UNIVERSITY OF PORT HARCOURT

GEOPHYSICS,
a panacea for
NATIONAL WEALTH AND SAFETY

An Inaugural Lecture

By

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DEDICATION

This inaugural lecture is dedicated to GOD ALMIGHTY for all his Mercies throughout my life. And secondly, to my children – Joseph Jr., John, Jane (USA), James (USA) and Joshua, who have made my life worth living even with all the traumas. Without these children, I would not have been where I am today. And finally to my elder brother – S/Sgt C. A. Ebeniro (of the blessed memories) for giving me the head start.

ACKNOWLEDGEMENT

Mr. Vice Chancellor, Sir, in life no one is an island. Whatever contributions one has made must be as a result of the encouragements, assistance and even the contributions of others in the person's life. I will also use this singular opportunity to acknowledge those many individuals and organizations who have really made it possible for me to be talking to you on this podium today. Whatever I am today started from the village elementary school where Mr Francis Nwachukwu took special interest in me pushing me hard to excel in Arithmetic and elementary science. At the secondary school level Reverend Father Ford (Blessed Memory) who took me as one of his three sons in the school raised us to appreciate discipline. Mr Maranzu taught me Geography from where the appreciation of the workings of nature came into focus. Mr Maranzu was really my gem, he turned me around from a not so good a geography student to an "A-1" student in the subject. This really resulted in creating the geoscientist that I am today. Prof J. E. A. Oseimekhian put me into the right pedestal of geophysics at the university level when after giving me the basic geophysics course supervised my undergraduate project on Deconvolution at the University of Lagos. At this juncture, the seed of my geophysics career has been sown. This career was consummated when Mr Fidelis Nwokike and Dr Victor Moghalu (Borno Medical Clinic, Maiduguri) facilitated my journey to the University of Texas at Austin to continue with the quest for knowledge in Geophysics. At the University of Texas, the great minds in Geophysics gave out their best to me and my association with that university has continued till today. Profs Yosio Nakamura, Clark Wilson, Milo Backus, Paul Stoffa, John Sclater, Jim Dorman, John Castagna etc are few of the greatest geophysicist who bequitted to me the norms of the profession.

Ms Patty Ganey-Curry is a special family friend who is still keeping my family at heart. All these persons I have mentioned, though incomplete, share one thing in common. They made me the geoscientist I am today. I will ever remain grateful and pray to God to continue to give them long life and prosperity.

Now let us come down to contemporary issues. The acknowledgement will be incomplete without the mention of the great people of University of Port Harcourt. Prof Charles O. Ofoegbu encouraged and worked hard to enlist me into the university when he was the Head of Department of Physics. Prof Levi C. Amajor has remain to be a friend, mentor confidant and among others a father. He encouraged and even pushed me hard to apply for professorial assessment and even almost physically pursued my assessment when it was becoming extremely too long for the results to be released. He has always been there for me to emulate especially with his encouragements to keep in touch with the village setting. I really appreciate you. To my colleagues, Prof O. E. Abumere (my only foreign brother and current Dean, Faculty of Science), Prof I. O. Owate (my orator), Dr. C. N. Ehirim (my reliable mentee), I appreciate you all. To my former and current post graduate students. especially Drs Meshach Omudu, Ogagarue, Nwankwo, I implore you to keep the profession going with the research we have started. Be focused, consistent and principled, humane and still be firm in your life dealings. Ms Ajidua, Mr Edoja, Mr Essien, Mr Dagogo and other students whose research kept the dream of geophysics in the department in top burner, I appreciate your efforts. My colleagues at the CORDEC office, your hard works under very strict and perfectionist supervision brought out the best of service. You are all appreciated.

Shell Petroleum Development Company (SPDC) has always aided our geophysics research focus in the Department of Physics. She equipped a Geophysics Analysis Laboratory and had been funding researches being carried out in this laboratory for our mutual benefit. I will ever remain appreciative.

Let me here appreciate my good friend, Prof Don Baridam – the former Vice Chancellor of University of Port Harcourt. He really assisted me to be myself in the university by bringing me out to face challenges never done before. I appreciate your immense courage. I think you really captured my personality when in your book – Raising the Bar you said "Ebeniro is one man who believes that great feats could be accomplished without unnecessarily mystifying simple issues. A man of immense knowledge and versatility, Prof Ebeniro wears a highly deceptive casual surface that hides a serious-minded public officer with a knack for great accomplishments". Thank you, Sir, for your courage.

For the current Vice Chancellor, Prof J. A. Ajienka and his team of principal officers, I will ever remain grateful for allowing me time to make this presentation at this time. Our friendship started long before you became the Vice Chancellor. This friendship will also continue even after we all stand down what we are doing now in our quest for excellence both within and outside the university. Thank you sir and wish you all the best.

Finally, what will I be doing here if not for the support and encouragement of my immediate and extended family? My aged father (Chief Michael Ebeniro Ukpabi of the blessed memories) although a stark illiterate gave me a head start in education. My mother (Mrs Margret Chimegbulem Ebeniro) made sure we had food on the table to enable us survive the war and continue with my quest for knowledge. My immediate elder brother – S/Sgt Cyprian Adimoha Ebeniro (Rtd) made sure I was sent to a secondary school under all odds. Although, he is dead, he is still alive in me always. To my immediate family Mrs Felicia Oyiriwonu Ike, Mr. Batholomew Onyekachi Ebeniro, Mr Giles Ugochukwu Ebeniro, Mrs Chinyere Asasa and Benerdette Baby Ebeniro, you all have been an inspiration for me to continue to struggle to make sure we get out of the situation we found ourselves at birth. To my Children, Joseph Jr (Onyekwere) Jr., John (Emeka), Jane (Adanma), James (Iyke), Joshua (Chimaobi), you really grew up with me. I appreciate you all for your steadfastness to succeed in life. You are my pride and remain so also. God Bless you all.

There are so many others who are so dear to me on the quest for knowledge and I could not accommodate in this acknowledgement. Please bear with me and remain blessed.

Is it really possible to be what you are or what you want to be without Someone Infinite? Definitely not! Thus, this presentation will never be complete without acknowledging the Almighty God - My Infinite Father, who has always been my strength, courage and my all and all, guiding and protecting me from the myriads of distractions and temptations

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PROTOCOL

The Vice Chancellor,

Deputy Vice Chancellors,

Registrar and other Principal Officers,

Provost College of Health Sciences,

Dean School of Graduate Studies,

Dean Faculty of Education,

Deans of Faculties,

Distinguished Professors and Scholars,

Director of Institutes and Units,

Heads of Departments,

Distinguished Guests and Friends,

Great Students of Uniport,

Members of the Press,

Ladies and Gentlemen.

Introduction

What is Geophysics?

The word "Geophysics" is developed from the two words "Geo" – Earth and "Physics"- study of matter in relation to energy. Thus, one can easily define the word as the science that applies the principles of physics to the study of the earth. In order to achieve this, measurements are made at or near the earth surface to obtain data that when analyzed are used to reveal the internal structures of the earth (rocks and minerals). Interpretations of this data are capable of delineating local and regional features which could be of economic importance to the human being. Most features that would be of economic interest comprise the concentrations of specific minerals contained in pore spaces holding fluid of interest – water and hydrocarbon. These concentrations are not usually common. Thus Geophysics seeks to look for contrasts in rock properties associated with uncommon specific structures which can contain the minerals being sought for. These specific minerals only show up as ***anomalies*** in the measured data. Geophysics is a very broad subject and includes subjects that many would not comprehend such as Oceanography, Seismology, Volcanology, Magnetism, Gravitation, Meteorology and Geodesy (Fig. 1)

Geophysics is classified into two major scales. These are the Global Geophysics (GG) and Exploration Geophysics (EG). Global Geophysics is that branch of geophysics that looks at the whole earth. It is with this aspect that earthquake seismology comes into focus. Exploration Geophysics is that which looks at geographically restricted areas in the upper crust in order to determine the distribution of physical properties at depth. This provides a rapid and cost effective means of deriving information of the subsurface resources of potential interest. The main goal is to identify and define geologic strata that contain minerals and especially hydrocarbon of economic interest.

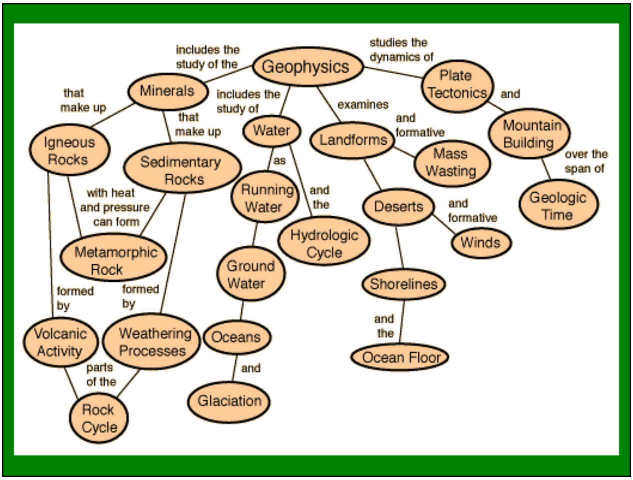


Figure 1: General Geophysics Organogram

My Vice Chancellor sir, after this basic introduction of what the word Geophysics represents, let us now introduce the main geophysical surveying techniques that are in use today. There are two broad divisions of geophysical surveying methods.

1. Those that make use of natural fields of the earth, and
2. Those that require the input into the ground of artificially generated energy.

