EARTH TREMORS IN NIGERIA AND THE SOCIO-ECONOMIC IMPACT

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ABSTRACT

Earth tremor is a physical phenomenon that can originate from different sources such as the interior of the solid earth, the aqueous earth, the atmospheric earth; and from outer space. In all these, the initial effect is on the solid earth, causing it to shake. Then later, the tremor is finally transmitted to the surface of the solid earth in obedience to the principles of physics, which involve energy, force and motion. The surface structures, which could not withstand the ensuing stress/strain, will either collapse or become deformed. Quite a number of physical occurrences on the surface of the earth can be traced to earth tremors, which may not have been felt instantly until later, but the ones that attract attention are those that occur on macro scale. There are some reported cases of earth tremors in Nigeria. Areas that may be prone to earth tremor in Nigeria are those indicated by possible major active fault lines deduced from the Primary Gravity Network of Nigeria, which was established by Osazuwa in 1985. Earth tremors are not known to enhance socio-economic relief to the inhabitants in the regions at the time of their occurrence. However, when maintenance works are carried out on areas and structures affected by earth tremor, the socio-economic setback can be boosted. Efforts were made by Nigerian scientists to study the occurrence of earthquakes and earth tremors in West Africa generally and Nigeria in particular. In all sincerity, Nigerian intellectuals perform excellently well outside the Nigerian boarder, but back home in Nigeria, the story is different, probably due to frustration arising from lack of enabling infrastructure. In all the research activities that have taken place in Nigeria, the initial impetus from the appropriate government organ is often very high, but transient. In conclusion, Nigeria will continue to experience Earth Tremors due to its location within the West African mobile belt. Some recommendations are made to mitigate the effect of earth tremors in Nigeria.

INTRODUCTION

The earth is one of the planets created by God within the universe. The existence of the earth is governed by some unique motions, which ensure her stability within the universe. While the earth remains in dynamic equilibrium with the other planets, the earth is also subjected to bombardment by myriads of relatively smaller particles called meteorites. As if this is not enough, the earth is subjected to continuous showers of cosmic radiations. When God created heavens and earth He gave everything free without pre conditions to mankind to explore and exploit. Even the phenomenal changes that surround the creation of the planets and the other meteorites that ensure their stability and/or otherwise, are open to us to study. Among such numerous events and occurrences that are noticeable on the surface of the earth are *Earthquake* and *Earth Tremor*. It is the freedom to investigate divine creations and their immediate effect on humanity that made scientists to embark on research to expose the root-cause of earthquake and earth tremor; Nigerian scientists are not left out in this all-important investigation.

What is Earth Tremor?

The ordinary dictionary meaning of tremor is "shake". Ordinarily therefore, earth tremor means "*the shaking of the earth*". Bates and Jackson (1987) defined tremor - as it relates to the earth – as a minor earthquake, especially a *foreshock* or an *aftershock*. Since shaking involves *motion*, then there must be *force*, consequently *energy* must be involved. Therefore, *earth tremor* is an important physical phenomenon whose origin must be known and its aftereffect must be discerned for the purpose of either exploiting it for human benefit or preventing it in order to protect humanity and his resources. Figure 1 is a flow chart of the physical phenomena that lead to the shaking of the earth.

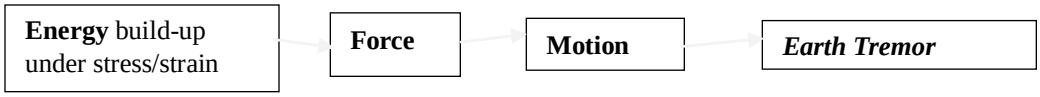


Figure 1: Processes leading to *Earth Tremor*, which is felt on the surface of the Earth

Earthquake and Earth Tremor

Earth tremor seems to be mythical in the sense that different attributes were given to its origin; for instance, some scientists called it pre-effect, while others called it post effect of *earthquake*. Then what is earthquake? According to Bates and Jackson (1987) earthquake is defined as: a sudden motion or trembling in the earth caused by the abrupt release of slowly accumulated strain; they go further to say that earthquake is a partial synonym to *seismic event*, and synonymous to: *shock*; *quake*; *seism*; *microseism*; *temblor*. The precursor and aftereffect of each of these events represent one form of tremor or the other, depending on their magnitude and direction, but independent on their origins.

Broadly speaking, the energy released during earthquake or earth tremor is derived from wave motion within the earth called seismicity; its study is known as seismology. The seismicity within the earth, which results in widespread devastation on the surface of the earth, is known as earthquake. An example of the effect of earthquake is shown in Figure 2. On the other hand, any shaking suffered by the earth (no matter its magnitude) which does not result in widespread devastations is regarded as Earth Tremor. The magnitude of Seismicity of the earth is measured on *Richter* scale. All the seismicity that have ever happen in Nigeria and West Africa are earth tremors. An example of the effect of earth tremor is shown in Figure 3.

