IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 4, Issue 3 Ver. I (May. - Jun. 2016), PP 57-62
www.iosrjournals.org

Geoelectrical Investigation of a Failed Portion of Ajaokuta-Itobe Road, North-Central Nigeria.

Onoja S.O*[1], Okwoli.E[1], Maji M.A[1], Abdullahi. R.U[2], Akinola A.M[2]
[1]*Department of Physics, Kogi State University, Anyigba, Nigeria;*
[2]*Department of Applied Geophysics, Federal University of Technology, Akure, Nigeria*

Abstract: *A Geoelectrical investigation was carried out along a segment of the Ajaokuta- Itobe highway in Kogi State, North-Central Nigeria with the aim of establishing the cause(s) of the failure of that portion of the road. Vertical Electrical Sounding (VES) involving the Schlumberger array and 2-D imaging using the dipole-dipole configuration were both utilized along a 200m traverse established parallel to the road covering both the stable and failed portions. Four subsurface geologic layers were inferred from the result of the 2D imagine. A topsoil with resistivity values ranging from 42Ωm to 84.4Ωm, weathered layer with very low resistivity values from 14.7Ωm to 38Ωm, fractured basement (Resistivity varying between 92.1Ωm to 227Ωm) and the fresh basement with resistivity value as high as 2440Ωm. The curve types identified from the interpretation of the Vertical electrical Sounding were HA, AA, HA, and A type, with the number of layers delineated by the geoelectric section being four (4). The topsoil (sandy clay) for the first three (3) VES points have resistivity values of 54Ωm, 27Ωm and 50Ωm with thickness of 0.9,m 0.9m and 0.7m respectively. For the fourth VES point, the topsoil has been replaced by the weathered layer with resistivity value of 42Ωm and thickness of 6.7m. The second layer (clay) has resistivity values ranging from 10Ωm to 45Ωm and its thickness is in the range of 2 to 7m. The third layer delineated with resistivity values of 57Ωm, 182Ωm, 74Ωm and 406Ωm (which is the weathered basement) is very thick at VES point 1(36m) but almost disappears at VES point 3. Its thickness at VES points 2 and 4 are 10m and 4.4m respectively. The fourth layer having resistivity values between 406Ωm and infinity represents the fresh basement rock.*
The causes of the failure in the studied highway may be attributed to the presence of low resistivity materials (clay) at the topsoil/sub-grade and the probable presence of near-surface linear features such as faults, fractures and lithologcal contacts beneath the failing portion of the highway.
Keywords: *geoelectrical investigation, failed portion, Ajaokuta-Itobe*

I. Introduction

Travelling across Nigeria reveals the very troubling state of most highways in the country. Incessant failure of highways has become a common phenomenon in many parts of Nigeria and the continuous rehabilitation of these roads has continued to drain the meager resources that would have been spent on more pressing challenges such as health, security and so on. These failed and failing portions of most roads across the country has not only increased astronomically the time spent in transit across the country but has also caused the painful loss of countless lives and properties. It has also made the transportation of farm produce from farms and rural areas to the urban areas both tedious and expensive.

The factors responsible for road failure range from geological, through geomorphological, to geotechnical. They also include road usage, construction practices, and maintenance (Adegoke, 1987, Ajayi, 1987). The geological factors influencing road failures include the nature of soils (laterites) and the near surface geologic sequence, existence of geological structures such as fractures and faults, presences of laterites, existence of ancient stream channels, and shear zones (Adiat *et. al*, 2009). However, geological factors are rarely considered as precipitators of road failure even though the highway pavement is founded on the geology (Momoh et al., 2008).

Geophysics has found increasing relevance in highway site investigations (Nelson and Haigh, 1990) and electrical resistivity method (ER) in particular has been used with a great degree of success in mapping subsurface geologic sequence and concealed geological structures (Olorunfemi*et al.*, 2004). This study is therefore aimed at investigating the failed portions of the Ajokuta-Itobe road (Figure 2.0) using electrical resistivity methods. This road which is one of the two roads that link the eastern part of Nigeria to the northern part passes through the Ajaokuta Steel Company and experience heavy traffic.