The natural field geophysics utilize gravitational, magnetic, electrical and electromagnetic fields of the earth, searching for local perturbations of these naturally occurring fields that may be caused by concealed geological features of economic or other interest. Generally, natural field methods can provide information on earth properties to significantly greater depths and the logistics for this method is quite simple. Artificial source geophysics involve the generation of local electrical or electromagnetic fields that may be used analogously to natural fields, or, in the most important single group of geophysical surveying methods, the generation of seismic waves whose propagation velocities and transmission paths through the subsurface are mapped to provide information on the distribution of geological boundaries at depth. Though, artificial source methods are capable of producing a more detailed and better resolved picture of the subsurface geology, their logistics are laborious and requires a lot of expertise. The depths of investigation are quite small in comparison.

The range of application of each method is determined by the physical property of the earth material which it responds to (Table 1). For example, the magnetic method is very suitable for locating buried magnetite ore bodies because of their high magnetic susceptibility. Similarly, seismic and electrical methods are suitable for the location of a buried water table because saturated rock may be distinguished by its higher seismic velocity and higher electrical conductivity. Geophysical surveys can be carried out in two modes: reconnaissance and detailed. The distinction between the two depends on the objective either to find features of interest in geology and geophysics or to map those features. Reconnaissance surveys are often carried out from the air because of its high speed of operation. When the first geophysical operations for location of oil and gas were carried out in the Niger Delta, aerial gravity and magnetic surveys were carried out mainly to locate the presence of large sedimentary basin – the Niger Delta basin. This first round of geophysical exploration techniques may highlight areas of particular interest where further detailed seismic work needs to be carried out. In such cases, both electrical and seismic methods are not applicable, since they require ground contrast for the direct input of energy.

Table 1: ***Geophysical Surveying Methods***

Method	Measured Parameters	Physical Property
Seismic	Travel time of reflected and refracted seismic waves	Density and elastic moduli, which determine the velocity of seismic waves
Gravity	Spatial variations in the strength of the gravitational field of the earth	Density of the earth materials
Magnetic	Spatial variations in the strength of the geomagnetic field of the earth	Magnetic susceptibility and remanence
Electrical Resistivity Induced Polarization Self Potential	 Earth Resistance Polarization voltages or frequency dependents ground resistance Electrical Potentials	 Electrical Conductivity Electrical Capacitance Electrical Conductivity
Electromagnetic	Response to the electromagnetic radiation	Electrical Conductivity and inductance
Radar	Travel times of reflected radar pulse	Dielectric Constant

As a matter of fact, geophysical methods are often used in combination. For example, the initial search for metalliferous mineral deposits often utilizes airborne magnetic and electromagnetic surveying. As mentioned earlier, reconnaissance of continental shelf areas often includes simultaneous gravity, magnetic and seismic surveying. In offshore search for oil and gas, an initial gravity reconnaissance survey may reveal the presence of large sedimentary basin that is subsequently explored using seismic techniques. During interpretation, ambiguity arising from one technique may be removed by considering the results of the other technique. The main field of application of geophysical surveying and their most appropriate surveying technique for each application is shown in Table 2.

Table 2: ***Geophysical surveying applications***

Application	**Appropriate survey methods***
Exploration for oil and gas	S, G, M, (EM)
Exploration for metals	M, EM, E, SP, IP
Exploration for sand and gravel	S, (E), (G)
Exploration for underground Water	E, S, (G)
Engineering/Construction site investigation	E, S, (G), (M)

*G: Gravity; M: Magnetics; S: Seismic; E: Electrical; SP: Self Potential; IP: Induced Polarization; EM: Electromagnetic; Subsidiary methods are in brackets.

At this juncture, Mr Vice Chancellor sir, I will have to limit myself on the areas of geophysics that focus on the inaugural lecture topic of National wealth and safety. National wealth is dependent on the exploration and exploitation of oil and gas for now. National safety will be focusing on taking a cursory look at how we can respond to earth-related natural disasters (earthquake). This points towards the recent earth tremors that happened in both Haiti and Japan. How will we, as a nation, respond to such if and when such phenomenon occurs around us?

Mr. Chairman Sir, our national wealth depends virtually on the oil and gas which controls more than 90% of our national wealth. The branches of geophysics that control this include gravity, magnetic and seismic. Let me use this opportunity to review their processes as they are used to explore for oil and gas.

Gravity Method

This is a passive method that measures the spatial variations in the earth's gravitational field with its operative physical property as the density/mass of the earth rocks that determine the gravitational acceleration.

The basic physics law stated by the gravitation law shows that any two bodies in the universe are attracted to themselves. The law of attractions depends on the mass of the bodies and their distance apart. Their mass is dependent on the force of gravity which is dependent on the density. In gravity method of geophysics, lateral density changes in the subsurface cause a change in the force of gravity at the surface. The intensity of the force of gravity due to a buried mass difference (concentration or void) is superimposed on the larger force of gravity due to the total mass of the earth. Thus, two components of gravity forces are measured at the Earth's surface: first, a general and relatively uniform component due to the total earth, and second, a component of much smaller size that varies due to lateral density changes (the gravity anomaly) . By very precise measurement of gravity fields and by careful correction for variations in the larger component due to the whole Earth, a gravity survey can sometimes detect natural or man-made voids, variations in the depth to bedrock, and geologic structures of exploration and engineering interest.

Figure 2: A Lacoste Romberg Gravimeter

In gravity prospecting, we measure very small variations in the force of gravity from rocks within the earth using highly precise equipment called a "gravimeter" (Fig. 2). Different types of rocks have different densities, and the dense rocks have the greater gravitational attraction. Application of gravity methods include:-

- Defining the size and extent of ore bodies
- Depth of the Bedrock
- Delineating intrusive bodies
- Defining buried river channels
- Demarcating faults (changing of anomaly shape)
- Delineation of extent of sedimentary basins
- Detection of salt dome and salt deposits and reefs(-ve anomalies)

Delineation of the extent of the sedimentary basin is the major application of this method adopted during the exploration of oil and gas. Thus gravity method is used as a reconnaissance tool before the use of more detailed methods to locate zones in the earth where accumulation of oil and gas is possible.

Magnetic Method

This is another passive method used to detect magnetic anomalies within the earth's magnetic field which are caused by the magnetic properties of the underlying rocks. Its operative physical property is the magnetic susceptibility and remanance which determine magnetizability

In magnetic prospecting we look for variations in the magnetic field of the earth. The magnetic field of sedimentary rocks is usually much smaller than igneous or metamorphic rocks. This lets us measure the thickness of the sedimentary section of the earth's crust.

Magnetic surveying investigates the subsurface geology of an area by detecting magnetic anomalies within the Earth's magnetic field, which are caused by the magnetic properties of the underlying rocks. Most rock-forming minerals are non-magnetic but a few rock types contain sufficient amounts of magnetic minerals, which can impart a magnetism to their host rocks and thus produce detectable magnetic anomalies. Rock magnetism has both magnitude and direction, the latter being determined by the host rocks position relative to the past and present magnetic poles of the Earth.

Figure 3: A magnetometer being used in the field

This is the oldest geophysical prospecting method as Von Wrede used variations in the earth's field to locate deposits of magnetic ore in 1843. Earlier on, in the 16th century, Sir Gilbert found that the earth behaves like a North-South permanent Bar magnet.

Magnetic surveys are generally carried out from the air, but ground and marine surveys can also be used. In a simple land survey an operator might use portable equipment called a "magnetometer" to measure the field at the surface of the Earth at selected points that form a grid over a suspected geological structure (Fig. 3). This method is slow but it yields a detailed pattern of the magnetic field anomaly over the structure, because the measurements are made close to the source of the anomaly. For land surveys, inter-station spacing varies from 5m to about 50m or more depending on the depth of structure of interest. Base station must be set up and reoccupied every 2 to 3 hrs to keep track of diurnal variations and drift. Stations should not be near railroads, power lines, wire fences, culverts, vehicles, belt buckles, knives, Jewelry etc.

Large surveys are covered with air-borne work. In practice, the surveying of magnetic anomalies is most efficiently carried out from an aircraft, since this is both cheap and rapid. The magnetometer must be removed as far as possible from the magnetic environment of the aircraft. Airborne magnetic surveying (Fig. 4) is an economical method of surveying a large territory in a short time and has become a routine part of the initial stage of the geophysical exploration of an unexplored region. A disadvantage of airborne surveying is related to the speed at which it is done, since a small error in heading or speed measurement produces a large error in the calculated position, although the use of the Global Positioning Satellite data gets around this problem.

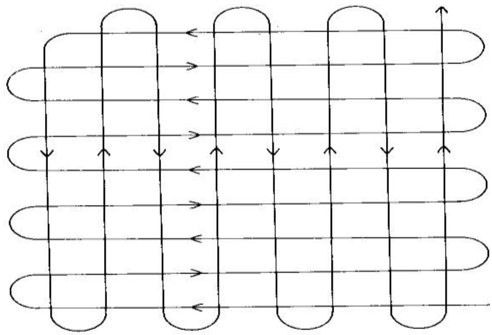


Fig. 4: A typical flight plan for an aeromagnetic survey

The magnetic field in the marine environment may also be surveyed from the air. However, most of the marine magnetic data has been obtained by ship-borne surveying. In the marine application a proton-precession magnetometer mounted in a waterproof ''fish'' is towed behind the ship at the end of a long cable. To minimize the large magnetic disturbance caused by the towing vessel, the tow-cable must be about 100-300m in length. At this distance the ''fish'' will be located well below the water surface. At a typical survey speed of 10km hr^{-1} its operation depth is about 10-20m.

