because of eclipse of the sun or a passing comet for example. The turn of the new millennium has led to the death of hundreds (by suicide and possible murder) of worshipers of 'End of World Church' in Uganda this year. The Ogun and Sango priests are still influential people in some Yoruba communities.

Later, fear gave way to curiosity about the natural environment. The Greek philosophers and thinkers as exemplified by Aristotle (384 - 322 BC) started to speculate about the earth and the physical phenomena that occur on earth. The Greek and the Romans also made actual observations and tried to explain some of the natural phenomena based on these observations. They were able to prove that the earth is round but considered it to be at the centre of the solar system. It was not until 1543 that Nicholas Copernicus concluded that our solar system is sun-centred and that the earth and the other planets revolve around the sun.

The Jews had, along the line discovered one God (Yahweh) and got the Ten Commandments. According to the book of Genesis, the earth was created in seven days and man was made in God's image. The woman was later made to keep man company. Implicit in the bible story of creation is that the earth is in the centre of the universe and man was made to lord it over everything. The world was later destroyed by the Noachian flood because of the sins of the people.

The spread of the Christian religion across Europe and the later emergence of Europe to leadership position in science and technology, particularly after the Renaissance, greatly influenced the thinking about the origin of the earth. For example, in 1654, Anglican Archbishop Ussher announced that based on his analysis of the scriptures, the world was created precisely on 26 October 4004 BC. Another authority later dated the Noachian Deluge at 18 November 2349 BC. Practically all the leading intellectuals of Europe accepted the 6000-year age of the earth for almost 200 years. It was heretical to say something different and you could be burnt at the stake. Somehow, the intellectuals refused to see that the Bible also says:

"For a thousand years in your sight are like a day that has gone by or like a watch in the night." *(Psalm 90 v. 4.)*

In spite of the religious handicap about the age of the earth, the intellectuals continued to make observations about the earth and other heavenly bodies, and collect crystals of minerals as well as fossils as objects of curiosity.

The Biblical age of the earth was slowly but surely overturned by the careful and painstaking observations made on rock exposures and in mines

and engineering excavations by the intellectuals of the day. Foremost among these intellectuals is James Hutton, (1726 -1797) a Scottish physician and gentleman farmer who, after careful observation and study, concluded that rocks change gradually into soil, which is slowly washed into the sea where the particles slowly accumulate and become hard rock again. He concluded that the earth is constantly changing at slow, almost imperceptible rates. Hutton's ideas were later developed into the principle of ***uniformanitarianism*** which, simply put, says that the present is the key to the past i.e. the present processes that we are observing on earth have always taken place throughout earth's history. An implication of this is that geological processes take very long periods and that the earth is very old. This is a fundamental principle that underlies most of geology and Hutton is considered to be one of the founding fathers of geology.

Geology as a subject developed rapidly simultaneously with advances in science and technology following the Industrial Revolution in Europe. Geologic principles were used to discover mineral deposits while technology helped to mine them and convert them into useful things and engineer the surface of the earth e.g. constructing seaports, railways, dams and tunnels. Man has used more earth materials in the 20th Century than throughout human history put together.

The Geological Sciences

"Geology is Earth History. The history of the earth is clearly a matter of the greatest interest and importance to all of us who live upon its surface - of interest because we should like to understand the environment in which we find ourselves, of importance because some of the events are recorded in materials such as coal, oil and ores upon which our civilization is found."
(H. H. Read 1949).

Geology is defined as the scientific study of the earth. It deals with all matters concerning the earth - the processes that are presently operating in and on the surface of the earth and, from the rock records, the processes that have taken place from the time the earth was born about 4,600 million years ago. The primary aim of geology therefore is to study the history of the earth, including the history of life on earth.

Geology as a science is only about 200 years old and it is the youngest of the natural sciences. It is traditionally concerned with the solid earth or the rocks *(the lithosphere)*. However, about 70% of the earth's surface is covered by water *(the hydrosphere)* and the earth is surrounded by a layer of gases which form *the atmosphere* while the animal and plant life *(the biosphere)* occurs in the three others. There is continuous interaction between the

lithosphere, the hydrosphere, the biosphere and the atmosphere.

Change is an integral part of nature. Pictures from space show that the earth's atmosphere and hydrosphere are in constant motion. Experience on the ground confirms this. Rocks are very slowly being changed into soil by processes of weathering and the fragments are gradually being moved away by rainwater through gutters, streams and rivers into the oceans. People who live in the northern parts of Nigeria are aware of the harmattan haze, which is in fact rock and mineral particles, some of which have been transported by wind thousands of kilometers from the Sahara Desert. These particles end up in the oceans and, eventually, form rocks.

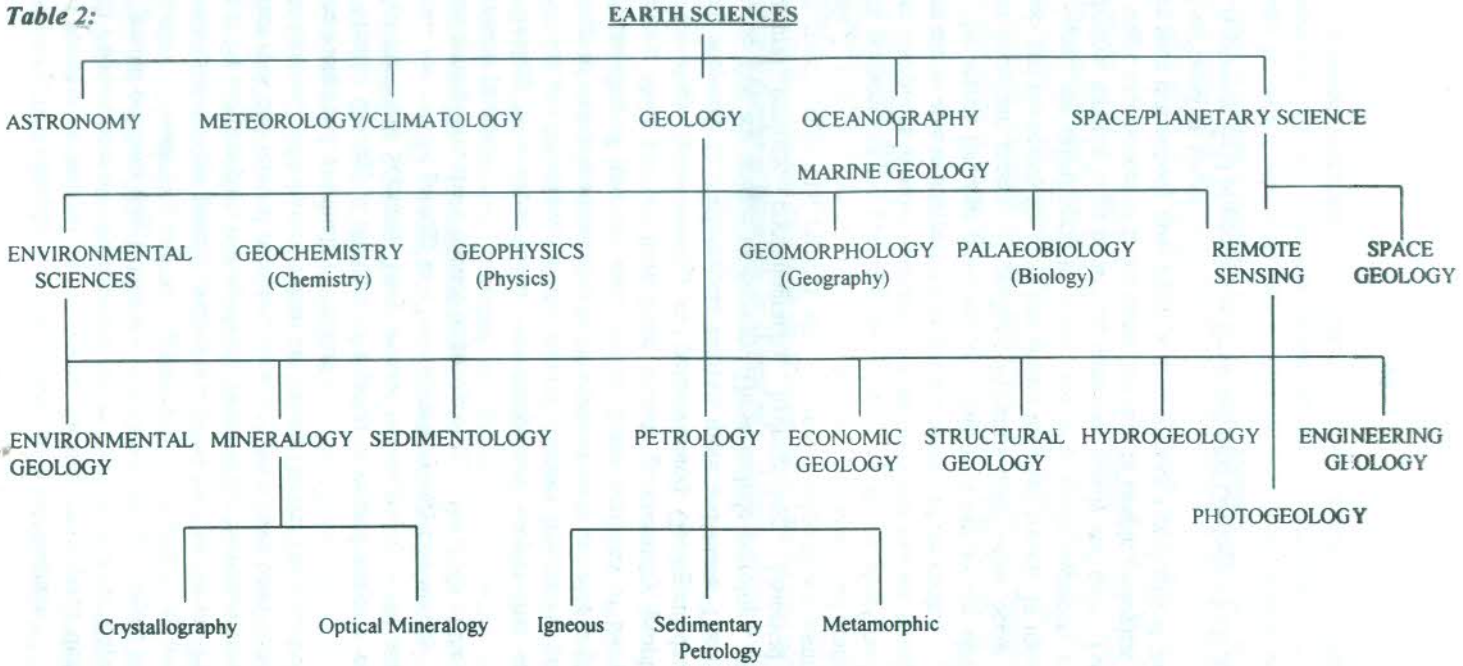
Modern Geology is the core of a group of related subjects, collectively called the Earth Sciences. They include oceanography – the study of the oceans with marine geology as a branch; meteorology/climatology – the study of the atmosphere; space science or astrogeology – the study of the moon and the nearer planets.

Geology is a broad-based, interdisciplinary subject that applies the principles and techniques of the natural sciences (chemistry, physics and biology as well as mathematics) to the study of rocks in order to gain greater understanding of how the earth works. Some branches of the geological sciences, which evolved from these, include geochemistry, geophysics and palaeobiology (palaeontology and palaeobotany). Geological data are now being subjected to mathematical analysis more and more. There are other subjects that are unique to geology. These include petrology, mineralogy, structural geology, crystallography, hydrogeology, historical geology, stratigraphy, economic geology etc. The major subjects are summarized in Table 2. It is clear that no single scientist can specialize in all branches of the earth sciences but the geologist must know something about each of these other disciplines in order to understand the processes that are taking place on earth and be able to interpret the origin and history of the earth.

The search for, and discovery of, mineral resources are obviously the most important aspects of geology. Minerals quite often occur in remote places and the search for them has always involved travels. In modern times, geologists are called upon to advise and help guide engineers in planning highways, tunnels, large buildings, harbours, canals and dams. For example the tragic experiences of failed dams, because of simple geological problems, were such that nobody now builds a dam without a geologist at the planning and construction stages.