Figure 2: Seismicity leading to Earthquake and resulting in the devastation of a town. This devastation would not have been this much if it were Earth Tremor

Figure 3: Seismicity leading to Earth Tremor and resulting in the tilting of the super building in 2006 at ABU, Zaria, Nigeria (Egwuonwu*et. al.*, 2009). This tilting would have been more severe and widespread if it were earthquake

ORIGIN OF EARTH TREMOR

Earth tremor can originate from either the interior of the solid earth or from the aqueous earth or from the atmospheric earth; also earth tremor can originate from outer space. In all these, the initial effect is on the solid earth, causing it to shake. Then later, the tremor is finally transmitted to the surface of the solid earth.

Continental Origin of Earth Tremor

The major cause of earth tremor is the heterogeneity in the crustal structure of the earth, which allows stress buildup when force and pressure of varying magnitude and direction are applied within the solid earth; this is synonymous to driving a vehicle along a rough road. The resultant obstruction of the ensuing wave due to fractures and other inhomogeneity often lead to earth tremor, which may lead to earthquake and associated massive destruction in earthquake prone zones of the world. Earth tremors arising from natural phenomena within the solid earth can be classified as *continental earth tremor*. Some of such causes are discussed below.

Different Stages of separation of South America from Africa and fracture formation

At the beginning the surface of the ellipsoidal solid earth was smooth. As time goes on major fractures began to develop on the continental surface along weak zones due to the inhomogeneity of the crust to form plates. The plate boundaries were marked underneath by ridges which constitute the source of the upward force that triggered the plate tectonics. Since the crustal plates are underlain by molten homogeneous mantle, they began to drift apart under the phenomenon known as continental drift. As the plates drifted apart, the spaces between them were occupied by the ocean and the ridges became submerged under the ocean to become known as mid oceanic ridges. The various stages of the separation of the South American plate from the African plate are shown in Figure 4.

In earthquake-prone zones of the world, earth tremor must precede earthquake, and there must be earth tremor after the occurrence of earthquake. Since West Africa and, of course, Nigeria are not earthquake prone zones, the type of earth tremor we may expect may not be one that ends up in earthquake of high magnitude originating from the interior of the earth. We must quickly remember here that, even though the greater portion of West Africa continental area is within a cratonic zone, but Nigeria lays within the *mobile belt*.in the region. The reason for this is not farfetched; during the process of separation of South America from Africa (Figure 4) there were secondary fractures on the African continent at the zone of attachment of the two continents as a result of the separation.

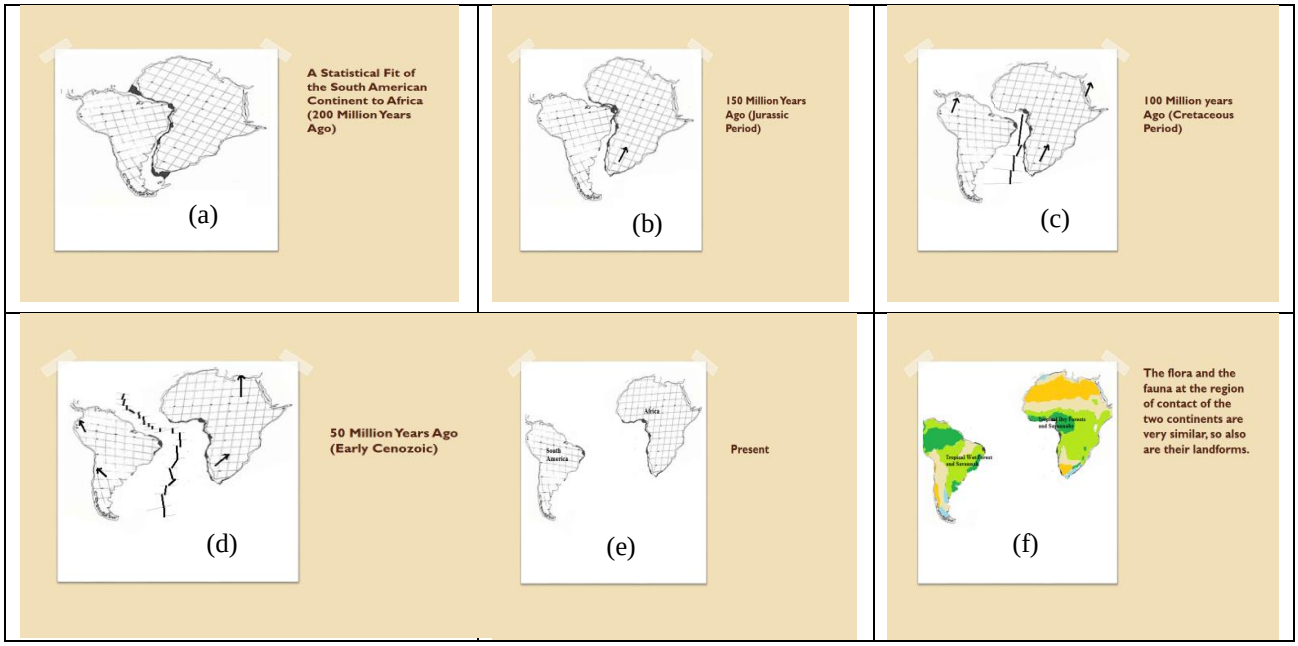


Figure 4: Separation of South America from Africa: (a) began 200 ma; (b) situation 150 ma – Jurassic; (c) situation 100 ma – cretaceous; (d) situation 50 ma – early Cenozoic; (e) present situation; (f) the flora and fauna at region of contact in both continent.