II. The Study Area

The study area is situated along Ajaokuta-Itobe road In Kogi State North-central Nigeria. It lies between longitude $6^0 40'$E and $6^0 48'$E and latitude $7^0 22'$N and $7^0 30'$N (Figure 1.0). The study area falls within the extreme eastern part of the south-western Basement Complex of Nigeria (Imasuen et al, 2013).The Nigerian basement complex consists of Eburnean granite and metamorphic rocks into which are folded Upper Proterozoic supra-crustal low grade metasediments and metavolcanic rocks forming N-S elongated belts. Pan-African granitoids mark the last major event and they have intrusive and/or tectonic relationships with the earlier units (Woakes et al., 1989). Field geologic and petrographic studies of the marble and the associated rocks of Itobe area in central Nigeria show that the structures observed in the rocks include foliation, minor folds, joints and fractures.(Onimisi and Daniel, 2014),

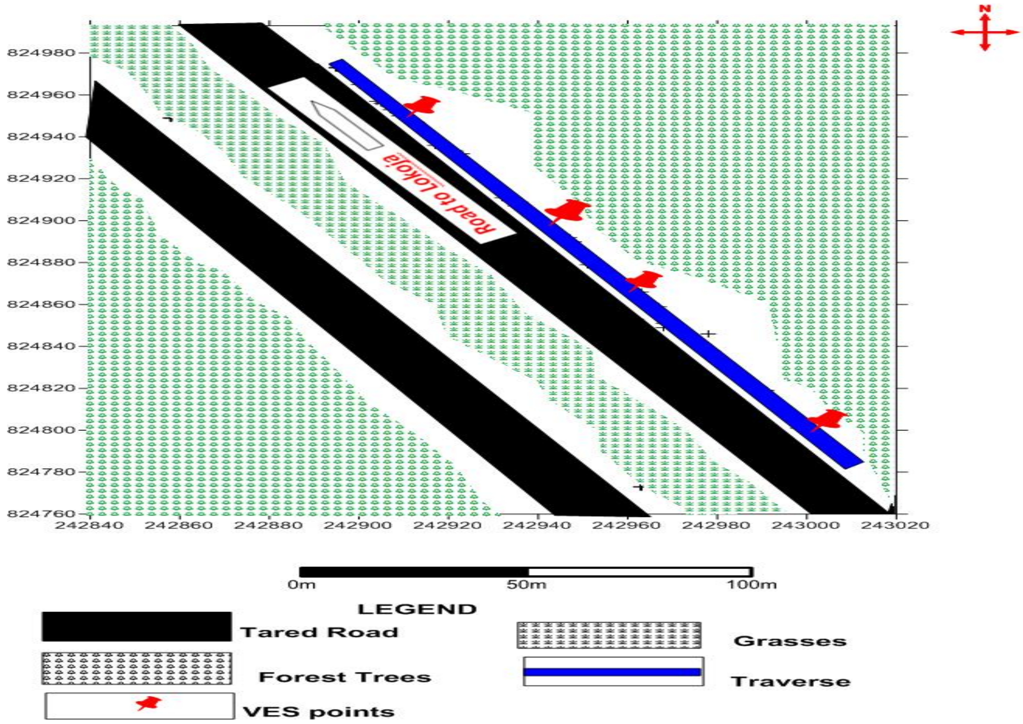

Figure 1.0: The base Map of the Study Area

III. Methodology

Following a preliminary site visitation that enabled survey planning and geologic mapping, an approximately NW – SE Traverse of over 200m was established parallel to the road pavement, and was made to cut across the stable and the failed segment of the road (Figure 2.0). Electrical resistivity method involving Vertical Electrical Sounding (employing Schlumberger array) and 2-D electrical imaging (utilizing dipole-dipole configuration) was then used for the geophysical investigation. For the 2-D resistivity imagine, an inter-electrode spacing of 5m was adopted while inter-dipole expansion factor (n) was varied from 1 to 5. The dipole-dipole data was inverted using the DIPRO software and the result was presented as pseudosections. Four Sounding stations were established at 15m, 85m, 115m and 170m as informed by the interpretation of the 2-D imagine (4.0). The apparent resistivity values which were obtained at current electrode spacing (AB/2) ranging from 1 to 65m were plotted against the electrode spacing (AB/2) on bi-logarithmic graph sheets. Partial curve matching was carried out and this was followed by 1-D forward modeling using WinResist geophysical software version 1.0 (Vander Velpen, 1988). The result of the VES interpretation was further used for the construction of geoelectric sections along the traverse.

Figure 2.0 Failed portions of Ajaokuta-Itobe Road.