A growing field of geology is Environmental Geology which studies how

Table 2:


EARTH SCIENCES
ASTRONOMY
METEOROLOGY/CLIMATOLOGY
GEOLOGY
OCEANOGRAPHY
SPACE/PLANETARY SCIENCE
MARINE GEOLOGY
ENVIRONMENTAL SCIENCES
GEOCHEMISTRY (Chemistry)
GEOPHYSICS (Physics)
GEOMORPHOLOGY (Geography)
PALAEOBIOLOGY (Biology)
REMOTE SENSING
SPACE GEOLOGY
ENVIRONMENTAL GEOLOGY
MINERALOGY
SEDIMENTOLOGY
PETROLOGY
ECONOMIC GEOLOGY
STRUCTURAL GEOLOGY
HYDROGEOLOGY
ENGINEERING GEOLOGY
PHOTOGEOLOGY
Crystallography
Optical Mineralogy
Igneous
Sedimentary Petrology
Metamorphic

natural and man-made hazards such as landslides, floods, volcanic eruptions, earth quakes, beach erosion can be predicted, avoided or dealt with effectively. I will talk briefly about this later.

The Geologist

Geology is an observational subject and the geologist interprets the history of the earth based on his own observations, some of which interpretations were often in direct conflict with the accepted religious dogma. According to Coates (1981), geology was once described as the subject of the noblemen because the early geologists were people of special character, heritage and lifestyle. They were people who did not have to wait for a salary and 'who had sufficient day-light time to make careful field observations, money for travel and independence of thought'.

The modern geologist travels more extensively as travelling has become much easier in the new 'Global Village'. He prospects for minerals wherever they may occur anywhere in the world and he can now be found on the highest mountains, under the seas studying the ocean floor, in the Desert or the Polar regions or even in the city-centre studying urban geology. Some geologists work in the laboratory or in the office. There are many global study-groups which organize field trips to areas of interesting geology in the different continents and to which some of us are invited. The geologist's life can be very tough but exciting. A geologist has actually landed on the moon. One important attribute of a geologist, which is hardly written about but which is very relevant to our contemporary society, is INTEGRITY. I emphasize this to my students all the time as the mining industry, including the oil industry, invest huge sums of money based on the reports and recommendations of the geologist and nobody can go and check all the observations of another geologist.

Because geologists know that minerals are wasting assets or non-renewable resources and appreciate the work involved in the discovery, mining, processing of the minerals etc., they are in the vanguard of people advocating maintenance culture, conservation and recycling. They are actively involved in the search for new mineral deposits and alternative sources of energy for example. They are also very much involved in environmental issues.

Geology is different from the other sciences in two important respects: time and scale. Geological processes are extremely slow on a human time scale; many are believed to take millions of years and so can not be subjected to 'normal' experimentation. Secondly, the whole earth is the object of study and only a small part of the outer layer of the earth is accessible to the geologist for observation and sampling. The geologist has to depend on indirect methods for studying the larger features and the deeper parts of the

earth. These two characteristics have made geology an excitingly controversial subject. There is always more than one possible interpretation of the same features and this has led to the evolution of different schools of thought.

While many geologists believe in God, we also believe in geology and in the evolution of the species. I do not see any conflict. I am aware that some orthodox Jews do not allow geology to be taught in their schools but the State of Israel has trained, and continues to train, very good geologists and hydrogeologists who have virtually turned desert into green fields. In this regard, I cannot operate as a geologist if I continue to believe in the existence of spirits and many other Yoruba traditional beliefs, and indeed, some of the things in many religious books and some of the interpretations of the bible by the so-called Pentecostal churches. It is unlikely that geologists will want to fight for religion as happened three days ago in Kaduna. The disturbances prevented some of my former colleagues in Kaduna and Zaria from being physically present at this Inaugural Lecture. In any case, geology is a practical subject which helps you to have a better life here on earth while religion is based on faith for a better hereafter.

Present State of Knowledge of the Earth

As soon as reasonably accurate maps of the world became available, scientists noticed some striking similarities between the western coast of Africa and the northeastern coast of South America. They seem to fit like parts of a jigsaw puzzle. Alfred Wegener, a German meteorologist, in a series of articles published between 1912 and 1935, provided various lines of evidence to show that Africa and South America were once joined together and later split and drifted over 6000km apart. He also postulated that all the continents were once joined together as a megacontinent, which he called Pangaea. Pangaea started to split and drift apart about 200 million years ago.

Continental Drift is now accepted as just one aspect of a much broader theory known as Plate Tectonics. According to the Plate Tectonics theory, the rigid, rocky uppermost parts of the earth (the crust and parts of the mantle going down about 100km) is divided into a number of plates which are always moving relative to one another on the plastic underlying mantle. Some are moving away from each other, others are moving towards and colliding with each other, while others glide past each other.

Major geological phenomena such as earthquakes and volcanic eruptions are now known to take place mainly along plate boundaries. Plate Tectonics helps to explain why some parts of the world e.g. Japan, Indonesia, China, Mexico, California (USA) and Cyprus are susceptible to earthquakes or why there are volcanic eruptions in the West Indies, Indonesia, Hawaii and Italy for example. We also know from the theory of Plate Tectonics why we do not

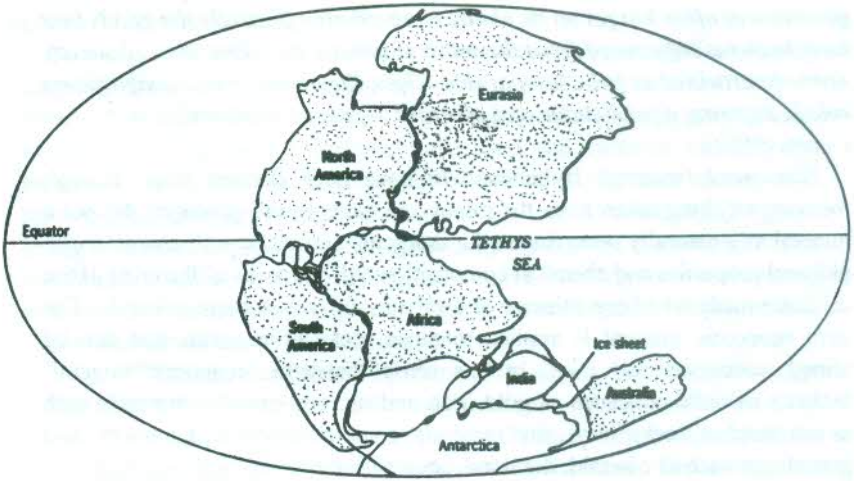


Figure 1. Pangaea (All Land). A reconstruction of the continents to their pre-drift positions about 200 million years ago

expect a major occurrence of any of these phenomena in Nigeria.

Minerals and Development

"Minerals and their derived products permeate all aspects of human civilization - its institutions, its businesses, its welfare, and the very quality of life. Wars have been won and lost over rights to minerals. Exploration for their discovery has led to colonization of new lands. Indeed, 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 often hinges 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".
Coates (1981).

The word 'mineral' is believed to have been derived from 'mines', meaning anything taken from the mines. In general, the geologist defines a mineral as a naturally occurring solid, inorganic substance with characteristic physical properties and chemical composition. All the rocks of the crust of the earth are made up of one mineral or a mixture of two or more minerals. The term economic mineral is applied to those rocks or minerals that can be mined, processed and used. In this sense the term ''economic mineral' includes metallic ores such as gold, iron and tin; non-metallic minerals such as salt, sulphur, rocks, clays, fuel minerals (coal, petroleum and uranium) and gem stones such as emerald, diamond, aquamarine etc.

Mineral deposits are not randomly distributed in the earth crust. They tend to be concentrated in certain zones as a result of geological processes. From the beginning, the location of suitable stones and, later, metallic ores and pigment minerals, have required the *knowledge* of the stones or ores targeted, the *experience* in finding them and the *technology/skill* to smelt the ore to get the metal and use the metal to make useful things.

A classification of minerals according to use is given in Table 3.

Mining is one of the most tedious and dangerous occupations in the world it has always been. During the Greek civilization, only slaves were used in the silver mines and their life expectancy was said to be less than 30 years.

Getting the mineral out of the ground has always taxed man's engineering ingenuity. Ancient mineshafts (holes) down to depths of 20-100m have been discovered in many parts of the world, some of the shafts dating back to 2000-1000 BC. The breaking loose of the ore, the lifting of the broken material to the surface, the crushing of the ore to free valuable constituents from the gangue and the smelting of the concentrated ore to get the metal all posed massive ***technical*** and ***organizational*** problems.

Mining and technological development have always kept pace with each

other. The demands of mining have always led to technological innovations while technological innovations have led to ability to mine deeper and lower grade ores etc. For example, water pumps were invented to keep the mines free of water, lifts were invented to lift people to the mine face and hoist the ore to the surface. The mines have to be aerated to make it possible for the miners to continue working. We take the production of petroleum in this country for granted, obviously because we do not know what is involved. Offshore operation is perhaps one of the most dangerous activities but the oil companies apply the 'state of the art' technology which makes their operations reasonably safe.