When South America finally separated from Africa, the zone of final disengagement is majorly the Niger delta coastal region of Nigeria. The unavoidable laceration, which occurred along weak zones, took place along a fracture zone that extended from the coast up to Lokoja and westward to Futajalon highland - River Niger flowed through this fracture zone. Another arm of the fracture zone developed from Lokoja and moved eastward to terminate at Cameroun Mountain; this fracture zone was named Benue Trough, along which River Benue flowed to meet River Niger at a confluence at Lokoja (Figure 5). Nigeria is probably the only country in Africa with this type of unique *Y-shaped* fracturing over her landmass. There is always a good correlation between fracture and hydrological systems; Nigeria is a classical example; this combined with the fact that Nigeria lies within the mobile belt, then the entire Nigerian landmass is prone to Earth Tremor.

Occurrence of Macro and Micro Tremors in Nigeria

The fractures and sub-fractures arising from the separation of South America from Africa may have resulted into macro and micro tremors of the earth in Nigeria and, by extension, West Africa The River Benue arm of the fracture was so severe that it resulted in mantle upwelling (Osazuwa, 1978; Osazuwa*et al.*, 1981) along the entire Benue Trough from Lokoja, and the consequent thinning of the crust in the area.

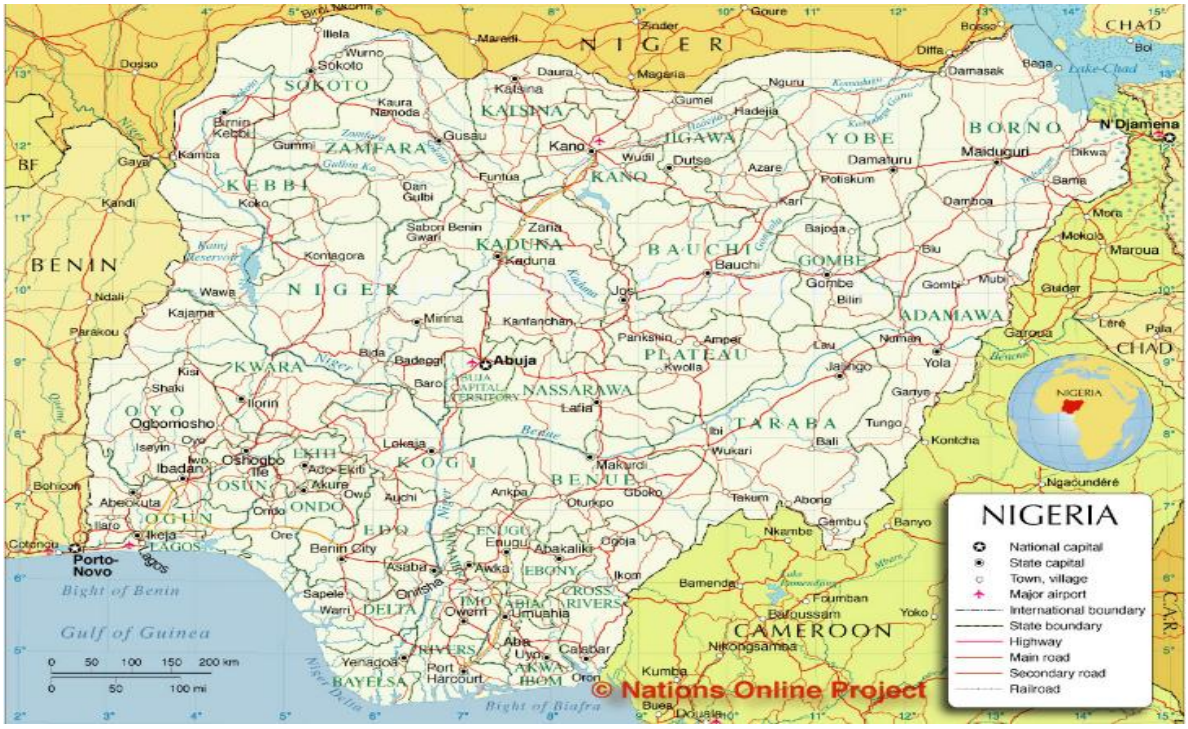


Figure 5: Physical map of Nigeria showing Rivers Niger and Benue. The network of rivers flanking the two major rivers is an evidence that Nigeria must have been severely fractured as a result of the separation of the two continents of Africa and South America.

Accumulation of Stress and Strain

The set of fractures arising from the separation of South America from Africa were later filled with sediments during the cretaceous era. They thus become a target for the accumulation of stress/strain - the release of which could result in earth tremor. Since the release of stress/strain is a continuous and periodic process then earth tremor must occur periodically within the zone. The earth tremor along the flanks of the Benue arm would be more frequent and severe because of the upwelling of the mantle in the region.