IV. Results And Discussion

2-D Imaging

Figure 3.0 shows the pseudosection generated for the acquired 2-D resistivity imaging. Four subsurface geologic layers can be inferred from the result of the 2D imagine. A topsoil with resistivity values ranging from 42Ωm to 84.4Ωm, weathered layer with very low resistivity values from 14.7Ωm to 38Ωm, fractured basement (Resistivity varying between 92.1Ωm to 227Ωm) and the fresh basement with resistivity value as high as 2440Ωm.

The topsoil which is probably sandy clay varies in thickness from the failed portion of the road to the stable portion. At the stable portion (a distance between 25m and 90m), this topsoil is about 2.5m thick whereas; at the failed portion (between 90m and 190m) the very low resistivity along this path is closely related to the weathered layer which indicate that the topsoil have probably been washed away by erosion along this area or is merged with the weathered layer.

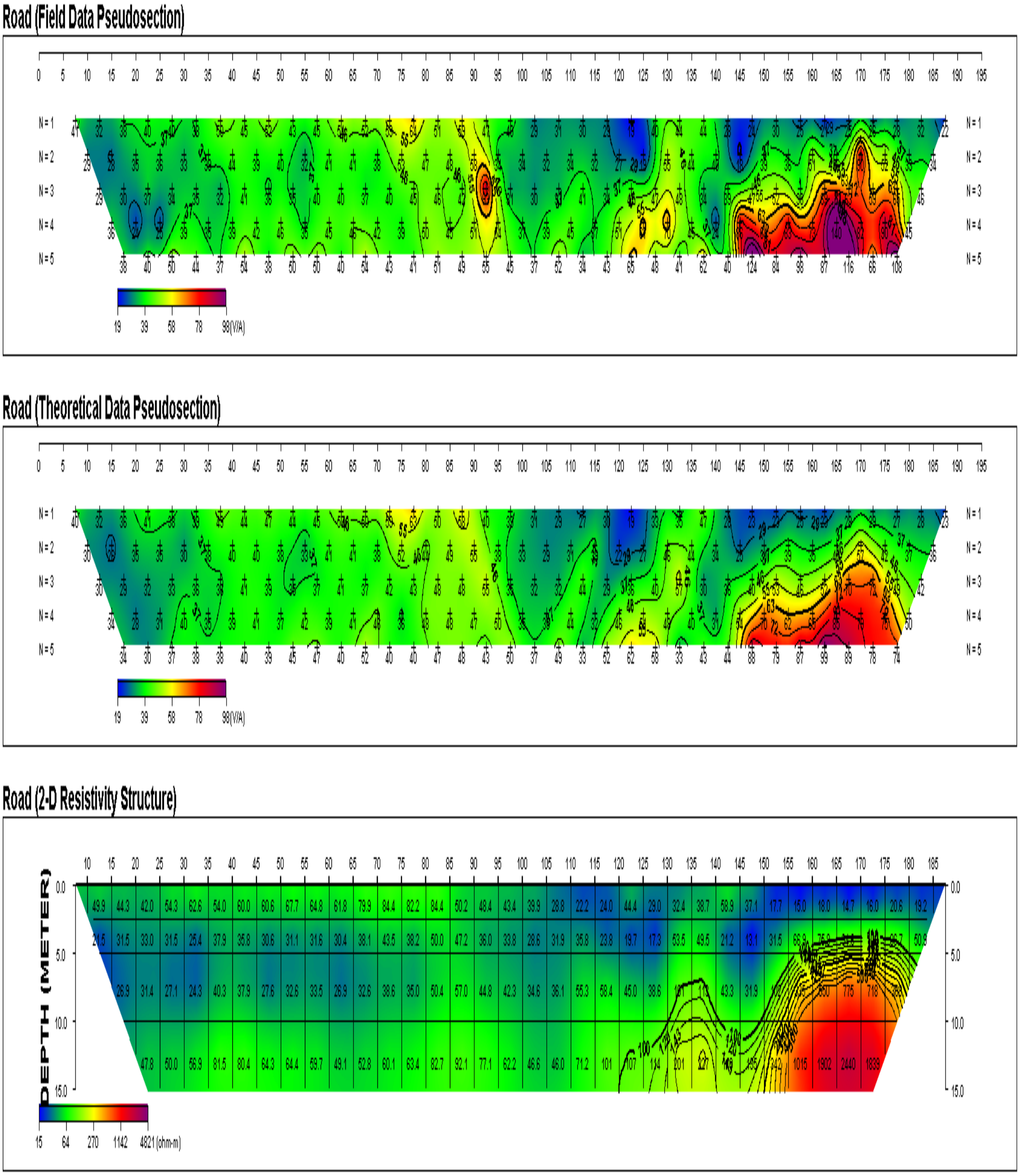

Figure 3.0 The inversion model of traverse:(A) Field Data Pseudo section (B) Theoretical Data Pseudo section (C) 2-D resistivity structure