Underground mines often become a network of tunnels at different levels (depths). Some gold mines in the Republic of South Africa are as deep as three kilometers. The countries with mining, particularly underground mining technology and experience have used and continue to apply the technology to normal life. Examples of benefits accruing from underground mining experience are many. They include Underground railways/Subways in big cities and tunneling as exemplified by the Europe tunnel built under the British Channel to link England and France. Underground shelters and storage facilities are commonplace. There is an underground Airforce base which was carved out of granitic rocks in Sweden.

The 20th century was marked by tremendous development in technology, which help in improving the quality of life of man on earth. Man has been able to use metals to construct machines, which are in turn used to construct other machines that are applied for engineering the earth. Technology has made virtually everything and anything possible and man is capable of creating hills, lakes or rivers where none existed before. He has also built machines for transport as in railway, cars, ships and airplanes. He is now able to work under the sea, underground and in space. The level of development of a country is usually measured by the per capita use of minerals and mineral products- energy (fuel), water, iron, stone etc.

Geology and the Nigerian Society

"The problem of underdevelopment and poverty in the third world is directly related to that of lack of education about the earth. The more we know about the earth, its resources and the environment, the better we can understand, use and appreciate it." *(Lyn White, 1971).*

I grew up in a society in which a large proportion of the people believed in spirits, superstitions and taboos and saw natural processes in terms of the supernatural. Shango, the Yoruba god of thunder who struck evil doers, floods and draughts were punishment for the sins of the people. Any unusual boulder or prominent rock exposure was believed to be inhabited by one god or another. Some people actually believed that polluted water did not

Table 3: **A CLASSIFICATION OF MINERALS**

I. METALLIC ORES	IRON ORE	e.g.	Haematite Magnetite
	IRON ALLOY ORES	e.g.	Chromite
	NON-FERROUS	e.g	Galena
	PRECIOUS METALS	e.g.	Gold Silver
II. NON-METALLIC (INDUSTRIAL) MINERALS AND ROCKS	CONSTRUCTION MATERIALS	e.g.	Granite for aggregate Limestone for cement Clays for bricks
	CERAMICS	e.g.	Kaolin Silica and Feldspar
	CHEMICALS	e.g.	Limestone Sodium Chloride (Rock Salt) Sulphur
	FERTILIZER MINERALS	e.g.	Phosphate rock Sulphur
	REFRACTORY MINERALS	e.g.	Fire clays Magnesite Chromite Kyanite Graphite
	ABRASIVES	e.g.	Industrial Diamond Corundum Garnet Quartz
	FILLERS	e.g.	Clays Limestones Talc
III. ENERGY AND FUEL MINERALS/ MATERIALS	-		Coals Oil and Gas Tar sand Radioactive mineral
IV. GEMSTONES	-		Sapphire Aquamarine Garnet Amethyst

kill. Some people were credited with supernatural powers to do many things such as the ability to disappear and re-appear at will. Fifty years on, some of these taboos and 'traditional' beliefs are still held by many, including some of our educated people, scientists and Christians. Many Christians now flock into the so-called prosperity churches and spend a lot of time praying to God to provide them money to buy cars, televisions and other luxury items. Other people perform crazy rituals, which we read about in the newspapers, in order to get rich. In the meantime, the people who make these luxury goods and create the wealth of the world, continue to work hard to improve upon their skills and capabilities as exemplified by the current Information/Communication Technology which is reducing the world into a true 'global village'.

Black Africa was for a long time, largely insulated from the other continents and in particular from the activities going on in the Mediterranean region until about the 15th century when the Portuguese first visited parts of West Africa. For example, we missed the Islamic Civilization, which extended from Spain to India between the 9th and the 13th centuries. This isolation led to its being left far behind in development by its immediate neighbours in the Middle East and Europe. The next real contacts with the Europeans led to the slave trade between the 17th and 19th centuries. The slave trade ieft a big scar on Africans. The slave trade was succeeded by the Christian missionaries, the Trading Companies and, eventually, the Colonialists.

As soon as the warring kingdoms of southwestern Nigeria and the Caliphate were conquered in the late 1890s and the early 1900s respectively, the Southern and Northern Protectorates were established. The British immediately sent geologists on expedition to the Protectorates to examine known mineral occurrences and explore for new ones. The results of these expeditions were published in a series of reports between 1906 and 1914. The Geological Survey of Nigeria was established in 1919 in place of the Mineral Surveys.

The British geologists discovered several mineral occurrences including lignites in Asaba, bitumen "in the swampy country east of Lagos", coal in Udi (Enugu) and Lead ores in Abakaliki. They examined the brine springs of Arufu and Awe, the tin deposits (earlier located by the Royal Niger Company) in the Jos Plateau, marble at Jakura west of Lokoja and Iron ore on mount Patti at Lokoja as well as Limestones in Sokoto. Gold was later discovered in parts of Sokoto, Zaria and Niger provinces.

The Geological Survey started off with the mapping of the Plateau tinfields; the country around the Port Harcourt - Enugu and the Lagos - Okuku railway lines as well as and the investigation of the Enugu coals. The work of the colonial geologists led to the fairly extensive mining of tin and, later, columbite on the Jos Plateau, coal in Udi (Enugu) and small scale gold

mining operations in Maru, Yelwa, Minna, Diko and Ilesha.

Mapping and production of geological maps of parts of Nigeria have continued ever since and several other minerals were discovered and investigated. These include the limestone deposits in Nkalagu, Ewekoro, Shagamu and Yandev. Clay and sand deposits were investigated and reported upon in various parts of the country. Between 1928 and 1947 the Geological survey was engaged in sinking wells and boreholes for the rural population in the northern parts of Nigeria in order to provide them with clean and unpolluted water. Water supply was an important section of the Geological Survey when I joined the department in 1967.

Geologists of Shell D'Arcy commenced exploration for oil in the Niger Delta and the Benue trough in 1937. This eventually led to the discovery of large gas and oil deposits in the Niger Delta. The first shipment of oil out of the Oloibiri field was in 1958.

Over 35 years ago Professor Reyment (1963) the first Professor of Geology in Nigeria, gave his inaugural lecture titled "**The Future of Geology in Nigeria**". Nine years later, Professor Cooray (1972) spoke on "**Geological sciences in the service of Nigeria**". These were two foreign geologists, one from a Developed country of Europe, the other from a Developing Country of Asia telling us what contributions the geological sciences could and were making to the development of Nigeria. Professor Oyawoye, the first Nigerian Professor of Geology, gave his own inaugural lecture on "**Politics and Economics of Mineral Resources in Developing Countries**" in 1972.

Oyawoye observed:

"Many of the underdeveloped countries were former colonies, whose economy was not only integrated into that of the master country but geared to meet its needs. Thus in most African countries the system is well established of selling mineral and other resources to Britain, France, Belgium and United States and receiving manufactured goods in exchange. It was not in the interest of the master country to promote in the colonial territory industrialization based on local mineral resources since this not only endangered the supply of raw materials for home industry but also reduced the market in the colonies... There was also developed in the African countries, perhaps understandably, a desire to copy the habits and living standards of the master countries. This gave rise to a perverted appetite for imported luxury goods and extreme reluctance to destroy the colonial economic structure and undergo the painful task of building up from a new foundation a structure related to their ultimate well being. In general, independence has left former colonies far more economically dependent on the master country than ever before".

This quotation has not only remained true of the present, the situation has

in fact got much worse, 28 years after. It nicely summarizes Nigeria's and, indeed, Africa's problems. We now import virtually everything from cars, to electronic equipment to office pins and, many times, bulk constructional and utility materials such as cement and ceramic products of all descriptions. Indeed some of the 'traditional/cultural materials' that we use, for example, the beads won by the Yoruba Obas and Chiefs are minerals which are imported from other countries! (The same is true of the adopted traditional dresses of the other tribes or ethnic groups). The rich in the society now take pride in importing most of the materials for their mansions, instead of using the locally available building materials. The supplier countries of our imports, (who more or less dump their goods on us), now include India, Malaysia, Indonesia, China, Korea, Brazil etc. When the Naira was devalued and its purchasing power greatly reduced, we started importing second hand goods. Able-bodied young men, including the so-called street children, can be seen hawking imported (or smuggled) articles including second hand clothing and electronic equipment and even apples on streets of major cities. The country is gradually looking like a big village of 'rowdy' petty traders rather than a country of farmers or industrialists.

In addition, we still depend largely on foreigners to design and build our roads and bridges; our cities and public buildings, including our new Federal Capital (Abuja), the Legislative Buildings and even the State House. We depend on them for getting portable water and electricity for our towns and villages. These foreign experts also help us to build factories that breakdown soon after they, the 'Technical Partners' leave. Such industries include the Steel Rolling Mills, Aluminum Smelting Complex, Machine Tools Factories and various assembly plants.