Marine origin of Earth Tremor

Aqueous earth tremor, otherwise known as marine earth tremor, is traceable to the ocean or sea bottom. It is also called *Tsunamis* (or tidal wave), which is described as a gravitational sea wave (Bates and Jackson, 1987). Tsunamis is produced by any large-scale, short-duration disturbances of the ocean or sea floor, principally by a shallow submarine earthquake. Tsunamis can also be produced by submarine earth movement, subsidence, or volcanic eruption. According to Bates and Jackson (1987), tsunamis is characterized by great speed of

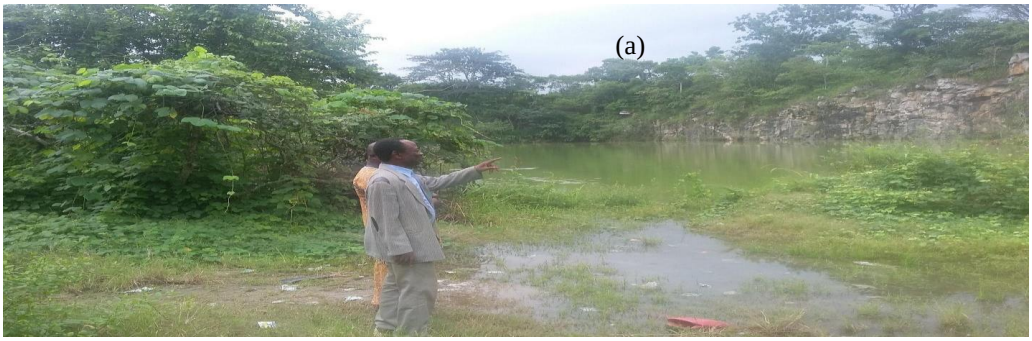
propagation (up to 950 km/hr), long wavelength (up to 200 km), long period (varying from 5 min to a few hours, but generally 10-60 min). Even though it has low observable amplitude on the open sea, it may pile up to heights of 30 m or more and cause much damage on entering shallow water along an exposed coast (often thousands of kilometres from the source). An example of this type of tsunamis was the type that happened along the coast of Singapore in 1999, leading to the death of many tourists.

Atmospheric Origin of Earth Tremor

In the case of atmospheric earth, the source of the tremor can originate from the atmosphere. During thunder-storm, the source originates from the cloud; the sound (or acoustic) wave produced can give rise to micro tremor on reaching the solid earth. Manmade surface structures are known to vibrate in response to severe thunderstorm, but it may not result in physical destruction of structures. However, the lightening, which is accompanied by the thunderstorm, can cause severe electrocution and even burning of trees. Lightening is associated with the incandescent flashes of light as a result of the breakdown of the insulation property of the cloud and the setting up of extremely high voltage of thousands of volts. On the other hand, thunder is associated with the acoustic wave of high magnitude, leading to extremely high sound. Thunder storm is a common phenomenon in the tropical rainfall region of the world, which Nigeria belongs.

Earth Tremor originating from outer space as a result of Meteorite fall

Impact on solid earth due to meteorite fall can lead to instant earth tremor and surface impressions, like lakes and fractures, are left on the surface of the earth. Several of such impact had happen in Nigeria in the past. A typical incidence of lake formation occurred about 1950's at a quarry site in the vicinity of *Omi-Alafia* village in Ose Local Government Area of Ondo State, Nigeria. The lake was said to have come about overnight after the workers had closed from work and packed up their tools and the quarrying machines as usual. The following day, when they reported for work at the site, they met an amphibious lake with their tools and machineries submerged completely under the lake. The profile of the lake and the surrounding granitic rocks are shown in Figure 6. From the ensuing profile of the granitic hills surrounding the vicinity of the lake and the branches of the lake, it is likely that an external body from outer space may have impacted on the hills diagonally. The enormity of the impact may have ruptured the subsurface and caused the ejection of water from the aquifer, which is now serving as a source to the lake.



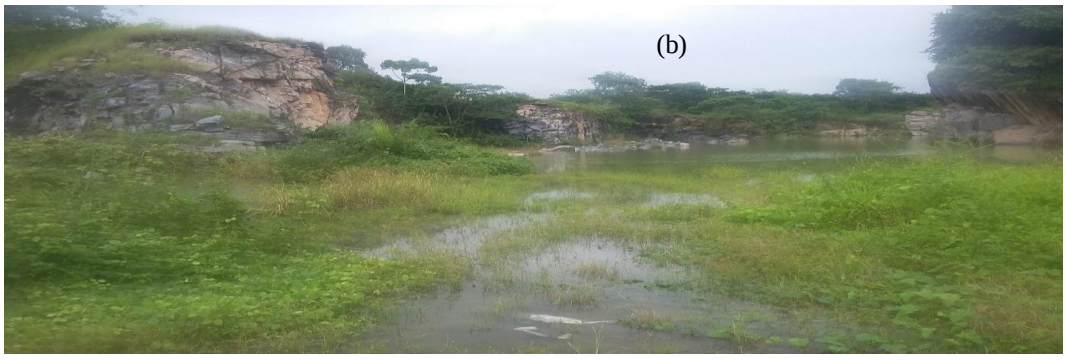


Figure 6: Crater Lake at Omi-alafa near Ifon in Ose Local Government Area, Ondo State Nigeria (a), (b), (c) and (d) are different arms of the lake. The author can be seen explaining some aspects of the lake.