V. Vertical Electrical Sounding (Ves)

The interpreted VES curves obtained from the study area is summarized as shown in table 1.0. The curve types identified include HA, AA, HA, and A type, with the number of layers delineated by the geoelectric section being four (4) (Fig 6.0). The topsoil (sandy clay) for the first three (3) VES points have resistivity values of 54Ωm, 27Ωm and 50Ωm with thickness of 0.9,m 0.9m and 0.7m respectively. For the fourth VES point, the topsoil has been replaced by the weathered layer with resistivity value of 42Ωm and thickness of 6.7m. The second layer (clay) has resistivity values ranging from 10Ωm to 45Ωm and its thickness is in the range of 2 to 7m. The third layer delineated with resistivity values of 57Ωm, 182Ωm, 74Ωm and 406Ωm (which is the weathered basement) is very thick at VES point 1(36m) but almost disappears at VES point 3. Its thickness at VES points 2 and 4 are 10m and 4.4m respectively. The fourth layer having resistivity values between 406Ωm and infinity represents the fresh basement rock.

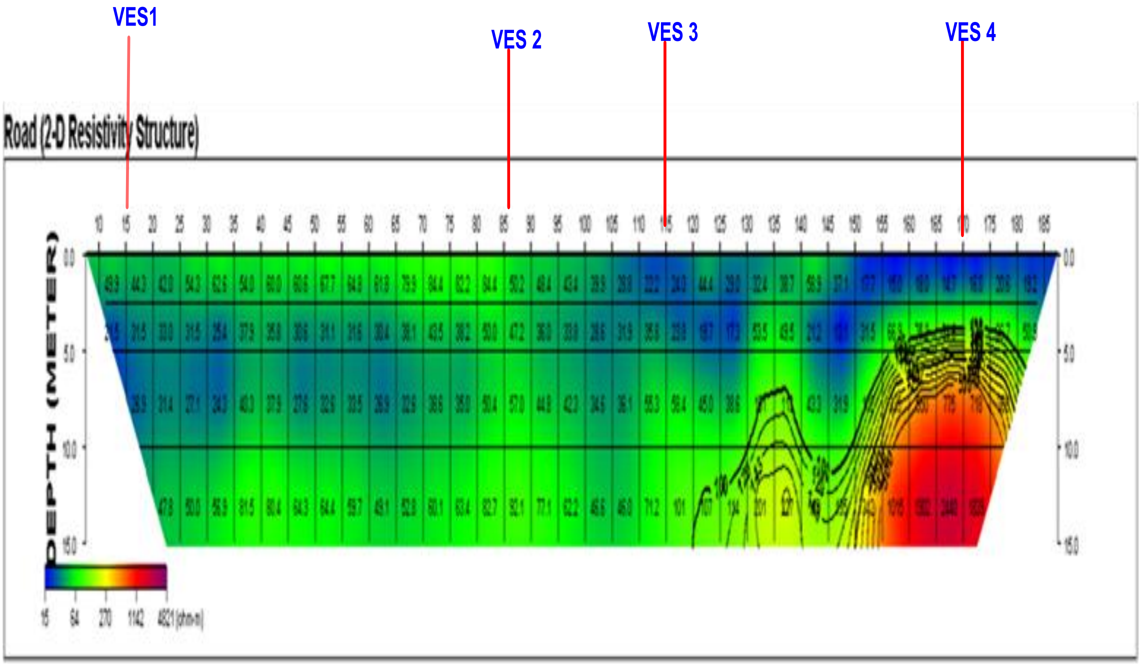

Figure 4.0: location of VES points on pseudosection.