Of immediate relevance is the establishment of a Federal Ministry of Solid Mineral Development, about six years ago, in a renewed effort to resuscitate the solid minerals sector, presumably to develop the metallic and fuel mineral deposits *for export and foreign exchange earning*. It is not generally realized in Nigeria that, compared to many other African countries like Zimbabwe, Zambia, South Africa, Ghana, Sierra Leone, Angola, Liberia etc., Nigeria is not richly endowed in solid minerals, particularly, metallic minerals. (I am aware of the fact that Nigeria was once one of the major producers of tin and, at one time, the world's greatest producer of columbite). Some very important minerals that have so far *not* been discovered in ***commercial quantities*** include copper, aluminum, manganese, nickel, cobalt, mercury, salt, asbestos, sulphur etc.

In order to illustrate the point, we can look at gold, a mineral that is known to occur in Nigeria and which has attracted, and continues to attract, attention in the country. The published gold production figures for 1986, in tonnes, are as follows:

South Africa	*640.0*	*Zimbabwe*	*14.9*
USA	*108.0*	*Ghana*	*11.5*
Brazil	*67.4*	*Dominican Rep.*	*9.1*

Nigeria has produced about 13.0 tonnes from 1913 to 1986.

In other words, the total amount of gold ever produced in Nigeria is less than the amount produced by Zimbabwe in one year.

What Nigeria missed in metallic minerals, it got in the abundant energy minerals (oil and gas, coal, bitumen and, hopefully uranium) and industrial minerals.

The Challenge of Technology

"Endowment with natural and human resources does not necessarily make a country rich. *A country can remain potentially rich on a* ***permanent basis whilst a country that is not generously endowed with natural resources, can become very rich. Ultimately, it is the quality of the human resources not merely the endowment of natural resources, that determines whether or not a country becomes rich".*** *(Okigbo, 1999).*

We the Nigerian elite pride ourselves as being brilliant and sometimes boast that we are capable of doing many things- and rightly so. We talk of how well we performed academically when we studied abroad, particularly in Europe and the USA. When there was adequate funding, the academics, including scientists and engineers delivered papers at international conferences and got their papers published in reputable international journals. Some others have patented their inventions, although many of these, we are told, are yet to be taken up and commercialized by investors (because there is no industrial base)! Nigerians have also excelled in various fields of endeavor wherever they go in other parts of the world etc. A Nigerian has actually won the coveted Nobel Price for literature. We therefore have a good claim to having high quality manpower resources. But we are unable to quarry and use our stones as other people do or as the colonial people and the miners did on the Jos Plateau. We are unable to use our clays for bricks or for roof, floor and wall tiles! We continue to import cement and glazed ceramic products to meet local demands. In addition, many university campuses in Nigeria do not have adequate supply of water, some no water at all. Meanwhile our geology and engineering lecturers and their students know all the theory about underground water. Our scientists also know all there is to know about the different methods of reducing iron ores to obtain the metal while the Ajaokuta Steel Complex remains a money guzzler and the iron ore remains in the ground in Itakpe. We have not been able to use our abundant coal resources. This underscores the

difference between knowing **theoretically** and **academically** on the one hand and knowing how to do things practically and **industrially** on the other hand.

The enormous revenue accruing from crude oil has given us a lot of illusions. We have, over the years, embarked on gigantic, supposed 'developmental' projects, which are invariably conceived, in part at least, designed and executed by foreign consultants and contractors. Many of these projects break down or fold up, soon after completion or are abandoned midstream. We tend to *mistake the ability to pay for ability to do.* Those who have the technology help us to get the oil from the ground, pay for it and give us the illusion of richness and greatness. However, these people take the money from us as soon as (or even before) they pay us. We eventually fell into the debt trap. We are now perpetually indebted to 'the Paris Club', 'the London Club' etc. because we depend on them for our imports.

The oil money has led to pockets of stupendous affluence amidst poverty and deprivation. It has also led to rapid urbanization with the attendant social, economic and environmental problems in the cities. In spite of Nigeria's oil money and the potential human resources, it is still considered to be one of the poorest countries on earth. If we must continue to divide the world on account of developmental parameters, Nigeria and many other African countries will fall into the 6^{th}, 7^{th} or 8^{th} World. We definitely do not belong in the same 'world' as the 'Asian Tigers' and the South American countries who have acquired substantial amounts of technological capabilities and are able to solve many of their developmental problems. They make things.

In my view, Nigeria has no business being poor or being in debt – if we have tried to acquire the technology to handle the most basic locally available earth resources such as stones, clays and water instead of importing the finished products. One can give a catalogue of things that we ought to have been doing or which we should have learnt to do ourselves but which we continue to contract out to foreign experts and contractors. There are many others, which we import instead of learning to make ourselves.

To make matters worse, we also establish some industries that have little local material input while our industrial minerals remain in the ground and our children are without work. Car Assembly Plants, Aluminum Smelting Plant, Asbestos cement plants, or even corrugated iron roofing sheets, paints and cosmetic industries, all of which depend heavily on imported raw materials, were established. Indeed some companies import certain minerals such as limestone and kaolin under funny trade names, perhaps to enable them repatriate their profits and keep their home industries in

business. According to Nwangwu (1992) virtually all the barytes used in the oil industry as drilling mud was imported because the 'Mud Companies' said that the Nigerian deposits were unsuitable. The good thing is that the Nigerian Mining Company is currently mining the barytes and I know that the Drilling Companies are now using it.

The figures for the amount of hard currency that we spend on some of these imports are not available to me but we can assume that it is substantial and could have been better applied to some other projects would have helped to alleviate poverty in the country and even help move the country forward.

Let us look at constructional materials, particularly stones and clays as well as the oil industry to illustrate the challenges of technology.

Construction Materials

Building stones. Stones have been used for thousands of years by many ancient cultures e.g. the Egyptians, Greeks, Romans, Indians, Arabs and the Chinese who built houses, monuments and fortifications of stones and used stone for sculpture. In modern days, stones are extensively quarried and used as dimension stones for building the walls of houses; polished for wall facing, floor tiles and table tops in public and private buildings; for monuments, sculpture and tombstones. *Slate* (a rock) is used as roofing tile in some countries where there are slates. *Crushed Stones* are used as concrete aggregates for building and other civil engineering constructions. Stones are the largest extractive minerals in most countries.

The colonialists and missionaries introduced the use of stones to Nigeria by building modern houses of stones wherever stones were abundant, for example the Jos area where many of the mines houses, churches and public buildings were built of stone. Individual Nigerians started to use stones to build their houses as can be seen along the Naraguta Road in Jos. My secondary school, Christ's School, Ado-Ekiti, is built on a hill of granite and that was what the then British Headmaster used for building the classrooms and hostels in the 1950s. Stone-faced buildings are characteristic of Baptist schools in Nigeria.

The introduction of cement blocks greatly reduced the use of stones in Jos. It is instructive to know that the University of Jos, which was established in the 1970s, has not built one house with stone! No other school has been built of stone in Ado-Ekiti where there is abundant stones- just like the Minna area.

Clays: Virtually every culture has used clay for hundreds or even thousands of years. The ancient Babylonians and the Egyptians of the Pharaohic times built houses with mud and straw. Baked mud brick walls, dating about 2000

BC, have been dug up at Harappa India. In Nigeria, the so called Nok culture left Terra Cotta heads made of clay, dated at about 300 BC.

Brick clays are the most common clays and are used in the building industry for bricks. In many parts of the world, brick clays are the main building materials, for example, Brazil. The new capital of Brasilia is built using bricks and clay roofing tiles from locally available clays. The same is true of Milton Keynes, a new town near London, England.

In 1974/75 our Ports were clogged by cement-carrying ships because of massive importation of cement for building Army Barracks across the country. We lost a lot of money to 'International Crooks' who sent ships to our ports for the purpose of collecting demurrage. We apparently never learnt any lesson. It is interesting to note that Abuja, the new Nigerian Federal capital, has been built from the beginning up to now, using a lot of imported constructional materials, including cement. Abuja area is actually known to have large deposits of clays.

Although there are clay-brick factories in the country, somebody came up with the idea of big, hollow bricks rather than the normal small universal sizes apparently because they believe Nigerians do not have the patience to learn to use the standard size.

Of particular interest to me are roofing materials, which are largely imported or based on imported raw materials. Few people realize that ***ALL*** the corrugated iron roofing sheets and aluminum sheets, whether long- or short span, are imported. The asbestos roofing sheets that we use are based on cement and imported asbestos. There is no proven economic deposit of asbestos in Nigeria.

There is no reason why we should not learn to use our clays to make roofing tiles. Clay roofing tiles are not only aesthetically beautiful; they are very good for our hot climate. Some of the contractors in Abuja have built their offices with bricks and roofed the houses with clay roofing tiles. I think they are trying to tell us something.

Kaolin (China Clay or Pottery Clay). This is white clay in which kaolinite predominates. The name kaolin is believed to be a corrupted form of the Chinese Kavling or Kao ling, the Chinese hill where the clay has been used for chinaware since 500 AD. Kaolin is extensively used in the ceramic industry for the manufacture of different types of chinaware, toilet ware, wall and floor tiles etc.