A resent meteorite fall in Nigeria happened at *Achi-Ido* in Goronyo Local Government Area, Sokoto State, Nigeria, on 3rd November, 2001 and the incidence was reported later at Abuja Congress (Ike *et al*., 2003a) and also published (Ike *et al*., 2003b). The incidence was marked by very bright light and loud sound, which were attested to by the local inhabitants in Achi-Ido.

Artificial Causes of Earth Tremor

The earth can surfer tremor as a result of imbalance in its subsurface and surface mass distribution. This imbalance in mass distribution, leading to gravity field alteration and redistribution, gives rise to isostatic disequilibrium and the consequent earth tremor. Artificial causes of earth tremor can be traced to human activities, some of which are listed below:

i. ***Tunneling in road construction*** – this is very common in the developed countries for underground railway (like the metro lines in London, United Kingdom and Vienna, Austria) or railway and roads constructed to pass through hills (like the roads in Sweden and the apian ways in Italy);

ii. ***Massive quarrying at granite outcrops*** – this is done for building and construction purposes. This can lead to the formation of very shallow artificial lake or pool of water. This type of pool of water is very common at the quarrying sites in Aviation Area of Zaria in Sabogari Local Government Area of Kaduna State, Nigeria;

iii. ***Induced seismicity*** – this is a major geophysical activity during petroleum exploration. The oil producing regions of Nigeria are classical examples of areas where induced seismicity can cause earth tremor;

iv. ***Construction of long span bridges***– especially in areas where there is heavy traffic such as the third mainland bridge in Lagos, Nigeria;

v. ***Movement of heavy vehicles*** –along roads and rail lines when conveying goods from one location to the other, which is common along Nigerian highways;

vi. ***Massive movement of earth materials***– during road construction; this is very common during

road or building constructions, when sand-filling has to be done;

vii. ***Construction of high-rise or multi-story buildings***– which are typical of modern cities and towns. Earth Tremor in this case may arise as a result of the settling of the buildings;

viii. ***Landfilling***–which could alter the surface topography of the environment. This arises from the movement of earth material from another location to where the landfilling is required, this is also common along roads in Nigeria, which are under construction;

ix. ***Large-scale mineral exploitation***– which involves the excavation of large earth materials in order to access the mineral. Examples of this can be found in the mining and petroleum industrial areas such as **in Bukuru area in Plateau State, Nigeria,** where large scale alluvial mining of solid minerals such as cassiterite has been taking place for more than two centuries; and also **in the Niger Delta region inNigeria** where oil wells are drilled**;**

x. ***Bombing and Explosion***– During warfare, bombing activities are common; this is to cause massive destruction of surface structures as a result of the seismic vibration generated from the bombing. Similarly, during search for petroleum exploration, explosives are detonated at depts. (not surface) some metres into the subsurface. The resulting seismic wave generated travels far into the subsurface, thus leading to the discovery of the accumulation of crude oil. However, this exercise must be preceded by reconnaissance survey, using the potential field method of gravity and magnetics.

OCCURRENCES TRACEABLE TO EARTH TREMORS

Quite a number of physical occurrences on the surface of the earth can be traced to earth tremors, which may not have been felt instantly until later; some examples are given below.

(i) The collapse of embankment (called dam) in large artificial reservoir of water;
(ii) Collapse of surface structures, such as buildings and bridges;
(iii) Road failures due to formation of graben faults of several kilometers long and hundreds of metres wide; for example, the graben fault that happened after Auchi, along Auchi/Abuja federal highway in 2011, was more than three kilometers long and over one hundred metres wide. It cuts across the federal highway.
(iv) A section of the federal highway at *Omi-alafa* between Owo and Ifon in Ondo State, Nigeria is under threat of laceration arising from earth tremor.

REPORTED CASES OF EARTH TREMOR AND RELATED EVENTS

There are countless cases of earth tremors which happen on daily bases, but the ones that attract attention, especially in earthquake-free zones, are those that occur on macro scale. Some of the reported cases are:

(i) The earth tremor in Ibadan/ Ijebu-Ode areas in Southwestern Nigeria in 1984. During the ensuing Workshop in 1985 on earthquakes occurrences in Nigeria, Ajakaiye (1985) presented a Keynote Address which highlighted the earthquakes and earth tremors that had occurred in Nigeria and West Africa.
(ii) In recent time, cases of continental earth tremors have been reported in Nigeria; these are the ones that happened in Kaduna State in 2017 and Abuja, the Federal Capital Territory (FCT), in 2018.
(iii) Besides earth tremor there has been reported cases of avalanche (a type of destructive landslide caused by earth tremors that can take place in rugged sedimentary terrains) in Nigeria. Such case was reported in *Agwuata* area of Anambra State in 2005.
(iv) In October 2019 a huge rock, hanging on top of a granitic hill, at Ado-Ekiti, the capital of Ekiti State, Nigeria, cascaded down the hill and destroyed a house at the foot of the hill. This incidence could be attributed to a localized earth tremor which shifted the centre of gravity of the top rock due to the weakening of the "neck" at the point of attachment of the rock to the granitic hill.
(v) Shaking and collapse of buildings have taken place in Nigeria. In the early 1960s the then Electricity Corporation of Nigeria (ECN) building, popularly known as *Sango* house, along Marina, Lagos was shaken to its foundation. So also was the 39-story building in Lagos Island, not too far from the ECN building, was reported to have suffered tremor in the 1980s. In 1997, a large story building collapsed in *Kabala* Area of Kaduna metropolis.
(vi) On September 12, 2014, the six story building of Synagogue Church of All Nations was reported to have sunk (not collapsed) at *Egbeda* in Lagos State, Nigeria. The sinking of the building was related to a mysterious aircraft which flew over it multiple times, beginning from 11:30 am and lasted for about 24 minutes. This event is more of a Mistry than scientific. In anyway, there is a *meeting point* between *Mistry* and *Science*.