Magnetic surveying is a very rapid and very cheap technique. While not very widely used in hydrocarbon exploration, magnetic surveying is a very useful aid in geological mapping in areas with thick sedimentary cover and may reveal intrusives, structural features if magnetic horizons such as ferruginous sandstones, tuffs or lavas are present. Alternatively, if the basin fill contains no magnetic sediments, a magnetic survey has the ability to "see through" the cover to disclose the nature and form of the crystalline basement and thus the depth and character of the boundaries of the sedimentary basin. In both cases, it might reveal the location of structural traps within the sediments or features of basement topography, which influenced the development of the basin fill. Applications of magnetic method include:-

- ✖ Investigation of large-scale crustal features
- ✖ Search for metalliferous ore deposits bodies
- ✖ Location of both massive sulphide deposits and iron ores
- ✖ Used to map areas with thick sedimentary cover that may reveal intrusives, structural features such as ferruginous sandstones, tuffs or lavas
- ✖ Also "sees through" the sedimentary cover to disclose the nature and type of the crystalline basement thus revealing the depth and character of the boundaries of the sedimentary basin
- ✖ Used to reveal the location of structural traps within the sediments or features of the basement topography which influenced the development of the basin fill
- ✖ Used to reveal the position of the continents at various times in the past – Continental drift, Seafloor spreading

"Seeing through" the sedimentary cover is the main feature of this technique in the exploration for oil and gas. This reveals the thickness of the overlying sediments which is usually analyzed to determine if the sediment is mature enough to contain any hydrocarbon.

Seismic Method

Seismic methods, in comparison to gravity and magnetic methods, are active methods of geophysical methods. In seismic surveying, seismic waves are propagated through the earth's interior and the travel times are measured of waves that return to the surface after refraction or reflection at geological boundaries within the earth. The magnitude of the travel times are determined by the distance from the source to the detector and the elastic properties of the materials between the source and the detectors. These travel times may be converted into depth values and, hence, the distribution of the subsurface interfaces of geological and economic interest may be systematically mapped. One of the first active seismic experiments was conducted in 1845 by Robert Mallet when he measured the time of transmission of surface waves generated by an explosion using the ripple formed at the surface of mercury after an explosion. In 1909, Andrija Mohorovicic used travel-times from earthquake sources to perform a seismic refraction experiment and discovered the existence of the crust-mantle boundary now called the *Moho*.

The earliest uses of seismic observations for the exploration of oil and mineral resources date back to the 1920s. The seismic refraction technique was used extensively in Iran to delineate structures that contained oil. The seismic reflection method, now the most commonly used seismic method in the oil industry, was first demonstrated in Oklahoma in 1921. Seismic surveying methods as adopted for the oil and gas industry are divided into two methods:- Refraction and Reflection Seismology

Refraction Seismology

Refraction experiments are based on the times of arrival of the initial ground movement generated by a source recorded at a variety of distances. The source and receivers are separated by distances that are large with respect to the depth of the refracting surface (Fig. 5). The waves therefore travel over great horizontal distances. Later-arriving complications in the recorded ground motion are discarded. Thus, the data set derived from refraction experiments consists of a series of times versus distances. These are then interpreted in terms of the depths to subsurface interfaces and the speeds at which waves travels through the subsurface within each layer. These speeds are controlled by a set of physical constants, called *elastic parameters* that describe the material.

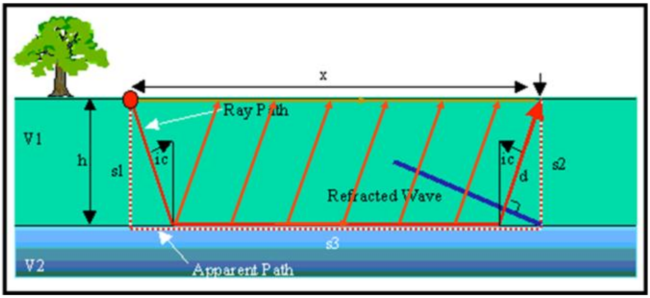


Figure 5: Refraction geometry

Reflection Seismology

In reflection seismology, elastic waves are injected into the earth and geologic structures are mapped from the echoes returning to the surface from the depths. In contrast with the refraction seismology, reflection techniques measure travel times of waves that arrive from subsurface interfaces between media of different strength at offsets much smaller than the depth of these interfaces (Fig. 6). In this sense, reflection seismology is a very sophisticated version of the echo sounding used in submarines, ships, and radar systems. In addition to examining the times of arrival of these, reflection seismic processing extracts information about the subsurface from the strength of the arrival (amplitude) and shape of the ground motion. The travel time and amplitude depend on the nature of the reflection boundary and on the path that the wave has followed from the source to the reflection boundary and to the receiver. Subsurface structures can be complex in shape but like the refraction methods, are interpreted in terms of boundaries separating material with differing elastic parameters.

Although, reflection technique is more expensive to conduct, the petroleum industry uses it in exclusion to other exploration techniques. This is because of its potential for being more powerful in terms of its ability to generate interpretable observations over complex geological structures and its high accuracy to provide the most detailed information necessary to locate oil and gas from the surface. It provides sophistication and requires a lot of expertise and experience.

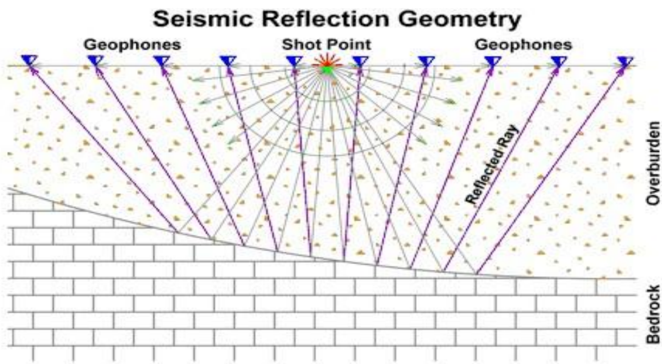


Figure 6: Seismic Reflection Geometry

My Vice Chancellor Sir, after the foregone introductory remarks and the basic description of geophysical survey techniques, I will now try to capture what, to my own belief, the inaugural lecture is meant to convey to the society. To me, I believe that an inaugural lecture gives the lecturer an opportunity to showcase himself what he believes he has been professing to the society. It is neither meant as a promotion criterion or for a professor to come out and tell us about himself without fulfilling quality aspect of the human endeavor he has been working on throughout his academic life. With this in mind, sir, I will here try to chronicle the trail of my academic enquiry from inception and summarize by trying as much as possible to emphasize what I believe is my own contribution to knowledge.

My quest for knowledge began when after my high school days, I was admitted to pursue a Higher School Certificate in St. Augustine's Nkwerre (now, Nkwerre High School) to study a rare combination of subjects (Maths, Physics, Geography). One may ask where this combination should lead someone in life. At this point, my wish was to pursue a course in either one of the following – Marine Engineering, Aeronautic Engineering or Geosciences. I ended up with Physics in University of Lagos where I did a project on Deconvolution under the supervision of a foremost Geophysicist – Prof J. E. A. Oseimehkian. Deconvolution is really a mathematical operation which is designed to restore a wave-shape to the form it was before it underwent a linear filtering action. This project was carried out manually without the aid of computers. One can imagine what was done then. This is really how I started my journey into the geosciences world.

From this point, I will try to chronicle what I believe I have been contributing to geosciences as a profession.

Surface Waves Studies

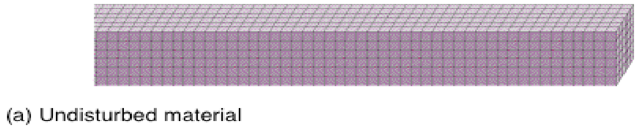


*Fig. 6***:** (a) Undisturbed material

My initial research work centered on the use of surface waves in exploration. Before going into this effort, one would need to introduce the term “seismic waves”. In Geophysics, seismic waves are parcels of elastic strain energy that propagate outwards from a seismic source such as an explosion or an earthquake. There are two groups of seismic waves- *body waves and surface waves*.

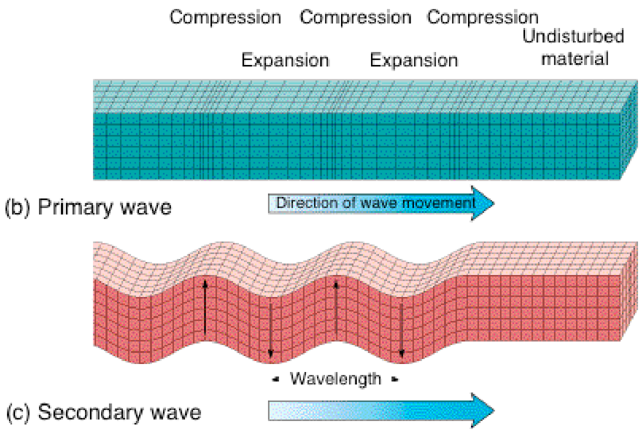


*Fig. 7***:** Body wave; (b) Primary, (c) Secondary

Body waves made of two types can propagate through the body of an elastic solid. The first type of body waves – Compressional waves (Primary P-waves) propagate by compressional and dilatational uniaxial strains in the direction of the wave travel. The second body waves – Shear waves

(Secondary S-waves) propagate by a pure shear strain in a direction perpendicular to the direction of wave travel (Fig. 7a, b).