Kaolin and other clays have wide applications in modern industries, particularly in the paper, plastic, pharmaceutical, textile and other industries. Although these clays occur and are locally abundant in the country, many industries import them into the country under funny trade names.

Safe Drinking Water

"He who gives water gives life"

After air that we breathe, water is undoubtedly the most important need of man. Water is the life-blood of man and other living things as most body functions depend on it. While it is possible for a human being to live for up to four weeks without food, he will die in three to five days without water. The availability and maintenance of sufficiently fresh and pure water is a worldwide problem and has been from the beginning of human history.

Because of differences in climate and other factors, fresh water is not uniformly distributed on earth. Some areas have more fresh water than others. Water has always been a major consideration in human settlement patterns. Indeed, water is considered to be at the heart of human civilization. The quest for water has made man in those areas with little rainfall to device means of importing water and getting water from underground. Earliest human recorded history and civilization are centred around the Nile, the Euphrates, the Yellow River Valley in China and the Indus River Valley in India. These are semi-arid regions where there was shortage of water. There is the thesis that the need to harness and use this scarce resource provided the impetus for organizing the society for the good of all, in other words, civilization.

In modern times, prodigious amounts of fresh water are required for domestic uses in urban and rural areas; in agriculture for irrigation and livestock and in the various industries, including hydroelectric generation; mineral processing and manufacturing industries.

The problem of water in many parts of the world, these days, is that it is either too little (as in drought) or too much (as in floods) or too polluted. Polluted water is the carrier of many water-borne diseases such as typhoid, guineaworm, dysentery, cholera and other debilitating diseases. In this lecture, I plan to concentrate on drinking water in Nigeria. Safe drinking water is still a matter of survival in Nigeria and in many other countries of the Third World. Women and children spend many hours each day fetching water, sometime from highly polluted sources far from their homes. We got drinking water from a spring located over four kilometers from my home when I was young.

One can confidently say that adequate supply of portable water is still a national problem in Nigeria. Although there are municipal water supplies in many towns, one can never take the availability of water, anywhere in the country, for granted. In many places, the more affluent people supplement the municipal water supply by sinking boreholes or shallow wells to obtain water of questionable quality. We have had to sink a number of boreholes on this campus in the last few months in order to augment the municipal supply and meet the demands of the university community.

The activities and engineering works associated with water delivery and disposal are said to be the most costly items in the budget of many countries. For example Libya has only recently completed the 'Great River' which in fact is the transportation of water by pipes over several thousand kilometers.

The United Nations General Assembly declared in 1980s the International Water Supply and Sanitation Decade. The aim was to mobilize governments and non-government organizations and needy communities in a concerted effort to provide safe water and sanitation for all by the end of the decade. The Federal Government launched the National Borehole Programme while the state governments also launched major water supply projects. Niger State for example awarded a major contract for the sinking of boreholes for the rural areas of the state. In spite of all the programmes, many villages in Niger State still do not have safe drinking water. Niger State is littered with beautiful water tank towers, which were imported and installed by the contractors but are without water in them.

It has taken the recent publicity of the occurrence of guineaworm (including documentary films on State television showing gory pictures of people infected by guinea worm in the rural areas) to attract attention to the problem of safe drinking water in the state. The State Government and the International Agencies such as UNICEF (RUWANSAN), President Jimmy Carter's 'Global 2000', Gen. Gowon's programme and the Japanese International Cooperation Agency (JICA) have sunk boreholes in some of the villages in Niger State in recent years.

The role of the geologist and the problem of technology are best illustrated by the JICA project with which I became familiar. The State Ministry of Health invited JICA through the Federal Government in connection with the eradication of guineaworm in the State. The ministry was expecting medical personnel. JICA sent an advance party of three geologists consisting of two hydrogeologists and one consultant geologist. This is because it is known that guineaworm can best be controlled through the provision of safe drinking water and in these areas of sparse population, the easiest way to obtain portable water is from boreholes. JICA hydrogeologists obtained the available geological data from our department. The drilling crew, engineers and other technicians moved in later. The completion of the project was delayed by over three months because the simple Indian Mark II hand pumps ordered did not arrive on time.

The problems of water supply to both rural and urban areas do not stop with the sinking of boreholes, installing of pumps or in building major dams. The boreholes in Nigeria (and other parts of black Africa) often break down soon after completion because of lack of maintenance, and we are left with broken pumps, empty water tanks and abandoned sewer lines. In the old Ondo State, two major dams, the Ero and Egbe Dams, were designed and

constructed to serve several towns and villages in Ekiti Division, the new Ekiti State. Ado-Ekiti, the capital of the new state (population > 200,000), which incidentally also has its own smaller dam, is able to service only a very small part of the town on a regular basis. Many parts of the town, including my own house, get no water at all from the municipal supply! The reasons are either that the pumps have broken down or there are no water treatment chemicals, which are invariably imported. The same is true of many other big towns in Nigeria.

We seem not to fully appreciate the importance of water to a nation's economy. There is a Ministry of Tourism. It is said that today's tourist may be tomorrow's investor. Tourism is considered one of the major industries of the future. No tourist will go to where there is no running water in the taps.

The Oil Industry. The story of the oil industry in Nigeria is even more challenging to us the elite of this country. It was known from the outset that Nigeria's natural gas is over two times its oil in energy terms, having over 120 trillion cubic feet of gas in ultimate recoverable reserve. Until recently, over 95% of the gas from the producing wells and refineries was flared because we could not, on our own, harness and could not get the oil companies to harness, the gas. In addition, our petrochemical industry never took off the ground. I hasten to add that the oil industry applies the most up-to-date technologies available to mankind in the exploration, production, processing and marketing of oil and gas. The know-how and the capital involved are concentrated mainly in the hands of the major multinational oil companies. However there are many downstream activities which Nigerians are capable of handling and should have trained people to learn to be involved in but which we have not. The result is that the country has never got the full benefits derivable from the oil industry.

According to an advertisement in the Nigerian Guardian of October 3 1992, by the Nigerian National Petroleum Company (NNPC):

'The challenge in the area of petrochemicals were clearly on the ability of Nigeria to produce all the raw materials need of the petrochemicals industry in Nigeria by producing such raw materials at home instead of importing them. This is in view of the fact that what is needed for petrochemicals production abound in the country¼ .

These raw materials range from plastic resins such as: polypropylene, polyethylene, and polyvinylchloride (PVC) to Carbon Black, Linear Alkyl Benzene and Fertilizers. Materials required for their production come from refineries and natural gas. There are four refineries in the country from which feedstock for petrochemicals could be obtained. Also, the nation produces gas of which over 800,000,000 cu feet is produced daily.

This is more than what is needed in an average petrochemicals production plant....

'Petrochemical production in Nigeria is a major challenge considering that it is one way to add value to refinery products and natural gas. In addition to this petrochemical is a major ingredient in industrialization process and only nations with a good petrochemicals base can aspire to meaningful industrialization. Apart from this, petrochemicals is an industrial multiplier. Its capacity to generate employment is almost limitless because of its wide use in many small, medium and large-scale industrial establishments. The potentials for exporting petrochemical products is also very large for Nigeria'.

In spite of this advertisement, we still import many raw materials such as polypropylene, polyethylene and polyvinyl chloride (PVC), carbon black, fertilizers etc., which we should have been getting from our natural gas and refineries. The refineries in the country were neglected until they virtually ground to a stop in the late 1990s and Nigerians, perhaps more than people anywhere else in the world, in peace time, were subjected to massive and embarrassing shortages of petroleum products. There was no petrol for our cars, kerosene for our lamps, cooking gas for our stoves, diesel for our trucks, plants and industrial machines and generators, (in the absence of NEPA the municipal power supply). Nigeria has been embarrassed by power outages during important international events, particularly football in 1999 and more recently during the Confederation of African Football competition, tagged Ghana/Nigeria 2000, in January. There was also power outage in November, 1998 during the 50th year anniversary celebrations of the University of Ibadan at the anniversary lecture. The audience, which included former lecturers who came from abroad, could see the deterioration of the facilities in that university first hand. One can not carry out meaningful research without reliable power supply. Energy is said to be what keeps the world running. Shortage of energy can undermine the national economy and even national security.

The good news is that the new government has more or less solved the problem of fuel shortage and the first shipment of Liquefied Natural Gas was made on 9 October 1999. We are promised regular supply of electricity in the next two years *(although the electricity supply has actually gone from bad to worse since the lecture).*

The inference one can make from the examples given above is that in spite of the accomplishments of the individuals in the various fields of academic and political life, ***the Industrial Revolution has not really taken place yet in Nigeria and other black African countries.*** This is the challenge of technology.

Environmental geology

Natural or Geological hazards, like earthquakes, volcanic eruptions, gully erosion, landslides, desertification and lightning are normal, natural processes that have occurred from the time the earth came into being. They occur daily in different parts of the world. They become hazards only when man gets in the way.