(vii) The resent one happened at Ogbese, near Akure in Ondo State of Nigeria. It happened early in the morning of 28th March, 2020 when a trailer carrying heavy load of explosives on its way towards Benin City exploded accidentally. The resultant tremor on the physical structures was very severe and visible. Severe crater was created across the federal highway in the area... Some of the surface structures, like church, school and story buildings, suffered severe vertical cracks meaning they were shaken beyond foundation. Some geologists mistook the event for meteorite fall. If it were meteorite fall, the energy from the seismic (or acoustic) wave would not have been strong enough to cause vertical cracks relative to the motion of the meteorite; also there would have been fragments of the meteorite whose density would be far more than the mean density of the surrounding rocks; compare the meteorite fall at Achi-Ido in Goronyo Local Government Area of Sokoto State, Nigeria, on 3rd November, 2001 (Ike *et al.*, 2003).

TREND OF LIKELY EARTH TREMOR ZONES IN NIGERIA

Areas that may be prone to earth tremor in Nigeria are shorn in Figure 7. The alignment of points as indicated by arrow on the map is an indication of possible major active fault lines; this is in agreement with what Osazuwa (2006) deduced from the Primary Gravity Network of Nigeria (PGNN) established by Osazuwa (1985a). The deduction is presented in Figure 8.

SOCIO-ECONOMIC IMPACT OF EARTH TREMOR

Earth tremor is a physical phenomenon that can originate from different sources as explained in section 2 of this article; the target of attack in all the occurrences is the Solid Earth. Since each event involves energy built-up, force and motion, the target, which is the solid earth, must be shaken and the degree of shaking must be felt on the continental surface of the earth. Therefore, surface structures which could not withstand the ensuing stress/strain would either collapse or become deformed. Thus, buildings, bridges, highways, dams, *etc.*, which are constructed to improve the social life of the citizens are mutilated. In order to maintain the social status of the environment, the impaired structures or facilities must be reconstructed, and this involves a lot of economic setback to governments and the local inhabitants. No earth tremor is known to enhance economic relief to the citizens living in its region at the time of occurrence. However, when maintenance works are carried out in earth tremor affected areas and, consequently, on damaged structures, the socio-economic setback can be boosted

Figure 7: Map of Nigeria showing some of the Areas that may be prone to Earth Tremor. The long arrow indicates a possible major fault

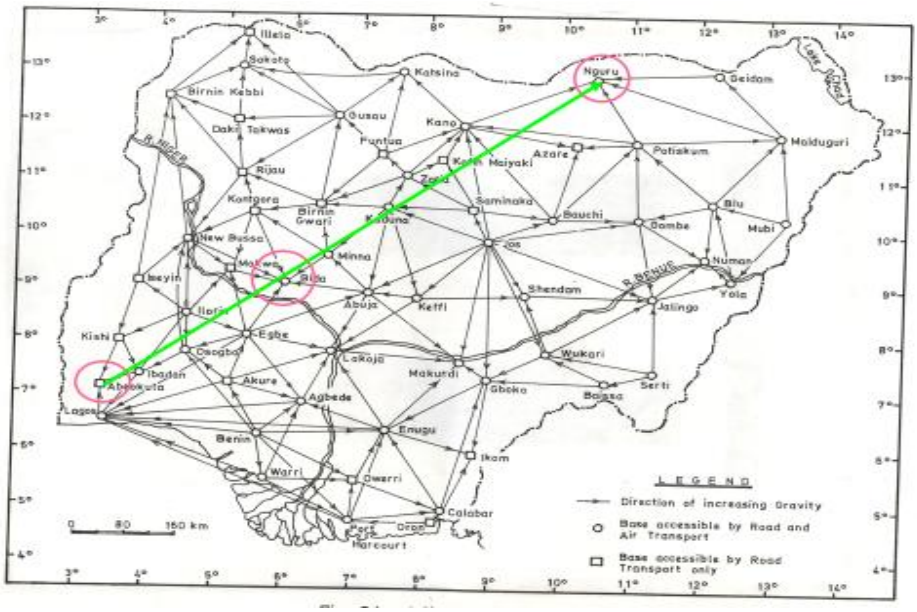


Figure 8: Map of Nigeria showing a major fracture trend deduced from gravity data by Osazuwa (2006). The long arrow indicates a possible major fault

CHALLENGES OF EARTHQUAKES AND EARTH TREMORS RESEARCH TO NIGERIAN SCIENTISTS

Since the mobile belts are predominant in Nigeria among the other countries in the West African sub-region, then there is bound to be occurrence of earth tremors in Nigeria. Efforts were made by Nigerian scientists to study the occurrence of earthquakes and earth tremors in West Africa generally and Nigeria in particular. Some of the efforts made by Nigerian scientists are explained below.