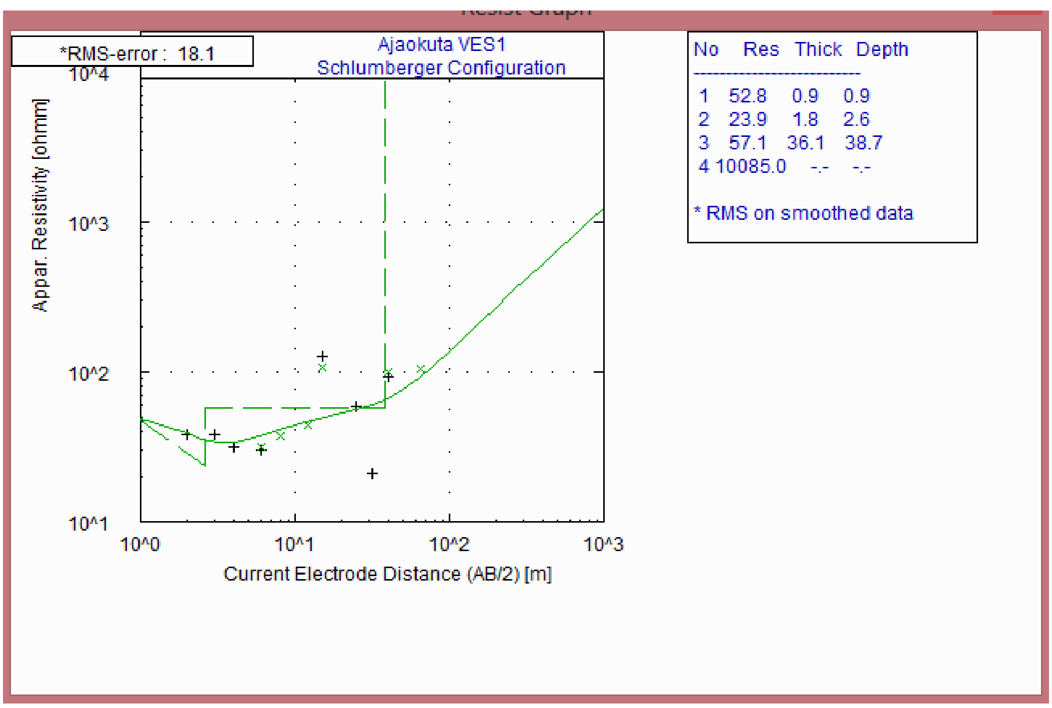

Figure 5.0: Typical Vertical Electrical Sounding Curve and Model Parameters

Table1.0: Summary of geoelectric parameters.

VES point	Curve Type	Thickness (m)	Depth (m)	Resistivity (ohm-m)	Inferred Lithologies
1	HA	0.9 1.8 36.1	0.9 2.6 38.7	53 24 57 10085	Topsoil weathered layer Weathered/Fracture layer Fresh basement
2	AA	0.9 6.4 10.1	0.9 7.3 17.4	27 45 182 16580	Topsoil Weathered Layer Weathered/Fracturedlayer Fresh basement
3	HA	0.7 1.1 1.3	0.7 1.7 3.0	50 10 74 32925	Topsoil Weathered layer Weathered/Fracturedlayer Fresh basemen
4	A	6.7 4.4	6.7 11.1	42 406 3067	Topsoil Weathered Layer Fresh basement