The surface waves propagate along the surface, or along the boundary between two dissimilar solid media with associated motions being elliptical in a plane perpendicular to the surface and containing the direction of propagation (Rayleigh waves). A second surface waves – Love waves are polarized shear waves with an associated oscillatory particle motion parallel to the free surface and perpendicular to the direction of wave motion (Fig. 7d, e). These surface waves, because their properties are considered as noise in exploration, all effort is made to reduce their impact in exploration. They contain large energies that travel longer distances since they decay slower when compared to the body waves from the same sources.

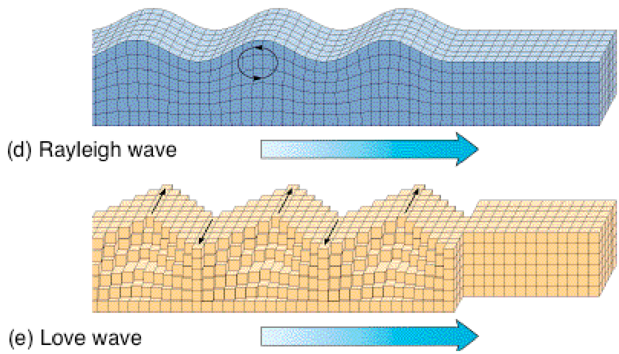


Fig. 7: Surface wave; (d) Rayleigh, (e) Love

Though called noise in exploration, we analyzed these waves recorded in the Texas Refugio County of the Gulf Coast of America. In a crustal refraction experiment in Refugio County, Texas, surface waves were identified as dispersed late arriving wave groups at ranges out to about 64 km (Fig. 8). Our surface wave research analyzed these waves to obtain smoothly varying P and S velocity structures by comparing group and phase velocity data with dispersion curves computed from a liquid and a layered solid. These analyses provided information concerning the P velocity structure to a depth of 1.0 km and the shear velocity structure to a few hundred meters depth (Fig. 7). The fundamental mode Rayleigh wave data suggest a sharp increase in shear velocity at a depth of 175-200 m which is confirmed by a shale-sand transition shown in an SP log near the station and a change in porosity noted in the resistivity log associated with a change in the shear strength of the sediments.

The results of this study were published in Geophysics and is one of the earliest times where surface waves dispersion was used as a means of determining the shallow velocity structures of sediments. These are useful in exploration (Ebeniro et al., 1983).

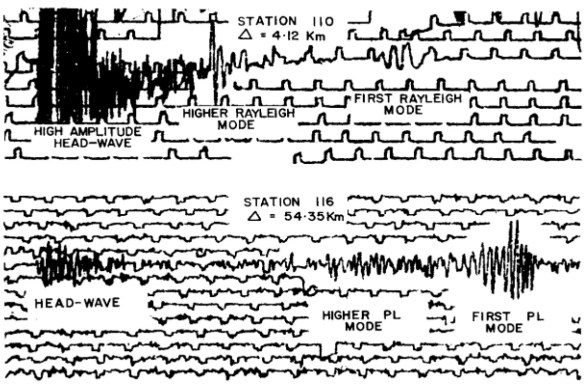


Figure 8: Typical Seismograms recorded at two stations

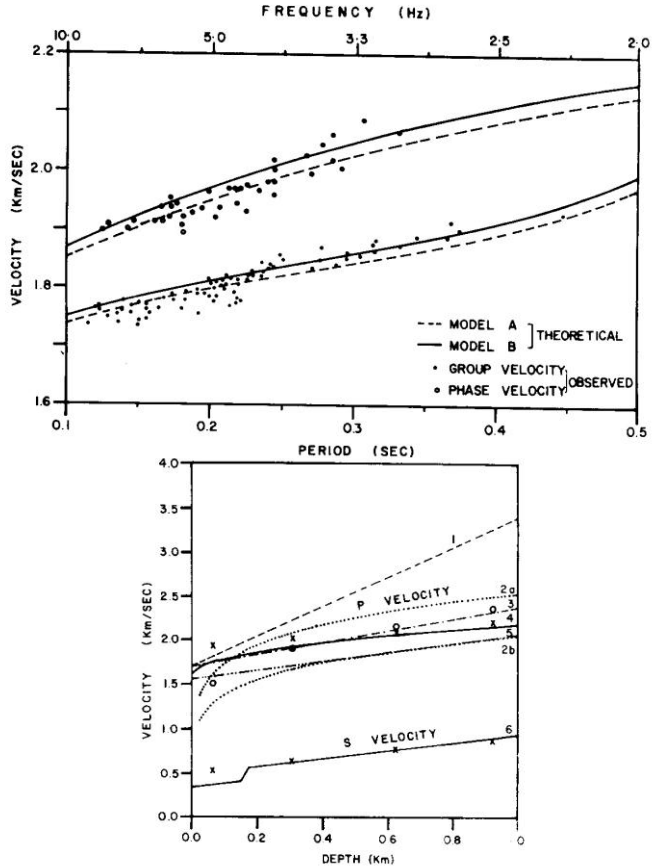


Fig. 9: Smoothly varying velocity structure computed from the surface wave data

Beyond the surface waves, I further engaged in regional studies in the Gulf of Mexico. These studies took me through several scientific expeditions from Galveston, Texas through the Alaminos Canyon, Green Canyon, North western Gulf of Mexico and South Florida Bank area using the University of Texas at Austin Research Vessels – RV Ida Green and RV

Fred Moore (Plate 1). Well over 60 days of seafaring activities were involved and resulted in several conclusions. The main objectives of these studies included the determination of the character of the Basement structure and thus the thickness of the sedimentary cover underlying the exploratory zones of the Gulf of Mexico. These sediment thicknesses are necessary for oil and gas exploration. All these studies were funded by the industrial associates of the University of Texas at Austin. I will here give a few details of the results of the expedition.

Plate 1: RV Fred Moore – UTIG Research Vessel

South Florida Platform Study

The study was carried out using the newly designed and built digital Ocean-Bottom Seismograph (OBS) (Fig. 10) of University of Texas Institute for Geophysics (UTIG). The study was designed to acquire five large offset refraction data using the University's Research Ship – RV Ida Green. Out of the fifteen OBS drops in this experiment, thirteen of them returned data. These data were used to determine the elusive basement character underlying the carbonate platform. Until now the deep structures underneath the Florida Platform have eluded seismologist. However, the results demonstrated that useful information about the regional crustal structure can be gathered using this new OBS technology. The result confirmed that the basement under the Florida Platform is a continental type basement since throughout the experiment, no velocities considered as those of the mantle arrivals were recorded. This region, thus, is part of the continental margin surrounding the oceanic crust of the Gulf of Mexico (Ebeniro et al., 1986)

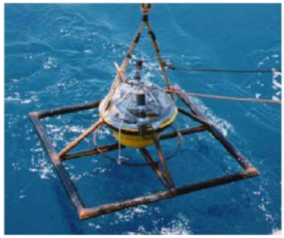


Fig. 10: Ocean Bottom Seismograph ready for deployment

The presence of tectonized shallow salt structures is a major impediment to exploration efforts in many sedimentary basins including the northern Gulf of Mexico. The salt here forms a mobile tongue of high-velocity material emplaced between lower-velocity sediments. Using conventional seismic reflection techniques, explorationists often find it difficult to identify the base of the salt tongue since most seismic energy does not return to the surface for detection. Only in very few occasions have the base of the salt tongue been identified. Furthermore, interfaces below the salt are even more rarely observed. These difficulties were ameliorated by the use of OBS in acquiring wide angle air-gun data. These data enable us to look at the details of the salt structure and to estimate its thickness using very unconventional techniques in analyzing the data. Amplitude variations of wide angle arrivals through the salt were used to “see through” the salt to accurately locate the base of the salt and as such the underlying sedimentary structures were eventually mapped (Fig. 11). Such information, which is not generally available in conventional reflection surveys, is essential for correct interpretation of underlying structures (Ebeniro et al., 1987).

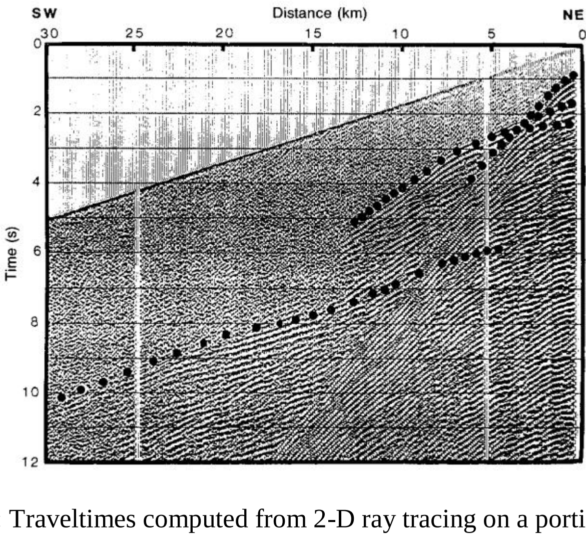


Fig. 11: Traveltimes computed from 2-D ray tracing on a portion of an OBS record

Northwestern Gulf of Mexico Study

Although the exploration for oil and gas in the Gulf of Mexico has resulted in the acquisition of massive knowledge about the thick infilling sediments of the area, the character, nature and distribution of the underlying crust and mantle are much less well known. The thought of this lack of knowledge resulted in the determination to carry out extensive seismic reflection/refraction survey to determine the nature of the crust underneath the Gulf of Mexico basin. Several attempts at this determination had been made before the study of Ebeniro et al, (1988) revealed the crust in the central part of the Gulf basin is really oceanic with typical thickness of about 6-8 km. We used modern digital ocean-bottom seismographs (OBS) to record large (4,000 in^3), closely spaced (50 m) airgun shots at ranges up to 90 km in the northern Gulf of Mexico (Fig. 13A). Their Line 5 was located just south of the Sigsbee Escarpment (Figs. 13A and 14), the basin ward edge of an extensive salt(s) and within crust identified as oceanic Fig. 13). These and data from two other ocean-bottom seismographs along Line 5 allowed Ebeniro and others (1988) to obtain a reasonably well-constrained velocity-depth structure for the oceanic crust under Line 5 (Figs. 13B and 13C).