(i) In the early 1980s Professor Deborah EniloAjakaiye influenced the International Association of Geodesy (IAG) to set up the 11th World Wide Standardized Seismograph Network (WWSSN) in Nigeria. The WWSSN was to serve as a more centralized archiving approach that would facilitate effective data exchange. Zaria, a city located in the northwestern Nigerian basement complex, was appropriately selected. IAG shipped large crates of seismological equipment to Department of Physics, Ahmadu Bello University (ABU), Zaria; appropriate site was selected within ABU main campus at Samaru, Zaria and an observatory was constructed according to IAG specification with relevant seismic and gravity observation piers for the installation of additional relevant equipment. A few months later some hoodlums vandalized the observatory, thinking it was meant to harbor secrete cult, and made away with the electrical fittings. The crates of equipment to be installed in the observatory are still lying in the Mechanical Workshop in the Department of Physics of ABU, Zaria, Nigeria.

(ii) Osazuwa (1985b) designed a model microgravity network over Ibadan/Ijebu-Ode axis where earth tremor occurred in 1984. The model gravity network is shown in Figure 9. The essence of the network is to be monitoring the variation in the gravity field in the area, on a micro-scale, due to possible occurrence of earth tremor.

(iii) In 1993, Professor Ebun Oni, then at the University of Ibadan, Nigeria, headed a National Committee on earthquakes phenomenon in Nigeria. The Committee recommended a number of places across Nigeria where seismic observatories could be sited.

In about 1995 a teleseismic station was established behind the Geophysics Postgraduate Research Workshop in the Physics Department at ABU, Zaria as part of the ongoing research in seismology. There was an automatic seismograph system in the research laboratory that plotted the analog seismic signal on continuous basis. The system was powered by a heavy-duty 12-volt battery connected to AC supply through a trickle charger. This was meant to be recording earthquakes or earth tremors not only in Nigeria, but also elsewhere outside Nigeria. In fact, an M.Sc. student (Oniku (1999), now a Professor) was assigned a research topic from this project and he was jointly supervised by Professor S. B.

Ojo and Professor I. B. Osazuwa; the results of the research were also presented at a conference (Onikue*t al*, 2004). We were able to pick earthquakes that occurred in some places in West African other than Nigeria and beyond during the period.

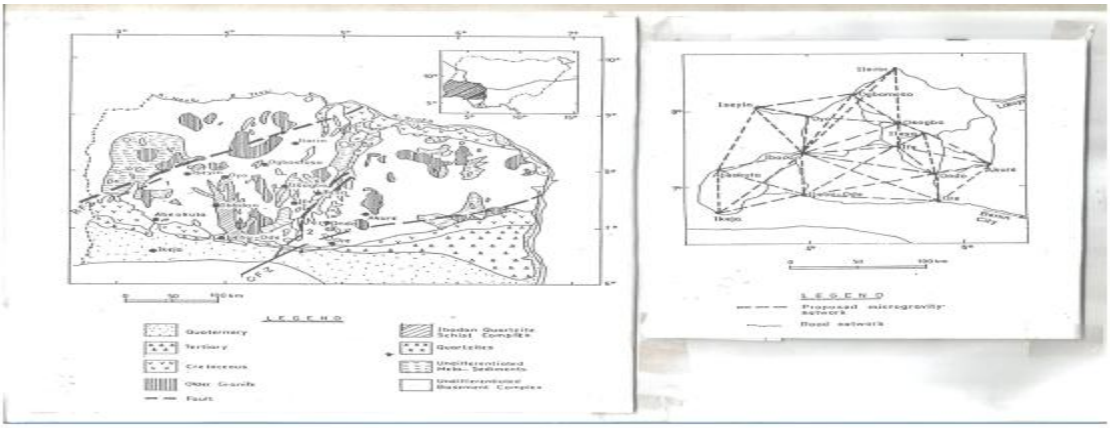


Figure 9: The Earth Tremor event of 1984 at Ibadan/Ijebu-Ode Area – (a) simplified geology and fracture map of Southwestern Nigeria; (b) proposed microgravity network of the Area.

GENERAL ATTITUDE OF NIGERIAN INTELLECTUALS TOWARDS RESEARCH

In all sincerity, Nigerian intellectuals perform excellently well outside the Nigerian boarder – particularly in Europe and America. Back home in Nigeria, the story is different, probably due to frustration arising from lack of infrastructures. Some examples are cited below.

(i) With the initiative of Professor Fubara of Rivers State University of Science and Technology Port Harcourt, a Centre for Geodesy and Space Research was set up at Toro in Bauchi State in the early 1990s; the Centre is still managing to survive.