From the geological point of view, Nigeria is very lucky to be located in one of the most stable parts of the world and we normally do not expect massive earthquakes, volcanic eruptions, typhoons and hurricanes etc. Records of geological disasters across the world are kept in many laboratories and so there are data for study. Unfortunately the most thickly populated countries in the world - China, Japan, Indonesia, India, Pakistan, Western USA, are more susceptible to these geological hazards, often with tens or occasionally hundreds of thousands of deaths recorded. In monetary terms, billions of dollars are lost to geological hazards every year.

Geologists and other scientists study these phenomena in order to understand them and have a scientific basis to evaluate and predict their occurrence so as to reduce their effects on man and his property.

Man made hazards. Man started to modify the environment from the time he discovered fire and settled in communities and started farming. Modern man's ingenuity and technology have enabled him to extract materials from mines deep within the earth and engineer the earth by building dams, canals, pipe lines, roads, railway lines etc. He has also built machines- cars, aircraft and other vehicular contraptions- that burn fossil fuel and emit gasses which pollute the atmosphere.

Environmental problems are truly global in many respects and some people have described the earth as the global space ship. Topical issues like global warming, depletion of the ozone layer, greenhouse effect and acid rain are of global interest.

Perhaps the greatest environmental challenge that Nigeria will face in the future will be caused by urbanization and population growth. The management and disposal of municipal and industrial solid and liquid wastes are already becoming a serious problem in our cities for example Lagos, Ibadan, Enugu, Port-Harcourt, Kano and even Minna and Abuja. The advice and services of geologists will be required more and more in the future, particularly in identifying waste disposal sites and help protect groundwater from pollution.

There is oil pollution and loss of means of livelihood in the oil producing areas of Nigeria. The youths of these areas have now become very militant apparently because there are no employment opportunities. The oil company geologists and other environmental scientists are quietly helping to remedy

the problems

Although there is now a Federal Ministry of Environment, it will appear that the geologist, who is primarily concerned with man's environment, is not sufficiently involved in the activities of the Ministry yet. Whatever we do, there must be collaboration among the stakeholders- the town planners, the environmental scientists including geologists and the politicians. We must put order and discipline into our lives so that some privileged people do not build their houses without consideration for the approved layout plans of an area or town as we used to do in the past and now even in Abuja, the new Federal Capital. For example cities must be zoned to avoid people building along flood plains as was done along the Ogunpa River flood plains in Ibadan, a practice that has led to periodic flooding and resultant loss of lives and property over the years.

My work. I am primarily a field geologist, who produces geological maps. I have been working on the Precambrian rocks of the northwestern and north-central parts of Nigeria, centered around Zungeru and Minna. I actually started my field career as a young geologist in the Geological Survey in 1967. As we have seen above, field geology is the most basic and perhaps the most important aspect of any geological investigation. The field observations are normally followed by the physical, chemical and biological analyses of the samples collected. Some of my maps are exhibited in this Lecture Theater.

Geological maps are useful as a starting point for other geological investigations such as water supply, engineering geology mineral and environmental investigations. In addition geological maps are used by the soil scientists, the agriculturist, the civil engineer and the town planner etc. These maps were used in the last few years by the consultants planning the proposed Zungeru dam and by the Japanese geologists who sank boreholes for JICA in parts of Niger State among others.

The Department of Geology of this university of which I was the founding Head was one of the first departments to be established in the university. Geology as we said earlier, is an interdisciplinary subject that applies the techniques and principles of the other sciences. A geology department is therefore a very expensive department requiring field transport and other specialized equipment as well as some of the equipment used in physics, chemistry and biology (and sometime engineering) departments

Geology is best taught in the field. Unfortunately lack of funds and transport are making it difficult for the department to arrange as many field trips as are necessary. We also believe that all science students should know something about geology i.e. man's environment. We were able to convince the Senate of this university about the importance and relevance of geology to most of the other disciplines in the university in the 1980s and a five-unit

course in geology was designed for non-geologists. The NUC Minimum Academic Standards (MAS) made the university change its own Academic Brief, which to my mind is superior to that of the NUC. I suggest that geology electives be reintroduced particularly for Civil-, Mechanical- and Agricultural Engineering Students as well as Agriculture and Environmental Technology students.

Most geological investigations have practical (or potentially practical) applications. In other lands, governments and industry pay for or support geological research. Our geological maps and information on mineral deposits as well as the results of our groundwater investigations are definitely going to be of use to the government one time or the other. We have given advice to Niger State government functionaries on several occasions,

The Geological Survey is the premier geological institution in this country and we owe a lot to the pioneering work of the colonial geologists who discovered most of the known mineral deposits in the country. The Director of the Geological Survey was a member of the Colonial Executive Council, just to show you the importance attached to the establishment by the colonial government.

Most of the older Nigerian geologists, including myself, passed through the survey. The Directorship of the Geological Survey of a country is one of the greatest honours a geologist can have. However, the Geological Survey of Nigeria and the position of its Director have been relegated in the scheme of things in recent times and one of the Ministers committed the sacrilege of appointing a non-geoscientist as Director in the 1990s.

The Survey is charged with the responsibility of mapping the country geologically, investigate the mineral occurrences and publish the geological maps and their explanation.

Although the Geological Survey has lost many of its experienced geologists over the years, I do not believe that the solution to any problems the Survey may have lies in the wholesale contracting out of its work to consulting companies (local or foreign) as was attempted in the mid -1990s. In my view, it is Nigerians who can map, and should map, the country geologically and in detail. There are a number of experienced field geologists in the universities and outside who can be used to train and re-train the Survey geologists; help supervise the field mapping, the preparation of the maps and other aspects of the office and laboratory investigations and the preparation of the reports. We must fight the dependency mentality and learn to do things ourselves using our own resources at least up to a point that we can then get assistance from other people.

The Way Ahead

In order to know the way ahead, we should look back a little. I believe that Africa has achieved a lot in terms of educational and technological advancement in the last 100 years - granting its history, which we referred to earlier. However, because Africa has been left behind for so long, and because technological innovations have been growing ever so fast, the governments have tended to adopt 'crash' programmes, 'quick fix' or 'fire brigade' approach to development in general and to education and technology acquisition in particular. Many times, we got carried away by what **ought** to be done and left what **could** be done. In the process, we left the very basics and so we have a very poor or weak foundation in technology.

Human history is characterized by the domination and enslavement of the weak by the strong. In the last few centuries there was the Trans-Atlantic slave trade (which is perhaps the worst type of slavery in human history) involving the forceful transportation of the weak Africans to the Americas by the strong Europeans. In addition to the slave trade, the Europeans colonized the rest of the world (the Americas, Asia, Australia, Africa etc.). In the 20th century, two world wars were fought to prevent Germany from subjugating the rest of the world. The victors shared the spoils of the wars. Also, the Japanese subjugated the Koreans and the Chinese while the Russians subjugated the countries making up the defunct Soviet Union and the East European countries. Our present world is ruled by those who have the technology and they dominate the rest of us economically and militarily. Some countries, especially those of Asia and South America, have been working very hard to acquire the necessary technology and free themselves from this domination. Africa remains the weakest of the continents.

Meanwhile Africa is one of the most well endowed continents in mineral resources. However its people lack the technology to get and use these minerals. The minerals were first exploited by the European colonialists and, since independence, by the multinational companies and some individuals who have the technology. The current troubles in Sierra Leone, Angola and the Democratic Republic of the Congo (which I believe are encouraged by some of the mining companies) show how the occurrence of precious minerals in a country without home-based or indigenous technology can be a curse rather than a blessing. These countries would have been better off without the precious stones, particularly diamond.

Education

Education is usually described as the key to personal and national socio-economic development while minerals have been described as the building blocks of the physical environment we call civilization. It is appropriate here

to re-examine the interrelationship between geology (mineral), technology, development and education. We have seen that civilization has always depended on mineral resources and the technology to get and use them. Technology is said to be the engine that drives the economy of nations. It is usually said that 'knowledge is power'. An NTA (Nigerian Television Authority) programme jingle also says 'Technology is Power'.

I was pleasantly surprised in recent years when the Prime Minister of the United Kingdom, Tony Blair, the President of the United States of America Bill Clinton, (and lately Mrs. Laura Bush, the wife of the 2000 Republican USA Presidential candidate) emphasized education during their electioneering campaigns. Mrs. Bush said *'if you can get the education right, it will be well with the country* (USA)'. What we need in Nigeria is to continue trying until we get the education right and it will be well with the country.

Which Education?

The provision of the essentials of life for the people is the responsibility of the government of a country. The success or failure of a government can be measured by the quality and amount of these facilities that it provides. We have established that many developmental problems can be solved through education and technology acquisition. In order to have meaningful development, and break the circle of under-development, we must create a sound educational base with a clear, realistic strategy for technological acquisition. To do this, we must change the way we do things. We should have a good look at our educational system and compare with those of the successful countries, developed and developing, to see if we are doing the right things or not.

According to Lyn White Jr. 1971:

"Natural science, conceived as the effort to understand the nature of things, had flourished in several eras and among several peoples. Similarly there had been an age-old accumulation of technological skills, sometimes growing rapidly, sometimes slowly. But it was not until about four generations ago that Western Europe and North America arranged a marriage between science and technology¼ Science was traditionally aristocratic, speculative, intellectual in intent; technology was lower class, empirical, action-oriented".