Mr Vice Chancellor Sir, investigating the generalized cross-section in Figure 14 shows two major findings. Firstly, we have been able to define accurately the bottom of the allochthonous salt body which has eluded seismologists for a very long time just by using the characters of the wide angle reflections as noted above. Secondly, there seems to be a crustal thinning underneath the Line 3 location. This is being interpreted for the first time that there exists alternate axis of crustal extension during the formation of the Gulf of Mexico basin which may have failed to proceed to sea floor spreading.

This was the first time this interpretation was being made for the Gulf of Mexico and has been quoted severally since this report.

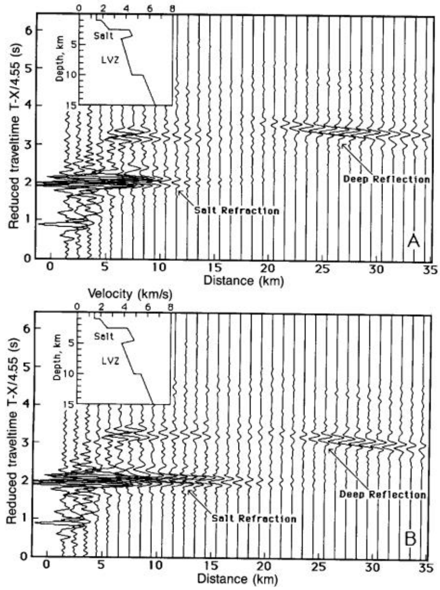


Fig. 12: Synthetic seismograms for two velocity models with shallow salt showing the effect of the thickness of the shallow salt on the extent of the refraction arrivals through the salt. Note the difference in the extent of the strong salt refractions (Ebeniro et al., 1987).

My Vice Chancellor Sir, the foregone catalogues the initial research efforts which I was engaged in before proceeding back to Nigeria with a lot of enthusiasm. This enthusiasm lulled for the lack of where withal in Research processes and focus in the country. This did not stop me from continuing with what I may call contemporary research efforts which I had to adopt in the country. Amongst these are my sting in Seismic Multiples and Velocity Studies, Environmental Research, Water Resources Exploitation and Management

Research and currently Seismic Analysis Research which has culminated in the direct indication of bypassed hydrocarbon in the mature fields of the Niger Delta. Let me use this opportunity to give you a few highlights of the some of results of the research efforts.

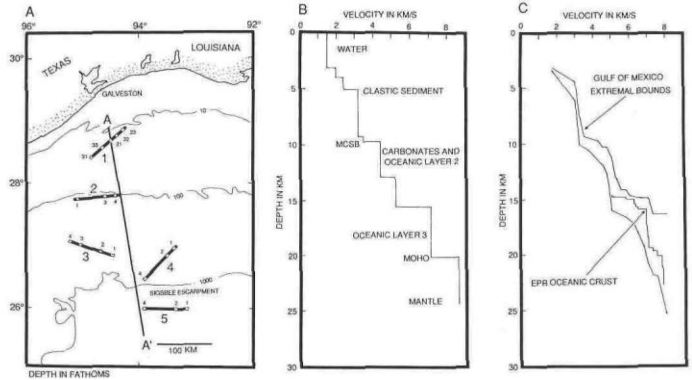


Fig. 13. A, Location map for a wide-angle seismic experiment reported by Ebeniro and others (1988). Large numbers identify lines 1 through 5. Smaller numbers identify ocean-bottom seismograph locations along each line. The lines were 90 km long and large airgun shots were fired at an interval of 50 m along each line. Each instrument recorded all the shots on its line. A-A' is the location of a composite cross section shown as Figure 14. Fig.12C. is the comparison of extremal bounds solution obtained by Ebeniro and others (1988) from Line 5 instrument 2 with a detailed velocity-depth model obtained by Spudich and Orcutt (1980) for unequivocal oceanic crust near the East Pacific Rise (EPR). The two extremal bounds curves represent a seismic data inversion for the maximum and minimum depths at which rocks of each velocity will be found.

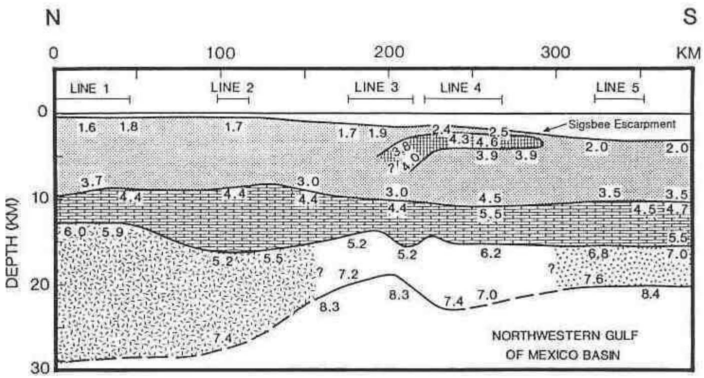


Fig. 14: Generalized cross section of the northern Gulf of Mexico margin from Ebeniro and others (1988); see Fig. 11A for location of section line and data used). The interpreted horizons are dashed where not well constrained. Oceanic crust is indicated by the v-pattern shading on the right side of the figure. The velocities and greater thickness of the crust on the left are diagnostic of continental or modified continental crust. We suggest that it is all thin transitional crust. There seems to be a crust thickness minimum under Line 3 that may correspond to an alternate axis of crustal extension during the formation of the Gulf of Mexico basin that failed to proceed to sea-floor spreading.

Multiple Studies

In addition to the primary arrivals in seismic operations, there exists in a layered subsurface, rays that may return to the surface after reflections at more than one interface. These rays are called multiple reflections (Fig. 15) and they cause a lot of problems to the seismologist. The importance of suppressing these arrivals in seismic operations was highlighted in the published work (Ebeniro, 1994).

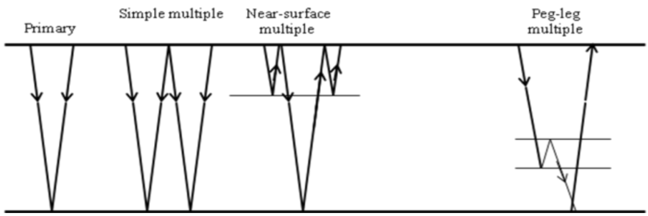


Fig. 15: Varying types of seismic multiples

One major example of the importance is the reduction in the effectiveness of the slope of the DHI computations in seismic analysis (Fig. 16). This figure shows the amplitude versus-offset (AVO) response of a seismic CMP gather before and after multiple suppression. This gather is recorded on a gas/light oil sand. The distribution of the points on this amplitude-offset crossplot prior to multiple suppression demonstrates the interference of the multiples with the primaries especially in the offset range of 1.0-2.5 km, an offset range critical in AVO computation. The solid line is the least square line fitted to the data points plotted along it. Although, the calculated amplitude at zero offset decreased by about 40%, the slope increased more dramatically after multiple suppression. This ensures the positive indication of the presence of gas/light oil in the zone. A low scatter of the data points is also observed after multiple suppression.

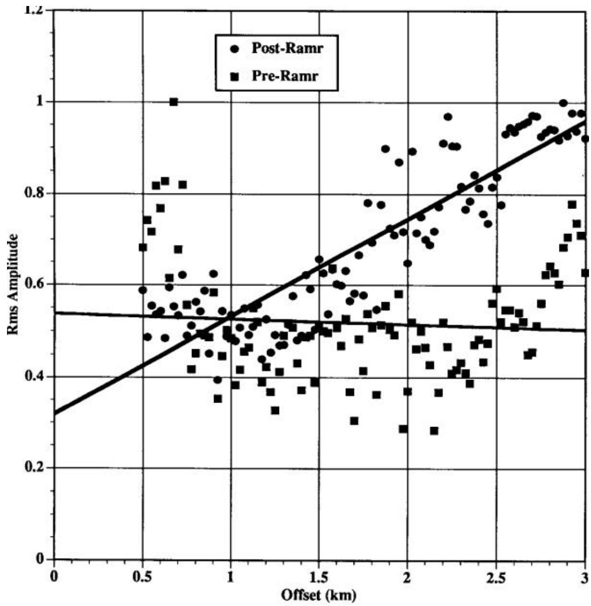


Fig. 16: AVO response of an event at 3.8s time before and after multiple suppression. The negative slope has changed to a positive depicting high HCI

The importance of suppression of multiples manifests itself in the reduction of the values of the stacking velocities needed for all operations in seismic technology (Fig. 17).