(ii) During the military regimes of General OlusegunObasanjo as military Head of State, he set up two vibrant nuclear research Centres – one at Ahmadu Bello University (ABU) and the other at ObafemiAwolowo University (OAU). The progress made by the handlers of those Centres is there for anybody to see.

(iii) Also, General OlusegunObasanjo set up solar energy research Centres at UsmanuDanfodiyo University (UDU), Sokoto and University of Nigeria Nsuka (UNN), and another Centre for Automobile Research at Ahmadu Bello University (ABU); up till now the desired results for setting up these research Centres are yet to be realized.

(iv) In contrast, the Gravity Network Project was the "baby" of the then Federal Surveys of Nigeria (FSN). Before the project could progress halfway, FSN withdrew its financial support. The supervisory University, ABU, could not take over the financial responsibility for the project because, according to her, the project is not viable and that the project was too extensive and too intellectually challenging. The postgraduate student (Isaac B. Osazuwa) handling the project at that time continued to persevere and through the fellowship granted to him by ISP (IPPS) of Uppsala University, Uppsala, Sweden, the project was successfully completed with so many intellectual discoveries. The Primary Gravity Network of Nigeria (PGNN) is rated as the best gravity network so far in the world (Ebong*et al.*, 1991) in terms of its completeness, homogeneity and symmetry (Osazuwa and Ajakaiye, 1986).

THE ROLE OF GOVERNMENT IN EARTHQUAKE RESEARCH

The bane of research in Nigeria is lack of continuity due to non-availability of funds to sustain the research that the scientist may choose to embark on. In all the research activities that have taking place in Nigeria, the initial impetus from the appropriate government organ is often very high, but transient. Nothing is heard again about the microgravity network proposed by Osazuwa (1985b) for monitoring earthquake or earth tremor because of lack of funds and equipment for the research. The National Committee on earthquake set up by Professor Ebun Oni in 1993 is moribund due to lack of funds to continue the project. Probably the only government agency that is very active is the Nigerian

Geological Survey Agency (NGSA). The NGSA has maintained her research cooperation with tertiary institutions across Nigeria to date.

CONCLUSION AND RECOMMENDATION

Conclusion

In view of her location within the mobile belt of the West African sub-region, Nigerian will continue to experience Earth Tremor. The possibility of earthquake occurrence in Nigeria is however, doubtful. There are several human activities on the surface of the earth that can lead to earth tremor over a time. Some of such activities are unavoidable for economic and developmental reasons; for example, civil engineering practice in the West African sub-region generally and Nigeria in particular, involves large-scale movement of earth materials during road or building construction. Nevertheless, human safety should not be compromised for whatever reason; therefore, in such cases, better scientific and technological approach should be adopted.

Recommendation

The following recommendations are proffered.

i) The National Assembly should legislate against the practice of setting up any surface super structure in Nigeria without prior geophysical survey. Even the siting of boreholes/wells in search of groundwater should be preceded by geophysical survey.

ii) Scientific research for the monitoring of Earth Tremor in the mobile belt of West Africa should be intensified; in this regard, government should provide adequate funding for such research.

iii) The cost of geophysical equipment for monitoring Earth Tremor is prohibitive; therefore, group research and centralization of research equipment should be pursued vigorously.

iv) There should be a central national research council that will coordinate the activities of the various research fund providers like PTDF, TETFund, and so on.

v) It should be made mandatory for every university lecturer of the rank of Senior Lecturer and above to apply for research grant and such applicant should be given some grant provided the research proposal has passed through the "eye of the needle" after the screening and interview.

vi) A research grant applicant who failed the interview or whose proposal could not meet the standard should be availed with valid reasons why that is so and should be encouraged to reapply at the next opportune time. Statement like "research not viable" should be avoided as much as possible.

vii) Geophysical research is very challenging because it involves the application of the principles of physics in its entirety; therefore, routine research in geophysics, especially at postgraduate level, should be discouraged.

viii) Earth Science research is highly localized because, for example, the geology of Nigeria is different from the geology of Canada or Britain or China, and so on; therefore, postgraduate training should be done locally while postdoctoral research visit should be made mandatory for the purpose of exposure in countries with better facilities than Nigeria. If possible, collaboration should be entered into with such foreign institutions.

ix) The proposed Central National Research Council (CNRC) Should provide funds for the research visits, while senior professors should facilitate such arrangement by searching for organizations in the advanced countries to collaborate with. The International Science Programmes (ISP) at Uppsala University, Uppsala, Sweden is a classical example to emulate. ISP has provided such assistance to acclaimed Nigerian scientists in the Physical, Chemical and Mathematical sciences and related fields. The ISP assistance is also extended generally to the third world countries of Africa, Asia and Latin America.

Nigeria is engaged in a "battle" against the rapid decline of her education system – particularly at the university level. All retired professors with stark intellectual record should be recalled for this "battle" and serve as mentors. They should also be encouraged to set up research laboratories to train/groom upcoming Nigerian intellectuals. Age should not be used as a yardstick to play such people to the background; after all a Nobel Prize winner in Chemistry for 2019 did so at the age of 91 years and he is still running his laboratory.

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