Western education was first introduced into Nigeria by the European missionaries about the middle of the 19th Century. These missionaries established schools to train interpreters, clerks, cathechists etc. I started school when each mother had to spin, dye and weave her children's school uniform and when houses were built entirely of locally available materials (mud, bricks, wood and grass) and some villages specialized in pottery etc.

(In addition, village libraries or 'Reading Rooms' were also built). Along the line, we jettisoned the local industries and we started importing everything. Subsequently, our educational system seems to have been producing consumers rather than innovators and producers of goods and services.

Over the years, the Nigerian governments have talked about the acquisition of technology and worked out some strategies, including the establishment of Polytechnics and Universities of Technology as well as a Ministry of Science and Technology for actualizing this. However, these institutions, are in practice, unable to achieve the noble objectives because of inadequate funding and, many times, overcrowding. It is not uncommon to have geology departments with over 100 students in a class. The same is true of many science and engineering departments. The end result is that many of the departments are not able to organize practicals and fieldwork. The students are taught a lot of theories and little practicals. Our potential geniuses are not given any chance to develop their ingenuity and talents. Our educational system is therefore still largely speculative, theoretical and intellectual in content, hardly ever action oriented. We have not been able to arrange a marriage between science and technology yet. It is those who can use their hand as well as their heads that will move this country forward.

A national Universal Basic Education (UBE) Progamme was launched on September 30 1999. It is not clear to me yet what direction the education will go hereafter. Government must decide what type of education will best meet the long-term needs and circumstances of the country. That is, government must have well-articulated GOALS and work out the strategies of how to use the educational system to achieve these goals. We can not afford education for its own sake or for the sake of acquiring a certificate. It is not uncommon to see people study for a Ph.D. degree within or outside Nigeria only for the sake of being called a 'doctor' and the thesis, whatever the quality, is never published or the results used. This is a monumental waste. It is said that a research is not deemed to be done until it is communicated by way of publications.

Also, the government research outfits continue to carry out research and the results, good or bad, are invariably filed away. In the universities research are often based on the researchers' fancy or curiosity and many of them may have little or no relevance to the society. Some people get their results published in journals for promotion purposes.

The latest craze in town is the proliferation of Satellite Campuses or Study Centres of universities and other tertiary institutions in the urban centres across the country. This phenomenon emphasizes our values-certificate without skill. Again, it is government who must decide whether these will serve the needs of the country or not.

I like to quote from what some eminent Nigerians said about technology

and technological education:

Okigbo (1999) describes technology as ***'the language of the new age and science the grammar of that age and those countries that do not prepare themselves fully for the future by mastering its language and grammar will be left far behind.***

He continued ***'Obtaining a certificate does not necessarily make one a skilled worker or a professional; it takes more than a certificate to have the requisite skills, just as having a degree in science does not automatically make one a scientist'.***

Ezepwe in the Daily Times of 4 October 1984 said ***"What we have lacked is a scientifically sound plan to acquire technological capability coupled with the discipline and devotion, which the involved hard work demands.....***

"In technological education we should realize that it is not the number of institutions and students that matter more but the quality and appropriateness of the technological education which is given. Tertiary institutions should therefore be comparatively few, but each should be well staffed, well-equipped for teaching and provided with an industrial centre for real-life training of students and for the research and development work of staff".

Late Professor Ezepwe subsequently became the Minister of Science and Technology and, later the Vice Chairman of NASENI (National Science and Engineering Infrastructure)

Conclusions and Recommendations

In preparing this lecture, I read many published Inaugural Lectures from the older Nigerian universities. I also read some official documents, including the National Policy on Education (1981), the National Policy on Science and Technology (1986), aspects of the 'Vision 2010' (1998) etc. In addition, I read reports by international bodies such as the UNESCO, The Association of African Universities (AAU), the Association of Commonwealth Universities (ACU) etc. These documents contain a lot of valuable materials/information, and suggestions that are relevant to our educational, technological and economic development. I recommend that government officials should study some of these documents to see which of the information can best be applied to our situation.

Africa's problems right now include ignorance, poverty and lack of technological skill. These have led to Africans being dependent on other people for the exploitation of their natural resources and the supply of many of their basic needs. The result has been economic 'colonization', subjugation and indebtedness. In recent years, we have seen the promotion of civil wars and the attendant atrocities perpetrated against the population in Sierra Leone,

Angola and the Democratic Republic of the Congo because of the minerals being exploited.

From the dawn of human history, dominated people have had to fight or work their way out of slavery or domination. It appears that Nigerians prefer to fight over the sharing of the 'national cake'. In the process, we neglected or refused to consider the efficient management and preservation of the already baked cake or, indeed, baking new cake for the present and future generations of Nigerians. What I am saying is that we have been fighting over the sharing of the oil money, while neglecting to maintain the infrastructure that we have been able to put in place (the oil refineries, roads, hospitals electric generating plants etc. Nigerian rulers and the elite class, particularly the senior military officers, politicians and public servants including university teachers, have been behaving as if Nigeria is a very rich country as shown by the life-style of many of these people. We have been importing literally anything and everything. We never encourage local industry. We do not seem to realize that importation creates dependency mentality, kills incentive and encourages laziness and other vices, including fraud. Able-bodied young people and the so-called 'street children' hawk various imported or smuggled goods-new and used-instead of working in the mines or quarries, in the factories or on the farms.

A country that has not mastered the technology of clay bricks and stone quarrying but import cement and ceramic products of all descriptions can not alleviate poverty. I think that the first thing to do is for government to identify some things which we can make ourselves but which we have hitherto been importing. A practical starting point is building materials. The government should provide the encouragement and enabling environment. The relevant university departments, the Roads and Building Research Institute and other relevant public establishments should be given the task of resuscitating all broken-down clay factories and opening new ones for making baked bricks as well as roofing and floor tiles etc. I have no doubts in my mind that if government *decides and directs* that all public buildings should contain at least 80% local content in five years, it will be done.

We should also learn to use our coal. One possible use is for firing the bricks and for cooking to save our forests and help reduce the effects and incidence of desertification particularly in the northern parts of the country. The Raw Materials Research and Development Authority's mandate is along the line envisaged.

We must work out a strategy to get the most out of the petroleum industry by stopping the unending 'Turn Around Maintenance' of the refineries and remove the need to import refined petroleum products. We should as a matter of priority get the petrochemicals industry off the ground. The money we save by not importing the things we used to import and learning to do some things

we used to contract out to foreign companies; the money we make from exporting finished petrochemical products; the jobs we create and the skills we acquire doing these will go a long way to alleviate poverty in Nigeria in the long run more than any measures we may take now. *This is a short time strategy.*

Education remains the surest way of acquiring the knowledge and skills necessary for us to be able to join the rest of the world technologically and industrially. This is necessarily a long-term strategy but which we must get right. In this regard, we must first look at our cultural practices so as to find a way of promoting group scientific culture among our peoples. A subtle way of making the populace think scientifically is to introduce weighing scales to the markets instead of our market men and women selling yams, rice, pepper, groundnuts etc. by volume (and visual assessment) as is done now. It needs to be stated here that the scales should be made in Nigeria.

I will like to see some introductory geology, the study of the earth, taught at the secondary and tertiary levels as part of a general knowledge. We should re-introduce public libraries and reading rooms into the urban and rural areas as was done during the colonial days.

We should have a good and honest look at our present educational system. We should ask ourselves if the 6-3-3-4-education system is working or if it is better than the previous 6-5-2-3 system. What happened to the Introductory Technology concept and the equipment purchased? We need to know the constraints and to see how any barriers (sociological or cultural) that stand between us and technological development can be removed.

Virtually all the public primary, secondary and tertiary schools in the country are overflowing with students. We all know that if you crowd even chicken, they will start to peck (and kill) each other. This is true of virtually all living things. Some of the problems of Nigerian universities, including cultism, can actually be traced to overcrowding.

Tertiary education has become politicized in Nigeria in recent years and the numbers of institutions, the number of courses and the populations have got out of control. For example, the facilities we have in our Geology Department in this university can not cater for much more than 20 students in a class. However, for various reasons, including funding parameters, we have more than 50 in some classes. I know some other Departments of Geology with over 100 students in a class. However, we must realize that, as a nation, it is far more beneficial to graduate 200 well-trained chemists, geologists, engineers, technologists or any other professionals, annually, than to turn out 2000 poorly trained ones. It is the well-trained scientists and technologists that will help Nigeria achieve scientific, technological and industrial take-off. We are already experiencing the dangerous effects of mass education with little skill and no jobs in our society!

Special Schools: I have always been of the opinion that the marriage between science and technology can best be arranged in Nigeria at the secondary level of the education system. A suggestion is the establishment of special Secondary Schools into which *bright children* of ages 10-12 will be recruited and be exposed to practical training in all aspects of engineering and technology, including the installation and maintenance of equipment, in addition to normal academic subjects. They should be given the facilities to design, fabricate and test whatever they fancy so as to encourage their creativity. This is what is usually referred to as "catching them young". The emphasis is on their ability to use their heads AND their hands. It will not work if the schools are overcrowded or are not well-funded or well staffed. I believe that the Military School in Zaria was established by the Colonial Military Authorities to meet such needs, as we are talking about. I also believe that it worked, until we started to overcrowd it and we are not able to maintain the original standards of the school.