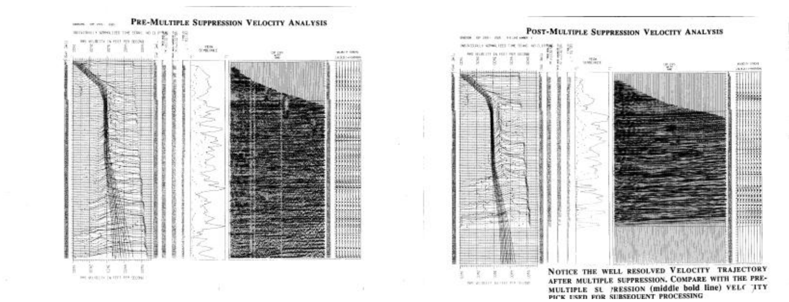
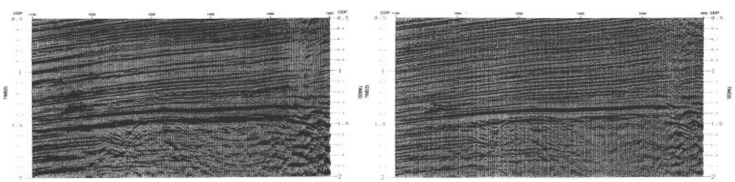


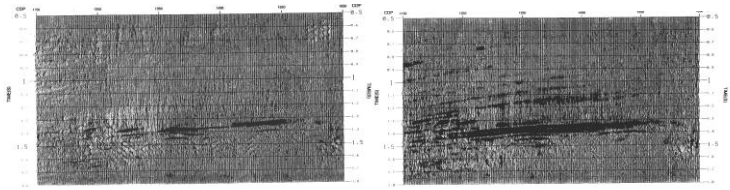
Fig. 17: Velocity analyses plot of a CMP gather from a West African data (a) pre- (b) post multiple suppression. Without suppressing the multiples, the velocity picks were at least 15% below the more accurate values obtained after multiple suppression

Other areas where I have applied this technology included my work to enhance Direct Hydrocarbon Indication (DHI) in Alaska for ARCO Oil and Gas Company. The results here are proprietary and were not published (Figs 18 – 19).



(a) (b)

Fig. 18: Plot of the stack of the CDP range around an amplitude anomaly (a) before and (b) after multiple suppression. Notice the elimination of the strong arrival immediately below the amplitude anomaly after multiple suppression



(a) (b)

Fig. 19: Plot of hydrocarbon indicator of the amplitude anomaly (a) before and (b) after multiple suppression. True amplitudes plotted show the enhancement of the amplitude after the multiple suppression.

Velocity Studies

The accurate mapping of any subsurface structure is determined by the accuracy with which the velocities of the overlying structure are determined. Normal moveout corrections applied to reflections in CMP gathers depend on these velocities and are based on some assumptions of wave propagation in the earth. Usually a small spread assumption is made and this simplifies the computation by limiting the indefinite travel time equation to just two terms. But currently, large offsets are involved in seismic operations resulting in better resolved velocity structures. I used the shifted-hyperbolic technique of De Bazelaire (1988) to extend the useable offset range of the synthetic data from 5.0 km to about 11.0 km (Ebeniro, 1994). Using these larger ranges will improve the velocity information needed to improve lithological information and structural content evaluation of the subsurface (Fig. 20).

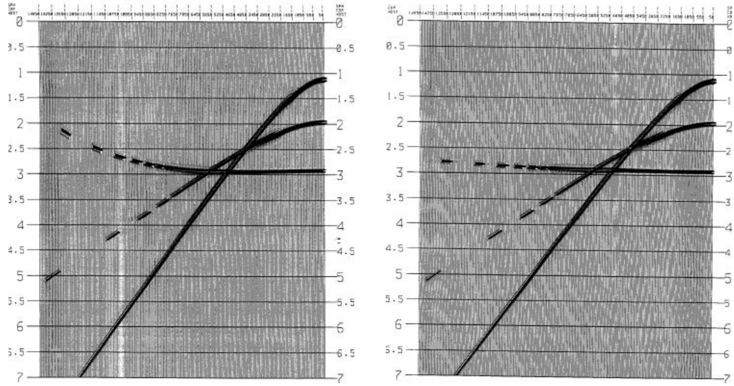


Fig 20: (a) Normal moveout theory application and (b) Shifted-hyberbola technique applied to a synthetic model with event at 2.928 s. Notice that the regular NMO flattened the reflection out to 5.0 km while the shifted-hyperbola flattened the event out to about 11.0 km.

Niger Delta Studies

My Vice Chancellor Sir, I have so far catalogued my research efforts outside the boarders of this country. Now let me go through some of the works that have engaged my expertise within Nigeria since I came back from my sojourn in Texas, USA. I will divide this discussion into about three areas, namely, environmental research, seismic research and earthquake research.

Environmental Research

Lake Nyos in Northwestern Cameroun is known to be violent historically (Fig. 21). In 1986, this lake that is perched about 1.34 km above sea level released high CO_2 into the atmosphere. This heavy gas asphyxiated more that 1000 people and numerous livestock and wild animals in the country. This lake contains large volume of CO_2 rich water at this height within a geologically formed Lake Nyos Dam. This dam has been eroding at an alarming rate with over 600 m of it already eroded. Only 40 m of the dam is left and is already weak as noticed from the lake waters spewing out underneath the lowest part of the dam. Also, during the rainy seasons, the lake water spills over the dam’s spillway into the valley below (Fig. 22b). The failure of this containing dam is expected to release millions of tons of CO_2 rich water all the way from the lake’s high elevation cascading North and East to Kumbi and Mbum Rivers’ drainage system down to Katsina Ala River Drainage system and other systems in Nigeria. This phenomenon will flood all these drainages and all the other adjourning low-lying areas and towns in Cameroun and up to the densely populated Nigerian Towns including Katsina Ala, Adikpo and even Obudu which are 155, 150 and 165 km away, respectively from Lake Nyos. It is against this background that the Nigeria Technical Committee on Earthquake Phenomenon (NTCEP) set up a scientific team comprising geoscientist and engineers to study the structural disposition of the Lake Nyos Dam area(Plates 2-5). The results of the study confirmed the presence of a shallow basement at 113 m depth and the saturated pyroclast and weathered basement at a depth of 110 m with probable 10 m thick agglomerate occurring at about 6 m depth from the surface. This revelation suggests that we must find a way to either strengthen the dam at its lowest point or carry out a controlled release of the lake waters to reduce its level and potential strength (Okwueze et al., 1994).

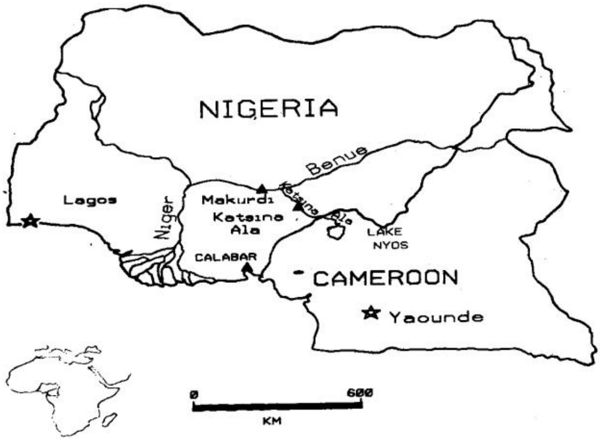
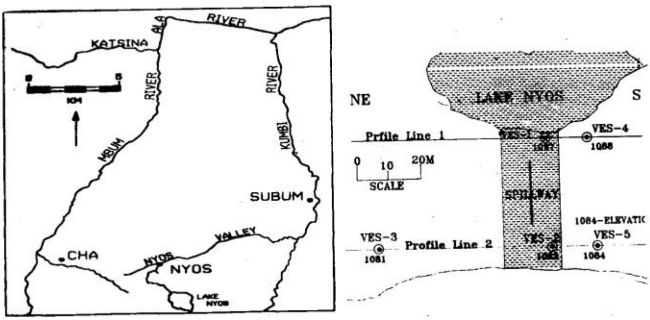


Fig. 21: Nigeria and Cameroun showing locations of Lake Nyos and some important cities and drainages



(**a**) (**b**)

Fig. 22: (a) Area north of Lake Nyos showing principal drainages (After Lockwood et al, 1988); (b) Survey area with sounding points and a profile line with elevation values (Okwueze et al, 1995)

Plate 2: Scientific Team standing on Lake Nyos Dam

Plate 3: Dr J. O. Ebeniro backing the Lake Nyos spillway

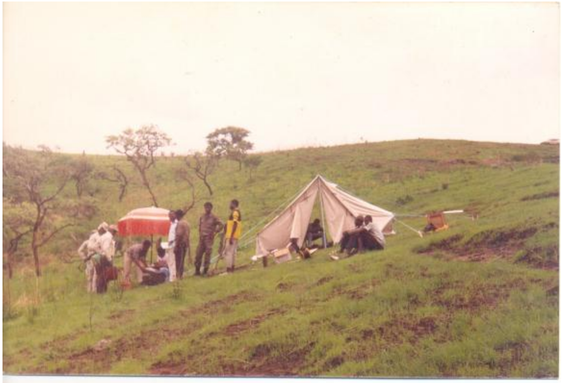


Plate 4: Scientific Team taking a reading on top of the dam

Plate 5: A Cameroonian labourer standing on top of the spillway

Some other environmental studies include several environmental pollution studies ranging from Environmental Noise Assessment, Radiation Level Assessment, Gas-Flaring studies and Investigation of Solid Waste Landfill problems. The conclusions drawn from all these investigation have already been published in diverse literature (Ebeniro and Abumere, 1999; Avwiri and Ebeniro, 1998; Avwiri and Ebeniro, 2002; Abumere et al., 1999; Ebeniro and Avwiri, 1996; Avwiri and Ebeniro, 1995; Ehirim et al. 2009a, Ehirim et al., 2009b).