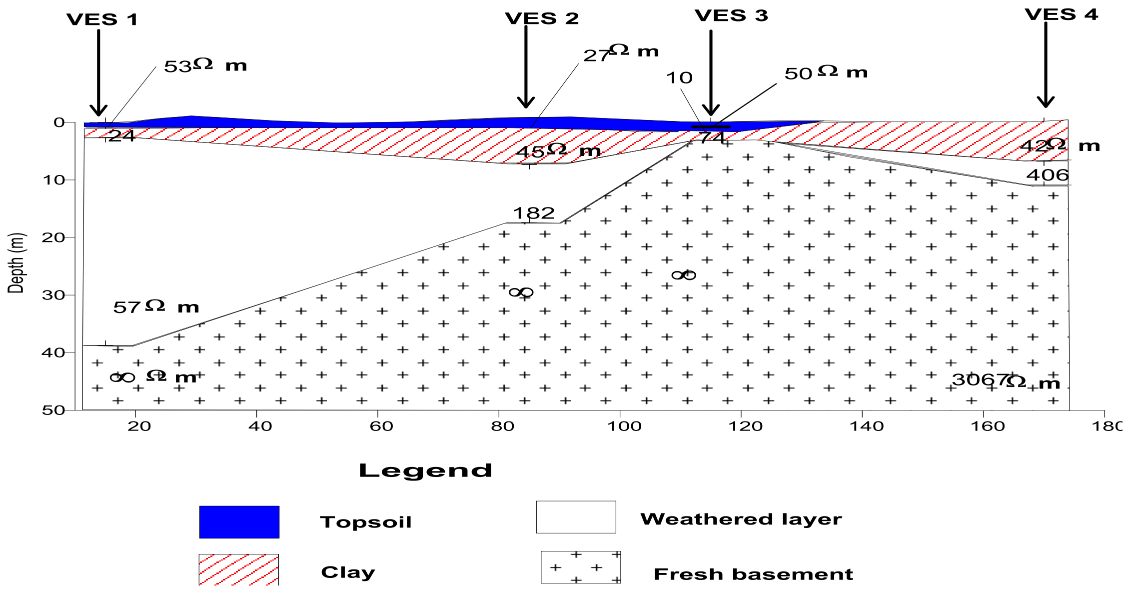

Figure6.0: Geoelectric section along the established traverse.

VI. Conclusion

The interpretation of the 2D resistivity imaging as well as the geoelectric section generated from the VES shows that the failed portion of the road is underlain by a low resistivity material (probably clayey sand) with the clay layer making it to the surface at some points. Whereas, the subsurface soil beneath a stable highway pavement is expected to possess sufficient strength to enable it support the load imposed on it. Unfortunately clay cannot be described as a competent material because; though it is highly porous, it is less permeable owing to poor connectivity of its pores; it will therefore expand and retain water easily but will collapse if exposed to sufficient pressure from the weight of vehicles. This repeated expansion and collapse is inimical to road construction and will eventually lead to road failure. It is therefore clear from the interpreted results that, a possible cause of the failure is the presence of Clay and even the clayey nature of the topsoil on which the road pavement is founded. Another possible cause is the closeness of the weathered layer to the surface since these is also an incompetent material. Finally, the presence of near surface linear features such as faults, fractured zones, fissures and joints may have contributed to the failure however; a more detailed geophysical investigation will be needed to draw such a conclusion. It is recommended therefore that a lasting repair or construction may be done by cutting to a depth beyond the incompetent materials and filling with more competent materials like laterite or concrete.

Reference

[1]. Adegoke-Anthony, W.C. and O.A. Agada. 1987. "Geotechnical Characteristics of some Residual soils and their implications on Road design in Nigeria". Technical Lecture. Lagos, Nigeria. 1-16.

[2]. Ajayi L.A 1987. "Thought on Road Failures in Nigeria".The Nigerian Engineer. 22 (1): 10-17.

[3]. Imasuen O. I., Olatunji J. A. and Onyeobi T. U. S. (2013); Geological observations of basement rocks, around Ganaja, Kogi State, Nigeria, *International Research Journal of Geology and Mining (IRJGM)* (2276-6618) Vol. 3(2) pp. 57-66.

[4]. K.A.N. Adiat, A.O. Adelusi, and M.A. Ayuk (2009); Relevance of Geophysics in Road Failures Investigation in a Typical Basement Complex of Southwestern Nigeria. *The Pacific Journal of Science and Technology,* Volume 10. Number 1

[5]. Momoh L.O AkintorinwaO, and Olorunfemi M.O. 2008. "Geophysical Investigation of Highway Failure – A Case Study from the Basement Complex Terrian of Southwestern Nigeria".*Journal of Applied Sciences Research. 4(6): 637-648.*

[6]. Nelson R.G and Haigh J.H 1990."Geophysical Investigation in Lateritic Terrain".*Geotechnical and Environmental Geophysiscs.*Ward S.H. (Ed), (Geotechnical), SEG, Tulsia. 2:133-154.

[7]. Olorunfemi M.O., Idornigie A.I., Corker A.T and Babadiya G.C. 2004."Assessment of Anomalous Seepage Conditions in the Opa Dam Embankment, Ile-Ife South-Western Nigeria".Global Journal of Geological Sciences. 2(2):191-198.

[8]. Onimisi, M., Daniel A.; (2014), Structural Features and Metamorphism of the Marble and Associated Rocks in Itobe Area, Central Nigeria, *International Journal of Science and Technology* Volume 3 No. 1

[9]. Woakes, M., Rahaman, M. A., & Ajibade, A. C. (1989). Some metallogenetic features of the Nigerian Basement: in Geology of Nigeria edited by Kogbe Pp 111-121.