I am aware of some special schools in Europe and the United States of America that introduce innovative ideas to technological (and other specialized) education. The latest of these schools I know of is the Oklahoma School of Science and Mathematics, Oklahoma, USA. I recommend that the Federal and State Ministries of Education find out more about these schools, as I believe we have a lot to learn from them.

In addition, we need to designate **one or two** Universities and Polytechnics as 'Special' or 'Technology Incubation' or 'Industrial Training Centers' where there will be say a department of Manufacturing which could actually move things forward a little by mass-producing some of the inventions. This may be one of the ways of creating an indigenous industrial base in Nigeria. The institution must be of world standard and provided with necessary infrastructure so that it can attract scholars and those with relevant expertise (Nigerians and other nationals) from in and outside the country, to come and help. This type of school is not cheap. It should be realized that investment in good education is good investment in the future of Nigeria

What I am saying here is that we have, over the years, been leveling our education by allowing the old missionary and public schools to lose their identity and traditions through overcrowding. But no country can develop by leveling the educational system. You can only level down. For example, the University of Ibadan was internationally known for Medicine and the Sciences in the 1960s and 1970s; Obafemi Awolowo University Ile-Ife, for Agriculture and Ahmadu Bello University, Zaria, for Engineering etc. but they have been allowed to lose their reputations. The Universities of Technology were established in the 1980, to among other things,

"identify the technological problems and needs of the society and to find solution to them within the context of overall national development..."

There must be centers **of excellence** at the secondary and tertiary levels. These centres should attract only the very best, that is: admission should be strictly by merit. To get around our political problems of quota etc., each state may establish one such center by converting one of the existing institutions.

According to Lyn White, 1971, ***"One thing is certain that it seems stupid to verbalize it: both modern technology and modern science are distinctively Occidental. Our technology has absorbed elements from all over the world notably China, yet everywhere today, whether in Japan or in Nigeria, successful technology is Western. Our science is the heir to all the sciences of the past, especially perhaps to the work of the great Islamic Scientists of the Middle Ages.....***

Today, around the globe, all significant science is Western in style and method, whatever the pigmentation or language of the scientist".

We must learn the western style and method of doing science. The American universities and the industry were fully involved in the space project from the outset. In this regard, government must get the tertiary institutions and industry involved in its developmental programmes. Research projects (Institutional, Departmental or personal) in the universities and other tertiary institutions and Research Institutes should, as much as possible, be within the framework of the overall National Goals and Developmental Agenda and should be funded on that basis i.e. our research must be RELEVANT to our developmental programmes. This also implies that there will be communication, co-operation and collaboration between the universities and relevant government departments, as is done elsewhere.

In my view, we need to work very hard and go even beyond the conventional to acquire technological know-how and EXPERIENCE. For example, our Mechanical Engineering Departments should work closely with the Steel and Aluminum Complexes (when they are working) and the Machine Tools Company. Foundry and Forge Technology, often referred to as the 'Mother of Industries', should be a very important and compulsory course of our Bachelors degree in Mechanical Engineering curriculum - irrespective of what the 'standard' or conventional degree curriculum says. This is probably the best way to build a solid foundation for industrialization and the commercialization of the inventions and innovations of our researchers and technologists. However, we can not do all these successfully if we do not put some order, discipline, honesty and transparency in our lives and into our society.

If Nigeria must develop its mineral resources and be prepared for the new millennium, the Geological Survey must be returned to its pre-eminent position and be provided with the tools with which to carry out its

responsibility of mapping the country geologically. One of these tools is money, which should be released on time considering the fact that geology fieldwork is season-bound. Money released after the field season will not be of much use and can be liable to be wasted and can encourage fraud. The Survey and the other geological establishments (the Nigeria Mining Corporation, the Water Resources Department and the NSRMREA etc.) should be strengthened to enable them continue to discharge their statutory functions. There should be collaboration and cooperation between the geologists in these establishments and the university-based geologists. I know that our geologists in these government establishments will benefit from on-the-job training and re-training. A lot of the retraining can be done with the assistance of university geologists with the necessary expertise and experience. Under no circumstance must a non-earth scientist be appointed Director of any geological establishment.

We should learn from our performances in sports and, in particular, football in recent years. It has now been established beyond any doubts that we have the same potentials as any other people as shown first by the under 17- and the under 21 year old football teams. The Olympic and the national teams have shown that we can be as good as any other people individually and that with hard work, we can beat the world as Nigeria did in the 1996 Atlanta Olympics. However, we must have the humility to recognize the limitations of our facilities, organizational ability and experience in these things.

I wish to end this lecture by quoting Radolph W. Bromery a Black American Geologist who became President of the Geological Society of America in 1989:

"The economic and environmental future of our country and this planet will be shaped to a large extent by those of us in the various geological professions. The United States now holds the leadership position in research and application of groundwater and surface water exploration and development techniques, earth resources exploration and development, and waste disposal and environmental planning and protection technology. Geology will continue to play a key role in the critically important areas "

Lessons from human history show that Nigeria (and other black African countries) will, eventually, join the rest of the global village as active participants. I am confident that Nigerians will acquire the necessary technology and there will be true indigenous industrialization. Industrialization will lead to increased demand for minerals (metallic, non-metallic, fossil fuel and fertilizer minerals) for local industries. In addition, there will be need to provide more water for domestic, industrial and agricultural use. Industrialization will lead to urban growth. Urbanization will put stress on the environment. We shall continue to require the

services of well-trained geologists to meet our development needs and help protect our environment in the future -just as Bromery said of the USA- Geology is the subject of the future in Nigeria.

References

Bromery, Randolf W. 1992. Geology: An unexpected but rewarding career. Guest Essay: In: *Physical Geology* by James S. Monroe and Reed Wicander. West Publishing Co. p. 293.

Coates, Donald R. 1981. *Environmental Geology.* John Wiley.

Cooray P.G. 1972 The Geological Sciences in the service of Nigeria. Inaugural Lecture. University of Ife, Ile-Ife.

Cooray, P.G. 1987. Presidential Address. AGID News,1987.

Cooray, P.G, 1991. Geosciences and Development - The way ahead. In Dorrick A.V. Stow & Deryck JC. Laming (eds) *Geosciences in Development* AGID/Balkema, pp 3-13.

Davies, W., 1971. Minerals and Man. Inaugural Lecture. University College of Wales, Aberystwyth.

Nwangwu, Uka. 1992 Your wealth could be in mud. Presidential Address. *Nigeria Mining & Geosciences Society Annual Conference.* Port-Harcourt.

Okigbo, Pius, 1999. The Grammar of the Future. In Azubuike A. Elueze and Chukwuemeka J. Ikelionwu (eds). *Nigeria Mining and Geosciences Society, Annual Lecture Series* Vol. 1 (5th Lecture, November 12,1996). pp 35-57

Oyawaye, M.O. 1972 Politics and Economics of Mineral Resources in Developing Countries. Inaugural Lecture. University of Ibadan, Nigeria.

Read, H.H., 1949. Geology: An introduction to earth history. Home University Library.

Reyment R.A., 1963. The future of Geology in Nigeria, Inaugural Lecture. University of Ibadan, Nigeria.

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References

Bromery, Randolf W. 1992. Geology: An unexpected but rewarding career. Guest Essay: In: *Physical Geology* by James S. Monroe and Reed Wicander. West Publishing Co. p. 293.

Coates, Donald R. 1981. *Environmental Geology*. John Wiley.

Cooray P.G. 1972 The Geological Sciences in the service of Nigeria. Inaugural Lecture. University of Ife, Ile-Ife.

Cooray, P.G. 1987. Presidential Address. AGID News,1987.

Cooray, P.G, 1991. Geosciences and Development - The way ahead. In Dorrick A.V. Stow & Deryck JC. Laming (eds) *Geosciences in Development* AGID/Balkema, pp 3-13.

Davies, W., 1971. Minerals and Man. Inaugural Lecture. University College of Wales, Aberystwyth.

Nwangwu, Uka. 1992 Your wealth could be in mud. Presidential Address. *Nigeria Mining & Geosciences Society Annual Conference.* Port-Harcourt.

Okigbo, Pius, 1999. The Grammar of the Future. In Azubuike A. Elueze and Chukwuemeka J. Ikelionwu (eds). *Nigeria Mining and Geosciences Society, Annual Lecture Series* Vol. 1 (5th Lecture, November 12,1996). pp 35-57

Oyawaye, M.O. 1972 Politics and Economics of Mineral Resources in Developing Countries. Inaugural Lecture. University of Ibadan, Nigeria.

Read, H.H., 1949. Geology: An introduction to earth history. Home University Library.

Reyment R.A., 1963. The future of Geology in Nigeria, Inaugural Lecture. University of Ibadan, Nigeria.