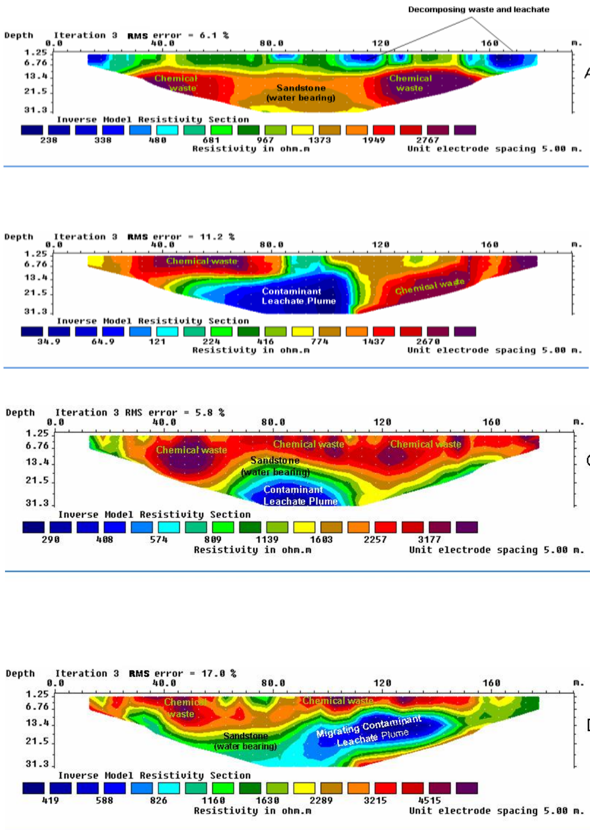


Fig. 21: Interpreted 2-D Pseudo sections of the profiles (A - D) around a waste landfill in Port Harcourt. Profile A is south of the landfill while profiles B-D are located ESE of the landfill. The contaminated tongue emanated from the landfill is moving at a rate of about 5 m per annum at a depth of about the locations of the private boreholes in the municipality.

Mr. Vice Chancellor Sir, permit me to now showcase what I have been doing in the contemporary periods as it concerns my research focus. As the country wants to increase the total reserve base for hydrocarbons, it becomes imperative to develop novel methods of finding more hydrocarbons. We thus have to go back to the drawing board to look into the depleted fields and further investigate if we missed some of the hydrocarbons during the earlier discoveries. Thus when I was offered a sabbatical placement with SPDC in the early 2003, I initiated two research areas viz – Direct Hydrocarbon Indication (DHI) using crossplotting of rock properties and Multiple Studies. Eventually, the first area was approved and since then I have been working on it with my students. This technique has continued to be very relevant in the contemporary literature. We have therefore been pursuing it with a lot of vigour and have thus generated a lot of results most of which are yet to be published in the literature while several are already published in the contemporary literature (Ebeniro et al, 2003; Ebeniro, 2006; Ebeniro and Omudu, 2006; Omudu et al., 2007a; Omudu et al., 2007b; Omudu et al., 2007c; Omudu and Ebeniro, 2007; Omudu et al., 2008).

Some of these results are currently being adopted in the company to assess the mature fields of Niger Delta. Since 2009, we have been carrying out studies for SPDC to locate by-passed petroleum in one of their mature fields in the swamps of Niger Delta. This was completed last year and we have started application of the techniques in other fields for SPDC (Ajiduah et al., 2011; Edoja et al., 2011; Dagogo et al, 2011). Currently, we have also initiated another research focus towards the use of surface waves observed in one of the land acquisitions in exploration. This technique have been successfully applied sometime ago in Texas. We hope to use the results of this study to effectively improve our analysis of velocities needed for inversion of seismic data.

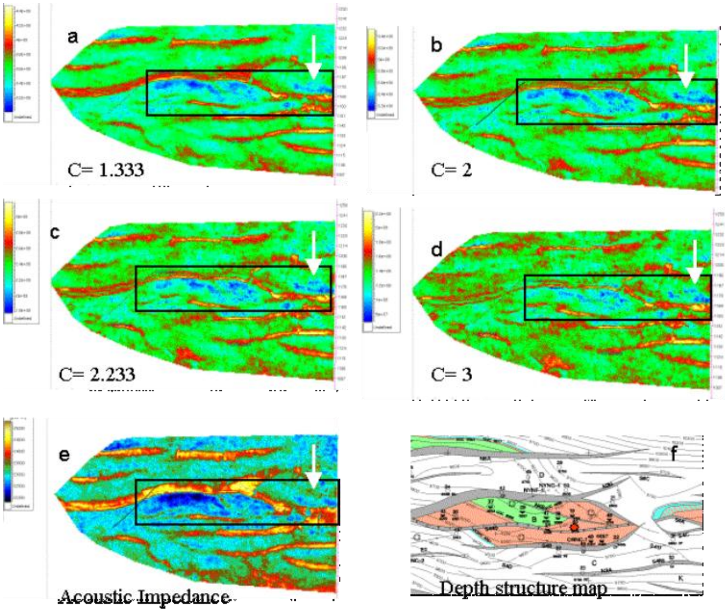


Figure 22: shows the horizon rms map of $\lambda\rho$ attribute at varying values of C, the inverted acoustic impedance and the depth structure map. Figure 22(a-d) shows that as the value of C increase, the fluid characterization and fault delineation deteriorates. The hydrocarbon charged zones are indicated by low $\lambda\rho$ and acoustic impedance values as indicated by the depth structure map. $\lambda\rho$ attribute better characterizes the hydrocarbon charged zone indicated by the white arrow.

Another area of exploration interest in Niger Delta is the improvement of velocity profiles for the sediments as we explore deeper horizons. The normal velocities we adopt generally for both processing and interpretation in seismic exploration have always been the Dix stacking velocities. But as we explore deeper in the Niger Delta, we now realized that the accuracy of these velocities becomes questionable. In most cases, the predicted stacking velocities are higher just because of the assumption that the earth is isotropic. Using these higher stacking velocities for interpretation, locates our targets at shallow depths. We have thus developed a more accurate velocity mapping technique which takes into consideration the anisotropic nature of Niger Delta sediments (Ogagarue et al., 2010).

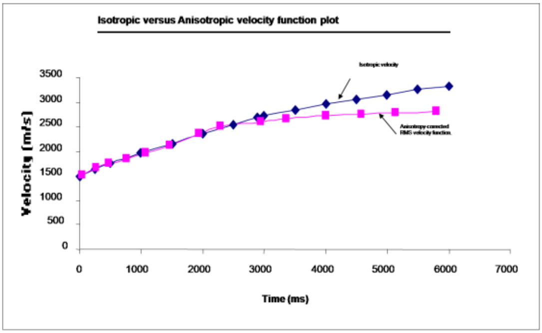


Fig. 23: Final isotropic and anisotropy-corrected velocity functions at a CDP location along the survey

Haitian Earthquake: Is Nigeria Vulnerable?

Mr. Vice Chancellor Sir, in January 2010, the whole world was jolted when a magnitude 7.0 earthquake hit one of the poorest countries in this hemisphere (Fig. 24). Haitian Earthquake claimed over 316,000 lives and almost destroyed the whole country including the capital city of Port-Au-Prince. This destruction brings to the fore-front the power of an earthquake which one can expect in any major earthquake. This earthquake is rated as the 5th deadliest earthquake in the world. The ability for the country to cope with such a disaster was also noted. The reaction of the whole world to rally around the affected persons shows that without others, most people cannot expect to survive for a long time alone during natural and unpredictable disasters.

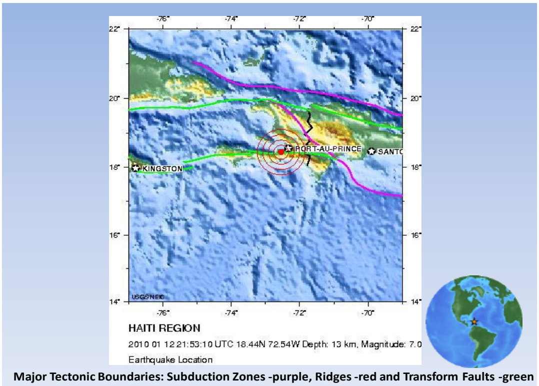


Figure 24: Major Tectonic Boundaries surrounding the Island of Hispaniola: Subduction Zones-purple, Ridges-red and Transform Faults-green. (http://neic.usgs.gov/neis/bulletin/neic_rja6_l,html)

Following the Haitian earthquake is the one that hit a well developed country of Japan in March 11, 2011. This earthquake was rated as a 9.0 magnitude earthquake (Fig. 25). This is about 20 times larger in power than that of the Haitian earthquake. The devastation in Japan was not really caused by the direct effect of the earthquake but the resultant flooding caused by the surging ocean waters (tsunami). The earthquake epicenter is about 70 km offshore Japanese coast with a depth of about 32 km under the water. This great earthquake of our time killed only 21,000 people as compared to the Haitian earthquake that killed over 316,000 people. Japan will require over $300bn to rebuild their destroyed infrastructure.

These two powerful earthquakes seem to call to question about the preparedness of our country to handle natural disasters.

Fig. 25: 2011 Tohoku earthquake observed tsunami heights (http://en.wikipedea.org/wiki/file:2011_Tohoku_earthquake_observed_tsunami_height_en,png)**.**

Although Nigeria may not be on any location considered to be at danger of any powerful earthquake. But it can never be ruled out that a much smaller earthquake can cause a lot of damage to the national psyche. In the recent times, several earth tremors have been observed in the West African sub-region (Table 2). Although West Africa has been adjudged as an seismic region, these earthquakes have been recorded (Ajakaiye et. al, 1987; Onuoha, 1985). The Haitian earthquake happened at a location where two plates are shearing past each other. We are aware there are some fracture zones out there in the Atlantic ocean whose continental-ward extension is not quite understood under the Nigerian Niger Delta region (Figs. 27 and 28). If these shear zones are dormant, no one can predict where and when this quiescence will change. It is therefore to the interest of all to start bracing up that someday and somehow, anything can happen.

Table 2: Recent earth tremors recorded in West African Sub region

S/N	Location	Year
1	Warri	1933
2	Accra	June, 1939
3	Ohafia, Umuahia	July, 1961
4	Ijebu-Ode	1963
5	Danbata, Kano	July, 1975
6	Bauchi	1981
7	Yola	December, 1984
8	Ijebu Ode	August, 1984
9	Gombe	1985
10	Jere, Kaduna	April, 1990
10	Ogun	2009

It could be in the nature of a relatively small earthquake onshore. But if it happens offshore and generates some tsunami, not necessarily the 40m water wave of Japan earthquake, it could cause some major damages. As a mater of fact, University of Port Harcourt is standing less than 6m above sea level. Just a 10 m water wave will inundate the university. What then will happen to all the costal region of southern Nigeria from Calabar through Bonny, Warri, to Lagos? Recently, there was great flooding of the Lekki peninsular and some environs of Lagos City. We are yet to come to terms on what really caused it. Could it be an offshore event which no one has been able to ascertain because of lack of seismic stations in the Country?

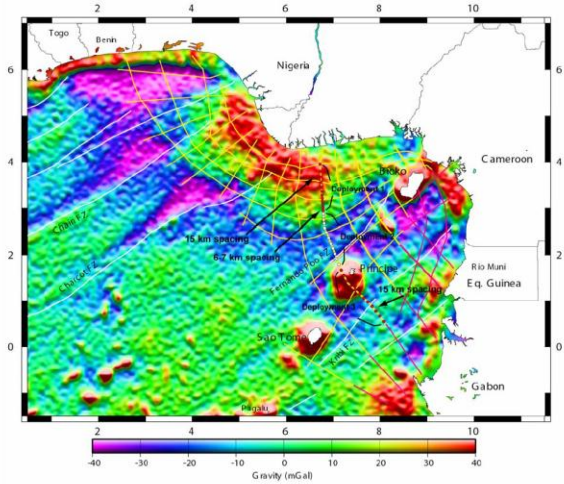


Fig. 27: West African sub-region gravity responses showing the fracture zones

Mr. Vice Chancellor Sir, are we really immuned to this natural disasters called “earthquake”? I will not stand here and tell you that Nigeria is indeed not vulnerable. Rather, I will request that our governments should immediately harness our resources to start sensitizing the populace of the possibility of such no matter how small in magnitude. The situation in Haiti should be a wake up call to all of us. Haitian earthquake which is 20 times less in magnitude killed over 316,000 people which is about 14 times the number of people killed after the Japanese earthquake that killed only 21,000 people. Poverty also took its own toll on the disaster.

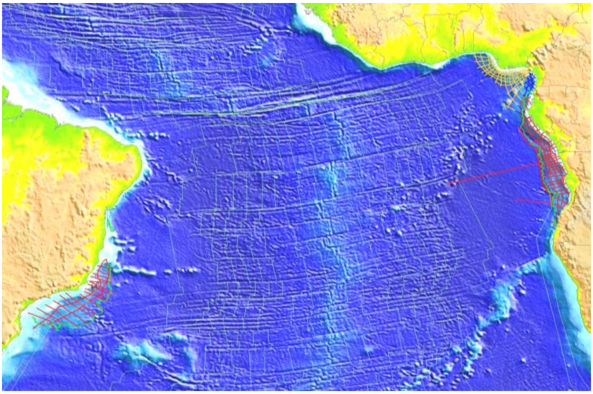


Fig. 28: South Atlantic features showing the mid-Atlantic ridge system and the fracture zone features pointing towards the West African sub-region

Concluding Remarks

Mr Vice Chancellor Sir, What is really our take home from this presentation? Nigeria as a nation has been enjoying petroleum resources of enormous magnitude since the discovery of Oil in commercial quantities in Olobiri, Bayelsa State in 1956. The first shipment of petroleum out of Niger Delta was in 1958. None of these discoveries and shipment would have been possible without the expertise of the geophysicists, the wiggle users. These are the first guys who wade into the harsh environment (the bush, deserts, mangrove swamps, seas and ice caps) x-raying the subsurface for signs of any pool of oil. Currently, Nigeria ranks the largest oil producer in Africa with about 2.6 million barrels of oil per day production. She ranks about the 11th largest producer in the world with total reserves of about 36 billion barrels of oil and 187 Tcf of gas. We are progressing to increasing our total reserve to over 40 billion of oil which would have been possible by now but for the Niger Delta insecurity problems which slowed down the oil and gas prospecting activities in the last decade.

We thus see that the wealth of the country, as at now dependent on oil and gas resource, would not have been possible without the ingenuity of the geophysicist. As a medical doctor looks through the human body using the x-ray technology, so does the geophysicist look through the earth for the precious oil and gas using his own geophysical technology. Note please, the geophysicists do it with the wiggles.

My people, this is the time we have to advise the government at all levels to initiate the process of taking safety of both live and property to heart. We should learn from the experiences of other nations rather than others using our own experiences to solve their problems. The experiences of the nation of Haiti after the earthquake should be a wake-up call for us all. We should not wait thinking it will never happen to us. Nothing is sacrosanct in the earth since anything is possible.

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WHO IS PROFESSOR JOSEPH O. EBENIRO?

Joseph Onukansi Ebeniro was born in a little roadside rural village – Amainyiukwu Ihitte, Imo State. After his initial primary and secondary education in the rural settings, he ventured into the city of Lagos for his university education where he obtained a Bachelor degree in Special Physics from the University of Lagos. Beyond here, he left the shores of Nigeria, but focused on what he wanted, to pursue a doctoral degree in Geological Sciences from the University of Texas at Austin. He eventually completed his higher degrees (M. A and Ph. D) in 1986 before joining the University of Port Harcourt as a lecturer 1 on arriving back to the country in 1987. Joseph O. Ebeniro rose to the rank of a senior lecturer a year later and became a Professor of Physics barely 8 eight years after joining the University of Port Harcourt and barely 9 years after obtaining his Doctoral degree. The following year, in collaboration with the then Head of Department, Prof C. O. Ofoegbu, we started the graduate programme in Applied Geophysics in the Department of Physics. In 1990, Joseph was invited back to USA on a research fellowship with ARCO Oil and Gas Company, Plano, Texas. This invitation was to carry out several researches on wide angle seismic operation, the use of ground roll on exploration, multiple suppression and amplitude studies using data from differing geological and complex environments. These he accomplished within the two years he was with the company before coming back to continue his contribution to the development of the University. For these 25 years in the university, he has served and made very significant contributions to the growth of the university ranging from serving as a Head of Department (1992 – 1995) to a member of the Governing Council of the University of Port Harcourt. In 2005, he was appointed to serve as the Managing Director, Consultancy, Research and Development Centre (CORDEC). At the point of this appointment, CORDEC was moribund, owing salaries to her staff up to seven months, owing FIRS tax for several years, owing her consultants for jobs they have completed and could not generate any monies for the university. This situation negates the vision of the establishment of the Consultancy. Currently, CORDEC has established itself in the nation and has contributed immensely some revenues to the coffers of the University under his directorship. She has even broken into construction, carrying out several construction projects within the university thereby saving a lot of funds which could have been paid to outside contractors. CORDEC is indeed a very viable company. Prof Ebeniro was really an insider in the last administration which is being adjudged one of the best, if not the best, performing University of Port Harcourt administration. He has also continued to contribute his knowledge and experience to the current administration of Prof J. A. Ajienka.

Outside the university, Joseph has served in several capacities of leadership, including the Chairman of Physics Writer Series (2006 – 2010), Fellow, Nigerian Institute of Physics, Geophysical Advisor and Specialist Consultant (SPDC), Chairman, EIA review panel, Federal Ministry of

Environment, Member National Technical Committee on Earthquake Phenomenon (NTCEP) and Scientific team to Lake Nyos, Cameroun, Member, Scientific Committee of the International Junior Science Olympiad (IJSO), Federal Ministry of Science and Technology and Member of the Membership Committee of Society of Exploration Geophysicist, Tulsa, USA.

Currently, he attracted SPDC to establish a Geophysical Data Analysis Laboratory in the Department of Physics for research and training of Graduate students. He is now researching on locating by-passed petroleum in the matured fields of the Niger Delta in this laboratory. This is funded by SPDC. The annual Engineering and Geosciences Summer School was also brought into the University by his association with SPDC. This school trains high performers from four to five universities in the Niger Delta with faculties wholly drawn from SPDC and I acting as the Coordinator in collaboration with the University Liaison office of Shell. Prof Ebeniro has also attracted the extension of five international software licenses (RokDoc, Hampson-Russel, Seisware, OpenTech and GEDCO) into the Geophysical Laboratory. These softwares are currently being used in a myriad of researches at the laboratory under his advice. He single-handedly negotiated the linkage between University of Texas at Austin, Texas and the University of Port Harcourt. The linkage ensures staff, students and research exchanges between the two universities also the linkage has culminated in the donation of over 40 cartons of current books and journals from the Prof Yosio Nakamura, his Ph. D. supervisor and an emeritus professor of University of Texas Jackson School of Geosciences.

Prof Joseph O. Ebeniro has to his credit over 90 academic publications in various aspects of his field. He has supervised and examined many Masters Degree and several Doctoral degree candidates.

This is the way it is, for now and thank you for listening. God bless you all.

Prof. Israel Owate